MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Energy Efficiency and Conservation Authority
Te Tari Tiaki Pūngao

Process Heat in New Zealand

Process Heat in New Zealand:
Opportunities and barriers to lowering emissions

Technical paper
January 2019

New Zealand Government

How to have your say

Making a submission

You are invited to make a written submission on Process Heat in New Zealand: Opportunities and barriers to lowering emissions.

This paper includes questions you may like to respond to in your submission. Your submission does not need to answer all of these questions.

The Ministry of Business, Innovation and Employment (MBIE) and the Energy Efficiency and Conservation Authority (EECA) also encourages any other comments you may have regarding process heat use and the transition to a low emissions economy. Where possible, please include evidence to support your views, for example, references to facts and figures, or relevant examples.

Please send your submission before 5pm on Friday, 22 February 2019. Please include your name, or the name of your organisation, and contact details. You can make your submission by:

- Attaching your submission as a Microsoft Word or PDF attachment and sending it to *energymarkets@mbie.govt.nz* or
- Mailing your submission to:

  Energy Markets
Ministry of Business, Innovation, and Employment
PO Box 1473
Wellington 6140
New Zealand

Please direct any questions that you may have in relation to the submission process to: *energymarkets@mbie.govt.nz*

Use of information

The information provided in submissions may be used to inform MBIE and EECA's work on process heat and advice to Ministers. We may contact submitters directly if we require clarification of any matters in submissions.

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Please indicate on the front of your submission if it contains confidential information and mark the text accordingly. If you wish to make a submission which includes confidential information, please send us a separate version excluding the relevant information for publication on our website.

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Process Heat in New Zealand

Contents

1) Introduction

The transition to a low emissions economy: improving energy productivity and increasing the use of renewable energy in industry

1. In order to transition to a low emissions economy, our energy use needs to be more efficient and move away from a reliance on fossil fuels. To our advantage, New Zealand has a predominately renewables-based electricity system. While more can and will be done there, our biggest opportunities for further reduction of energy-related emissions lie in two areas – transport and process heat.

2. Process heat refers to thermal energy (heat) used to manufacture products in industry. More than half of process heat demand is met by burning natural gas or coal. Consequently, decreasing emissions from process heat systems is necessary to ensure New Zealand achieves its climate change goals and obligations.

3. The New Zealand Energy Efficiency and Conservation Strategy 2017-2022 (NZECCS) outlines process heat as a key focus area for improving energy efficiency and increasing the use of renewable energy. The NZEECS directs the Ministry of Business Innovation and Employment (MBIE) and the Energy Efficiency and Conservation Authority (EECA) to develop a process heat action plan.

4. Addressing emissions reductions in process heat can be achieved directly through two means, improving the energy productivity of existing processes, and fuel switching (i.e. increasing the proportion of renewable energy used to supply heat). Process heat-related emissions can also be indirectly reduced through encouraging the use of low-emission products such as timber, instead of emissions-intensive products such as steel, and 'lower emissions' products such as 'green' cement.[1]

5. Viable opportunities for process heat users to reduce emissions already exist and can be deployed in a short timeframe.[2] However, these users often face barriers to the adoption of new technology (described in section 3) and, for rational reasons, do not enact these opportunities to reduce emissions. This document seeks feedback on our understanding of these barriers.

Understanding the status quo and barriers to the more efficient and renewable use of process heat is the first step

6. In order to enable the transition to a net zero future, we need to understand the status quo of process heat use in New Zealand. The features of process heat use, and the sectors in which it is used, mean that there are many barriers to reducing emissions and they are diverse and interrelated.

[1] Green cement is a material that at minimum meets the functional performance capabilities of ordinary cement by incorporating and optimizing recycled materials into the production process.
[2] *Low-emissions economy report, Productivity Commission, 2018.*

7. MBIE and EECA have been gathering information about the use of process heat across sectors and regions, as well as the mitigation options available to different users. We have published several sector-specific fact sheets on our website and will continue to add information resources over the coming months.[3] We have also been researching what barriers exist that might prevent firms from investing in energy efficiency improvements or renewable processes; and which barriers are the most significant to process heat users.

8. This document and our website set out what we know so far about the current state of process heat use in New Zealand. We also seek industry and public feedback on our understanding of the barriers to lowering emissions from process heat.

9. **We invite you to provide written responses to the questions posed throughout this document** and provide us with any further information or evidence you think may help inform our understanding of the issues. Please annotate your responses, where possible, with the relevant barrier (letters A to N) accordingly.

[3] www.mbie.govt.nz/PHiNZ

2) Context

The use of process heat in New Zealand

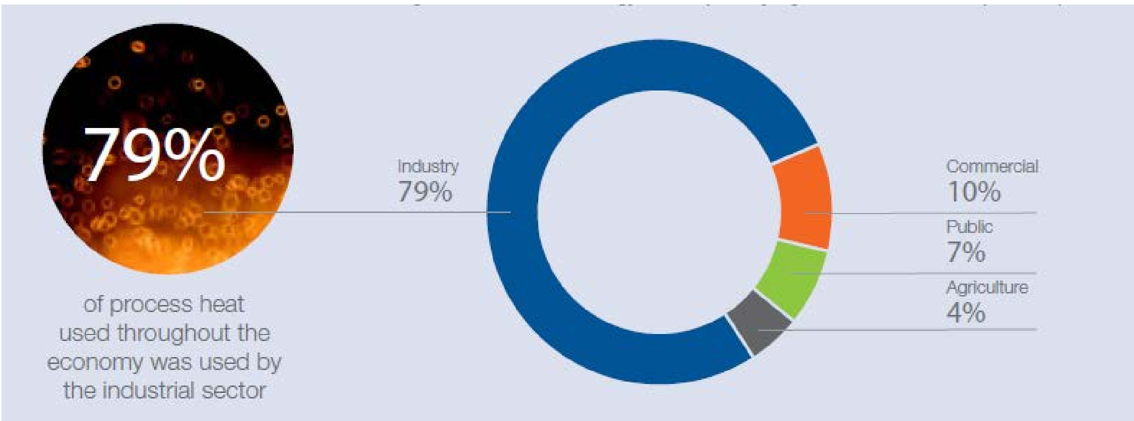
10. The energy sector (including transport) accounted for 40 per cent, or 31.3 million tonnes, of New Zealand's gross greenhouse gas (GHG) emissions.[4] Of this, process heat accounted for about 8.5 million tonnes of carbon dioxide equivalent (CO_2-e) and 27 per cent of all energy-related GHG emissions. It is the second largest source of energy-related GHG emissions behind transport.

11. The 2016 figures show that over half of process heat demand is met by burning coal, natural gas, and liquid fossil fuels (e.g. diesel). The remaining demand is largely met by electricity, bioenergy and direct use of geothermal energy. The availability of bioenergy and geothermal energy resources is highly dependent on location and sector.

