Submission to Victoria's Gas Substitution Roadmap Consultation

From: Bruce Barbour
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Thank you for the opportunity to submit some brief comments for consideration as part of the consultation process.

Heating of Domestic / Commercial Space and Hot Water

The consultation paper suggests four alternatives for the replacement of natural gas:

1. replacement with bio-methane;
2. replacement with hydrogen produced from coal;
3. replacement with hydrogen produced by the electrolysis of water; or
4. replacement with electricity.

My main comments relate to in home use.

Preliminary Comments on Costs

All homes will continue to have the option of choosing electricity as their choice of energy source to provide in home heating going into the future. Consequently if natural gas is substituted with either hydrogen or bio-methane is it going to have to compete with the cost of energy from electricity. If the alternative ends up more expensive than the electric alternative there will be drift away from the gas alternative to electricity. This trend can already been seen as the cost of heat from electricity using heat pumps is already significantly cheaper than heat from natural gas.

There will be further discussion on costs in later sections.

Replacement with Bio-methane

There are numerous issues with this approach.

The first is getting enough organic matter to be able to produce the quantity of bio-methane needed. Some of the sources would be domestic organic waste that is collected by local councils, organic waste from the food production and some other industries and also crop waste by-product. If that is still insufficient then crops would need to be grown specifically for the bio-digesters. If that is required it is a matter of how much land is required, how much it will impact on food production (whether some land formerly used for food crops is going to be converted to crops for to bio-methane production), how much energy is needed to produce that crop, to harvest it and cart it to the bio-digesters.

The second is the energy needed to run the bio-digesters.

If there is a large agriculture requirement this has potential to impact on the quantity of food produced and the cost of the food. This may become an even greater issue if climate change (increased heat and drought etc.) impacts adversely on crop production.

There is also the issue of fugitive emissions of the bio-methane. It could be argued that the carbon produced during bio-methane production is part of the natural carbon cycle. It came from natural sources and will go back to natural sources. But that argument is suspect. If the crop waste or other organic waste was left to decompose naturally or commercially composted, much of it would decompose and release largely carbon dioxide. With the bio-methane production primarily methane is going to be produced. The bio-methane if released into the atmosphere will have the same greenhouse impact as the methane from natural gas. Methane is over 70 times more potent as a greenhouse gas than carbon dioxide over a 20 year period. Bio-methane is going to leak in the same ways that natural gas leaks – during production, distribution and use. It would have to be accurately accounted for, which in itself is problematic, and then offset – which adds to the cost of bio-methane.

I do not know what the likely cost of providing heat energy from bio-methane. As noted in the Preliminary Comments on Costs section if chosen as the gas substitute to be successful the gas would have to be competitive with the electrical alternative.

Not a preferred alternative.

Replacement with Hydrogen from Coal

The proposal for hydrogen produced from coal with carbon capture has very many issues associated. Even if the entire greenhouse gases from the conversion process are successfully captured, there will still be fugitive emissions from the mining process. An element of carbon offsetting would need to be introduced for this. While carbon capture and storage has been talked about for decades there are still few large scale commercial operations around the World, despite assurances from the fossil fuel industry as to its technical feasibility and financial cost. That would suggest that caution should be adopted when considering assurances of being able to implement carbon capture and storage on a large commercial and ongoing basis.

To state the obvious hydrogen from coal is not a renewable resource.

As well as the cost of producing the hydrogen there would be the not insignificant cost of converting the gas distribution system to be able to handle hydrogen. And also the cost of converting the existing appliances from natural gas to hydrogen.

As a side issue I also believe that high quality carbon storage areas are going to be important in the future. Most climate and carbon modelling suggests that the World will overshoot its carbon budget and will then have to remove carbon from the atmosphere. High quality proven storage areas – such as the Bass Strait depleted oil and gas fields - may become valuable for future atmospheric carbon removal projects and should therefore not be squandered on new fossil fuel based energy generation processes. This is speculation on my part but it should at least be examined before committing to carbon storage for new fossil fuel based generation that would have to continue into the foreseeable future.

I do not know what the likely cost of providing heat energy from hydrogen from coal. As noted in the Preliminary Comments on Costs section if chosen as the gas substitute to be successful the gas would have to be competitive with the electrical alternative.

