MINISTRY OF BUSINESS,
INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

BRIEFING

Economic impacts of declining gas supply

Date:	23 January 2026	**Priority:**	Medium
Security classification:	In Confidence	**Tracking number:**	BRIEFING-REQ- 0025931

Action sought		
	Action sought	**Deadline**
Hon Simon Watts **Minister for Energy**	**Indicate** if you wish to discuss the outcomes of this modelling at the next officials meeting **Forward** to the Minister of Finance	30 January 2026
Hon Shane Jones **Minister for Resources**	**Indicate** if you wish to discuss the outcomes of this modelling at the next officials meeting	30 January 2026

Contact for telephone discussion (if required)			
Name	**Position**	**Telephone**	**1st contact**
Scott Russell	Manager, Energy Use Policy	Privacy of natural persons [redacted]	✓
Glen Baxter	Policy Adviser, Energy Use Policy		

The following departments/agencies have been consulted

Minister's office to complete:

- ☐ Approved
- ☐ Declined
- ☐ Noted
- ☐ Needs change
- ☐ Seen
- ☐ Overtaken by Events
- ☐ See Minister's Notes
- ☐ Withdrawn

Comments

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Purpose

The purpose of this briefing is to provide you with an overview of Sense Partner's final report *Regional and industry impacts of declining gas supply.*

Executive summary

In 2025 MBIE commissioned modelling to better understand the economic impacts of declining gas supply in New Zealand. The modelling used three illustrative scenarios (baseline, high price, Liquefied Natural Gas (LNG) facility) to explore how declining gas supply could drive up gas prices and the potential economic impacts at a national, regional and industry level.

Overall, the modelling indicates the New Zealand economy will still grow over the next decade, even with higher gas prices. However, this growth will be marginally slower than if gas prices held relatively steady at today's levels (the baseline scenario).

The modelling shows the transition away from gas will be painful for specific industries and communities, especially in Taranaki. However, a large share of the adjustment in response to declining gas supply has already happened or is 'locked in' to the baseline. Further gas price increases over and above the baseline will have relatively modest ***additional*** economic impacts.

The modelling also shows that the price cap expected from introducing an LNG import facility should moderate the potential economic costs. Compared to the high price scenario, importing LNG reduces negative GDP impacts by around 25 per cent below baseline by 2035 at the national economy level. At a regional level, importing LNG reduces negative GDP impacts in Taranaki by around 40 per cent below baseline and most other regions' GDP reduces by 15-25 per cent below baseline.

Many stakeholders are aware of this modelling. MBIE intends to publish the modelling following announcement of the Government's LNG decisions. There will likely be media interest in this work. MBIE will work with your office on preparing reactive communications to support.

Recommended action

The Ministry of Business, Innovation and Employment recommends that you:

a **Note** that current gas prices are already high compared to historic levels, and that this is having a negative impact on growth.

Noted

b **Note** that further increases in gas prices will likely have an additional, albeit small, negative impact on economic growth, compared to the baseline scenario.

Noted

c **Note** the transition away from gas will be painful for specific industries and regional communities, especially in Taranaki.

Noted

d **Note** the modelling indicates that availability of an LNG facility ‘takes the top’ off the economic costs of higher gas price scenarios, reducing GDP losses by around 25 per cent.

Noted

e **Note** MBIE intends to publish this report following announcement of the government’s LNG decisions as part of the proactive release of LNG Cabinet decision documents.

Noted

f **Indicate** if you wish to discuss the outcomes of this modelling at the next officials meeting.

Yes / No

g **Forward** to the Minister of Finance, and Economic Growth.

Agree / Disagree

Scott Russell
Manager, Energy Use Policy
Energy Markets, MBIE

..... / ...... / ......

Hon Simon Watts
Minister for Energy

..... / ...... / ......

Hon Shane Jones
Minister for Resources

..... / ...... / ......

Modelling to understand the economic impacts of declining gas supply

Background

1. In October 2025, MBIE commissioned Sense Partners to undertake economic modelling to assess the economic impacts of declining gas supply on the New Zealand economy, including specific impacts for 16 regions, and 81 industrial sectors. The final report *Regional and industry impacts of declining gas supply* is attached at **Annex One.**

2. The purpose of the modelling is to help inform future policy work on potential options to manage the effects of our declining domestic gas supply. This includes decisions on the role of LNG in the economy.

3. MBIE will also publish the report on its website following the LNG decision announcement. We will provide you with suggested talking points and reactive Q&A to support the publication of the report as part of the proactive release of LNG Cabinet decision documents.

Modelling approach

The modelling explores how declining gas supply could force up gas prices

4. The computable general equilibrium (CGE) modelling tested, three illustrative scenarios for gas price paths out to 2035:

    a. **Baseline:** prices rise in the near term reflecting ongoing tight supply conditions and recent observations on contract prices ($15-$17/GJ).

    b. **High price scenario:** prices double in real terms between 2025 and 2032 and then hold steady at $26/GJ out to 2035.

    c. **LNG terminal scenario[1]:** prices rise for the same reasons as the high price scenario, however from 2029 prices are capped at $21/GJ (assumed price of imported LNG).

[1] Note this report is not intended to be a detailed study on the feasibility or desirability of an LNG terminal. In addition, the model did not consider the construction impacts and funding costs of building an LNG terminal. Implicit in the LNG terminal scenario design is that the price paid for imported gas includes some portion for cost-recovery.

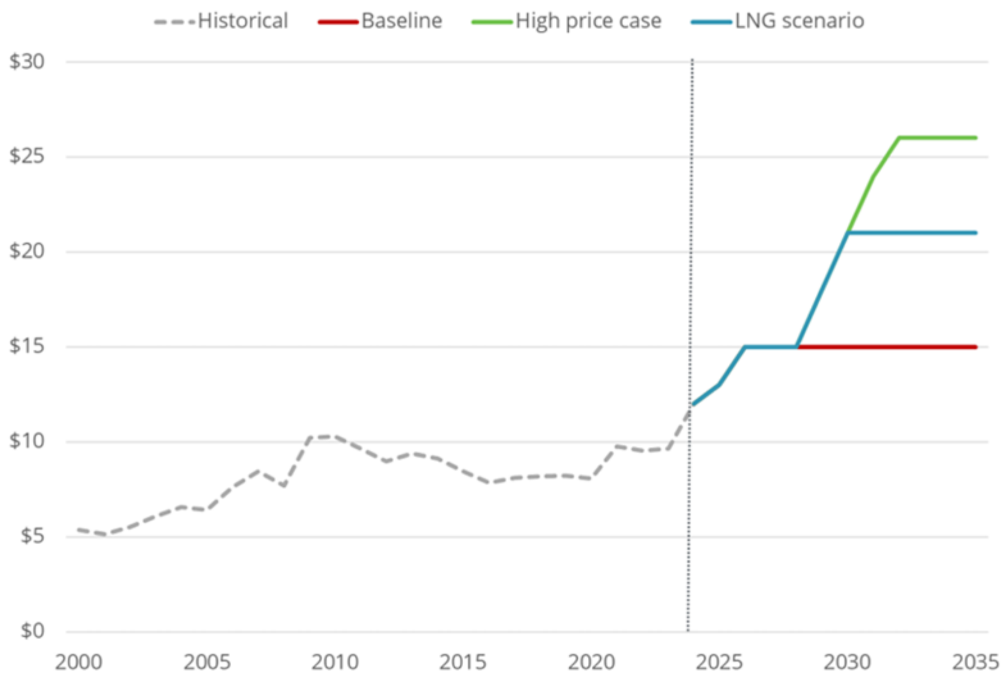


Figure 1: Wholesale gas prices, real, NZD/GJ

5. All scenarios assume[2]:

    a. full closure of Methanex and Ballance Agri-Nutrients in Taranaki by 2029

    b. electrification of dairy processing boilers (to reflect current Fonterra fuel switching announcements)

    c. some additional investment in machinery required to facilitate fuel-switching by gas intensive users

    d. gas price paths based on an economy-wide wholesale price excluding carbon costs.

6. These scenarios provide a range of possible futures to support our analysis but are <u>not forecasts.</u>

Overview of key findings

National economic impacts

GDP impacts

7. As gas prices rise, higher costs impact business margins reducing investment. In addition, there may be temporary duplication of part of the capital stock (i.e. industrial sites with both a legacy gas boiler and new electrode boiler) for some industries ahead of a full fuel switch, temporarily reducing economic efficiency and returns to capital. If the modelling extended beyond 2035 to cover the life of the assets, this new capital would start delivering productivity gains rather than being only a drag on output.

8. The modelled reductions in GDP are:

    a. $4.5 billion (0.96 per cent) less than the baseline in the high price scenario

    b. $3.3 billion (0.71 per cent) less than the baseline in the LNG scenario.

[2] The scenarios are not fact but potential scenarios used to test potential economic impacts

Employment impacts

9. As gas prices rise, economic growth slows. As output falls relative to the baseline, firms need fewer workers.

10. The modelled FTE job losses across the economy is:

    a. around 9,500 below baseline in the high price scenario by 2032

    b. around 7,300 below baseline in the LNG scenario by 2030 and 4,600 by 2032.

11. Note over time, employment starts to return towards baseline level as workers retrain or find employment in new industries. In the long-term, employment is determined mainly by the size of the labour force and population growth. As this happens, weaker labour demand shows up through lower real wages between 0.85 per cent and 1.22 per cent below baseline by 2035. This reflects that while workers may be able to find new jobs as industries adapt to gas price shocks, these jobs may be lower paid.

Tax revenue impacts

12. As company and household incomes drop, so does government revenue from company and income tax. Declining household incomes mean consumers spend less on goods and services, impacting GST revenue. Production taxes (including ETS revenue) decline marginally due to weaker overall economic activity.

13. The modelled tax revenue decline is:

    a. $2.5 billion below baseline in the high price scenario

    b. $1.8 billion below baseline in the LNG scenario.

Industry impacts

14. In New Zealand gas is used intensively by a small number of industries, collectively accounting for around 5 per cent of GDP. Much of the economy uses little or no gas directly – commercial and government services account for over two-thirds of GDP and use very little gas.

15. Industries most negatively affected include electricity generation, gas extraction and gas distribution, and gas-intensive manufacturing such as chemicals and metal products. Some supplying industries (e.g. construction services and professional, scientific and technical services) also contract as gas-intensive activity slows.

16. There are partial offsets to the contraction of the gas-intensive industries:

    a. High gas prices push energy demand and investment toward renewable sources, expanding biomass, geothermal, solar and wind electricity.

    b. Labour-intensive export industries (especially tourism) benefit from lower real wages and a weaker real exchange rate.

    c. Machinery and equipment manufacturing benefits from additional capital spending linked to investment in electrification.

Regional impacts

17. Taranaki is most exposed given its gas-intensive industry mix (including gas extraction), with real GDP falling 5.3 per cent below baseline by 2035 in the high price scenario. The graphs below highlight the GDP impacts on the Taranaki region (in blue) compared to other regions across the high price and LNG scenarios modelled.

