NZ Gas Infrastructure Future

Findings Report

The New Zealand Government is looking to take decisive action to address climate change – and this will have a profound impact on the use of natural gas. A working group was established to consider the potential impacts from a gas infrastructure perspective. This is the working group's Findings Report that makes key findings and recommendations for government to consider when developing its policy in response to the Climate Change Commission's final advice.

13 August 2021

Disclaimer: the views expressed in this paper reflect the culmination of initial research and discussion undertaken by the working group. They do not necessarily reflect the views of the organisations represented in the working group. The views may also differ from those that the working group includes in future outputs.

Contents

Part A: Findings, recommendations, and next steps

NZ Gas Infrastructure Future

EXECUTIVE SUMMARY

Government decisions in response to the Climate Change Commission's (CCC) final advice will have profound impacts on the future of the natural gas and LPG supply industry in New Zealand.

A carefully managed transition is required to ensure continuity of a safe, reliable, and affordable energy supply as gas and LPG consumers transition their consumption to zero-carbon gas or alternative renewable energy sources. Without effective management and economic regulation, there is a real risk that consumers will be unnecessarily harmed by facing higher costs or poorer service outcomes that could otherwise be avoided, or that progress towards environmental goals is not sustained due to consumer or public pushback against higher energy prices. Gas pipelines currently supply over 760,000 residential gas consumers.

Broadly, natural gas infrastructure faces two very different future scenarios:

- **Infrastructure winddown** | where gas consumption is phased out and gas pipelines are decommissioned in a safe and orderly way, and all consumers switch to other zero (or low) carbon energy sources.
- **Infrastructure repurposing** | where gas consumption transitions from natural gas to 'green gasses' (most likely hydrogen, biomethane or some blend of these) and some or all existing pipelines are repurposed to deliver these green gasses to consumers.

These represent the 'bookends' of what could occur and are a useful high-level way to discuss the future, although in practice the future could fall somewhere between.

Infrastructure repurposing

- **There is significant interest in the potential for zero-carbon gasses – hydrogen and bio methane produced from biogas – to play a role in New Zealand's energy transition** | as part of this, there is interest in the potential role for repurposing gas pipelines, which would underpin, and require, a larger scale zero-carbon gas industry in New Zealand. Global interest in these gasses is also significant.
- **Green hydrogen has a role for 'hard to abate' applications but there is uncertainty about its role in other applications that can more readily use electricity or other energy sources as an alternative to natural gas** | the extent of its role will become clearer over time. As the scale of the transport task for distributing green hydrogen – and other zero-carbon gases – increases, using a repurposed pipeline network will likely become a more efficient and acceptable solution than alternatives like trucking hydrogen. A future involving transportation of green hydrogen using repurposed gas pipelines will require a large enough current and future market to justify the high fixed investment costs required to repurpose and maintain and replace pipeline and consumer assets over time. Confidence in the size of the market will require widespread acceptance of hydrogen by consumers.

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Government decisions in response to the Climate Change Commission's final report will have profound impacts on the future of the natural gas and LPG supply industry in New Zealand.

There are two credible future scenarios:

- Infrastructure windown
- Infrastructure repurposing

There is significant interest in the potential for green gasses. Green hydrogen has a role for 'hard to abate' energy uses.

Uncertainty over the future potential for green hydrogen and biogas production in New Zealand supports decisions to create or preserve optionality to convert existing gas pipeline and appliance infrastructure to accommodate such zero-carbon gases.

- **Biomethane is an attractive but limited option** | biogas can be 'cleaned' to form biomethane that can be used as a direct substitute for natural gas meaning pipeline assets and appliances do not require modification or replacement. However, there is limited biogas feedstock available in New Zealand, which means it is unlikely to be a complete solution.
- **The feasibility of repurposing pipelines** | there are questions around the costs and feasibility of repurposing transmission pipelines due to the issue of hydrogen embrittlement. Gas distribution networks do not appear to face this issue in any material way.
- **There are a range of technical options that could facilitate repurposing** | these include: gas pipeline owners considering opportunities for 'future proofing' their ongoing maintenance and replacement programs; consumers installing dual fuel appliances; and mothballing of natural gas pipelines.
- **Economic regulation will likely need updating to address incentive and financial sustainability concerns** | this should ensure that gas infrastructure businesses can continue to maintain and invest in pipeline assets as they are repurposed.
- **Changes to gas industry regulation will be required to enable repurposing of pipelines** | no immediate action is required but progress needs to continue. The Gas Industry Company (GIC) is currently liaising with relevant parties about regulatory issues. Gas quality and safety regulations will likely require changes to enable hydrogen but ensuring appropriate gas safety outcomes is expected to be manageable. Combustion of hydrogen produces nitrogen oxide emissions – this issue will need monitoring.

Infrastructure winddown

- **Any winddown of gas pipelines will need to be undertaken safely and in a coordinated manner** | this will enable switching of consumer demand to alternative energy sources, in particular electricity. A proactive process is required by which consumer switching occurs in a timely, orderly, and cost-effective way and the pipelines are switched off and decommissioned. No significant operational concerns about the winddown scenario have been identified. However, there are concerns about potential cost impacts. CCC analysis indicates estimated costs of $5.3 billion out to 2050 to make the required changes to space and water heating appliances in homes and commercial buildings.
- **Work is required to understand appliance replacement and lifecycle cost estimates** | some preliminary estimates are available, but if the winddown scenario becomes more likely, further work is suggested to better understand the avoided costs from repurposing and to understand the nature of any impacts on vulnerable consumers.
- **Residential and commercial consumer issues need to be better understood** | initial feedback from consumers such as restaurant, horticulture, and crematoria sectors highlight potential difficulties with moving away from natural gas. Similarly, feedback from residential gas consumers has been strongly against removing the option of using gas for home heating and cooking.

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But production cost uncertainty means that there is uncertainty about hydrogen's role in other energy uses.

There are a range of technical options that could facilitate repurposing gas pipelines to transport hydrogen.

Any winddown of gas pipelines will need to be undertaken safely and in a coordinated manner. Significant electricity distribution investment will be required.

- **A coordinated plan will be required** | to ensure an orderly process for switching consumers to other energy sources and a related gas pipeline decommissioning plan for regions and cities. Experience with the removal of other services (such as rail or airline services) highlights the need for clear consumer communication and sufficient lead times before services are withdrawn.
- **Workforce implications have been identified** | gas transmission and distribution businesses will need to retain a workforce until their gas networks are ready to be switched off. Sufficient gas fitting skills will be critical to the safe withdrawal of gas services. There may be potential issues in organising and coordinating a sufficiently large workforce in an area to install electricity (and other) appliances, and for undertaking building and electrical, plumbing, and gas fitting trades.
- **While a manageable issue, significant electricity distribution investment will be required** | to enable electricity to substitute for gas. The impacts on generation and transmission investment and costs should be manageable.

Stakeholder perspectives

- **Vulnerable consumers** | preliminary analysis suggests that there are over 140,000 existing gas consumers that could be categorised as vulnerable that are located in low-income areas. For these consumers, covering their share of the $5.3 billion in estimated appliance conversion costs will be a real struggle.
- **Industrial consumers** | how the transition is managed in either scenario raises major questions. Demand from industrial consumers will be essential for underpinning growth in zero-carbon gases under a repurposing scenario. Whether that will arise is unclear. Abrupt changes to the sustainability of industrial consumers, brought about by phasing out natural gas, could have material economic impacts in local areas. These sorts of issues are being monitored through the Just Transition Unit in MBIE.
- **Concerns about the 'regulatory compact'** | regulated gas infrastructure businesses make large investments in network assets that deliver long-term benefits to consumers in exchange for an assurance that they will be able to fully recover the efficient cost of those investments over the assumed life of those assets. This is known as the 'regulatory compact'. The businesses have immediate concerns about whether the regulatory compact may break if government takes action to transition gas users off their networks before the full costs of those investments can be recovered. This may harm the long-term interest of gas consumers if needed investment is discouraged. It may also harm consumers of other regulated services, since electricity network businesses, for example, may also be concerned about similar stranding risk.

Government policy

- **Keep options open** | Government policy should keep options open in the face of uncertainty of how future scenarios may play out.
- **Energy strategy should be developed with clear objectives and principles, and developed through a collaborative approach** | this would be the best approach for developing this element of the national energy strategy recommended by the CCC.

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Pipeline businesses have immediate concern that the government may break the 'regulatory compact', which could undermine consumers interests.

Keep open the option of repurposing gas pipelines in the long-term interest of energy consumers.

National energy strategy should be developed with clear objectives and principles, and developed through a collaborative approach.

- **There is a case for coordination** | currently, New Zealand does not have a coordinated plan or planning process for considering which of the two broad scenarios best promotes the long-term interests of energy consumers, and what types of decisions and level of coordination are needed to support good outcomes.
- **Government should consider support for taking risks, attracting private capital for innovation, building the local market, and understanding local issues** | opportunities for government support include supporting demonstration projects for hydrogen production and blending; and support for studies into biogas feedstock availability and use of biogas for industrial and other applications.

A partnership with government

- The gas infrastructure businesses are keen to explore a partnership with government and key stakeholders to develop and implement a managed transition that supports the government's zero carbon target, promotes the long-term interests of energy consumers, and creates economic development and job opportunities.

Short term recommendations

Over the next 12 months, the government should:

- keep open the option of repurposing gas pipelines in the long-term interest of energy consumers, consistent with CCC's advice
- use the next 12 months to: consider the option of repurposing gas pipelines in the long-term interest of energy consumers; consider low cost actions that it could take to maintain or improve this option, and avoid, unless considered necessary, actions that would limit this option
- along with the Commerce Commission, start to consider the future economic regulation arrangements
- consider either amending the Commerce Act to defer the timing for when the Commerce Commission needs to determine the next default price path (DPP) for the gas infrastructure businesses or issuing a Government Policy Statement to help clarify the policy direction that the Commerce Commission should consider when determining that price path
- consider support to accelerate development of the hydrogen and biogas industry and improving the optionality for future gas pipeline repurposing
- actively contribute to and guide further industry-led analysis, including on (a) the impact of falling demand and revenues (e.g. on financial sustainability) and (b) the processes, resources and likely costs required to implement the winddown scenario.

Long term

Over the next 3 years, the government should:

- when responding to the CCC's recommendation to develop a national energy strategy, ensure that any such strategy is principle-led and recognises interdependencies within the energy sector and with other sectors
- consider the role of public funding to support transition to either scenario.

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The gas infrastructure businesses are keen to explore a partnership with government.

Need to analyse the impact of falling demand, revenues and the impact on financial sustainability.

Also, need to consider the future economic regulation arrangements.

Next steps

- This Findings Report establishes a fact base for future policy and regulatory development.
- Given the uncertainty and important policy and regulatory questions noted above, significant further work is needed to shape the future of gas infrastructure in New Zealand in a way that promotes the government's climate objectives and the long-term interests of energy consumers.
- Some work is already underway by MBIE, GIC, and the Commerce Commission.
- The working group could also provide this report to a broader group of stakeholders and undertake consultation on it.
- The working group could also play a useful role to support that work and the policy and regulatory development related to gas infrastructure more generally. Working group participants are actively exploring opportunities.

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Significant policy and regulatory development relevant to the future of gas infrastructure is needed.

Working group actively considering opportunities to support that development.

1. INTRODUCTION

The government is committed to taking decisive action to address climate change. The government will be making decisions in response to the CCC's final report, which was tabled in parliament on 9 June 2021.

Such action will have profound impacts on the future of the natural gas and LPG supply industry in New Zealand. A carefully managed transition is required to ensure continuity of a safe, reliable, and affordable energy supply as gas and LPG consumers transition their consumption to zero-carbon gas or alternative renewable energy sources. A managed transition may also address broader economic impacts such as investor confidence in regulated infrastructure.

The Gas Infrastructure Future Working Group (working group) was established to offer constructive input to the government's response to the CCC's advice. The working group was formed in early May 2021 and this Findings Report reflects initial work undertaken over a reasonably short period (eight weeks). It is intended to provide a starting point for future policy development and dialogue between government and affected stakeholders.

Appendix A sets out the working group charter. The working group comprises the three major gas infrastructure businesses (Firstgas, Powerco, and Vector) as members, and observers from the Gas Industry Company, Ministry of Business, Innovation and Employment (MBIE), the Commerce Commission, the Electricity Authority, and the Major Gas Users Group.

While the working group's focus is on gas infrastructure, it has needed to look broadly across the energy sector. The working group process so far has been valuable as it has enabled the members and observers to exchange information and perspectives and gain a common view of the future challenges.

This report is split into three parts:

- **Part A** | provides the findings (section 2) and recommendations (section 3) identified by the working group and intended next steps for the working group (section 4)
- **Part B** | sets out the working group's analysis on the problem definition (section 5), prospects for repurposing the gas infrastructure for green gas (section 7), implications of winding down gas infrastructure (section 8), key insights from gas consumer preferences and demographics (section 6), economic regulation considerations (section 9), potential roles for government (section 10), and alignment with the CCC's final advice (section 11)
- **Part C** | comprises appendices, including additional details of the working group's research and analysis and the working group's charter.

This report presents the working group's findings following work undertaken through May and June 2021. As such, this report presents information, initial analysis, and thinking at a point in time, and which is likely to evolve. This report does not include all the research that has been undertaken by the working group, but that research can be provided if required. Although care has been taken to prepare this report, the views expressed in it may not reflect those of the organisations that the members and observers are from – and so should not be attributed to them.

2. FINDINGS

This section identifies the key findings of the working group. These are structured as follows:

- The gas pipeline industry (section 2.1)
- Potential futures for gas infrastructure (section 2.2), including prospects for repurposing gas infrastructure (section 2.3) and implications of winding down gas infrastructure (section 2.4)
- Stakeholder perspectives (section 2.5)
- Benefit of creating and retaining options (section 2.6)
- Roles of economic regulation (section 2.7) and government (section 2.8)
- The case for coordination (section 2.9) and a potential partnership with government (section 2.10)
- Alignment with the CCC's advice (section 2.11).

The findings are supported by analysis in Part B and other material in Part C.

2.1. The gas pipeline industry and market

F1. All natural gas supply and network infrastructure is located in the North Island. Bottled LPG is available to consumers throughout New Zealand, and small unregulated reticulated LPG networks are located in the South Island.

F2. That gas pipeline infrastructure is as follows:

a. **Gas transmission** | Firstgas owns the gas transmission infrastructure in the North Island. The transmission network takes gas from more than 15 producing fields in Taranaki and transports it to gas distribution networks, industrial facilities (dairy processors, the steel mill, wood processors), and electricity generators. The transmission network is subject to economic regulation by the Commerce Commission.

b. **Gas distribution** | Natural gas flows from production stations through the gas transmission networks to the gas distribution networks and then to end consumers. There are 12 gas distribution networks in the North Island supplying Auckland, Wellington, and the large provincial cities and surrounding areas. They are owned by Firstgas, Powerco, Vector and GasNet.[1] The distribution networks are also subject to economic regulation by the Commerce Commission.[2]

c. **Profile** | Table 2.1 profile of transmission and distribution pipelines sets out a profile of the transmission and distribution businesses.

TABLE 2.1 PROFILE OF TRANSMISSION AND DISTRIBUTION PIPELINES

	Transmission	Distribution
Pipeline Length	2,500km of high-pressure transmission pipelines	17,748km of low, medium and high pressure distribution pipelines
Employees	200	291

[1] Firstgas Distribution owned networks are in Northland, Waikato, the Central Plateau, Bay of Plenty, Gisborne and Kapiti. Vector owns the Auckland Gas Distribution network. Powerco owned networks are in Taranaki, Hawke's Bay, Manawatu and Horowhenua, Wellington and the Hutt Valley and Porirua. GasNet owned networks are in Wanganui. Nova Gas owns unregulated (bypass) networks in Auckland, Hastings, Hawera and Wellington.

[2] Nova owns unregulated natural gas networks.

	Transmission	Distribution
Regulatory asset base	$850M	$996M
Planned total capex (next 10 years) - prior to CCC report	$480M	$657M
Planned renewal and replacement capex (next 10 years) - prior to CCC report	$344M	$133M

Source: Information Disclosures, Vector, Powerco and Firstgas. Data does not include non-regulated pipelines.

d. **LPG** | Bottled LPG is delivered to consumers throughout New Zealand by various suppliers (e.g. Elgas, Rockgas (Firstgas subsidiary), Vector, Genesis, Trustpower). Small, reticulated LPG networks are located in Dunedin, Christchurch, Queenstown and Wanaka. Bottled and reticulated LPG are not subject to economic regulation. There are an estimated 180,000 LPG connections in the 45kg segment in New Zealand.

F3. The consumers served by the gas pipeline industry are shown in Table 2.2, with almost 300,000 active gas connections to the regulated gas distribution networks and over 177 PJ of gas consumption per year across New Zealand.

TABLE 2.2 NATURAL GAS CONSUMPTION, CONNECTION POINTS, AND CONSUMERS

Consumer Type	Consumption (2020, PJ)	Active connection points
Methanex / non-energy use (i.e. feedstock)	46.2	6[3]
Electricity generation	53.8	6[4]
Industrial	62.1	330
Commercial	7.9	15,600
Residential	7.2	276,500 (or an estimated 762,524 consumers)
Total	**177.2**	**292,442**

Sources: MBIE for consumption data, which covers all of New Zealand. Firstgas for connection points based on GIC data. Connection points are connections to the gas networks that have a unique identifier number assigned. In contrast, consumers are the people that are supplied gas through the network, which is generally a larger number (e.g. a household may have one connection that serves multiple people).

F4. Preliminary analysis indicates that residential gas consumers are skewed towards higher income groups, young families, and families with stretched budgets. Unsurprisingly, gas consumers are also skewed towards urban areas.

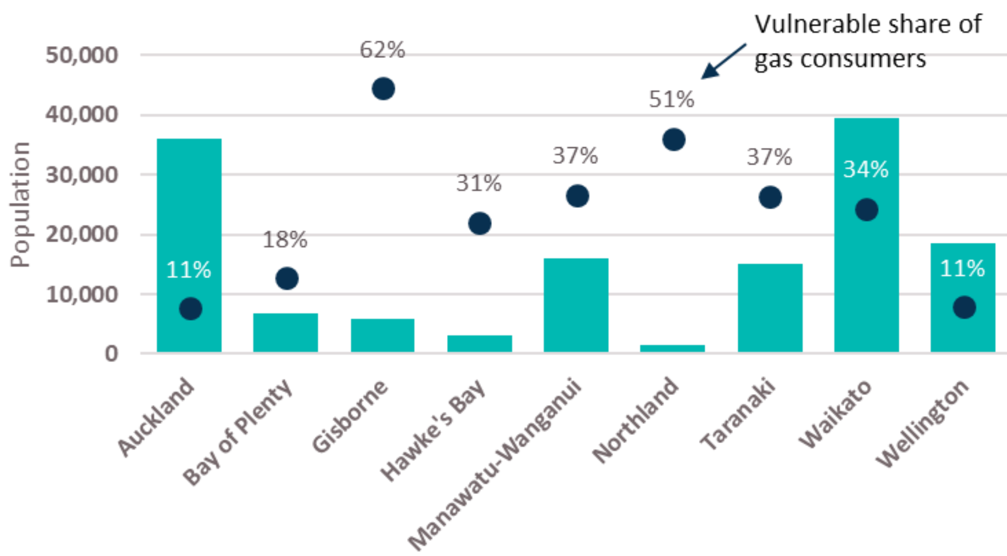
F5. That analysis also indicates that there are over 140,000 residential gas consumers (roughly 19%) relying on the gas pipelines that may be considered vulnerable, with these consumers distributed across North Island regions. [5]

3 Methanex (3 ICPs), Ballance (2 ICPs), Kiwitahi peroxide

4 Huntly, Mangorei, Hunua, Stratford (2), TCC, Te Rapa (Te Rapa, a cogen plant/power station, is included as it is significant in terms of its gas use and its electricity exports. Smaller cogen units not included.

5 Vulnerability is assessed as being gas consumers that fall within deciles 8–10 of the Environmental Health Intelligence Agency’s deprivation index. ‘Gas consumers’ are estimated by converting gas connections into population numbers using Census data.

FIGURE 2.1: DISTRIBUTION OF VULNERABLE GAS CONSUMERS BY REGION



F6. The exact nature of gas appliance infrastructure is less clear than that of gas pipeline infrastructure. Data published by the Energy Efficiency & Conservation Authority (EECA) shows that more than 300,000 gas water heaters have been installed over the 2012 to 2020 period, with more than 48,000 installed in 2020.

F7. According to MBIE, natural gas consumption currently contributes around 10% of New Zealand's annual carbon emissions. As shown in Table 2.3, most of these emissions come from the industrial use of gas, with less than 1% of New Zealand's emissions generated from the use of natural gas in homes.

TABLE 2.3 NATURAL GAS EMISSIONS

Consumer Type	Emissions (million tonnes of CO2e in 2018)	Share of total New Zealand emissions (%)
Methanex / non-energy use (i.e. feedstock)	1.5	1.8%
Electricity generation	2.4	3.0%
Industrial	2.2	2.9%
Commercial	0.5	0.6%
Residential	0.4	0.5%
Fugitive emissions[6]	0.9	1.2%
Total	**7.8**	**9.9%**

Sources: MBIE for the natural gas emissions data.[7] Statistics New Zealand for total reported emissions for New Zealand (of 78.9 million tonnes of CO2e in 2018). [8] Non-energy use includes chemical manufacturing.

6 The fugitive emissions estimate published by MBIE is sensitive to the assumptions adopted. Alternative assumptions can lead to lower estimates.

7 See: https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/new-zealand-energy-sector-greenhouse-gas-emissions/.

8 See: https://www.stats.govt.nz/indicators/new-zealands-greenhouse-gas-emissions.

Industrial includes petroleum refining, oil and gas extraction and processing, as well as other industrial activities.

2.2. Potential future of gas infrastructure

F8. New Zealand has committed to reaching net-zero emissions of long-lived greenhouse gasses by 2050. The CCC's analysis implies that the operation of emission budgets and the Emissions Trading Scheme (ETS) will cause natural gas along with other fossil fuels to become increasingly expensive, resulting in the eventual phasing out of natural gas. The CCC has made other recommendations that would further accelerate reductions in the demand for natural gas.

F9. Broadly, natural gas infrastructure faces two future scenarios:

a. **Infrastructure winddown** | where gas consumption is phased out and gas pipelines are decommissioned in a safe and orderly way, and all consumers switch to other zero (or low) carbon energy sources

b. **Infrastructure repurposing** | where gas consumption transitions from natural gas to 'green gasses' (most likely hydrogen, biomethane or some blend of these) and some or all existing pipelines are repurposed to deliver these green gasses to consumers.

F10. These scenarios represent the two 'bookends' of what could occur and are a useful high-level way to discuss the future. In practice the future could fall somewhere between the two scenarios.[9]

F11. Any assessment of these scenarios should consider the interests of all energy consumers, not just gas consumers.[10]

F12. The working group's analysis suggests that both scenarios are credible – and therefore both justify consideration at this time as means to promote the long-term interests of energy consumers, and New Zealand more generally.

F13. Reasons why it is credible that a repurposing scenario could be in the long-term interests of energy consumers include:

a. there are authoritative, though uncertain, forecasts that hydrogen production costs – which are presently high – will fail to make it competitive in a wide range of end-use applications including those that suit use of repurposed pipelines

b. there is strong interest internationally in hydrogen with some governments (Japan, Korea) considering large scale importation of hydrogen, and many others – including Australia – funding large scale research and development (R&D) programs including on pipeline repurposing demonstration projects

c. it may emerge internationally that repurposing of pipelines becomes a widely adopted solution, which would increase confidence and likely bring benefits from global innovation, cost reduction and competition in end use appliance markets

9 For example, natural gas and some related infrastructure could continue to play a role in niche applications such as high temperature process heat, peaking electricity generation, if used in conjunction with Carbon Capture, Utilisation and Storage (CCUS) or if emissions were offset. In addition, for various reasons not every pipeline will necessarily follow the same scenario; a pipeline or some sections of a pipeline could be wound down with other sections of a pipeline being repurposed; and there could be new pipeline segments built as part of a repurposing scenario. Reasons include: green gases will be produced in different locations in New Zealand compared to where natural gas is produced now; and it is unclear whether there will be sufficient demand in each location in each market to support the current configuration of pipelines.

10 For instance, to the extent gas demand switches to electricity as part of a winddown scenario, then this could lead to a significant step up in electricity generation and transportation costs and has other strategic implications.

d. zero-carbon gasses can be transported in various ways (e.g. by road and rail) but the existing pipeline network would be a more efficient and acceptable solution for transporting green gasses at large scale direct to large numbers of end consumers

e. it may help establish New Zealand's hydrogen industry by providing some demand certainty and by increasing economies of scale across a broader range of hydrogen users, including as a heavy transport fuel and hydrogen exports

f. hydrogen can be readily stored, including in transmission pipelines, and thereby supports energy system resilience (security and reliability) – hydrogen delivered by pipelines would contribute further to the reliance of the New Zealand energy systems

g. it appears technically feasible to repurpose distribution pipelines, and while there are technical and cost challenges for repurposing transmission pipelines these may be addressed

h. biomethane is a well-established technology that tracks expected improvements in the management of organic wastes and is also expected to reduce in cost as interest in the energy source grows internationally

i. from a national perspective, gas pipelines comprise long life assets and to a large extent the investment is a sunk cost – the economic case for repurposing gas pipelines should only consider future costs but ignore sunk costs

j. if gas pipelines are wound down and consumers need to switch to other fuels (including electricity) then this will come at a significant cost in terms of new appliances and additional electricity system costs – these costs and conversion challenges could be avoided, perhaps to a significant extent, in a repurposing scenario

k. it would help maintain a gas supply for industrial consumers that cannot feasibly transition to electricity – meaning that they would have the option to remain in operation rather than close

l. there may be feasible options for progressively introducing dual fuel (gas/hydrogen) appliances at reasonable cost – this could reduce eventual appliance conversion costs and produce a better experience for consumers when conversion of appliances is required, compared to the counterfactual where consumers need to convert to electricity (and other) appliances

m. there are options available that could support a repurposing scenario including mothballing of pipelines and 'future proofing' of pipeline maintenance and replacement programs.