Key facts on process heat:

- Process heat accounts for 34 per cent of New Zealand's energy consumption.
- About 56 per cent of process heat demand is supplied by burning fossil fuels, mainly coal or natural gas.
- About 68 per cent of process heat is generated by boiler systems.

Figure 1: Process heat energy consumption by high level sectors in 2016 (% of PJs)



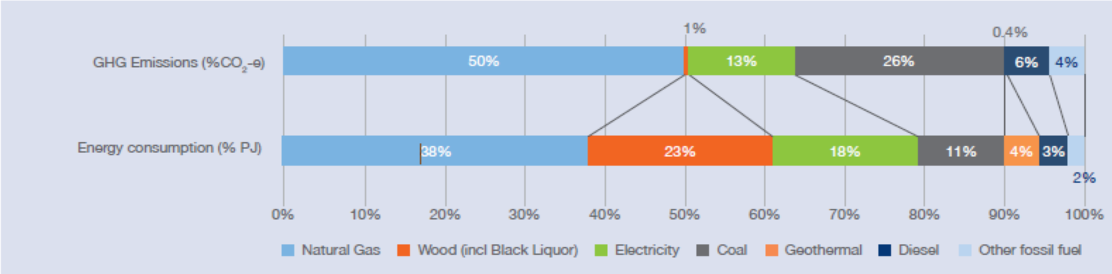
Fuel use and emissions[5]

13. Natural gas is the primary fuel used for process heat. It accounts for the greatest share, 37 per cent, of process heat energy consumption and the greatest share, 50 per cent, of emissions. Coal accounts for just 13 per cent of consumption, yet it makes up 26 per cent of emissions. Wood-derived fuels (wood 15 per cent and black

[4] Ministry for the Environment (2018). New Zealand's Greenhouse Gas Inventory 1990–2016.
[5] Based on 2016 figures: EECA's Energy End Use Database

liquor 9 per cent) comprise the second-greatest share, 26 per cent, of consumption, whilst contributing just 1.3 per cent of total process heat-related emissions.

Figure 2: Energy consumption and GHG emissions from process heat in 2016 - by fuel type



Note 1: Percentages may not sum to 100% due to rounding.
Note 2: The 'Other fossil fuels' group is made up of LPG, fuel oil, and petrol.
Note 3: Energy-related GHG emissions are allocated in proportion to consumption based on MBIE's GHG emission factors.

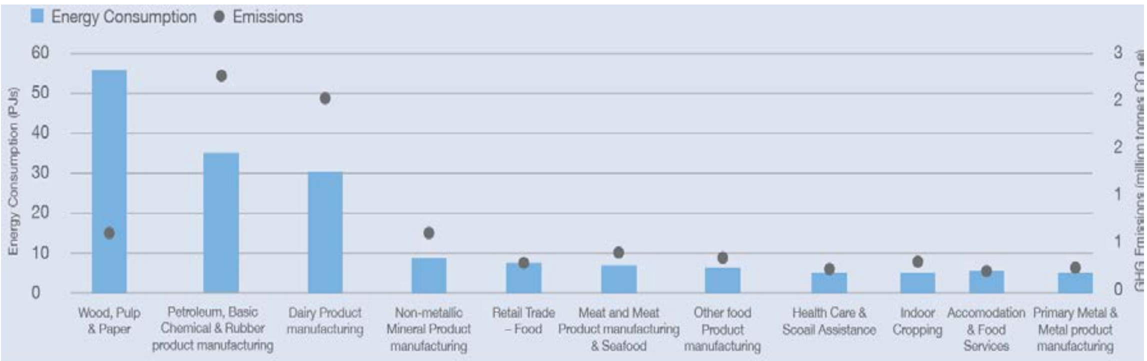
14. The wood, pulp and paper manufacturing sector uses the most process heat-related energy. This sector has relatively low emissions due to its heavy use of wood-derived fuels; however, it relies on fossil fuels for co-firing boilers, pulp flash dryers and drying kilns.

15. The petroleum, basic chemicals and rubber product manufacturing sector, and the dairy product manufacturing sector both have relatively high energy use and emissions.

16. The petroleum, basic chemicals and rubber product manufacturing sector is the largest user of natural gas. Process heat is integral to manufacturing processes in the sector. Another important aspect of this sector is that it is characterised by having a small number of large sites.

17. The metal and metal product manufacturing sector is also characterised by having a small number of large sites, with the use of heat tending to be tightly integrated with its manufacturing process.

Figure 3: Energy consumption and emissions from process heat in 2016



Note: the sectors shown accounted for 88% of all process heat energy consumption. 24 further sectors accounted for the remaining 12% which amounted to total consumption of around 25 PJs in 2016.

18. Most process heat emissions are produced by a relatively small number of super-large heat plant fuelled by coal and gas, with over 90 per cent of the emissions come from less than 5 per cent of the heat plant.[6]

Location and availability affect the choice of fuel type

19. Currently neither geothermal nor natural gas is available in the South Island. As a result, coal is used in the South Island for many operations of scale, which might be fuelled by geothermal or natural gas in the North Island.

20. Almost all bioenergy is used in the wood, pulp and paper manufacturing sector, where residues from processing operations can be recycled as fuel.

21. Other factors affecting the choice of energy source are:

- The temperatures required for the process.
- The relative cost of different fuels.
- The transport cost of fuel i.e. the distance between fuel source and site can impact final costs.
- Storage on-site. For example, wood and coal need to be stored on-site, while natural gas is supplied to the site as required (generally by pipeline). Storing on-site has the advantage of being readily available as required, but the disadvantage of requiring storage space. Due to their lower densities, wood fuels tend to require more storage space than coal.

Processes can have significantly different scale and temperature requirements

22. The nature of different manufacturing processes restricts how the heat can be supplied and used. Temperature requirements can be classified as low, medium or high, as set out in figure 4 below.

Figure 4: Process heat temperature requirements

Category	Temperature requirements	Uses	Examples
Low	Less than 100°C	Water heating Space heating	Sanitisation of equipment in the food processing sector
Medium	Between 100 and 300°C	Industrial processes	Drying wood products Drying food products, such as milk powder
High	Greater than 300°C	Industrial processes	Oil refining Melting metals Chemical manufacturing

[6] Concept Consulting (2017) *Energy-related carbon abatement opportunities*. Parliamentary Commissioner for the Environment.

23. Temperature requirements differ both within and across sectors:

- The majority of processes in food manufacturing use hot water and relatively low temperature steam. The highest temperature required for food processing is around 200°C for drying milk powder. A small-scale food processor needing only hot water may have a peak heating load of less than 0.1 MW.
- In contrast, steel making requires temperatures in excess of 1000°C, with a heating load consistently above 100 MW.

