The Future of the Natural Gas System in a Carbon Constrained Economy.

This submission relates to how the major infrastructure could have a place in a carbon constrained economy. The focus is on the existing assets and does not eliminate or reduce the need to find alternative supplies of gas from environmentally acceptable sources.

There are several major issues with the operation of the natural gas networks in a carbon constrained economy

1. The inefficiencies in distribution, from production to consumer.
2. As gas usage decrease the risk of the stranded assets scenario developing, resulting in significant asset write downs.

Efficiency

The gas distribution network is very inefficient. Large compressors are used to compress the gas to pressure suitable for distribution along several hundreds of kilometres. A side effect of increasing the gas pressure is heat. This heat is dissipated by coolers at the compressors sometimes across several stages to protect the compressors and limit the temperature in the pipes.

At the pressure reduction sites (required to reduce the pressure to a safe and usable value across differing networks) it is common for the pressure reduction to cause excessive cooling (the opposite of what happens in compressors). The gas temperature can reduce to a value that is unsatisfactory, causing damage to equipment and possible freezing of contaminates in the gas stream resulting dangerous conditions and undesirable blockages. To overcome this, it is common to heat the gas in water bath heaters before the pressure reduction so that the low temperature is avoided. It is usual that some gas is burnt in a combustion chamber of the water baths to provide the heat energy.

In summary, energy is provided at the compressor and it is dissipated it to the environment, only to require that energy be added at the pressure reduction sites. It doesn't take a thorough analysis to realise this is quite wasteful.

The recovery of energy (as electrical energy) at the compressor sites can be achieved by low temperature heat recovery systems but they tend to be inefficient in the amount of energy recovered and are capital intensive They are not usually considered although the remain a technically viable solution to increase efficiency. A use for the low temperature heat energy is usually not available at the compressor sites.

Energy recovery at the pressure reducing sites is viable providing an expansion turbine replaces the expansion valves and additional heat energy is applied before the turbine. Additional heat energy is required as a turbine, producing work to turn a generator, lowers the temperature of the gas by a considerable amount more than the reduction associated with a normal pressure reducing valve.

The key is to the supply of required heat energy and a method of achieving this is via the use of modern heat pumps. Heat pumps can extract energy from a source (such as the air) and elevate it to temperature suitable to support the heating of the gas stream so that the turbine can, without risk to the consumer, create what is effectively renewable energy.

For example: Data from a large gas consumer has revealed utilising waste heat and heat pumps a 2 Megawatt net output (taking into account energy to operate heat pumps) continuous power

plant is feasible. The equivalent of 5 of the largest wind turbine operating in Australia, at a fraction of the capital cost.

Even if heat pumps replace the water bath heating source (turbine not installed) a calculation reveals that if a gas fired generator of 40% efficiency generated the electrical energy for a modern heat pump, the net gas usage would be half that of using gas as the heating source for the bath. An immediate 50% reduction in gas consumption and associated GHG emissions.

The use of pressure reducing turbines to generate electrical energy has been implemented in other countries and proven successful. (refer Turboden company website for working examples). A point of difference is the use of heat pumps (due to the unavailability of alternate heat sources) provides a renewable energy option to add to the renewable energy mix.

Why isn't this being done now?

This hasn't been done for two major reasons; Australia has developed a culture of if it hasn't been done before we are not doing it. Unfortunately, combined with risk adverse management from both the private and government sectors, this results in lost opportunities. The supply of silver bullets is not available, so we need to accept that innovation and some risk is required.

The second is economics, the water baths supplying major customers are owned by the gas network owner, but who pays for the gas they consume? The customer!

So why would the gas network owner invest in capital equipment that costs them revenue? Of course, they wont, there needs to be another driver by way of regulations/penalties/rewards implemented.

Stranded Assets

As the move away from gas and other fossil fuels gains momentum it is possible that much of the gas infrastructure will become what is known as a "stranded asset", meaning it has lost its value and its scrap value will be more that its operational value.

The proposal is given the information contained in the efficiency argument above, could the gas network become a renewable energy storage option?

The existing pressure zones are allowed to float between values to provide a storage buffer between production and consumption. It is only at the customer that the pressure is tightly controlled as a requirement.

For example: a high pressure trunk main may operate between 80 to 120 Bar. A downstream section may operate between 10 to 40 Bar. Under times of excess renewable energy compressors pump from the low pressure (providing it is safe to do so) to the high pressure main. Heat energy is recovered from the compressors and stored, possibly as hot water. When electrical energy is required the high pressure gas expands through the turbines, heat is provided by previously stored heat from compressors and possibly supplemented by heat pump sourced energy. This continues until the low pressure upper pressure limit is reached.

The scheme is not dissimilar to other pumped energy schemes including pumped hydro and compressed air. There are important considerations.

- The use of hot water (around 100 deg C) would require a storage of less than around $1/200^{th}$ the size of an equivalent 100 metre head pumped hydro scheme.

- The natural gas is circulated in the system, it is not consumed when operating as an energy storage/transfer system.
- Gas not circulated, and therefore continuing to customers will be an energy producer.
- Compared to proposed underground/mine site compressed air system this scheme would be a fractional cost, as the main storage infrastructure (pipes) already exist in a suitable form. The proposed compressed air systems will also require similar compressors and turbines as are required in the suggested scheme.
- There is no doubt the amount of gas circulated will be high and large compressor/turbine installation will be required, however, the need for large systems applies to all significant energy storage options
- The compressors/turbine station could be placed at several locations allowing a distributed storage/recovery option.

The use of compressed natural gas storage capacity in pipelines is already used, for a differing purpose.

The Colongra power station in New South Wales was completed in 2009. It is a 667 MW peaking plant and when in operation places significant demand on the upstream gas infrastructure. To enable extended operation of the power station gas is compressed from a nominal 68 Bar to 138 Bar in a pipeline. The pipeline itself is not a straight run but has multiple lengths installed to increase the volume for a given distance using pipes that can withstand the high pressure.

In the report Jemena (owner of distribution network) Safety Management Manual 30th January 2017 Section 4.2.2 this section of pipeline is described as a gas storage "bottle".

Note that the water bath heater required to heat the gas before the pressure is lowered back to 29 Bar (at the gas turbine acceptance point) is a significant 5MW capacity. This is 5 MW worth of wasted gas with the intermittent nature of operation the only saving grace.

I believe that the consideration of energy recovery option combined with the use of natural gas infrastructure as an energy storage mechanism should be considered as vital to ensure continuous operation of the natural gas network in the future. The proposed scheme, under a more thorough examination, would rate highly when compared with other energy storage options being considered.