F14. Reasons why it is credible that a winddown scenario could be in long term interests of energy consumers include:

a. hydrogen production is currently relatively high cost and only currently economic for certain 'hard to abate' applications – while forecasts show significant cost reductions, it is uncertain whether costs will fall sufficiently to be competitive in the end-use applications that suit use of repurposed pipelines

b. even if hydrogen production costs reduce significantly, it is unclear whether this will occur in the timeframes needed to enable New Zealand's transition to net zero-carbon emissions by 2050

c. internationally, repurposing of pipelines may not develop rapidly as a widely adopted solution

d. it will take considerable time, effort and cost to plan and develop green gas production and plan for a repurposed pipeline industry – whereas the electricity industry can scale up to meet the needs of most end use applications, other than some 'hard to abate' end use applications that don't necessarily need gas pipeline infrastructure

e. some aspects of renewable electricity production are also expected to experience cost reductions, such as utility scale and rooftop solar and batteries

f. similarly, the costs of electric alternatives to household gas appliances – such as induction cooktops, heat pumps, and hot water heaters – are expected to reduce

g. biogas feedstocks in New Zealand that are required to produce biomethane appear limited or otherwise uncertain as to whether enough biogas could be produced cost-effectively to substitute for current natural gas demand

h. biogas has an existing value for direct combustion, or onsite co-generation and it is unclear whether the economics of building a biogas to biomethane cleaning facility represents the best use case

i. there are technical and cost challenges for repurposing high pressure transmission pipelines for hydrogen, which may turn out to be more significant.

F15. There are also broader strategic energy policy considerations that government may wish to consider in considering the future of gas pipelines. These are:

a. **Energy sector resilience** | preserving the option to repurpose pipelines to enable a large-scale green gas industry could arguably make New Zealand's energy sector more resilient to certain risks (fuel types and delivery diversity), improve options for adopting innovations emerging from the global hydrogen industry in coming decades, and reduce over-reliance on the electricity industry, which otherwise will be the dominant energy sector in New Zealand with associated systemic risk issues.

b. **Energy sector competitiveness and consumer choice** | a successful large scale green gas sector supported by repurposed pipelines would improve competitiveness and consumer choice in many of New Zealand's end use markets such as heavy transport, industrial processes, heating, hot water, and cooking applications.

c. **Certainty of decarbonization outcomes** | on the one hand the electricity industry – aside from the issue of dry year risk – arguably has a relatively high level of capability and is readily scalable. Therefore, reliance on electrification (in a winddown scenario) might have advantages if government places weight on certainty of achieving net zero-carbon emissions by 2050 objective. On the other hand, certainty of achieving the objective could also be supported by maintaining the widest range options.

2.3. Prospect of repurposing gas infrastructure

F16. There is significant interest in the potential for green gasses – hydrogen and bio methane produced from biogas – to play a role in New Zealand's energy transition. As part of this, there is interest in the potential role for repurposing gas pipelines which would underpin, and require, a larger scale green gas industry in New Zealand. There are several demonstration projects underway. Contact Energy and Meridian Energy are currently undertaking a study into the potential for large scale hydrogen production.

2.3.1. Hydrogen

F17. Green hydrogen (e.g. hydrogen produced by electrolysing water using renewable electricity) is being actively considered by developed countries to support the energy transition. It offers a solution to decarbonisation of certain 'hard to abate' processes and economic sectors that are not well suited to a direct renewable electricity solution. Green hydrogen can also be a vector for renewable energy storage and transport, and in New Zealand could provide dry year electricity storage. There is no physical limit to the volume of hydrogen that could be produced; its use is only limited by economics. The current economic constraints are the costs and limitations of hydrogen production – in particular electricity costs – as well as appliance conversion and provision of transport and storage infrastructure.

F18. It is understood that the government would primarily be interested in promoting 'green' hydrogen gas as part of a re-purposing scenario, with government policy likely to phase out alternatives (i.e. fossil based hydrogen).

F19. At a minimum, green hydrogen is likely to have a role in New Zealand's future renewable energy sector for 'hard to abate' applications. There are already a small number of use cases and trials underway.

F20. There is significant uncertainty about what role green hydrogen can play in other applications that can more readily use electricity or other energy sources as an alternative to natural gas and where current hydrogen production costs make it uncompetitive.

F21. The extent of its role will become clearer over time as information emerges on its cost competitiveness against alternatives, in particular electrification.

F22. Huge expenditures are being undertaken on hydrogen projects – it is reported that globally there are now 228 large-scale projects for a combined $300 billion of proposed investment through to 2030.

F23. Like natural gas and oil, hydrogen could be transported from one location to another by road, rail, or coastal shipping. As the scale of the transport task increases – such as distributing to many widely spread end consumers – using a pipeline network (in this case an existing repurposed network) will likely be a more efficient and acceptable solution. This is due to the capital intensity and economies of scale benefits of pipelines compared to other transport modes.

F24. A future involving transportation of green hydrogen using repurposed gas pipelines will require a large enough current and future market to justify the high fixed investment costs required to repurpose, and then maintain and replace, pipeline assets over time. Confidence in the size of the market will require widespread acceptance of hydrogen by consumers.

F25. Uncertainty over the future potential for hydrogen and biogas production in New Zealand may support decisions to create or preserve optionality to convert existing gas pipeline and appliance infrastructure to accommodate such zero-carbon gases. This may support taking low-cost actions in the short term, including avoiding taking actions to accelerate gas demand reduction until there is a better understanding of the options.

F26. Absent strong government and/or energy retailer involvement to accelerate acceptance of hydrogen by consumers, wide-spread hydrogen use for residential and commercial consumers is likely to take many years as hydrogen is still a new concept (or unknown) for many consumers and the economics are currently highly uncertain.

F27. An early step being adopted by other countries that are leading hydrogen development is hydrogen blending (i.e. blending up to 10-20% of hydrogen with natural gas in existing gas pipelines) as this does not require significant network expenditure or appliance conversion and this can help reduce carbon emissions in the short term and demonstrate longer-term viability.

F28. There may be a case for government funding or policy mechanisms to help accelerate the development of the hydrogen industry; for example, by supporting hydrogen blending demonstration projects.

2.3.2. Biogas

F29. Biogas can be 'cleaned' to form biomethane[11] that can be used as a direct substitute for natural gas. This means that it can avoid the need to replace or modify appliances – which is a significant cost and logistical challenge under alternatives based on electrification or hydrogen – and is suitable for certain industrial processes.

F30. A key CCC recommendation is to reduce emissions from waste by increasing the recovery of resources including biogas. Current information on feedstock availability suggests additional biomethane potential represents approximately 10% of New Zealand's current annual natural gas consumption, including non- energy uses. Although

11 Biomethane is chemically identical to natural gas.

sufficient to substitute current residential and commercial natural gas demand, biogas may be limited in its ability to replace *all* natural gas use at current levels.

F31. As New Zealand approaches net zero emissions it would seem reasonable to rely on market forces to efficiently allocate the limited biogas feedstock to its highest value uses after adjusting for local feedstock availability, transport, and production costs. Such market forces could also help inform whether existing transmission pipelines should play a role in transporting biogas.

2.3.3. Feasibility of repurposing existing pipeline infrastructure

F32. Pipelines do not require conversion to accommodate biomethane, but there are questions around the costs and feasibility of repurposing pipelines to flow hydrogen. Firstgas's recent feasibility study has considered these questions.

F33. One of the more significant issues is hydrogen embrittlement – which is where high pressure steel pipes become brittle after being exposed to hydrogen atoms. Firstgas's hydrogen feasibility study found that embrittlement issues could affect part of its transmission network.

2.3.4. Converting existing appliances to handle zero-carbon gases

F34. Appliances do not require conversion to accommodate biomethane or low levels of hydrogen blending but with current technology there would be significant cost and logistical issues for converting appliances to enable burning of higher levels of hydrogen.

F35. Technology developments underway aim to produce dual fuel appliances designed to be converted from natural gas to hydrogen at low cost. This could provide optionality that improves the economics of repurposing gas pipelines and reduces the practical challenges of converting appliances. The UK Department for Business, Energy and Industrial Strategy (BEIS) has a research program to explore a transition from natural gas to hydrogen in the UK for cooking and heating.

F36. Firstgas's hydrogen feasibility study considers that hydrogen blends of up to 20% can be implemented without adversely impacting appliances. A report by GPA Engineering for Australia's National Hydrogen Strategy found that Australian domestic, commercial, and industrial appliances are likely to be suitable for hydrogen blending of up to 10% by volume. Australia's Future Fuels Cooperative Research Centre is currently undertaking detailed assessment of the compatibility of various types of appliances with blended hydrogen.

2.3.5. Technical options that could facilitate repurposing

F37. Gas pipeline owners are considering opportunities for 'future proofing' their ongoing maintenance and replacement programs. This opportunity particularly applies to transmission pipelines.

F38. Consumers will have opportunities to install dual fuel appliances that can use hydrogen if it is blended into the gas network.

F39. Natural gas pipelines are capable of being mothballed. An example is a lateral transmission pipeline in Taranaki that has been mothballed. Incurring mothballing expenditure could be a way of creating option value – for example, where for whatever reason it is appropriate to cease using a pipeline, but there was a sufficient likelihood that the pipeline could be put back into service in future.

2.3.6. Gas industry regulation

F40. There are a range of gas industry regulations (separate from economic regulation) that apply currently. Under the repurposing scenario the government will need to consider what changes to gas industry regulation may be required.

F41. No immediate action is required but progress needs to continue. The Gas Industry Company is currently liaising with relevant parties about regulatory issues, including Standards New Zealand in relation to potential changes to the gas specification standard needed to accommodate hydrogen. Firstgas has undertaken a high-level assessment of the regulations involved in gas production, transportation and use to understand the relevant regulation and the requirement for change to accommodate hydrogen. Current regulation covers regulation of gas safety, health and safety, hazardous substances, wholesale gas market regulation and rules (switching, compliance, critical contingency management), and retail gas and distribution market schemes.

F42. Gas safety regulations will likely require changes to cover hydrogen. The 'Town Gas' industry that existed in the UK and New Zealand prior to the advent of natural gas comprised high levels of hydrogen, so ensuring safe use of hydrogen is not a new issue. Ensuring appropriate gas safety outcomes for hydrogen is expected to be manageable. There will be workforce training requirements. Actions to promote community confidence in the use of hydrogen may also be required.

F43. In Australia there is regulatory review work underway to support hydrogen blending.

F44. Combustion of hydrogen can produce nitrogen oxide (NOx) and there are questions about whether in some circumstances NOx emissions may exceed safe levels. There are solutions being developed. This issue should continue to be monitored.

2.4. Implications of winding down gas infrastructure

F45. The winddown scenario means that as consumers switch to other energy sources – none of which would be delivered by existing gas pipeline infrastructure – there is a gradual or stepwise process to reduce utilisation, and then to shut down and decommission pipelines.

F46. The winddown of a gas pipeline will need to be undertaken safely and in a coordinated manner so as to enable switching of consumer demand to alternative energy sources, in particular electricity. Other developed countries are considering this issue.

F47. The government will be concerned about the potential for unserved demand[12] – particularly for small commercial and residential consumers – and this aspect will therefore require an appropriate and proportionate form of oversight or coordination.

F48. It is assumed that gas pipelines will need to keep operating to some degree until all consumers have switched to an alternative energy source, which is likely to take many years. To minimise operating costs once a decision is taken on target dates for switching off gas pipelines, there will need to be a proactive process by which consumer switching occurs in a timely, orderly, and cost-effective way. For practical reasons, the gas pipeline operator will likely need to switch off the pipeline in stages (by suburbs, cities, towns, sectors etc.).

2.4.1. Future demand, revenues, and financial sustainability

F49. Natural gas demand is expected to fall over time. As there are likely to be limits to increasing prices (e.g. consumer willingness to pay), this will likely result in a progressive reduction in revenues for gas pipelines. As a high proportion

[12] 'Unserved demand' is demand for energy that is not served through existing energy supply chains, which could occur if gas pipelines a shutdown before consumers have switched to alternative energy sources.

of gas pipeline costs are fixed this raises questions about financial sustainability, which has several dimensions. The first dimension is that – absent some regulatory or other solution – a gas infrastructure business may not be able to attract private sector equity and debt funding due to the risk of asset stranding and expected returns not being commensurate with future risks. A second dimension is the potential for negative cash flows if operating and essential 'stay in business' capital expenditure costs exceed revenues.

F50. Unless the government makes decisions now that make it unlikely that pipelines will need to wind down, then the most important action at this time is to develop a more detailed understanding of the potential future trajectory for demand, revenues, and financial sustainability for New Zealand's gas pipelines.

F51. Developing an early understanding of the potential trajectory for falling demand, revenues and financial sustainability will enable:

a. the government and stakeholders to be better informed about the effects of discretionary policy actions to accelerate reduced gas demand (e.g. banning new gas connections) and scenarios for trends in retail gas and electricity prices

b. a better understanding of the context for the Commerce Commission, government, and other stakeholders to consider future economic regulation arrangements, including:

   i. the nature and extent of asset stranding concerns

   ii. regulatory settings within the existing regulatory framework required to address the winddown scenario

   iii. potential changes to the regulatory framework to support the transition away from natural gas use

c. all parties to better understand the potential timing for when various decisions may need to be made

d. a better understanding of the practical financial and operational aspects of managing a winddown, including how to meet the costs of a pipeline that has lost a substantial portion of its revenues but needs to keep operating reliably until the remaining consumers can be switched in a safe and orderly manner.

F52. No significant operational concerns about the winddown scenario have been identified. It is understood that a gas pipeline can be safely operated with low throughput provided that enough gas is being injected into the system.

2.4.2. Appliance and other conversion costs

F53. Conversion costs are also likely be a key consideration for government – as it will be for gas consumers. These are expected to be substantial. In its final advice, CCC projects that converting space and water heating appliances to electric equivalents could cost $5.3 billion over the period to 2050 – an average of $178 million per year for 30 years.[13]

F54. At an individual consumer level, preliminary estimates based on data from one gas distribution business indicate that the weighted average retrofit costs for consumers switching their gas appliances to electricity today would be around $4,000 per household, but with a wide range around this depending on the range of appliances used. A consumer with the full range of appliances – a water heater, hobs, and central or radiator heating – may face an

[13] Conversion costs include the costs of acquiring and installing new appliances as well as the costs of removing old appliances (including make-good costs). See: CCC, 24 June 2021, *Data for figures in the Commission's 2021 final advice to Government, Ināia tonu nei: a low emissions future for Aotearoa*, 'Chapter 8' sheet. Link: https://ccc-production-media.s3.ap-southeast-2.amazonaws.com/public/Inaia-tonu-nei-a-low-emissions-future-for-Aotearoa/Modelling-files/Charts-and-data-for-2021-final-advice.xlsx.

average retrofit cost of around $10,400. Kainga Ora estimates that it costs, on average, around $8,000 per residence to convert its properties from gas to electricity.[14] These estimates are only indicative.

F55. Should the winddown scenario become more likely – and to better understand the avoided costs from repurposing – the government could consider further work to improve appliance replacement and lifecycle cost estimates. This would also assist in understanding the nature of any impacts on vulnerable consumers.

F56. Given the substantial cost, the government should also consider whether it may be more cost effective to pursue other pathways to decarbonise New Zealand's existing natural gas use. For instance, using biogas to replace natural gas use.[15]

2.4.3. Commercial consumers and end use applications reliant on natural gas

F57. Preliminary feedback from some types of small commercial consumers highlights potential difficulties with moving away from natural gas. These consumers include restaurants, horticulture industries, and crematoria. While the latter group is small in terms of usage, it may still raise concerns from a social perspective. Should the winddown scenario become more likely it would be prudent for the government to ensure that there is a proportionate but comprehensive process to identify all consumers that may face difficulties with moving away from natural gas, and to work with them to find solutions.

2.4.4. Coordinated plan for switching and gas pipeline decommissioning

F58. If a winddown scenario occurs, decisions will need to be made about whether and when to shut down and decommission some or all of the gas pipeline infrastructure, likely in a staged process. A coordinated plan will be required to ensure an orderly process for switching consumers to other energy sources (primarily electricity) and a related gas pipeline decommissioning plan for regions and cities.

F59. A recommended early action is to understand in greater detail the practical processes and resources required to implement this plan. For example, if it is assumed that every gas consumer would need at least one visit to ensure that the consumer is ready to have gas supply switched off, then this would involve a significant cost. Understanding these costs would be a relevant input to policy decisions about alternatives, which could avoid the need to incur these costs – for example enabling repurposing of pipelines using dual fuel appliances.

F60. It will be important to understand the implications of a winddown scenario on the workforce, safety, and the electricity sector when developing a coordinated plan for switching and gas pipeline decommissioning.

F61. Workforce implications identified are:

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[14] Kainga Ora has a programme of switching its properties from gas to electricity. Kainga Ora estimates that it costs around $8,000 per residence to replace gas cooking, space heating, and water heating appliances, assuming there are no asbestos or other complications. Actual costs depend on how many appliances are being converted, whether there is an asbestos flue that needs to be removed, the class of asbestos (A or B), whether scaffolding is required, and what appliances are being installed (e.g. heat pump, electric heater or nothing). Given the volume of work it commissions, Kainga Ora is likely to face lower average costs than individual gas consumers.

[15] By way of illustration, a biogas facility that produces 200 TJs of biogas per year could cost around $30 million in upfront capital costs. If the objective were to replace all the almost 15 PJs in natural gas currently consumed by residential and commercial consumers each year, then this would require 75 such facilities and cost $2.25 billion. This compares with the $5.3 billion in space and water heating appliance conversion costs that the CCC estimated residential and commercial consumers could face over the period to 2050.

See: https://www.stuff.co.nz/business/green-business/125666696/biogas-could-supply-20pc-of-nzs-gas-needs-by-2050-says-beca.

a. Gas distribution businesses will need to retain a workforce until the gas network is ready to be switched off to undertake the switching off and decommissioning process. This will be in an environment where there is no ongoing job and the workforce will likely be concerned about job security.

b. Depending on the number of consumers that need to be switched and over what timeframe, appliance installers and related building and electrical trades may need access to a skilled labour pool well beyond what is normally available in a region. There may be lessons from the broadband rollout for how the labour force can be established (training etc.) and how efficiencies can be gained.

F62. Maintaining safety is a high priority for the gas infrastructure businesses, and a legal requirement. As winding down gas pipelines is not an ordinary part of their business, it remains unclear exactly what steps would be needed to ensure that the pipelines remain safe if they are wound down and decommissioned at the scale required for this scenario. Considerations identified include:

a. the need to continue safely supplying all consumers until all consumers are able to be disconnected and a section of gas pipeline can be switched off

b. ensuring that decommissioned or mothballed pipelines are maintained or dismantled in a safe manner.

2.4.5. Electricity system impacts

F63. A high-level review has been undertaken of the impacts on electricity generation, transmission and distribution investment arising from residential and commercial consumers needing to switch away from gas.

F64. The most significant issue identified is the likely need for significant investment in additional electricity distribution capacity in certain parts of relevant networks to enable electricity to substitute for gas. This is likely to be a significant issue for electricity networks that service consumers that currently use gas for heating and cooking during peak times, such as early evening. For instance, converting all of Wellington's natural gas use across to electricity could add 200–300MW to Wellington Electricity's peak load and require $380–575 million in network upgrades.[16,17] A similar order of magnitude is expected for Auckland.

F65. The impacts on generation and transmission investment and costs should be manageable given that residential and commercial gas demand are small relative to the size of the electricity system and provided there is sufficient advance notice and certainty of the winddown of a particular gas network occurring.

2.5. Stakeholder perspectives

F66. This section outlines an assessment of perspectives from businesses and consumers.

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[16] In its submission on the draft CCC advice, Wellington Electricity estimates that the project growth in electric vehicle use and converting gas demand across to electricity will increase peak load by up to 520MW. Visual inspection of the chart presented suggests that around 200MW relates to the gas to electricity conversion. Wellington Electricity estimate that it will cost around $1 billion in network investment to address a 520MW increase in peak load, which implies around $380 million to address the electricity to gas conversion.

See: Wellington Electricity, 28 March 2021, *Re: Draft Advice for Consultation – meeting the Climate Change Commission's proposed emissions budgets*, p.6.

[17] Similarly, in its submission on the draft CCC advice, Powerco estimates that transitioning all of its more than 65,000 residential and commercial gas connections to Wellington Electricity would add 250MW to peak electricity demand at a cost of $575 million. This analysis is conservative because it does not include the impact on Todd Energy's gas consumers.

See: Powerco, 28 March 2021, *Feedback on draft advice to Government*, p.12.

2.5.1. Pipeline businesses' perspectives

Concerns about the regulatory compact

F67. Regulated gas infrastructure businesses make large investments in network assets that deliver long-term benefits to consumers in exchange for an assurance that they will be able to recover fully the efficient cost of those investments over the assumed life of those assets. This is referred to as the 'regulatory compact'. The businesses have immediate concerns about whether the regulatory compact may break if government takes action to transition gas users off their networks before the full costs of those investments can be recovered.

F68. Breaking the compact in that way is likely to deter:

a. efficient gas infrastructure businesses making investments that are necessary to continue the operation of those networks during the transition phase (including for use by hard to abate industries) – which would not be in the interest of consumers, and

b. regulated businesses in other industries (e.g. electricity network businesses), which may be concerned that similar investment stranding could befall them.

F69. If the gas infrastructure businesses had not been subject to economic regulation, then they would have been free to manage their business risks created by the likely phase out of natural gas by, for example, setting prices to recover asset related costs more quickly, seeking a rate of return commensurate with the increased risks, and sharing the asset life risk with consumers through contracts.

F70. If the actual life of an asset is shorter than expected, the full cost of the asset will not be recovered – the business's investment in the asset will be stranded.[18] While it is possible that some of the asset value could be recovered in a repurposing scenario, this is highly uncertain. And as noted above it may be in the national interest to pursue repurposing of pipelines *even if* sunk costs are unable to be recovered.

F71. It is this risk of asset stranding that becomes a serious problem for gas infrastructure businesses under any plan to transition consumers off the gas networks as part of a pathway to net zero-carbon by 2050.

F72. Under the existing economic regulatory framework, gas infrastructure businesses will be unable to recover their past pipeline infrastructure investments. This applies equally to the investments in the network that gas infrastructure businesses have made to date, and the investments in the network that gas infrastructure businesses would need to make in the future in order to ensure that the existing network can continue to serve gas consumers.

F73. If consumers are transitioned off the gas network by 2050, then the existing framework will mean that the businesses will be unable to recover the cost of its existing network assets and any future incremental investments.

F74. To preserve incentives for gas infrastructure businesses to make necessary investments in the existing gas infrastructure businesses, therefore, it will likely be important to preserve – in some way – the regulatory compact to ensure that the costs of efficient investments in gas networks can be recovered by the businesses that made these investments.

F75. As discussed above it will be necessary to make efficient ongoing investments in the gas networks, even if there is a winddown. These investments could consist of investments in asset replacements, new connections or system growth to provide gas to consumers who will benefit from the use of gas during the transition. These investments will certainly also involve expenditure to maintain the reliability and safety of existing systems.

F76. In the absence of these efficient investments, consumers will be worse off. Consumers that are unable to connect to the gas networks will not be able to benefit from using gas during the transition, diminishing the welfare they derive

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[18] The value of stranded assets will be affected by the profile of economic depreciation reflected in regulated tariffs. Applying indexation, for instance, defers cost recovery until later in an asset's life, which can increase the potential impact of stranding.

from being able to use natural gas. Consumers that are forced off the gas networks prematurely because the investments required to maintain the reliability and safety of the assets cannot be justified would be worse off as a result – as they would be forced to forego the use of natural gas and incur sooner the costs of switching to alternatives to gas.

F77. A related legal consideration is that directors have duties to act in the best interest of their companies – which means that they must be mindful of stranding risk and the general risk-reward trade-off when deciding whether to invest in the networks.

F78. An immediate implication is that gas infrastructure businesses may defer or suspend discretionary investments in long lived investments given the uncertainty over how policy decisions could affect their ability to recover their investments and earn commercially fair returns. In some cases, deferral or suspension of investment will cause immediate difficulties, such as where assets need to be relocated to meet external stakeholder requirements (e.g. transport projects) or where some critical expenditure is required immediately. In other cases, such as routine renewals and replacement, deferral or suspension of investment may not have an immediate adverse effect on gas consumers, but it will if continued indefinitely (e.g. degrading asset health and performance, and higher risk).

Long term considerations

F79. Pipeline businesses have varying positions about the long term. Firstgas has been active in exploring the feasibility of a repurposing scenario.[19] The other large gas distributors, Powerco and Vector, are working with Firstgas to further investigate the feasibility.

2.5.2. Consumer perspectives

F80. Consumers' perspectives vary across consumer type as follows:

a. **Industrial consumers** | How the transition is managed for industrial consumers in either scenario raises major questions. The large potential energy demand of industrial consumers – particularly major consumers – for green gas in a repurposing scenario is an important factor in the overall viability of a repurposing scenario. This highlights that the energy system is highly interconnected as the attractiveness of zero-carbon gasses delivered by pipeline will depend on many other factors, including the availability of green gases that can be delivered in other ways, electricity pricing and ETS prices. Some industrial consumers may need to rethink their operations entirely (e.g. abandon or relocate). The government is understood to be concerned about any abrupt changes that have material economic impacts on local areas, including on the workforce. These issues are understood to be already well recognised by the industrial market and the government is aware of and monitoring this impact, through government energy policy and the Just Transitions Unit in MBIE.

b. **Commercial and residential consumers** | Current gas consumers will be concerned about whether they can continue to use gas – whether zero-carbon or otherwise – to meet their energy needs including at times when they need to make significant commitments (for example investment decisions in new long-lived equipment). Although gas consumers are unlikely to individually drive decisions over whether New Zealand should pursue either the winddown or repurposing scenario, expectations over the extent to which gas consumers will collectively use forms of zero-carbon gas in the future will clearly affect investment decisions that influence that outcome. Perceived costs differences appear to be the dominant reason guiding consumers' current choices for gas over electricity, which suggests that messaging around how those differences may change if zero-carbon gases are used will be critical to influencing consumer acceptance.

c. **Vulnerable consumers** | The government is likely to be concerned to understand and potentially manage any material cost impacts for vulnerable consumers. Preliminary analysis suggests that there are over 140,000

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19 Aqua Consultants and Element Energy, *New Zealand Hydrogen, Pipeline Feasibility, A study for Firstgas*, 29 March 2021

existing residential population served by gas that fall into deciles 8–10 of the Environmental Health Intelligence New Zealand's (EHINZ's) deprivation index,[20] which indicates some level of vulnerability.[21] These consumers are geographically diverse across the North Island.

