FUEL SECURITY STUDY

Prepared for Ministry of Business, Innovation and Employment

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Executive Summary

New Zealand's economy is highly dependent on imported fossil fuels. The jet fuel essential for export freight and tourism, diesel powering road, rail, and maritime transport, and petrol fuelling both private and commercial vehicles is all imported to our small and remote economy. Since the closure of the Marsden Point Refinery (MPR) and conversion to an import terminal in 2022, New Zealand meets all its fuel demand from fuels refined overseas. Prior to the closure and conversion, MPR supplied 70% of domestic fuel demand. MPR closed due to the culmination of long-term changes in refining economics — it faced rising operational costs and larger-scale refineries in Asia. New Zealand is now totally dependent on refined fuel supply chains rather than a mix of crude and refined fuel supply chains.

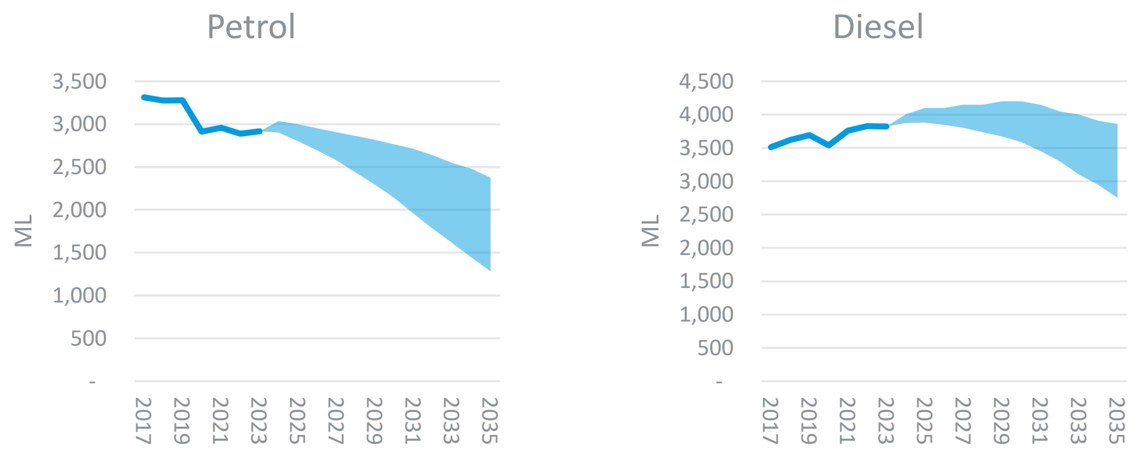
The Ministry of Business, Innovation and Employment (MBIE) is mandated to advise Government Ministers on fuel security matters. MBIE has commissioned Envisory and Castalia to prepare this fuel security study to guide policy on resilience and fuel supply sustainability and assist in the development of a Fuel Security Plan.

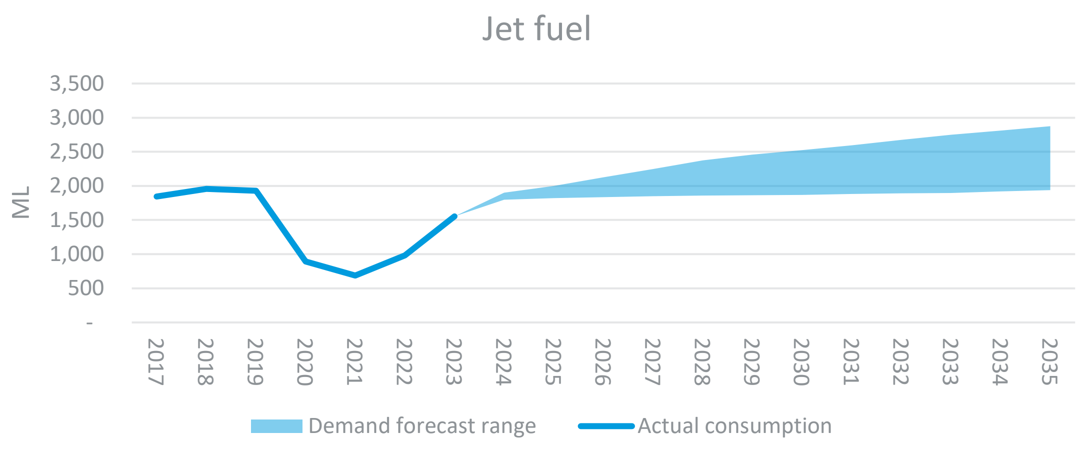
This report sets out the results of Envisory/Castalia's analysis of New Zealand's fuel security challenges, and approaches to mitigate risks. It has been informed by discussions and engagement with fuel importers and suppliers, major fuel users, Government agencies and representatives of stakeholder groups.

New Zealand's fuel demand will change faster for petrol than for diesel as the vehicle fleet transitions, while jet fuel consumption is likely to rise

New Zealand's economy and living standards of New Zealanders rely heavily on fossil fuels. However, over time, the reliance is diminishing. The petrol vehicle fleet is forecast to transition to battery electric vehicles (EVs) over time. Households' light passenger vehicles (LPVs) and light commercial vehicles will transition as widely accepted falls in EV capital costs occurs, and EVs become more established as a viable alternative. Heavy vehicles will transition more slowly, as economical alternatives to diesel trucks are not as advanced, resulting in a slower decline in diesel consumption. Jet fuel consumption is likely to rise as there are no realistic options for alternative aircraft fuel in the short to medium term. In time, sustainable aviation fuel produced from renewable sources could meet some of this demand. Graphic 1 illustrates these forecast changes in demand for petrol, diesel and jet fuel.

Graphic 1: Fuel demand trends to 2035





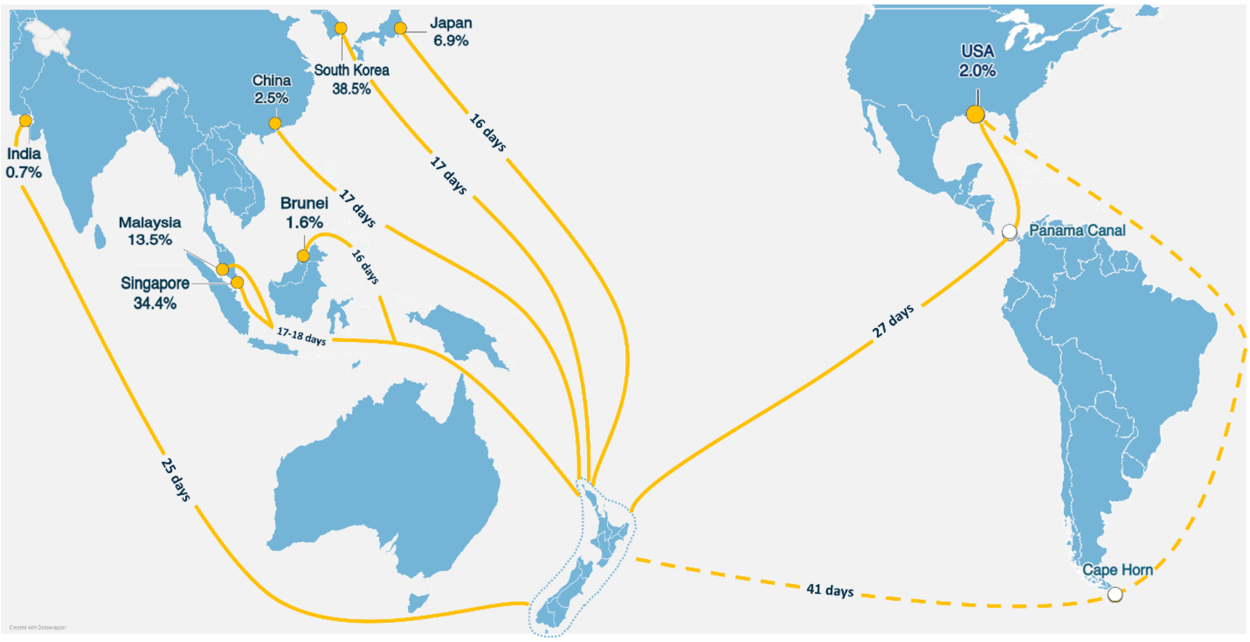
New Zealand faces some risks to its fuel security given dependency on imported refined fuels

Like any imported product, refined fuel supply chains can be interrupted. Due to the critical nature of fuels in the economy, and the global nature of oil and fuel markets, prices can change in response to such events. The risks to New Zealand's fuel supply are international and domestic.

International risks include supply chain disruptions from geopolitical conflict and natural or physical disasters that impede shipping. New Zealand is also vulnerable to price shocks[1] caused by global events in oil producing regions. As Graphic 2 illustrates, New Zealand is at the end of fuel shipping routes. New Zealand is particularly vulnerable to disruptions in South-East and East Asia, due to the reliance on refineries located there and the shipping routes to New Zealand. In 2023, 70% of New Zealand's fuel supply came from Singapore and South Korea. However, fuel companies are adept at adjusting supply chains as production and transport costs change and will source fuel supply from elsewhere in South-East, South and North Asia and even North America if economic or during disruption events.

[1] New Zealand is less likely to experience a fuel shortage in an international disruption to fuel supply because of its lower relative demand to the rest of the world and greater relative wealth, so the country can purchase enough fuel to meet demand.

Graphic 2: New Zealand's refined fuel supply chains

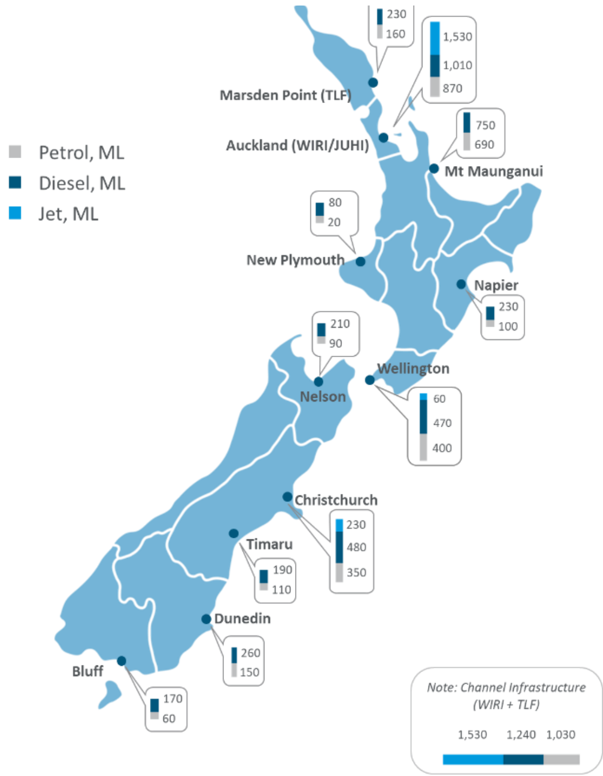


Domestic risks include infrastructure failures, whether from natural disasters or human intervention. New Zealand's fuel supply chain relies on some key infrastructure assets:

- Channel Infrastructure's import terminal at Marsden Point
- the Ruakaka-to-Auckland pipeline (RAP)
- the Wiri storage facility in South Auckland
- the Joint User Hydrant Interplane terminal (JUHI) at Auckland Airport
- Port terminals including major terminals at Mt Maunganui, Wellington and Lyttleton.

Key storage and distribution facilities are located around the country as shown in Graphic 3.

Graphic 3: Fuel Terminals



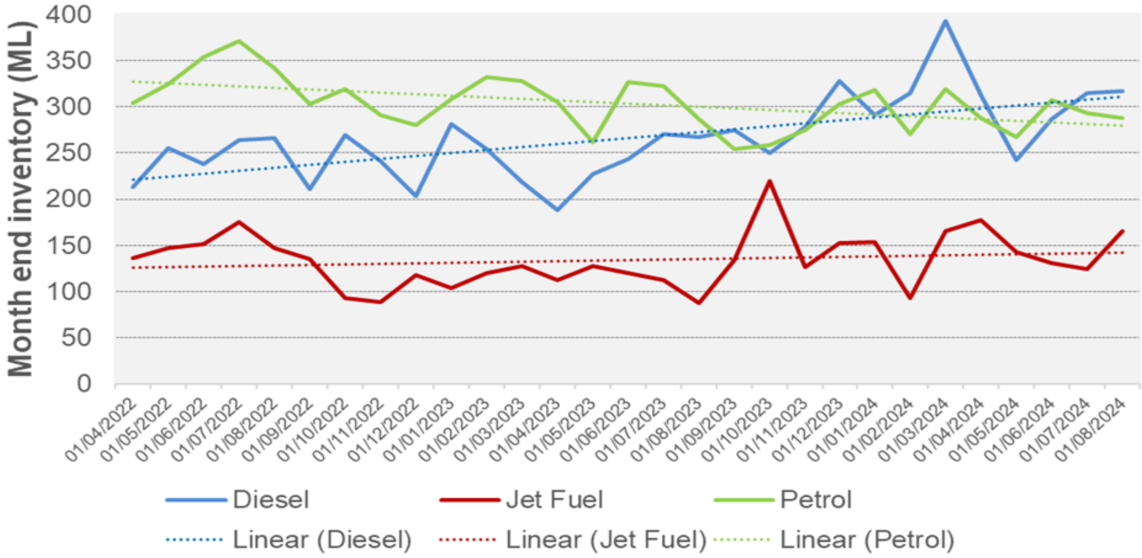
Stock levels are increasing and provide a buffer to manage disruptions

Stock levels for jet fuel and diesel have increased since the closure of the MPR with the provision of more storage. They should increase further with the implementation of the Minimum Stock Obligation (MSO) from January 2025.

Stocks are critical during disruption, providing time to rearrange supply chains or a buffer while infrastructure is repaired. We have analysed recent stock levels.

- Stock levels are above MSO levels on average, as companies need an operating buffer to ensure compliance, and due to the size of fuel deliveries.
- Petrol stocks (28 days MSO) are typically higher, providing a good buffer for disruption. There will be the opportunity to reallocate some petrol storage to other fuels as demand declines with the transition.
- Jet fuel stocks (24 days MSO) should increase with the implementation of the MSO as, at times, they have been below this level. Stock levels above the MSO should provide a sufficient buffer for operational disruptions.
- Diesel stocks (21 days MSO) are typically higher than the MSO level. We calculate that this is necessary as at the MSO level, they may not be sufficient to manage expected disruption events. The additional seven days diesel stock being considered would significantly improve resilience.

Graphic 4: Stock change since refinery closure [2]



International supply disruptions or domestic logistics disruptions can impact fuel supply

New Zealand's fuel supply is vulnerable to international and domestic disruptions and many events could impact fuel supply. Our analysis groups the disruptions according to supply or logistics events.

- **International supply disruption:** Events that impact the import supply of refined fuels, possibly causing a shortage of fuel in New Zealand. This could be from a small event such as an off-specification cargo or a late ship, an international disruption such as seen with the Ukraine war, or a complete disruption of fuel flows to New Zealand. In all cases, the event would cause volume shortage for a period. Larger disruptions will generally be related to an international event (i.e. something outside New Zealand's borders), impacting sources of fuel supply and/or shipping routes to New Zealand.

[2] Stock change shown as a total volume (not day's cover) as consumption during this period was impacted by COVID restrictions which made stock days cover reporting not representative of normal activity.

- **Domestic logistics disruption:** Events that impact the distribution of fuel to where the customer requires it. These include road outages/slips, to the loss of a major terminal or critical infrastructure (such as the RAP). Logistics disruptions require establishing alternative logistics routes to maintain fuel supply or greater inventory levels to ensure supply while the infrastructure is repaired. These logistics disruption events are domestic, with the supply of refined fuel to New Zealand not impacted.

For both international and domestic disruption events, we have created scenarios of varying impact: from short-term to longer-term, with a greater volume of fuel affected. The events are categorised as severe, major and minor. These scenarios were informed by extensive engagement with fuel suppliers, major fuel customers, Government officials and wider stakeholders.

Supply disruption scenarios from international events are severe, major and minor

We examined three categories of supply disruption scenarios due to international events:

- A severe disruption is an extreme event that disrupts supply to New Zealand completely, for an extended period. There are several potential causes, and New Zealand's economy would be drastically and seriously impacted beyond fuel supply.
- A major disruption is an event for which there are several precedents over the past 50 years such as a major conflict or natural disaster that disrupts oil production or international fuel supply chains. This leads to some of New Zealand's fuel supply being disrupted, with international and local price increases.
- A minor disruption would be all or part of a cargo lost, delayed or off-specification.

In each case, we analysed the impact on New Zealand and, therefore, the potential value of fuel security mitigation options.

The severe event would be better described as a national security event, as anything that completely halts fuel supply chains is likely to impact all imports and exports. The Government would need to act quickly, including actions to manage remaining fuel supplies and their allocation to essential services. We modelled a 90-day complete cessation of supply and found the following demand levels could be met over that 90-day period.

Graphic 5: Cover available with no fuel supply for 90-days

Disruption	Petrol	Jet Fuel	Diesel
% normal demand met from inventories	31%	29%	27% (33% if additional 7 days stock held)
COVID Level 4 fuel demand	20-25%	20-30%	30-40%

The demand covered is relatively similar to, or above the consumption levels during the COVID Level 4 restrictions. An event where all trade is impacted may see demand falling below COVID Level 4 consumption. Measurement of demand for the critical functions of state and essential services (lifeline utilities), including defence are well below this level at around 5% of normal diesel consumption and 3% of petrol.

We do not model the economic impacts of minor disruptions. Our modelling shows that once the MSO is in place, these events should not impact consumers, although, for diesel, it is very tight without some additional stock above the 21 day MSO being held.

Domestic logistics disruption scenarios examine specific impacts from infrastructure outages

We tested the impact from outages of critical infrastructure. We do not focus on the specific cause of the disruption, as the key concern is the duration of its impact on fuel logistics. We tested 14-day outages for the RAP and Wiri terminal, and 60-day outages of the RAP, Wiri terminal, Marsden Point import terminal and Wellington and Lyttleton terminals. In the event of an outage, the amount of stored fuel for each fuel type will determine the extent of the economic impact.

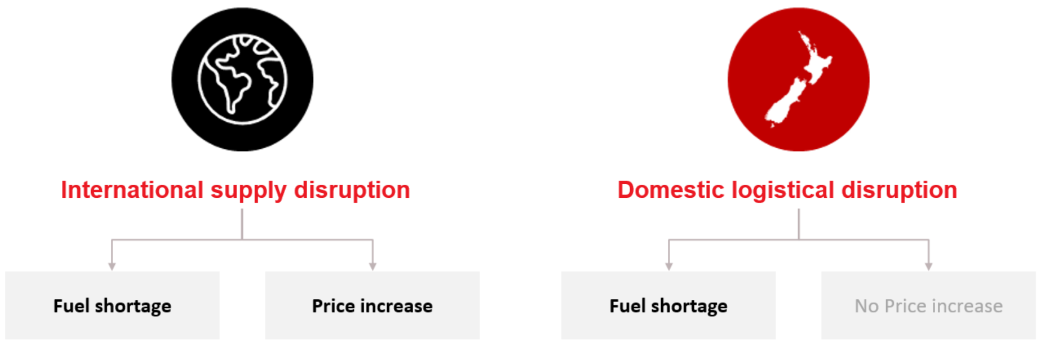
The impact of disruption is mitigated by increasing supply from neighbouring terminals and increasing utilisation of trucking resources for petrol and diesel. Supply can get back close to normal levels in most cases, although more trucks (likely from offshore) and drivers will be required for the largest disruption scenarios.

There are fewer options for disruption to jet fuel supply chains. Domestic airlines have some capacity to move demand to other domestic airports and there can be tankering where aircrafts coming to New Zealand bring sufficient fuel for the return leg. This is only feasible for shorter-haul international movements (e.g. Australia, Fiji). As a result, jet fuel stocks play a critical role in maintaining some supply in these events, and the economic impact from disruption can be large. The reputational damage from the loss of confidence in the fuel supply to New Zealand's major airports would also have ongoing implications.