Not a preferred alternative.

Replacement with Hydrogen from Electrolysis of Water using Renewable Energy

From my understanding there are few environmental issues associated with producing hydrogen by electrolysis using renewable energy. Hydrogen produced by the electrolysis of water using renewable energy is 100% greenhouse gas free. There is the issue of having to increase the amount of renewable electricity available to be able to supply this process.

There is also the issue of having to supply of clean water supply for this process. Melbourne uses desalinated water as part of its potable water supply. Presumably because the hydrogen production process would be an additional demand on the water supply it would mean that in quite a few years all the water for the electrolysis process would come from the desalination plant. Desalinating water requires electrical energy. Even if all the electricity for desalination comes from renewable sources it would impact on the overall efficiency of the electrolysis process. Of course if the water is from other sources this may be less of an issue.

My main concern with hydrogen from electrolysis is the cost of the gas. However if the economics can be made to work I would support its use as a natural gas substitute for all sectors of the community – domestic, commercial and industry. It would actually be the preferred course going forward.

I urge a full cost analysis be undertaken prior to undertaking an expansion of the hydrogen generation to include supply to the domestic market to determine what will be the cost per Megajoule of energy provided by hydrogen gas to the retail market, and compare that to the current price of natural gas and the price of heat energy supplied through a heat pump. This should include the cost of converting the current natural gas distribution system to be capable of distributing hydrogen.

As noted in the “Preliminary Comments on Costs” section it is already cheaper for residents to supply all domestic space and water heating with electrically driven heat pumps than using solely natural gas. Electricity is going to remain in competition with any gas substitute (hydrogen or bio-methane). People would have the free choice. If hydrogen is not competitive with the electrical alternatives overtime people will choose the electrical alternatives.

I note that the Discussion paper says “While hydrogen is currently more expensive than natural gas, it is projected to become more cost competitive in the future as electrolyser production economies of scale ramp up and as electricity prices decline.” The economies of scale will lower the price. However a decline in the cost of electricity will also lower the cost of heat delivered through electrically driven heat pumps by a comparable percentage.

The production of hydrogen by electrolysis is about 80% efficient. (This does not include consideration of the energy, if any, for the use of desalinated water or other water treatment.) The base efficiency makes the hydrogen a further 20% less efficient for the production of heat for residential and commercial use in comparison with heat from electrically driven heat pumps. Which, in the domestic setting, begs the question: Why would you use a process which introduces further inefficiency in the heat production process when it is not necessary? Instead of using the electricity to produce hydrogen to burn to produce heat, use it directly in the homes to produce heat with heat pumps, at a much higher efficiency.

If 1 kWh (3.6MJ) of electrical energy was used to generate hydrogen that hydrogen would contain 0.8 kWh of energy. Say this hydrogen was used for in-home heating. It would then be burnt in a heater or a furnace with say an efficiency of 84% (5 Star). The total delivered heat to the home would be 0.67 kWh (2.4 MJ). Now take that same 1 kWh of electricity and deliver it straight to the house to operate a heat pump air conditioning system. The heat pump could easily have a coefficient of performance (COP) of, say, 4. If that was the case the total heat delivered to the home would be 4 kWh (14.4 MJ), 6 times more heat than from the produced hydrogen. Even if the COP of the heat pump air conditioner was only 3 the heat delivered would still be many time that of the heat from burning hydrogen.

Even for cooking directly using the electricity makes more sense than converting it to hydrogen and then burning it for cooking.

One way that heat produced from the burning of electrolysis produced hydrogen could be cheaper than using it directly in heat pump is if the hydrogen is produced at times when the unit price of wholesale electricity is very much cheaper than normal. For example the middle of sunny days when photovoltaic panels are producing electricity in excess of normal demand. However if the hydrogen is going to be required for domestic and commercial heating most of the hydrogen would be required over the winter months when excess / cheap renewable electricity is less likely. (Perhaps cross seasonal storage is an option.)

The cost of construction of the equipment and the energy supply to produce hydrogen will be high. As a significant proportion of the gas distribution pipe network may have to be upgraded to be able to handle hydrogen, which may mean physically digging the existing pipes out and replacing with new pipes and valves in some areas. If this was the case the cost would be significant.