2.6. Benefit of creating and retaining options

F81. Given the significant uncertainty described above and the potential upside to energy consumers (and New Zealand) from repurposing the pipelines, there is likely to be value in retaining the option to do so for some time until uncertainty is resolved.

F82. This is consistent with the CCC's advice that government (and New Zealand) should 'keep options open as far as possible' as the energy system decarbonises.[22]

F83. Options identified include:

a. Deferring a winddown until better information is available on the viability of the repurposing scenario, and commencing hydrogen or biomethane blending projects in the interim to begin reducing emissions until a decision is made on whether to wind down or repurpose

b. installing duel fuel appliances when replacing existing gas appliances – which will reduce the need to convert appliances in the future if hydrogen becomes prominent under a repurposing scenario

c. using future proofing materials when replacing and maintaining existing pipeline assets in the ordinary course of business – which would progressively increase the feasibility of transporting hydrogen

d. mothballing of pipelines where not needed for a period of time – which makes it easier to repurpose them in the future if economic to do so

e. including ducting capability in new sub-divisions that would be capable of accommodating zero-carbon gas in the future.

F84. Active steps may be needed by government to ensure that these and other options remain available in the future.

F85. Various analytical tools exist for assessing optionality and making decisions in a world of uncertainty, such as adaptive management and real options analysis. The government may find that these tools provide a useful way to make robust policy decisions for the future of gas infrastructure in New Zealand – building on the high level policy direction recommended by the CCC while the preferred future remains unclear.

2.7. Role of economic regulation

F86. Early attention is required by the government as to whether the legislatively required timing for the Commerce Commission's next DPP determination – currently planned for May 2022, with a draft expected around mid-Feb 2022 – remains appropriate while the government's policy intentions for gas use and the consequential effect on gas infrastructure businesses are unclear.

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20 HEINZ's deprivation index is described here: https://www.ehinz.ac.nz/indicators/population-vulnerability/socioeconomic-deprivation-profile/.

21 Given that a consumer connection serves more than one person in most cases, the actual number of vulnerable people that rely on gas is likely to be noticeably higher than 60,000. For instance, if we assume that the average connection services 2 people, then this equates to an affected population greater than 120,000. Statistics New Zealand estimates that the average household is 2.7 people. See: https://www.stats.govt.nz/news/new-data-shows-1-in-9-children-under-the-age-of-five-lives-in-a-multi-family-household.

22 CCC, 31 May 2021, *Ināia tonu nei: a low emissions future for Aotearoa*, p.277

F87. It may be appropriate to delay the DPP reset by a short period given that that determination will affect pipeline revenues and prices for a 5 year period. A delay would provide an opportunity for government to make policy decisions that provide appropriate direction to the Commerce Commission, and which would better promote both the government's emission reduction objectives and the long-term interests of natural gas consumers.

F88. As discussed above, the possibility of a winddown scenario raises concerns about stranded assets and ongoing incentives to ensure needed investment to maintain services and ensure safety. A repurposing scenario could also raise the risk of stranded assets. The uncertainty over which scenario may play out – and the need to keep options open – raises further challenges.

F89. Given these challenges, it is unlikely that all current elements of the economic regulation framework applying to gas pipelines today will be fit for purpose under either the winddown or repurposing scenarios, or some combination of the two.

F90. Gas pipeline businesses have ongoing consumers demand for new energy supply. This creates challenges if there is new capital expenditure required to meet this demand, but it is possible that that the assets will not be able to be used for their full technical life. The gas infrastructure businesses may, where appropriate seek to shift use risk to consumers through contracts or high levels of consumer contributions.

F91. Other specific questions about how the current economic regulation framework applies and whether changes are needed to it include:

a. What are the appropriate timeframes for review and making decisions about any changes required?

b. Are there adequate incentives for gas pipelines to invest to maintain services during the winddown period or during a period where it is unclear whether a winddown or repurposing will occur?

c. Is there a case for addressing economic stranding risk given that the lives assumed in the current DPP for some pipeline assets are 60–80 years (which means that those assets are assumed to be economic beyond 2050)?[23]

d. How should the gas infrastructure businesses deal with consumer demand that requires growth capital expenditure?

e. Is there a need for changed incentives for pipelines to invest in innovation to better enable a future where repurposed pipelines transport green gasses (i.e. incentives to create and maintain options)?

f. Is there a potential problem for a trend to higher network tariffs as gas pipeline demand reduces; what are the potential impacts on different consumer groups, and how could these impacts be managed?

g. Are changes required in the interface between government policy and regulatory decision making?

h. Should some type of emission reduction objective be included as a matter the Commerce Commission should have regard to?

i. What is the future rationale (if any) for economic regulation (e.g. what may trigger removal of full economic regulation)? What are the implications for the economic framework of a potential reduction in market power in the event of winddown scenario? And of a repurposing scenario? Should there be a threshold or trigger for when Part 4 may no longer apply? Will gas pipelines be considered as providing an essential service during transition that justifies some kind of regulation, even if there is limited market power?

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23 For instance, the Commerce Commission's input methodologies assume lives are 60–80 years for pipeline assets and 60–70 years for service connections. S See: Commerce Commission, 3 April 2018, *Gas Distribution Services Input Methodologies Determination in 2020*, p.138. Link: https://comcom.govt.nz/__data/assets/pdf_file/0029/59717/Gas-distribution-services-input-methodologies-determination-2012-consolidated-April-2018-3-April-2018.pdf.

F92. Some possible solutions include considering accelerating deprecation or providing for an appropriate risk premium (as was adopted for Chorus).[24] However, the Findings Report does not analyse these issues or discuss potential solutions in depth. The proposed work to understand the potential future trajectory for demand, revenues, and financial sustainability for gas pipelines will be important context to understanding these economic regulation framework issues and the time scales on which they may need to be addressed.

2.8. Role of government

F93. The government will likely have roles in both a repurposing scenario and a winddown scenario.

F94. There is not sufficient certainty at present to know if repurposing pipelines will be the best outcome for New Zealand, or what exactly are the best models for producing green gasses that would use repurposed pipelines.

F95. There is, therefore, a good case for government to consider – together with consumer and industry stakeholders – how options could be created at low costs that make a future for repurposed gas pipelines that is in the long-term interests of energy consumers more likely.

F96. New Zealand's energy market policy framework relies on competitive markets in sectors where competition is possible and provides for:

a. economic regulation of natural monopoly infrastructure

b. coordination of wholesale electricity and gas markets

c. other regulations to address market failure and promote the public interest, and

d. wholly or partially owned state-owned energy companies operating as businesses and competing with private, council, and community owned entities.

F97. The working group assumes that the New Zealand government will continue with this framework going forward, with the government's overall role being to assess whether markets are producing appropriate outcomes, monitoring the performance of government institutions – such as regulators and market bodies – and addressing areas of market failure. This includes supporting the development of options where private markets on their own may underinvest or act too slowly relative to outcomes that are in the public interest.

F98. Internationally there is significant commercial interest in the potential role for green gasses – particularly hydrogen. This is reflected in New Zealand by the recent interest shown by companies such as Firstgas, Meridian Energy, and Contact Energy. However, this commercial interest is at a very early stage – it has only emerged over the past 12 to 18 months. Many governments internationally are taking actions to increase the speed of industry transition, including investing in research and development.

F99. In a winddown scenario the government would likely wish to establish some kind of oversight of winddown planning and implementation to ensure that consumers' interests are protected and it us undertaken in a safe and orderly way.

F100. Local government will also influence the repurposing and winddown scenarios. For example, local government planning will influence:

a. the provision of ducting capability in new sub-divisions that would be capable of accommodating zero-carbon gas in future

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24 See: Commerce Commission, 13 October 2020, *Fibre input methodologies: main final decisions – reasons paper*, pp.541–607. Link: https://comcom.govt.nz/__data/assets/pdf_file/0022/226507/Fibre-Input-Methodologies-Main-final-decisions-reasons-paper-13-October-2020.pdf.

b. requirements for undergrounding of new electricity distribution infrastructure in a winddown scenario

c. building standards which may exclude natural gas but should consider future supply of green gasses.

2.8.1. Energy strategy

F101. The CCC has recommended that government develops an energy strategy. The approach and recommendations in this Findings Report could form a starting point for considering the option of a larger scale green gas industry based on repurposed pipelines – which should be an element of any energy strategy developed by government.

F102. The development of an energy strategy should recognise links between decisions on the future of gas infrastructure and other energy market issues. For example, the potential role of hydrogen in managing dry year electricity risk and the need for significant electricity distribution investment in the event of a winddown scenario.

F103. The gas infrastructure businesses suggest that the best approach for developing this element of an energy strategy is one based on clear objectives and principles, and developed though a collaborative approach.

F104. The working group considers that decision making on the short term priorities set out in this report should not be delayed as a result of government efforts to commence developing an energy strategy.

2.8.2. Consistent sectoral policy choices

F105. The government should also consider the benefits of adopting consistent policies across energy and other sectors, including transport and waste sectors.

F106. Specific matters it should consider include:

a. setting waste management policies (including waste levies) so as to be consistent with objectives for promoting efficient expansion of biogas feedstock

b. ensuring that limited biogas feedstock is allocated to end uses with the higher economic value and avoiding measures which distort the allocation of biogas way from its highest value use.

2.8.3. Government support for R&D

F107. The International Energy Agency (IEA) advocates for developed economy governments to support R&D to bring down hydrogen costs:[25]

> *Alongside cost reductions from economies of scale R&D is crucial to lower costs and improve performance, including for fuel cells, hydrogen based fuels and electrolysers. Government actions, including use of public funds, are critical in setting the research agenda, taking risks and attracting private capital for innovation.*

F108. As New Zealand will largely be a global technology follower, the rationale for funding support for the development of green gasses would be to assist in taking risks, attracting private capital for innovation, building the local market, and understanding local issues. Such issues may include the technical and commercial issues associated with repurposing New Zealand natural gas networks for hydrogen and how to mitigate impacts on consumers.

F109. Immediate opportunities identified by the working group for government support are:

a. supporting demonstration projects for hydrogen production and blending (along the lines of the ARENA's Australian hydrogen projects)

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[25] International Energy Agency, *The Future of Hydrogen, Report prepared by the IEA for the G20*, June 2019, p16.

b. supporting further studies into biogas feedstock availability and use of biogas for industrial applications in New Zealand.

F110. An alternative to supporting individual projects would be a green gas incentive scheme that could provide an additional incentive for developing green gases over and above the incentives created by ETS. It may be preferable to provide support this way rather than direct development assistance as it avoids government 'picking winners' and avoids any direct cost to government.

F111. The government could also consider using its own energy procurement processes to accelerate the development of a green gas industry, such as to underwrite zero-carbon gas production and delivery.

2.9. The case for coordination

F112. Given the considerations outlined above, the end point for New Zealand's gas infrastructure is presently unclear. As both scenarios are considered credible, the working group considers that the key policy questions for New Zealand at this time are:

a. Which of the two broad scenarios best promotes the long-term interests of energy consumers?

b. What types of decisions and level of coordination are needed to support realising good outcomes for energy consumers and New Zealand under each scenario?

F113. Currently, New Zealand does not have a coordinated plan or planning process for answering these questions. It is possible that a repurposing scenario might emerge organically without any government involvement. But, if not, and if there is sufficient probability that that scenario would give the best long-term outcome for energy consumers and the wider economy, then there is a real risk that this would result in a sub-optimal outcome for New Zealand.

F114. This risk supports the case for coordination.

2.10. A partnership with government

F115. Faced with the challenges and uncertainties discussed above, the gas infrastructure businesses are keen to partner with government and key stakeholders to develop and implement a managed transition that supports the government's net zero-carbon target, promotes the long-term interests of energy consumers and which could promote economic development and job opportunities.

F116. Such a partnership will involve mutual commitments from all sides. Gas infrastructure businesses may need to commit to strategic investments that keep open or create new options that support development of a large-scale zero-carbon gas industry in New Zealand. The government will need to consider what supporting commitments and investments it can make to create the right environment for this investment. The gas infrastructure businesses are keen to engage with the government over the next few months to further explore the basis for such a partnership.

F117. There also needs to be engagement with other stakeholders including current and potential hydrogen and biogas producers, appliance manufacturers, and Master Plumbers NZ.[26] These interests could be covered under a broader industry accord with government that provides a multi-year plan and commitments.

[26] Other stakeholders will also have a strong interest in the outcomes from any such partnership.

2.11. Alignment with the Climate Change Commission's advice

F118. The CCC advises the government to phase out natural gas from New Zealand's energy mix. The Findings Report was developed under the assumption that such a phase out would happen but did not resolve the question of whether this would lead to a winddown of gas networks or repurposing them to distribute net zero-carbon gases.

F119. The CCC's other gas related advice is aligned with the findings noted above in the following regards:

a. although hydrogen and biogas can help reduce New Zealand's emissions, it is currently uncertain whether they will be cost effective or could feasibly be used in existing gas infrastructure

b. government should make choices that keep options open as long as possible, including by adopting preliminary policies that buy time for industry to assess the effectiveness of low emissions gases and by considering whether gas pipeline infrastructure should be retained to repurpose to transport those gases

c. careful management is needed to transition existing natural gas use towards lower emissions alternatives, including to:

   i. ensure that electricity remains reliable and affordable, and

   ii. recognise that natural gas lends itself to critical applications that support services needed in the transition such as security of supply and high temperature process heat and feedstock (where alternative energy sources are limited)

d. projected costs to consumers of transitioning from natural gas to electricity would be substantial, with the CCC's modelling suggesting a net cost to New Zealand until at least 2040 (if emissions benefits are factored) or 2050 (if not), and

e. government will need to take measures to:

   i. support security of supply, residential consumer choice around gas, energy affordability, network considerations, workforce planning, and high temperature heating needs

   ii. promote innovation investment needed to develop ways to displace natural gas use, and

   iii. develop and communicate its plan and intentions early to improve predictability for families, businesses, and public entities.

F120. The CCC advises that the potential to use low emissions gases is insufficient reason to warrant continued expansion of gas network infrastructure, at least until there is substantial evidence that blending or fully converting the gas networks to low emissions gases will not increase costs to consumers.[27] The Findings Report does not form a view on this issue yet, instead recommending that further work is undertaken to assess what trajectory is in the best interests of energy consumers and New Zealand.

F121. The CCC also advises that the government develops a national energy strategy. Although not covered directly in the Findings Report, the findings above do support the case for coordinated planning that considers the significant interrelationships between the future of gas and electricity supply.

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[27] Although not entirely clear, 'cost to consumers' is assumed to be relative to an alternative where gas consumption is converted to an alternative energy source such as renewable electricity.

3. RECOMMENDATIONS

The following recommendations assume that the government will make decisions in response to the CCC final advice that mean that gas pipelines will not continue to be used for natural gas in the long term and will be wound down, repurposed, or will have a future somewhere between these scenarios.

3.1. Short term recommendations

The following are recommendations that the government should consider actioning in the short term, indicatively prior to mid-2022. Over that period, the government should:

R1. Keep open the option of repurposing gas pipelines in the long-term interest of energy consumers. The government should use the next twelve months (at least) to:

  a. consider the option of repurposing gas pipelines in the long-term interest of energy consumers

  b. consider low cost actions that it could take to maintain or improve this option, and

  c. avoid, unless considered necessary, actions that would limit this option.

R2. Consider options for government support to accelerate development of the hydrogen and biogas industry and improving the optionality for future gas pipeline repurposing.

As part of its existing work developing the Hydrogen Road Map, the government should consider whether to accelerate the development of the hydrogen industry, and to improve the optionality for future gas pipeline repurposing. Such options would aim to gain experience on local issues.

Options include:

  a. support for hydrogen blending demonstration projects and other small-scale hydrogen projects

  b. a green gas incentive scheme

  c. using government procurement processes to transition government energy consumption away from natural gas to zero-carbon gases.

R3. Work with the gas infrastructure businesses (and other stakeholders) to explore some kind of partnership – including strategic investments that keep open or create new options for the positive future development of a large scale zero-carbon gas industry in New Zealand.

R4. Along with the Commerce Commission, immediately start to consider the future economic regulation arrangements, including by:

  a. considering whether to delay, for a short period, the next DPP determination – currently planned for May 2022, with a draft expected around mid-Feb 2022 – and if so how this could be effected

  b. during the delay period, making policy decisions that provide appropriate direction to the Commerce Commission so as to promote both its emission reduction objectives and the long-term interests of energy consumers

  c. considering the longer-term potential consequences for the 'regulatory compact', including the risk of asset stranding and incentives for needed ongoing investment

d. acknowledging that the current economic regulation framework applying to gas pipelines is not likely to be fit for purpose and consider the rationale (if any) for economic regulation applying in the future, mindful that:

   i. market power is likely to reduce if either a winddown or repurposing scenario occurs and so the traditional case for economic regulation may no longer apply, and

   ii. gas pipelines may be providing an essential service during transition that justifies some economic regulation.

In the interim, the Commerce Commission should proactively consider whether the gas infrastructure business have adequate incentives to invest in and maintain gas pipelines to ensure appropriate service levels in the short term.

R5. Actively contribute to and guide further industry-led analysis, including on:

a. the impact of falling demand and revenues, including on financial sustainability of gas infrastructure businesses, and

b. the processes, resources. and likely costs required to implement the winddown scenario including implementing a plan to ensure consumers have switched to an alternative energy source so as to enable gas supply to be switched off.

The government could request that this work be led by the gas infrastructure businesses in consultation with MBIE.

3.2. Longer term recommendations

The following are recommendations that could be actioned over a longer timeframe, indicatively over the next 3 years.

R6. The government should:

a. When responding to the CCC's recommendation to develop a national energy strategy, ensure that any such strategy:

   i. starts with guiding principles for reduction of emissions, security of supply, reliability, and affordability

   ii. recognise key inter dependencies within the energy sector and between the energy sector and other sectors

b. Consider the role for public funding to support the transition to either scenario – for example in relation to vulnerable customers, managing winddown consequences, and research and development.

R7. Gas infrastructure businesses pipeline businesses in partnership with government and key stakeholders should:

a. considers local and international development including zero-carbon gas technologies and costs, dual fuel appliances, and pipeline repurposing costs and feasibility, and

b. consider the potential for repurposing or winding down gas pipelines in the long-term interests of energy consumers.

4. NEXT STEPS

N1. With the Findings Report now complete, the working group has delivered its two key deliverables. However, this work only marks the start of the policy and regulatory development that needs to occur to shape the future of gas infrastructure in New Zealand in a way that promotes the government's climate objectives and the long-term interests of energy consumers.

N2. Some work is already underway. For instance, GIC is currently investigating responsibilities in relation to hydrogen and the potential for a zero-carbon gas certification scheme, among other activities related to a repurposing scenario.[28] MBIE is developing a roadmap for hydrogen in New Zealand.[29] The Commerce Commission is working on its DPP for regulated gas infrastructure businesses.[30] This work all needs to continue.

N3. The working group could also provide this report to a broader group of stakeholders and undertake consultation on it.

N4. The working group itself could also continue in some form, including to support MBIE's policy development and the Commerce Commission's regulatory decision making in relation to gas infrastructure, including the forthcoming DPP determination process.

N5. Working group participants are keen to continue supporting government as it develops policy that responses to the CCC's advice and recommendations and are actively exploring opportunities.

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28 See: https://www.gasindustry.co.nz/work-programmes/hydrogenandbiogas/. See also: GIC, May 2020, *Gas Market Settings Investigation – Consultation paper*. Link: https://www.gasindustry.co.nz/work-programmes/gas-market-settings-investigation/developing-2/consultation-3/document/7263.

29 See: https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-strategies-for-new-zealand/a-vision-for-hydrogen-in-new-zealand/roadmap-for-hydrogen-in-new-zealand/.

30 See: https://comcom.govt.nz/news-and-media/media-releases/2021/commission-seeks-views-on-regulatory-priorities-for-energy-networks-and-airports.

Part B: The working group’s analysis

Summary

This part of the Findings Report provides the detailed analysis undertaken by the working group. It is supported by additional information contained in Part C.

This part starts with the problem definition and information about consumers, before exploring the repurposing and winddown scenarios further. It then considers economic regulation, role of government, and the CCC’s recommendations.

5. PROBLEM DEFINITION

The working group started by developing and agreeing a problem definition. This problem definition statement is presented in Appendix B and summarised in Box 1 below. While details of this problem definition could be refined to reflect the information collected and analysis subsequently undertaken, the problem definition summary below continues to be appropriate.

Box 1: Problem definition summary

- Government will need to make decisions about how to address climate change that will have profound impacts on the future of natural gas and LPG supply in New Zealand.
- Broadly, gas faces two potential futures in New Zealand:
    - **Infrastructure winddown** | where gas consumption is phased out and gas pipelines are decommissioned in a safe and orderly way, and all consumers switch to other zero (or low) carbon energy sources
    - **Infrastructure repurposing** | where gas consumption transitions from natural gas to 'green gasses' (most likely hydrogen, biomethane or some blend of these) and some or all existing pipelines are repurposed to deliver these green gasses to consumers.
- Where we will end up, however, is unclear.
- Currently, New Zealand does not have a coordinated plan or planning process for significantly reducing or transitioning away from gas if the decision is made that piped gas should be a much smaller part of the energy mix or removed from the energy mix altogether.
- Absent such a plan, there is material risk that gas consumers and other industry participants will be harmed in a way that could be mitigated or avoided – which would likely undermine government's objectives.
- Given the risk of a sub-optimal outcome for New Zealand, the problem today is to decide:
    - What no regrets steps could be taken
    - What defensible modest cost steps could be taken
    - What option preserving steps could be taken that leave open the option of repurposing the natural gas pipelines if and when zero-carbon gas production reaches a sufficient level
    - What, if any, steps should be taken to align existing policy work (e.g. the roadmap for hydrogen).
- The working group's research and analysis seeks to assist those tasked with making such decisions.

6. UNDERSTANDING GAS CONSUMERS

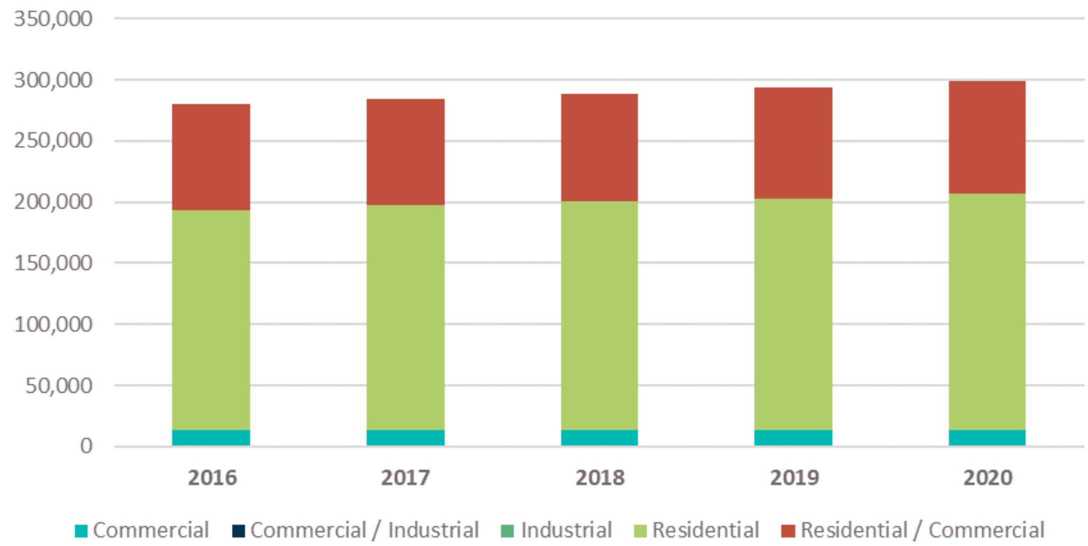
6.1. Introduction

Gas consumers are diverse in terms of where and how they use gas.[31] This section identifies key insights from gas consumer preferences, demographics, and appliance installations.

6.2. Connections and consumption

As shown in Figure 6.1, there are around 300,000 individual connections to the regulated gas distribution networks, with the majority being residential consumers. Connections have grown by around 7,000 per year over the last few years, primarily residential and small commercial consumers (as shown in Figure 6.2).

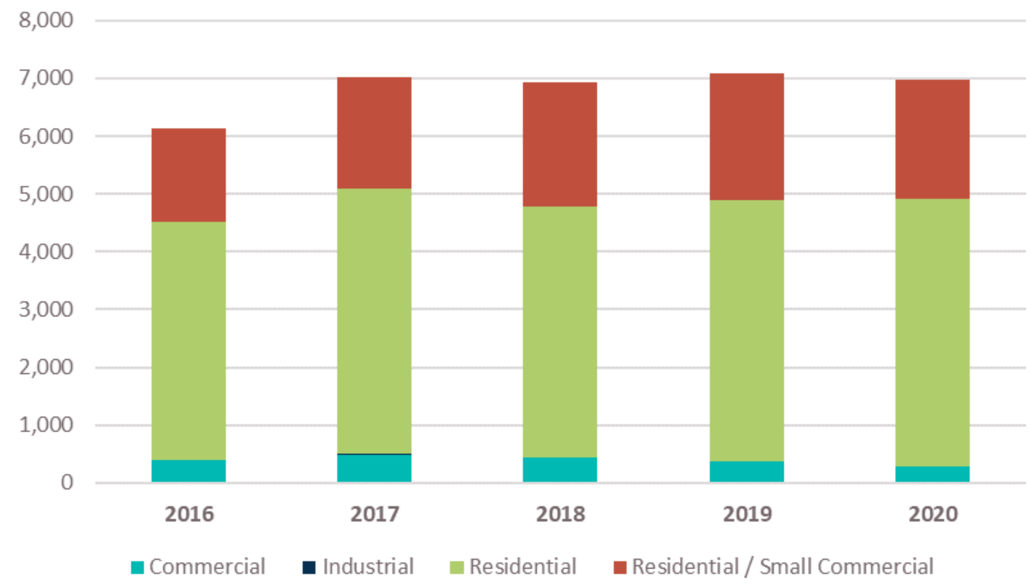
FIGURE 6.1: CONNECTIONS BY CONSUMER TYPE (AVERAGE ICPS OVER THE YEAR)



Source: Commerce Commission information disclosure database, based on data provided to it by the regulated gas distribution businesses. The ICPs contain both active and unactive connections. There are less than 400 connections identified as 'Commercial / Industrial' and 'Industrial', which is why they do not appear on the chart.