Economic impacts from disruption scenarios

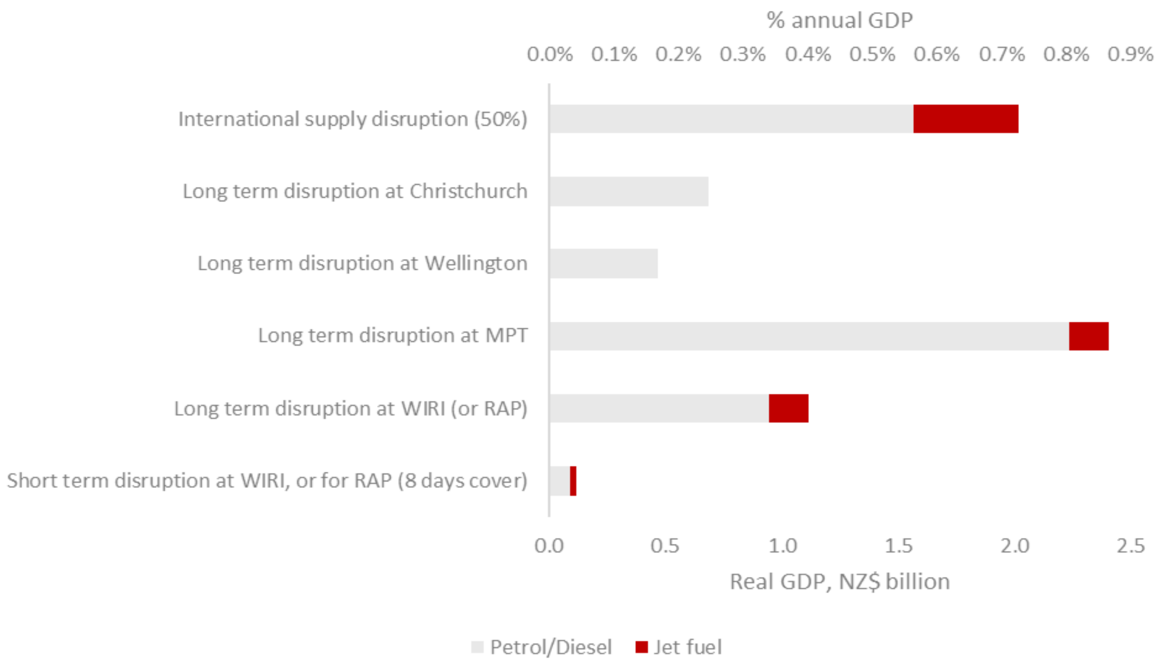
We estimated the economic impacts from disruption scenarios. The economic impact depends primarily on the severity of the fuel shortage caused by the disruption. In the case of an international disruption, a price increase accompanies the shortage. In the case of domestic disruption, fuel companies have historically avoided increasing prices. Graphic 6 illustrates the dynamic.

Graphic 6: Disruptions will result in fuel shortage and/or higher prices



Overall, the total economic cost of supply disruption is estimated to be between NZ$118 million (0.04% of GDP) and NZ$2.4 billion (0.85% of GDP), depending on the severity of the disruption. The most significant risks to the New Zealand economy come from long-term disruptions at Marsden Point (MPT), at Wiri or to the RAP, with the economic loss estimated to be around 0.85% of GDP. Followed by an international supply disruption scenario with a 50% fuel supply disruption, resulting in an economic loss of 0.72% of GDP. A summary of the economic impacts from the different scenarios are illustrated in Graphic 7.

Graphic 7: Summary of the economic impacts from the different scenarios



Mitigation strategies for potential disruptions

The report discusses multiple mitigation options. Some options have well-defined implementation pathways with clear costs and benefits. Other options require further research or may offer limited advantages. We have closely evaluated the options with clearly defined feasibility, costs, and potential benefits. The six mitigation options include:

- Reestablishing Marsden Point refinery[3]
- Increasing jet fuel and diesel storage capacity
- Expanding trucking capacity to alleviate petrol and diesel disruptions from infrastructure failure
- Investing in biofuels, renewable fuels, or low-carbon refineries
- Developing a refinery to process indigenous crude and condensate
- Accelerated transition to zero-emission road vehicles (Accelerated Transition).

We evaluated the options using a combination of quantitative and qualitative measures in order to get as close to an "apples with apples" comparison as possible. We quantified the annual costs and the benefits of each option in terms of additional fuel volume. Finally, we qualitatively scored the options according to their overall effectiveness in mitigating different fuel disruption scenarios.

The annual cost of each option is calculated as a marginal cost relative to the status quo, covering infrastructure investments, government incentives, and subsidies for biofuels or EV adoption. For

[3] As part of the project scope, the Envisory/Castalia team prepared an Interim Report on the viability of reestablishing MPR. That report highlighted the high costs of reestablishing a commercial refinery, and the challenges for operating it economically over the long term. It also highlighted the opportunities for alternative fuel production and other energy transformation at the site as part of the Marsden Point Energy Precinct Concept (https://channelnz.com/1811-2/).

infrastructure-related options, we estimate marginal costs based on the additional annualised capital and operating expenses required to implement and sustain these measures. For government incentive-related costs, we estimate the funding required to reduce the price gap between alternative fuels and conventional fuels or between EVs and internal combustion engine (ICE) vehicles (excluding the deadweight loss of taxation).

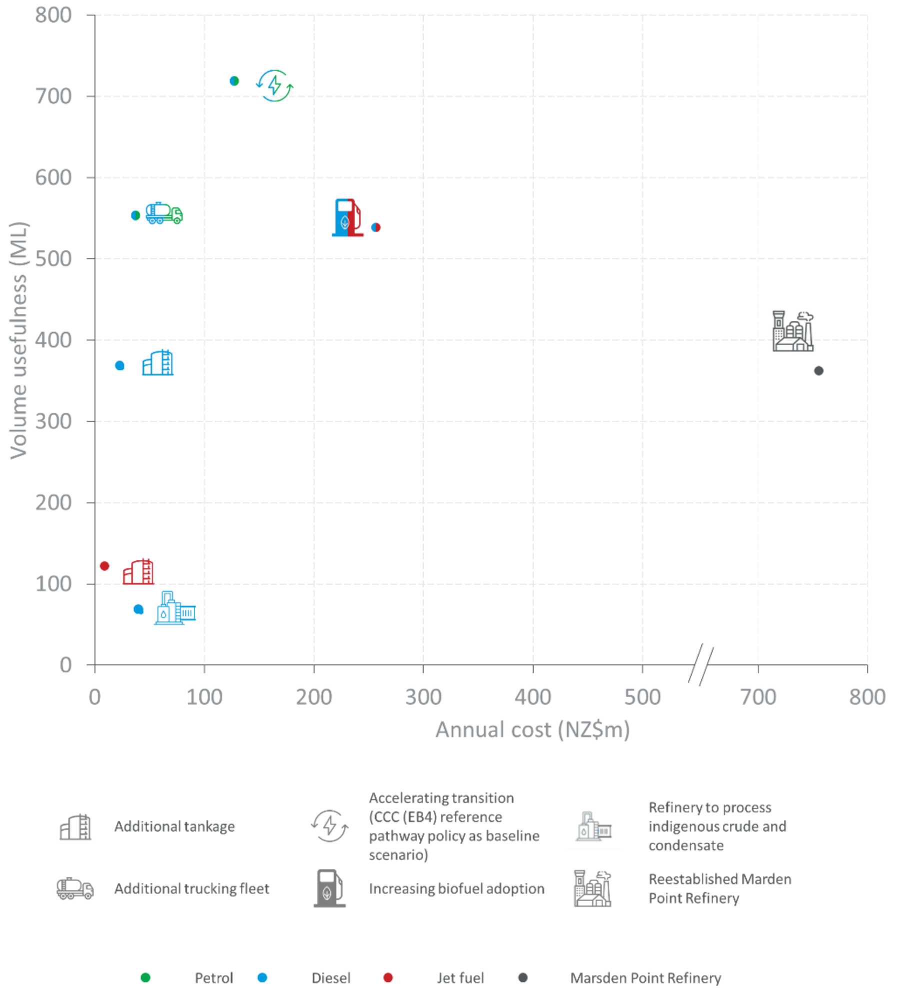
Overall, the costs associated with each option are primarily economic, and the burden will ultimately fall on the New Zealand economy. These costs may be reflected in different ways—either through government subsidies (a burden on taxpayers) or by consumers paying higher fuel prices because fuel companies or producers pass investment costs onto fuel consumers.

The benefits of each mitigation option are measured by its volume "usefulness"—the amount of fuel it adds to improve fuel resilience, adjusted by its scenario usefulness score, which reflects how effectively it addresses different disruption scenarios and whether this is on a one-off or continuous basis.

We compare all mitigation options to estimate:

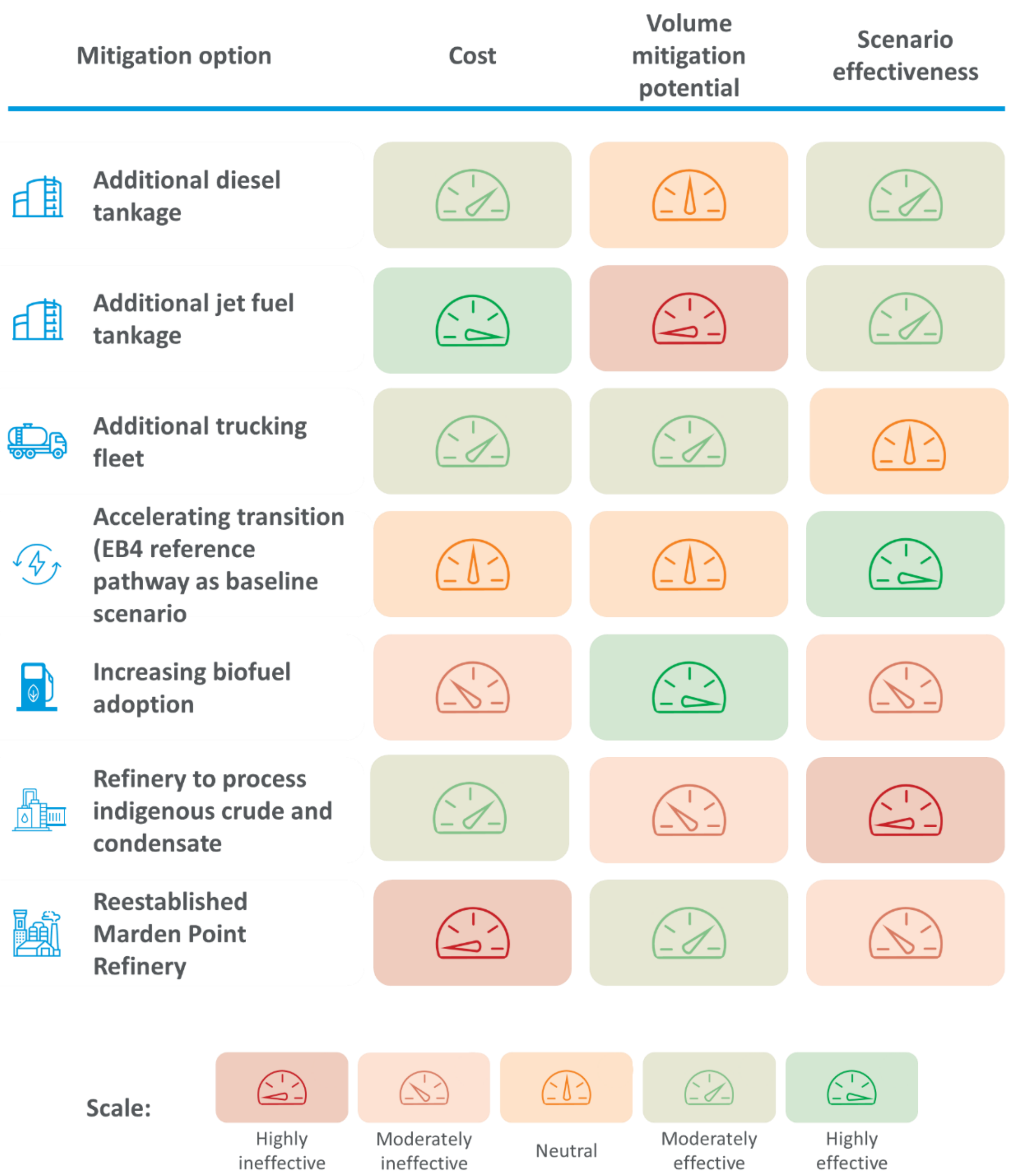
- How much volume usefulness (ML) at a given annual cost (NZ$ million) each option can provide, as shown in Graphic 8. The most effective options provide high fuel resilience at a lower cost, while less effective options either have high costs or contribute relatively little to mitigating fuel disruptions.

Graphic 8: Mitigation option effectiveness



- How each option scores in on three criteria: annual cost, scenario effectiveness and volume mitigation potential, as shown in Graphic 9:

Graphic 9: Mitigation option evaluation



Based on the results of the analysis above, we concluded that the most cost-effective strategies for enhancing fuel resilience is accelerating the transition to zero-emission vehicles, adding trucking capacity and increasing diesel storage. These measures provide the highest resilience benefits at for the cost.

For jet fuel, increasing storage is the most cost-effective option. Investing in biofuels could also be viable for both jet fuel and diesel, but it requires further analysis and comes with higher costs.

In contrast, reestablishing Marsden Point Refinery or developing a new refinery for indigenous crude proved inefficient due to either high costs and/or limited effectiveness across all fuel types.

We also assessed the following mitigation options:

- Increasing supply diversity; and
- International Arrangements/Agreements.

There was a cost for increasing supply diversity but no identifiable benefit beyond what the current suppliers are doing and have the capability to do in their organisations. Therefore, this option was not analysed further. The government is continuing to develop and enhance international arrangements to protect and secure New Zealand's supply chains including refined fuel. This includes stronger partnerships with some of our key fuel suppliers. This work is very important, particularly to protect against severe supply disruptions. However specific costs and benefits were not identified to include in the analysis.

Conclusion

This study sets out the key risks to New Zealand's fuel security, given the global and domestic supply chain and existing infrastructure. New Zealand's fuel security for petrol, and to a lesser extent diesel, will improve as the vehicle fleet transitions to EVs and alternative fuels. However, there are some key risks related to critical infrastructure assets. The economic impact of disruptions to fuel supply are potentially significant, especially if there are logistics interruptions in the domestic supply chain. Global events will have a price impact, but international fuel supply chains are adept at adjusting in response to events. Even if supply from the refineries that currently supply most of New Zealand's fuel is interrupted, the time lag before supply arrives from alternative sources would have a comparatively lower impact.

New Zealand can improve its fuel security with several mitigation options. A portfolio of the options we identified would be required to improve security across the three key fuels. However, each option has costs.

MBIE can incorporate our findings on key risks, estimated economic impact, and mitigation options and costs in its advice when the Government develops its Fuel Security Plan.

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Glossary

Term	Description
bbl	Barrel (a barrel contains 159 litres)
GDP	Gross Domestic Product
IEA	International Energy Agency
JUHI	Joint User Hydrant Interplane terminal
kb/d	Thousand barrels per day
LR1/LR2	Long Range Tanker (ship)
mb/d	Million barrels per day
ML or ML/d	Million Litres (/day)
MPR	The Marsden Point Refinery (closed in March 2022)
MRT	Medium Range Tanker (ship)
MSO	Minimum Stock Obligation
RAP	Ruakaka to Auckland Pipeline (formerly Refinery to Auckland pipeline)
Refined fuels	Refined fuels are used in this report to refer to the main transport fuels including petrol, jet fuel and diesel. Fuel oil and bitumen are not included in this definition.
WAP	Wiri to Auckland Airport Pipeline

1.0 Introduction

A secure and resilient supply of refined engine fuels is critical to New Zealand's economy. The closure of the Marsden Point oil refinery (MPR) in March 2022 changed the nature of risks to New Zealand's security of refined fuel supply. As a small, remote market that imports its fuel, New Zealand is particularly vulnerable to supply disruptions. The consequences of a severe and sustained disruption would impact industry and cause significant hardship for New Zealanders.

In 2023, the New Zealand Government committed to commissioning a study into New Zealand's fuel security requirements and investigating the reopening of the MPR as part of the National Party and New Zealand First Coalition Agreement[4].

The Ministry of Business, Innovation and Employment (MBIE), the Government's lead advisor on national fuel security, commissioned Envisory and Castalia to undertake the Fuel Security Study on fuel security requirements for New Zealand up to 2035. The findings from the study will feed into the development of a Fuel Security Plan to safeguard our transport and logistics systems and emergency services from any international or domestic disruption. The Fuel Security Plan (also part of the Coalition Agreement) will be a strategy document for building resilience in the medium to long term.

The Fuel Security Study's scope has five focus areas (the scope is in Appendix A). These include:

- Investigate the reopening of the Marsden Point oil refinery
- Investigate the strategic importance of infrastructure at Marsden Point and the role it could play in underpinning New Zealand's fuel resilience
- An understanding of the risks, impacts and mitigation measures of an extended fuel supply shortage
- Understanding of potential domestic disruptions to fuel distribution
- Mapping fuel consumption trends and how they could impact fuel security.

The option of reestablishing the Marsden Point oil refinery as a mitigation issue to improve New Zealand's fuel security is considered within this report. The detailed investigation into reestablishing the refinery is covered in an Interim Report published separately from this report.

[4] https://www.nzfirst.nz/coalition-agreement pg. 6

2.0 Study methodology

The Envisory/Castalia team worked closely with MBIE to fulfil the scope requirements. The work involved:

- Reviewing and summarising New Zealand's international fuel supply chains
- Mapping the fuel supply chains and analysing two and a half years of supply and stocks data from operating with 100% import supply
- Consulting widely both on reestablishing the MPR and fuel supply security more generally (a full list of those consulted is in Appendix B)
- Detailed investigations into the reestablishing the MPR covering feasibility, cost and commercial structures that may be required
- Mapping fuel consumption trends to 2035 and assessing how they may impact fuel security
- Workshop with MBIE on disruption scenarios to be analysed so that a broad range of events and possible impacts might be analysed without focus on a specific event/outcome
- Modelling the impact on consumers of various forms of fuel disruption and how industry might respond to mitigate those impacts
- Evaluating the economic impact of different fuel disruption scenarios including the expected price response where relevant using regression models, and validating with input-output analysis
- Assessing various mitigation options including the cost and how they might benefit New Zealand's fuel security in terms of fuel volume avoided and versatility against different disruption scenario types
- Conducting cost-benefit analysis of various mitigation options to evaluation the overall effectiveness and comparative benefit to New Zealand.

3.0 International fuel supply chain

This section reviews the global refined fuel demand and supply available from the refining industry, focusing on the expected changes over the rest of the decade. We explain how New Zealand secures its refined fuels and the typical supply chains, including the shipping used. Appendix C provides more detail on the global outlook for supply, demand, and refining.

3.1 Global refining industry

Global crude oil refining capacity is abundant but undergoing rationalisation, particularly in the Atlantic Basin, as the centre of petroleum demand growth continues shifting to developing and emerging economies in the Eastern hemisphere. Capacity additions focus on meeting the level and composition of new demand, particularly petrochemicals[5]. These dynamics see ample crude oil and refined fuels flowing to and from the Asia-Pacific region but may increase competition for jet fuel in the longer term.

- World oil supply is set to rise by 6 million barrels per day (mb/d) from under 108mb/d to nearly 113.8 mb/d by 2030, 8 mb/d above projected global demand of 105.4 mb/d.
- New fuels demand growth is centred in Asia, driven by emerging and developing economies, especially China and India. In contrast, fuel consumption in advanced economies will fall by 3 mb/d between 2023 and 2030.
- Refining capacity grows in China, India and the Middle East and contracts in the Atlantic Basin (particularly Europe). Global refining capacity is forecast to expand by 3.3 mb/d to 2030, up from 103.5 mb/d in 2023. Most investment is made in emerging and developing economies of Asia (China and India), while in Europe, up to 1.5 mb/d of refinery capacity risks closure by 2030.
- The pace of closures is linked to the energy transition as fossil fuels are increasingly replaced by unrefined fuels[6] and biofuels. The rise of EVs also pressures refinery operating rates and profitability of older refineries in mature markets. Unrefined fuel and biofuel supply is forecast to increase by a combined 2.5 mb/d and capture more than 75% of projected fuels demand growth from petroleum refiners over the period 2023 to 2030.
- Crude oil and refined fuels continue to move between regions depending on relative demand. International fuels trade and distribution networks shift away from the Atlantic basin surplus towards Asia's growing structural shortfall across the outlook period. The Middle East remains the top exporter of crude oil and refined fuels. If Asia is short of fuels, it can import from the Middle East and/or the Americas. By 2030, Europe is expected to develop a product shortfall in diesel and jet fuel, and the United States is short on jet fuel only.
- Refiners must progressively modify their product output to make more jet fuel and less petrol. The shifting composition of fuels demand displaces about 6 mb/d of petrol and diesel demand by 2030. Jet fuel will recover 2019 demand levels by 2028 and grow beyond the outlook period. The strength of jet fuel demand may become a challenge in the 2030s as refiners reach the limits of normal product slate adjustments.