Hydrogen from electrolysis of water is a preferred alternative however its viability for the domestic / commercial market depends completely on the cost in comparison to energy and heat from heat pumps using electricity.

Replacement with Electricity

All in home heating can be provided with electricity, and in many cases for less cost than with natural gas. There is no need for any further development of the electric appliances to achieve this – though I imagine such development will continue.

House heating can be provided by heat pumps, that is reverse cycle air conditioners, either split air conditioners or ducted. Heating the house with heat pumps is currently cheaper than using the heat from burning of natural gas.

Presently if the natural gas heating in an existing home breaks down and needs to be replaced then financially the home owner is well advised to replace that heating system with heat pumps. The situation is similar with new housing.

For hot water, if an all natural gas system breaks down then the home owner is will get cheaper hot water if they replace the natural gas unit with a heat pump.

Without taking into account the gas connection charge, simple analysis shows that at present:

- a good quality natural gas boosted solar hot water will provide less expensive hot water than a heat pump running solely on grid electricity.
- cooking on a natural gas cook top and oven may also be cheaper than on an electric cook top and oven (even considering induction cook tops).

However when the gas connection charge cost is taken into account often this cost will mean that the total annual cost of gas for hot water (solar boosted or otherwise) and cooking and space heating, will be higher for a house that uses gas than for a house uses all electrical energy. If an all electric house has a rooftop solar photovoltaic system and the heat pump hot water is set up to run during the middle of the day this will provide even cheaper total household space and water heating costs.

What this effectively means is that for any gas substitute for the domestic and commercial markets to be viable in the long term the substitute gas (hydrogen or bio-methane) needs to be cheaper than the current price of natural gas and competitive with electricity. If it is not cheaper and competitive with electricity there will be a steady migration of consumers away from the gas substitute (hydrogen or bio-methane) to electrical means of providing heat as it is realised that cost savings can be made. The speed of migration may increase further if the cost of grid electricity continues to drop and as rooftop photovoltaic systems and other renewable electrical generation further penetrate the market. Market forces will prevail regardless of recommendations of the Roadmap and the consequent system upgrades.

If natural gas replacement with electricity was the adopted policy for the housing market then the conversion of the existing housing stock to all electric will be a major project considering the 2 million plus homes currently connected to gas. If this becomes the policy the sooner this is announced the better. The policy would obviously mean the end of the gas appliance supply and installation industry. The industry would have to shut down as it would be illogical to keep installing new gas appliances only to have to replace them in the medium term. There may need to be a small window to allow the suppliers, if they are able, to convert to a heat pump supplying business. However many brands and businesses have already "seen the writing on the wall" and supply both gas and heat pump appliances, so the impact on businesses may be less than thought. There obviously would be flow on effects on employment in this sector – please see my comments regarding this later in this document.

If this policy was in place there would need to be a plan to convert all space and low temperature hot water heating to heat pump in domestic and commercial settings. Conversion would need to occur by 2040 at the latest. In this 18 year window a significant percentage of existing gas appliances would need to be replaced anyway due to breakdown or excessive maintenance costs. Some financial assistance should be considered for replacement of a broken or old gas appliance with an electrical version as there would be greater costs for providing a new electrical connection to service the electrical appliance than simply reinstalling a new gas appliance. In the later stages rebates would have to be introduced to encourage a greater level voluntary replacement before end of life of the appliance, and finally mandatory replacement again with rebates – higher for low income families.

Complete electrification of in-house heating would increase electricity demand. This would be addressed by increased large scale renewable generation and storage and also increasing rooftop photovoltaic (PV) panels. Increased building and appliance efficiency should also be part of the response.

Substitution of natural gas with electricity is a preferred alternative.

Hydrogen for Industrial Processes

There may be a need for hydrogen in the future for industrial purposes. If there is a need it is primarily going to be for processes that require high heat and maybe for some cooking processes. If hydrogen is only required for industrial processes (and not domestic) this will cut the total amount of hydrogen needed by at least 75%, probably more, making it easier to achieve.

Reasonably high heat can be provided by electricity for industrial processes. Industrial heat pumps can provide heat well over 100 degrees Celsius. Direct electric resistance heating may be able to provide higher temperatures again. The Portland smelters ran off subsidized electricity for years. The heat required was many hundreds of degrees Celsius. However there may be some industrial processes that require even higher heat.