31 For instance, the gas distribution businesses have networks in Whangerei, Auckland, Bay of Plenty, Hamilton, Taupo, Gisborne, Napier, Hastings, New Plymouth, Wanganui, Palmerton North, Kapiti Coast, and Wellington.

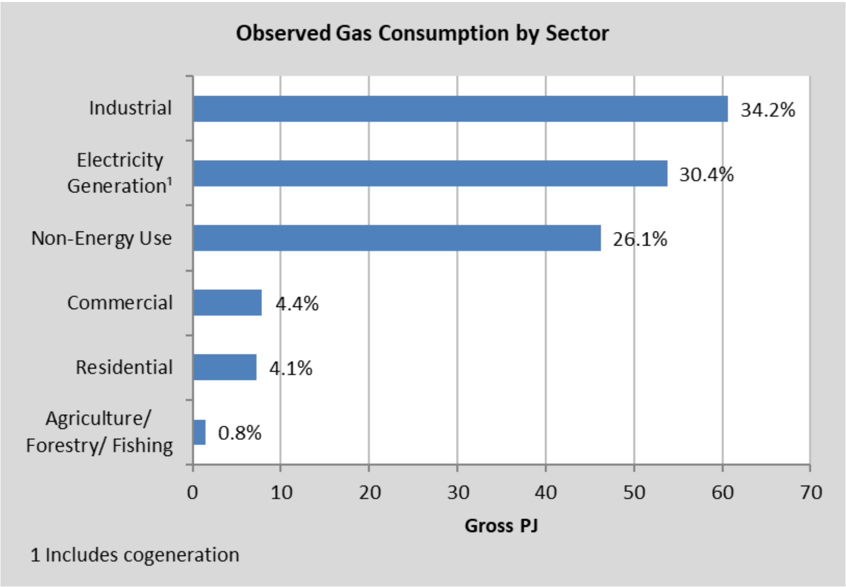
FIGURE 6.2: NEW CONNECTIONS BY CONSUMER TYPE



Source: Commerce Commission information disclosure database, based on data provided to it by the regulated gas distribution businesses.

New Zealand consumed 177.2 petajoules of natural gas in 2020, with the majority of this being by industrial consumers and for electricity generation. As shown in Figure 6.3, commercial and residential consumers only accounted for around 8.5% of natural gas use.

FIGURE 6.3: OBSERVED GAS CONSUMPTION BY SECTOR (2020)



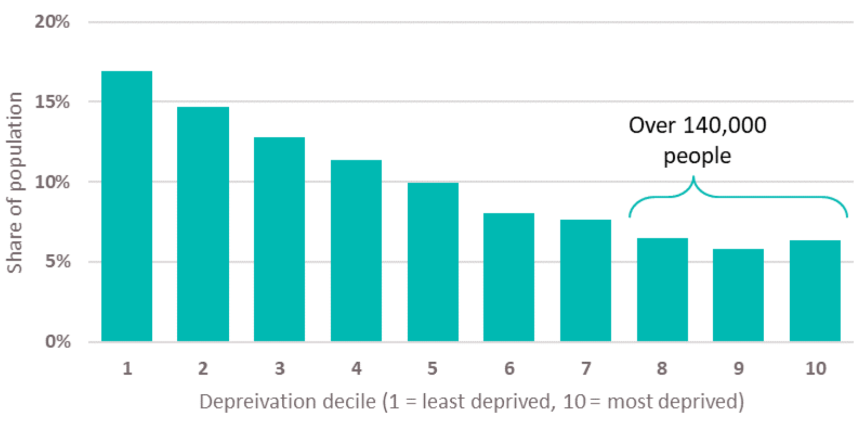
Source: MBIE. The data covers all natural gas consumption, not just that transported using the regulated gas transmission and distribution networks.

6.3. Demographics and vulnerability

At a residential level, gas consumers skew towards higher income groups, young families, and families with stretched budgets, and heavily away from rural groups.

In terms of socio-economic distribution, preliminary analysis – summarised in Figure 6.4 – indicates that there are over 140,000 existing residential population served by gas in areas of New Zealand that fall into deciles 8–10 of the EHINZ's deprivation index, or 19%.[32] This indicates some level of vulnerability for gas consumers in terms of low incomes or limited wealth. For those consumers, it is likely that the costs of converting their existing gas appliances to an alternative energy source (e.g. electricity) will be a real struggle.[33]

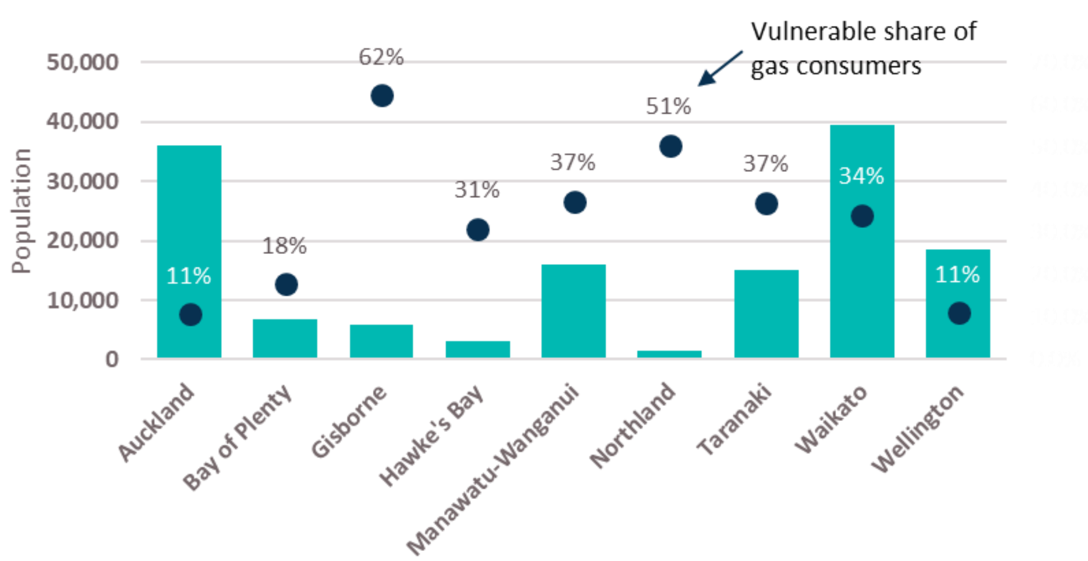
FIGURE 6.4: DISTRIBUTION OF GAS CONSUMERS BY DEPRIVATION DECILE



Source: Vector analysis. ICP data from Powerco, Firstgas and Vector.

As shown in Figure 6.5, vulnerable residential gas consumers are spread across North Island regions, with some regions exhibiting significantly higher levels of vulnerability (e.g. Gisborne and Northland) than others (e.g. Bay of Plenty).

FIGURE 6.5: DISTRIBUTION OF VULNERABLE GAS CONSUMERS BY REGION



Source: Vector analysis. ICP data from Powerco, Firstgas and Vector.

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32 HEINZ's deprivation index is described here: https://www.ehinz.ac.nz/indicators/population-vulnerability/socioeconomic-deprivation-profile/. Gas connection data was converted to gas consumers using localised census data on the average size of households.

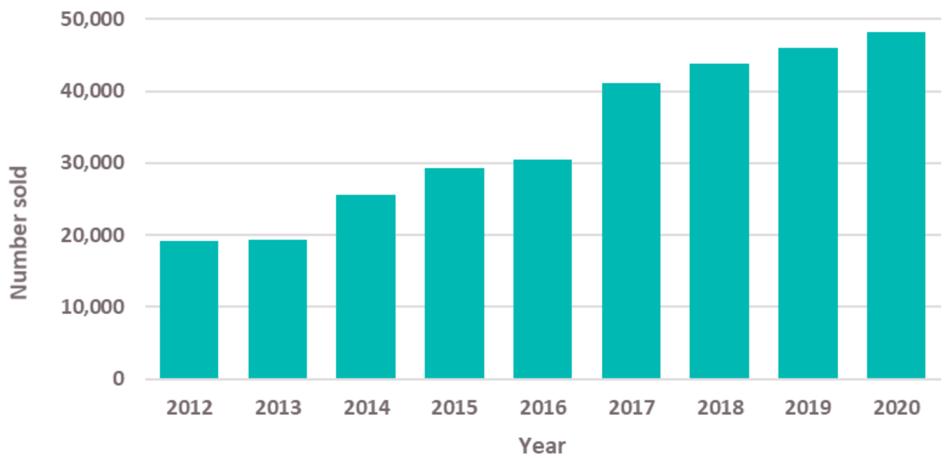
33 Vulnerable gas consumers may also suffer from fuel poverty whereby they cannot afford basic energy services (e.g. to cover heating costs).

Other gas consumers, like small businesses, are likely to also be vulnerable to the costs of converting from gas to electric alternatives. For instance, small restaurants that currently use gas cooking appliances to prepare food will likely face significant costs or, in some cases, become unsustainable if they are required to convert.[34]

6.4. Gas appliances

The information available about gas appliances is limited. The EECA does report some data on gas water heaters, which shows (Figure 6.6) that gas water heater installations have increased year on year over the last 9 years with just over 48,000 installed in 2020 and over 300,000 over the period. This suggests that there is a large stock of relatively new gas appliances.

FIGURE 6.6: GAS WATER HEATER INSTALLATIONS



Source: EECA. This includes appliances connected to LPG as well as reticulated gas infrastructure.

All residential and commercial gas appliances are substitutable by electricity – and in the case of hot water, by solar systems. Certain industrial applications are not substitutable by electricity.

For instance:

- **Cooking** | induction stove tops can substitute for gas cooking. [35] The CCC emissions budgets assume that small business use of fossil gas for cooking will need to lower emissions solutions such as biogas or electrification.
- **Heating** | electric heating is readily substitutable for gas heating. Electric heating already has high market share compared to gas. Gas heaters and fireplaces and central heating have a low market share compared to electric plugin heaters and heat pumps. Heat pumps are being more commonly used and can also be used for cooling.
- **Water heating** | fixed storage electric water heating is readily substitutable for gas water heating. Electric water heating already has high market share compared to gas water heating.

6.5. Consumer preferences

Powerco, Vector, and Firstgas all undertake various surveys of their consumers and others.

As a general theme, perceived cost difference is the dominant reason guiding consumers' choice between gas over electricity. Other benefits also play a role including better hot water and cooking. This suggests that in terms of consumer

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34 See: Restaurant Association of New Zealand, 29 March 2021, *Restaurant Association of New Zealand submission to He Pou a Rangi – the Climate Change Commission*. Link: https://www.restaurantnz.co.nz/2021/03/29/restaurant-association-of-new-zealand-submission-to-he-pou-a-rangi-the-climate-change-commission/.

35 CCC, May 2021, *Ināia tonu nei: a low emissions future for Aotearoa*, p.69.

preferences going forward under both scenarios it will be important to understand the difference in total bills as well as other reasons why consumers choose to get and retain gas as their fuel of choice.

Appendix C summarises this and other insights from the Powerco, Vector, and Firstgas surveys.

7. REPURPOSING GAS INFRASTRUCTURE

7.1. Introduction

There is significant interest in the potential for green gasses – primarily hydrogen and bio methane produced from biogas – to play a role in New Zealand's energy transition. As part of this, there is interest in the potential role for repurposing gas pipelines which would underpin, and require, a larger scale green gas industry in New Zealand.

The CCC's final report recommends that consideration be given to whether gas pipeline infrastructure should be retained to repurpose for low emissions cases like biogas or hydrogen. The CCC also notes that it is possible that low emissions gases such as hydrogen or biogas could be blended into natural gas to lower its emissions intensity.

This section provides a brief overview of hydrogen and biogas and discusses key issues related to repurposing existing natural gas pipeline infrastructure to transport green gasses.

7.2. Hydrogen

This report focusses on green hydrogen. 'Green hydrogen' is generally produced by electrolysing water in an electrolyser powered by renewable electricity. It can also be produced by reforming biogas or biochemical conversion of biomass if in compliance with sustainability requirements.

Based on the CCC's recommendations, it is expected that the government would only be interested in promoting zero emissions green hydrogen gas as part of a repurposing scenario, and not alternative 'grey' or 'blue' fossil based hydrogen. Carbon capture and storage (CCS) is considered to be an option for reducing emissions from certain large-scale point sources (e.g. steel, cement) and also can be used to create low emission 'blue hydrogen' but its economies are challenging due to the high costs of CCS.

Internationally there is strong interest in green hydrogen, as illustrated by the European Commission Hydrogen Strategy:

> *Hydrogen offers a solution to decarbonise industrial processes and economic sectors where reducing carbon emissions is both urgent and hard to achieve.*
>
> *Renewable electricity is expected to decarbonise a large share of the EU energy consumption by 2050, but not all of it.*
>
> *Hydrogen has a strong potential to bridge some of this gap, as a vector for renewable energy storage, alongside batteries, and transport, ensuring back up for seasonal variations and connecting production locations to more distant demand centres.*
>
> *Hydrogen can replace fossil fuels in some carbon intensive industrial processes, such as in the steel or chemical sectors, lowering greenhouse gas emissions and further strengthening global competitiveness for those industries.*
>
> *It can offer solutions for hard to abate parts of the transport system, in addition to what can be achieved through electrification and other renewable and low-carbon fuels.* [36]

There are several advantages of hydrogen as a fuel source, including that it:

- is flexible in its production profile – and hence hydrogen production might focus on periods when electricity prices are low/lower than average (or even when production would have otherwise been curtailed)

[36] European Commission, *A hydrogen strategy for a climate-neutral Europe*, 8 July 2020.

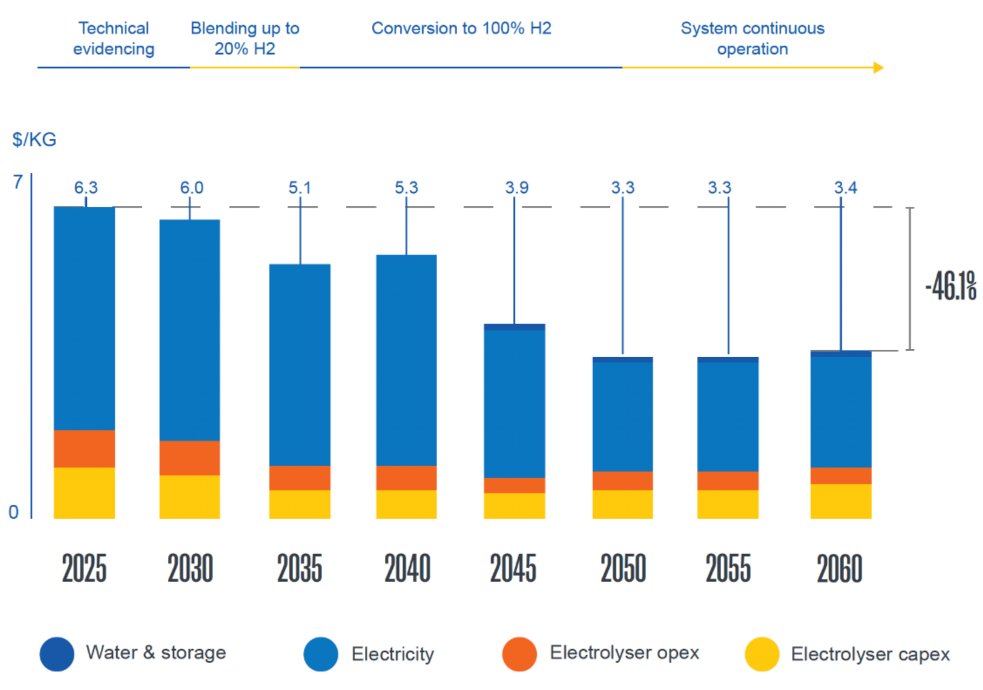
- is flexible with regards to its location – particularly if it is grid-connected
- is flexible in terms of its use – for instance, heavy vehicles, electricity generation
- is scalable – which implicitly provides option value, and is in direct contrast to biogas/biomethane which requires organic waste as a feedstock
- can be used to support the broader electricity system – including to:
    - boost energy security, noting that 'dry year' coverage is particularly important in NZ (and will be even more so in the future with even more Variable Renewable Energy (VRE)
    - provide other ancillary services such as frequency control and voltage support
- can be stored and used to provide peaking services into the gas grid and is also able to meet high temperature process heat needs.

At a minimum, green hydrogen is likely to have a role in New Zealand's future renewable energy sector for 'hard to abate' applications, and there are already a small number of use cases and trials underway.

There is significant uncertainty about how much more of a role it can play for other applications which can more readily use electricity or other sources. The extent of its role will become clearer over time as information emerges on its cost competitiveness against alternatives in particular electrification. Some will be internationally sourced information (e.g. reductions in the cost of electrolysers and hydrogen appliances) and some will be local information (the cost of renewable electricity used to produce hydrogen).

Currently, the largest component of the production cost of green hydrogen is the electricity purchase cost, as illustrated in Figure 7.1, but this cost is forecast to fall significantly over time.

FIGURE 7.1: ESTIMATED HYDROGEN COSTS AND MAIN COST COMPONENTS



Source: Firstgas.

Recent reports by government bodies in other jurisdictions have targeted much more aggressive cost reductions, including an AU$2/kg target by the Australian Government in its National Hydrogen Strategy[37] and a US$1/kg target by 2030 by the US Department of Energy.[38] The European Commission observed in 2020 that:

> *Electrolyser costs have already been reduced by 60% in the last ten years, and are expected to halve in 2030 compared to today with economies of scale.* [39]

The largest potential for cost reduction for green hydrogen is the electricity purchase cost. Minimizing electricity costs will likely require 'smart' optimization for example producing hydrogen when renewable electricity energy is plentiful and low cost and co-locating production with industrial offtakes.

Under a repurposing scenario involving green hydrogen, hydrogen is likely to be produced in New Zealand from renewable electricity rather than imported.

Hydrogen production in New Zealand is limited, although there is meaningful interest in its potential. As such, potential green hydrogen models for New Zealand are still being considered. There are several hydrogen projects currently underway in New Zealand, but they are limited to small-scale trials and demonstration projects. For example, Meridian Energy recently announced a green hydrogen feasibility study, which is to be completed by August 2021 in partnership with Contact Energy.

MBIE is currently developing a roadmap for hydrogen in New Zealand.

Appendix D provides more detail on the potential use cases for hydrogen, current hydrogen trials in New Zealand and the potential different models for how a hydrogen industry could develop in New Zealand.

To the extent hydrogen becomes a larger part of New Zealand's energy mix, there may be a mix of models both geographically and over time. For instance, some models might emerge initially – such as small-scale network blending and large-consumer specific hydrogen production – and eventually transition to alternative models if a large scale upstream market is established.

Potential commercial investors considering significant investment in hydrogen production will focus on managing uncertainty, including by deferring decisions as long as possible, seeking long term offtake contracts, choosing projects which maximize demand optionality, or seeking government risk sharing.

A future involving transportation of green hydrogen using repurposed transmission gas pipelines will require a large enough current and future market to justify the high fixed investment costs required to repurpose and then maintain and replace transmission pipeline assets over time. Confidence in the size of the market will require widespread acceptance of hydrogen by consumers. However, as there are not significant costs in repurposing distribution pipelines, and as hydrogen electrolysers can be located in a distribution network, the market size required for economic viability will be lower and localised.

In the absence of strong government and/or energy retailer involvement to accelerate acceptance of hydrogen by consumers, wide-spread hydrogen use for residential and commercial consumers is likely to take many years as hydrogen is still a new concept (or unknown) for many consumers and the economics are currently highly uncertain.

An early step being adopted by other developed countries is hydrogen blending, as this does not require significant network expenditure or appliance conversion. There is likely to be merit in industry commencing hydrogen blending demonstration projects and other small-scale projects, to gain experience and reduce emissions in the interim until more information

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37 COAG Energy Council, *Australia's National Hydrogen Strategy*, 2019.

38 US Department of Energy, Office of Energy Efficiency and Renewable Energy – see https://www.energy.gov/eere/fuelcells/hydrogen-and-fuel-cell-technologies-office-funding-opportunities#rfi

39 European Commission, *A hydrogen strategy for a climate-neutral Eu*rope, 8 July 2020, p4.

emerges on the potential future role of hydrogen. There may be a case for government funding or policy mechanisms to help accelerate the development of the hydrogen industry.

Appendix E provides more details on hydrogen blending.

Uncertainty over the future potential for hydrogen (and biogas) production in New Zealand may support positive action to create or preserve optionality to convert existing gas pipeline and appliance infrastructure to accommodate such low or zero-carbon gases. This may support taking low-cost actions in the short term.

7.3. Biomethane and biogas

Biogas is a mixture of methane (CH4) and carbon dioxide (CO2) and can be 'cleaned' to form biomethane – sometimes called 'renewable natural gas' – which can be used as a direct substitute for natural gas.[40]

Biomethane is an attractive option to consider for repurposing gas pipelines, as it:

- avoids the need to replace appliances, which is a significant cost and logistical challenge under alternatives based on electrification or hydrogen
- can use existing gas pipelines, including high grade steel pipelines without causing embrittlement[41] issues, and
- is suitable for certain industrial processes.

BioLPG – or renewable LPG – is also available as a direct substitute for conventional LPG. BioLPG is an attractive option for reducing emissions from LPG as it is a drop-in substitute for conventional, with no investment required in either infrastructure or appliances.

Biomethane supply costs can be complex to estimate because costs depend on the feedstock, and production facilities can have multiple revenue streams, but broadly biomethane appears likely to be attractive in some applications as the cost or natural gas increases.

Current information on feedstock availability suggests additional biomethane potential represents approximately 10% of New Zealand's current annual natural gas consumption excluding electricity generation (based on estimates by Beca). Although there may be a larger feedstock available in New Zealand than currently estimated, it appears insufficient to replace all existing piped natural gas use. However, biomethane could provide a much larger share of future gas use if natural gas demand reduces significantly as forecast by the CCC, e.g. the CCC forecasts 25PJ of gas use by 2050, while Beca estimates that biomethane production could be increased to around 20PJ.

Biomethane could, therefore, assist in decarbonising piped gas consumption on the way to achieving net-zero emissions. If the potential for biomethane is actually much higher than the 10% estimated by Beca, then its role in decarbonising that consumption could be much greater as well.

Given this, the potential way forward for using biogas and biomethane appears to depend heavily on the policy framework adopted by government. Where biogas and biomethane industries have developed strongly internationally this appears due to bespoke subsidies of various forms to specifically drive the industry development, and sometimes to drive use in specific applications.

As New Zealand approaches net-zero emissions it would seem reasonable to rely on market forces to efficiently allocate the limited biogas feedstock to its highest value uses (taking into account local feedstock availability, transport and production costs), including whether existing transmission pipelines should play a role in transporting biogas. This is already occurring

[40] Biomethane can therefore be used in a gas network. Biogas however is not compatible with use in a distribution network.

[41] Hydrogen embrittlement is a potential issue for high pressure pipelines.

to some degree. For example, Beca, EECA, Firstgas Group and Fonterra recently published a study to assess the potential of raw biogas by treating it so it becomes a possible substitute for natural gas.[42]

If there is a viable option for using North Island gas pipelines to enable transportation of biomethane, then it would appear to be possible to use some or all of Firstgas' existing transmission network, perhaps with dedicated connections to certain industrial plants. In the South Island – due to the lack of existing natural gas pipeline network – current distribution networks of compressed natural gas and liquified natural gas could be used for biomethane applications.

Appendix F provides more information on potential applications for biogas, and studies on its potential use in New Zealand.

7.4. Costs and feasibility of repurposing existing pipeline infrastructure

It is important to understand both the costs and feasibility of converting existing gas pipeline infrastructure to use zero-carbon gases.

Pipelines do not require conversion to accommodate biomethane, but there are questions around the costs and feasibility of repurposing pipelines to flow hydrogen. Firstgas's recent feasibility study has considered these questions.

The most significant issue is hydrogen embrittlement, which is where steel pipes become brittle after being exposed to hydrogen atoms at high pressure. Firstgas's hydrogen feasibility study found that embrittlement issues could affect part of its transmission network, but no concerns were raised in relation to distribution networks. New Zealand's gas distribution networks appear to face low risk of embrittlement due to the low pressure at which they operate and the materials that are used, e.g. polyethylene.

Appendix G sets out further detail on the costs and feasibility of repurposing existing pipeline infrastructure drawing on Firstgas's recent feasibility study and other information.

7.5. Converting existing appliances to handle zero-carbon gases

As with pipeline infrastructure, it is also important to understand the costs and feasibility of converting appliances to use zero-carbon gases.

Appliances do not require conversion to accommodate biomethane or low levels of hydrogen blending but there are significant issues for converting appliances to enable burning of higher levels of hydrogen.

Firstgas' hydrogen feasibility study considers that hydrogen blends of up to 20% can be implemented without impact on appliances. Some appliances are already available in New Zealand that are specifically marketed and labelled as ready to accept up to 20% hydrogen, such as Rinnai's 'H_2 Ready' commercial water heater.

A report by GPA Engineering for Australia's National Hydrogen Strategy found that domestic, commercial, and industrial appliances are likely to be suitable for hydrogen blending of up to 10% by volume based on current Australian standards. The Future Fuels Cooperative Research Centre is currently undertaking detailed assessment of the compatibility of various types of appliances with blended hydrogen.

The development of dual fuel appliances designed to be converted from natural gas to hydrogen at low cost could provide optionality which could significantly support the economies of repurposing of gas pipelines and reduce the practical challenges of converting appliances.