24. The end-use (e.g. milk powder drying) and the fuel source restrict the opportunities available for emissions-reducing investments. Most opportunities to reduce process heat-related emissions are currently for medium to low temperature heating processes. These opportunities include process efficiencies, using high temperature heat pumps and switching to low emission fuels in boiler systems.[7] High-temperature (i.e. over 300°C) heat users have very few viable short-term economic abatement opportunities.

End-use technologies and equipment lifecycles

25. The industrial sector is particularly diverse, so when looking at the barriers to reducing emissions, we need to understand how energy is being used at a detailed level across a wide variety of plant types. End-use technologies can be broadly categorised as either in-built or replaceable technologies.

In-built technologies

26. In-built technologies are those built into the plant for the duration of its life. These in-built technologies are highly bespoke, embedded into a plant and tend to be specific to a given industrial process. Examples of industries in New Zealand with in-built technologies include chemicals, petrochemicals, cement, aluminium and steel. These industries are also characterised as being single-plant and highly process heat-intensive. For this category, there are typically only limited opportunities to switch to different technologies without re-building the plant. There are, however, operational energy efficiency improvement opportunities within strategic energy management, operations and maintenance practices. The industries with in-built technologies tend to produce globally-traded commodities and are considered at risk of emissions leakage[8] under the New Zealand Emissions Trading Scheme (NZ ETS).

[7] Productivity Commission (2018)

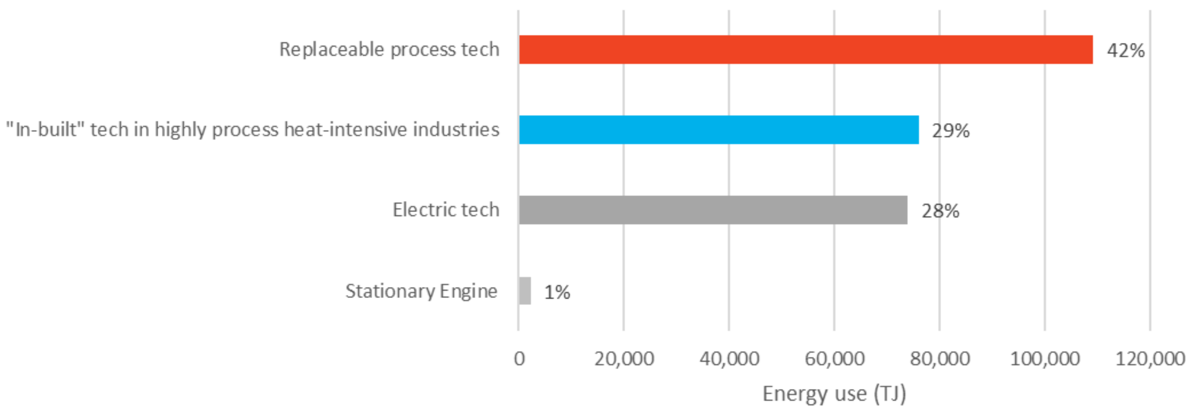
[8] Emissions leakage could occur when there is an increase in emissions in one country as a result of an emissions reduction by a second country which imposes higher costs on businesses through environmental policy.

Replaceable technologies

27. Replaceable technologies are those technologies that are replaced multiple times within an existing facility over the plant's life. These tend to apply to manufacturing industries such as food processing. Replaceable technology can be broken down into:

- **Common technologies and appliances** (e.g. pumps, fans, motors, lighting) for both commercial users and industrial users. Common technologies tend to be available "off the shelf". For this category, it is relatively easy to switch from a less, to a more efficient model. Common technologies are more frequently replaced.
- **Specialised technologies** (e.g. furnaces, agitators), that are built to order and require custom installation. They are often larger pieces of equipment, with higher energy use per installation but fewer instances of adoption. Replacements occur less frequently due to much longer lifetimes.
- Technologies operating in systems with interdependent component parts (e.g. process heating systems, conveyors, crushers, compressed air systems). **Technology systems** require design work and custom installation. Optimal design and installation can ensure technology systems operate efficiently. The efficiency of an individual technology component within a system would not capture how efficiently these systems operate overall. Replacements occur less frequently.

Figure 5: Technology opportunities in process heat use



28. Most process heating technologies have a life span of about 10 years or more. Some older plant might last substantially longer because they were more conservatively designed. Even though there are opportunities to use more carbon-efficient equipment (e.g. boilers and cooling systems), uptake may be limited because equipment is long-lived and purchased infrequently. A substantial proportion of existing equipment has significant remaining economic life.

About 70 per cent of process heat is generated in boiler systems

29. The majority of process heat is generated in boilers, which are used in all sectors of the economy. Despite their economic life span of 20 to 30 years, boilers are often used for much longer periods of time (40 years or more). For certain industrial

applications for which high temperatures are a requirement, direct heating is done in ovens, furnaces and kilns.

Reducing industrial process emissions from energy intensive industries is technically limited and is not yet economic

30. Many of our highly energy-intensive industrial plants were built in the 1960s to 1980s. Today, the plants that remain in operation have relatively outdated technologies. These were often built with Government investment. For these single-plant, energy-intensive industries, the main means to reduce emissions is investment in new plant at the end of the existing plant's useful life.

31. Understanding the opportunities for these industries to reduce emissions requires a case-by-case consideration of broader issues including:

    - The remaining life of the site, and the risks of emissions-intensive technology lock-in, stranded assets and sunk costs.
    - The likelihood of the industry investing in new plant, considering the high upfront investment, economies-of-scale, international commodity trade, and New Zealand's relatively small market (when compared to other countries).
    - The emissions benefits (or costs) of producing the products in New Zealand compared with offshore.
    - Other benefits of having these domestic based industries, including employment or strategic value to New Zealand, and the case for any Government investment in, or support for, these industries.

32. For these emissions-intensive sectors, a very high carbon price would likely be required to switch to renewable technologies (where applicable) - both for fuel used as energy and feedstock, (e.g. replacing the gas used to make methanol) - to be cost-effective. However, if New Zealand's carbon price is significantly higher than carbon prices in other parts of the world, or the price increases too sharply, emissions leakage is likely to occur.

3) Opportunities and barriers to lowering emissions from process heat

33. As set out in the introduction (Section 1), emissions reduction opportunities in process heat can be achieved directly through two means: improving the energy productivity of existing processes, and fuel switching (i.e. increasing the proportion of renewable energy used to supply heat).

34. The barriers to the renewable and efficient use of process heat in New Zealand are diverse and complex given the different energy and temperature requirements, technologies, fuels and process requirements across sectors and sites, locations and products.