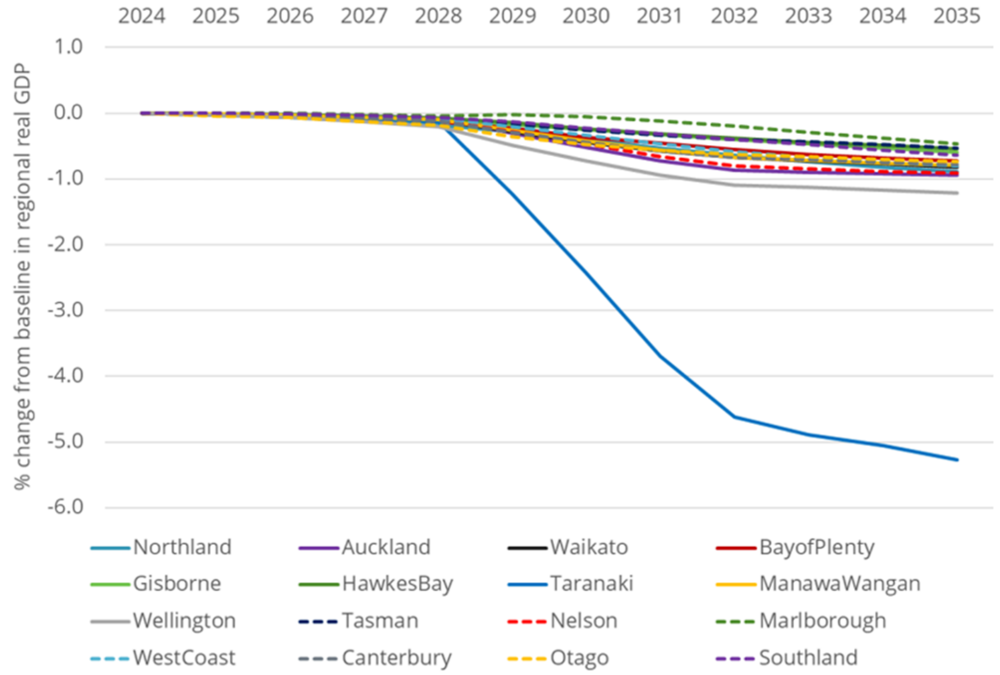


Figure 2: High price: % change in regional real GDP from baseline

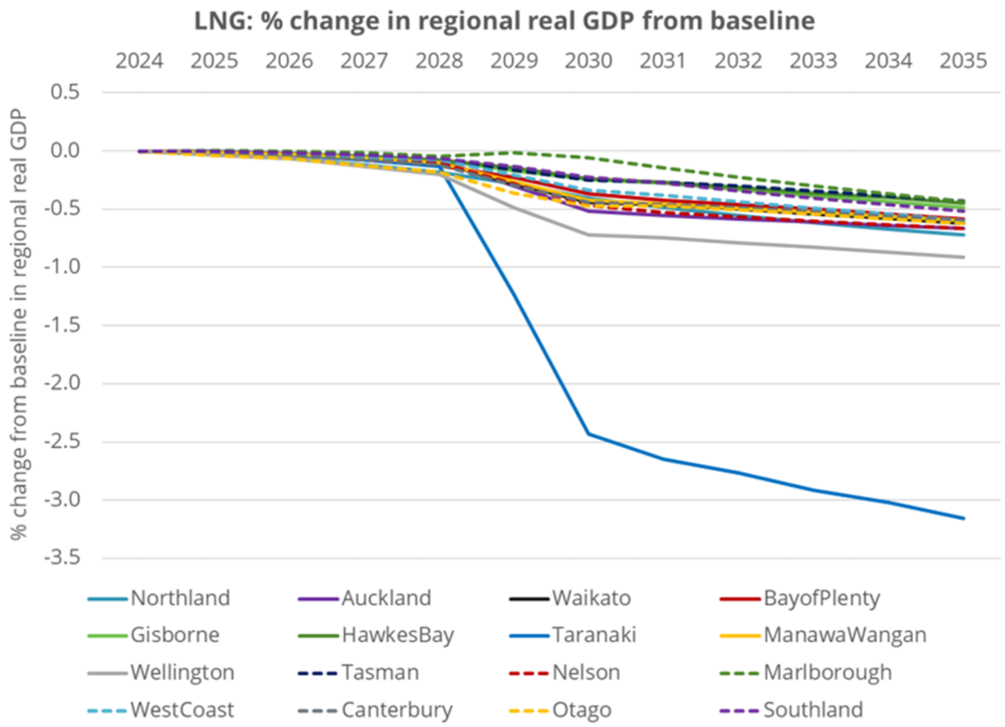


Figure 3: LNG: % change in regional real GDP from baseline

18. Wellington is next most affected (1.2 per cent below baseline by 2035). This is mainly driven by its concentration in government and commercial service activities that soften when national income and tax revenue decline (rather than a direct effect of gas prices).

19. Most other regions experience modest GDP impacts in the high price scenario, with a drop of between 0.5 per cent to 0.9 per cent below baseline by 2035. Marlborough is least affected due to limited direct gas exposure and a comparatively large share of labour-intensive/export-oriented activity.

20. These negative regional impacts are all moderated with an LNG terminal in place. GDP in Taranaki is reduced by around 40 per cent below baseline and most other regions' GDP reduces by 15-25 per cent below baseline.

21. The regional employment impacts are smaller than might be expected because the most affected industries are relatively capital-intensive and at least some labour can be reallocated between industries over time. As highlighted in the graph below, most regions see employment fall by 0.1 per cent to 0.4 per cent below baseline in the early 2030s in the high price scenario.

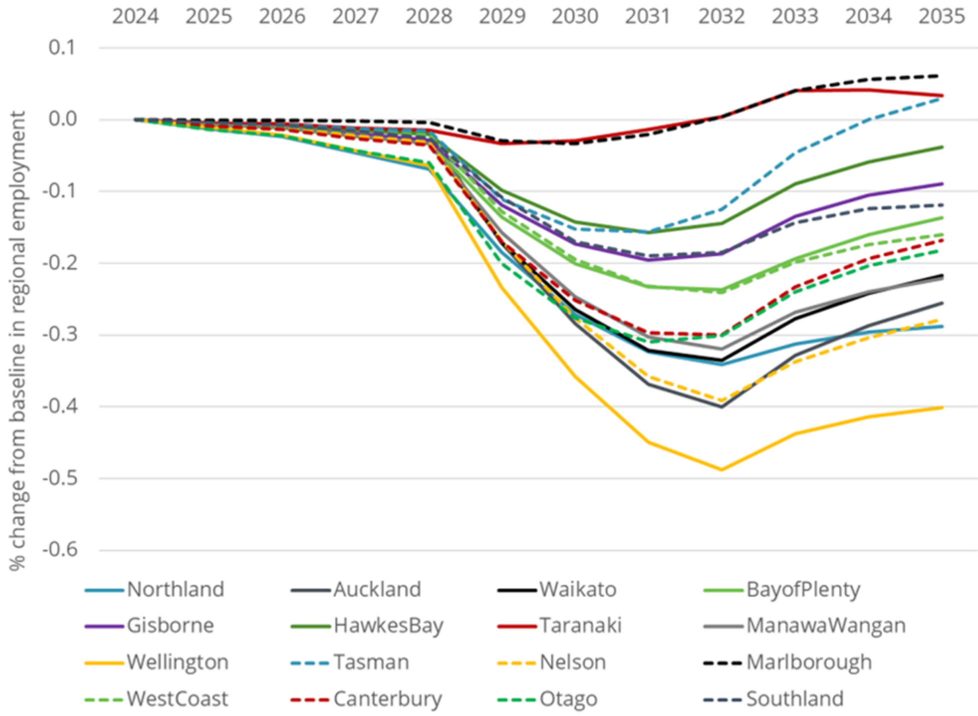


Figure 4: Regional employment impacts, % change from baseline, high price scenario

Risks

22. There will likely be media interest in this work. MBIE will work with your office on preparing reactive communications to support its release.

23. The results that have fallen out of this modelling, although scenarios (rather than real outcomes), do present a particularly bad news story for the Taranaki region.

Next steps

24. Should you wish, we are available to discuss this report with you at your regular meeting with officials.

25. We intend to publish this report on the MBIE website following announcement of the Government's LNG decisions as part of the proactive release of LNG Cabinet decision documents. We do not propose any proactive communications of the report.

Annexes

Annex One: Regional and industry impacts of declining gas supply

Annex One: Regional and industry impacts of declining gas supply

Regional and industry impacts of declining gas supply

A dynamic CGE analysis

Final report to MBIE, 19 December 2025

SENSE PARTNERS
DATA LOGIC ACTION

Key points on a page

Headline takeaways

- The New Zealand economy will still grow across the next decade, but marginally more slowly than if gas prices held relatively steady as in the baseline.
- The transition away from gas will be painful for specific firms and communities, especially in Taranaki. But much adjustment has already happened, is underway now or is assumed to occur in the future baseline. Further gas price increases over and above the baseline will have relatively modest additional economic impacts.
- The availability of an LNG terminal from 2030 onwards 'takes the top' off the economic costs of higher gas prices, reducing GDP losses by around 25%.

What we did and how we did it

- Using the MDG-NZ dynamic regional CGE model, we explore the potential economic impacts of declines in New Zealand's gas supply that force up gas prices, based on illustrative scenarios. We run the model in its top-down regional specification for 16 regions and 81 industries.
- We first project the economy out to 2035 in a baseline scenario that incorporates relatively moderate real gas price increases to 2030 and flat prices thereafter.
- We then model two counterfactual futures. These are 'what if?' scenarios rather than forecasts of what will happen.
- The first sees gas prices rise sharply between 2025 and 2032 ('High price scenario'); the second considers the impacts of an LNG terminal that draws in imported gas when domestic prices rise above a certain level ('LNG scenario').
- All scenarios include the full closure of Methanex and Ballance by 2029, the electrification of dairy processing boilers, and additional investment in machinery to facilitate fuel-switching by gas-intensive users. As such, these features do not contribute to the differences between the baseline and counterfactual outcomes.

National level impacts

- Higher-than-baseline gas prices without an LNG terminal reduce New Zealand's real GDP by $4.5bn (0.96%) below baseline by 2035. With an LNG terminal in place by 2030, the GDP impact is smaller at $3.3bn (0.71%) below baseline by 2035.
- The GDP impacts are driven mainly by weaker economy-wide investment due to lower output and squeezed margins. In some industries looking to switch fuels, ahead-of-time investment in electrification temporarily duplicates part of the capital stock, reducing efficiency and returns to capital.
- Households are negatively affected through the labour market. Under the model's sticky-wage dynamics, weaker labour demand shows up first as lower employment. The number of FTE jobs economywide falls by around 9,500 below baseline by 2032 in the High price scenario. Under the LNG scenario, job losses are moderated, falling by around 7,300 below baseline by 2030.

- Further out, employment trends back toward baseline and the adjustment occurs more via lower real wages (between 0.85% and 1.22% below baseline by 2035).
- Slower growth also reduces tax revenue. The modelled tax revenue decline is $2.5bn below baseline in the High price scenario and $1.8bn in the LNG scenario.

Industry impacts

- Natural gas is used intensively by a small number of industries collectively accounting for around 5% of GDP. Much of the economy uses little or no gas directly – commercial and government services account for over two-thirds of GDP and use very little gas.
- Industries most negatively affected include gas electricity generation, natural gas extraction and gas distribution, and gas-intensive manufacturing such as basic chemicals, other chemicals, polymer and rubber, fertiliser and pesticide, and metal products. Some supplying industries (e.g. construction services and professional, scientific and technical services) also contract as gas-intensive activity slows.
- There are partial offsets to the contraction of the gas-intensive industries:
    - High gas prices push energy demand toward renewable sources, expanding biomass, geothermal, solar and wind electricity.
    - Labour-intensive export industries – especially tourism – benefit from lower real wages and a weaker real exchange rate.
    - Machinery and equipment manufacturing benefits from additional capital spending linked to electrification investment.

Regional impacts

- In this top-down regional specification, regional impacts depend largely on national industry output changes and each region's industry composition.
- Taranaki is most exposed given its gas-intensive industry mix (including gas extraction), with real GDP falling 5.3% below baseline by 2035 in the High price scenario.
- Wellington is next most affected (1.2% below baseline by 2035), driven less by direct gas exposure and more by its concentration in government and commercial service activities that soften when national income and tax revenue decline.
- Most other regions experience modest GDP impacts in the High price scenario – around 0.5% to 0.9% below baseline by 2035. Marlborough is least affected due to limited direct gas exposure and a comparatively large share of labour-intensive/export-oriented activity.
- These negative regional impacts are all moderated with an LNG terminal in place. GDP losses in Taranaki are around 40% lower, and most other regions' GDP losses are around 15-25% lower.
- Regional employment impacts are smaller than might be expected because the most affected industries are relatively capital-intensive and at least some labour can be reallocated between industries over time. Most regions see employment fall by 0.1% to 0.4% below baseline in the early 2030s in the High price scenario.