As New Zealand is likely to be a technology follower, increased availability of dual-fuel appliances will depend on the success of such technology development internationally. BEIS has set up the Hy4Heat Research and Innovation Programme

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42 EECA, Beca, Fonterra, Firstgas Group, 1 July 2021, *Unlocking New Zealand's Biomethane Potential – Biogas and Biomethane in New Zealand*. Link: https://www.beca.com/getmedia/4294a6b9-3ed3-48ce-8997-a16729aff608/Biogas-and-Biomethane-in-NZ-Unlocking-New-Zealand-s-Renewable-Natural-Gas-Potential-Final.pdf.

to explore a transition from natural gas to hydrogen for cooking and heating in the UK. This work is exploring the safety and functionality of hydrogen-fuelled and hydrogen/natural gas dual-fuelled or converted appliances including boilers, cookers, and fires.[43]

The working group identified examples from the UK where replacing a gas appliance with a new appliance that is designed to handle both natural gas and hydrogen adds only £100 to the cost. This could be an attractive option for consumers who understood that there was a 'future proofing' benefit in purchasing a dual fuel appliance, given that decision to replace an appliance had already been made.

Dual fuel appliances available at a small additional cost raises the possibility that if early action was taken to enable or encourage the conversion of the appliance stock to dual fuel appliances as appliances need replacing, that by the time New Zealand was ready to convert to high levels of hydrogen, the remaining conversion costs and challenges would be reduced, perhaps significantly.

7.6. Options that could facilitate repurposing

Other options that could facilitate the repurposing of gas pipelines for green gasses include:

- **Mothballing of gas pipelines |** Natural gas pipelines are capable of being mothballed. Incurring mothballing expenditure could be a way of creating option value – for example, where for whatever reason it is appropriate to cease using a pipeline but there was a sufficient likelihood that the pipeline could be put back into service in future – say, if hydrogen production becomes cheaper and more viable and demand might emerge at a later time. If this option is pursued, then there will be questions about who owns and manages any mothballed assets, and who bears the costs of doing so. It is also unclear whether, once mothballed, there will ever be sufficient likelihood that those assets will be put back into service.
- **Future proofing of maintenance programs |** Gas pipelines owners have opportunities to including 'future proofing' in their ongoing maintenance and replacement programs. This opportunity particularly applies to transmission pipelines. This would include opportunities for replacing pipeline components with components designed specifically for conversion to hydrogen.

7.7. Gas industry regulation

Should the repurposing scenario become likely then the government will need to consider what changes to gas industry regulation may be required. No immediate action is required.

Firstgas has undertaken a high-level assessment of the regulations involved in gas production, transportation and use to understand the relevant regulation and the requirement for change to accommodate hydrogen. Current regulation covers regulation of gas safety, health and safety, hazardous substances, wholesale gas market regulation and rules (switching, compliance, critical contingency management), and retail gas and distribution market schemes.

The Gas Industry Company is developing a summary of the regulatory roles and responsibilities in relation to hydrogen production, transportation, storage, markets and end use.

Gas safety regulation will require changes to address hydrogen and there will be workforce training required. An issue for the government to be aware of would be the need to promote community confidence given the lack of familiarity with hydrogen.

43 See, for instance: https://www.worcester-bosch.co.uk/hydrogen.

In Australia there have been detailed reviews of the regulation of hydrogen and hydrogen blending, and reforms are underway to support hydrogen blending.

7.8. Nitrogen Oxide emissions

Combustion of hydrogen can produce nitrogen oxide (NOx) and there are questions about whether in some circumstances NOx emissions may exceed safe levels. Gas infrastructure business technical advice suggests that at low blending levels there are only marginal differences compared to pure natural gas. NOx levels increase with 100% hydrogen due to the increase in flame temperature. There is significant research being undertaken to improve appliance and burner design to minimise the increase in flame temperature and thus minimise NOx emissions. This issue will require ongoing monitoring.

8. IMPLICATIONS OF WINDING DOWN GAS INFRASTRUCTURE

8.1. Introduction

Under the winddown scenario, all current users of natural gas would switch to renewable electricity or other energy sources that are not delivered by existing natural gas pipelines. This would result in a gradual or stepwise process to reduce utilization, and then to shut down and decommission, existing gas pipelines. A pipeline (or pipeline sections) could be permanently decommissioned, or could possibly be mothballed for potential later recommissioning to use green gases.

The winddown of a gas pipeline will need to be undertaken safely and in a coordinated manner to enable switching of consumer demand to alternative energy sources, in particular electricity. The government will be concerned about the potential for unserved demand, particularly for small commercial and residential consumers, and this aspect will therefore require an appropriate and proportionate form of oversight.

It is assumed that pipelines will need to keep operating until all consumers have switched to an alternative. However, in order to minimize operating costs, it will necessary that that once a decision is taken to switch off, that there is a proactive process to ensure switching occurs in a timely and orderly way. For practical reasons, the gas pipeline operator will likely need to switch off the pipeline in stages (by suburbs, cities, towns, sectors etc.).

8.2. Future demand, revenues, and sustainability

There is a clear need to better understand the trajectory of falling demand, revenues, and financial sustainability.

Unless the government makes decisions now that make it unlikely that pipelines will need to be wound down, the most important action at this time is to develop a more detailed understanding of the potential future trajectory for demand, revenues and financial sustainability for gas pipelines.

This work is needed because:

- As gas volumes decline (for example in response to the ETS pricing incentives, consumer preferences or government policy (e.g. to ban new connections)) then gas infrastructure businesses will have declining consumers and throughput from which to recover their costs which remain largely fixed.
- In principle, gas infrastructure businesses could adopt some combination of increasing prices to the remaining connected consumers, reducing expenditure, and/or reducing returns to shareholders, but these options will be in practice be limited, and at some point would become unsustainable as there is a declining number of consumers from which to recover the pipeline's costs
- There will likely be a 'cliff edge' for the gas distribution businesses' financial sustainability rather than steady gradual decline.[44]

Developing an early understanding of the potential trajectory for falling demand, revenues and financial sustainability will enable:

- the government and stakeholders to be better informed about the effects of policy actions that may accelerate reduced gas demand (e.g. banning new gas connections)
- all parties to better understanding the potential timing for when various decisions may need to be made

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[44] For instance, such a cliff edge will likely be affected by whether debt investors are willing to lend funds to the gas infrastructure businesses and, if so, the financing costs they will charge. If investors are unwilling to lend or only at rates that are too high because of concern about future revenues, then this may prompt the businesses to shut down operations abruptly.

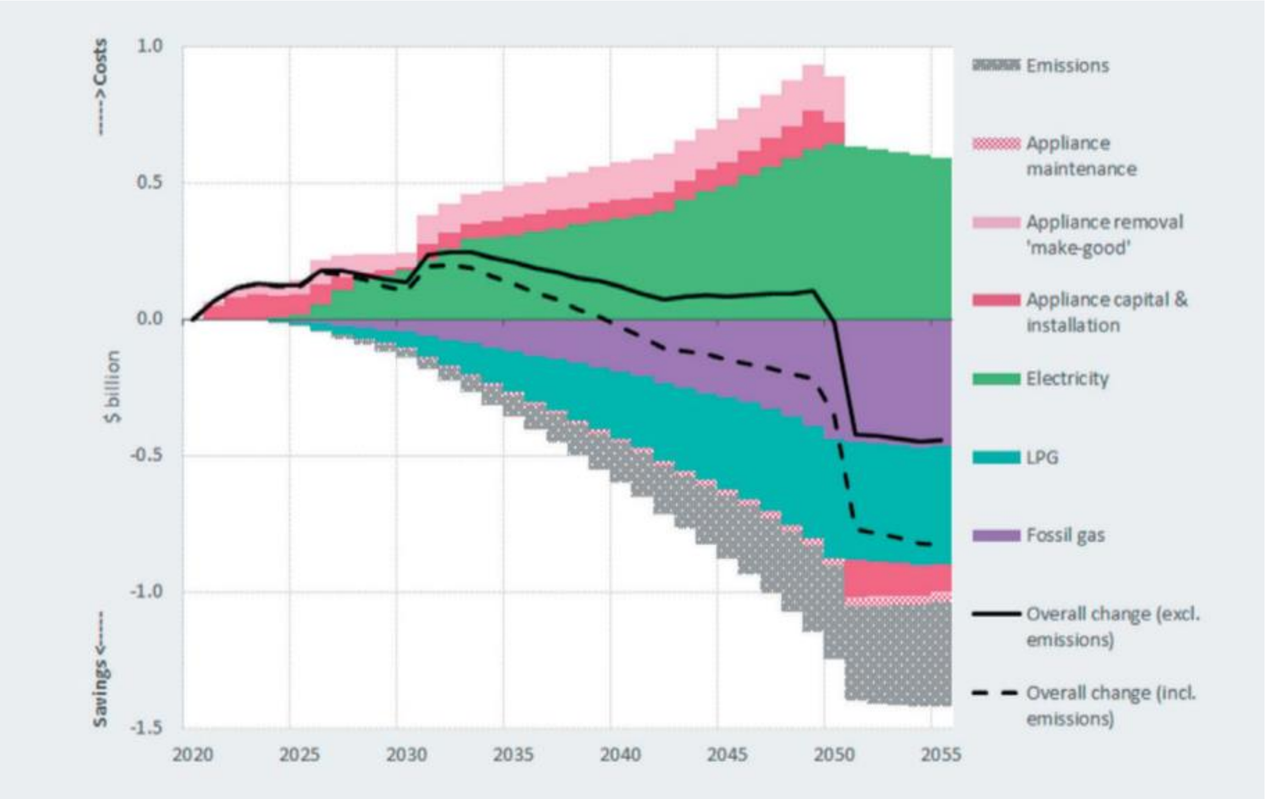
- a better understanding of the context for the Commerce Commission, government, and other stakeholders to consider future economic regulation, including:
  - the nature of any asset stranding effects
  - regulatory settings within the existing regulatory framework to address the winddown scenario
  - potential changes to the regulatory framework (see section 9 below)
  - the timing for when decisions may be needed
- a better understanding of the practical, financial and operational aspects of managing a winddown, including how to meet the costs that need to be recovered to stay in business, for a pipeline which has lost a substantial portion of its revenues but needs to keep operating until the remaining consumers can be switched in an orderly manner.

No significant operational concerns about the winddown scenario have been identified. It understood that a gas pipeline can be safely operated with low throughput.

8.3. Residential gas appliance conversion costs

Conversion costs are likely be a key consideration for government – is it will be for gas consumers. These are expected to be substantial. For instance, in its final advice, CCC projects that it could cost residential and commercial consumers $5.3 billion to convert space and water heating appliances to electric equivalents over the period out to 2050. This cost is reflected in Figure 8.1.

FIGURE 8.1: PROJECTED COSTS AND SAVINGS FROM TRANSITIONING GAS SPACE AND WATER HEATING TO ELECTRICITY [FIGURE 8.3 OF CCC FINAL ADVICE]



Source: CCC final advice, Figure 8.3.

Note: the chart shows the projected increase and decrease in different elements of space and water heating costs for homes and businesses in the demonstration path compared to the current policy reference, excluding energy efficiency improvements. Under the CCC's modelling, all space and water heating in buildings is assumed to be electrified by 2050. There is a net cost of the transition while this happens due to the costs of converting existing building, but once complete there will be overall net savings from the transition.

Costs will be incurred in converting residential and small business consumers from natural gas to electricity or other fuel sources. Relevant cost elements include:

- purchase costs of alternative appliances
- installation costs of alternative appliances (including any building alterations, wiring changes, etc.)
- removal of old gas appliances
- disposal and potential recycling of old gas appliances
- differences in expected operating costs
- disconnection of the gas supply, removal of the meter etc.

As shown in Figure 8.2 below, preliminary estimates have been made by consultants Oakley Greenwood of the cost for replacing residential gas appliances with electric appliances based on data from Powerco. This indicates that the weighted average retrofit costs for these consumers are about $4,000 but with a wide range around this depending on the range of appliances used. A consumer with the full range of appliances (a water heater, hobs and central or radiator heating) will face an average retrofit cost of around $10,400.[45] Similarly, Kainga Ora estimates that it costs, on average, around $8,000 per residence to convert its properties from gas to electricity.[46]

FIGURE 8.2: ESTIMATED RESIDENTIAL APPLIANCE REPLACEMENT COSTS

End-use appliances	Annual gas load (GJ)	Approximate proportion of Powerco customers with this suite of appliances	Retrofit cost[34]
Water heater + hobs[35]	<14	27%	$2,025
Water heater and space heating (simple system / low consumption)	14-30	37%	$2,778
Water heater and space heating (medium complexity system / medium consumption)	30-40	12%	$3,525
Water heater and space heating (complex system / high consumption)	40-50	8%	$4,687
Water heater + hobs and Central or Radiator heating	50+	16%	$10,425
Weighted average retrofit cost		100%	$4,011

A key consideration for government is likely to be the impact of these costs on vulnerable consumers, and policy mechanisms are likely to be needed to support those consumers.

45 Oakley Greenwood, p.41.

46 Kainga Ora has a programme of switching its properties from gas to electricity. Kainga Ora's estimate of $8,000 per residence is to replace gas cooking, space heating, and water heating appliances, assuming there is no asbestos or other complications. Actual costs depend on how many appliances are being converted, whether there is an asbestos flue that needs to be removed, the class of asbestos (A or B), whether scaffolding is required, and what appliances are being installed (e.g. heat pump, electric heater or nothing). Given the volume of work it commissions, Kainga Ora is likely to face lower average costs than individual gas consumers.

Oakley Greenwood estimated energy supply costs if residential and commercial gas consumers' current gas consumption was converted to electricity. If conversion occurred at today's long run production costs, decommissioning gas pipelines and converting current gas use to electricity would result in average increases of:

- 6.5% for residential consumers
- 50.5% for commercial consumers.

Should the winddown scenario become more likely, then the government could consider further work to improve appliance replacement cost estimates and to develop appliance lifecycle costs estimates.

Appendix C provides more information and data on gas consumer demographics and their current reasons for preferring gas appliances over alternatives. This data, for instance, shows that gas consumers have been installing many gas water heaters in recent years. Given that these heaters generally have 12–20 year lives, this suggests that they will not be due for replacement for some time.

8.4. Coordinated plan for switching and gas pipeline decommissioning

If the winddown scenario occurs, a coordinated plan will be required to ensure an orderly process for switching consumers to other energy source, (primarily electricity) and a related gas pipeline decommissioning plan for a region/city.

Key aspects of this plan would be target dates for completing installation and commissioning of any new or augmented electricity infrastructure and other appliances that have not already switched, and a target date for switching off the gas network in each location.

As discussed above, it is assumed that pipelines will need to keep operating until all consumers have switched to an alternative, which is likely to be logistically challenging and a key part of the switching and decommissioning plan. As part of developing this aspect of the plan, relevant issues to consider include:

- ensuring that all gas consumers are aware of the impending changes and switch off dates so that, where possible and reasonable, consumers manage their own appliance switching
- providing consumers with information on their options
- identifying vulnerable consumers who might need assistance to switch, and anticipating what sort of assistance may be needed
- including clear steps and responsibilities to check that all consumers in an area have switched prior to switching off the gas network
- considering whether to provide temporary solutions to consumers who have not switched (e.g. replace piped gas with temporary bottled gas during a specified transitional period).

The main parties involved in developing and implementing the plan would be the relevant gas and electricity network companies. There may also need to be coordination with the appliance industry, appliance installers, and building and electrical trades needed to undertake any building and electrical modifications, install electrical appliances and remove gas appliances.

There would be value in considering the experience from the recent broadband fibre roll out and the switch from analogue to digital TV.

Other key issues that would need to be considered as part of the development of a decommissioning and switching plan are discussed in Appendix H.

8.5. Other implications

Other material implications of a winddown scenario discussed in the findings in Part A include:

- work force implications for gas pipelines and appliance installers
- the impacts on electricity generation, transmission and distribution investment arising from consumers needing to switch away from gas
- maintenance of safety during the winddown.

The environmental impacts of a winddown should also be considered and there is likely to be value in the government undertaking work to better understand these impacts. Issues that should be considered include:

- the carbon intensity of alternative energy sources, which will partly depend on the relative timing of the winddown in natural gas usage and the replacement of fossil fuels for electricity generation with renewable electricity
- the risk of carbon leakage to other countries, particularly ifs industrial users of gas simply relocate their production to other countries
- environmental risks from the disposal of large numbers of gas appliances
- environmental impacts of the removal of gas pipelines.

It will also be important to understand the legal requirements for a winddown scenario and the costs of complying with those requirements, e.g. do exiting gas pipelines need to be removed or simply decommissioned and made safe.

A range other issues have been identified by the working group that need to be considered should the winddown scenario become more likely, but these do not need to be addressed in the short term.

9. ECONOMIC REGULATION CONSIDERATIONS

9.1. Overview

By design, economic regulation affects the incentives faced by gas transmission and distribution infrastructure businesses. Core to the economic regulation framework is a 'regulatory compact', whereby regulated businesses invest in their networks with the expectation that they will be able to recover from consumers the costs of efficient investment that is in their long-term interests. In return for a high level of certainty of returns, economic regulation limits the rate of return that can be achieved.

The current framework is based on the premise that pipeline infrastructure will continue to supply gas to consumers in the future. Transitioning the pipelines to either a repurposing or winddown scenario calls into question whether that framework remains appropriate. It also raises the risk that pipeline investment that is yet to be recovered from consumers will become economically stranded (i.e. unable to be recovered). Unless mitigated, such risk will affect the incentives faced by the pipeline businesses by undermining the regulatory compact.

9.2. Current economic regulation framework

Transmission and distribution pipeline businesses are subject to economic regulation to promote outcomes that are in the long-term interests (or benefit) of gas consumers. Bottled and reticulated LPG gas are not subject to economic regulation.

The intent of Part 4 of the Commerce Act is to ensure that regulated gas infrastructure businesses are incentivised to invest and innovate in their networks, while preventing them from making excessive profits given the degree of market power that they possess. The Commerce Commission regulates gas transmission and distribution businesses through price-quality path regulation which sets the maximum revenue each business can collect from consumers and the minimum quality standards they must maintain. Price paths are reset every 5 years.

The Commerce Act Part 4 arrangements can be viewed as a 'regulatory compact'. Because investments in gas networks are large and lumpy, the costs of these investments are recovered from consumers over time – usually over several decades – rather than all at once when the investment is made. Under the Part 4 arrangements, gas infrastructure businesses recover the costs they incur investing in their networks over the assumed live of the assets. The Commerce Commission has made clear its view that the cost of capital should be reasonable and commercially realistic given investors exposure to risk – which, if applied, ensures that that real rate of return is consistent with the principle of financial capital maintenance (sometimes referred to as the 'NPV=0' principle).[47]

This is referred to as the 'regulatory compact' – where regulated gas infrastructure businesses make large investments in network assets that deliver long-term benefits to consumers in exchange for an assurance that they will be able to recover fully the efficient cost of those investments over the assumed life of those assets.

9.3. Economic regulation issues identified

The working group raised questions about whether the current economic regulation framework and practice is appropriate given the uncertain future use of gas infrastructure – or, indeed, whether changes may be needed. These questions are briefly described in Box 2 and some are explained in further detail.

This report does not analyse these questions in any depth or discuss potential solutions to them. The proposed work to understand the potential future trajectory for demand, revenues, and financial sustainability for gas pipelines will be important context to better analysing these questions.

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47 Commerce Commission, 16 June 2016, *Input methodologies review draft decisions, Topic paper 4: Cost of capital issues*, s61.

Box 2: Economic regulation issues

1. **What are the appropriate time frames for review and making decisions about any changes to the economic regulation framework or how it is applied?**

   Government and stakeholders need to understand the impact of falling demand, revenues, the effect on financial sustainability for gas infrastructure businesses, and the time frames over which pressures on financial sustainability might play out.

2. **Are there adequate incentives for gas pipeline to invest to maintain services?**

   To preserve incentives for investment in regulated assets that promote the long-term interests of gas consumers, it is important to preserve the 'regulatory compact' and to ensure that the costs of efficient investments in gas networks can be recovered by the businesses that made those investments. Given the prospect of declining consumer demand and revenues, pipeline owners are not likely to have adequate incentives to invest, maintain, and deliver service quality if there is uncertainty about whether they can recover new investment (through depreciation charges) and a reasonable opportunity to earn a rate of return commensurate with the investment risk. As noted in section 9.4, deferral of expenditure may not have an immediate adverse effect on gas consumers, but it would do so over time.

3. **Is there a case for addressing economic stranding risk given the economic lives assumed for pipelines is as long as 60- 80 years with the weighted average years assumed for new assets is 45 years - which means new assets are assumed to be economic beyond 2050?**

   Any rational business would invest only if it expects to at least recover, over a period of time, the original cost of the investment. A business that does not expect to recover the cost of its investments would suffer economic losses that are ultimately borne by its owners.

   Current regulatory practice is to adopt economic lives for asset types that align with their technical or engineering lives. Many assets have lives of 50 years or longer:[48]

   - Pipelines: 60-80 years
   - Service connections: 60-70 years
   - Stations: 50 years.

   This means that when a gas infrastructure business does capital maintenance on a pipeline with an assumed asset life of up to 80 years in 2021, then under the current rules the full return on capital would not be achieved until 2101.

   The aggregate value of the Regulatory Asset Base (RAB) for the three largest gas distribution businesses is currently around $966M and for Firstgas's transmission network is $850M (See Box

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48 Although an assumed life of 45 years is adopted for new assets on a prospective basis for the 2017–22 DPP, this reflects a weighted average of lives across assets with longer and shorter lives. The assumed life is not used to roll forward the regulatory asset base from one period to the next, which instead relies on depreciation calculated using the more granular breakdown of lives.

See: Commerce Commission, 3 April 2018, *Gas Distribution Services Input Methodologies Determination in 2020*, p.138. Link: https://comcom.govt.nz/__data/assets/pdf_file/0029/59717/Gas-distribution-services-input-methodologies-determination-2012-consolidated-April-2018-3-April-2018.pdf.

3).[49] It is likely to be desirable to consider the case for either eliminating or mitigating stranding risk – the inability for investors to recover their past and future capital expenditure. One consideration is the potential effect on investors' perception of risk and their willingness to invest in New Zealand.

If stranding risk remains, regulated businesses may make investment decisions that do not promote consumers' long-term interests. A business will only be prepared to make substantial ongoing capital investments in its gas network if it expects the additional revenue it will be able to earn from those investments will enable it to recover the cost of those investments.

4. **How should the gas infrastructure businesses deal with consumer demand that requires growth capital expenditure?**

Gas infrastructure businesses face ongoing consumer demand for new energy supply. This creates challenges if new capital expenditure is required to meet this demand while there is a prospect that that the assets will not be used for their full technical life.

Gas infrastructure businesses may, where appropriate, seek to shift risk to consumers through contracts or higher levels of consumer contributions. For instance, Vector recently updated its capital contribution policy to require consumers connecting to its gas network to contribute 100% of the costs of doing so.[50]

In some cases, these responses may cause consumers to consider zero-carbon alternatives. However, from a new consumer's perspective this could be challenging (e.g. with different treatment than that applying to existing consumers).

5. **Is there a need for changed incentives for pipelines to invest in innovation to better enable a future where repurposed pipelines transport green gasses?**

Gas pipelines could invest in innovations to start to prepare for a future transporting zero-carbon gases, for example hydrogen blending. This raises questions such as whether such incentives are desirable; and, if so, what the objectives of such incentives are, and how costs and risks are allocated.

6. **Is there a potential problem for a trend to higher network tariffs as gas pipeline demand reduces, what are the potential impacts on different consumer groups, and how could these impacts be managed?**

The current regulatory model means that as demand reduces – due to gas demand being substituted for by other energy sources –network tariffs will tend to increase as fixed costs need to be recovered over a declining demand base. In addition, depreciation charges could be potentially brought forward to reduce asset stranding risk.

Different consumer groups may be impacted in different way (e.g. new consumers vs existing consumers). Intergenerational equity questions need also to be considered

7. **Whether changes are required in the interface between government policy and regulatory decision making?**

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49 The RAB represents the value of investment undertaken by gas infrastructure businesses that has not yet been recovered through regulated tariffs.

50 See: https://www.vector.co.nz/news/gas-distribution-2021-capital-contributions-poli.

Part 4 of the Commerce Act was designed based on a 'steady state' gas industry and arguably did not contemplate either the potential winddown or repurposing of gas pipelines. It aims to promote outcomes that are in the long-term interest of consumers, whereas some questions for the future of gas pipeline infrastructure affect all energy consumers.

The current regulatory framework is clear about the scope of government policy and the obligations and discretion of the Commerce Commission. But the future challenges raise important questions about the interface between government policy, and the economic framework established by Part 4 of the Commerce Act that is administered by the Commerce Commission.

8. **Should some type of emission reduction objective be included as a matter the Commerce Commission should have regard to?**

   Given the critical role that emission reductions will play in determining the services provided and efficient costs it may be desirable to include in Part 4 of the Commerce Act a specific emission reduction objective as a matter the Commerce Commission should have regard to.

9. **What are the implications for the economic framework of a potential reduction in market power in the event of winddown scenario?**

   If gas pipeline use were to be completely phased out over time, then a question arises as to whether – at some future point – gas infrastructure businesses would continue to possess sufficient market power to justify the current approach to economic regulation.

   In this situation, rather than a concern with an ability to make excessive profits, the concern may be that pipeline owners may make insufficient profits to encourage them to invest and maintain the assets.

10. **What is future rationale for economic regulation? What are the implications for the economic framework of a potential reduction in market power in the event of winddown scenario? And of a repurposing scenario? Should there be a threshold for when Part 4 may no longer apply? Will gas pipelines be considered as providing an essential service during transition that justifies some kind of regulation, even if there is limited market power?**

    When economic regulation was introduced, gas networks were already in place, end use markets were well developed, and gas infrastructure was considered to have market power. If zero-carbon gas production markets are viable, then these markets need to be developed and zero-carbon gas infrastructure needs addressed.

    Most end use applications – other than hard to abate use applications – will face competition from electricity or other energy sources. Gas networks may therefore be constrained from increasing network prices as they need to compete to attract consumers.

    This raises questions such as whether gas pipelines would have sufficient market power to justify economic regulation, or whether a light-handed form of regulation (e.g. price monitoring) may be more appropriate. Should there be a threshold established for when Part 4 may no longer apply?