35. This section sets out our understanding of the barriers for each of the main opportunity areas:

- improving energy efficiency and the uptake of renewables in process heat systems
- electrification of production, and
- use of woody biomass.

36. We also discuss other opportunities such as self-generation, use of hydrogen and the direct use of geothermal energy, and the barriers to their use.

37. We have sought to identify primary causes (barriers or market failures), not just the symptoms. This approach will allow us to identify policy responses to address the barriers to reducing process heat related emissions.

Barrier A: The cost of emissions is not fully priced

38. Historically, low emissions prices have had a small or negligible impact on the economics of firm-level decisions regarding the renewable and efficient use of process heat. The current maximum emissions price set through the NZ ETS has meant that renewable fuels are relatively more expensive than fossil fuels.

39. In addition, the low emissions price may have had an impact on the relative cost of process heat technologies. In general, the upfront capital costs of low emission technologies are more expensive than fossil fuel technologies. In comparison to incumbent fossil fuel technologies, Low emission process heat technology markets have struggled to develop and achieve economies of scale. Low historical emission prices, and uncertainty about future emissions prices and policy, have contributed to maintaining fossil fuel technologies' on-going attractiveness for investment even if costs are considered over the entire life cycle of a heat plant (20 years or more).

40. In December 2018, the Government finalised the first of two planned tranches of improvements to NZ ETS following public consultation. The package of improvements

includes a framework to enable the scheme to be capped in the future, which will provide more certainty to scheme participants.

41. The Government allocates New Zealand Units (NZUs) to businesses for producing specific products that are emissions-intensive (i.e. emission costs are significant in relation to revenue) and trade-exposed.[9] The 2009 amendments to the NZ ETS changed the basis for the industrial allocation of NZUs, with the amount allocated being on an 'emissions intensity' basis.[10] Eligible firms receive a set amount of NZUs (the rate is product dependent) based on their output of the eligible product.

42. Even though industrial allocation is expected to reduce over time, a significant proportion (approximately two-thirds) of process heat users are sheltered from the NZ ETS cost of their emissions because of the level of industrial allocation they receive.

43. The two tranches of improvements to the NZ ETS will address this market failure. However, it is likely that price signals from the NZ ETS alone will not, or are unlikely to, influence behaviour for many process heat users. There are multiple market barriers and different sector characteristics which may mean:

- Businesses are accounting for the emissions price but face other decision making barriers to reducing emissions such as short payback requirements (as described in the next section);
- Businesses are accounting for emissions prices, but are unresponsive to changes in the emissions price;
- The industrial allocation regime provides an incentive at the margin to reduce or not to increase emissions intensity. However, it may not provide an incentive to significantly reduce emissions beyond current levels or invest in new technologies. As a result, firms might not have the incentive to achieve best practice in their energy use;
- The NZ ETS incentivises emissions reductions where they are the 'least cost' in the economy, however to achieve a low emission New Zealand will also need to begin to address moderate and higher cost emission reductions.

[9] The purpose of industrial allocation is to mitigate the risk of emissions leakage. Emissions leakage would occur if the cost of ETS obligations in New Zealand means that the activity is unable to compete with a similar activity offshore, which has no similar costs from carbon pricing or other climate policies.

[10] Currently highly EITE activities (emissions intensity greater than 1,600 tCO^2e /$1 million revenue) are covered for 90 per cent of their ETS cost exposure with gifted NZUs while moderate EITE activities (emissions intensity greater than 800 tCO^2e /$1 million revenue) receive 60 per cent free allocation.

Q1: To what extent has the NZ ETS influenced process heat investments in your business?

Q2: To what extent do you agree that businesses are accounting for the price (and future price) of emissions, but face other barriers to reducing process heat related emissions?

Q3: To what extent do you agree that businesses are accounting for emissions prices but are unresponsive to changes in the emissions price?

Q4: Does the NZ ETS provide an incentive to significantly reduce emissions beyond current levels for business who receive industrial allocation?

Barriers to improving energy efficiency and the uptake of renewables in process heat systems

44. This section describes the barriers to the uptake of new technologies in an existing process heat system. This includes energy efficiency projects and renewable energy projects, such as installing a co-fired biomass boiler or a high temperature heat pump. For the following section, we have described the barriers to energy efficiency and the use of renewable energy as one and the same.

There is evidence that an energy efficiency gap exists for many process heat users in New Zealand

45. Some process heat users are not making decisions that maximise energy efficiency. Operational efficiencies offer significant scope to reduce emissions associated with process heat, although the largest potential gains especially for large energy users, have likely already occurred. Qualitative research by PwC (2018)[11] with nine large process heat users in New Zealand found that: "organisations appear to make sensible decisions in regards to investing in energy efficiency. However, the rational barriers that organisations face affect the way in which they are able to allocate capital. They derive from financial preferences and the processes used to ensure good investment decisions inside organisations."

Barrier B: Energy projects have to compete with other capital investment projects

46. Businesses' primary objectives when considering investments are based on risk and return. Risk-and-return objectives might be magnified if firms face future uncertainty in their industry, or are pressured by shareholders, boards, or CEOs to increase profits or dividends.

47. Objectives such as environmental sustainability or social responsibility are usually only considered as secondary objectives once the risk and return criteria have been met. This may be because some firms do not view energy efficiency or energy use as a strategic objective for their business. Conversely, if these stakeholders do value

[11] PwC (2018). Large process heat users and energy efficiency in New Zealand. Available at https://www.eeca.govt.nz/assets/Resources-Main/Large-process-heat-users-and-energy-efficiency-in-New-Zealand.pdf

energy efficiency, or low emissions performance, then firms might strategically prioritise relevant investments.

48. For large process heat users in New Zealand – where energy costs are in their top three operating costs – energy cost savings is the main driver for new investment in energy efficiency projects.

49. Energy improvements have opportunity costs and organisations will invest where there is the greatest economic return. Most businesses use their general capital pools to fund energy-efficiency technologies and the same risk-and-return requirements are used to prioritise energy projects along with other capital projects. Therefore, energy efficiency or emission reducing projects compete for funding with other capital projects of a similar scale. For small capital projects, payback periods of 12 to 18 months are typically required to meet investment thresholds. This partially helps to explain the "energy efficiency gap".

50. Larger capital investments, such as replacement projects, tend to focus on core business, production capacity additions, business survival and making returns on the investment. Energy efficiency is generally seen as an additional benefit of the overall project. Most organisations do not explicitly incorporate the price of carbon, and the risk of price hikes, in their analysis (PwC, 2018).

Barrier C: Access to capital

51. Access to capital is a commonly cited barrier to energy investments. In some cases, firms that wish to access loan finance are unable to find a willing lender, for example due to creditworthiness concerns. This is limited access to capital.

