Submission

Process Heat in NZ – Opportunities and Barriers to Lowering Emissions
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General
I am supportive of most of the data, analysis and perspectives in this paper.

As an academic I have generally not responded to questions targeted at businesses except where my interaction with businesses has indicated preferences and constraints.

Detailed Comments and Answers to Questions

Footnote 8, p10 – A more detailed definition of emissions leakage include an example would be useful for many readers.

Para 27 –Most process heating technology is replaced on a very long time cycle which is a barrier to change. This is alluded to in para 28 but not stated particularly strongly.

Para 30 – I am unconvinced by the statement that "the plants that remain in operation have relatively out-dated technologies". Most remaining energy intensive plants are exposed to international cost-competitiveness and therefore need to remain relatively close to cutting edge technology or their viability will erode. A major exception might be where lower environmental compliance in NZ than off-shore might provide a cost advantage to remain in NZ despite slightly inferior technology.

Q2 & Q3 – My experience is that few businesses account for the future price of emissions because of the uncertainty but also, often because of the short business time frame that they operate. At best they may assume the current price will persist but given the experience of a low international carbon prices immediately post the GFC in 2008, even current carbon price may not be taken into account. Greater certainty on future prices (e.g. at least minimums) that will be experienced is required to change this behaviour.

Para 89 – Some electro-technology is perceived as experimental and risky but the relatively high capital costs of many such technologies is often at least as significant as a barrier. This is certainly the case for high temperature heat pumps.

Q15-18 – A major barrier of electrification is the costs to upgrade the electrical supply within the business's site (as well as externally) as the electric demand grows. This can often be just as large as the investment in the electro-technology itself.

Q19-22 - Not all biomass mass fuels will be able to be supplied from waste biomass. The barriers in the paper do not explicitly consider that biomass fuels also complete with the value of wood (or other biomass) as a product itself.

Heat pump (HP) technology is likely to be a significant contributor to decarbonising process heat in NZ. However, a major limitation of the paper is that it does not provide sufficient technical and economic detail to define to potential to replace boiler and other fossil fuel based combustion technologies. My very quick summary is:

- HPs are generally more expensive that traditional heating technologies so the extra capital must be justified by the lower on-going cost of the "fuel". Carbon prices help make electricity more favourable relative to fossil fuels but the efficiency of the HP (measured by the Coefficient of Performance, COP) is also critical. The HP COP must be greater than the fuel price ratio (included carbon charges) for HPs to be economically viable.
- The laws of thermodynamics mean that HP COPs decrease as the temperature of the heat requirement increases. Similarly, the capital cost of HP will tend to increase as the temperature level increases. Combined, these mean that the temperature range that HPs can be applied to will limited economically. R&D will stretch this economic limit to higher temperatures (a greater fraction of the process heat demand) over time.
- HPs for temperatures below 100^{o}C are now a relatively mature technology. While there are some lingering perceptions of technical risk related to mixed performance of early installations 10-20 years ago, adoption of HP up to 100^{o}C is now largely limited by other barriers such as recovering the high capital cost from lower operating energy costs.
- HP pumps for temperatures between 100^{o}C and 150^{o}C are starting to appear internationally but there are often technical challenges (e.g. lubrication at high temperatures, availability of suitable equipment at scale, refrigerant constraints such as flammability) and the economic case is incrementally harder to make because of the increase in capital and decrease in COP. More R&D and early stage demonstration projects should help define the best opportunities to apply HPs.
- The economics of high temperature HP above 100^{o}C significantly improve if there are high temperature heat sources (e.g. above 70^{o}C). However, in NZ such heat sources are not available to most sites or, if they are available, there are usually far more cost-effective direct uses of this heat than heat pumping to higher temperature. Most "waste" heat in NZ industries is below 50^{o}C so any consideration of HP technology to decarbonise process heat should be based on heat sources at such temperatures or they will be unrealistically optimistic about the potential.
- If heat pumping is being considered then linkage to process cooling requirements can improve the economics (if can be possible to both provide both useful process cooling and useful process heating with the same HP). Process heating should not be considered in isolation from cooling demands.