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[5] Petrochemicals covers the range of chemicals produced from petroleum that are the building blocks for a wide range of industrial and consumer products (e.g. plastics, synthetic fibres, fertilisers).

[6] Unrefined fuels include fractionated Natural Gas Liquids (e.g. LNG, CNG, LPG).

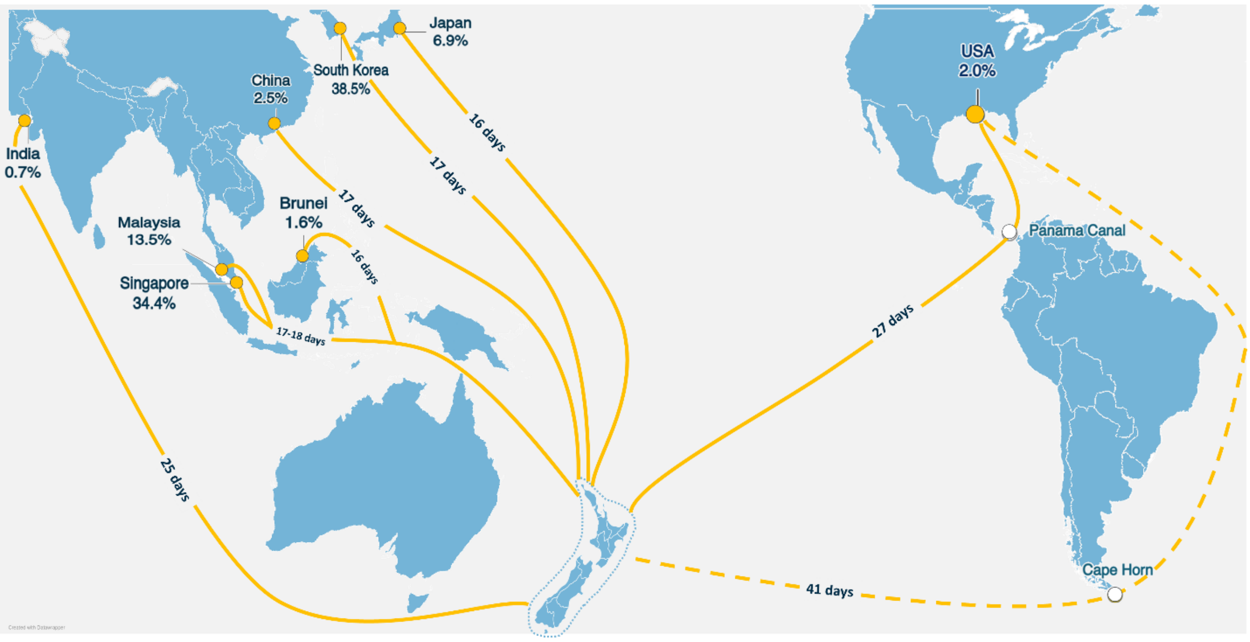
The total demand for petrol, diesel and jet fuel in New Zealand is around 153kb/d (24 million litres/day)[7], which is only ~ 0.15% of the global demand for those fuels. Focusing only on traded refined fuel volumes, New Zealand requires ~0.8% of global supply.[8]

3.2 New Zealand's fuel supply

New Zealand's refined fuel supply largely comes from the major Asian refining centres in South Korea and Singapore. Figure 1 shows the source of refined fuels in 2023, with those two locations supplying over 70% of the demand.

The source of supply changes with market dynamics, and there are large swings in volumes from different locations. Typically, North Asia (South Korea, Japan, and China) supplies a larger proportion of diesel, with Singapore supplying more petrol, although most locations can produce all of these fuels if required. Singapore, as well as having an export refining industry, is a large petrol blending and storage location as the main petrol-importing countries are in Southeast Asia (particularly Indonesia).

Figure 1: New Zealand's fuel supply chains[9]



India has very large export-focused refineries, although they primarily trade to the Middle East, Africa and Europe rather than into this region. They can supply Asia-Pacific, where there is an economic incentive, and, in the case of disruption, it would be a major option for delivering more fuel. The map illustrates that the most direct shipping route from India to New Zealand goes to the south of Australia, well away from congested shipping lanes which would be at greater risk of disruption or piracy.

[7] This is total demand including international and reflects 2019 demand. Current demand is still a little lower than this level.

[8] Data was provided by Z Energy.

[9] Data from Industry Sources for the 2023 year. This is different than the data published by MBIE and is considered more accurate.

The United States is now a major refined fuel exporter, although, other than LPG, there generally is not a demand for its production in Asia (it largely goes to Central/South America and, at times, Europe due to more favourable economics). There is an incentive from time to time, and some non-transport products can also be supplied from that region to New Zealand.[10] The shipping routes from the United States to New Zealand are largely in international waters, a long way from land.

New Zealand's location means our supply chains are long but provide flexibility for alternate shipping routes, avoiding trouble spots if necessary. Only a small proportion of the fuel supplied goes through the South China Sea or the Straits of Malacca. The refineries supplying New Zealand are supplied from and through more congested waters, and this issue is addressed in the disruption analysis.

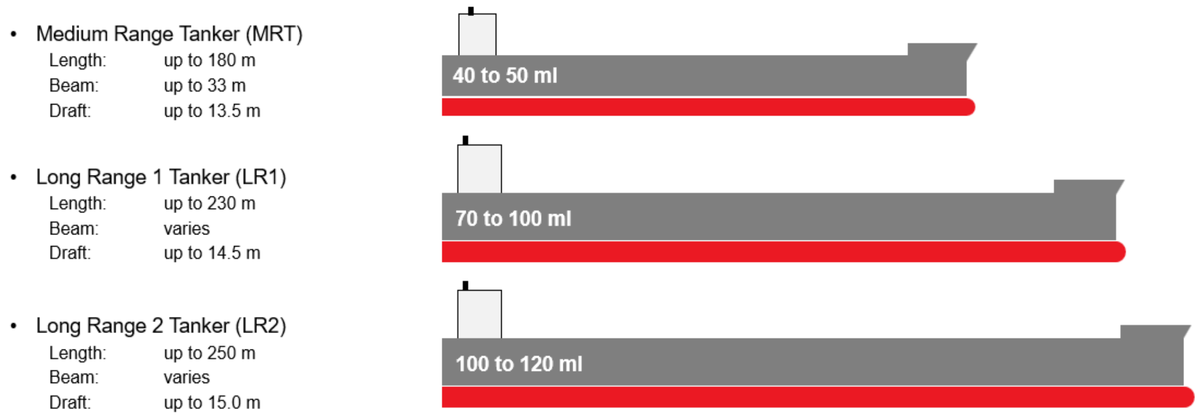
Many different refineries can supply New Zealand fuels, with one supplier noting that it uses 15 different refineries. There is a lot of storage around the main trading centre (Singapore/Malaysia), with some suppliers noting that they contract storage and hold stock for their system centrally so they can respond immediately to any disruption events.

New Zealand's fuel requirement is only ~3.1% of Asia & Oceania's refined fuel trade.[11]

3.3 Shipping

There are three classes of ships used to import refined fuels to New Zealand, as shown in Figure 2.

Figure 2: Tankers delivering refined fuel to New Zealand



Larger LR1 and LR2 tankers can be accommodated at Marsden Point. The smaller MRTs also supply fuel to Marsden Point and are used for all other ports due to port constraints such as draft, maximum vessel length, and wharf structure limitations. Table 1 shows the indicative global tanker fleet for MRT, LR1, and LR2.

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[10] The map proportions include 5% of product demand covering other products such as fuel oil, bitumen and other minor petroleum products.

[11] Z Energy

Table 1: Global tanker fleet

Cargo	MRT	LR1	LR2
Clean refined fuel	1,300	250	275
All cargoes[12]	1,900	475	1,225

Source: Gibson Shipping, Industry Sources

Marsden Point Terminal

The Marsden Point terminal has a deep-water berth that can receive MRT, LR1, and LR2 tankers. Due to its large tankage capacity, these tankers will typically discharge their full cargo. The normal allowance for discharging an MRT is 36 hours, with the LR2s taking around three days to discharge.

In the event of disruption at Marsden Point, the MRTs could be diverted to other ports around New Zealand, but the long-range tankers would need to discharge on the East Coast of Australia, with a fresh MRT supply sourced for New Zealand. Ship-to-ship transfer could be an option if large tankers are unable to berth (LR1/2 tankers directly transferring their cargo to MRT tankers). This is a routine operation approved in other countries, including Australia, although we are not aware of it being used in New Zealand.

Other coastal ports

The other coastal ports can only receive MRTs, with cargoes normally discharged at several locations. There are three ports (in addition to Marsden Point) that can accommodate a full MRT (Mount Maunganui, New Plymouth and Lyttelton). Draft constraints at the other ports require the MRTs to be partially discharged prior to arrival, with tank capacity capping the proportion of each fuel discharged.

The number of ports used to discharge a MRT will vary for each importer, although typically, two to four ports would be required. Typical voyage patterns might include:

- Mount Maunganui to Napier and Wellington and/or Nelson;
- New Plymouth[13] to Wellington and Nelson and/or Napier;
- Lyttelton to Timaru, and sometimes Dunedin, and
- Lyttelton to Bluff and Dunedin

The tanker is likely to be in New Zealand waters for 5 to 7 days completing the voyage and discharges at multiple ports.

MRT shipping provides significant flexibility, with the ability to alter discharge volumes and ports prior to the ship's arrival and even during cargo discharge. Depending on the ship's charter arrangements, it may be permissible to add an additional port call to the voyage to bolster supply at

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[12] All cargoes include dirty fuels such as crude oil and fuel oil. The larger ships (LR2) are primarily engaged in crude oil trade.

[13] While New Plymouth would be the first port call, the volume discharged would be small (reflecting demand), to reduce the arrival draft of the vessel for Wellington.

another location. This flexibility provides enhanced supply resilience compared to pipeline supply, although ensuring ships arrive at a prescribed time is more difficult.

Tankers have an arrival laycan (often 3 days) with ships arriving in this window considered to have performed according to the contract. Ship arrival timing will depend on the ability to find a ship that aligns with the loading widow at the source refinery or storage terminal, as well as weather conditions that might require a vessel to steam slower or even seek shelter for severe events like typhoons, cyclones and hurricanes. Occasionally, ship non-performance issues such as loss of power or slow loading or discharge capacity can impact the timing of vessel arrival.

Shipping task for New Zealand

We calculate the shipping task to deliver all refined fuels to New Zealand for a year assuming 50% of the volume to Marsden Point is supplied by LR2s and the rest on MRTs.

Table 2: New Zealand's annual import shipping task

Vessel	Current			2035 (faster transition case)		
	Volume (ML)	Voyages (#/yr)	Required Fleet (#)	Volume (ML)	Voyages (#/yr)	Required Fleet (#)
LR2	2,284	21	2.3	1,437	13	1.4
MRT	6,453	129	14.1	4,531	91	9.9
Total	8,737	150	16.4	5,968	104	11.4

Table 2 also indicates the size of the shipping task in 2035 based on the faster transition demand forecast case which is the case where the demand for fossil fuels reduces most quickly (the transition cases are covered in Section 5.0).

4.0 New Zealand's fuel supply chain

This section summarises our mapping of the New Zealand supply chain, including the changes made since the MPR closure.

4.1 New Zealand terminals

There are eleven major terminal locations around the country, as shown in Figure 3. There are ten port entry ports with the Marden Point terminal suppling two terminals (Wiri and Marsden Point) through pipelines. One port (Wellington) has three different berths.

Throughputs for petrol and diesel roughly correlates with population, so demand is about 50% in the northern half of the North Island. Jet fuel demand is concentrated at Auckland Airport as it is driven by demand from long-haul international flights. Figure 3 shows the estimated throughput for each terminal.

Many locations have multiple separate terminals, which increases their resilience. To a lesser extent, having nearby port alternatives can help improve resilience between locations like Auckland and Mount Maunganui or Christchurch and Timaru. In total, there are nearly 30 separate terminals, although not every terminal has all refined fuels available.

Changes since refinery closure

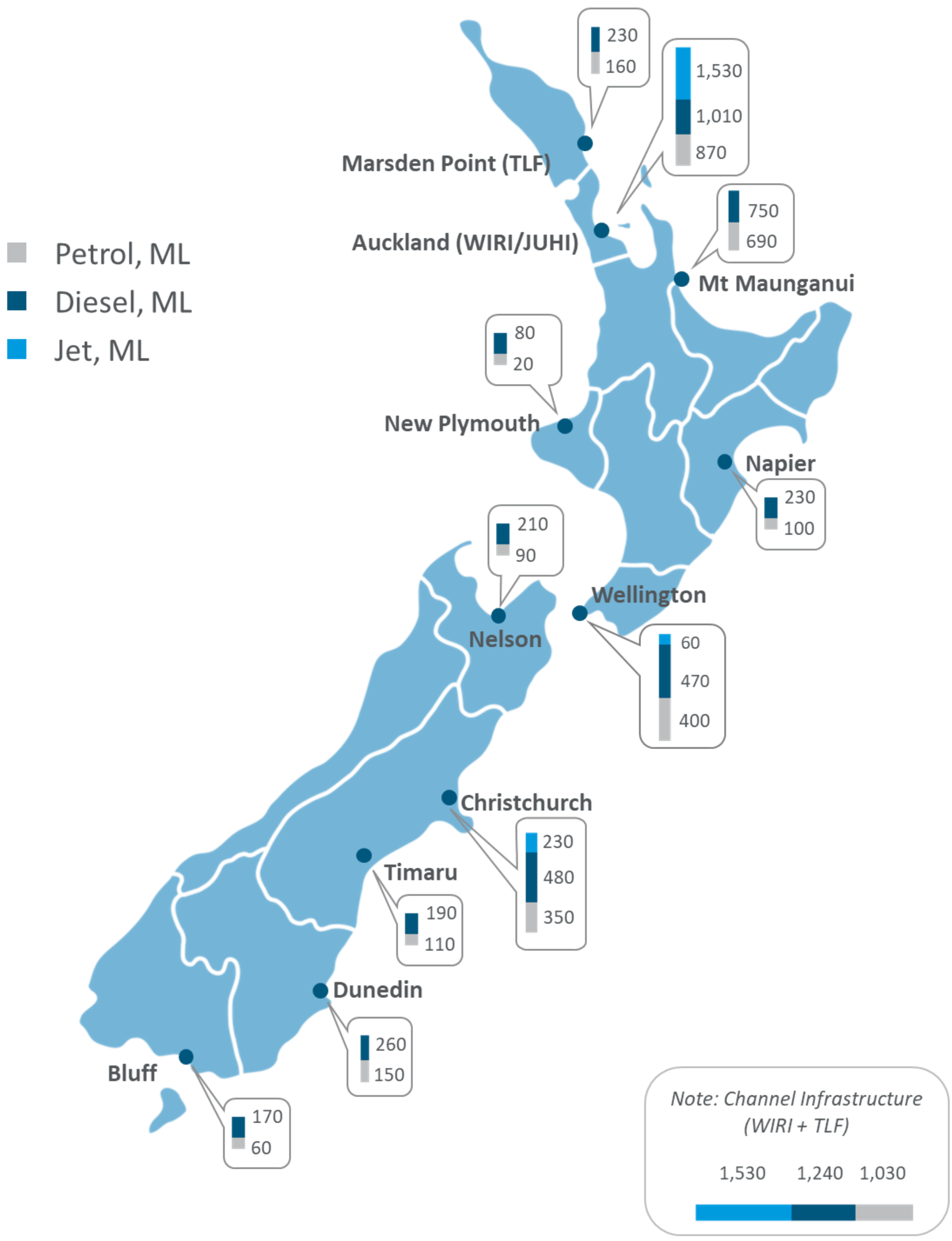
The major change to the terminal infrastructure since the refinery closure is the conversion of Channel Infrastructure's Marsden Point facility to a major import terminal. The main terminal of 180 ML is shared by Channel Infrastructure's three major customers (bp, Mobil, Z Energy), and collectively, those companies have contracted another 100 ML capacity[14]. This enables the import of fuel on much larger tankers. Z Energy has recently contracted more jet fuel storage, which is expected to be available in early 2027.

Channel Infrastructure's terminal supplies refined fuel to a Truck Loading Facility (TLF) at Marsden Point and via the Ruakaka to Auckland pipeline (RAP) to the Wiri terminal in South Auckland.

Since the refinery closure, the other terminals around the country are similar, although there has been some reallocation of tank service. In particular, many tanks that were previously used for light fuel oil supply are now used to store and supply diesel, increasing total diesel storage.

[14] https://channelnz.com/who-we-are/

Figure 3: New Zealand's fuel terminals



Other fuel terminals

This report focuses on the major transport fuels: petrol, jet fuel, and diesel. Fuel oil is also used for marine transport, and bitumen is used for road construction. We do not analyse these supply chains in detail but make the following comments.

Fuel Oil

Demand for fuel oil has fallen significantly since New Zealand acceded to MARPOL Annex 6[15], which limits the sulphur content of fuels used by ships in our territorial waters. Marine bunker fuel is the primary use for fuel oil, and many consumers have now shifted to using diesel. Fuel oil only makes up around 1% of New Zealand's petroleum demand, with over half that demand for international supply rather than local. The reduced demand has resulted in terminal rationalisation, and to our knowledge, fuel oil is only available at the following locations:

- Marsden Point
- Auckland (using a barge that loads at Marsden Point)
- Wellington (using barge)

Fuel oil imports are large relative to demand, which leads to higher inventory levels in days cover compared to the main transport fuels.

Bitumen

Bitumen supply shifted to 100% import when it stopped being produced by the MPR at the end of 2020. The market had previously been around 60% refinery supply and 40% import. Bitumen is included under other products in the petroleum statistics and makes up 2-3% of the total petroleum imports. Bitumen imports are now managed directly by the companies that own the bitumen terminals. There are bitumen import terminals at:

- Mt Maunganui
- Napier
- New Plymouth
- Nelson
- Lyttelton
- Dunedin
- Bluff

Some of these locations have multiple terminals, but not all of them may be currently operational. In addition, in November 2024 Channel Infrastructure announced it would develop a new bitumen import terminal for Higgins at Marsden Point.[16]

Bitumen imports and tank capacity are large relative to demand, which leads to higher inventory levels in days cover compared to the main transport fuels.

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[15] While MARPOL Annex 6 took effect from 1 January 2020, New Zealand only acceded to this convention on 22 August 2022.

[16] https://channelnz.com/channel-infrastructure-to-build-new-bitumen-import-terminal-for-higgins-at-marsden-point/

4.2 Internal distribution

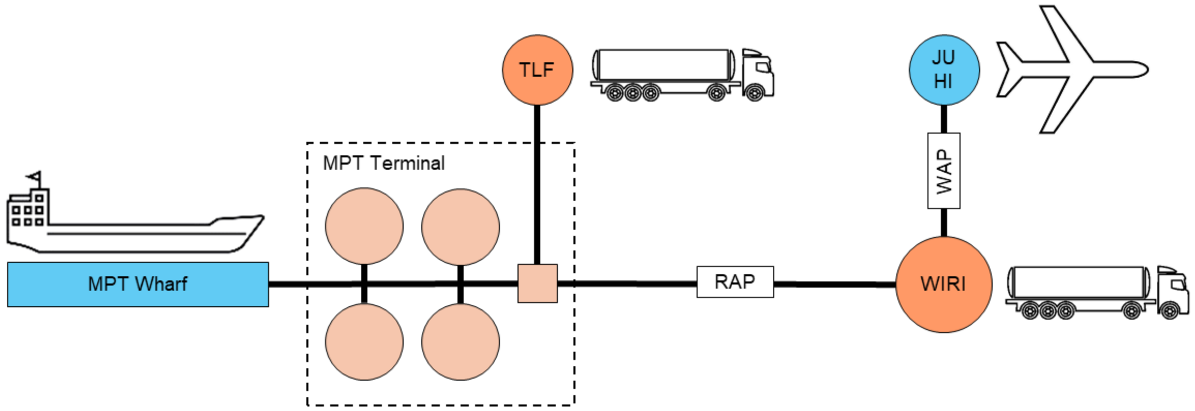
Refined fuels are distributed from the terminals by pipelines and trucks.

Marsden Point, Northland and Auckland

Petrol and diesel supply to Auckland is mainly done by truck from the Wiri Terminal operated by Wiri Oil Services Limited (WOSL)[17], although some petrol and diesel is trucked in from Mount Maunganui.