    Will gas pipelines be considered as providing an essential service during transition that justifies some kind of regulation, even if they have limited market power?

    Recognising these issues, European regulators have proposed regulatory principles to apply to the development of hydrogen pipeline networks. See Appendix I.

Box 3: Gas Infrastructure Businesses – Regulatory Asset Base Value

Gas infrastructure business	Closing RAB (2020) ($)
Gas distribution	
Firstgas	174,405,000
Powerco	387,505,000
Vector	434,256,000
Total	**996,166,000**
Gas transmission	
Firstgas	849,688,000

Source: Schedule 4 disclosures for RAB roll-forwards for 2020. Both Powerco and FGL NI Distribution report their disclosures on a 30 September basis while Vector GDB reports on a 30 June Disclosure Year. Values are in forecast nominal dollars.

9.4. Incentives for gas pipelines to invest in and maintain pipelines

This section sets out more detailed information relevant to considering whether the incentives gas pipelines face to continue to undertake investment to maintain services and meet safety requirements are appropriate. This information suggests that there could be an immediate issue confronting the gas infrastructure businesses.

Prior to the recent CCC proposals, the three largest gas distribution business were planning to undertake capital expenditure of $656M over the next 10 years, while Firstgas's transmission network is projected to spend $480M. See Box 4.

The gas infrastructure businesses are established as companies under the Companies Act 1993. The Companies Act requires that board directors of a company must act in what the director believes to be the best interests of the company.[51] This duty raises several questions. For example, would directors be acting in the best interest of the companies they serve by approving capital expenditure on long-lived assets when they know that there was a significant probability that the expenditure may be 'stranded' and not recoverable and/or it was unlikely that expected return on that investment was not commensurate with the future risks of stranding.

51 See: s 131 Companies Act 1993. Directors have a duty to act in good faith and in best interests of company.

Box 4: 10 Year Capital expenditures forecasts for Firstgas, Powerco and Vector

Gas infrastructure business	10 year total capex forecast ($)	10 year replacement and renewals capex forecast ($)	Replacement and renewals as a share of total capex (%)
Gas distribution			
Firstgas	202,218,000	50,728,000	25.1%
Powerco	201,855,000	49,833,000	24.7%
Vector	248,567,000	30,974,000	12.5%
Total	**655,919,000**	**131,535,000**	**20.1%**
Gas transmission			
Firstgas	480,425,000	344,425,000	71.7%

Notes: Asset Management 10 Year CAPEX projections – based on published 2020 AMPs on a net contribution view. Both Powerco and FGL NI Distribution report their disclosures on a 30 September basis while Vector GDB reports on a 30 June year basis. Values are in forecast nominal dollars.

Although gas distribution infrastructure businesses may be able to avoid or defer significant replacement and renewals expenditure, this appears less feasible for gas transmission infrastructure as such expenditure is largely focused on addressing risks caused by geohazards, corrosion and other similar factors.

10. POTENTIAL ROLES FOR GOVERNMENT

There is insufficient certainty at present to know if repurposing pipelines will be the best outcome for New Zealand, or what exactly are the best models for producing zero-carbon gasses that would use repurposed pipelines.

However, there is a good case for government to consider – together with industry stakeholders – how options could be created to make an efficient and effective future for repurposed gas pipelines in the long-term interests of energy consumers more likely.

10.1. Energy market policy framework

New Zealand's energy market policy framework relies on competitive markets in sectors where competition is possible and provides for:

- economic regulation of natural monopoly infrastructure
- coordination of wholesale electricity and gas markets
- other regulation to address market failure and promote the public interest
- wholly or partially owned state-owned energy companies operating as businesses and competing with private, council and community owned entities.

The working group assumes that the New Zealand government will continue with this framework going forward, with the government's overall role being to:

- assess whether markets are producing appropriate outcomes
- monitor the performance of government institutions (i.e. regulators, market bodies), and
- address areas of market failure.

This includes supporting the development of options, where private markets on their own may underinvest, or act too slowly relative to outcomes that are in the public interest.

10.2. Strategic considerations

The government should consider the following broader strategic considerations:

- **Energy sector resilience |** preserving the option to repurpose pipelines to enable a large-scale green gas industry could arguably make New Zealand's energy sector more resilient to certain risks (for example by increasing the storage buffers in the system), improve options for adopting innovations emerging from the global hydrogen industry in coming decades (if new technologies emerge and hydrogen costs fall), and reduce over-reliance on a single dominant industry - the electricity industry.
- **Energy sector competitiveness and consumer choice |** a successful large scale green gas sector supported by repurposed pipelines would improve competitiveness and consumer choice in many of New Zealand's end use markets such as heavy transport, heating, hot water, and cooking applications.
- **Certainty of decarbonization outcomes |** on the one hand the electricity industry – aside from the issue of dry year risk – arguably has a relatively high level of capability and is readily scalable. Therefore reliance on electrification (in a winddown scenario) might have advantages if government places weight on the certainty of achieving the net zero-carbon emissions by 2050 objective. On the other hand, certainty of achieving the objective could be supported by maintaining the widest range of options.

10.3.Research and Development

Internationally there is significant commercial interest in the potential role for zero-carbon gasses – particularly hydrogen. This interest is spurred on by demand from gas-reliant countries, such as Japan and South Korea.

In New Zealand this is reinforced by recent interest shown by companies such as Firstgas, Meridian Energy, and Contact Energy. However, this commercial interest is at a very early stage – it has only emerged over the past 12 to 18 months.

The CCC has recommended that the government should use a carbon pricing mechanism – namely, the ETS scheme – to drive carbon abatement towards zero net carbon but in some cases this will not be sufficient and other government interventions will be required. Countries with similar energy market frameworks as New Zealand are considering and implementing various interventions to accelerate development of a green gas industry beyond relying on carbon prices.

The IEA advocates for developed economy governments to support R&D to bring down hydrogen costs:

> *Alongside cost reductions from economies of scale R&D is crucial to lower costs and improve performance, including for fuel cells, hydrogen-based fuels and electrolysers. Government actions, including use of public funds, are critical in setting the research agenda, taking risks and attracting private capital for innovation.* [52]

It is reported that there are now 228 large-scale hydrogen projects underway for a combined $300 USD billion of proposed investment through to 2030. USD$80 billion of the proposed investments are either in advanced planning, having passed a final investment decision, or are under construction or commissioned. Over 30 countries had national hydrogen strategies in place by early 2021. Some 85% of proposed large-scale projects came from Europe, Asia and Australia. [53]

As New Zealand will largely be a global technology follower, the rationale for funding support for the development of green gasses would be assisting in taking risks, attracting private capital for innovation, building the local market, and understanding local issues. Such issues may include the technical and commercial issues associated with repurposing New Zealand natural gas networks for hydrogen and how to mitigate impacts on consumers.

Immediate opportunities identified by the working group for government support include:

- demonstration projects for hydrogen production and blending (along the lines of the ARENA's Australian hydrogen projects)
- studies into the use of biogas for industrial applications in New Zealand.

10.4.Incentive scheme

Another option would be a green gas incentive scheme that could provide an additional incentive for developing green gases over and above the incentives created by ETS. There are different ways a scheme could be designed. Such a scheme would be designed to incentivise the development of green gas producers to produce green gases at the least cost to consumers, shifting risk to the industry thereby encouraging innovation. It may be preferable to provide support this way rather than direct development assistance as it avoids government 'picking winners', and avoids any direct cost to government. [54]

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52 IEA, June 2019, *The Future of Hydrogen – Seizing today's opportunities*, p.16.

53 S&P Global Patts 'Global hydrogen projects accelerating with $300 billion proposed investment: report' https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/021821-global-hydrogen-projects-accelerating-with-300-billion-proposed-investment-report, 18 February 2021

54 This approach is aligned to feedback MBIE has received in its recent consultation on measures to reduce greenhouse gas emissions for the building and consultation sector. Many designers and architects raised the need for appropriate regulatory

10.5.Government procurement

The government is a significant gas consumer and could consider using its own energy procurement processes to accelerate the development of a green gas industry, such as underwriting zero-carbon gas production and delivery. The EECA administers a fund to reduce emissions in the state sector, including in hospital and schools.[55] This funding arrangement, or a similar future fund, could be used to support government procurement of zero-carbon gas in a way that helps the industry develop.

performance requirements to encourage sustainable building and reduce carbon emissions. They also advocated for 'lean design', the removal of barriers in reusing construction materials, and incentivising use of low-emissions material.

See: MBIE, May 2021, *Building for climate change: Summary Report*, p.40.

55 See: https://www.eeca.govt.nz/our-work/programmes-and-funding/government-leadership/state-sector-decarbonisation-fund/

11. ALIGNMENT WITH THE CLIMATE CHANGE COMMISSION'S FINAL ADVICE

11.1. Introduction

The CCC advises the government to phase out natural gas from New Zealand's energy mix along with other related recommendations. This is a key premise of the Findings Report.

This section summarises the CCC recommendations that are relevant to the future of gas infrastructure in the future and identifies how, if at all, they have been considered in the Findings Report. The report, however, is not intended to be exhaustive and so there may be some aspects of the CCC's advice that are not captured here that may nevertheless be relevant to the future of that infrastructure.

11.2. CCC's final advice to government

Table 11.1 identifies key aspects of the CCC's advice that are relevant to the future of gas infrastructure. The table then identifies how this is addressed in this report.

In brief, CCC advice that is aligned with the findings and recommendations included in sections 2 and 3 includes:

- although hydrogen and biogas can help reduce New Zealand's emissions, it is currently uncertain whether they will be cost effective or could feasibly be used in existing gas infrastructure
- government should make choices that keep options open as long as possible, including by adopting preliminary policies that buy time for industry to assess the effectiveness of low emissions gases and by considering whether gas pipeline infrastructure should be retained to repurpose to transport those gases
- careful management is needed to transition existing natural gas use towards lower emissions alternatives, including to:
  - ensure that electricity remains reliable and affordable, and
  - recognise that natural gas lends itself to critical applications that support services needed in the transition such as security of supply and high temperature process heat and feedstock (where alternative energy sources are limited)
- projected costs to consumers of transitioning from natural gas to electricity would be substantial, with the CCC's modelling suggesting a net cost to New Zealand until at least 2040 (if emissions benefits are factored) or 2050 (if not)
- government will need to take measures to:
  - support security of supply, residential consumer choice around gas, energy affordability, network considerations, workforce planning, and high temperature heating needs
  - promote innovation investment needed to develop ways to displace natural gas use, and
  - develop and communicate its plan and intentions early to improve predictability for families, businesses, and public entities.

The CCC also advises that the potential to use low emissions gases is insufficient reason to warrant continued expansion of gas network infrastructure, at least until there is substantial evidence that blending or fully converting the gas networks to low emissions gases will not increase costs to consumers. The Findings Report does not form a view on this issue yet, instead recommending that further work is undertaken to assess what trajectory is in the best interests of energy consumers and New Zealand.

The CCC also advises that the government develops a national energy strategy. Although not covered directly in the Findings Report, the findings above do support the case for coordinated planning that considers the significant interrelationships between the future of gas and electricity supply.

Appendix J summaries relevant aspects of the CCC's advice to government.

TABLE 11.1: RELEVANT ASPECTS OF THE CCC'S FINAL ADVICE

CCC advice to government	How addressed in Findings Report, if at all
New Zealand needs to avoid locking in new natural gas assets and phase down how much natural gas is used in existing residential, commercial, and public buildings.	**Addressed –** a key premise behind the Findings Report is that natural gas use will need to reduce. This need to change to address government's policy direction forms part of the problem definition.
Options to reduce emissions from natural gas use include: • a moratorium on new natural gas connections • set a date after which no new natural gas connections occur • cap operational emissions from natural gas used in buildings. Options will provide time for industry to assess the effectiveness of low-emissions gases as a way to reduce emissions.	**Partially addressed** – the Findings Report does not explore these options specifically. However, the Findings Report explores the potential role for low-emissions gases under a repurposing scenario in terms of both value and likelihood. The report recommends that the government keep its options open so that it can respond if low-emissions gases become economically feasible.
Government should consider whether gas pipeline infrastructure should be retained to repurpose for low emissions gases like biogas or hydrogen. Government should make choices that keep options open for as long as possible.	**Addressed** – the Findings Report highlights the importance of retaining or creating optionality to repurpose the existing pipeline and appliance infrastructure to support low emissions gases.
Government will later need to consider how to transition existing natural gas towards lower emissions alternatives	**Partially addressed** – although the Findings Report does not identify a specific pathway for how the government could transition existing natural gas use, it does consider the role of government in managing the transition to lower emissions alternatives. The report explores the implications of reducing natural gas use under either a winddown or repurposing scenario.
Reductions in the use of natural gas for electricity generation need careful management to ensure that electricity remains reliable and affordable. Additional measures will be needed to support security of supply, residential consumer choice around gas, energy affordability, network considerations, workforce planning and high temperature heating needs.	**Addressed** – when looking at the winddown scenario, the Findings Report highlights concerns around the potential impact on electricity generation and infrastructure if natural gas demand switches to electricity. It also looks at other implications, such as on safety, security of supply, energy affordability, network costs, workforce, and hard to abate gas users. Consistent with CCC's advice, the Findings Report recommends that further work is undertaken to better understand these implications and potential measures to address them. Some work is already underway, including by the Gas Industry Company.[56]

[56] See: Gas Industry Company, May 2021, *Gas Market Settings Investigation – Consultation Paper*. Link: https://www.gasindustry.co.nz/work-programmes/gas-market-settings-investigation/developing-2/consultation-3/document/7263.

CCC advice to government	How addressed in Findings Report, if at all
Government will have a role to play in promoting innovation investment needed to develop ways to displace the remaining uses of natural fuel.	**Addressed** – the Findings Report makes clear that government should consider promoting innovation investment, especially if it wishes to support the hydrogen economy.
Opportunity to move away from natural gas use for industries that use it for process heat or feedstock is limited.	**Addressed** – the Findings Report recognises this challenge. It also identifies the role that zero-carbon gases could play to support these industries as part of a transition away from natural gas under a repurposing scenario.
Natural gas lends itself to critical applications that support services needed in the transition such as security of supply and high temperature process heat.	**Partially addressed** – although the Findings Report does not explore such critical applications in detail, it does highlight the need to manage a transition away from natural gas. This will likely involve finding ways to support those applications.
It is uncertain whether distributing low emissions gases through existing gas network infrastructure is possible or cost effective. It is possible that low emissions gases such as hydrogen or biogas could be blended into natural gas to lower its emissions intensity. However, it is highly uncertain what role hydrogen will play.	**Addressed** – the Findings Report looks at this in some detail. Although zero-carbon gases are technically feasible, it is unclear whether it will be economic to use it instead of other low carbon energies such as renewable electricity. Given this uncertainty, the report recommends that government consider how best to create and retain options to repurpose the existing gas infrastructure.
The possible availability of low emissions gas is insufficient reason to warrant continued expansion of gas network infrastructure until there is substantial evidence that blending or fully converting the gas networks to low emissions gases will not increase cost to consumers.	**Not addressed** – the Findings Report does not form a view on this issue yet, instead recommending that further work is undertaken to assess what trajectory is in the best interests of energy consumers and New Zealand.
Households could reduce costs by not installing new natural gas appliances and replacing existing natural gas appliances with low emissions alternatives when the appliances come to end of life.	**Partially addressed** – the Findings Report considers the potential costs to gas consumers of converting existing gas appliances to electric equivalents. Data suggests that many gas water heaters have been installed in recent years, which suggests that they will not be due for replacement for some time yet.
Modelling suggests that net benefits from transitioning space and water for homes and businesses from natural gas to electricity are negative until 2050 if emissions are ignored and 2040 if they are included. That modelling also indicates that net costs could exceed $200 million per year for at least a 10 year period.	**Partially addressed** – although the Findings Report does not include any new modelling, it does highlight that affordability will be a key concern for energy consumers. The report also recommends that further work is undertaken to better understand the cost implications of a winddown scenario, including how shifting energy demand from gas to electricity could affect electricity generation and transportation costs.

CCC advice to government	How addressed in Findings Report, if at all
Government should develop a national energy strategy that: • supports a coordinated approach • considers a plan for diminishing the role of natural gas and addressing consequences for network infrastructure and workforce in a transition.	**Partially addressed** – although not covered directly in the Findings Report, the report findings do support the case for coordinated planning that considers the significant interrelationships between the future of gas and electricity supply. These findings suggest that a national energy strategy should: • reflect a collaboration between government and those affected, including consumers and gas infrastructure providers • look at issues holistically across both gas and electricity supply chains. Although such a strategy will be important for New Zealand, the government cannot wait for it to be finalised before adopting some key policy decisions. Some policy will need to be developed sooner to promote the long-term interests of energy consumers, especially given the impact that uncertainty can have on investment decisions.
Government should assess and communicate to the public the potential impact of a significant change in the balance of supply and demand from accelerated electrification of transport and process heat.	**Partially addressed** – the Findings Report recommends that government undertake or champion further analysis to better understand the potential impact of a winddown scenario on wholesale electricity prices.
Government should signal its plan earlier to improve predictability for families, businesses, and public entities.	**Partially addressed** – although not considered directly, the Findings Report does highlight the importance of government making policy decisions that support the long-term interests of consumers and New Zealand. This will undoubtably involve being clear about its intended policy direction.

Part C: Appendices

Summary

This part of the Findings Report includes the additional information that supports Parts A and B.

This part starts with the working group charter and is then followed by appendices on gas consumers, green hydrogen, hydrogen blending, biogas, repurposing, winddown, European energy regulators, and the CCC's advice.

APPENDIX A. WORKING GROUP CHARTER

Adopted: 20 May 2021; Amended: 7 July 2021

A.1. Background

The government is committed to taking decisive action to address climate change. The government will be making decisions on receipt of the Climate Change Commission's final advice expected in May 2021.

It is clear there will be profound impacts on the future of the natural gas industry. A carefully managed transition is required to ensure continuity of supply and deliver gas safety and other service outcomes sought by gas consumers.

Achieving this transition requires a view across New Zealand's gas value stream, including the upstream and downstream markets, as well as the national and regional energy mix.

The Minister of Energy and Resources recently commissioned work to be undertaken by the GIC regarding transparency and suitability of commercial arrangements and generation supply in the upstream market.

A.2. Purpose

The three major natural gas infrastructure providers (Vector, Firstgas and Powerco) with the support of the MBIE have decided to establish a Gas Infrastructure Future Working Group.

The working group's purpose is to provide input to Government and key industry stakeholders about the future downstream gas industry, including as to:

- potential scenarios for the end state and transition options
- potential solutions to achieve the objectives of Government, infrastructure owners and consumers.

A.3. Sponsors

Vector, Firstgas and Powerco.

A.4. Members, Observers, and Consulted Parties

Members include representatives of regulated gas networks, namely from Vector, Firstgas and Powerco. GasNet is invited to join as a member or otherwise be involved as a Consulted Party.

GIC, MBIE, the Commerce Commission, and the Major Gas Users Group (MGUG) are invited as Observers.

The working group recognise that there are other parties who have an interest in its work, including other gas consumer representatives, the Electricity Authority, and small gas infrastructure companies. The working group will consult with these Consulted Parties as appropriate.

Members, Observers, and potential Consulted Parties are set out in Attachment A.

A.5. Deliverable

A document to be submitted to the Minister of Energy and Resources by early July 2021 to align with the timing for when the GIC is expected to submit its deliverable.[57] The working group may also consider preparing other deliverables as required.

A.6. Scope

A key early task for the working group will be to agree the scope of its analysis and advice. The working group will also consider the extent to which member organisations could commit to a gas infrastructure transition plan that may aid policy and regulatory decision-making.

A.7. Decision Making

Members will ultimately make decisions having considered the input from Observers and Consulted Parties. The working group deliverable will reflect areas of agreement and be transparent as to where there is diversity of views. Although desirable, there is no requirement for Members, Observers and Consulted Parties to adopt a common view.

A.8. Input

Input from Members, Observers and Consulted Parties could be via discussion in person at meetings or in written form. Although active participation is encouraged, no one is obligated to attend working group meetings, participate in discussions, or provide written input.

A.9. Competition Law

The working group acknowledges that its purpose is to consider the future of gas infrastructure in New Zealand from a policy perspective and to not engage in activities that may undermine competition law. Working group Members, Observers and Consulted Parties will not share commercially sensitive information or make commitments that could have the effect of undermining competition law.

A.10. Funding

It is proposed that the costs of the working group be co-funded, on an equal basis, by the Sponsors.

A.11. Facilitation

The Sponsors have appointed farrierswier as interim facilitator to assist in establishing the working group and assist in delivering its initial outputs. Once established, the working group will consider whether an alternative facilitator is needed.

A.12. Indicative Timeline and Deliverables:

April - May 2021 | Commence and complete establishment stage.

End May 2021 - Interim report | Report on initial work, including outlining the challenges facing the future of gas in New Zealand and potential end states / transitions for further consideration.

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[57] Note that consultation on the report closed on 24 June 2021 and the report is now likely be completed in August 2021.

Early July 2021 - **Final report to the Minister** | Analysis, findings and recommendations to help inform the Minister and from which further work could be readily initiated.

A.13. Future role

Following delivery of the report to the Minister in early July, the Sponsors will discuss with MBIE and other stakeholders how best to provide ongoing input to government and key industry stakeholders about the future downstream gas industry.

Attachment A Members, Observers, and Consulted Parties

	Organisation	Name
Working Group Members	Vector	Mark Toner / Neil Williams
	Firstgas	Ben Gerritsen
	Powerco	Stuart Dickson
	GasNet (invited)	To be confirmed
Observers	Gas Industry Company	Andrew Knight / Tim Kerr
	Ministry of Business, Innovation and Employment	Andrew Marriot / Osmond Borthwick
	Commerce Commission	Andy Burgess / John Groot
	Major Gas Users Group	Richard Hale
Potential Consulted Parties	Other consumer representatives	To be confirmed
	Electricity Authority	James Tipping
Independent facilitators	farrierswier	Eli Grace-Webb / Geoff Swier

APPENDIX B. PROBLEM DEFINITION

B.1. Introduction

This appendix sets out the full problem definition. The working group started in early May 2021 by developing and agreeing a problem definition which is set below. It has not been updated for subsequent work undertaken.

B.2. Context

The government is committed to taking decisive action to address climate change. The government will be making decisions in response to the CCC's final report.

It is clear that such action will have profound impacts on the future of the natural gas and LPG supply industry. A carefully managed transition is required to ensure continuity of a safe, reliable, and affordable energy supply as gas and LPG consumers transition their consumption to zero-carbon gas or alternative renewable energy sources. A managed transition may also address broader economic impacts.

Achieving this transition requires coordination across New Zealand's gas value stream, including the upstream and downstream markets, as well as managing the impact on the national and regional energy mix including supply of electricity.

This section identifies the essential features of the problems created by this transition for piped gas.

B.3. The problem

New Zealand currently does not have a coordinated plan or planning process for significantly reducing or transitioning away from natural gas and LPG. Absent such a plan, there is material risk that gas consumers and other industry participants will be harmed in ways that could be mitigated or avoided – which would likely undermine the government's objectives.

Though there are many considerations, root causes of the problem are:

- **End point uncertainty** – it is unclear what end point the New Zealand gas infrastructure and retailing sectors and the gas consumption it serves will transition to. It is possible that existing infrastructure could be used with zero-carbon gases even if natural gas were phased out. There may also be technological developments that cannot be foreseen today, which may change our current view over time of the possible future solutions. Depending on the type of gas, consumer appliances could also continue to be used. But it is also possible that those infrastructure and consumer assets will no longer be needed or to the same extent.

- **Pathway uncertainty** – even if an end point were clear, it is unclear what pathway New Zealand gas infrastructure and retailing sectors will take to reach it. Faced with uncertainty, gas consumers and industry participants may make decisions (e.g. to abandon assets) that undermine New Zealand's ability to efficiently transition to a future where zero-carbon gases are used. Such uncertainty can undermine the investment and other activities needed to reach that end point. Transitioning to zero-carbon gases, for instance, can only work if a new supply chain is developed to replace the existing gas producers and upstream infrastructure. But potential investors may be reluctant to fund that development until it is clearer how the transition will work.

Such uncertainty can have many effects or outcomes. Two potential undesirable outcomes are:

- **Stranded assets** – both gas consumers and industry participants have assets that are very likely to be stranded if gas is phased out before the assets reach the end of their technical lives and that fuel supply is not replaced with an alternative that can reuse those assets (e.g. zero-carbon gas). Some gas consumers, for instance, would need to replace gas appliances with electric equivalents or may choose to do so when faced with uncertainty. Other gas consumers may decide to relocate their operations overseas to where gas is available or cease operations altogether. Infrastructure investors may abandon assets that could otherwise provide value to New Zealand in the future (e.g. to support energy security of supply or zero-carbon gases once production capability matures).

- **Future price shocks** – shifting gas demand to alternative energy sources, or the potential for this to occur, could lead to price increases for both that alternative energy and gas. For instance, moving demand for gas heating and cooking to electricity consumption at peak times will require more electricity distribution capacity, which will come at a cost. At the same time, reducing demand for gas heating and cooking will increase the fixed costs per gas consumer (i.e. as capital costs are spread over smaller volumes).

Without a coordinated plan that can evolve over time, gas consumers and industry participants may make decisions about how to supply and use gas that are individually sensible but lead to social harms that could be mitigated or avoided.

There is value in considering this problem across short and long time scales and from different stakeholders' perspectives.

Critical perspectives are those of investors and consumers. Table 11.2 summarises the problem over investor and consumer perspectives[58] and those two time scales. The next section elaborates on these perspectives.

The government will wish to promote and protect the interests of consumers generally as well as potentially some specific groups of consumers (e.g. vulnerable consumers or regional consumers that may face particular challenges) and may have perspectives on other matters that emerge including environmental impacts. The Commerce Commission's role is to promote the long-term interests of consumers and it has an interest in ensuring that investors have adequate incentives to invest.