Table of contents

1. Objectives, scope and caveats

1.1. Objectives of research

The Ministry for Business, Innovation and Employment has engaged Sense Partners, supported by its US-based partner Phylleos, to examine the industry, regional and national economic impacts of ongoing declines in New Zealand's natural gas supply that put upwards pressure on gas prices.

We use a dynamic, regional Computable General Equilibrium model to estimate the direct and flow-on effects of declining gas supply. We look at the impacts on 16 regions and 81 industries out to 2035.

1.2. Scope and caveats of research

The price paths we model are based on an economy-wide wholesale price, excluding carbon costs. We assume all industries face this price. Individual firms will of course have contracted prices and hedging arrangements in place. But hedge contracts can only shield users for a limited amount of time. As such the broad direction and magnitude of impacts estimated are likely to be reasonable, given the assumptions we have made.

Our 81-industry aggregation allows a reasonable level of detail in terms of demonstrating industry effects. However, in an economy-wide modelling exercise we cannot pragmatically look at how higher gas prices might affect specific firms. For example, while we report impacts on the paper products manufacturing industry, this industry comprises several different firms and should not be interpreted as the impact on (say) Oji Fibre Solutions.

We recognise that different firms within an industry will have different cost structures and resilience to higher-priced inputs. The results presented should be interpreted as *average* impacts for all firms in each industry, with some firms suffering more – even closing – and some less.

In addition, in a top-down regional simulation as used here, we assume an industry has the same cost and sales structure in all regions. This means, for example, the share of gas in the paper products manufacturing industry's input structure in the Bay of Plenty is the same as the cost share for that industry in Canterbury. This is a simplification but necessary given the time and resources available for this project.

The price paths for the baseline and counterfactual scenarios are not forecasts of what gas prices *will* be out to 2035, rather what they *could* be under certain assumptions and worldviews.

It is important to note that a CGE modelling exercise estimates scenario impacts relative to the assumed dynamic baseline. That is not the same as comparing the economy in 2035 to how it looks today.

The baseline reflects what might reasonably be expected to happen to the economy and its industries over the next 10 years in the absence of major shocks, guided by Treasury macroeconomic forecasts and historical trends in industry growth. It incorporates changes in industrial output that have occurred in recent years in response to high energy prices[1] and projects industry output forward to take account of these (and other) shifts.

In addition, the baseline in this project includes two important gas demand-side effects:

(i) A reduction in the size of the Basic Chemicals and Fertiliser and Pesticide Manufacturing industries to reflect the anticipated closures of Methanex and Ballance respectively by 2029.

(ii) A transition away from gas-fuelled boilers to electric boilers in the dairy processing industry to reflect Fonterra's announced investments.

Since these changes occur in both the baseline and counterfactual scenarios, they have no direct effects on the economic impacts presented.

Fuel-switching is not without cost for industries, even if relative prices make it sensible for them to do so. And purchases of new plant and equipment to facilitate fuel-switching can be both sizeable and 'lumpy'. To incorporate these costs, we design shocks in the counterfactual scenarios that direct gas-intensive industries to start investing in extra plant in advance of higher gas prices, rather than solely in response to them happening. Knowing precisely how much investment would be required and over what timeframe is challenging in an economy-wide modelling exercise, but in our view this approach acknowledges in some measure the capital cost impacts some industries will face.

Our approach to modelling the economic impacts of an LNG import terminal focuses solely on the gas price substitution benefits it offers. We do not explicitly model the regional or national impacts of constructing the terminal[2], nor specify in which region it would be located.

The model used for this project runs on an annual basis. This means we cannot capture changes in energy demand and supply within years (e.g. during dry months or winter peaks). We do not predict whether New Zealand will have dry years or any other specific meteorological conditions over the period to 2035. If desirable, specific dry years can be modelled in future scenario analysis by reducing the efficiency of natural resource use (i.e. water) by hydrothermal electricity generation.

[1] For example, nominal value added in the Pulp, paper and converted paper product manufacturing industry dropped 62% in the year ended March 2024. See StatsNZ. 2025. 'National accounts (industry production and investment): Year ended March 2024'. https://www.stats.govt.nz/information-releases/national-accounts-industry-production-and-investment-year-ended-march-2024/

[2] Implicitly we assume the terminal's capital costs are incorporated into the LNG gas price and thus paid off by users over time. We understand this is a simplification of how the terminal might be funded in practice.

2. Overview of methodology

We use our Global Systems Model of New Zealand (GSM-NZ) dynamic regional CGE model for this research. We aggregate our detailed database to 82 industries and 16 regions.

GSM-NZ has been used extensively to look at the economic and emissions impacts of policy changes, natural resource limits, regulatory proposals and commercial decisions.[3] Details on the GSM-NZ model are in Appendix A.

Dynamic CGE modelling is widely regarded as a robust technique for examining economic impacts, as it:

- Estimates direct and flow-on effects, both positive and negative, after allowing for capital accumulation, investment, savings and debt over time, allowing assessment of short-run vs. long-run impacts.
- Explicitly captures how resources (labour, capital, etc.) are reallocated over time following a shock to the economy.
- Imposes economy-wide budget constraints, factor endowments and market-clearing conditions, preventing "free" creation of labour, capital or imports that often occurs implicitly in input-output or multiplier analysis.
- Considers how firms, households and investors respond to changes in relative prices induced by the shocks, allowing substitution between inputs, goods, and factors.
- Incorporates technological change to explore shifts in economic structure over time.
- Captures distributional impacts across industries, regions and sources of final demand.

Due to the incorporation of feedback loops, resource constraints, price responses and intertemporal dynamics, CGE modelling will tend to produce more moderate and defendable economic impacts than input-output or multiplier analysis.

For this project, we model the New Zealand and regional economies each year out to 2035 in a baseline or Business as Usual (BAU) scenario where gas prices increase faster than historically but relatively modestly compared to some of the more dire projections contemplated by energy commentators.

We then model two counterfactual scenarios that characterise alternative future states of the gas industry in New Zealand. The first sees gas prices rise sharply between 2025 and 2030; the second considers the impacts of an LNG terminal that draws in imported gas when domestic prices rise above a certain level.

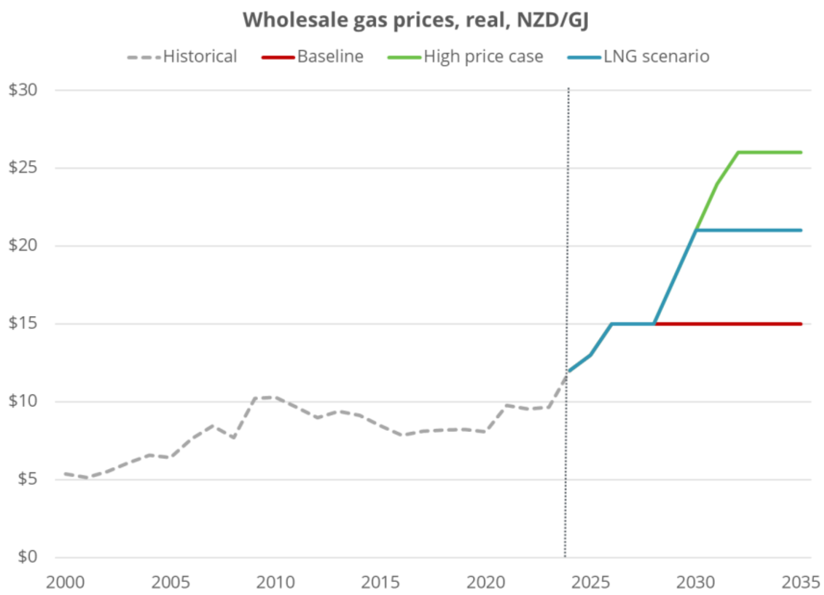
[3] Recent New Zealand clients include Treasury, Transpower, MBIE, Oji Fibre Solutions, Climate Forest Association, Ministry of Transport, Auckland International Airport and KiwiRail.

3. Scenario features

3.1. Overview of scenarios

The key objective of this research is to explore the economic impacts of declining gas supply and hence increased gas prices. Based on discussions with officials, Figure 1 summarises the price paths built into each scenario. More detail on the scenario design follows below.

FIGURE 1 WHOLESALE REAL GAS PRICES, EXCLUSIVE OF CARBON AND TRANSPORT COSTS



SOURCE: MBIE (HISTORICAL PRICES)

3.2. Baseline scenario

3.2.1. Economic projections

The baseline scenario incorporates known policies and 'normal' expectations around the domestic and international economic environment. The aim is to project the economy out to 2035 on the basis that there won't be significant shifts in policy direction, technology or the way New Zealand produces and consumes goods and services.

We take Treasury's latest macroeconomic forecasts for the first 5 years, and then Treasury's Long-Term Fiscal Model projections out to 2035. This gives us economic growth projections that determine the overall size of the economy.

We then apportion the economy between the 81 industries in our model. We do this using historical trends in industry growth rates plus assumptions around technological change in each industry. The projections are therefore essentially a continuation of historic trends in the composition of the economy, without any large structural change or disruptive technologies being introduced.

3.2.2. Gas market assumptions

Prices rise in the near term reflecting ongoing tight supply conditions and recent observations on contract prices ($15-$17/GJ).

Demand eases in 2027-2029 as large users close (Ballance, Methanex). As noted in section 1.2, we do not carry out the modelling at the firm level, but pro-rate down Methanex's share of the Basic Chemicals industry output and Ballance's share of the Fertiliser and Pesticide Manufacturing industry output through reducing their labour and capital inputs.

Fonterra has announced plans to electrify its gas boilers, which further moderates demand-side pressure. We incorporate these plans in the baseline by 'twisting' the dairy processing industry's energy intermediate input mix away from gas towards electricity and increasing its demand for machinery and equipment slightly more and faster than would otherwise occur due solely to relative price shifts.[4]

We assume gas field supply-side adjustment limits the effects of the closures and dairy processing electrification on prices. Further out, improved investor confidence and higher prices (by historical standards) provide sufficient return on investment to keep production up at existing fields and keep real prices stable at around $15/GJ (they increase in nominal terms at around 2.5% per year).

To generate the desired price paths we adjust the output (supply) of the natural gas by exogenously adjusting its capital inputs. We also switch off the normal capital accumulation dynamics in the natural gas industry, so it does not respond to higher prices by increasing its investment.

Ordinarily, when domestic prices rise faster than import prices for a commodity, industries increase their imports of that commodity. In this analysis, higher domestic gas prices would usually lead to increased imports of natural gas. But in the baseline (and High price scenario below) there is no LNG terminal so no imports of natural gas are possible. To capture this, we exogenise imports of natural gas so they cannot increase.[5]

3.3. High price and LNG terminal scenarios

The High price and LNG terminal scenarios are similar in design, with the main difference being that we allow imports of natural gas in the LNG terminal scenario.

In both scenarios, domestic natural gas prices increase at the same rate as the baseline to 2028. They then start rising sharply as the underlying economics of existing fields come under

[4] Fonterra accounts for around 80% of the dairy processing industry. Since we do not model individual firms, we apply the electrification shocks to the entire industry. This assumption will not make a material difference to the regional and economy-wide results.

[5] The model cannot create imports when there are absolutely zero imports in the database, so we add a nominal amount of imports ($100,000) to our database. This is necessary to allow the model to solve later in the LNG scenario and has no impact on the results in the baseline and High price scenarios.

pressure. This can be thought of as fields becoming more expensive to operate at lower volumes, and/or an accelerated shutdown of production at some fields.