Jet fuel for the Joint User Hydrant Interplane Terminal (JUHI) at Auckland Airport comes from the Wiri Terminal through a pipeline known as the WAP (Wiri to Auckland Pipeline). Aircraft at the airport are fuelled either by a refueller truck for domestic use or by an underground hydrant system for international use.

Figure 4: Northern New Zealand fuel infrastructure



Source: Envisory

As shown in Figure 4, petrol, diesel, and jet fuel are pumped to the Wiri Terminal via the RAP. The RAP is 170km long and 250mm in diameter. It consecutively pumps petrol, jet fuel, and diesel in controlled batches at a maximum pressure of around 82 barg (~1,200 psi).

When previously consulted, Channel advised that its RAP contingencies include holding 100m of spare pipe, a spare pump, and hot tap equipment, along with a contract to access specialist welders if RAP was disrupted.

Petrol and diesel are also piped to the small TLF terminal located at Marsden Point for fuel distribution by truck to customer sites in the Northland region.

Other terminal locations

Fuels are mostly trucked to customers from other terminals, except as explained below:

- Christchurch, where some petroleum fuels are pumped from the Lyttelton terminals to the inland Mobil Woolston terminal via a pipeline over the Port Hills.

[17] WOSL is a joint venture company owned by bp, Mobil and Z Energy

- Jet fuel for Wellington Airport, which is piped from the Miramar Terminal to JUHI day tanks.
- Diesel for marine vessels, where in some locations, these bunkers are done by connecting the vessel to a bunker pipeline at the wharf.

Trucking activities

The truck and trailer units used for transporting petroleum fuels are specially made with electrical isolation systems and purposely built trailer units. These typically hold 30-35,000 litres across several internal tank compartments. These units may be owned by fuel importers, fuel distributors or independent transportation firms that specialise in fuel distribution.

Logistics optimisation has improved the efficiency of the fuel distribution task. Many trucks now operate with a double shift (i.e. two drivers) and do single fuel drops, which means fewer vehicles are delivering more fuel than a couple of decades ago. Comments from the consultations indicate the fleet can accommodate some additional trucking from alternative terminals for a short period, even at peak demand.

Consultations have confirmed the findings from previous studies that there is some spare capacity within the trucking fleet. About 10 spare trucks are held by industry across New Zealand, and some trucks only operate 12 hours per day. However, utilising this capacity quickly would depend on having prompt access to suitably qualified and certified drivers.

Legislation limits the total laden weight of Tractor Semi-Trailers (a common setup used for hauling fuel) to 39 tonnes. There are rules that allow high-productivity motor vehicles (HPMV) to carry more load on approved routes. NZTA issues HPMV permits for the state highway network and road controlling authorities (RCA) for local roads. This can make it hard to obtain approval for fuel haulage where approval from NZTA and more than one RCA is involved. The decision to issue an HPMV permit depends on the type and capability of the vehicle, plus the condition of the roads and bridges on the proposed route.

4.3 Refined fuel stocks

This section reviews New Zealand's refined fuel stocks, how these have changed over time, and what are the capability of stocks to manage disruption events.

4.3.1 What do refined fuel stocks provide

Refined fuel stocks are critical to a fuel supply chain. They provide the ability for fuel to flow through the supply chain to the customer, enable the reception of cargoes, and sustain supply between deliveries. They provide a cushion to manage variation in demand and disruption events so that supply can be maintained while supply chains are reorganised, so customers are not impacted. Fuel suppliers hold stocks at levels they assess provide their customers with a secure and reliable supply. Governments can decide that higher stock levels should be held to cover events that commercial operators may not fully consider, such as geopolitical events. New Zealand is implementing a minimum stock obligation (MSO) from 1 January 2025, and such systems are common around the world[18].

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[18] Appendix 1 of the January 2022 MBIE consultation paper on Onshore Fuel Stockholding has a comprehensive list of international stock holding policies. This is available at https://www.mbie.govt.nz/dmsdocument/18594-consultation-paper-onshore-fuel-stockholding

Stocks are drawn down during disruption events, providing time to rearrange disrupted supply chains or repair broken infrastructure. We have modelled New Zealand fuel stocks to assess different disruption events and how supply chains might respond.

4.3.2 New Zealand fuel stock levels

New Zealand's MSO is to hold a minimum stock level of 28 days of demand for petrol, 24 days of jet fuel and 21 days of diesel. The intention is to hold another 7 days of diesel (a total of 28 days), with the Government currently consulting on how this might be done. Average stock levels will typically be higher than the MSO as:

- Companies will operate with a buffer above the MSO so they do not risk breaching the minimum level from normal operational issues such as demand variation and late ships;
- The national stock level is an average across all suppliers, and as most import independently, not all will be low at the same time, resulting in a higher level on average;
- Not all fuels will be low at the same time as often petrol is delivered on different ships than jet fuel or diesel; and
- Shipments are large relative to supply (some large ships can supply 5 days of NZ demand) particularly where they deliver a single grade. As minimum levels must be met, stocks can be high after a delivery, increasing average levels.

The MSO is on gross stock held. This is all stock in the system, including operational stock and heel stock. Heel stock is the bottom portion of the tank and cannot be accessed in normal operation. Heels are typically larger in petrol tanks compared to jet fuel or diesel tanks due to petrol tanks having floating roofs or internal floating blankets. Heel stock can be removed (for instance, when tanks are cleaned for maintenance), but this is a slow operation with the heel fuel removed from the tank via smaller pipes such as those used for water draw-off. We treat this stock as unavailable for normal disruption response, although some could be accessed in a severe emergency.

Stock on ships that are in New Zealand waters that are about to discharge or partially discharged (many import ships discharge at least three ports, so they are here for a reasonable number of days) are counted in stocks. This is consistent with the International Energy Agency's methodology of reporting stocks. We estimate, on average, approximately three days of supply in New Zealand waters not yet discharged, although the quantity and type of fuel will vary over time. This provides a flexible source of fuel when responding to disruption events, as deliveries can be adjusted at short notice.

Fuel stocks have risen since the immediate aftermath of the refinery closure and are now higher than estimated for 100% refined fuel import in the Fuel Security and Fuel Stockholding Costs and Benefits 2020 report[19]. This is because the three companies (bp, Mobil and Z Energy) importing through Channel Infrastructure's terminal have contracted an additional 100ML of private storage above the base terminal volume. This allows them to bring in larger tankers, which improves the supply economics. The tankers coming into Channel Infrastructure can bring more than twice the volume of the tankers servicing other ports. Larger shipments increase average stocks as the arrival timing is at a similar minimum point, with the stocks going higher than they would with smaller shipments. We also expect the upcoming implementation of the MSO has encouraged companies to

[19] Fuel Security and Fuel Stockholding Costs and Benefits 2020, Hale & Twomey, December 2020. Available at https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-generation-and-markets/liquid-fuel-market/fuel-security-in-new-zealand

operate as they might if it was in operation. There has also been some conversion of tanks, particularly former fuel oil tanks to diesel,[20] which has increased the country's total diesel storage.

Table 3: Days of main fuel stocks (from New Zealand month-end inventories)

	Petrol	Jet Fuel	Diesel
Daily demand (2024 estimate ML)	8.1	5.1	10.7
Minimum stock obligation (gross days) from January 2025	28	24	21 (possibly +7)
Last 12 months average stock level (gross days)[21]	35.3	29.3	28.1
Last 12 months minimum reported stock level (gross days)	31.4	24.9[22]	22.6
Estimated heel stock (days)[23]	7.2	3.0	3.2
Last 12 months average stock level (operational days)	28.1	26.3	24.9

Source: MBIE month end data, Envisory analysis

The last 12 months are used to reflect the period when most new storage had been commissioned. The MSO is not yet in operation, although the data reflects how the industry operates its tankage, and that collectively, the MSO is largely already met[24]. This does not mean individual companies would have met the obligation level, and we expect some increase in minimum stock levels once the MSO is implemented.

4.3.3 Stock level trends

The data shows that average stock levels are higher than the MSO, as expected. They are also higher than modelled prior to the refinery shutdown, so some of the stock reduction expected following the refinery closure has been mitigated. The data shows an increase in stock levels since 2022 as more storage has been commissioned at Marsden Point, particularly for jet fuel and diesel (Figure 5)[25].

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[20] Suppliers provided information on these changes during the consultation.

[21] Based on stocks reported to the IEA, which include stocks in New Zealand waters but yet to be discharged. We expect reported stocks to increase by about one day when this information is formally captured as part of the MSO reporting.

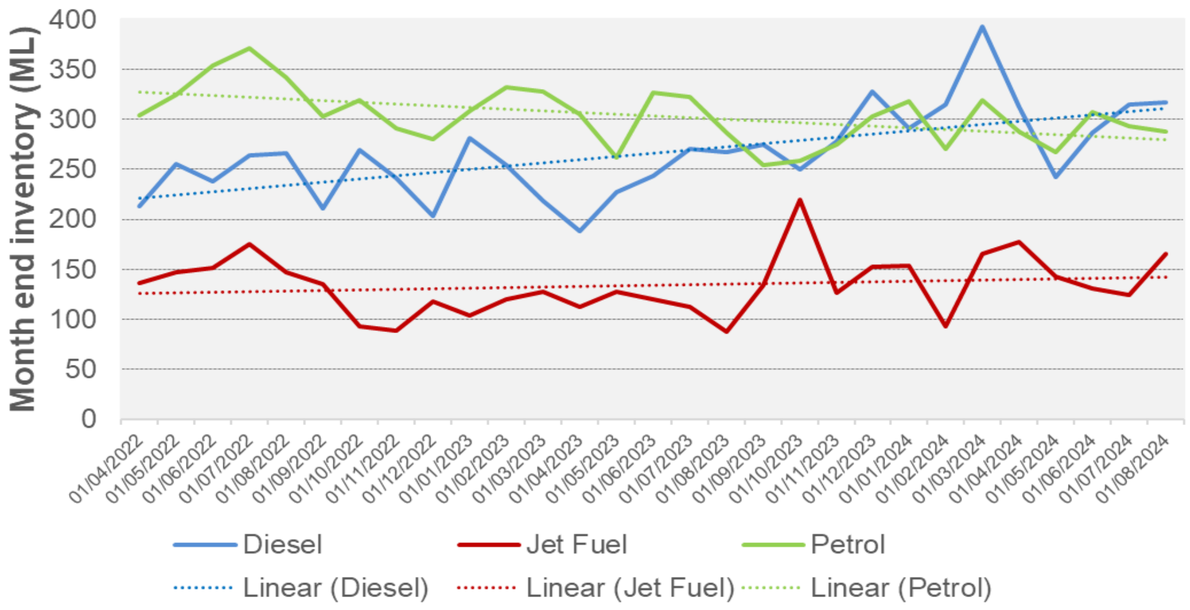
[22] This is a reduced period to reflect the full commissioning of private jet fuel storage. One month ended with lower stock, but stock on water may not have been correctly captured.

[23] Petrol heel stock days are higher as the tank heels are typically larger, and with two grades, there is a larger number of tanks and tank capacity in total.

[24] This is not surprising as the MSO was set using historical stock levels and designed to maintain a minimum level into the future.

[25] We show the stock trend as a physical volume to demonstrate the trend. A measure in days demand would be impacted by Covid restrictions impacting normal demand over the period reviewed.

Figure 5: Month-end reported fuel stock trends since the refinery closure



Source: MBIE month end data, Envisory analysis

- Petrol stocks appear to be declining, but some of this is due to COVID lockdowns in 2022, which resulted in higher stocks when demand fell suddenly. Stocks have been more typical in 2023/2024. There have been some changes made in storage (petrol tanks converted to other services), which we expect given declining petrol demand and good provision of capacity relative to other fuels.
- Jet fuel stock was unusually high (relative to tank capacity) in 2022 due to low demand with Covid restrictions, which disguises the increase since mid-2023 with more storage provided at Marsden Point. We expect the MSO implementation will result in an increase in the low points in the chart over the last 12 months (therefore increasing average stock levels).
- Diesel stock has increased with increased storage (at Marsden Point and other ports) and possibly some operational changes in preparation for the MSO implementation. This may also include an impact from more comprehensive stock reporting.

Stocks have increased recently, but it is important to look further back to see trends and whether fuel security has been improving or eroding. Earlier storage data is not available, but other than the recent additional storage at Channel Infrastructure, tank fuel reallocations and the Timaru Oil Service terminal in Timaru, there has not been much change in the last 20 years. There has been some new terminal capacity and some capacity removal. We assume those offset for this analysis.

Table 4: Estimated change in stock cover over the past 20 years

	Petrol	Jet Fuel	Diesel
2024 demand (ML/day)	8.1	5.1	10.7
2004 demand (ML/day)	9.0	3.7	7.2
Change	-10%	+36%	+48%
Days cover 2024 (gross days average)	35.3	29.3	28.1
Days cover 2004 (estimated)[26]	27.1	25.4	32.5
Change (days)	+8.2	+3.9	-4.4

New Zealand had a refinery in 2004, so the analysis is not a like-for-like. It does, however, confirm some important trends.

- Petrol stock days cover is higher due to declining demand. Demand is expected to continue to decline, so stock cover (already the highest of the transport fuels) may rise further. This may provide scope to convert petrol storage to other fuel use, which is already happening in some locations.
- Jet fuel demand has increased significantly over the past 20 years (noting 2024 demand is still 5%-10% down on 2018/2019 demand). Stocks have increased recently with more storage at Marsden Point, although more may be required as demand increases and to add security to the supply chain in the absence of a refinery. The analysis does not include the additional jet fuel storage deal recently announced by Channel Infrastructure and Z Energy or any possible change/addition of storage near Auckland Airport.
- Diesel throughput has increased nearly 50% since 2024, yet there has been minimal net increase in storage until the additions since the refinery closure. The drop in stock cover (or at least the ability to hold higher levels of stock) highlights the importance of the current consultation on holding more diesel stock in the country.

Refined fuel stock should be higher under a 100% import model compared to a partial refinery supply model to offset the large stockholding at an operational refinery. Jet fuel and diesel stocks have increased since the immediate aftermath of the refinery closure, but in the case of diesel, not to the extent of providing as much cover as when demand was much lower.

The stocks modelled in this section are used for the disruption analysis, although we consider the impact of additions that are announced or are under consideration. These includes:

- Addition of jet fuel storage capacity at Wiri/JUHI (in line with recommendations of the Government Inquiry into the Auckland Fuel Supply Disruption (RAP inquiry)[27]);
- The announced additional jet fuel storage capacity at Marsden Point will be available from Q1 2027, and
- A possible addition of seven days of diesel stocks and/or increasing the MSO for diesel to 28 days.

[26] Removes recent tank capacity additions and accounts for less fuel stocks in New Zealand waters in 2004.

[27] https://www.dia.govt.nz/Government-Inquiry-into-the-Auckland-Fuel-Supply-Disruption

Available stock

The system needs a certain amount of stock to keep fuel flowing to customers. Tanks throughout the system cannot be all low at the same time and ships need to deliver appropriate parcels into each port so ensure cover until the next delivery is expected. We calculate that around 12-15 days of operational stock is required to keep fuel flowing to customers without significant interruption through stock outs. This includes stock on ships in coastal waters. The number of days is a little higher for petrol and jet fuel whereas diesel is at the lower end of the range. The stock above this level (i.e. between this level and normal average stock levels) is available stock to manage supply disruptions with the aim of limiting any impact on customer supply, although to reduce to this level, companies would need an exemption from MSO to deal with any disruption event.

In a severe disruption, all operational stock could be drawn down, and some of the heel stock could be accessed. This is feasible if supply is rationed to essential services.

5.0 Demand forecast for refined fuels

We outline the recent demand for refined petroleum fuels, principally petrol, diesel and jet fuel. We also set out a 10-year demand forecast for these three fuels, which informs the analysis of fuel security options.

5.1 Demand for petrol has declined and is stable or rising for diesel and jet fuel

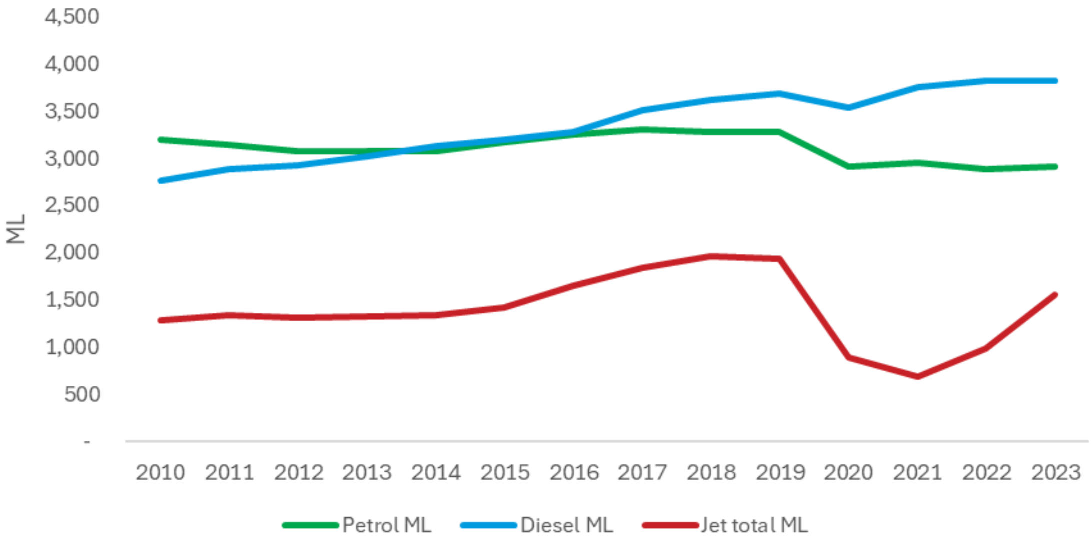
New Zealand's demand for refined petroleum fuels—specifically petrol, diesel, and jet fuel—has fluctuated in recent years, largely due to COVID-19, economic conditions, and changes in consumption patterns.

Demand for refined fuels is principally driven by transport in New Zealand. Petrol is the primary fuel for private vehicles, with about 94% of petrol used for light passenger vehicles. Approximately 70% of diesel is consumed by the transport sector. The remaining diesel usage is split among the industrial sector (11%), primarily for manufacturing and construction, agriculture and fishing (10%), the commercial sector (5%), retail (2%), and international shipping (2%). Jet fuel demand is mostly for international aircraft on long-haul flights (80%) with domestic aviation accounting for 20%.

Figure 6 shows the demand trends for refined fuels from 2010 to 2023. Before 2020, diesel, and jet fuel grew steadily, while petrol demand was relatively flat, peaking in 2017. However, the global pandemic caused significant disruptions, particularly affecting the aviation sector.

In 2020, demand for petrol dropped by 11% due to the impact of COVID-19. It has since recovered but never returned to pre-pandemic levels, reaching 2.9 billion litres in 2023 relative to 3.3 billion litres in 2017. Diesel consumption, on the other hand, has risen steadily, increasing by 10% between 2017 and 2023, with total consumption reaching 3.8 billion litres. Jet fuel demand, although recovering post-pandemic, reached 1.5 billion litres in 2023 but remained below pre-COVID-19 levels of close to 2 billion litres.

Figure 6: Historical consumption of refined fuels in NZ, ML



Source: Castalia/Envisory analysis

5.2 Demand is forecast to decline for petrol, and rise or remain stable for diesel and jet fuel over the next decade

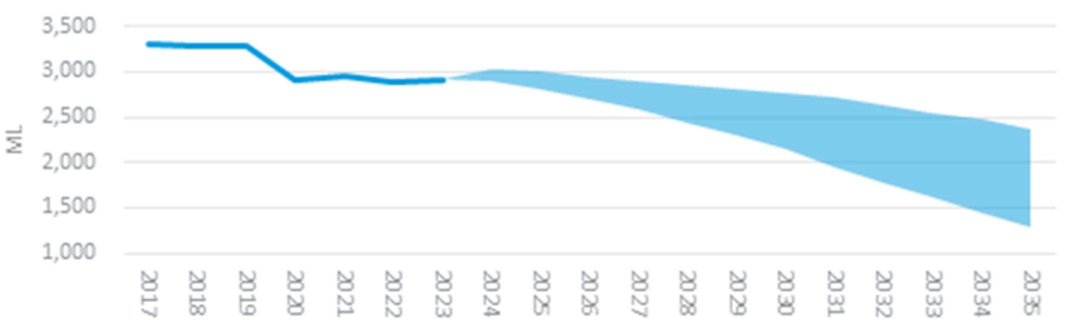
New Zealand's transport sector is expected to undergo significant change in the next decade. Emission reduction targets and technology change will drive this change. Falling capital costs for electric vehicles (EVs), a changing carbon price, and broader efforts are expected to reduce demand for refined fuels.