TABLE 11.2: PROBLEM PERSPECTIVES AND TIMESCALE

	Short term	Long term (e.g. 7-10 years)
Infrastructure investors' perspective	Stranded asset risk: Potential disincentive to invest in connections, augmentation, and renewals	Scenarios: 1. Winddown scenario 2. Repurposing scenario
Gas consumers' perspective	Stranded asset risk: Impediment to new consumer connections, high new connection costs	Transition issues: 1. Transition costs to alternatives under any scenario (e.g. appliance costs, energy supply costs, etc), potentially leading to hardship 2. Continuity and safety of supply 3. Potential increase in network tariffs (at the same time as other cost increases, e.g. gas wholesale and carbon costs) 4. Restriction of choice (i.e. not being able to access gas appliances or supply)

58 The perspective of government and regulators including the Commerce Commission and Gas Industry Company will also be important, but these are not considered here. Others may also be affected, such as employees working in the gas and LPG supply chains – work force issues are considered in other parts of this report.

B.4. Gas infrastructure investors' perspective

Investors in long-lived assets like gas pipelines are generally concerned about the prospect of achieving risk adjusted returns. Although such investors will likely be concerned about asset stranding risk in the short term, ultimately their long-term decisions will affect longer term gas supply capability in New Zealand.

Long term

When making longer term investment decisions, infrastructure investors are likely to consider the winddown and repurposing scenarios discussed above.

The winddown scenario is clearly an easier one to foretell, but the repurposing scenario may better address some of the potential harms discussed above and lead to better economic and social outcomes for New Zealand.

The challenge with the repurposing scenario, however, is that future zero-carbon gas technologies and fuel production costs are uncertain. It will require gas supply chain participants (e.g. producers, infrastructure investors, and consumers) to align their decision making – but this is at a time when the proof of concept is unproven in New Zealand and to a large extent internationally.

There is also uncertainty over whether the repurposing scenario might emerge organically without any coordination at all. If not, *and* if there is sufficient probability that that scenario would give the best long term outcome for energy consumers and the wider economy, then there is a real risk that a sub-optimal outcome for New Zealand is reached.

A key question for New Zealand is:

> *which of the two broad scenarios best promotes the long-term interests of energy consumers and what types of decisions and level of coordination is needed to support realising good outcomes under each scenario.*

The answer as to which of the two potential scenarios is likely to be preferable in the long term is unclear at present because:

- winding down the existing natural gas pipelines will invariably harm gas consumers, but it is unclear the scope for and cost of mitigations
- repurposing existing infrastructure will take time and cost and there are many ways of doing this, but the investment case for doing so is presently unclear – and so it is unclear whether private investors will ultimately support the actions and investments needed in a timely way
- the net benefit to gas consumers of repurposing the infrastructure is also unclear – and so it is unclear whether the cost of doing so is justified.

Appropriate analysis tools and processes will be needed to help manage uncertainty and enable the good decisions to be made today and into the future.

Short term

In the short term, infrastructure investors will likely be concerned about asset stranding risk and may defer discretionary investments in long lived investments given the uncertainty over how policy decisions (e.g. gas connections and appliances) could affect their returns.[59]

Although such deferral may not have an immediate adverse effect on gas consumers, it will if continued indefinitely.

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[59] The technical lives of gas pipelines can often exceed 45 years, which is significantly longer the lives of gas appliances of around 20 years.

B.5. Gas consumers' perspective

Gas consumers will be concerned about whether they can continue to use gas – whether zero-carbon or otherwise – to meet their energy needs including at times when they need to make significant commitments (for example investment decisions in new long-lived equipment). Many gas consumers can transition to electric alternatives (e.g. for heating and cooking), albeit at a cost. Some larger consumers may not and will need to rethink their operations entirely (e.g. abandon or relocate).

Although gas consumers are unlikely to individually drive decisions over whether New Zealand should pursue either the winddown or repurpose scenarios, expectations over the extent to which gas consumers will collectively use forms of zero-carbon gas in the future *will* clearly affect investment decisions that influence that outcome.

Long term

In the longer term, today's gas consumers will either continue to use gas in a similar way to how they do now, will have switched to alternative energy sources, or will have ceased their operations in New Zealand. There could also be major technology developments that create a different outcome that cannot be foreseen today.

If the repurposing scenario plays out, then gas consumers will continue to benefit from consuming gas. They may also face higher wholesale costs where the costs of producing hydrogen, biogas and other zero-carbon gases exceeds that of natural gas. They may also face higher network charges to the extent that some gas consumers switch to alternative non-gas energy sources, leaving remaining gas consumers to face a larger share of any fixed shared asset costs that cannot otherwise be repurposed or optimised.

The government may be concerned to understand and potentially manage any material cost impacts for vulnerable consumers (for example the costs in transitioning to new appliances and/or meeting higher energy supply costs).

However, if the winddown scenario is pursued, then gas consumers will incur costs to transition their existing energy needs to alternatives:

- residential gas consumers will need to replace cooking, space and water heating appliances (along with associated building, rewiring, and other costs), which will be a particular concern for vulnerable consumers that may struggle to fund the costs without support
- business consumers will need to weigh up the cost of transitioning with the ongoing viability of their businesses, which may affect wider economic outcomes
- industrial consumers may need to rethink their businesses entirely including whether to exit New Zealand (e.g. if they depend critically on the heating value offered by gas).

As well as cost, phasing out gas may also undermine energy security of supply and gas safety. If such a transition is not managed effectively, then gas-powered electricity generation may not be available at peak times – potentially leading to higher wholesale electricity costs at the same time as gas consumers switch to using electricity to service their energy needs. Similarly, turning off gas supply can create safety issues where, unlike electricity, it is not as simple as turning off a switch.

Another important question for New Zealand, therefore, is:

> *what actions can and should be taken to mitigate these potential effects and at what cost.*

If the social cost of mitigating these effects (and any residual effects) exceeds the net social cost of repurposing the existing gas infrastructure, then it may be preferable for New Zealand to actively pursue the repurposing scenario instead.

Short term

In the short term – and in a similar way to gas infrastructure investors – gas consumers will likely be concerned about asset stranding risk. Although on a smaller scale, gas consumers will likely defer gas appliance and related infrastructure investment until there is greater certainty about whether gas will be available in the future.

In some cases, gas consumers may switch their energy needs to electricity before the future direction is clear. Impediments to using gas – such as restrictions on new gas connections or to acquire gas appliances – will only hasten this shift. This shift will lead to inefficient outcomes if a repurposing scenario eventuates.

B.6. LPG supply industry

The LPG industry faces similar questions to piped natural gas. However, supply of bottled LPG does not involve as much long-life infrastructure assets as natural gas supply and the existing reticulated LPG networks are small and not regulated. It is less clear that there is a need for coordinated planning and – if there is – it is probably smaller in scope.[60]

It is, therefore, suggested to focus at this time on gaining a consensus on the problem definition for piped natural gas, and later consider the implications for LPG.

[60] Given that LPG is predominantly supplied from domestic gas sources, some coordination may be needed if this to be supplied from overseas (e.g. investment in import terminals).

APPENDIX C. GAS CONSUMER PREFERENCES

This appendix summarises some insights from separate surveys undertaking or commissioned by Firstgas, Powerco and Vector.

C.1. Reasons for choosing gas

The Firstgas and Powerco surveys both indicate that the most common reason why consumers use gas over electricity is a perception of lower cost (i.e. 31% in the Firstgas survey;[61] for Powerco it was the top reason cited). Less common reasons given were:

- continuous hot water (Powerco second most common reason cited)
- better for cooking (Firstgas 13%)
- 'speed' (Firstgas 10%).

The Powerco survey showed the Net Promoter Score for gas was 62% ('satisfactory') down from 73% in the previous year.[62]

Vector's survey suggests that the likelihood of a consumer who does not currently have gas deciding to install gas where it is available in the street is 15%. [63] Vector's study suggested the reason why consumers did not select gas when it is available in the street were: [64]

- safety concerns (28%)
- initial cost of connection (18%).
- the cost of switching from electricity to gas appliances (13%).

C.2. Gas versus electricity price perceptions

The Firstgas survey shows that nearly half (48%) of New Zealanders thought that the cost of electricity and gas are about the same, while 36% thought that it was less expensive.

C.3. Perceptions about emissions

The Firstgas study indicates that coal has significantly worse perceptions about its emissions then natural gas. Respondents appear to be less sure about gas emissions with around 50% being neutral. Younger New Zealanders (40%) and no-gas users (35%) are more likely to see gas as a form of energy that produces high emissions.[65]

The Firstgas study also indicated that 42% of New Zealanders thought there should be no change to use of gas to address environmental concerns while 39% of New Zealanders thought that gas usage needed to reduce or significantly reduce. A large majority thought that coal use had to reduce substantially and use of renewables – especially solar and wind – should increase.

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61 Firstgas, August 2020, *Public opinions report*, p.14.

62 Market-Eye Ltd, March 2021, *The Gas Hub / Powerco – Explanatory Research – Client Review*, p.8.

63 Vector, 2019, *Vector electricity & gas consumer engagement survey 2019*, p.16.

64 Note however that these results are not very stable year to year – safety concerns have risen substantially in the most recent year).

65 Firstgas, August 2020, *Public opinions report*, p.16.

C.4. Confidence in the availability of gas

The Firstgas survey suggests most New Zealanders (55%) are unsure whether gas will be available in 10 years' time, while 30% of New Zealanders are confident that gas will be available in 10 years' time. The survey results do not break down the results by whether respondents used gas or not.

Importantly, the survey was undertaken before the CCC's draft and final advice was release in January and June 2021. It is unclear what the results would change if the survey was undertaken now that that advice is available.

APPENDIX D. GREEN HYDROGEN IN NEW ZEALAND

This appendix provides more detail on the potential use cases for hydrogen, current hydrogen trials in New Zealand and the potential different models for how a hydrogen industry could develop in New Zealand.

D.1. Potential applications of hydrogen

The initial focus for hydrogen use internationally is on converting existing uses of fossil energy to low-carbon hydrogen in ways that do not immediately require significant new transmission and distribution infrastructure investment. This includes hydrogen being used:

- to produce ammonia, as an alternative to current grey hydrogen production using fossil fuels
- in industry, including refineries and power plants
- to power vehicles
- to blend hydrogen with natural gas for distribution to end-users
- to replace lost or unaccounted for gas in distribution networks.

The main focus for hydrogen internationally is on uses that cannot be readily electrified. For example, Firstgas's Hydrogen Feasibility Study report notes that key uses are likely to be decarbonising:

- industrial energy uses that are not well suited to electricity, such as steel, cement, chemicals
- transport applications that are not well suited to electricity, such as heavy vehicles, marine, aviation.

Firstgas's report also notes that key roles for hydrogen are likely to include:

- removing the need to overbuild renewable generation to achieve a 100% renewable grid
- providing inter-seasonal storage
- allowing on-demand power generation to support renewables.

There are a wide range of other potential uses of hydrogen, depending on its cost competitiveness with electrification, including:

- conversion of natural gas pipelines
- light vehicles – there are several hydrogen fuel cell electric vehicles currently on the market, but the availability of vehicles and refuelling stations is much more limited than battery electric vehicles
- storage for small consumers – hydrogen is being explored as a form of battery, with the Australian firm Lavo recently announcing plans to make one available to retail consumers.[66] At current prices, hydrogen storage is unlikely to be cost competitive with battery storage systems, but significant price reductions are forecast.

The production of hydrogen by electrolysis also produces oxygen, which can be sold to improve the overall profitability of hydrogen production. For example, AGIG's Australian hydrogen blending project – recently funded by ARENA – involves a hydrogen production facility that is located at an existing wastewater treatment plant in Wodonga, Victoria. The project involves using recycled water to produce hydrogen and oxygen, with the oxygen being a valuable input into the wastewater treatment process. Similar multi-use facilities are feasible in New Zealand.

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66 See https://lavo.com.au/

D.2. New Zealand hydrogen trials and studies

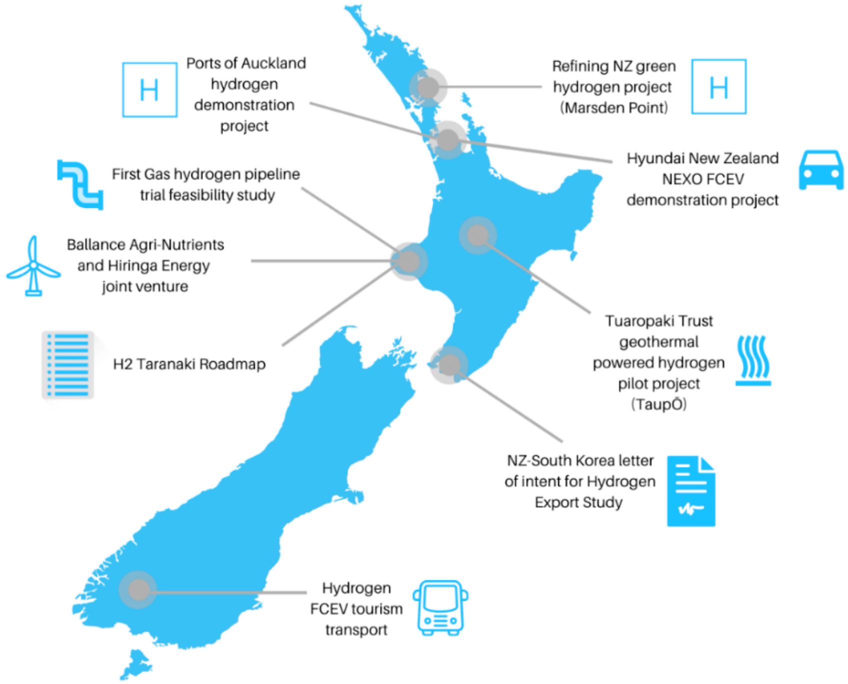
Hydrogen production in New Zealand is currently limited, although there is meaningful interest in its potential. As such, potential green hydrogen models for New Zealand are still being considered.

In undertaking its research, the working group considered:

- information published by the New Zealand Hydrogen Council on current projects – see Figure D-1
- some initial work published by MBIE on the hydrogen road map including a report prepared by Castalia for MBIE - which is summarised in Box 5
- the hydrogen feasibility study published by Firstgas in March 2021
- recent announcements by Meridian Energy and Contact Energy only feasibility of hydrogen opportunities in New Zealand – which are summarised in Box 6
- the Oakley Greenwood report submitted to the CCC in March 2021.[67]

There are several current hydrogen projects in New Zealand, but they are limited to small-scale trials and demonstration projects as illustrated below.[68]

FIGURE D-1: CURRENT HYDROGEN PROJECTS IN NEW ZEALAND



The Infrastructure Reference Group has also provisionally approved $20 million for Hiringa Energy to establish New Zealand's first nationwide network of hydrogen fueling stations. The initiative will involve the installation of eight hydrogen refueling stations located in Waikato, Bay of Plenty, Taranaki, Manawatu, Auckland, Taupō, Wellington, and

67 Oakley Greenwood, *Response to the NZ Climate Change Commission's Advice*, (attached to Firstgas's submission to the CCC) March 2021.

68 New Zealand Hydrogen Council website: https://www.nzhydrogen.org/nz-hydrogen-projects.

Christchurch. These stations will provide refueling for zero emissions heavy FCEVs (hydrogen-powered fuel cell electric vehicles) such as trucks and buses.

Box 5: MBIE roadmap for hydrogen in New Zealand[69]

The hydrogen strategy is a roadmap that will explore the issues that need to be resolved for hydrogen's use in the wider economy, and what steps need to be undertaken to resolve these and when.

MBIE has commissioned a preliminary study by Castalia which identified the key drivers for New Zealand's hydrogen economy future. The model shows that the major drivers of whether economic production of hydrogen is possible in New Zealand will be:

- the cost of electricity
- the capacity and scale of electrolysers.

New Zealand's role as exporter, importer or producer for domestic production will depend on relative electricity prices in possible competitor countries such as Australia.

The model suggests that demand for hydrogen is likely for heavy vehicle fleets, with other niche vehicle uses likely to follow similar technology tipping points. Gas pipeline blending is also possible.

Box 6: Meridian Energy / Contact Energy green hydrogen feasibility study

Meridian Energy recently announced a green hydrogen feasibility study, which is to be completed by August 2021.[70] Contact Energy is partnering with Meridian on the study.[71] Key points about the study are as follows.

Contact Energy

There are many potential pathways, including:

- ammonia and liquid hydrogen are the two likely carriers
- they enable numerous use case options spanning heavy transport, power generation and industrial process substitution.

There are many variables:

- optimal use cases, carrier options and potential partners are unclear
- best strategy is to keep our options open for as long as possible.

Economic gap driven by:

- the cost of producing green hydrogen is currently significantly higher than fossil fuels.
- carbon taxes or subsidies will be key enablers.

Dry year solution:

- may provide 35-40% of NZ's dry year flexibility requirement
- Likely to be lowest cost option for New Zealand.

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69 https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-strategies-for-new-zealand/a-vision-for-hydrogen-in-new-zealand/roadmap-for-hydrogen-in-new-zealand/

70 Meridian Energy Investor Day presentation, 11 May 2021

71 Contact Energy, Capital Markets Day, 20 May 2021

New Zealand has a real opportunity given:

- the combination of existing generation and transmission infrastructure combined with industrial sites and port access makes New Zealand's offer unique
- an initial export opportunity could facilitate a lower entry cost and earlier domestic opportunity.

Meridian Energy

This year Meridian Energy intents to:

- investigate the feasibility of large-scale renewable energy hydrogen production in New Zealand
- explore appropriate incentive mechanisms to kickstart the hydrogen economy
- investigate potential business models and partnerships
- determine the benefits of using hydrogen for dry year energy supply management
- seek expressions of interest for offtake
- assess New Zealand's hydrogen opportunity.

D.3. Possible models for New Zealand

Based on the New Zealand work reviewed and international experience there are a range of options models for how a hydrogen industry could develop in New Zealand. These are shown in Table D-1 with a particular focus on the role that gas networks can play.

The table explores how different hydrogen models could vary in terms of:

- **Value creation:**
  - **Higher value** is likely to be created where the model contributes strongly to the decarbonisation goals by addressing 'hard to abate' applications and zero-carbon dry year electricity generation storage, which are applications that may have a higher willingness to pay.
  - **Lower value** will be created where the model involves producing hydrogen energy aimed at competing with renewable electricity or other energy sources, which may limit willingness to pay.
- **Hydrogen production costs**: the size of electrolyser size affects economies of scale and the level of hydrogen production costs that that can be achieved. This will be influenced the size of the market that can be served.
- **Investment costs and risk**: the level of up-front costs and investment risk vary significantly depending on factors such as whether or not existing gas networks are needed and the extent of network and appliance conversion costs.
- **Counterparty complexity:** some models involve only knowledgeable counterparties (such as energy and industrial companies) whereas other models involve significant counterparty complexity where they have significant impact on small consumers.
- **Location:** for example, is hydrogen production and use primarily limited to the North Island to reuse existing infrastructure or does it extend to the South Island.

Table D-1: Possible pathways for how a hydrogen industry could develop in New Zealand

Pathway	Description	Networks	Example	Advantages / Disadvantages	
Stand-alone hydrogen production or multi-use hubs for domestic consumption	Hydrogen production and storage plant located close to off-takers (such as electricity generation; industrial users, heavy transport fuelling facility etc). Could be lo-located with other facilities, e.g. waste water treatment plants to provide water and utilise oxygen.	Purpose built connections or small purpose built network Could be built adjacent to a network connection to provide future optionality for accessing other markets in future	Contact and Meridian studies ENGIE's and AGIG's Western Australia and Victorian hydrogen projects funded by ARENA	• High value: Focused on addressing 'hard to abate' applications and/ or dry year electricity generation • Lower costs: Little or no network investment • Low counterparty complexity: knowledgeable counterparties	• Limits on market size • Tend to limit electrolyser economies of scale - depends on how much load can be aggregated in one location • Reliability considerations, concentrated production risk • Issues in managing demand – production imbalances
Stand-alone hydrogen production for export	Hydrogen production, conversion to ammonia or liquid hydrogen for export. Likely combined with other markets as above	As above	Contact and Meridian studies 'Export superpower' scenario being developed by AEMO for its Integrated System Plan	• Low costs: Little or no network investment • Lower counterparty complexity: knowledgeable counterparties • Export of competitive NZ renewable energy (competitiveness is critical) • Large market means electrolyser can be sized to achieve economies of scale	• Export consumers will likely have high willingness to pay but will be able to source through competitive markets – which will be challenging. • High levels of investment required and significant risks to be managed. • Viability will depend on the relative costs of renewable electricity generation in NZ vs other countries

Pathway	Description	Networks	Example	Advantages / Disadvantages	
Distribution blending	Hydrogen production plant injecting Hydrogen into distribution network for blending up to 10-20% by volume	Distribution network(s)	AGIG's Murray Valley Hydrogen Park in Wodonga, Victoria funded by ARENA	• Low costs: use existing distribution network as an alternative to trucking; no appliance conversion costs • Low complexity: consumers unaffected • Can be combined with other uses, e.g. AGIG's project aims to sell hydrogen for transport and industrial uses and oxygen for water treatment • Could be a staged introduction by network area	• Lower value: competing with electricity in many applications • Limits on market size
High level of hydrogen injected into distribution networks	Could be 100% Hydrogen or a Green gas blend with high (>20%) hydrogen content. May involve a more decentralised gas network than at present, e.g. numerous electrolysers supplying local distribution networks with little or no transmission	Distribution network(s)		• Likely can use existing distribution network, but may need capacity upgrades and some extra or modified equipment	• Higher costs: appliance conversion costs • Higher complexity: consumers involved in change processes • Somewhat large market size • Limit electrolyser economies of scale

Pathway	Description	Networks	Example	Advantages / Disadvantages	
Transmission and distribution blending	Hydrogen production plant injecting hydrogen into transmission and distribution network for blending (up to 10-20% by volume)	Transmission and distribution networks	Firstgas proposal, starting in 2030	• Can use existing distribution network • No appliance conversion costs • Low complexity: consumers unaffected • Enables access to larger market (whole of North Island) • Improved electrolyser economies of scale	• Questions about whether existing transmission pipelines can be used for hydrogen blending due to embrittlement issues with high-strength steel
High level of hydrogen injected into transmission and distribution	Could be 100% Hydrogen or a Green gas blend with high (>20%) hydrogen content	Transmission and distribution networks	Firstgas proposal for NI network – by 2050	• Likely can use existing distribution network, but may need capacity upgrades and some extra or modified equipment • Maximises market size; promotes economies of scale in electrolyser • Improves system reliability and flexibility	• Higher cost • Hydrogen embrittlement issues for transmission need to be resolved • Appliance costs conversion • High complexity: small consumers involved

APPENDIX E. HYDROGEN BLENDING

E.1. Overview

Hydrogen can be blended at moderate levels with natural gas or with biomethane into a natural gas pipeline.

The International Energy Agency notes that hydrogen blending is one of the current focus areas internationally for developing the hydrogen economy because it does not immediately require new transmission and distribution infrastructure. [72] There is considerable interest in hydrogen blending in places such as Australia (see Box 7).

Box 7: Hydrogen blending trial projects in Australia

The Australian Renewable Energy Agency (ARENA) recently announced conditional approval of AU$60.8 million towards two commercial-scale renewable hydrogen blending projects:

- ATCO: ARENA will provide up to AU$28.7 million towards a 10 MW electrolyser for gas blending at ATCO's Clean Energy Innovation Park in Warradarge, Western Australia
- Australian Gas Networks: ARENA will provide up to AU$32.1 million in funding for a 10 MW electrolyser at Murray Valley Hydrogen Park in Wodonga (Victoria), which will be used for blending up to 10% hydrogen into AGIG's gas distribution network.

ARENA's funding assisted the projects cover the economic gap between their market revenues and costs.[73]

E.2. Applications

The Firstgas feasibility study found that hydrogen blends of up to 20% would be possible without requiring any change to existing appliances.

Current Australian hydrogen blending trials involve a maximum blending amount of 10% hydrogen by volume, which equates to only about 3-4% by energy content given that hydrogen's heating value is about a third of the heating value of natural gas. This 10% limit on blending is based on the maximum level that is currently considered to be comply with all of the requirements of the relevant Australian gas quality specifications and standards for natural gas (AS 4564) and not require any changes to most users' appliances.

A report by GPA Engineering for Australia's National Hydrogen Strategy found that domestic, commercial, and industrial appliances are likely to be suitable for hydrogen blending of to 10% by volume, but that further investigation of certain issues and appliances was recommended.[74] Different standards apply in New Zealand so the maximum amount of hydrogen that can be blended while complying with New Zealand standards may be different.

Current Australian hydrogen blending trials are limited to gas distribution networks and do not extend to transmission pipelines. Concerns regarding steel embrittlement risks mean that Australian gas transmission networks are currently considered unsuitable for even very low levels of hydrogen blending.

72 IEA, *Net Zero by 2050: A Roadmap for the Global Energy Sector*

73 https://arena.gov.au/news/over-100-million-to-build-australias-first-large-scale-hydrogen-plants/

74 GPA Engineering, *Hydrogen impacts on downstream installations and appliances*, 2019.

E.3. Blending hydrogen in New Zealand

Firstgas has announced a proposal to blend hydrogen into the North Island's natural gas network, with conversion to a 100 percent hydrogen grid by 2050.

Internationally and in Australia the case for considering hydrogen blending – in the context or a path toward net-zero emissions – includes:

- it is one means of helping to 'kick start' a green hydrogen economy and to develop experience and capability
- it can achieve modest carbon emissions reductions
- it creates optionality for the project specifically, and gas infrastructure generally, to move to zero emissions 'green gas' futures including:
  - green gas delivery using repurposed gas network infrastructure, such as:
    - 100% hydrogen or high hydrogen and biogas/biomethane blends, which would require appliance conversion, or
    - hydrogen/biomethane blends at levels that would not require any appliance conversion, and
  - potentially the electrolyser could switch or be shifted to supply a local hydrogen use application (with no distribution requirements) should the gas pipeline be decommissioned.

Hydrogen blending with natural gas is unlikely to be a viable long-term solution given that it still produces carbon emissions, whereas blending with biomethane could be a sustainable long-term solution. However, as discussed above, biomethane is constrained by the availably of biogas feedstock.

Hydrogen blending with biomethane could moderately extend the energy production capability of the limited biogas resource. However, it may not be a long-term solution for New Zealand if zero-carbon emissions is pursued.

APPENDIX F. BIOMETHANE AND BIOGAS IN NEW ZEALAND

This Appendix provides more detail on the potential applications for biomethane and biogas, its current use in New Zealand and studies on the potential for increased use of biogas in New Zealand.