In the High price scenario, prices double in real terms between 2025 and 2032 and then hold steady at $26/GJ (in real terms) out to 2035.

In the LNG terminal scenario, when domestic gas prices rise above $21/GJ – our assumed world price for LNG – industries switch towards imported LNG. The import price is effectively constant at $21/GJ in real terms because New Zealand is a global price taker and not large enough to materially change world LNG prices.

In both counterfactual scenarios, we assume industries know with a reasonable degree of confidence that natural gas prices will continue to rise above the baseline and hence start to purchase more machinery to support electrification. We assume they do this ahead of time to spread out their transition costs.[6]

To model this, we exogenously shock industries' demand for investment in machinery and equipment. The higher the share of gas in an industry's cost vector, and the higher the price of gas relative to the baseline, the larger the increases in investment.

Effectively this results in gas-intensive industries having a degree of 'duplication' in their capital stock – that which continues to be used for gas and additional capital that is being readied for electrification. As the electrification capital is not generating a return immediately[7], the rate of return on the industry's total capital stock declines. This can be characterised as a negative technological change shock in investment that results in less efficient production.

As noted in section 1.2, we do not model the construction impacts and funding costs of building an LNG terminal. It was not clear at the time of designing the scenarios how costly the terminal might be or how it would be funded. Implicit in our LNG terminal scenario design is that the price paid for imported gas includes some portion for cost-recovery.

3.4. A reminder

We emphasise that these are hypothetical scenarios, based on discussions with officials, to illustrate how higher gas prices, with and without an LNG terminal, might affect New Zealand's economy, regions and industries. We have used our professional judgement to design scenario shocks that characterise why prices rises and how industries might respond.

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[6] Consultation with industry stakeholders for this project emphasised the importance of ensuring the modelling captured the additional capital costs of fuel switching. This is one approach to capturing those effects. Since we do not model at the individual firm level, the fuel-switching shocks can be considered as averages for each industry, with some firms being enthusiastic early movers and other being laggards who are prepared to hold off investing more despite higher gas prices being expected.

[7] Even as industries switch fuel sources, it is reasonable to assume that gas-powered machinery will still have some years of useable life (and hence depreciation) remaining. This adds to industries' cost bases. The duplication impacts reduce over the ten-year projection period as an increasing amount of older capital reaches the end of its working life and is swapped out for newer capital. If we extended the modelling out past 2035 to cover a full investment cycle, this new capital would start delivering productivity gains rather than being a drag on output.

Reasonable people can disagree about how fast or how high prices might rise, and precisely how industries (or specific firms within industries) will react. It is not possible to capture every firm's likely response in an economy-wide model, and we might expect individual firm take-up of alternative technologies to distributed around the 'average' shocks we conceptualise here.

Alternative scenario specifications and shocks can be explored in future research.

3.5. Model closure assumptions

Not to be confused with shutting down of firms or whole industries, the 'closure' of a CGE model refers to the elements that we tell the model about (exogenous variables) and those which we want the model to tell us about (endogenous variables). In addition to the model settings described above in the scenario design, we use a standard set of core closure assumptions, including:

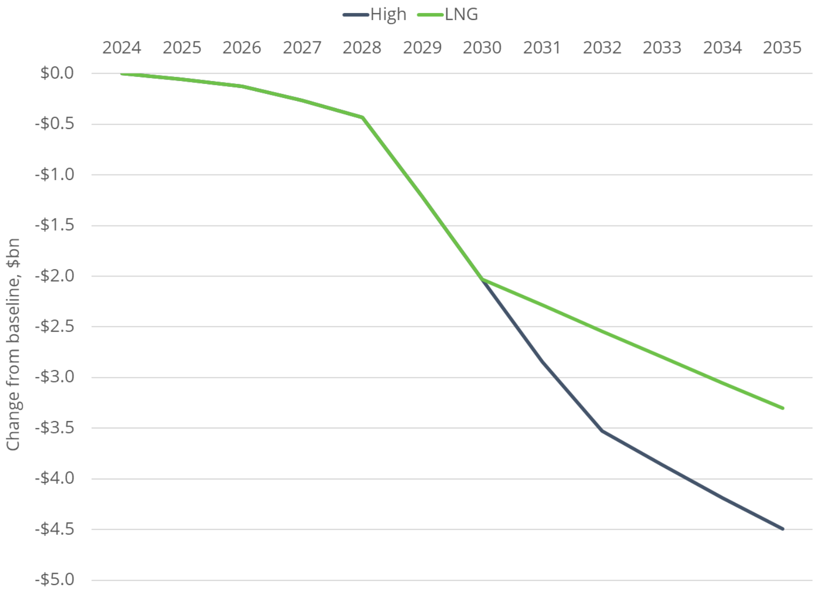
- The fiscal balance as a share of GDP in the policy scenarios remains the same as in the baseline, with indirect taxes as the adjusting variable.
- The balance of trade as a share of GDP in the policy scenarios remain the same as in the baseline, with the real exchange rate adjusting to ensure this holds.
- The economy is linearly transitioning to its Net Zero targets, with economy-wide ETS emissions exogenised and the ETS unit price varying to clear the emissions market (i.e. how much emissions can be generated by each industry).

4. Results

Based on the scenarios designed with officials and our choices around how to implement them in the model, this section outlines the key modelling results. All results are in percentage change or $ billions relative to the baseline projections, unless otherwise stated.

4.1. Economy-wide impacts

FIGURE 2 CHANGE IN REAL GDP RELATIVE TO THE BASELINE, $BN



SOURCE: CGE MODELLING

GDP is lower than the baseline in both counterfactuals…

Higher-than-baseline gas prices without an LNG terminal lead to New Zealand's real GDP being $4.5bn (0.96%) below baseline by 2035. This GDP result is driven by several factors:

(i) Despite additional investment in electrification machinery, overall investment across the economy falls relative to the baseline. As energy prices rise, higher production costs eat into industries' margins, leaving them less to invest. In addition, the temporary duplication of part of the capital stock as industries invest ahead of time in electrification equipment reduces overall rates of return on capital.

(ii) As the economy grows more slowly, the demand for labour softens. This is initially seen through lower aggregate employment. Over time, employment starts to return to its baseline level and the weaker labour market is seen through lower-than-baseline real wages. Lower wages and employment cause household incomes to fall below the baseline, curbing household spending after 2027.[8]

(iii) Declining domestic output of gas-intensive industries (see section 4.2) sees more imports of inputs that New Zealand still requires, such as fertiliser. Much of the new equipment required for electrification will also be imported. This sees imports rise slightly above the baseline.

(iv) The slowing growing economy reduces tax revenue, and under our closure assumptions, government expenditure moves proportionately down with it.

There is a very small increase in economy-wide export volumes early in the scenarios. While this may feel counterintuitive, given some gas-intensive industries are also exporters (e.g. wood processing), it occurs because:

- As the trade balance is fixed as a share of GDP, the increase in imports described above needs to be paid for with increased exports. To sell more exports, the real exchange rate declines.
- This depreciation, along with lower real wages, benefits labour-intensive exporters such as those in the tourism sector. The additional exports from these labour-intensive industries more than offsets the decline in gas-intensive industry exports.

As Figure 3 and Figure 4 show overleaf, the GDP impacts are primarily driven by the investment results. This feels intuitively sensible – the transition towards a lower fossil-fuel future may involve non-trivial adjustment costs.

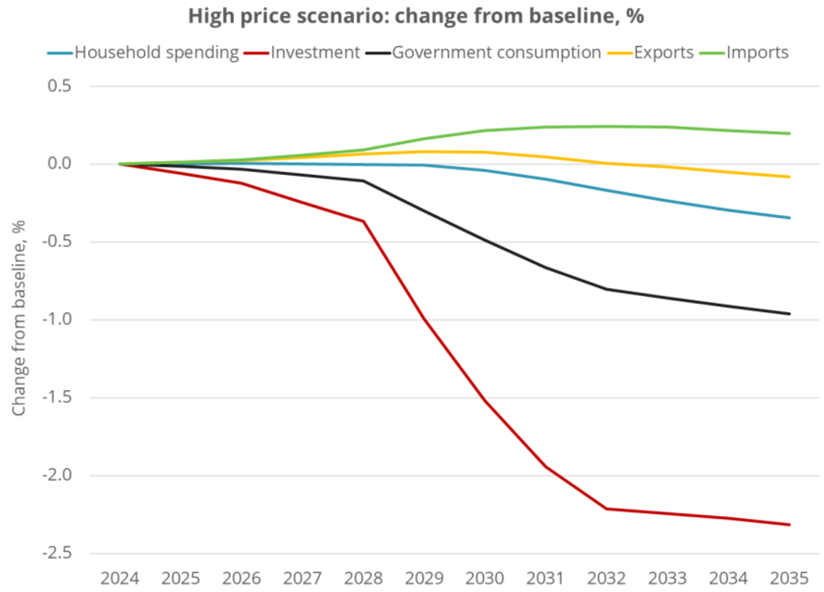
…but an LNG terminal moderates the impacts

When an LNG terminal is in place by 2030, an increase in domestic gas prices tilts demand towards imported gas (the price of which holds steady in real terms). This 'takes the top' off the impacts described above, as summarised in Figure 5.

Real GDP declines by $3.3bn (0.71%) relative to baseline in 2035, compared to $4.5bn (0.96%) in the High price scenario.

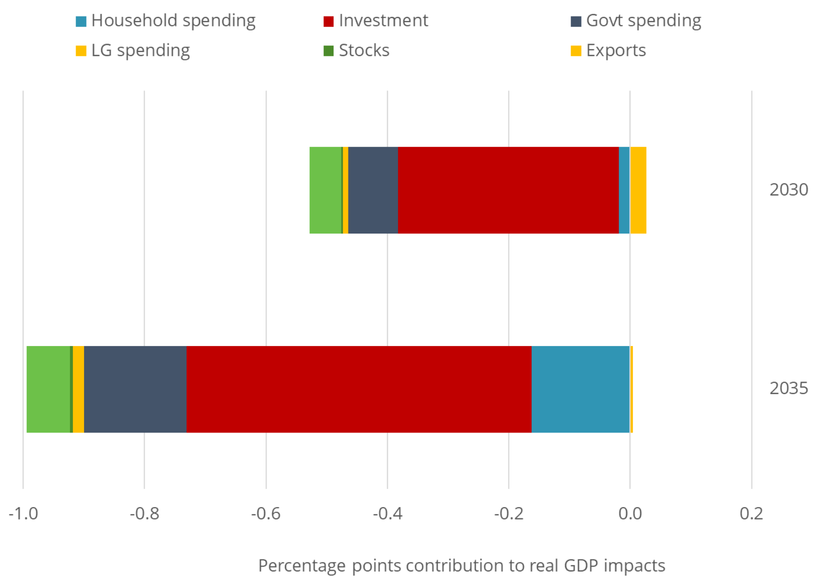
[8] Household spending is very marginally above baseline in the early part of the projection. This is because with lower investment demand, economy-wide savings increases, some of which is directed towards purchasing more goods and services. The average propensity to consume rises very slightly. Further out, the deteriorating labour market outcomes drive the results.