If there are industries that need hydrogen – for high heat or feedstock or restaurant cooking preference – this raises the question of how this could be achieved. There are a couple of options.

The backbone of the current natural gas distribution system could be converted to handle hydrogen and could have pipes into the industrial areas.

It may be more cost effective for industries or industrial estates to have their own hydrogen electrolyser and make hydrogen on site or to have it trucked in in tanks – rather than maintaining a whole gas production and distribution system. Or all industries requiring hydrogen moved to specific areas and only that part of the gas distribution system maintained. These alternatives should be investigated.

Impacts on Employment

Conversion to a natural gas substitute is not going to happen overnight. It will be phased in over a two decades, with the main conversion of existing houses to all electric occurring in the second decade, once the electricity grid has become more renewable. During the next two decades the levels of employment in the industry will have time to adjust to the new arrangements by attrition, retraining and moving to the new energy supply industry or another industry all together.

If electricity substitutes for natural gas (and natural gas banned) then this would impact the employment of those that work in the industry that installs natural gas and maintains appliances. It would also impact on any businesses that manufacture gas appliances in Australia and those that work in the gas supply and distribution industry. Many of the industry workers involved in installation are qualified as plumbers many would still be able to work doing water plumbing work. A ban on natural gas appliances will not impact on the total number of appliances that need to be installed – a heat pump hot water system still has to be installed where previously a gas hot water system was. What will not be installed in a new house is the gas line to the appliance which would be replaced with an electrical power connection. However in the medium term the number of jobs for the replacement of gas appliances with electrical appliances is going to be higher than a business as usual situation giving gas industry employment numbers time to adjust. If plumbers / gas fitters / other industry employees are not qualified to install heat pump equipment training and requalification should be offered.

For hydrogen substitution the impact on employment in the industry would be an increase while all the appliances were converted to be able to burn hydrogen. After that the employment levels would be unaffected. A new industry would be created for the production of the hydrogen.

For bio-methane substitution the employment levels would be unaffected. A new industry would be created for bio-methane production.

Energy from Waste

I note that energy from waste is still proposed as part of the electricity generation system. Energy from waste is not free from greenhouse gases – unless what is being burned is 100% organic. That is not the case – if it was the waste could and should be composted. The proposed local council 4 bin waste collection system includes a bin for green waste. Green waste placed in the bin will be composed of garden waste and kitchen food waste. I understand that this waste stream will be composted rather than burned. Paper and cardboard will also be collected in a separate bin for recycling. The waste that will be diverted from landfill to the energy from waste plant will contain an amount of paper/cardboard and other organic waste but it is also going to contain plastics, especially soft plastics as it is unclear how soft plastics are to be handled with the 4 bin system.

When the paper/organics burn they also generate carbon dioxide, however this is considered acceptable as the paper and organics are part of the natural carbon cycle and not fossil fuel based. However when plastics burn they generate carbon dioxide and a number of other chemical. Most plastics are from fossil fuels so any carbon dioxide they generate when burnt that is released into the atmosphere will add to the State's greenhouse gas emissions. In a zero greenhouse gas release future this would have to be offset or stopped. Otherwise it may be better just to bury the residual waste.

If waste to energy is to be part of the energy mix going forward the State Government should investigate capturing the carbon dioxide produced and arranging for its geological storage. If this was done such a generating plant would generate carbon credits for the organic waste it burns. It could also use other fuel sources such as crop waste to generate electricity and create additional carbon credits – which may add to its economic feasibility.

And Finally

I have included a section that is my speculation on what the future of the gas and energy distribution system may look like. This is in the attached Appendix 1.

Appendix 1.

Speculation on the Future Gas and Energy Distribution System.

This section is my speculation on what the gas and energy distribution system may look like in the future. This is based on most domestic heating applications being provided by electricity.