We have developed a demand forecast for petrol (both regular and premium), diesel, and jet fuel. This demand forecast takes into account policy, changing capital costs for vehicles and broader economic and consumer trends. Castalia and Envisory have each prepared fuel demand forecasts, which we have compared to the Climate Change Commission's (CCC) forecast contained in draft advice for the fourth emissions budget (EB4) period (2036–2040).

Our analysis includes two CCC scenarios: the reference scenario and the EB4 demonstration path. The reference scenario represents projected emissions if no additional reduction policies or measures are implemented beyond those in place as of 1 July 2023. In contrast, the EB4 demonstration path outlines a tested set of actions and strategies across sectors to meet the proposed emissions budget. This comparison provides a clearer view of future demand for refined fuels under varying levels of policy intervention.

The demand for petrol is forecast to decline by 19% to 56% by 2035, with consumption dropping to between 2.4 billion litres and 1.3 billion litres, as shown in Figure 7. The higher end of the forecast reflects the CCC reference scenario, while the lower end is based on the EB4 demonstration path. Forecasts from both Castalia and Envisory fall within this projected range.

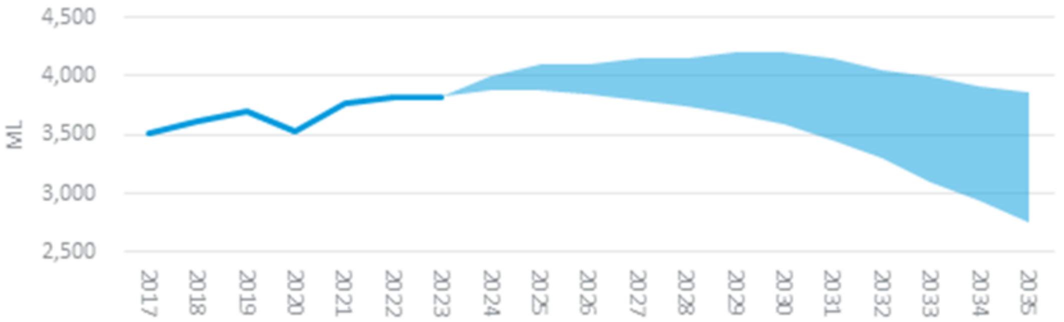
Figure 7: Demand forecast for petrol, ML



Source: Castalia/Envisory analysis

Diesel demand is projected to rise initially before declining. By 2035, in the upper range of the forecast, diesel consumption is expected to return to 2023 levels of 3.8 billion litres. On the lower end, diesel demand could decrease by 23%, falling to 2.9 billion litres, as illustrated in Figure 8. Both Castalia's and Envisory's forecasts align with or fall within the CCC's reference and demonstration paths. Substitute technologies for freight transport such as hydrogen fuel cell (HFC) or electric powered trucks are currently not cost competitive and major step-changes in the cost of green hydrogen production and/or alternatively fuelled vehicles are needed to result in an impact on diesel consumption. Therefore, unlike for petrol, diesel demand should remain robust.

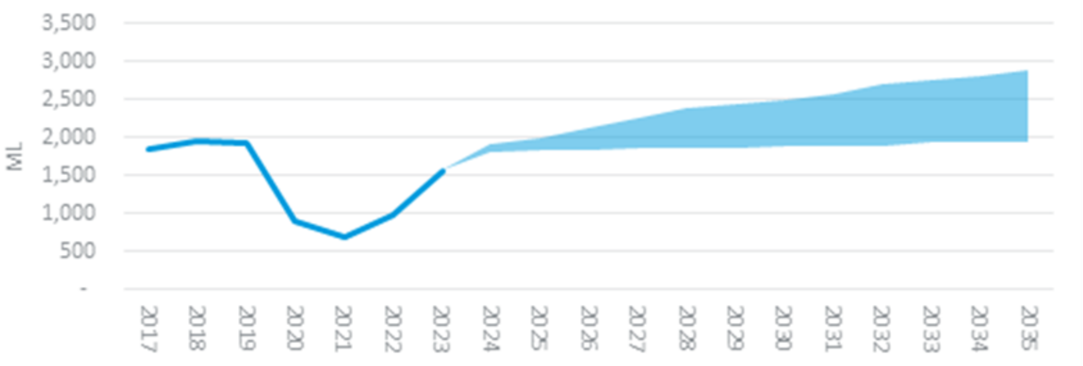
Figure 8: Demand forecast for diesel, ML



Source: Castalia/Envisory analysis

Jet fuel demand is expected to rise significantly. It could increase by 85% in the upper range, reaching 2.9 billion litres. On the lower end, a 25% increase is anticipated, bringing demand to 1.9 billion litres, as illustrated on Figure 9. Both projections are based on Envisory's data. The CCC's forecast suggests a lower range, with a 0.4 billion litre difference between the reference and demonstration paths. Due to high uncertainty in the aviation sector, we believe the potential demand range will likely exceed the CCC's estimates, thus, we have adopted Envisory's forecast range.

Figure 9: Demand forecast for jet fuel, ML



Source: Castalia/Envisory analysis

These demand changes will be driven by a combination of factors, including those CCC identified. They include:

- **Electrification of light vehicles and increasing engine efficiency.** The shift to EVs will play a crucial role, with the CCC predicting 85% of the light vehicle fleet (cars, utes, vans, and motorcycles) expected to be electric by 2040. All new vehicles entering the fleet will be electric, resulting in 80% of total light vehicle travel powered by electricity. This rapid adoption, spurred by government policies like the Clean Car Standard, will sharply reduce petrol demand in the transport sector. Furthermore, new internal combustion engine (ICE) light vehicles are becoming more fuel efficient, with an increasing share of hybrid vehicles entering the fleet.
- **Reduced fuel demand in heavy vehicles and mode shifts.** While the switch to electric heavy vehicles (e.g., trucks) will be slower than for light vehicles, progress is expected by the early 2030s due to lower operational costs. By 2040, almost all new

trucks will be electric, reducing diesel demand. A shift towards lower-emission transport options, such as rail and coastal shipping, will reduce vehicle kilometres travelled (VKT) by heavy vehicles by 10%, further lowering diesel consumption.

- **Increasing use of public transport, walking, and cycling.** The growth in public transport use, cycling, and walking will reduce the reliance on petrol and diesel-powered vehicles. By 2040, these modes are projected to make up 15% of all passenger kilometres travelled, up from the current 5%. This shift, coupled with the rise of remote work and denser urban development, will lead to an 18% reduction in overall vehicle kilometres compared to reference scenarios.
- **Aviation and low-carbon fuels.** Aviation presents unique challenges for decarbonisation due to its limited electrification potential. There is a possibility that low-carbon liquid fuels, such as Sustainable Aviation Fuel (SAF), and battery-electric aircraft for regional flights will play a role, which may reduce the demand for conventional jet fuel. However, at this stage, it is highly uncertain.

Overall, we expect the electrification of light vehicles and improved fuel efficiency to lead to a significant reduction in petrol demand. This shift will be further accelerated by policy decisions and investments in charging infrastructure to incentivise the switch to electric. However, the demand for diesel and jet fuel is likely to increase. This rise will be driven by factors such as growing GDP, which boosts economic activity, and population growth, which increases transportation needs. Additionally, sectors that rely heavily on diesel and jet fuel, like heavy-duty transport, aviation, and industrial applications, face significant challenges in adopting electrification. There are fewer cost-competitive electric heavy vehicle options and no economically feasible alternative to jet engines for aviation. These sectors may take longer to shift to alternative energy sources, sustaining the demand for these fuels in the near term.

6.0 Disruption mapping

The section summarises how we analyse various disruption events and categorise them into expected impacts on consumers.

6.1 Methodology of analysis

Many events could impact New Zealand's fuel supply, including those impacting international supply chains and/or domestic infrastructure. Since all possible disruption events are unlikely to be foreseen, we have grouped them into categories based on the impact they have on fuel supply and/or distribution infrastructure. This way, we can analyse how the market might respond to each category of disruption rather than focusing on a particular scenario.

We assess the impact on customers and the economy more generally based on the size and scale of possible events. Broadly, disruption events fall into two categories:

1. **International supply chain disruption:** These events impact the supply of refined fuels, possibly causing a shortage of fuel available for New Zealand consumers. This could be from a small event such as an off-specification cargo or a late ship, an international conflict such as seen with the Ukraine war, or a complete disruption of fuel flows to New Zealand. The key issue is the volume shortage and the duration of the disruption rather than the nature of the event itself. Larger disruptions will generally (but not always) be related to an international conflict (i.e. something outside New Zealand's borders), with that impacting sources of fuel supply and/or supply routes to New Zealand.
2. **Domestic disruption (infrastructure disruption):** This covers events that impact the distribution of fuel to where the customer requires it. These could be anything from road outages/slips to the loss of a major terminal or critical infrastructure (such as the RAP). These events require establishing alternative logistics routes to maintain fuel supply to consumers or fuel stocks that can be used while the infrastructure is repaired. These disruption events are domestic, with the supply of fuel to New Zealand not impacted.

In developing these disruption scenarios, we carefully examined various risks and evaluated whether there is a distinction between foreseeable and random disruptions. We consulted fuel suppliers, Government agencies, and key stakeholders to understand the nature of potential disruptions. We found no significant difference in the impact of foreseeable versus random disruptions. Additionally, all reasonably foreseeable circumstances are already accounted for in Government and industry planning. Therefore, our disruption mapping focuses on two types of supply disruptions: international supply and domestic logistics disruptions with varying scenario magnitudes.

6.1.1 International supply disruptions

There are a range of events that could disrupt New Zealand's supply chains. We have grouped these into severe, major and minor disruption as categories rather than by cause. Defining the disruption cause is not critical but could include events such as:

- War and regional conflict impact impacting crude supply, or countries supplying product (or areas they are shipped through like Straits of Hormuz or South China Sea);
- Disruption to a supplying country, such as war, pandemic or economic collapse;

- Severe natural disasters impacting a significant portion of crude oil or fuel supply (e.g. Hurricane Katrina on the US Gulf Coast);
- Financial disruption/collapse;
- Piracy/sabotage, etc;
- Space weather event (impact on GPS, power systems);
- Cyber-attack; or
- Shipping-focused attacks.

Table 5: International supply disruption modelling

Event severity	Impact	Case reasoning
Severe global failure of market mechanisms or other international events that isolate New Zealand from its normal supply chains for a period.	This would cause the fuel arriving in New Zealand to cease completely, leaving the country to manage with alternatives and/or stocks held in-country. As markets may have failed, there may not be a normal price response, indicating that normal market mechanisms are not functioning.	This is the most extreme case included for impact assessment. We do not speculate on the possible cause but note that such events would impact New Zealand far beyond fuel supply. Fuel supply and demand would be severely affected. In this scenario, 'business as usual' fuel demand cannot be assumed.
Major disruption to crude or fuel markets requiring supply chains to be rearranged.	Crude market disruption will impact New Zealand if it impacts refinery throughput in this region. Regional disruptions, such as conflict, could also impact supply chains. In either case, New Zealand would face similar consequences, with a portion of its fuel supply affected for a period. This would lead to higher international and local prices in response to the disruption.	This scenario covers a wide range of possible causes, such as events like the Ukraine war and the closure of shipping lanes due to regional conflict (e.g. Straits of Hormuz, South China Sea). These are the types of events that lead to international responses by the agencies set up to support countries, such as the International Energy Agency (IEA).
Minor disruption to supply.	The impact would be a loss of all or part of a cargo destined for New Zealand, either completely or for a period.	This scenario tests how the system can handle isolated incidents, which are more likely than the major events above. These incidents should normally be manageable without disrupting fuel supply to customers.

6.1.2 Domestic disruption (Logistics)

This category investigates the vulnerabilities of New Zealand's national fuel infrastructure and supply chains by considering the impact of temporarily losing critical terminal and pipeline assets.

The disruption may be caused by a range of events, such as:

- A natural event such as an earthquake or tsunami;
- Infrastructure failure caused by damage (intentional or otherwise) such as from third-party damage, a terminal fire and explosion; or
- Some other events prevent normal terminal operations, such as industrial action or loss of consent to operate.

The analysis focuses on the impact on fuel supply to consumers. We do this by assessing the most severe event for critical fuel infrastructure, such as a complete loss of a terminal or terminals at a location. The impact would be less severe for smaller-scale events, although smaller-scale events are more likely and compounding smaller events can lead to larger impacts. For example, a long-term outage at the Marsden Point terminal is less likely than a short-term disruption to the RAP pipeline.

Table 6: Domestic logistics disruption events modelled

Event severity	Impact	Case reasoning
Impact preventing fuel from being received at Channel Infrastructure's Marsden Point terminal for an extended period.	Disruption to 40% of New Zealand's fuel supply, including complete disruption to jet fuel supply to Auckland Airport (~ 80% of NZ's jet fuel demand).	As the largest terminal in New Zealand, this event provides the most severe domestic infrastructure loss to manage.
Long-term loss of Wiri terminal (or the RAP).	This is a subset of the above case but analysed separately, as it is arguably a more likely disruption.	Analyse the impact of import ability and road loading terminals that are still available at Marsden Point.
Impact disrupting Wellington or Lyttelton terminals.	Loss of a major supply point in the lower North Island or the central South Island, with an impact on the associated airports.	Loss of these terminal locations provides the most severe test of the response capacity for each region. The other major port is Mt Maunganui, although the loss of this supply point is managed more easily due to the Wiri terminal in the same part of the country.
Short-term disruption to RAP.	Loss of RAP for 2 weeks. This is the worst case for Channel Infrastructure, which expects to be able to repair expected pipeline events in 1-2 weeks.	Need to cover loss of fuel (especially jet fuel) while supply is reestablished. The 2017 RAP disruption was 12 days when recommissioning time was included.

Previous fuel security reports have analysed events that could impact more than one terminal, such as a very large tsunami. These are very high-impact, low-probability events. We do not analyse them again in this report but note that the demand for essential and critical services is low compared to normal demand (these demands are covered under severe disruption analysis in section 6.2.1). This demand could be met as long as a couple of terminals on each island remained open as well as the roading network.

6.1.3 Approach for assessing impacts

A specific disruption event will provide context on the likely duration, although the impact on the supply chains and the responses to these will be similar within each category. The analysis is agnostic to the cause of disruption. Instead, our analysis considers the market responses that would be triggered and how they might mitigate the magnitude of the disruption. Specifically for the two categories:

- International supply disruption: The key response will be establishing alternative supply routes and cargoes to replace the volume of fuel lost from the disruption. The analysis considers factors such as the geographic location of alternative supply, timeframes for reestablishment, and likely availability from that location. The ability of stocks held in New Zealand to keep the country supplied while alternatives are put in place is assessed. In the case of major disruption, the price impact on demand is also considered.
- Domestic logistic disruption: The primary response levers are using the remaining stocks at the disrupted terminal (assuming this was not lost as part of the disruption event) and establishing alternative supply from nearby terminal locations via trucking or for jet fuel shifting fuel demand to other airports and then tankering[28]. The analysis looks at the disruption to each market in total, and we acknowledge for jet fuel, not all airlines will be able to use all the mitigation options considered.

The analysis does not consider demand reduction as a response option other than for severe supply disruption. Instead, the modelling seeks to supply the normal consumer demand to the extent that the alternative infrastructure can manage that additional demand. Demand may be affected by natural disasters, often with a spike in demand (as consumers rush to fill up their vehicles) followed by a period of reduced demand. For the analysis, we ignore this demand behaviour as we expect the overall impact on demand to balance out over the disruption period. We accept that a major natural disaster may impact the demand for a longer period.

6.2 International supply disruption impacts

6.2.1 Severe supply disruption

We have been asked to consider a severe supply disruption where the supply of fuel to New Zealand is completely unavailable for an extended period. This is not a normal fuel supply disruption event (which is covered under the major supply disruption section) but an event with much broader disruption to the global economy so that oil markets cannot respond to the disruption through price and reallocation. We do not speculate on the cause of such an event. However, examples could include a major global war or a major sustained global banking failure where ships are not loaded due to a lack of confidence arising from the uncertainty of payment[29].

A severe supply disruption scenario would be so drastic and wide-reaching that all parts of the New Zealand economy and people would be affected. The whole New Zealand economy would be impacted for reasons unrelated to fuel supply: export markets would not demand New Zealand

[28] Tankering is where an aircraft loads sufficient fuel for its return journey, so it does not require refuelling at its destination. This does increase fuel consumption.

[29] Such a failure would impact all shipping and trade not only oil tankers.

products, consumers would not demand imports, and tourists would not travel. A failure of normal trading systems will quickly impact New Zealand, including:

- An almost immediate impact on New Zealand export industries as supply chains are forced to cease once warehouses and storage facilities reach capacity;
- A significant reduction in agricultural activity as a result;
- Loss of gas supply as producing fields will be forced to shut once storage tanks are full of crude and condensate that can no longer be exported;
- A severe downturn in international travel as there would be lack of confidence in normal tourist activities, for the same reasons that have stopped trade;
- All businesses reducing production due to loss of confidence, and
- Consumers reducing demand for goods and services.

These impacts extend well beyond a normal fuel disruption scenario, and a national security event is a more accurate description. The Government would need to act quickly to respond to the event, including actions to manage remaining fuel supplies and their allocation to essential services.

The actions taken when COVID-19 first impacted New Zealand in March 2020 provide a useful comparison for curtailing fuel demand. A severe fuel disruption would require similar extreme actions. The fuel consumption levels during various COVID-19-level responses (Table 7) indicate national fuel consumption when different activities are restricted.

Table 7: COVID level restrictions – fuel consumption compared to business as usual[30]

COVID Level	Restriction summary	Petrol	Jet Fuel	Diesel
Level 4	Stay-at-home order; Essential service businesses only; Travel severely restricted; All public venues closed.	20-25%	20-30%	30-40%
Level 3	Stay-at-home encouraged; Businesses allowed to operate for contactless transactions; Schools (year 1-10) open but attendance voluntary; Local travel only; Small gatherings only.	45-55%	20-30%	80-90%
Level 2	Business and schools open with safety measures; Domestic travel allowed; Public venues open; Gatherings with limits indoor.	80-90%	30-40%	90-95%

The impact on fuel demand from loss of trade flows is likely to exceed what occurred during Level 4 COVID restrictions due to a greater reduction in export industry activity.

We modelled a 90-day loss of fuel supply into the country (stock on the water would arrive, but then there would be a 90-day gap until re-supply arrives). In-country inventories would need to sustain the country over that period and could be reduced to very low levels while only critical users are supplied. Table 8 shows the average level of demand that could be met over that period.

[30] Source MBIE and Envisory data

Table 8: Level of normal demand met during disruption event

Disruption	Petrol	Jet Fuel	Diesel
% normal demand met from inventories	31%	29%	27% (33% if additional 7 days stock held)

Existing inventories would be sufficient for a 90-day event with similar demand reductions to the Level 4-COVID restrictions except for diesel. The additional seven days of diesel stock holding currently being considered by the Government would make a difference, lifting diesel coverage above 30% of demand (it currently has the lowest days cover).

Fuel demand requirements for lifeline utilities (power, gas, water, hospitals, emergency services including police, Defence Force, etc.) are included in the Regional Civil Defence Emergency Management (CDEM) Fuel Contingency Plans. These identify critical fuel supply points and demand requirements for each region. The data is not uniform across all plans, but many contain Baseline fuel demand requirements, demand for a major 24-hour power outage and demand following a major cyclonic storm. The Baseline demand is relevant for this analysis, with our analysis showing that lifeline utilities typically account for less than 5% of the normal diesel and less than 3% of the normal petrol demand. Adding critical transport use (e.g., food distribution and essential workers), which do not appear to be consistently included in CDEM plans, may only raise the demand for petrol and diesel by another 5-15% of the normal demand[31].

This highlights that New Zealand may be able to reduce fuel use more substantially (to about half of COVID Level 4 consumption) if focusing on the critical functions of state and essential services.

6.2.2 Major supply disruption

Major supply disruptions cover all events that specifically impact fuel supply chains. This includes events such as:

- Major disruption to crude supply chains, such as the Straits of Hormuz closure for a period (this would impact 20% of the global fuel supply chain) or war/boycott issues, such as seen following the Libyan civil war (2011) and more recently the Ukraine invasion and resultant boycott of Russian oil in 2022;
- Major disruption to refining centres from events such as war or natural disasters (e.g. war in North Asia and/or South China Sea/Taiwan, hurricane impacts like those in the US Gulf Coast (2005)); and
- Major disruption to trade flows or shipping.