FIGURE 3 MACROECONOMIC INDICATORS, % CHANGE FROM BASELINE, HIGH PRICE SCENARIO



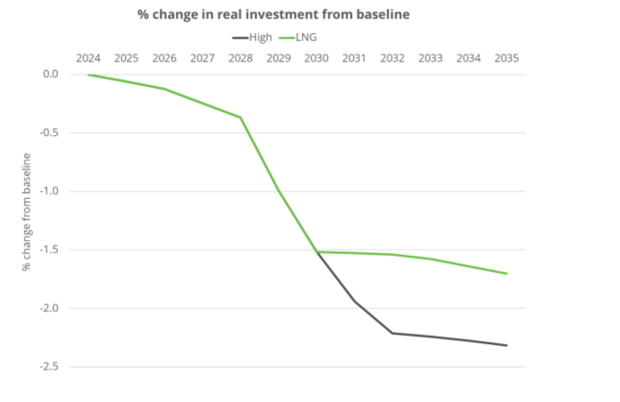
SOURCE: CGE MODELLING

FIGURE 4 DECOMPOSITION OF 2030 & 2035 REAL GDP IMPACTS, HIGH PRICE SCENARIO

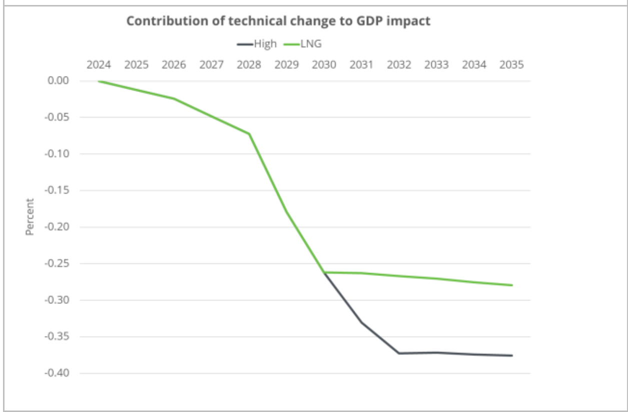


SOURCE: CGE MODELLING

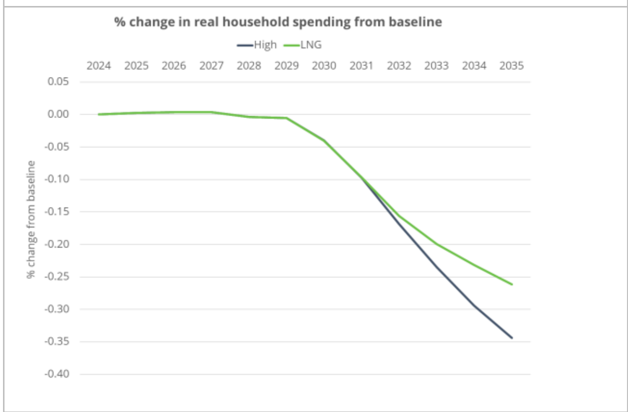
FIGURE 5 COMPARISON OF HIGH PRICE AND LNG SCENARIO DRIVERS



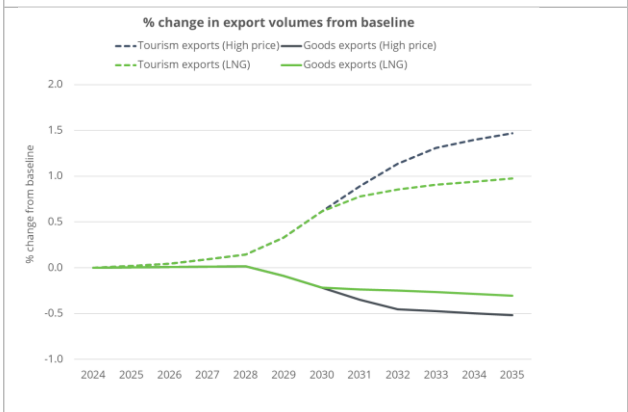
Investment still declines, but gas-intensive industries' output and margins are less affected than in the High price scenario so the overall effect is less severe.



Industries invest slightly less in electrification machinery, which removes some of the negative efficiency effects due to duplication.



Employment and real wage declines are lower, moderating the decrease in household spending.



Tourism exports benefits slightly less as real wages don't decline as much as in the High price scenario, and the exchange rate depreciates slightly less.

Labour market impacts: employment drops first, then real wages

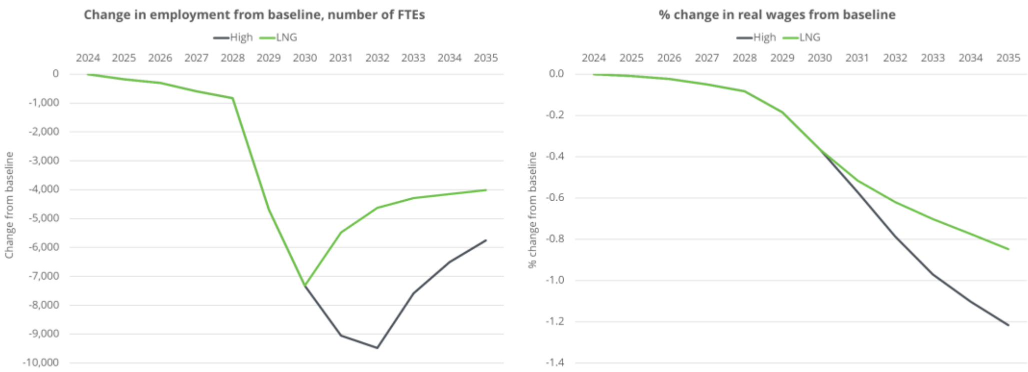
Under our 'sticky wage' labour market dynamics, a decline in the demand for labour is initially felt through declining employment. As gas prices rise through to the early 2030s – and especially over the 2028-2032 period in the High price scenario – the economy grows slower than in the baseline. As output falls relative to the baseline, firms need fewer workers.

The employment impacts bottom out at around 9,500 FTE jobs (0.3%) below baseline economy-wide by 2032 in the High price scenario. IN the LNG scenario, output declines less, meaning the number of FTE jobs falls by around 7,300 in 2030 and 4,600 in 2032.

Further out in the projection period, employment starts to return towards its baseline level. This is because in the longer run, employment is determined mainly by the size of the labour force (and hence population growth).

When this starts to happen, softer labour demand manifests itself through lower real wages (between 0.85% and 1.22% below baseline by 2035). This reflects the fact that while workers may be able to find new jobs as industries adjust to the gas price shocks, these jobs may not be as highly paid as their previous roles.

FIGURE 6 LABOUR MARKET IMPACTS, CHANGE FROM BASELINE



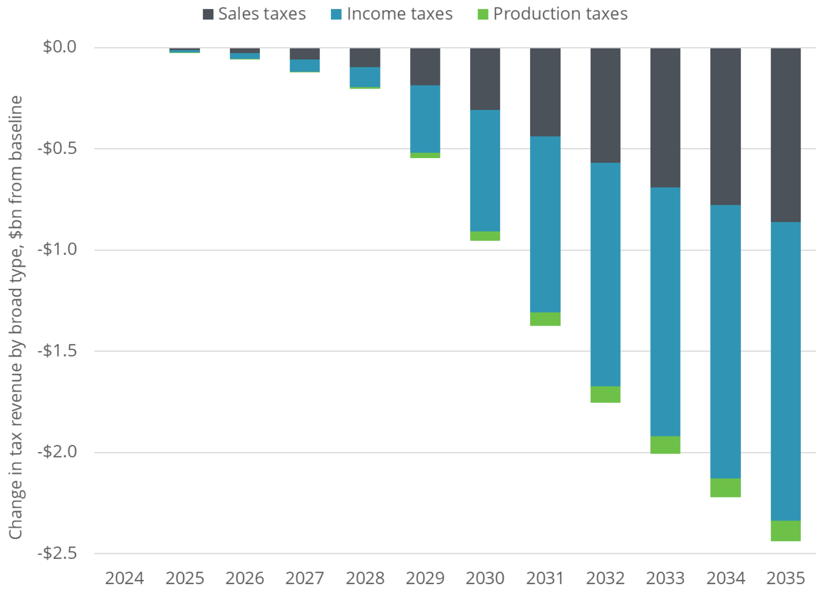
SOURCE: CGE MODELLING

Slower economic growth decreases tax revenue

As company and household incomes drop, government revenue from company and income tax follows suit. Declining household incomes also lead to consumers spending less on goods and services, making GST revenue softer. Production taxes, which include ETS revenue from activity CO2 emissions and energy resource levies, decline marginally due to weaker overall economic activity.

The overall tax revenue declines are between $1.8bn below baseline (LNG scenario) and $2.5bn (High price scenario).

FIGURE 7 TAX REVENUE IMPACTS OF HIGH GAS PRICES, HIGH PRICE SCENARIO



SOURCE: CGE MODELLING

4.2. Industry impacts

We focus initially on the negative impacts of higher gas prices on New Zealand's industrial base, before looking at other parts of the economy that benefit as relative prices change and resources move to their highest value uses.[9]

Higher gas prices affect relatively few industries…

Natural gas is used intensively by a relatively small number of industries, such as gas electricity generation and supply, chemicals manufacturing, polymer and rubber manufacturing, fertiliser and pesticide manufacturing, metal product manufacturing, and dairy processing (at least historically) – see Figure 8.[10]

Most industries use no or very little gas directly. To give a sense of scale, the commercial services and government services sectors account for over 2/3 of New Zealand's GDP, and they use just 3.7% of the combined output value of the gas and natural gas industries.[11]

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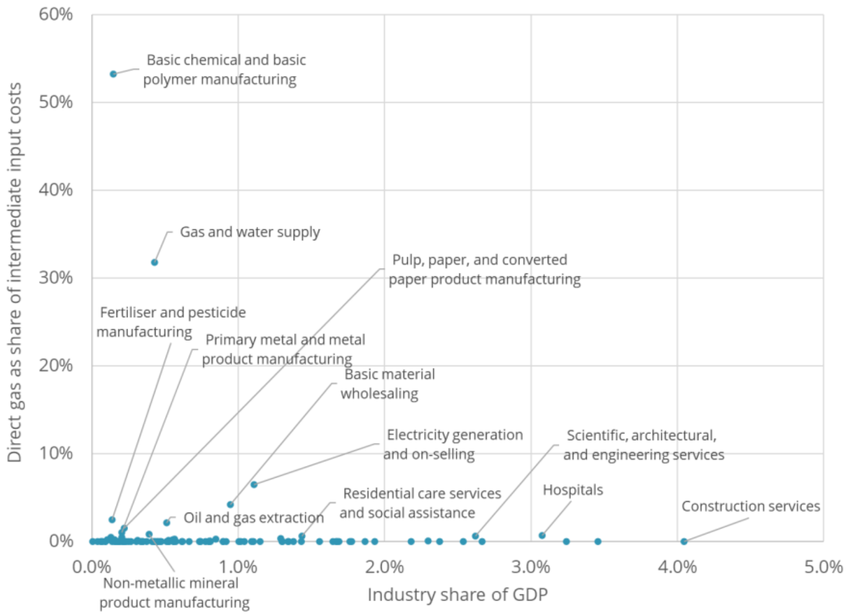
[9] It is not practical to show 81 sets of industry impacts for each scenario for each of the 10 years of the projection period. These results can be provided in spreadsheet form on request.
[10] The industry names in the chart differ slightly from those in our CGE database, as we have aggregated some sectors and split out others.
[11] Based on StatsNZ's 2020 input-output tables. The precise shares will have changed since then, but the point being made will still hold.

FIGURE 8 INDUSTRY USE OF GAS VS SHARE OF ECONOMY



SOURCE: STATSNZ INPUT-OUTPUT TABLE, YEAR ENDED MARCH 2020

… and much adjustment has already happened

It is important to note that our baseline captures:

(i) Historical changes in industry output, including recent declines in the output of gas-intensive industries such as wood processing, pulp and paper manufacturing, basic chemicals manufacturing (which includes Methanex) and fertiliser and pesticide manufacturing (which includes Ballance).

(ii) Assumed future demand-side responses to high gas prices, including the closure of Methanex and Ballance and the electrification of dairy processing boilers.

As such, higher gas prices will be felt by a smaller part of the industrial base (in terms of share of the economy) than would have been the case five or ten years ago.