52. In other cases, restrictions on capital are often self-imposed through concerns about the risk of increased gearing[12] as borrowing requirements and financing risk are likely to be assessed for the firm as a whole, and not for individual investments. High levels of gearing increase risk and raise a firm's cost of capital.

53. Higher levels of gearing exposes shareholders to greater risk whereby loan servicing diminishes the firm's profits. As a result, shareholders may demand higher returns from the investment as compensation. In addition, high levels of gearing also exposes lenders to greater risk as the firm's asset value may be insufficient to pay off outstanding loans in the event of liquidation. Due to this, lenders may demand higher interest payments on loans.

54. Loan finance carries risk in that it imposes obligations both to meet annual interest charges and principal repayments. In contrast, share dividends are not fixed obligations and are at the firm's discretion.

Barrier D: Aversion to production disruption

[12] Gearing refers to the ratio of loan finance to equity.

55. Interrupting production (i.e. operational outages) in order to retrofit new equipment is a significant opportunity cost. The savings achieved following retrofit may not outweigh risks to production, even if these are part of a normal maintenance cycle.

56. Production outages (or risk of disruption) can be very disruptive to organisations, but have the potential to impact organisations in different ways according to how they undertake maintenance and upgrades. Organisations that operate continuously tend to schedule outages in advance (i.e. annual or semi-annual operational outage) to conduct monitoring activities, do regular maintenance and replace equipment. They do this to mitigate any potential risks and impacts from disrupted production. Operators can also schedule outages to suit their business cycles, reduce risk and coincide with periods of reduced market activity where possible.

57. Introducing energy savings measures can have an impact on normal activity. The imperative to maintain output in energy-intensive production may outweigh the energy savings payback from implementing a new energy-efficient technology.

58. Organisations reported that a key factor in the decision making process was the operational risk and opportunity cost of lost production.[13] Temporary loss of energy supply can result in production delays and loss of economic value for the organisation's stakeholders. Accordingly, organisations consider these factors when assessing an energy-efficiency technology and will not upgrade or retrofit a technology unless there is no or minimal risk of disrupted production.

59. Organisations rarely disrupt their production processes, aside from required maintenance and upgrade outages. They have a clear aversion to the operational risk of incurring these costs. The perceived opportunity cost of lost production value outweighs the benefits of upgrading or retrofitting technologies out of this cycle.

Barrier E: Hidden costs and benefits of energy improvements

60. Production disruption is a hidden cost of energy investments. Three other possible sources of hidden costs include:

I. The general overhead costs (and time) of energy management. Such as the costs associated with employing specialists, energy information systems, monitoring, maintaining, and analysing gathered data;

II. Costs which are specific to making a given energy-efficient or energy-savings investment. This could include the cost of: identifying opportunities, detailed investigation and design, formal procedures such as approval of capital expenditure, specification and tendering for capital works to manufacturers and contractors, replacement or retraining of staff, inconvenience;

III. Potential loss of utility associated with energy efficient choices, such as problems with safety, noise, working conditions, service quality, adjustment, and reliability.

[13] PwC (2018)

61. Conversely, energy efficiency investments may also yield hidden benefits such as increased productivity, health and safety, staff wellbeing and product quality. For example, insulation on hot pipes can also prevent injury and therefore improve plant health and safety. These considerations increase the non-energy benefits of the project, thereby increasing the attractiveness of the business case for implementing the technology. In these cases, energy efficiency technologies complement other aspects of the operation.

62. The hidden costs and benefits of energy projects may be inadequately quantified or accounted for in engineering economic analyses or business cases. This creates a perception of high risk with regards to the investment. These perceived risks can outweigh the potential saving in energy costs. Alternatively, it may underestimate the reduction in overall operational risks as a result of the investment. A thorough assessment of potential co-benefits may eventually lead to a different final decision in favour of the investment.

Q5: To what extent does your business ring-fence capital for energy related projects?

Q6: To what extent are objectives such as sustainability incorporated into your organisations investments, i.e. is sustainability included in your KPIs?

Q7: Are these objectives considered secondary to risk and return?

Q8: Do you agree that energy efficiency or renewable projects are often not implemented as they are not core business investments?

Q9: Is your business limited by access to capital for energy related investments? Is this due to lender appetite or are these limits self-imposed?

Q10: To what extent do hidden costs or co-benefits (as described above) hinder or progress process heat investments?

Barrier F: Inadequate information on the emissions profiles of products or firms

63. There appears to be insufficient demand side pressure to incentivise firms to reduce emissions and switch to renewable fuels. We think a reason for this is that some consumers, investors and Government agents are not making informed choices when interacting with firms who produce emissions. Our assumption is that if consumers and investors did have adequate information on the emissions profiles of firms/products in some sectors, some firms would reduce emissions or manage carbon risks to meet expectations.

Barrier G: Some firms have poor information on their own energy use

64. According to PwC (2018), energy data is frequently monitored, reported and used by the large process heat users they interviewed. However, other businesses might have limited information on their own energy use and are therefore not demanding energy efficiency improvements. This is more likely to be the case in businesses where energy costs are a small proportion of total spend.

Barrier H: Lack of information or aversion to new technologies

65. The nine firms interviewed by PwC (2018) reported having sophisticated systems for monitoring energy and energy productivity. The firms use external energy consultants to help draft business cases in a way that translates information for senior decision-making. Organisations and energy consultants appeared to have a good understanding of common energy efficiency technologies, regardless of whether they had been implemented.

66. However, organisations do not have perfect information, particularly about new or emerging technologies, and engineering consultants can have a bias towards proven technology, i.e. what they know has worked in the past.

67. Firms and consultants tend to be risk averse with regards to new energy efficiency technologies. The PwC interviews suggested that if technology had been proven, or a successful small-scale pilot had been conducted, the perceived operational risk of a new technology would decrease.

Q11: Does your organisation actively monitor its energy use and/or its emissions?

Q12: Do you think that there would be benefits from publishing individual emissions data reported by NZ ETS participants and/or large process heat users?

Q13: Do any of the informational barriers described above have an impact on your organisation's decision to invest in process heat technologies, and if so, to what extent?

Q14: Could you please rank the three informational barriers as listed directly above this box in order of impact on your organisation?

Barriers to the electrification of production

68. The electrification of low to medium temperature processes offers large mitigation potential in process heat, due to our highly renewable electricity supply. Electricity as an energy source offers a range of benefits, including low emissions, high controllability, plant efficiency, and relatively low cost of capital plant.

69. In the South Island especially (due to lack of access to gas or geothermal, and proximity to large hydro generators), switching to electricity may be immediately feasible for some businesses whose heat needs are negatively correlated with electricity prices.[14] This would be the case if their production were to peak in summer and drop over the winter.