These events have massive impacts on fuel supply chains. Prices respond immediately and will rise quickly and substantially depending on the scale of disruption. Crude oil and refined fuel trading markets are deep, sophisticated and global and used to reacting to sudden, unplanned events. Crude oil and refined fuel are allocated where supply meets demand, and in disruption events, the price increases in the disrupted area, encouraging fuel supply from other regions to fill any gap. The 2020 Fuel Security and Fuel Stockholding Costs and Benefits Report[32] describes how this market

[31] There is no data available on the breakdown of critical uses beyond that captured in the CDEM plans. It could be worth expanding the critical fuel users surveyed when these plans are next updated to better capture the demand from essential service businesses.

[32] Fuel Security and Fuel Stockholding Costs and Benefits 2020, December 2020, Hale & Twomey for MBIE

mechanism mitigated any product shortages during the Hurricane Katrina impacts on the United States Gulf Coast refining centre.

There are well-established major multilateral institutions, such as the IEA, that coordinate responses to events within days[33]. Regular planning exercises are run, including the types of events described above. New Zealand has been a member of the IEA since 1977, and many of our major suppliers, such as South Korea, are members. In addition, IEA associate member countries (which agree to work together during supply disruptions) include China, India, and Singapore, among many others.

The original IEA rules require members to assist each other during disruptions, with the IEA helping allocate stocks. Many decades ago, it was accepted that the market would do this more efficiently than a centralised agency. The focus is now on the collective release of strategic petroleum reserves (from both IEA and associate member countries) to help cover the supply loss from the disruption event. New Zealand plays its part in these stock releases through its international holdings of reserve stocks. To date, IEA members have responded to:[34]

- 1991 Gulf War: Voluntary release of strategic reserves by some IEA members;
- 2005 Hurricane Katrina and Rita: Coordinated release of strategic reserves with a particular focus on product stocks where possible;
- 2011 Libyan Civil War: Partial release of strategic reserves (not all member countries had to participate); and
- 2022 Ukraine conflict: Coordinated release of over 60 million barrels of strategic reserves (this was two separate releases in March and April of 2022).

New Zealand participated in all these actions except the Libyan Civil War, in which we were not required to participate as we fell below the threshold allocated to each IEA member country. The 1991 Gulf War was a voluntary release by IEA members who supported the Gulf War intervention.

History shows that prices will rise in response to disruption, so prices will be elevated when the IEA takes action. However, the decision driver for an IEA response is a sudden physical loss of supply, not high market prices.

Events where market mechanisms fail, resulting in a complete lack of fuel flow rather than price allocation, are covered under severe supply disruption. We do not consider these severe events to be 'fuel supply only' events, hence their differentiation from the events covered in this section.

Modelling

We model a major disruption to our normal supply routes such that 50% of our supply is impacted and needs to be sourced from other locations. Examples might be a war in North Asia preventing supply from South Korea, Japan and China or an event that prevents the flow of fuel from Singapore/ Malaysia to New Zealand. A North Asian event is likely to have a greater impact on diesel supply and the South Asian event petrol supply. We model a loss of 50% supply across all fuels so we can assess the impact on a consistent basis.

- Most of the stock on ships coming from those destinations arrives, and then there are no further supplies from the disrupted locations.

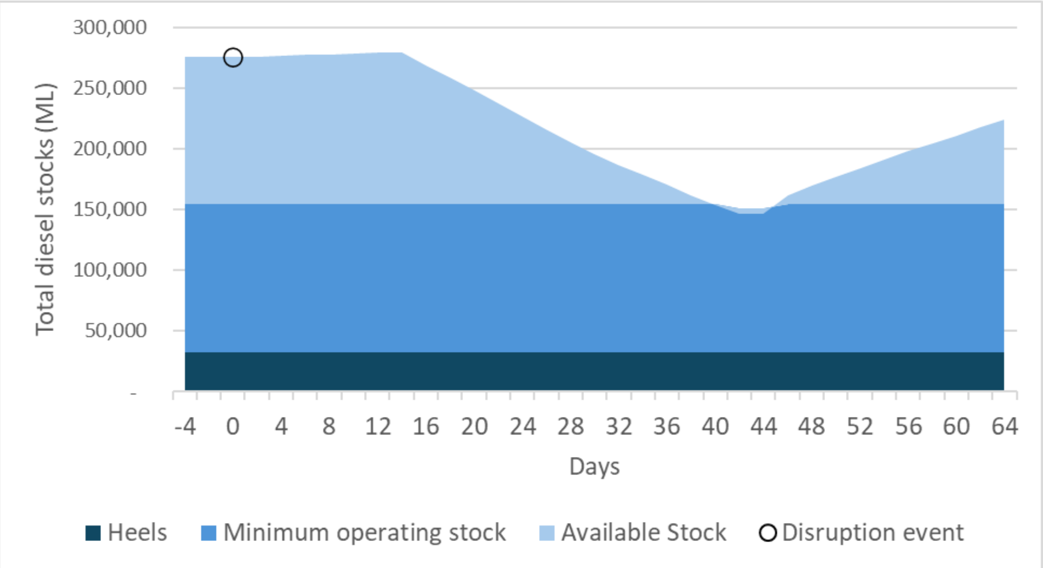
[33] The IEA was established in 1974 following the 1973-1974 oil crisis when an oil embargo by major producers pushed prices to historic levels.

[34] https://www.iea.org/about/oil-security-and-emergency-response

- A small amount (10%) of additional supply from this region (Asia-Pacific) can be secured in line with normal timelines for obtaining supply.
- Most replacement supplies and additional cargoes to restock come from further afield. In this example, the timing assumes India and the United States, although the Middle East could be another supply point.
- Resupply time builds in the time to secure the cargo and the ships from those locations. We have assumed conservative timings, and in a major disruption, these fuel movements may be organised more quickly.
- Inventories are drawn down to maintain supply while supply chains are reorganised.
- We assume normal supply to consumers is maintained (no significant stockout), so the system still needs to have sufficient operating stock levels (covered in Section 4.3.3).
- There will be a price impact (Section 7.1.2).

We find that petrol stocks are sufficient to cover this event, while there may be a small impact on diesel and jet fuel consumers. Should an additional 7 days of diesel be held in-country, there would be no impact on diesel consumers. Figure 10 shows the profile of national diesel inventories in such an event. Should the resupply be secured a week earlier, any impact could be avoided.

Figure 10: Diesel stock profile in major supply disruption



One fuel company shared its modelling of a similar scenario during consultation. The findings are similar (more diesel stocks may be needed), although our modelling shows a tighter situation for all fuels. This is due to our assumption on the minimum operating stocks required to maintain a close-to-normal supply to all consumers during the event.

6.2.3 Minor disruption to supply

These types of disruptions result in a loss of supply to New Zealand but no international market impact, so there would be no price impact on consumers. Examples include:

- Loss of a cargo on route to New Zealand (could be through loss of a vessel, piracy, etc.);
- Severe delay in a cargo arriving in New Zealand (ship breakage, weather, etc.); or

- Off-specification fuel for some or all of a cargo on arrival in New Zealand such that it cannot be blended with existing stocks, so it must be replaced.

The most severe of these events is likely to be the off-specification cargo, as it will only be identified as a problem on discharge when stocks are lower than average in anticipation of the delivery. It is unlikely that a whole cargo will be off-specification, although we model this as a worst-case scenario. One supplier noted that fuel quality incidents on arrival are less than 0.1% (less than 1 in 1,000 fuel parcels received).

Fuel suppliers stated that such events should not normally impact consumers. They acknowledged there had been incidents in the past three years where such events caused shortages, particularly for jet fuel supply at Auckland and Wellington airports. They stated that changes had been made so that similar events would no longer have the same impact. These include more fuel testing at load port and investing in more jet fuel storage. The focus remains on ensuring these events, particularly fuel quality impacts, do not happen in the first place.

We model these events by assessing whether the system could handle the loss of a complete cargo without impacting consumers once the MSO is in place. We assess whether stocks are sufficient to maintain supply while arranging a replacement cargo assuming companies would be able to use stocks below the MSO level while resupply is organised. That is, for events impacting national supply, the stocks held under the MSO level would be available for companies to use to mitigate any impact on consumers.

Section 3.3 covers shipping to New Zealand, and many deliveries have multiple fuel cargoes. However, some MRT cargoes are single grade (holding 50 million litres), and there can be a similar amount of each fuel on larger LR2 tankers delivering into Marsden Point. Therefore, for each of the fuels, we model the loss of a 50 million litre delivery on the system. Table 9 shows the number of days demand for each fuel with a 50 ML cargo size.

Table 9: National days demand from a maximum typical cargo

	Petrol	Diesel	Jet Fuel
Parcel size maximum (ML)	50	50	50
Days national demand	6.2	4.7	9.9

Stocks will be at lower levels (for the company delivering) when a ship is due, as stocks will be drawn down ahead of the replenishment. On a national level, the minimum observed petrol stock level was 31.4 days in the past 12 months[35] (gross stock) and the MSO is 28 days. After accounting for heels and operational stock to keep the system flowing, we calculate 10-15 days of available stock to draw down typically. A loss of ~6 days' supply would be manageable within the system, although for the company concerned, its stocks would likely drop below the MSO requirements and may need to arrange support from other suppliers.

The port(s) where the ship is delivering fuel will be impacted, although this can be mitigated by redirecting other cargoes and by trucking from neighbouring terminals.

Due to higher national consumption, a similar cargo size for diesel is under 5 days' demand. However, stocks are lower with a lower MSO obligation (21 days) and less tank capacity. The lowest month-end inventory in the last 12 months was 22.6 days (all gross). A loss of 5 days of

[35] This data is based on reported month end stocks received by MBIE.

diesel supply could be managed, although it is tighter than petrol, with only 6-10 days of stock able to be drawn down at a low point in the cycle without impacting consumers.

Diesel has similar flexibility to petrol in managing specific terminal shortages by redirecting ships and using trucking from other terminals as necessary. However, when diesel stocks are close to the MSO minimum, we expect managing supply without any disruption to customers will be tight in this type of event. In the consultations, some suppliers noted this from their analysis and have decided to target higher diesel stocks than the MSO. The analysis lends weight to the Government's consideration of increasing the New Zealand’s diesel stocks above the current MSO.

A similar loss of jet fuel cargo has a greater impact, as it provides more days' supply. However, a 50ML cargo is only used for delivery at Marsden Point, where most jet fuel stocks are held. A 50 ML cargo of jet fuel covers just over 12 days of jet fuel demand through Marsden Point. The minimum stock obligation is 24 days gross (~21 days net). Our analysis indicates that 12 days’ supply loss could be managed, although this would be tight and take stocks down to minimum operating levels. As jet fuel demand grows and stockholdings increase to maintain stocks above the MSO, the day's supply on any one cargo should reduce, easing this constraint. However, our analysis shows that the 24-day jet fuel MSO is a minimum to provide resilience to cover this sort of disruption event. One supplier mentioned setting a minimum of 14 days of operational stock in the Auckland Airport supply chain (Marsden Point through to Auckland). This is around 17 days of gross stock and is the minimum point at any time, rather than an average over a period as measured for the MSO. Our assessment is that this is the minimum operational level for the system while still meeting the MSO, and providing sufficient stock to cover the loss of a cargo without major impact on consumers. We note at these stock levels, companies would need to use stock below the MSO to cover events such as the loss of a cargo.

In summary, a loss of a large 50 ML cargo would cause challenges for supply but should not cause any significant supply disruption, given the stocks held under the MSO regulations. It is tighter for diesel than other products because of the lower MSO. The ability of the system to cope with a second (concurrent) supply disruption event would be more problematic, with the combined events more likely to result in some level of supply disruption to customers.

6.3 Domestic (logistics) disruptions and impacts

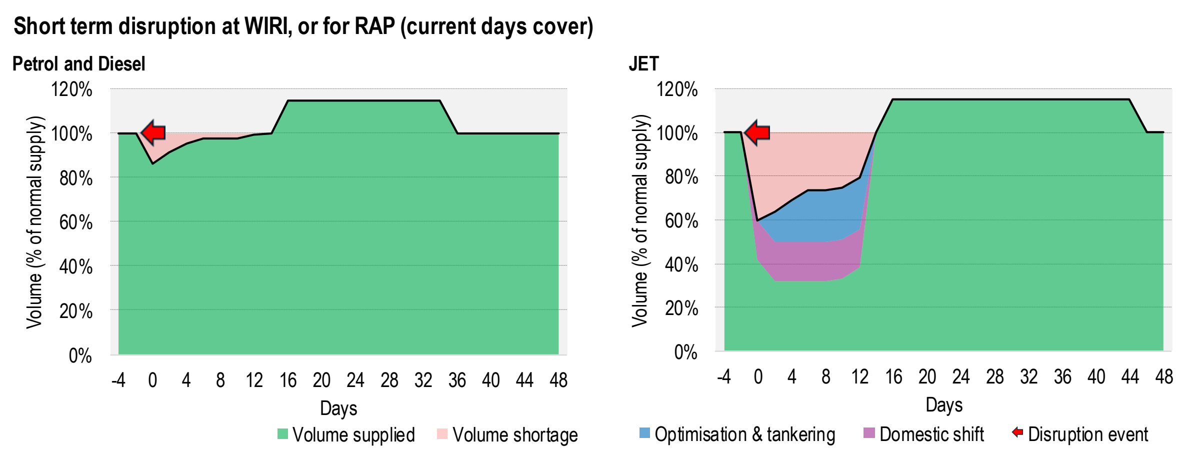
Within New Zealand, we have tested disruption at locations with critical infrastructure to understand the impact on domestic fuel supply. Generally, we do not consider the nature of the disruption event, as while there could be a range of disruptions (such as loss of a berth, pipeline, tankage, gantry, industrial action, or even a significant fuel quality incident that renders onshore stocks unusable), the key driver of the magnitude of the disruption is time.

In most cases, we model long-term disruption to day 64, by which time we expect alternative arrangements, such as imported trucks, would be in place. We model a shorter 14-day outage impact for the RAP and/or Wiri Terminal in addition to the long-term disruption cases.

6.3.1 14-day outage impacting RAP and/or WIRI

This scenario assumes a 12-day disruption to the RAP, with a further two days post-outage to get the RAP and Wiri Terminal back up and running. In total, the disruption is assumed to be 14 days in line with the longer end of the 1-2 week range that Channel Infrastructure advised for pipeline repair. This scenario is similar to previous Envisory assessments and the actual RAP outage in September 2017, where the repairs to the RAP took 10 days, with an additional 2 day recommissioning period before product flowed fully.

Figure 11: 14-days outage impacting RAP and/or Wiri impact



Petrol and diesel situation:

- While the total shortfall is estimated to be 37ML, around 30ML of this would be met by drawing down the remaining stock at Wiri Terminal.
- After maximising trucking from alternative locations and relocating spare trucking resources, the physical shortfall in supply would only be 7ML.
- While there may be some brief retail site stockouts, generally, we expect consumers will be able to purchase fuel as needed.

Jet fuel situation:

- The impact on jet fuel is more significant, as currently, we estimate there are around seven days of drawable stock ~30ML) at Wiri Terminal and JUHI. With no alternative supply routes, this stock would need to be rationed to airlines to cover the 14-day outage. We estimate the allocation outcome would be around 35% of normal demand.
- We expect airlines will quickly alter domestic refuelling patterns, with more jet fuel supplied at Wellington and Christchurch airports. Soon after, airlines would be forced to tanker fuel internationally, as was the case in the 2017 RAP incident.
- With all these measures in play, the shortfall is estimated to be 30%.

A key recommendation from the RAP Inquiry was for more jet fuel (equivalent to eight peak days demand) to be stored on or near Auckland Airport.[36] During consultations, airlines and Auckland Airport also raised the need for more jet fuel to be held nearby, with up to 14 days cover suggested, although the government consulted with options for 10 or 12 days stock cover of 80% peak demand. MBIE has advised the fuel companies are working on a solution that will see more jet fuel being held at the Wiri Terminal. We understand this will increase useable jet fuel stocks to at least 8 days peak demand (i.e. 10 days cover of 80% of peak demand).

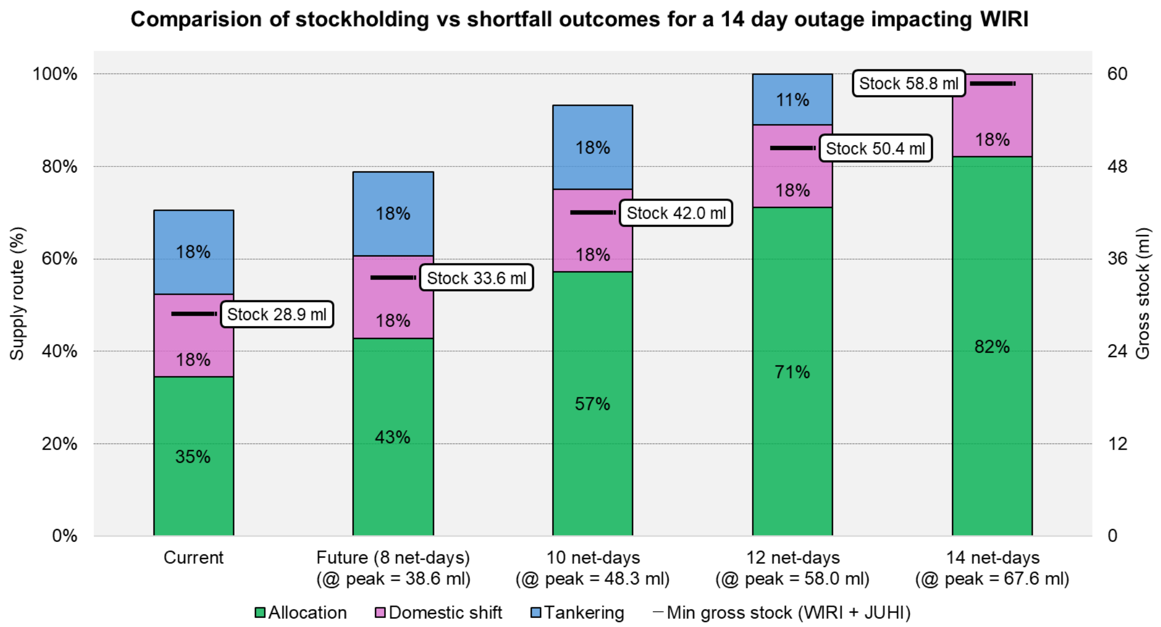
It is unclear from our review of the RAP Inquiry, the consultation options and the feedback given, if the days cover referred to is gross stock (i.e. includes heels) or net stock (i.e. useable days cover). For our analysis we calculate the net stock days cover (based on average daily demand), and the

[36] The RAP Inquiry recommendation was for "storage at or near Auckland Airport that provides at least 10 days' cover at 80% of operations, based on the average of the 30 non-contiguous peak days in a calendar year"

gross amount of stock that would be held to provide that cover. Figure 12 also shows the amount of gross stock that would be required for peak days cover.

We have used the disruption model to test the impact of differing levels of jet fuel across the Wiri Terminal and JUHI complex for the same 14-day outage, as shown in Figure 12. This chart also shows the gross amount of stock that would be held under each stockholding scenario.

Figure 12: Impact of different levels of jet fuel storage at or near Auckland Airport



Assessed jet fuel situation (assuming stocks are at the minimum) for each stockholding level with a 14-day outage:

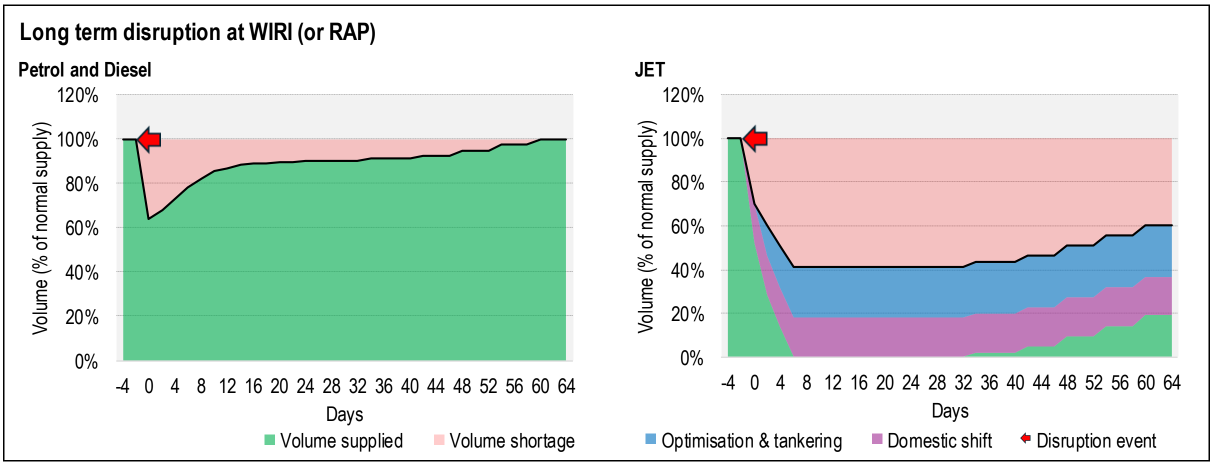
- 8 net-days: While this materially improves the supply situation (43% allocation is now possible), the supply shortage is still estimated to be 21%.
- 10 net-days: At this level, the allocation would be around 57%, with only 7% of the requirement unable to be met through stock drawdown, shifting domestic refuelling and tankering.
- 12 net-days: There would not be a shortfall with this level of stock, although international tankering would still be required, in addition to shifting domestic refuelling.
- 14 net-days: At this level, the useable stock would be double current levels, with allocation now able to be just over 80% and the need for international tankering unlikely.