Gas-intensive industries and their supplying industries suffer most

Figure 9 overleaf shows the negative impacts of higher gas prices on value-added[12] in selected industries of interest, in both counterfactual scenarios.

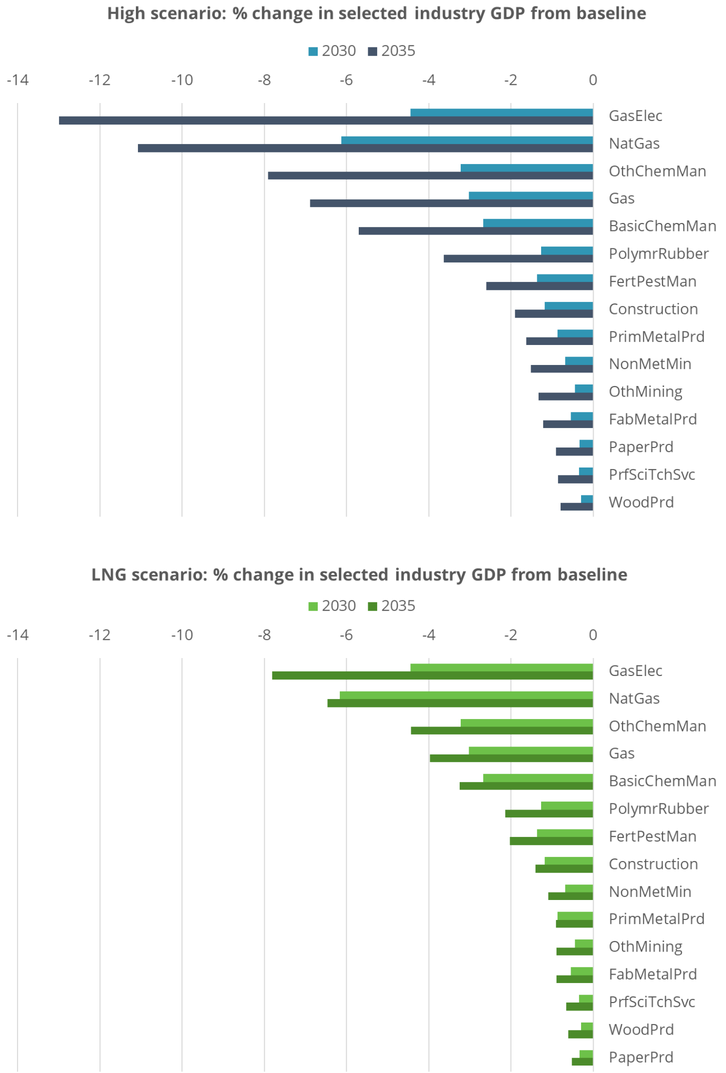
The largest declines in industry value-added include Gas electricity generation, Natural gas extraction and Gas distribution. Gas-intensive manufacturing industries such as Basic chemicals, Other chemicals, Polymer and rubber, Fertiliser and pesticide and Metal products.

Supplying industries to gas-intensive users also suffer, including Construction services and Professional, scientific and technical services. Output declines are moderated in the LNG

[12] Essentially equivalent to industry GDP.

terminal scenario as gas users are partially shielded from what would otherwise be very high domestic gas prices.

FIGURE 9 NEGATIVE IMPACTS ON VALUE-ADDED OF SELECTED INDUSTRIES, % CHANGE FROM BASELINE IN 2030 AND 2035



SOURCE: CGE MODELLING

Gains to the renewable energy sector and labour-intensive export industries provide a degree of offset

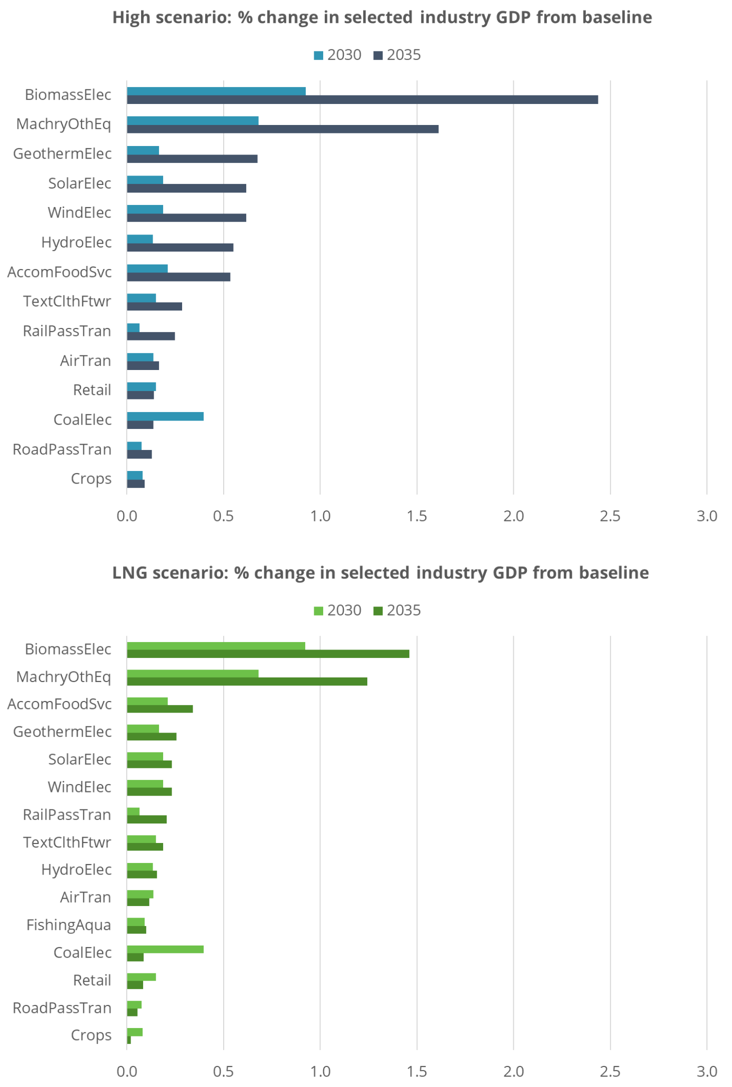
Ongoing high gas prices push users towards relatively cheaper sources of energy, including biomass electricity, geothermal, solar and wind electricity, which sees their output expand relative to the baseline.[13] Coal-fired generation also grows slightly.

[13] Some industries also have access to biomass as a direct fuel source.

Other 'winners' include export industries that use a lot of labour (which becomes relatively cheaper as real wages decline), especially those in the tourism sector such as Accommodation and food services, Air transport and Retail. The real exchange rate depreciation supports these export industries too.

The Machinery and other equipment manufacturing industry benefits from the additional capital spending of gas-intensive users that are investing ahead of time in electrification equipment.

FIGURE 10 POSITIVE IMPACTS ON VALUE-ADDED OF SELECTED INDUSTRIES, % CHANGE FROM BASELINE IN 2030 AND 2035



SOURCE: CGE MODELLING

4.3. Regional impacts

In this top-down CGE modelling exercise, the regional economic impacts shown in Figure 11 depend largely[14] on:

(i) The national-level industry output changes.

(ii) The shares of each industry in each region.

Nuances such as the movement of labour between regions and inter-regional trade are not captured in this approach but can be considered for future research using a bottom-up CGE model.

4.3.1. Regional GDP impacts

Unsurprisingly given its relatively gas-intensive industry composition, including the extraction of natural gas itself, Taranaki suffers most, with its real GDP falling between 3.2% to 5.3% below baseline by 2035. This may not sound particularly large, but as noted above the regional economy has already borne the costs of earlier high prices and the projected baseline include further assumed demand-side declines.

Wellington is the next most negatively affected. This is not due to its reliance on gas-intensive industries, but rather its concentration of central government workers (government services contract relative to the baseline as tax revenue declines), health and social services, construction services and professional services firms (which slow as the broader economy slows). These industries account for over 2/3 of Wellington's GDP decline by 2035.

Unlike many other regions, Wellington does not get much of an offsetting boost from tourism or other export industries as those are collectively a small part of the overall economy.

The services sector story is similar for Auckland, although it has a larger tourism and retail sector and some manufacturing exporters.

For the rest of New Zealand's regional economies, the impacts are relatively modest – around 0.5% to 0.9% below baseline by 2035 in the High price scenario.

The least affected region is Marlborough. Its manufacturing sector is not directly exposed to gas and its economy has a relatively large share of labour-intensive and/or export industries (tourism, retail, seafood processing, wine, etc.)

These regional patterns are the same in the LNG scenario, albeit slightly less negative for all regions, and markedly less bad for Taranaki.

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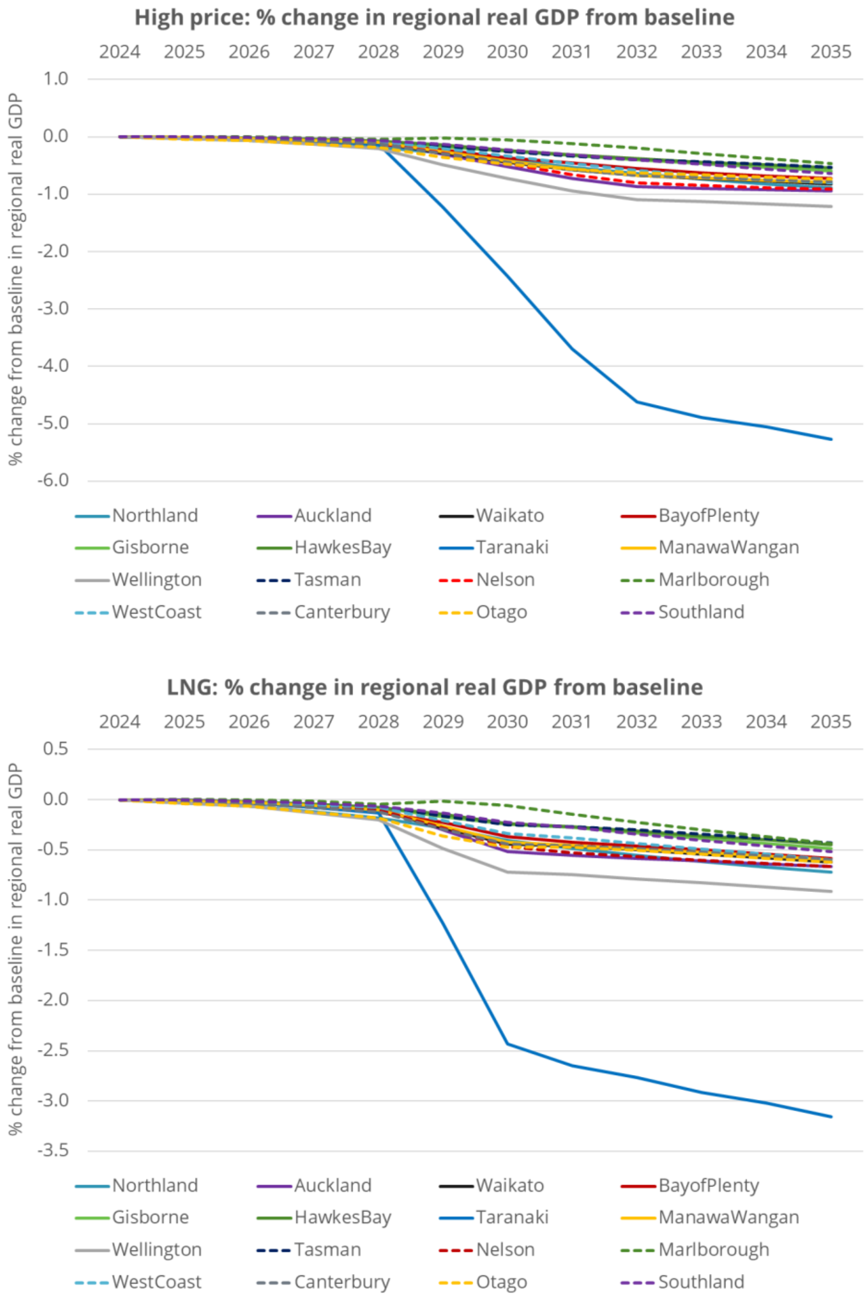
[14] We say largely because regional commodities are designated either as 'local' or 'national' products. 'Local' goods and services tend to be produced and consumed locally (e.g. restaurants and personal services such as haircuts). 'National' goods are impacted more by national economic drivers that affect all regions (e.g. manufacturing commodities).