70. The barriers faced by users considering electrification are numerous and complex, but can be summarised under three main themes: the high cost of electrical energy, the complexity and cost of electricity supply, and a historical bias whereby electricity has been the last choice fuel for industrial processes.

[14] Concept Consulting,(2017). *Energy-related carbon abatement opportunities*. Parliamentary Commissioner for the Environment.

Barrier I: High cost of electrical energy relative to other high carbon fuels

71. Largely this barrier arises because the negative externality of carbon emissions is not fully taken into account, especially in the long term. Electricity is currently more expensive to produce than other fuels, due to the complexity and cost of generating equipment, although these costs are falling over time. Further, in the case of new generating plant, the wholesale price of electricity needs to cover the full costs of plant and related infrastructure, in contrast with an existing asset which may only need to cover operating costs.

72. Consequently, in many cases electricity is not cost-competitive with cheaper fossil fuels. Many of these cheaper fuels have a higher overall cost to society when emissions, air quality and environmental impacts are considered, yet these impacts are not reflected in the prices of these fuels.

Barrier J: Electricity supply is fundamentally more complex than other fuels

73. Fossil fuels, such as coal or diesel are easy to physically store and transport, and can be stockpiled for later use. Most fossil fuel supply arrangements are relatively simple and often bilateral, directly between consumer and producer.

74. Electricity, on the other hand is difficult to store and supply needs to be matched with demand in real time. In practice, this means electricity is usually supplied as part of an integrated system, requiring co-ordination of production and transmission along with technical aspects to manage, such as voltage, frequency and standby reserves. This means that supplying and using electricity is fundamentally more complex than other fuels. This poses a challenge for existing users to manage, as well as a direct barrier to uptake for new users, which creates uncertainty for new applications.

75. In general, the only practical way for a large user to access electricity (at least-cost) is via the national electricity system. This means that the cost of supplying electricity to a particular site is affected by behaviours of other players within the overall system, as well as events impacting the system (such as extreme weather events).

76. Electricity prices vary across the system, both location-wise and temporally, due to a range of factors. While it is possible to manage price variations to some extent, this requires additional arrangements (such as three-year fixed price contracts) or futures trading that themselves add complexity and/or costs.

77. Complexity also means that long-term pricing (for example 20 years to match the life of a factory or heat plant) of electricity is more difficult than other fuels, and it is difficult for buyers and sellers to agree on a long-term electricity price. In general, fixed price contracts longer than about five years are not used for electricity supply. In contrast, longer term forward contracts are available for other fuels, such as coal.

78. Many other barriers stem from participation in the electricity system, including connection costs and time delays, perceived security of supply risks, and variable emissions intensity.

Barrier J1: Connection costs and the Transmission Pricing Methodology

79. Connecting to electricity networks requires specialised and expensive equipment. These costs are not part of a conventional fossil-fuelled process heat installation, and are therefore often considered additional, and/or may be under-estimated in an initial cost estimate.

80. Because the new equipment needs to be connected to the electricity networks, the network operator (Transpower or a local distributor) has control over many design, performance and cost specifications. This can create a situation where an entity is required to pay for an asset that they perceive as over-engineered in order to meet standards imposed by a third party.

81. Transpower could build a new line as part of its planning process, taking into account the expected demand from the consumer. Exactly who pays for what portion of transmission costs is defined in schedule 12.4 of Part 12 of the Electricity Code, which contains the transmission pricing methodology (TPM). Customers pay connection charges to recover the cost of providing connection assets. Interconnection charges recover the balance of Transpower's required revenue for the operation and maintenance of the network.

82. Under the current TPM, most of the cost of new interconnection investments is paid by grid users throughout the country, regardless of whether or not they benefit from those investments.

83. Many of the opportunities to electrify production are located in the regions. Some stakeholders argue that TPM disproportionally impacts some regional areas (i.e. they pay a larger proportion of the transmission costs) so it is perceived to be a regulatory barrier to the electrification of production.

Barrier J2: Time and costs associated with developing electricity connections and new generation plants

84. Electricity grid connections must be carefully designed to avoid negative impacts on the electricity system and the environment. This means the connection design process is involved and includes multiple steps. Resource consents, as well as consent from landowners is often required for new connections. The same applies to developing new electricity generation facilities.

85. The time required for obtaining a resource consent for an electrical connection and/or a new electricity generation facility can be quite long, and the cost involved is uncertain and can be prohibitive for businesses. It can take significantly longer, from planning and consenting to construction, to complete a new connection or a new electricity generation facility than to develop a new processing plant. A customer faced with this uncertainty and time delay may opt for an energy supply option that provides greater certainty.

86. Further, at present Transpower is required to recover all development costs[15] associated with new connections from the beneficiary (to avoid imposing costs on the wider consumer base that they may not benefit from), which means potential connection customers may need to pay upfront before they make a decision on a particular technology. This is particularly a problem where multiple potential users are not ready to invest in new connections at the same time. While Transpower could in theory negotiate with these potential users, they might not be able to reach agreement on the shared costs because they might have different investment timelines.

Barrier J3: Perceived risk of electricity supply disruptions

87. While the electricity system is highly reliable in practice, disruptions do occur. Transpower and other network operators are required to meet supply continuity standards that include very high levels of system availability and maximum periods of disruption. However, in the event of a disruption, continuity of supply to the end consumer is largely outside of the customer's control. Electricity supply disruption may therefore be a perceived barrier only in that consumers may incorrectly perceive their own backup generators/storage as more secure than the electricity system's capabilities (such as generation and transmission capacity) and storable fuel supplies. Perception of electricity supply uncertainty has been exacerbated by periods of low hydro inflows (known as dry years) over the last two decades. This resulted in some periods of high prices and, prior to the 2009 market reforms,[16] a genuine risk of supply shortfalls.

Barrier J4: Variable and uncertain emissions intensity of electricity use

88. For many energy sources, the emissions intensity is easily determined based on the chemistry of the fuel and the efficiency of the process. For electricity, the emissions intensity is variable, as it is based on the makeup of generating sources used to supply demand. Further, due to the ability to store fuel sources such as hydro, and the changing nature of the system over time, determining the true emissions intensity of any given unit of electricity is far more complex than for comparable fuel sources. This presents a potential barrier for converting to electricity because the emissions benefits of switching to electricity are hard to quantify, and therefore hard to evaluate for environmental impact or include in promotional material. In practice,

[15] Development costs are the costs of design and other pre-work for a transmission asset that has not yet begun construction. Once the decision to build is made, all costs that follow are construction costs that become part of the asset base and are recovered under the regulated asset methodology.