The scenarios for 10 – 14 days of useable stock cover may require several new tanks to be built beyond what is already planned.

6.3.2 Long-term disruption at WIRI

This scenario covers long-term disruption at Wiri Terminal. For the disruption, we assume no Wiri stock is available (just JUHI jet fuel stocks). Petrol and diesel supply would shift to nearby terminals, with spare trucks relocated. Later measures would include overloading trucks to fully utilise volumetric capacity and other actions like attended gantry loading. Two months after the disruption, we expect additional trucks and drivers to have arrived from offshore, likely Australia[37].

Figure 13: Impact of long-term disruption at Wiri



Petrol and diesel situation:

- While the initial shortfall would be around 35%, optimising the trucking fleet (including by overloading) would see supply quickly ramp up to around 90% of normal demand.
- To fully reestablish supply, we estimate that around 11 additional trucks (and therefore 22 drivers) would be required to supplement the existing trucking fleet.

Jet fuel situation:

- The jet fuel situation would be severe, with remaining JUHI stocks expected to be used within a few days, even if they are rationed to refuel aircraft already at Auckland Airport. Supply would quickly drop to around 40% of normal demand, with domestic refuelling shifting to Wellington and Christchurch and some international tankering the only supply options.
- We expect some form of temporary loading gantry would be established at Marsden Point. Once suitable jet fuel trucks are imported, a further 20% could be supplied at Auckland Airport (field testing has indicated the JUHI could receive 0.8ML of fuel daily by truck).
- With all these measures in play, the long-term shortfall would eventually be 40%.

The outcome of a loss of supply between the Wiri terminal and JUHI (such as from the loss of the WAP or the JUHI facility itself) would be similar to this a long-term disruption at Wiri. In this case, we expect 20% of the JUHI demand could quickly be met at Auckland Airport by trucking jet fuel directly from the Wiri Terminal.

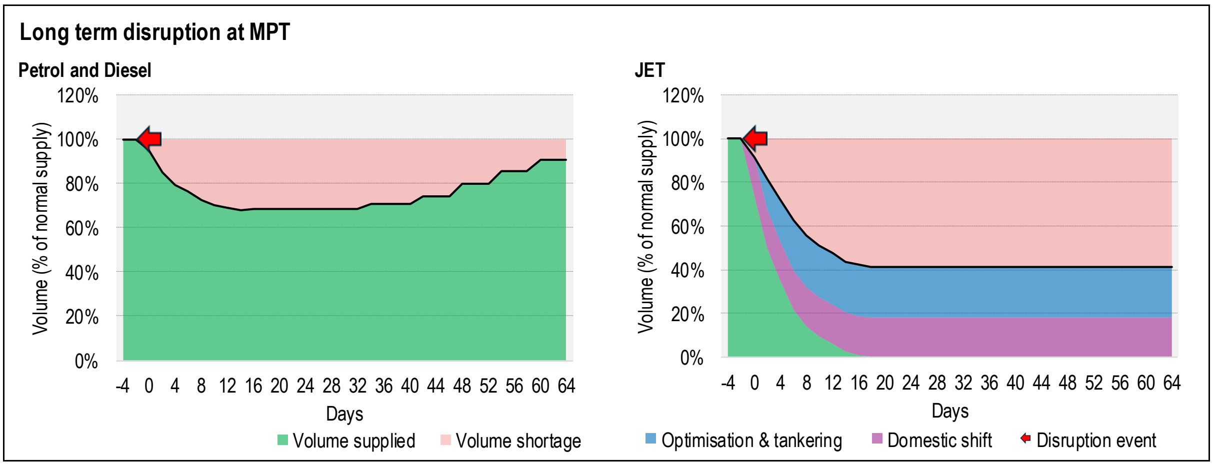
6.3.3 Long-term disruption at Marsden Point

This scenario is similar to the long-term disruption at Wiri in that supply to that terminal would cease. The stock would be available at Wiri and JUHI, although the disruption at Marsden Point

[37] These options were first covered in the 2011 RAP Contingencies Report, available at https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-generation-and-markets/liquid-fuel-market/fuel-security-in-new-zealand pg. 10

would mean the Marden Point Truck Loading Facility would not be usable. The measures deployed would be the same as in the long-term Wiri disruption scenario, although the eventual loading of jet fuel at Marsden Point would not be an option.

Figure 14: Impact of long-term disruption to the Marsden Point terminal



Petrol and diesel situation:

- The initial impact of the disruption would be mitigated by drawing down stocks at Wiri, and once the trucking is optimised, supply would be around 70% of normal demand.
- Using import trucks (31 would be required due to the greater trucking distances), we estimate that 91% of normal demand could be supplied before reaching capacity at the Mount Maunganui gantries (day 60 in analysis).
- It may be possible to reduce the supply shortfall by further optimising trucking arrangements from the other North Island terminals.

Jet fuel situation:

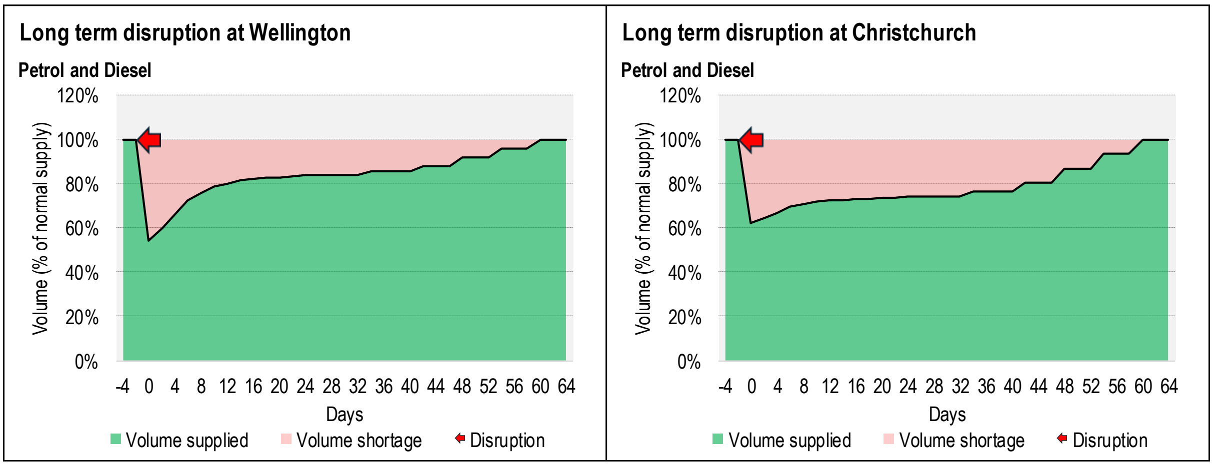
- The jet fuel situation would be even more severe than the long-term Wiri disruption scenario, with only 40% of normal demand supplied through shifting domestic refuelling to Wellington and Christchurch and some international tankering.

6.3.4 Long-term disruption at Wellington or Christchurch

The long-term disruption scenarios at the Wellington or Lyttelton terminals are the major terminal risks in the rest of the country. There are multiple terminals at each of these locations, although we assume the disruption has impacted all the terminals, with no fuel being able to be drawn down (so worst case). Like in other cases, the petrol and diesel supply would shift to nearby terminals, with spare trucks relocated. Later measures would include overloading trucks to fully utilise volumetric capacity and other actions, including attended gantry loading. Two months after the disruption, we expect new trucks and drivers will have arrived in the country.

We do not assess the impact from loss of jet fuel at Wellington or Christchurch as there are no credible supply alternatives for reestablishing supply from another terminal and less public availably of the storage and supply logistics. Unlike Auckland Airport, the jet fuel demand at these locations can be covered by refuelling domestic aircraft at the other main airports, or by tankering fuel for international short-haul flights.

Figure 15: Impact of long-term disruption at Wellington or Christchurch



Wellington situation:

- The initial shortfall would be around 45%, but optimising the trucking fleet (including by overloading) would see supply quickly ramp up to around 85% of normal demand.
- To fully reestablish supply from other locations, we estimate that around 13 additional trucks would be required to supplement the existing trucking fleet.

Lyttelton situation:

- The initial shortfall would be around 35%. Optimising the trucking fleet (including by overloading) would see supply quickly ramp up to around 75% of normal demand, which is lower than for Wellington as demand is greater, so the spare trucks cover less shortfall volume.
- We estimate over 30 additional trucks would be needed to supplement the existing trucking fleet to fully reestablish supply from other locations. This is higher due to the need to draw fuel from Nelson and Dunedin in addition to Timaru when gantry limits are reached.

6.4 Likelihood of disruption

Likelihood of disruption is not a critical input for the analysis in this report, but for completeness we provide a summary of disruption likelihood from earlier fuel security reports (where relevant) and comments on the additional scenarios covered in this report.

Table 10: Likelihood of disruption summary

Event	Likelihood
Severe Supply Disruption	We do not assess a likelihood as there are many variables involved, and it would require extensive geopolitical analysis (and would almost certainly be wrong).
Major Supply Disruption	This report models a 50% loss of supply from normal Asian fuel markets which does not have an international study as reference for probability. It is reasonable to assume a similar probability as the

	default in previous reviews (2.5% or 1 in 40 years). The previous fuel security reports used the following disruption scenario: Disruption of 10% (net of spare capacity) to the international crude oil market; ■ Probability of 2.5% of this disruption in any one year (1 in 40 years); and ■ 6 month duration.
Minor Supply Disruption	Ship delays are relatively frequently, and fuel quality events occur from time to time. In this report we model a fairly substantial impact (loss of whole cargo) which is more unusual or would reflect a number of smaller, compounding events occurring around the same time. One company said fuel quality incidents happen less than 1 in 1,000 fuel parcels. This would be one every 3-4 years based on New Zealand's delivery pattern. A significant ship delay would add to this probability, so it is reasonable to assume an event every couple of years (50% in any one year). This frequency is why sufficient stocks should be held to ensure that consumers are not normally impacted from these events.
Long Term Terminal Disruption	Between 0.2-0.3% (1 in 300-500 years) on any one terminal[38]. Marsden Point terminal (dispersed tank infrastructure) is expected to be at the lower end (1 in 500 years)
Short Term Terminal or RAP disruption	Between 0.5-1.0% (1 in 100-200 years)[39].

The probabilities covered above for infrastructure do not cover the likelihood of strike action or deliberate acts such as sabotage.

[38] Based on analysis in the Information for NZIER Report on Oil Security 2012 Report and updates in the New Zealand Petroleum Supply Security 2017 Update, Hale & Twomey for MBIE

[39] ibid

7.0 Economic impact from disruptions

Disruptions to fuel supply, whether caused by domestic logistical issues or international supply chain challenges, will impose significant economic costs on New Zealand. The magnitude of the cost will depend on the severity of the disruption scenario. Overall, the total economic cost of supply disruption is estimated to be between NZ$118 million (0.04% of GDP) and NZ$2.4 billion (0.85% of GDP). The most significant risks to the New Zealand economy come from long-term disruptions at MPT, at Wiri or to the RAP, with the economic loss estimated to be around 0.85% of GDP. Followed by an international supply disruption scenario with a 50% fuel supply disruption, resulting in an economic loss of 0.72% of GDP.[40]

The estimated GDP impact is modelled using econometric techniques based on the historical relationship between per capita fuel consumption and GDP. The resulting model describes the short-term relationships between GDP and ground fuel consumption, without establishing a causal relationship. We verified these results by cross-checking against an alternative input-output (I-O) analysis. The results were within the range of this alternative technique.

Economic modelling cannot fully account for the complex consumer behaviour responses that are likely to result from a fuel shock, such as switching to alternative modes of transportation, work, and travel adjustments. These behaviours are difficult to predict during a supply disruption and could lead to incorrect assumptions and an underestimation of the potential economic impact. This means that our estimate of GDP impact timing and magnitude of the impacts are highly uncertain.

7.1 Approach to economic analysis

Economic analysis of future potential fuel supply shocks is inherently uncertain. It provides an indication of the scale of impact and is useful to determine the differences between scenarios. However, it does not provide a precise effect on GDP. The box below explains the limitations of various approaches to analysing future potential supply shocks.

[40] We report GDP disruption costs in constant 2009 dollars, aligning with standard real GDP presentation practices.

Economic modelling has some limitations for informing policy decisions on fuel security. Outputs from econometric regression analysis (used by Castalia here), input-output analysis (used here to support econometric regression analysis), and CGE modelling (not used) can provide valuable insights into the scale of potential impacts from a fuel supply shock. However, they should not be interpreted as precise predictions. Economic models are based on a set of assumptions and historical data, and while they help understand the relative magnitudes of various outcomes, they cannot account for all the complexities and uncertainties inherent in real-world economic systems.

There are numerous confounding variables that are difficult to predict and quantify, such as changes in consumer behaviour, market dynamics, political responses, and external economic shocks. Additionally, the model's reliance on certain assumptions—such as the structure of the economy, the elasticity of demand, and the extent of market flexibility—may not always hold true in the face of unexpected developments.

The interplay between these variables, combined with the inherent unpredictability of how markets and industries will react to a sudden fuel supply disruption, means that the model outputs should be viewed as indicative rather than definitive. They are useful for understanding the magnitude of the potential economic disruptions, but they cannot provide an exact figure for GDP loss. The real-world impact of a fuel supply shock could differ due to factors outside the scope of the model.

The model results are uncertain and changes in underlying assumptions and real-time conditions will influence the actual future outcomes.

To assess the economic impact of fuel supply and logistics disruptions, we carried out the following steps, outlined in the sections that follow:

- We first identified the categories of consumers most affected by these disruptions.
- We examined how various disruption scenarios would impact these consumers, considering whether the effects would involve only price increases or also actual physical shortages of fuel.
- Finally, we developed a methodology to estimate the impact of higher fuel prices and physical fuel shortages on the New Zealand economy. The methodology is based on the analysis of historical price responses from disruptions in the international markets, past domestic disruption events and the relationship between real GDP per capita and land transport (ground) fuel consumption per capita.
- We also supplemented the econometric analysis with I-O analysis to strengthen our findings. The results of the I-O analysis reinforced the results of our econometric assessment.

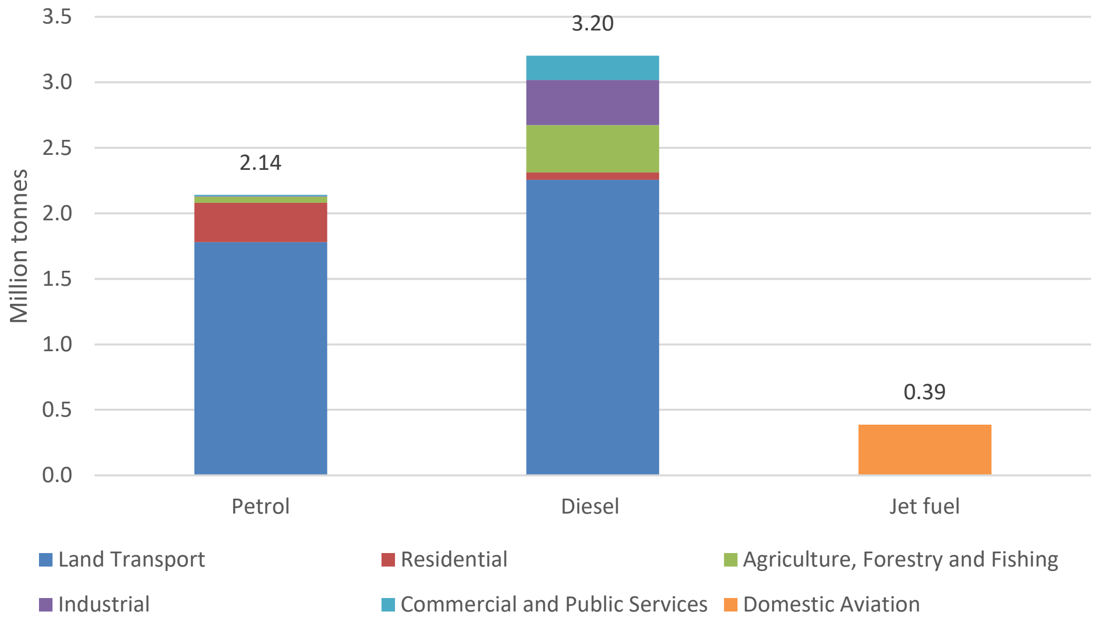
7.1.1 Identifying affected consumers by fuel disruptions

Transportation, especially road and air transport, is the most fuel-intensive sector. Road transport is heavily reliant on both petrol and diesel and aviation is primarily dependent on jet fuel.[41]

[41] Aviation services use diesel for non-aircraft equipment (ground support equipment and other land-based vehicles)—however, for this study we analyse fuel disruption effects on the aviation sector based on changes in jet fuel availability or price.

The domestic transport sector, including freight and public transport, consumes most of New Zealand's fuel, using 83% of petrol and 70% of diesel. Domestic transport is highly dependent on these fuels and, therefore, highly vulnerable to disruptions. Residential fuel users consume 14% of petrol and a small portion of diesel (2%). Agriculture, forestry, and fishing rely mainly on diesel (11%) for operations, with minimal petrol use, showing diesel's importance for these activities. The industrial, commercial and public services sectors similarly depend on diesel (11% and 6% respectively). Domestic aviation relies exclusively on jet fuel, consuming 100% of this fuel type, which makes it entirely dependent on jet fuel for passenger and cargo flights within New Zealand.

Table 11: Fuel consumption by sector[42]



Consumption category	Petrol		Diesel		Jet fuel	
	kt	%	kt	%	kt	%
Domestic Land Transport	1,780.56	83%	2,255.18	70%	0	0%
Residential	299.44	14%	56.56	2%	0	0%
Agriculture, Forestry and Fishing	46.43	2.20%	362.64	11%	0	0%
Industrial	4.96	0.20%	343.63	11%	0	0%
Commercial and Public Services	9.18	0.40%	186.26	6%	0	0%
Domestic Aviation	0	0%	0	0%	388.92	100%
Total	2,140.58	100%	3,204.27	100%	388.92	100%

Source: MBIE, Oil statistics, 2023 [43]

[42] Fuel demand from national defence and emergency services is included within the consumption categories of this table—however, we present the consumption categories in the most granular detail available, as presented by MBIE.

[43] MBIE, Oil statistics. Available at: https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-statistics-and-modelling/energy-statistics/oil-statistics

We divided New Zealand's consumption of petrol, diesel and jet fuel between the following consumer groups:

- Private, i.e. households mostly using petrol for domestic transportation and residential consumption
- Commercial, including manufacturing, services, and land transport that is most rely on diesel for the transportation of goods and provision of services
- Tourism and airfreight sectors that consume jet fuel for passenger and cargo transportation.

Each group will experience disruptions differently based on their reliance on specific fuel types.

Disruption in petrol supply would primarily impact households

Households account for about 97% of total petrol consumption, mostly for transportation and residential uses. A supply disruption would likely hinder household mobility, limiting people's ability to commute, access services, and engage in recreational activities. This shift could drive households to adjust travel habits, such as relying more on public transport and ridesharing or reducing non-essential travel, potentially affecting broader consumption patterns and service demand.