Electricity

- Most low level heating in houses and commercial premises (offices, shops, etc.) will be provided using electricity, with heat pumps being used in many situations. The large scale program of converting existing homes to all electricity can be delayed until the grid is at 50% to 60% renewable – commencing in, say, ten years. Gas boosted solar hot water would be the last appliance changed over. However installation of new gas space heating (including replacement of existing systems) may be banned at an earlier time. Some of this may depend on whether it is proposed to continue to supply hydrogen gas for domestic use in some areas – see later comments.
- Roof top solar PV would be encouraged for all houses (and perhaps mandatory for new housing), with the excess PV electricity converted to hydrogen – see further comments in the section below. The most cost effective arrangement for a house owner is to have rooftop PV and all electric space heating, water heating and cooking. Rooftop PV will decrease the impact of the additional demand on electricity for heating.
- Industrial heat will also mostly be provided by electricity – heat pumps if possible or electrical resistance heating. Some high level heating may be provided by hydrogen burning.

Gas – this depends on whether hydrogen is needed extensively for industry or only for a few factories. If it is only required for a few it will impact on how this is set up.

- Hydrogen will be generated for some industrial heating and for feedstock, and for energy storage / electricity regeneration (with fuel cells or standard gas engines). Some hydrogen may be used for cooking in restaurants and food production factories. Most low to medium level heating will be provided by electrically driven heat pumps or electrical resistance heating.
- Hydrogen will be generated by water electrolysis. It is likely to be more costly than current natural gas.
- The main gas distributors will be maintained and converted to handle hydrogen. These pipes will supply hydrogen into industrial and commercial areas and perhaps some domestic. The issues about suitability of the existing pipes to handle hydrogen will need to be resolved. If the cost of conversion is high then the extent of the distribution system may be smaller.
- The gas distribution pipe work servicing houses that would have to be replaced to allow its use with hydrogen will be abandoned or repurposed. The cost of upgrading unsuitable domestic distribution pipe work is probably too high given the availability of a cheaper alternative to provide heat - electricity with heat pumps. Some sections of domestic gas distribution pipes that can handle hydrogen without upgrade - area with plastic gas pipe already installed - may be retained provided it can be linked to the main distributor network easily. Unless the cost of hydrogen is competitive with electrical heat supply it is anticipated that the number of households opting to remain with hydrogen will decline over time. Cost

modelling would have to be undertaken to determine whether this partial retention of domestic hydrogen gas distribution is viable. If modelling shows that use will decline rapidly it may be preferable to go straight to electricity substitution for these areas.

- The hydrogen distributor pipes will be two way. That is the pipes could supply hydrogen but they could also accept hydrogen. This will allow the establishment of small to medium hydrogen gas production plants to be dotted about the suburbs. I anticipate that these would be modular, say the size of a half or full size shipping container that can be transported to site and connected up easily – however that would have to be determined. They will be remotely operated and monitored. With this in place hopefully it will not be necessary to throttle the booming domestic rooftop solar PV industry – all houses could have rooftop solar. Excess electricity generated from rooftop PV will be able to be converted into hydrogen and delivered into the hydrogen distribution pipe network. (This should also be considered if it is decided to do a complete substitution of natural gas with hydrogen – providing domestic hydrogen gas supply.) Variable pricing on domestic PV feed in may have to be considered. Battery storage – domestic and neighbourhood - will also play a part. Hydrogen production across the whole supply network would be largely decentralised. Hydrogen production would be switched off in times of high demand for electricity and/or low electrical energy production – hence part of the reason storage would be required.
- There may need to be large hydrogen centralised storage as well as smaller localised hydrogen gas storage. These may be cross seasonal – that is store hydrogen from summer for use in winter – for heat or electrical generation. The feasibility of this and the amount of storage would depend on systems modelling.
- Some industry will still need natural gas as a chemical feed stock. This could be achieved either my maintaining a small section of the natural gas distribution system and encouraging all industry that need natural gas as a feedstock to move into that area. Alternatively natural gas would have to be supplied by road tanker into site storage tanks. Any associated emissions would have to be offset.
- Sections of the abandoned residential gas pipe work system may be able to be repurposed as a recycled water distribution system or collected rainwater/stormwater distribution system for domestic and public garden and parks watering.

Interim arrangements

- Announce the phasing out of the use of gas for household and commercial use.
- Establish a plan of how and how quickly this will be achieved.
- Construction of some hydrogen electrolysis plants and feed the hydrogen into the natural gas distribution system – to 10% of total volume. (This is to decrease interim greenhouse gas emissions.)