FIGURE 11 REGIONAL IMPACTS OF HIGHER GAS PRICES



SOURCE: CGE MODELLING

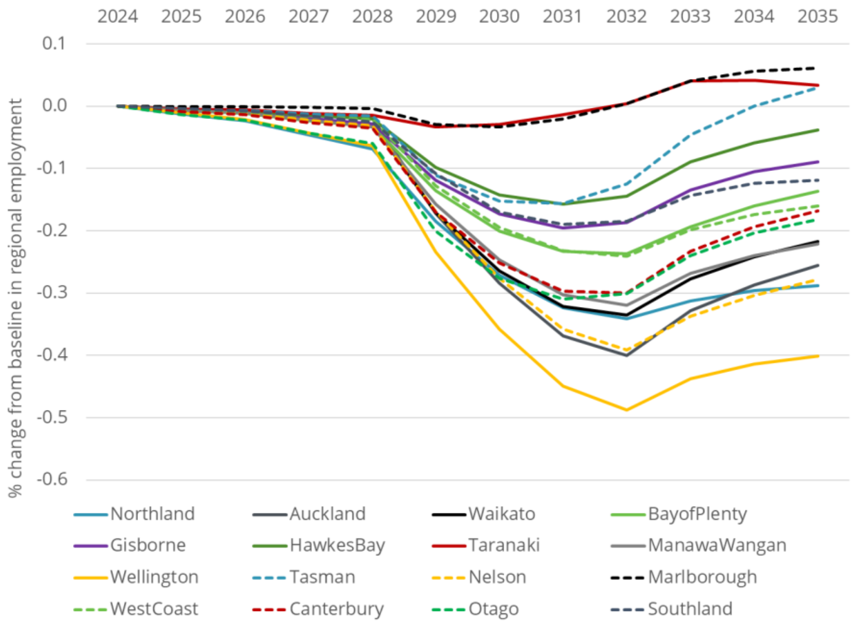
4.3.2. Regional employment impacts

As noted earlier in section 4.1, the employment impacts of higher gas prices are perhaps lower than might have been expected. This is because:

- The most heavily affected industries are capital-intensive, not labour-intensive. Given the output declines modelled are not enormous, reduced output does not necessarily lead to a huge number of jobs being cut.
- Real wages decline over time, meaning labour becomes cheap relative to capital. This encourages firms wanting to expand to take on more staff, at the margin.
- Our representation of the labour market allows workers to move between industries over time. It doesn't happen instantaneously as would occur if full employment in all periods was assumed, but over a period of years it is reasonable to think most laid off workers could find a different job elsewhere in the economy, albeit possibly with lower wages.[15]

At a regional level, employment drops by up to 0.5% below baseline in the High price scenario (Figure 12), and up to 0.35% below baseline in the LNG scenario (not shown but the same pattern at a lower level), both in the early 2030s.

FIGURE 12 REGIONAL EMPLOYMENT IMPACTS, % CHANGE FROM BASELINE, HIGH PRICE SCENARIO



SOURCE: CGE MODELLING

[15] This is very different to multiplier-type modelling exercises that do not have a time dimension and cannot capture workers finding new jobs if they lose theirs. For more on the limitations of multiplier modelling, see Australian Bureau of Statistics. 2021. 'Using I-O tables for analysis' which concludes: "While I-O multipliers may be useful as summary statistics to assist in understanding the degree to which an industry is integrated into the economy, **their inherent shortcomings make them inappropriate for economic impact analysis**. These shortcomings mean that I-O multipliers are likely to significantly overstate the impacts of projects or events. More complex methodologies, such as those inherent in Computable General Equilibrium (CGE) models, are required to overcome these shortcomings" (para 22.154, emphasis added).

In these scenarios, the employment impacts in each region are primarily driven by how much they rely on labour-intensive industries – especially those exporting:

- Wellington generates mainly non-tradable services jobs (government, healthcare, construction, professional services). These industries suffer as the economy slows below the baseline due to high gas prices. The region has relatively few labour-intensive export industries, so misses out on their growth.
- Marlborough, in contrast, gains jobs in beverage and tobacco manufacturing (read wine), seafood processing, retail, accommodation and food services (via tourism), crops and food processing – all important regional growth drivers that are labour-intensive and externally-focused.

The very modest employment decline in most years in Taranaki may raise eyebrows, given the significant and high-profile structural changes it has been through in recent years. But that is perhaps the key point – our baseline scenario takes into account painful pre-2025 adjustments *and* incorporates the closure of Ballance and Methanex out to 2029. These impacts are 'baked' into the baseline and won't show up as changes in the counterfactual scenarios.

At the risk of repetition, most of the negative impacts in Taranaki occur in capital-intensive industries, where mass lay-offs over and above those that are included in the baseline, are unlikely. The declining cost of labour also supports the re-employment of laid off workers elsewhere in the economy over time, albeit at lower real wage levels.

5. Summary and potential next steps

This report has explored the national, regional and industry economic impacts of illustrative higher gas price paths, both with and without an LNG terminal. Based on the numerous assumptions we have made in our scenarios, the key findings can be summarised as:

- Ongoing high gas prices will act as a drag on the economy, causing investment and household spending to fall relative to the baseline as profits and household incomes decline, respectively.
- The New Zealand economy will still grow across the next decade, but marginally more slowly than if gas prices held relatively steady as in the baseline.
- The transition away from gas has been – and will be – painful for specific firms and communities, especially in Taranaki.
- But much adjustment has already happened, is underway (e.g. Fonterra's electrification plans) or is assumed to occur in both the baseline and counterfactual scenarios (e.g. closure of Methanex and Ballance). This means much of the economic costs of higher gas prices have already been borne by industries and regions. The gas price paths we consider in our counterfactual scenarios have relatively modest *additional* economic impacts.
- Most of the New Zealand economy has very limited exposure to gas price fluctuations. Over 75% of the economy is in services, which use little gas; only around 5% of the economy is (directly) gas-intensive.
- Higher than expected gas prices without an LNG terminal in place will see the New Zealand economy being around 1% smaller than baseline by 2035.
- The availability of an LNG terminal from 2030 onwards dampens the negative impacts to 0.7%, a GDP 'saving' of $1.2bn by 2035.
- The number of FTE jobs economywide falls by around 9,500 below baseline by 2032 in the High price scenario. Under the LNG scenario, job losses are moderated, falling by around 7,300 below baseline by 2030. Real wages decline by between 0.85% (LNG scenario) and 1.22% (High price scenario) below baseline in 2035.
- Slower growth also reduces tax revenue. The modelled tax revenue decline is $2.5bn below baseline in the High price scenario and $1.8bn in the LNG scenario.

We conclude with a caveat – these are not cast-iron predictions of what will happen. There is much uncertainty about the likely future price path for gas; the availability, cost and suitability of alternative energy sources for industry; the nature of technological change and how it may affect New Zealand's industrial structure; and a host of other factors.

With more time and resources, these uncertainties could have been analysed through more scenarios and sensitivity analysis around key parameters (e.g. the world LNG price).

That said, we are confident that the reported impacts, both negative and positive, are indicative of the direction and magnitude that could be expected given the assumptions made and scenarios analysed.

Further work might usefully dig deeper into energy switching possibilities at the industry level and the costs associated with them. A bottom-up regional modelling exercise would allow for the movement of resources between regions (or even outside of New Zealand in the case of labour) in response to structural change, which would add greater realism and nuance. There may also be value in exploring longer projection timeframes that allow industries and factor markets to fully adjust to ongoing energy price shocks.

Appendix A GSM-NZ model

Origin of GSM-NZ

The Global Systems Model of New Zealand (GSM-NZ) model is a highly advanced and flexible dynamic Computable General Equilibrium (CGE) model. It was developed for Sense Partners in 2019 by Dr Ashley Winston of Phylleos Inc. in Washington, D.C.

The GSM-NZ modelling suite[16] is built on the foundation of the pathbreaking and proven US GSM model. Versions of the GSM modelling framework have informed key policy reform and other economic matters in dozens of countries, including advising The White House on US biofuels and other energy reform issues.

GSM-NZ has a lineage that traces back to the MONASH dynamic CGE model developed by the Centre of Policy Studies, then at Monash University, now at Victoria University, Melbourne.[17] Dr Winston implemented several improvements to the MONASH model as a PhD student under the tutelage of Professor Peter Dixon in the late 1990s/early 2000s.

Dr Winston continued developing dynamic CGE models throughout the next two decades, including the USAGE model of the US economy[18] and the FLAGSHIP suite of models for over 20 countries, before building and continually extending the proprietary GSM suite of models from 2015.

GSM-NZ is built and run in the GEMPACK software suite.[19]

We have used GSM-NZ[20] for several New Zealand clients including MBIE (on electricity prices, Accelerated Depreciation and biofuels mandates), Transpower, MoT, KiwiRail, Oji Fibre Solutions, New Zealand Climate Forestry Association, The Treasury, Auckland Airport, and a group of Economic Development Agencies.

What is a CGE model?

CGE models are commonly used tools for policy analysis. Such models typically consist of:

1. A **database** that represents an economy in a certain year based on input-output (IO) tables. The database specifies the interactions and relationships between various economic agents including firms, workers, households, the government and overseas markets.

[16] We use "suite" because we have a variety of modelling solutions, including comparative static, recursive dynamic, top-down regional, and bottom-up regional versions, with different levels of industry and commodity detail.
[17] See https://www.copsmodels.com/monmod.htm. Full documentation is in Dixon and Rimmer (2002b).
[18] See https://www.copsmodels.com/usage.htm. Dixon and Rimmer (2002a) has the technical documentation.
[19] See Horridge et al (2018).
[20] Earlier versions of GSM-NZ were called MDG-NZ.

2. Behavioural **parameters** governing agents' responses to relative price changes (e.g. elasticities).[21]

3. A **system of equations** that define the model specification or theory, which is generally based on standard neoclassical economic assumptions[22], but not necessarily constrained by them.

A CGE model considers the entire economy as an inter-linked system

GSM-NZ explores how the entire economy adjusts over time to changes in policy settings or shifts in the economic environment. It captures the interlinkages between industries, households, government, workers, investors, export markets, etc ('economic agents') and the greenhouse emissions associated with production and consumption.

A key benefit of CGE models is that they explicitly take resource constraints into account. In any year, the amount of labour, capital, land, energy and intermediate inputs to production are fixed, and resources flow to their most valuable use.

This means there are 'no free lunches' in any period. If one industry uses more of an input as demand for its good or service rises, there is less available to other industries and its price will rise for all users.[23] There will always be winners and losers in a CGE modelling exercise.

In its initial baseline (or BAU) equilibrium, in every year:

- Supply equals demand for all commodity outputs (i.e. goods and services) and intermediate inputs (including electricity).
- Supply equals demand in all factor markets (i.e. labour, capital, land, natural resources).[24]
- The economy is on a pathway to meet its Net Zero emissions targets.

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[21] We rely on published studies for elasticity estimates to calibrate GSM-NZ. Elasticities are set at values widely understood to be valid in the modelling community and can be replaced by country- or industry-specific estimates where available for specific projects.
[22] Alternative theoretical specifications can be incorporated as required.
[23] The exception is if the scenarios include technological change or efficiency/productivity improvements. In this case, the crowding out effects are moderated.
[24] However, in practice we allow for periods where labour demand and supply can be temporarily unbalanced, recognising that labour markets do not clear perfectly or immediately all the time.