[16] The 2009 market reforms changed the mix of assets held by generating companies, implemented more effective hedging arrangements and placed stronger incentives on retailers to avoid supply shortfalls, including a requirement to compensate consumers if a conversation campaign was needed and to report the financial impacts of a set of stress tests. While not conclusive, evidence from a number of dry periods since 2009 suggests the market is more able to deal with dry periods without encountering shortage.

there are established approaches to reporting emissions intensity that go some way to addressing this barrier.

Barrier K: Electricity has historically been a 'last choice fuel' for industrial processes

89. This is likely due to the barriers of cost and complexity discussed above. As a result, fossil fuel technologies are incumbent and economically mature, with a well-developed supply chain, while promising new electrical technologies (such as high temperature heat pumps) are perceived as experimental and risky. Additionally, firms and Government have limited information about the true costs and risks of using electricity for many potential industrial uses. A lack of demonstrated experience, including track record, best practice and transparency, is also a barrier.

Q15: Has your organisation considered electrifying part or all of a given site's heating process?

Q16: If so, to what extent do you agree with the barriers I to K listed above?

Q17: What does your organisation consider are the largest barriers to the electrification of its production?

Q18: Are there any costs or co-benefits of electrification that we have not included that your organisation has identified?

Barriers to the use of woody biomass

90. The following discussion relates primarily to using woody biomass on a site at significant scale, i.e. annual fuel use greater than 0.05 PJ/year (a typical South Island dairy factory's fuel usage is in the range of 1 to 3 PJ annually).

91. New Zealand's wood-processing sector uses energy from woody biomass (including black liquor) extensively to supply process heat, and woody biomass provides almost as much of New Zealand's process heat as natural gas and substantially more than coal.

92. Woody biomass is a renewable fuel of relatively high quality that is capable of producing medium and high-pressure steam. In this respect, it can technically substitute for fossil fuels in a wide range of process-heat uses. Furthermore, the ability to co-fire some coal boilers (after modification) means that wood fuels may potentially supplement coal. This can lessen perceived risk and offers a transitional way to reduce emissions when using equipment that still has substantial remaining operational life.

93. However, outside of the wood processing sector, using woody biomass as a process-heat fuel instead of fossil fuels is relatively rare. This has multiple, often interdependent, causes (i.e. beyond the lack of an effective price on greenhouse gas emissions).

Barrier L: The economics of biomass fuels is situationally dependent and complicated

94. A key barrier is that the economics and implications of using biomass fuel can be far more complicated than fossil-fuel alternatives especially at scale. For example, there are differing grades and types of woody biomass fuel and each grade has differing availability, cost, and handling characteristics (ease of use).

95. Biomass fuel availability is location-specific and the cost of harvesting depends on the topography of the planted land (steeper sites are more difficult to harvest). Transportation costs are a substantial part of the overall cost and increase with distance. To be economic biomass users generally need to be located close to the biomass source. Transportation costs also increase as the fuel's energy density decreases since more fuel is required for a given energy requirement. For example, low-cost fuel grades such as hog fuel have relatively high moisture content and hence lower energy density. Compared to coal, the lower energy density of biomass requires much higher fuel storage volumes and a greater number of truck movements to deliver fuel to site.

96. Biomass availability also varies over time. The harvesting of biomass varies by the time of year and year-to-year depending on historical planting decisions. Harvesting may not coincide with fuel demand profiles and stockpiling increases costs. As such, security of fuel supply could be a concern for large biomass users. The fuel demand of large-scale uses (such as dairy factories) may require a large proportion of, or even exceed, the amount of locally available fuel. This can cause a 'dis-economy' of scale when satisfying demand requires greater transportation distances and so the marginal cost of fuel increases rather decreases.

97. Capital costs vary depending on the fuel grade to be used. For example, lower-cost fuels tend to require more expensive boiler and fuel handling equipment. Some fuel grades (such as pellets, woodchips) may enable co-firing in a wide range of existing coal boilers, whereas others, such as hog fuel, generally cannot). There can be strong regional competition for some fuel grades that are also process feedstocks or exportable products (e.g. wood chips, pulp logs).

98. These factors can make it very difficult to determine the best approach, even if a preliminary investigation reveals the use of wood fuels to be economically viable. For large-scale users that are looking to invest in new equipment with high upfront capital costs, firms can face considerable uncertainty about long-term fuel supply, operating costs and equipment selection.

99. These complexities mean that there is a high transaction cost in obtaining adequate information about the true costs and risks, and therefore the viability, of switching to processes and technology that use woody biomass.

Barrier M: Biomass supply chains are undeveloped and face development difficulties

100. A lack of demand has hindered the development of a wood fuel supply chain in New Zealand beyond the wood processing sector. Potential biomass users, particularly those with large energy needs, are concerned about security of fuel supply over the

life of their plant but there are few parties that can contract to supply the required volumes of fuel required over the long term. In addition, there is only a small pool of consultants who have in-depth knowledge about the wood fuel supply options in New Zealand, and their knowledge is not widely shared.

101. Supplying large amounts of fuel requires significant capital investment in equipment (i.e. trucks and heavy machinery). A fuel supplier is unlikely to make these investments in the absence of a long-term supply contract. Securing large-scale, long-term fuel supplies will require long-term agreements with multiple partners, including the resource (forest) owners, contractors and the user. Given the number of parties involved, such agreements may be challenging to negotiate.

Barrier N: Air emissions regulations

102. The regulations covering air quality and emissions, especially for particulates, vary by consenting authority and are not always consistent with enabling the use of biomass to supply process heat. For example, a strict interpretation of some regional air plan rules would seem to prohibit the use of higher moisture content wood fuels such as harvest residues. The variation in local or regional air plan rules is consequently another barrier to the use of woody biomass.

Q19: Has your organisation considered biomass as a fuel source? If so, what did you conclude and why?

Q20: To what extent do you agree with the barriers L to M listed above?

Q21: What does your organisation consider to be the largest barrier(s) to the use of biomass for supplying heat?

Q22: Has your organisation identified any costs or co-benefits of using biomass that we have not included above?

Self-generation from renewable sources - wind or solar

103. For most industry internationally, increasing the use of renewable energy means building their own renewable generation. As the majority of our electricity generation in New Zealand is renewable, low emission electricity can be supplied from a third party instead. An exception is the wood product manufacturing industry, which generates heat and power from its biomass resources.

104. High upfront costs of building generation are the major barrier to organisations building their own electricity supply, even if the whole-of-life costs are economic. Organisations are capital constrained and tend to focus on core business projects based on risk and return (as described above). The construction costs associated with building their own generation may lead financial institutions to lend at higher rates, making it harder for industrial entities to justify the investment.