F.1. Applications

Biomethane can be used for all existing natural gas applications. Box 8 outlines the applications of biomethane and biogas observed internationally.[75]

Box 8: International applications for biomethane and biogas

Injection into the natural gas network:

- In Denmark, biogas is increasingly being upgraded to biomethane and injected into the gas grid and the country is on track to reach its target of 100% biomethane in its natural gas grid by 2050
- In France, 123 out of 860 biomethane plants injected biomethane into French gas distribution networks.

Electricity generation:

- Germany is a clear leader in global biogas/biomethane production, representing more than 50% of the total production in the EU. There were more than 10,900 biogas plants in Germany as of 2018 (EBA, 2018). Most of this biogas is used for electricity generation.
- Italian biogas plants generated 42.3% of the total electricity generated by bioenergy (or approximately 8% of total electricity generation from all sources)
- Denmark has traditionally used biogas for electricity production.

Transportation fuel:

- The US has incentives – both federal and state specific – to encourage the use of biomethane renewable natural gas as a transport fuel.

Export:

- Germany is a net exporter of biomethane, exporting an average of 150-200 GWh per year. The end destination of this biomethane is commonly countries like Sweden where incentives are geared towards the use of biofuels for transport.

It appears that where biogas and biomethane industries have developed successfully this has been due to government incentives including:

- financial incentives that support investment in new plants
- ongoing tariff and tax benefits
- long term guarantees on financial incentives (Germany).

The German experience emphasises the importance of long-term contracting to underpin low cost production.

[75] Beca, Biogas *Technical Memorandum Prepared for Firstgas*, March 2021 (attached to Firstgas's submission to the CCC), pp5-7. Sources are listed in the Beca report.

F.2. Supply costs and price competitiveness

Understanding long term biomethane supply costs is important.

Drawing on a range of sources, the Oakley Greenwood report for the CCC suggested adopting the following price assumptions for biomethane:[76]

- a starting benchmark price of $20/GJ
- a long-term price of $12/GJ assuming long term cost reductions of 30% to 40%.

The benchmark cost is highly situational dependent, such as what feedstock is relied upon. This raises several questions.

Although understanding supply costs is important, what matters is how competitive these costs are with that of alternative energy sources. Any such comparisons will depend on the use and the nature of the next best alternative source of energy. Oakley Greenwood state that a long-term cost of supply of $12/GJ is equivalent to $43/MWh based on a GJ to MWh conversion of 0.277778.

This is:

- equivalent to the CCC's assumed cost of importing LNG – which, according to its modelling, sets the ceiling wholesale price for domestic production; and
- well below the CCC's forecast electricity price.

On the latter, assuming a long-term wholesale electricity price of say $72MWh gives a parity price with electricity of around $20/GJ.

F.3. Biogas in New Zealand

There appear to be meaningful opportunities for biogas in New Zealand.

A report prepared by Beca for Firstgas provides technical evidence with respect to the opportunities of biogas and biomethane.[77] Beca noted that, in New Zealand, biogas is generated predominantly from landfills and wastewater treatment plants with a total biogas production of 3.63 PJ in 2020. Beca considered that further investment would allow an additional 14 PJ of biomethane to be produced.

The major biogas plants and their processes are:

- Mangere WWTP – mesophilic digesters operating continuously using wet digestion
- Rosedale WWTP – mesophilic digesters operating continuously using wet digestion
- Christchurch WWTP – both thermophilic and mesophilic digesters operating continuously using wet digestion.

Key conclusions of the Beca report are:

- **Feedstock availability |** New Zealand has good levels of identified feedstocks to allow a significant biogas and biomethane industry to be developed. Additional biomethane potential represents approximately 10% of New Zealand's annual natural gas consumption (excluding electricity generation). Beca notes that this could be an underestimate of the total production potential due to the high level assessment that was undertaken of feedstock availability in New Zealand.

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[76] Oakley Greenwood p.34.

[77] The report covered the mature and available biogas production and upgrading technologies, the use of biogas and biomethane internationally, the biogas and biomethane potential in New Zealand with consideration of available feedstocks, the quantities of biomethane that could be produced, and the opportunities and benefits of grid injection.

- **Role in decarbonisation |** biogas/biomethane could aid decarbonisation of industry, particularly the hard to decarbonise high temperature process heat, with minimal end-user capital investment required. To do this additional, biogas production and upgrading of plants will be required, which will have associated capital costs. Biomethane utilisation via grid injection could help achieve targets under the Zero Carbon Act and support the decarbonisation of industry outlined in the CCC's advice. Biomethane grid injection achieves a disconnection of waste/feedstocks generation and the end biomethane users, and decreases the decarbonisation challenges for natural gas end users.
- **Policy support |** policy that incentivises biogas and biomethane use with long-term guarantees has been shown to encourage investment in new plants internationally, and similar incentives will be required to facilitate growth in this industry in New Zealand.

There are gas quality challenges that need to be addressed for connecting and injecting biomethane into transmission pipelines. The specification for Reticulated Natural Gas (NZS 5442:2008) states the requirements for methane-based gas that is transported and supplied for use in natural gas burning appliances. The specification will need to be reviewed, specifically in regard to the upper oxygen content for biomethane injected into the transmission grid. Anaerobic digestion produced gas and landfill gas typically do contain unavoidable, albeit trace, levels of atmospheric oxygen and nitrogen that require extra gas polishing processes to remove. Biomethane injected into the local distribution grid has an upper limit of 1%-mol Oxygen, which will not typically require any further gas polishing process.[78]

[78] Section 9.2.5, EECA, Beca, Fonterra, Firstgas Group, 1 July 2021, Unlocking New Zealand's Biomethane Potential – Biogas and Biomethane in New Zealand

APPENDIX G. REPURPOSING EXISTING PIPELINE INFRASTRUCTURE

This appendix sets out the working group's research on key issues related to repurposing existing natural gas pipeline infrastructure to transport green gasses.

It is our understanding that pipelines do not require conversion to accommodate biogas or biomethane. This appendix, therefore, focuses on the costs and feasibility of repurposing pipelines to flow hydrogen.

G.1. Hydrogen in gas distribution networks

G.1.1. Hydrogen impact on distribution pipelines

Hydrogen embrittlement is where steel pipes become brittle after being exposed to hydrogen atom at high pressure. At extremes, this can lead to cracks in the pipes where gas could escape.

New Zealand's gas distribution networks, however, appear to face low risk of embrittlement as they operate at low pressure and use non-metallic materials (e.g. polyethylene pipes). As discussed below in relation to transmission networks, Firstgas's hydrogen feasibility study found that embrittlement issues could affect part of its transmission network, but no concerns were raised in relation to distribution networks.

Similar conclusions have been reached in Australia, where a report by GPA Engineering in partnership with Future Fuels Cooperative Research Centre for Australia's National Hydrogen Strategy undertook a detailed review of the various materials used in Australia's gas distribution networks and found that most distribution pipelines are constructed from plastics that are suitable for hydrogen and no material issues are expected to arise for 10% hydrogen blending.[79]

Firstgas' report concluded that:

- for 20% hydrogen blending, the only impacts on distribution networks would be that electrical equipment in hazardous areas may need changing and meters would need recalibration
- for 100% hydrogen, in addition to the above issues, the required changes may include some modification to seals, additional district regulator stations, replacement of pressure regulators, and replacement of some meters.

G.1.2. Capacity

Firstgas's study modelled a typical low-pressure gas distribution network – i.e. localised, lower pressure gas transportation network – and found that distribution networks are likely to be able to deliver enough hydrogen blends and 100% hydrogen for projected demands, with some reinforcement required.

Firstgas projected that about 400 km of network reinforcements would be needed to expand its capacity to deliver enough energy under a 100% hydrogen repurposing scenario. Firstgas' estimate of the cost of this capacity expansion was around $270 million in total for all gas distribution networks over the coming 30 years. These estimates may overstate costs and will depend on the future demand for gas, which may reduce significantly compared with current levels. Firstgas noted that, while this expenditure is significant, its Distribution Asset Management Plan already projects $100 million of capital expenditure over the next 10 years with similar (or greater) levels of investment planned on the other gas distribution systems owned by Vector and Powerco.

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[79] GPA Engineering report for the Government of South Australian in partnership with Future Fuels CRC, *Hydrogen in the gas distribution networks*, 2019.

G.2. Hydrogen in gas transmission networks

G.2.1. Hydrogen embrittlement of high-strength steel

Firstgas has undertaken a study to assess the typical components of its transmission network for likely risks when operating with hydrogen blends or 100% hydrogen. This assessment was made based on the current state of international research. Firstgas's feasibility study report states that:

- the key issue of hydrogen embrittlement of high-strength steel potentially applies to around one third of its transmission network
- this and other issues are being actively investigated in overseas research programs.

Firstgas expects that some of these technical issues are likely to be resolved as more work is done on gas pipelines overseas and by its forward R&D program.

As noted above, hydrogen blending trials in Australia have focused on distribution networks due to concerns about embrittlement of transmission networks. Australia's National Hydrogen Strategy in 2019 concluded:[80]

> *Lastly, regarding use of hydrogen in existing high pressure gas transmission networks, research has identified potential pipeline safety and longevity issues. Australian governments will not support the blending of hydrogen in existing gas transmission networks until such time as further evidence emerges that hydrogen embrittlement issues can be safely addressed. Options for setting and allowing for ongoing updates of safe limits for hydrogen blending in transmission networks will form part of the review in 2020. Industry and researchers will continue to complete relevant research through initiatives such as the Future Fuels Cooperative Research Centre.*

Given that gas will no longer need to be transported from gas fields to demand centres and electrolysers can instead be located in distribution networks or close to major gas users, it is possible that future gas networks under a repurposing scenario may be more decentralised than current gas networks, with less need for transmission networks.

G.2.2. Capacity

Hydrogen has 1/3 the energy content of natural gas on a volumetric basis; hence to deliver the same amount of energy, 3 times the volume of gas needs to be delivered. Everything else being equal, this derates existing gas networks, or it requires upgrades to the gas distribution networks – in particular, compression assets to accommodate the same amount of energy throughput.[81]

Firstgas states that its pipeline system has enough capacity to transport the projected energy demand as either a blend of hydrogen in natural gas, or entirely as hydrogen gas, with minimal capacity reinforcement.

G.2.3. Compressors

Firstgas's study states that it will need to change the configuration of its compressors as compression will be needed in different locations since hydrogen production will be distributed across the network. Changing compressors is likely to occur during the already programmed renewal of our assets prior to network conversion to hydrogen. The introduction of hydrogen also creates potential for reduced pipeline compression needs – with associated capex and opex savings – since electrolysers can likely inject hydrogen at pressure across the network.

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80 *Australia's National Hydrogen Strategy*, p43.

81 Oakley Greenwood, p24.

APPENDIX H. PLANNING FOR SWITCHING AND DECOMMISSIONING UNDER THE WINDDOWN SCENARIO

This appendix discusses some of the material issues that would need to be considered as part of planning a switching and decommissioning process under the winddown scenario. This Appendix is not intended to be exhaustive, but instead seeks to illustrate the complexity of the process that is likely to be required and the need for a comprehensive plan to manage it.

H.1. Planning for switching and decommissioning

Box 9 sets out initial thinking on the key steps for planning for switching off a gas distribution network and decommissioning. Many of the steps for transmission pipelines would be similar but there would be some important differences.

It would be valuable to draw from other equivalent network decommissioning or switchover processes when developing such a plan. For instance:

- although their requirements differed, there could be lessons from businesses involved in the local fibre network roll outs
- there may also be lessons from how the switch over from analogue to digital TV was managed – that process could provide lessons in relation to the need for longer term planning and staged timeframes, a government-led public communication program, a coordinated program for replacing appliances and the potential need for government support for the appliance switching costs incurred by vulnerable consumers.

BOX 9: STRAWPERSON STEPS TO PLAN FOR CONSUMER SWITCHING AND SWITCHING OFF AND DECOMMISSIONING A GAS NETWORK

- Developing an overall switching and decommissioning plan and planning process for a region/city
- Developing clear obligations and agreement on who is responsible for communicating information
- Longer term planning, which will likely require:
  - planning and actions by the electricity industry (networks and generation) and other energy providers to ensure that there will be sufficient capacity and energy supply for consumers switching from gas to electricity energy use
  - planning by the appliance industry to ensure sufficient appliances and installers
  - planning by gas companies to ensure there are adequate resources (technicians, field service staff etc) to switch off and decommission the gas network
- Setting a target date for switching off gas supply in each area (e.g. network, suburb, street etc.) – to guide tactical planning
- Tactical planning, including developing a detailed rollout plan so that available resources can move from one area to the next (e.g. by street, or group of streets) to install and commission new appliances, remove old appliances, switch off supply etc. as necessary
- Implementing the tactical plan, e.g. install alternative energy appliances, remove old appliances
- Prior to the target switch off date, checking that alternative energy appliances and energy supply are in place and operating
- Switching off the gas pipeline in an area

- Decommission the gas pipeline and related equipment
- Potential mitigations
- Identifying the parties involved (e.g. from different parts of the supply change)
- Considering necessary differences between distribution and transmission networks and interactions between them
- Communication / change management / consultation on the plan.

There will be a need for coordination between a broad range of stakeholders including various levels of government, gas pipeline companies, gas retailers, electricity networks and retailers, and other alternative energy providers, to give effect to such a plan. Failure to do so could lead to delays between when gas is disconnected and when consumers have their energy needs serviced by alternatives (e.g. electric heating and cooking).

H.2. Technical issues

Several important technical issues that would need to be considered leading up to gas pipelines being switched off. These are not addressed in the Findings Report.

Key questions include:

- What are the important technical issues to consider in the period leading up to switching off of a gas network, including any safety issues?
- What are the important technical issues to consider for decommissioning a gas pipeline and related equipment and assets?
- What is involved in decommissioning underground gas pipelines and related above ground equipment?
- Are there any significant risks?
- Can pipelines be left in the ground? If so, what is needed to make them safe? Does above ground equipment need to be removed?

H.3. Quantifying and meeting winddown costs

As the time for switching off a gas pipeline approaches, and afterwards, there will be various costs that need to be met but declining (or no) revenue for the pipeline operators to meet them.

These includes costs of:

- maintaining the assets in a secure and safe condition and supplying remaining consumers
- planning and coordinating the switching off process
- switching off the gas network
- decommissioning the gas network.

Further work should be undertaken to estimate these costs.

The above costs will need to be met by someone. Responsibility could fall on consumers, gas network companies, government, or a combination of them.

APPENDIX I. EUROPEAN ENERGY REGULATORS' VIEWS ON REGULATION

In the context of the recently announced EU Hydrogen Strategy[82] the need for, and scope of regulation for hydrogen networks has been reviewed by the European energy regulators, ACER and CEER who state:

> *In light of this future, the need for, and scope of, regulation of hydrogen networks will depend on how consumption and production of hydrogen will spread, and if hydrogen pipelines for transport over longer distances will emerge.*
>
> *If parties request access to a monopoly hydrogen transport infrastructure, as foreseen in the EU Hydrogen Strategy, the market might evolve to situations in which abuse of a dominant position might become an actual risk. However, the development of hydrogen infrastructure is still at an early stage and it is uncertain how it will evolve in practice.* [83]

Box 10 identifies the issues that ACER and CEER identify for further consideration.

BOX 10: European Energy regulators recommendation issues to be addressed in the future economic regulation of hydrogen networks [84]

- Consider a gradual approach to the regulation of hydrogen networks in line with market and infrastructure development for hydrogen
- Apply a dynamic regulatory approach based on periodic market monitoring
- Clarify the regulatory principles from the outset
- Foresee temporary regulatory exemptions for existing and new hydrogen infrastructure developed as business-to-business networks
- Value the benefits of repurposing of gas assets for hydrogen transport
- Apply cost-reflectivity to avoid cross-subsidisation between the gas and hydrogen network users

Following this approach, it is suggested that if it is possible that New Zealand gas infrastructure is to potentially follow the repurposing scenario then review may be warranted of:

- the need for, and scope of, future economic regulation as the market changes, and
- regulation of market structure (e.g. limits on vertical integration).
- Initial review of economic regulation could include considering the future 'trigger points' when different regulatory policy may need to apply.

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[82] The EU Hydrogen Strategy focuses on the development of renewable hydrogen production and outlines three phases:

From 2020 to 2024, at least 6 GW of renewable hydrogen electrolysers shall be installed with a production of up to one million tonnes of renewable hydrogen per year;

From 2025 to 2030, at least 40 GW of renewable hydrogen electrolysers shall be installed with a production of up to ten million tonnes of renewable hydrogen per year;

From 2030 to 2050, renewable hydrogen technologies should reach maturity and be deployed at large scale across all hard-to-decarbonise sectors.

[83] ACER is the European Union Agency for the Cooperation of Energy Regulators. CERR is the Council of European Energy Regulators, which is the European association of energy national regulatory authorities.

[84] ACER, *When and How to Regulate Hydrogen Networks? "European Green Deal" Regulatory White Paper series (paper #1) relevant to the European Commission's Hydrogen and Energy System Integration Strategies*, 9 February 2021

APPENDIX J. SUMMARY OF CCC ADVICE TO GOVERNMENT

J.1. Overview

This appendix summarises key aspects of the CCC's final report that are relevant to the future of gas infrastructure in New Zealand.

J.2. Gas use and infrastructure

J.2.1. Phasing down natural gas use

- To get on a low emissions path Aotearoa needs to avoid locking in new natural gas assets and phase down how much natural gas is used in existing residential, commercial, and public buildings.
- One option to reduce emissions from natural gas use, and safeguard consumers would be to place a moratorium on new natural gas connections. Another option would be to set a date after which no new natural gas connection occurs. These options avoid locking in new natural gas assets where there are existing low emissions alternatives until it can be proven that low emission gases are technically feasible an economically affordable.
- Alternatively, a cap on operational emissions from natural gas used in buildings that tightens over time could be applied to ensure substantial reductions in emissions. This could discourage new gas connections and new buildings but would not necessarily prevent the expansion of the gas network.
- These options would provide time for industry to assess the effectiveness of low-emission gases as a way to reduce emissions. Under any option the government will later consider how to transition existing natural gas towards lower-emissions alternatives.
- The Commission had greater concerns about the risks of phasing down the use of natural gas for electricity generation too quickly, noting that the speed with which natural gas use for electricity generation is reduced needs to be carefully managed to ensure electricity remains reliable and affordable. The Commission also noted there are limited opportunities for moving away from natural gas use for industries that use it for process heat or feedstock, and the decreasing role of gas needs to be carefully managed and sequenced.

J.2.2. Expansion of the gas network

- Some submission said continued expansion of gas network infrastructure should be allowed given that low-emissions gases may be able to be distributed through the same or upgraded infrastructure. However, the extent to which this is possible or cost effective remains uncertain. Doing this would also have costs for consumers.
- Low-emissions gases are currently more expensive than natural gas. Putting new low emissions gases through pipelines is also likely to require some reinforcement or replacement. The cost of the gas network are spread across users through their bills as the network is a regulated asset base. This means the same costs need to be recovered no matter how many users there are.
- The Commission's position is the possible availability of low emissions gas is insufficient reason to warrant continued expansion of gas network infrastructure until there is substantial evidence that blending or fully converting the gas networks to low emissions gases will not increase cost to consumers.

J.2.3. Gas lends itself to critical applications

- The use of natural gases must be phased down where low emissions alternatives are available. Because for some cases natural gas is less emissions intensive than coal, it lends itself to critical applications that support services needed in the transition such as security of supply and high temperature process heat.

J.3. Uncertainty and considerations

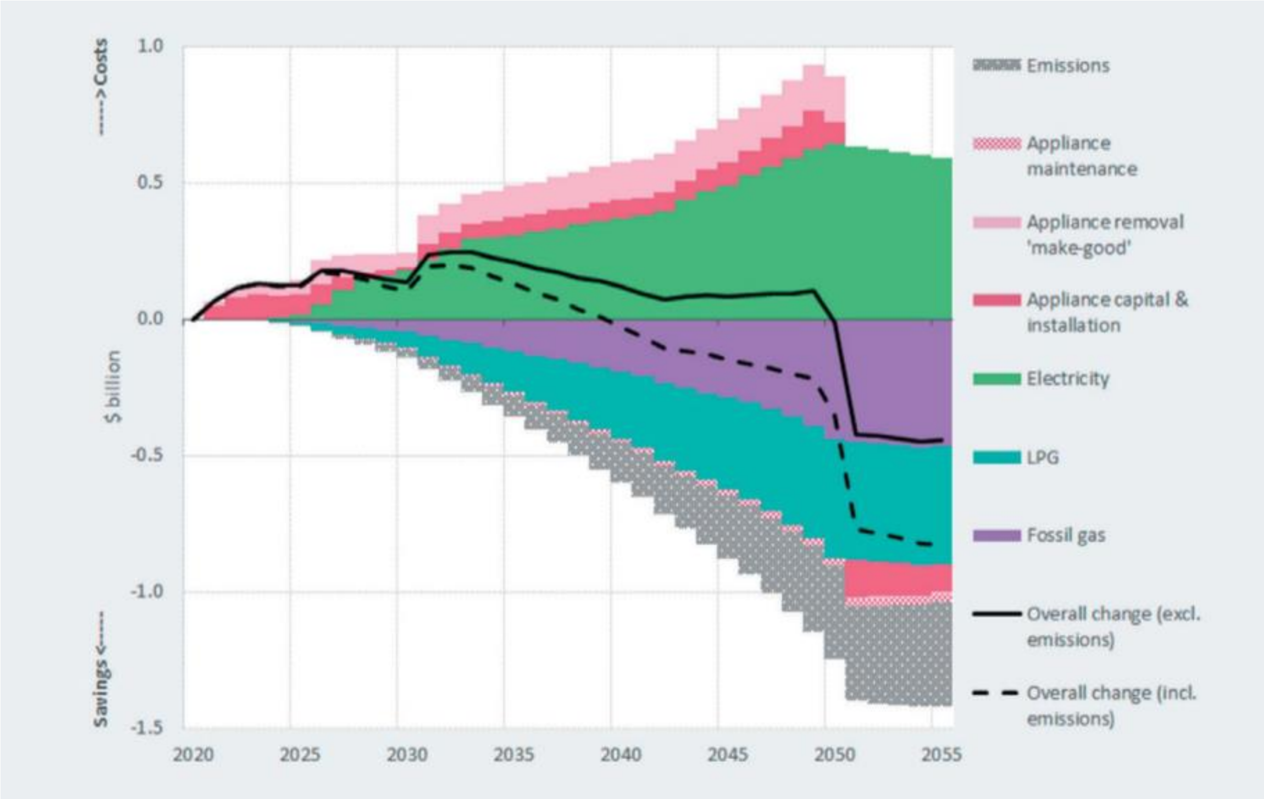
J.3.1. Hydrogen

- Hydrogen is an emerging industry. It is highly uncertain what role hydrogen will play.

J.3.2. Appliances

- Households could reduce costs by not installing new natural gas appliances and replacing existing natural gas appliances with low emissions alternatives when the appliances come to the end of life.
- The Commission modelled the impact on space and water heating costs for homes and businesses assuming all space and water heating was electrified by 2050. This modelling showed the costs exceeded the benefits until 2050 if emissions costs were not included (or until 2040 if emissions were included) due to the costs of replacing appliances and increased electricity costs, then net savings after 2050 – see Figure J-1. Similar modelling for process heating costs for the food processing sector showed significant net cost increases until beyond 2055 if emissions were not included or net savings from 2030 if emissions were included.

FIGURE J-1: COST AND BENEFITS IF NATURAL GAS IS PHASED OUT FROM SPACE AND WATER HEATING



Source: CCC final advice, Figure 8.3.

J.3.3. Electricity pricing

- If Tiwai closes at the end of 2024 then around 10 to 14% of electricity supply will become available for alternative uses. Modelling shows that changes in the dynamics of supply and demand could lower wholesale electricity prices by as much as $20 per MW for as much as a decade.
- It would be beneficial for the government to assess and communicate to the public the potential impact of a significant change in the balance of supply and demand on the accelerated electrification of transport and process heat.

J.3.4. Repurposing of gas pipelines

- Consideration should be given to whether gas pipeline infrastructure should be retained to repurpose for low emissions gases like biogas or hydrogen.

J.3.5. Blending

- It is possible that low emissions gases such as hydrogen or biogas could be blended into natural gas to lower its emissions intensity.

J.4. Government action

J.4.1. Energy strategy

- Aotearoa needs to have a national energy strategy which would supports a coordinated approach.
- The national energy strategy should consider a plan for diminishing the role of natural gas and associated consequences for network infrastructure and workforce in the transition.
- Choices the government makes should keep options open for as long as possible, and a strategy can help to ensure this.
- Benefit from government signalling plan earlier, e.g. improve predictability for families, businesses and public entities.

J.4.2. Measures required as natural gas use deceases

- As the use of natural gas decreases additional measures will be needed to support security of supply, residential consumer choice around gas, energy affordability accessibility, network consideration, workforce planning and high temperature heat needs.

J.4.3. Innovation

- Longer term, innovation investment will be needed to develop ways to displace these remaining uses of natural fuel. Government will have a role to play in an innovation.
- Recommendation 13 sets out recommendations to enable system level change through innovation, finance and behavior change.

J.4.4. Employment

- Phasing out natural gas will impact employment for those working that industry. Government should consider labour market policies to support workers caught up in this, such as job placement and brokerage programs, and re-training assistance.

APPENDIX K. GLOSSARY AND ABBREVIATIONS

Term	Definition
ARENA	Australian Renewable Energy Agency
BEIS	UK Department for Business, Energy and Industrial Strategy
CH4	Methane
CCC	Climate Change Commission
CCUS	Carbon Capture, Utilisation, and Storage
CO2	Carbon Dioxide
DPP	Default Price Path
EECA	Energy Efficiency & Conservation Authority
EHINZ	Environmental Health Intelligence New Zealand
ETS	Emissions Trading Scheme
GIC	Gas Industry Company
ICP	Individual Connection Point
IEA	International Energy Agency
MBIE	Ministry of Business, Innovation and Employment
MGUG	Major Gas Users Group
NOx	Nitrogen Oxide
PJ	Petajoules
R&D	Research and Development
RAB	Regulatory Asset Base
TJ	Terajoules