In addition, a novel feature of GSM-NZ is the inclusion of "slack capital" capabilities for dynamic projections using nested complementarity relationships. This allows for endogenously determined proportions of productive capital stocks and other "fixed" factors (like land and other natural endowments) to become idle at low rates of return during periods of falling demand. Along with the labour market treatment described above, the modelling suite is capable of more realistic dynamic simulations through the business cycle, tempering a standard dynamic CGE tendency to create unrealistically fast recoveries from downturns in response to low primary factor prices.

- Firms use intermediate inputs and factors of production (land, labour, capital, etc.) to minimise the costs (or maximise the profits) of producing a given amount of output. The choices of inputs used are governed by multiple layers of 'nests' of production technologies.[25]
- Firms make normal profits, so output prices equal the costs of production (including returns to capital, labour, land, natural resources, etc.).
- Households maximise utility by using their disposable incomes to buy goods and services and saving some of that income to fund future consumption.
- Government spending equals tax revenue plus any assumptions around borrowing (which must be funded via interest payments) and the fiscal balance.
- Export revenue less spending on imports determines the balance of trade, which must either be balanced via changes to the exchange rate or accompanied with increases in overseas borrowing.

Baseline and counterfactual scenarios

In our dynamic model, we first develop a BAU or baseline scenario and then 'shock' it off its equilibrium to reflect different scenarios. See sections 3.1 and 3.3 for explanation of the baseline and counterfactual scenarios in this project.

Changes in industry, investor or household behaviour in future scenarios are driven primarily by changes in relative prices (that is, the price of one good or service, or factor of production, relative to another). Each relative price shift has multiple flow-on effects, which filter through industries and the wider economy. For example:

- A shift in export demand towards more sustainably-produced products will push up the world price of (say) New Zealand's clean aluminium. This induces greater production by the aluminium industry.

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[25] A multi-nested production structure represents the way firms transform intermediate inputs and primary factors into output through a hierarchy of nested production functions. This structure reflects economic substitution possibilities at different levels of the production process.

At the top level, firms decide between intermediate inputs and a composite of primary factors. Within intermediate inputs, further nests group domestic and imported varieties using a CES (Constant Elasticity of Substitution) function. Primary factors (e.g., labour and capital) are similarly nested to allow for substitution and factor-specific technological change. This allows GSM-NZ to reflect observed economic behaviour, such as a firm substituting imports for domestic goods when relative prices change due to trade policy or exchange rate movements.

Deeper levels of the nesting hierarchy capture the technological and behavioural relationships *within* input bundles. For example, within intermediate inputs, a nest distinguishes between energy and non-energy goods, with further sub-nests separating electricity, gas and fuel. Similarly, within the primary factor nest, capital is disaggregated into industry-specific capital types. Labour is divided by occupation.

- More aluminium production requires more inputs (unless it's all due to a productivity improvement). The demand for electricity rises, pushing up its price.
- This higher price for electricity pushes other electricity-using industries (e.g. pulp and paper) to either reduce output or seek other inputs to use instead to maintain output levels.
- Higher aluminium exports lead to overseas buyers purchasing more New Zealand dollars. This pushes up the nominal exchange rate (the price of New Zealand's currency), which in turn makes other exporters less competitive.
- Other exporters reduce their output, including in labour-intensive industries such as tourism or tertiary education. This puts downwards pressure on wages (the price of labour).
- Relatively cheaper labour benefits the labour-intensive, non-tradable part of the economy, such as personal services like hairdressing or food services (restaurants, bars, etc.).
- Due to the exchange rate appreciation, imports become cheaper. This benefits households as the purchasing power of their wages rises. And it benefits industries using a lot of imported materials, such as road passenger transport (for both vehicles and petrol/diesel) and construction.

The chain of logic extends a long way. In any scenario, there are many thousands of prices changes – some of which we input into the model as exogenous variables as 'shocks', and others which adjust as the economy reacts.

In each scenario, unless we tell the model otherwise, the price of every input to production changes, as does the price of every industry's output.

These price changes flow into the demand functions of households, overseas buyers, investors and the government sector. The extent of changes in quantities demanded and supplied as prices move – behavioural change – is determined by thousands of elasticities of demand and elasticities of substitution. The larger the elasticity, the more demand or supply adjust. Each industry or economic agent has its own set of elasticities.

Results represent the difference between the initial and new equilibriums

Following the introduction of shocks to represent different scenarios, supply and demand iteratively adjust across commodity and factor markets until a new equilibrium is reached.

The results are reported as deviations – that is, as the difference between the baseline results and the policy simulation results for each variable. This enables us to report results that capture only the impact of the scenario shocks themselves.

The model produces results for every year, including macroeconomic aggregates (e.g. GDP, household spending) and a huge amount of detail at the industry level – output, value added, exports, employment and wages, capital investment, etc.

The model's results are generally presented as percentage changes from the baseline, but it also generates certain impacts as changes from the baseline in 'ordinary' or levels measures (dollars, PJs, MT CO_2-e, etc.)

We focus on the headline macroeconomic and regional results and industry impacts in our reporting and are happy to provide more detailed results in supporting spreadsheets to support your analysis and advice.

Key dynamic features of GSM-NZ

GSM-NZ contains four key dynamic mechanisms that link successive years:

1. The deviation in the real wage rate away from its forecast path in year *t* caused by a policy shock equals the deviation in year *t-1* plus a term reflecting the gap in year *t* between the employment deviation and the deviation in labour supply. That is, real wages deviate from the baseline based on the gap between the changes in the labour supply and employment caused by a policy shock.

   Real wages are sticky in the short term, meaning labour market impacts are felt more through changes in employment. Further out in the projection period, employment gradually returns to the baseline, meaning impacts are more commonly seen through real wage changes.

2. Capital at the start of year *t* equals capital at the end of year *t-1*.

   Capital stock in an industry at the end of year *t* equals the capital stock at the start of year *t,* depreciated at a given rate, plus investment in year *t* for that industry.

   Investment in year *t* for an industry is a function of the expected rate of return (i.e. gross operating surplus) in that industry. The expected rate of return is a function of the rental and asset prices of that industry's capital in year *t*, depreciation, taxes on capital, and expected changes in those variables.

3. Net foreign liabilities at the start of year *t* equal net foreign liabilities at the end of year *t-1.* Net foreign liabilities at the end of year *t* equal net foreign liabilities at the start of year *t* plus the current account deficit for year *t.*

   The current account deficit for year *t* is imports less exports plus interest payments for foreign liabilities less exports of royalties, and less net transfers from foreigners to New Zealand residents.

4. Public sector debt at the start of year *t* equals public sector debt at the end of year *t-1*.

   Public sector debt at the end of year *t* equals public sector debt at the start of year *t* plus the public sector deficit for year *t*.

Database aggregation for this project

In the interests of reducing computational time for solving the model, we have aggregated and diagonalised the database in this project to 81 single-product sectors.[26]

The greenhouse gas emissions associated with each sector's activities, and those of end users such as households, are also incorporated into our database.

The database for this project incorporates:

- 81 single-product industries, comprising:
  - 12 primary sector industries and primary processing industries
  - 4 extractive industries
  - 14 industrial manufacturing industries
  - 15 fuel industries
  - 8 types of electricity generation[27], plus an electricity distribution industry
  - 3 utilities industries
  - 7 freight and passenger transport and logistics industries
  - 17 government, business and recreational services industries.
- 10 natural resource endowments[28]
- 18 energy/fuel types[29]
- 17 types of greenhouse gas emitting activities[30], producing 8 different gases[31]
- 8 labour market occupations[32] in each industry
- Dozens of different tax and government spending instruments.

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[26] We have aggregated many of the dozens of services industries in the database, as they are not so crucial for this project.
[27] Hydro; Geothermal; Wind; Solar; Gas; Coal; Oil; Biomass.
[28] Forests; Fish; Coal; Oil; Gas; Metals and minerals; Arable land; Semi-arable land; Marginal land; Non-arable land.
[29] Coal, coke, and tar products; Natural gas; Petrol; Diesel; Advanced Aviation Fuel; Heavy Fuel Oil; Other Petroleum Products; Ethanol; Biodiesel; Advanced Marine Fuel; Biomass Fuel; Hydrogen; Light Vehicle Fuel blend; Heavy Vehicle Fuel blend; Aviation Fuel blend; Marine Fuel blend; Manufactured gas.
[30] Enteric fermentation; Manure management; Ag soils - excreta + other; Ag soils – fertiliser; Urea - CO2; Liming; Field burning; Coal mining fugitive; Gas fugitive; Oil fugitive; Chemical process; Non-metallic mineral production; Metals production; Geothermal fugitive; Sewage treatment fugitive; Waste processing fugitive; Land use, land use change & forestry.
[31] Carbon Dioxide; Methane; Nitrous Oxide; Fluorinated gases; Nitrogen Oxides; Carbon Monoxide; Non-methane Volatile Organic Compounds; Sulphur Dioxide. Converted to CO2-e using GWP.
[32] Managers; Professionals; Technicians and tradespeople; Community and personal services; Clerical and administration; Sales; machine operators and drivers; Labourers.

Regional module

Our regional database comprises 16 regions, with each regional economy consisting of the same 140 industries, producing 220 goods or services. We usually aggregate these industries and commodities to make the model more tractable – in this case to 82 industries producing 82 commodities.

Regional commodities are designated either as 'local' or 'national' products. These are analogous to non-tradeable and tradeable products at the national level.

'Local' goods are not traded a great deal and tend to be produced and consumed locally (e.g. restaurants and personal services such as haircuts). 'National' goods are impacted more by national economic drivers that affect all regions (e.g. manufacturing commodities).

There is no official IO data available for New Zealand's regional economies. To create our own regional IO tables, we start with the 2020 national level IO table and use Business Demography employment data from StatsNZ to apportion (in shares) economic activity by industry across New Zealand's regions. Regional GDP (or Gross Regional Product) and industry-level value added by region are consistent with StatsNZ's official estimates.

In a **bottom-up simulation**, regions and industries are linked through inter-regional trade flows, margins and factor flows. This allows for the application of region-specific shocks if required.

Each region has a representative household, which maximises utility subject to a budget constraint. Aggregate household spending is a function of aggregate household disposable income in that region. Households purchase goods and services from within their region and imports from other domestic regions and from overseas.

Other end users include other firms, central and local government, investors and the export sector.

Firms minimise costs for a given level of output, substituting between intermediate inputs and factors of production as relative process change. Firms determine their input mix using a nested structure:

- The first nest is a bundle of intermediate inputs and a bundle of primary factor use (land, labour, capital, etc.) using a Leontief (fixed proportions) structure. This means that if output grows by x%, so too does the demand for the bundles of intermediates and factors of production.
- The second level nest determines the mix of intermediate inputs between domestic inputs and inputs imported from overseas; and the split of primary factors across labour, land and capital.
- The third level nest determines where domestic intermediate inputs come from across the 16 regions. It also combines labour inputs across eight occupation types and different types of capital assets (plant, machinery & equipment, transport, residential buildings, non-residential buildings, intangible assets, etc.).

Factors of production are 'sticky' on a regional basis, apart from labour and capital, which can move across regional boundaries based on relative factor prices.

In a **top-down simulation**, there is no inter-regional trade, and national level economic impacts in policy scenarios are apportioned across regions based on each region's share of each 'tradable' national industry. The impacts on locally produced and consumed 'non-tradable' commodities (such as personal services) are driven primarily by changes in regional household incomes.

In top-down modelling, an industry has the same cost and sales structures across all regions. That is, the production structure of industry X in Auckland is the same as the production structure of industry X in Southland. The industry reacts the same (proportionately) to a shock in all regions.

Regional economic impacts are therefore driven largely by the national level industry responses and the weights of each industry in that region.

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