105. Further, building generation on site does not necessarily bypass the transmission or distribution grid. Some forms of renewable electricity generation are intermittent

(i.e. solar or wind), as such, either large-scale and expensive storage or a back-up connection to the grid will be required to ensure a reliable electricity supply.

106. Most industrial sites are poorly suited to building renewable generation. The intermittent nature of these generation sources means that picking the right location is key to maximising the capacity factor (annual generation) and return on investment. However, recent advances in technologies such as concentrated solar power may ease this constraint and could provide new options in the South Island.[17]

Q23: Has your organisation considered building onsite generation? If so, why did the project go ahead or not go ahead?

Q24: Are there any barriers to, or co-benefits from, the use of onsite generation that we have not included that your organisation has encountered?

The use of direct heat from geothermal

108. The use of direct heat from geothermal is used by New Zealand industrials and presents an opportunity to reduce process heat emissions. Its use however, is limited due to geographical dependence and can only be considered for a new-build industrial plant if the chosen site is located close to a geothermal source.

109. The New Zealand Geothermal Association has developed the Geoheat Strategy[18] and a complementary action plan that seeks to increase the use of direct heat in industry. The strategy outlines the opportunities and the approach to diversify the direct use of geothermal heat to create new businesses, decrease the use of fossil fuels in industry, support regional economic and social development, and carve out a role for New Zealand to promote the use of direct heat and associated technologies internationally.

110. The high upfront capital cost of geothermal direct heat is the major barrier for potential users. The economics are very situation specific and must be assessed on a case-by-case basis. Whole-of-life economics needs consideration for the use of direct heat from geothermal at a given site.

Q25: Does your organisation have the potential to use direct heat from geothermal?

Q26: If so, what are the key barriers that hinder your organisation from using direct heat from geothermal?

Q27: Has your organisation identified any other barriers to, or co-benefits from, the direct use of geothermal heat that we have not included above?

[17] Ross, (2018) *Solar flair for farming in South Australia*
[18] http://nzgeothermal.org.nz/geoheat/wp-content/uploads/sites/2/2017/06/Geoheat_Strategy_2017-2030__Web_Res_.pdf

Switching from coal to natural gas

111. Natural gas is a relatively inexpensive fuel source and has a lower emissions intensity than coal or diesel. The availability of natural gas is geographically constrained. In countries with access to natural gas networks, substituting natural gas for coal is one of the most cost effective ways for reducing emissions. Investment in new natural gas infrastructure however, is expensive and carries the risk of long-term emissions lock in. Conversion to natural gas-based energy production is capital-intensive and may leave a firm less able to change to lower- or no-emissions fuels over the medium term.

There are limited opportunities to substitute coal for natural gas in the North Island

112. The North Island has extensive natural gas networks and natural gas supplies most of the North Island’s industrial heat. However, coal still supplies some heat in the North Island and for those sites that are relatively close to a network there is potential to convert from using to gas.

There are no natural gas networks in the South Island

113. There are no natural gas networks in the South Island. Even if gas fields were discovered off the South Island’s coast, the costs to build the infrastructure for a reticulated gas network in the South Island are unlikely to be justified by the potential demand for the gas. However, we understand several companies have indicated their potential interest in using gas onshore in the South Island in the event of a gas discovery.

Security of supply may be a concern for potential gas users

114. For many process heat users, supply disruptions can have dramatic consequences leading to production losses and unanticipated costs. Natural gas is heavily dependent on delivery infrastructure to provide continuous supply. Gas has had periodic outages or disruptions in recent years, and storage is expensive and difficult.

115. In 2018 the gas market experienced supply constraints due to two unscheduled curtailments at the Pohokura gas field and issues with wells in another field. Together these reduced the supply of gas available to the market as well as the capacity to meet the large swings in seasonal demand required by some industrial gas users. The Pohokura field meets around 40 per cent of New Zealand’s current gas demand.

116. Because New Zealand has a small number of gas fields, an outage at a large field such as Pohokura will impact a wide range of gas users.

Co-generation opportunities exist but may not reduce system wide emissions in the medium term

117. Internationally, industrial combined heat and power (CHP) has delivered substantial energy savings. Provided there is a demand for both, CHP can deliver energy and carbon savings of up to 30 percent by reducing energy lost as waste heat, compared to separate power and heat generation from the same fuel. Electrical efficiency generally reduces as more heat is extracted, but the useful heat supplied tends to compensate for this loss of efficiency.

118. New Zealand has a highly renewable electricity system and an aim to move towards 100 per cent renewable electricity by 2035. For this reason, cogeneration from natural gas may not serve to reduce system wide emissions and achieve this target.

Hydrogen as a low emissions fuel for process heat

119. Hydrogen has been proposed as a potential low-emissions fuel for a wide range of applications, including industrial heat. Hydrogen does not occur naturally and must be manufactured. Typically the hydrogen used by chemical and industrial processes is made by a process called steam methane reforming (SMR) which converts methane into hydrogen and other gases. As the conversion process also produces carbon dioxide and requires energy input, hydrogen produced this way is more emissions intensive than directly using methane (natural gas).

120. There are two alternative pathways currently being considered for low emissions hydrogen manufacture. The first is electrolysis using renewable electricity (or 'green' hydrogen), and the second is steam methane reforming of natural gas with carbon capture and storage (or 'blue' hydrogen). Both of these pathways are more expensive and energy intensive than using either electricity or natural gas directly due to losses in the conversion and storage processes.

121. EECA and MBIE are participating in a joint research project to investigate potential for hydrogen usage and manufacture in New Zealand. The final results from this investigation are not yet available, however preliminary results indicate that hydrogen produced via either electrolysis or steam methane reforming is unlikely to be cost competitive compared with other process heat sources - namely coal, gas, electricity and biomass – even with carbon prices in excess of $100 per tonne. This analysis may need to be revisited in the event of very high carbon prices or major changes in the cost of electricity or carbon capture and storage technologies.

4) Summary

122. In order to enable the transition to a net zero future, we need to understand the how and where process heat is used in New Zealand. The features of process heat use, and the sectors in which it is used, mean that there are many barriers to reducing emissions and they are diverse and interrelated.

123. MBIE and EECA have been gathering information about the use of process heat across sectors and regions, as well as the mitigation options available to different users. We have published several sector-specific fact sheets on our website and will continue to add information resources over the coming months.[19] We have also been researching what barriers exist that might prevent firms from investing in energy efficiency improvements or renewable processes; and which barriers are the most significant to process heat users.

124. This document and our website set out what we know so far about the current state of process heat use in New Zealand. We seek industry and public feedback on our understanding of process heat use and the barriers to lowering emissions from process heat.

125. **Please give us your contact details and let us know if you would like the opportunity to should we need to clarify or further discuss your written submission with you.**

[19] www.mbie.govt.nz/PHiNZ

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