Diesel supply disruptions would have a larger effect on the commercial sector

Diesel supply disruptions would have a larger effect on the commercial sector, particularly in the transportation, agriculture, forestry, fishing and industrial sectors. Diesel shortages could reduce these businesses' production and transportation capacities, which rely heavily on diesel for machinery, transport fleets, and freight logistics. This could disrupt supply chains, lower manufacturing output, and delay goods transportation. Service industries with vehicle-dependent operations, like delivery and construction, would face operational slowdowns or shutdowns, impacting productivity and profitability (80% of light commercial vehicles run on diesel). Furthermore, with around 9% of light passenger vehicles running on diesel, household mobility could also suffer if diesel supplies are interrupted. [44]

Jet fuel disruption would result in flight disruption for passengers and cargo

Jet fuel disruption would directly affect the aviation sector, including passenger and goods transport. A shortage would hinder airlines' ability to maintain regular flight schedules, leading to fewer available flights and disruptions in both domestic and international travel. The tourism sector and airfreight industries are especially vulnerable because fuel shortages would prevent tourist visits and create barriers to the movement of high-value or time-sensitive goods, causing economic losses across sectors. Additionally, issues with providing professional aviation services risk reputational harm to airlines and New Zealand's national image.

7.1.2 Establishing the main consumer impacts of fuel disruptions

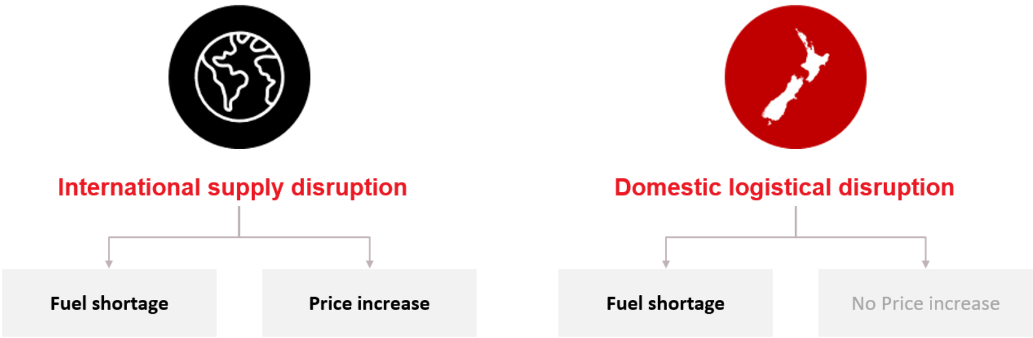
Supply disruptions, whether from logistics issues or international supply challenges, can lead to two primary impacts on consumers:

- increased fuel prices and/ or
- physical fuel shortages.

[44] Ministry of Transport, Annual fleet statistics. Available at: https://www.transport.govt.nz/statistics-and-insights/fleet-statistics/sheet/annual-fleet-statistics

Our analysis suggests that international supply disruptions are more likely to cause both price increases and fuel shortages. At the same time, domestic logistics issues typically result in physical shortages alone, with relatively stable fuel prices, as shown in Figure 16.

Figure 16: Disruptions will result in fuel shortage and/or higher prices



International fuel supply disruptions will result in higher fuel prices and some physical fuel shortages

International disruptions in fuel supply, such as the conflict in Ukraine, have demonstrated how the outbreak of war in Europe had a very significant impact on global petrol and diesel prices, as well as disruption to the fuel supply chain. In New Zealand, petrol prices rose by approximately 30%, diesel by 58%, and jet fuel by about 92%. Despite these increases, there was no physical fuel shortage; global supply chains adjusted to meet demand at higher prices. This example illustrates that international disruptions often lead to price hikes without immediately affecting physical availability, as market mechanisms respond to shifts in supply and demand dynamics. However, depending on the severity of the disruption, it can also lead to fuel shortages in addition to price increases.

Domestic logistics disruptions would result in physical fuel shortages while prices expected to remain unchanged

Domestic disruptions are unlikely to increase fuel prices. The main impact on consumers will come from the physical fuel shortage rather than price increases, based on feedback from fuel companies and experience from past events. During the 2017 RAP incident, which temporarily disrupted New Zealand's fuel supply, fuel companies absorbed the costs associated with restoring normal supply. Fuel prices remained stable for consumers because companies covered expenses through their operational adjustments rather than passing costs onto consumers.

There is precedent for New Zealand fuel companies absorbing the cost of short-term disruption events. The 2017 RAP incident suggests fuel companies are likely to manage future disruptions in infrastructure that they control, own or are significant customers similarly without increasing consumer prices. Infrastructure failures from events like fires, explosions, or third-party damage would likely prompt companies to avoid recouping repair costs from consumers. Consumers tend to perceive such failures as operational oversights or external risks within the companies' responsibility, making it unlikely that firms would adjust prices upward, especially given the strain already placed on consumers by interrupted fuel access.

7.1.3 Estimating the impact of disruptions on the economy

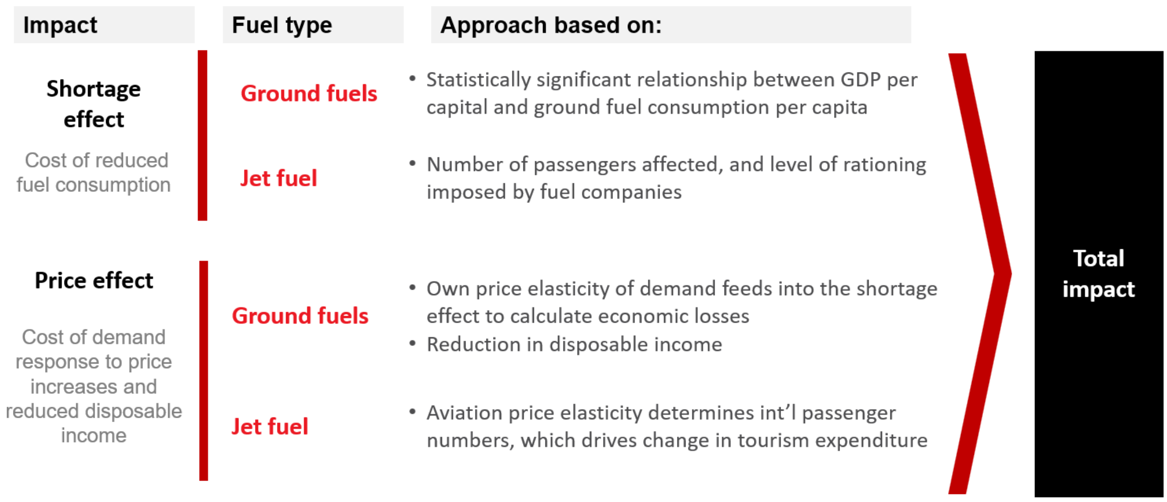
The approach to estimating the impact of fuel shortages and price increases that we applied in this analysis is based on historical data. We reviewed the relationship between per capita ground fuel consumption and GDP. We also reviewed past disruptions, including the 2017 RAP outage, to gauge potential impacts on the aviation sector and, consequently, on GDP.

We did not make any assumptions about potential changes in consumer behaviour and its impact on the economy. Using historical data provides clarity and transparency in calculations and assumptions by focusing on observed data rather than speculating on the varied behavioural responses from businesses and households during fuel shortages. Such responses can vary widely, as consumer and business behaviour under disruption conditions often defies easy prediction, reflecting diverse and dynamic decision-making processes rather than a single, consistent pattern.

Fuel is a critical input for all sectors of the economy, especially transportation, agriculture, and manufacturing. Shortages disrupt production and supply chains, driving up costs and reducing output. Consumer responses, influenced by price elasticity and available substitutes, complicate predictions, especially since fuel suppliers often control price increases. The time scale of the shortage, potential governmental actions, and long-term shifts in energy use further add complexity. Sector-specific impacts and global spillovers must also be considered, and the lack of real-time data makes it difficult to capture the full economic effect.

Figure 17 provides an overview of approaches used to estimate the impact of fuel security and price changes. The sections below discuss the methodology in detail.

Figure 17: Translating disruption impact into GDP impact



Impact of physical fuel shortage

Our model assumes that GDP output will decrease in response to reduced fuel consumption caused by physical fuel shortages. The impact on GDP depends on fuel type. For ground fuels (petrol, diesel), we produced regression models to estimate how GDP output responds to changes in consumption as an input. For jet fuel, we calculate the effect that fuel shortages have on aviation services, including freight and tourism, using the 2017 RAP rupture's impact on the aviation sector as a precedent.[45]

This analysis is at an aggregate level and does not account for how individual businesses respond to fuel shortages. Some firms may experience severe impacts, while others may experience little to

[45] For freight, we note that losses due to air freight disruptions will be recouped in the future.

no effect. For example, if milk tanker schedules are reduced during peak milking season, farmers might need to dump milk, which would directly reduce their revenues. In contrast, an IT or knowledge firm may be able to switch to alternative production processes (working from home). The impact of fuel shortages on the agriculture sector varies depending on the seasonal timing of the disruption. For instance, a shortage during seeding or harvest seasons could have a much greater impact than during the off-season. However, taking an aggregated approach allows us to smooth out the sensitivities of each business, providing a more balanced evaluation of economic impacts.

The approach also assumes a fixed elasticity between fuel consumption and GDP, which may not hold over time. Elasticities can vary due to technological advancements, changes in energy efficiency, or shifts in economic structure. For instance, as economies transition to renewable energy sources, the relationship between GDP and fossil fuel consumption could weaken or even reverse.

Using ground fuel consumption to calculate changes in real GDP

Following Soytas and Sari (2003),[46] we focused on the bivariate relationship between energy consumption and GDP. This model assumes that petrol and diesel function as factors of production with a constant elasticity concerning GDP. Our first step was to check whether GDP and fuel consumption have a long-term relationship (cointegration). We found evidence of cointegration, which means that fuel consumption and GDP move together in the long run. However, the long term elasticities and short-term dynamics produced by the model were not usable as model results exhibited a serial correlation of residuals. As a result, for simplicity and given that our focus is on the short-term impact of fuel consumption, we used short-term elasticities that ignore the presence of cointegration. We note that this may introduce a limitation to our model; namely, the model could have biases.

To cross-check the model's results and the impact of its potential limitations on the econometric model, we used input-output (I-O) analysis. The result of the I-O analysis supports our findings (as discussed below and in Section 7.2.3). Additionally, the modelling results are consistent with we reviewed findings from previous studies[47] that used other modelling techniques, such as the CGE model. This suggests that our econometric model's results are consistent with the magnitudes identified in those earlier studies.

This cross-checking provided us with enough confidence to proceed with the econometric model's results to establish the impact on the economy. Particularly, because no model forecasting economic impact is perfect, as noted in previous sections. The key focus is to establish the relative magnitude of the impact rather than an absolute value. All models have limitations, and none of them can predict an absolute value of the impact.

Appendix D provides further details on the model design.

Input-Output analysis to cross-check econometric results

Since the regression model examines the historical relationship between GDP and fuel consumption but does not directly quantify the impact of fuel shortages on GDP and may have biases, we developed an alternative input-output model to gauge the estimate from the regression and provide a range of possible economic impacts of a ground fuel shortage.

[46] Soytas, Ugur & Sari, Ramazan, 2003. "Energy consumption and GDP: causality relationship in G-7 countries and emerging markets," Energy Economics, Elsevier, vol. 25(1)

[47] Market Economics (2019), Economics of Fuel Supply Disruptions and Mitigations. Available at: https://www.mbie.govt.nz/assets/economics-of-fuel-supply-disruptions-and-mitigations.pdf

We isolated the role of freight services, road passenger transport, railway freight services, railway passenger transport, and postal and courier services as inputs into the outputs produced by all other sectors of the New Zealand economy. A fuel shortage would directly reduce the inputs of the transportation sector in industries that use some type of transportation. We also assume that the reduction in the use of transportation services would flow on and impact other inputs used in the industries. Using this approach, we estimated the percentage change in the economy's total output and, as a result, GDP.

The model quantifies these effects, using fuel consumption splits for different transport industries and the latest Input-Output Tables from Statistics NZ.

Using jet fuel consumption to calculate changes in real GDP

Our methodology for estimating the impact of jet fuel shortages draws on an analysis of disruptions caused by the RAP pipeline rupture in 2017. Since neither the Government nor industry has publicly released a comprehensive financial or economic assessment of this event, we used available data on flight disruptions and the number of affected passengers. Supplementing this with further research on the economic impacts of flight disruptions on airlines and the broader economy, we estimate the potential effects of jet fuel shortages under various forecasted scenarios.

In our analysis, we assume that airline losses will be proportionate to the number of passengers impacted by the disruption. The number of passengers affected by the disruption is a function of the expected level of rationing imposed by fuel companies and the duration of rationing. We apply a flight disruption cost of NZ$474 per passenger, comprising NZ$287 of costs sustained directly by airlines (from the cost of making additional fuel, crew, for example) and NZ$186 of costs sustained by passengers (lost time) and ancillary sectors (such as food, retail and hospitality).

Appendix D provides further details on the jet fuel shortage impact assumptions.

Impact of higher fuel prices on GDP

Higher fuel prices for land transport (ground fuels) and aviation have different GDP impacts.

Ground fuels: Own-price elasticity of fuel demand determines ground fuel consumption reduction

We analyse two ways that increasing ground fuel prices can decrease GDP:

- An increase in ground fuel prices will decrease demand. A decrease in ground fuel demand and consumption correlates with lower economic output
- An increase in ground fuel prices will increase household spending on ground fuels (since ground fuel demand is relatively inelastic). Therefore, consumption of goods and services decreases since households have less disposable income as household transportation costs increase.

For ground fuels, we estimate how consumer demand changes in response to price increases using own-price elasticity estimates. We then calculate the resulting GDP impact using the framework outlined in the previous subsection on GDP loss due to reduced fuel consumption.

We estimated the own-price elasticity of ground fuels using a distributed lag model.[48] Appendix D includes a more detailed explanation of the modelling approach.

[48] Domestic Transport Costs and Charges Annual Research, Motu Economic and Public Policy Research (2023), available at: https://www.transport.govt.nz/assets/Uploads/DTCC-Estimation-of-transport-related-elasticities_Oct2023-1.pdf

Jet fuel: Rising jet fuel prices reduce net tourism travel

For jet fuel, research suggests that increased jet fuel prices reduce international air passenger travel as airfares rise in response.[49, 50] We model the effect that these jet fuel prices have on New Zealand's current account balance as fewer foreign tourists arrive in New Zealand and fewer New Zealand travellers leave.

To calculate the net tourism loss, we use average spending per tourist. For inbound tourists, this is NZ$6,248 (2009 dollars), derived from 2019 travel service exports (NZ$12.0 billion)[51] divided by total arrivals (2,110,892).[52] Outbound tourists spend approximately NZ$1,794 each.

Our research shows that a 1% increase in jet fuel prices reduces international travel by approximately 0.6%[53]. We apply this rate to pre-COVID-19 passenger volumes (2,110,892 inbound,[121] 3,098,493 outbound[54]) and multiply by average spending to estimate tourism's GDP impact.

Appendix D includes a more detailed explanation of the modelling approach.

7.2 Economic cost of disruptions

The total economic cost of supply disruption is estimated to be between NZ$118 million (0.04% of GDP) and NZ$2.4 billion (0.85% of GDP), depending on the severity of the disruption. New Zealand-based logistics disruptions are likely to reduce GDP by NZ$118 million (0.04% of GDP) for shorter-term disruptions and between NZ$1.1 and 2.4 billion for long-term disruptions (0.40% and 0.85% of GDP, respectively), as shown in Figure 18.

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[49] How do fuel use and emissions respond to price changes?, Bureau of Infrastructure, Transport and Regional Economics (2008), available at: https://www.bitre.gov.au/sites/default/files/other_006_bitre_briefing.pdf

[50] Price elasticities in aviation and marine shipping (literature study),CE Delft (2009), available at: https://cedelft.eu/publications/price-elasticities-in-aviation-and-marine-shipping-literature-study/#:~:text=A%20likely%20figure%20for%20aviation,and%202.0%20for%20holiday%20flights.

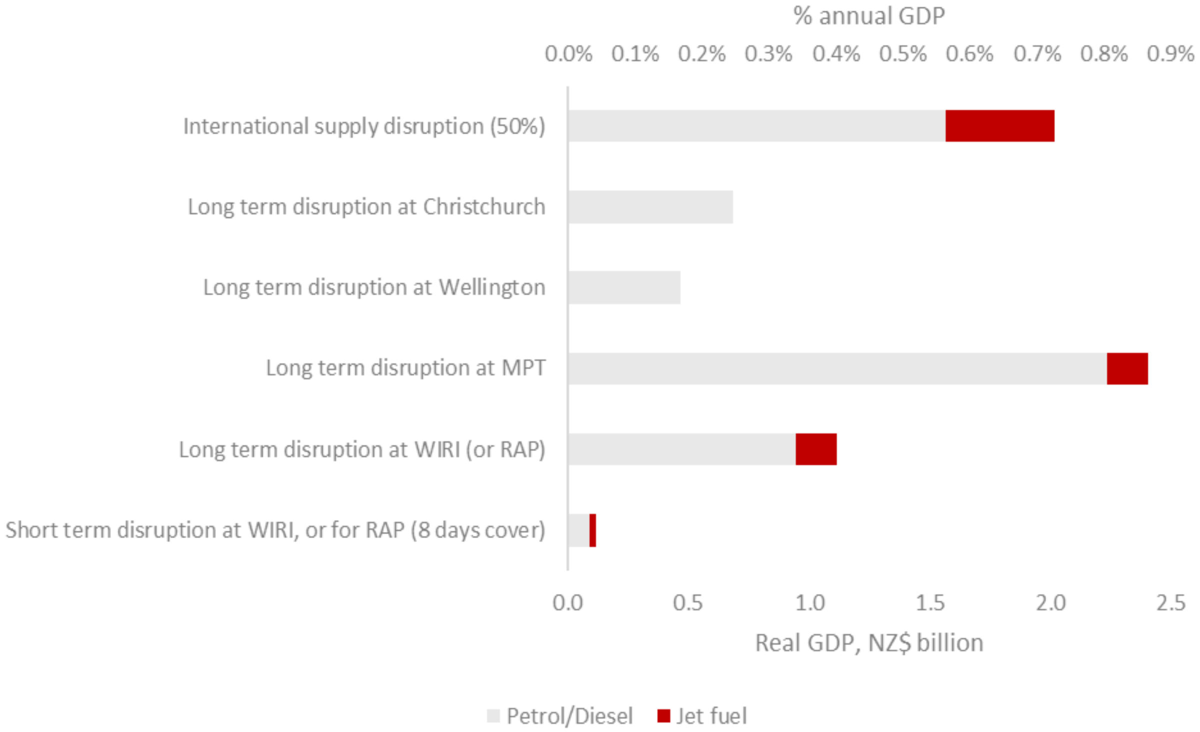
[51] BPM6 Annual, Current account services (Annual-Mar), Infoshare (retrieved November 2024).

[52] Visitor arrivals by country of residence, age and visa type (Annual-Mar), Infoshare (retrieved November 2024).

[53] Assuming that a 10% increase in jet fuel prices results in a 6% decrease in international travel (footnote 119), following the same linear relationship.

[54] NZ-resident traveller departure totals (Annual-Mar), Infoshare (retrieved November 2024).

Figure 18: Estimated economic impact under each disruption scenario



The following sections detail the economic impact of international supply disruptions and New Zealand-based logistics disruptions.

7.2.1 International supply disruptions

Supply disruptions refer to events that impact the supply of fuel, possibly causing a shortage of fuel available in New Zealand. Our analysis shows that as a result of price increases and shortages in diesel and jet fuel, the New Zealand economy might face GDP losses of up to 0.72% or NZ$2.0 billion.

Fuel shortage and price increases

As discussed in Section 6.2.2, the international supply chain disruption scenario in North Asian countries, including South Korea, Japan, and China, would interrupt about 50% of New Zealand's fuel supply. This event would lead to diesel and jet fuel shortages, though petrol supplies would remain stable, as detailed in Table 12.

Table 12: Fuel shortage summary

Fuel type	Shortage, kl	Duration, days	Proportional to the total demand,%
Petrol	0	0	0%
Diesel	17,881	5 days	2.3%
Jet	11,730	5 days	3.4%

In addition to fuel shortages, we anticipate price increases across all fuel types due to international market reactions. When a disruption occurs, the global market typically responds with almost immediate price hikes. The severity of these price increases would depend directly on the extent of the shortage.

For example, following the Ukraine invasion, sanctions on Russia severely limited its oil and refined fuel exports, which drove up international oil and fuel prices sharply. [55] In New Zealand, this international price surge translated into domestic price increases, though to a somewhat lesser extent due to the margins and tax component in domestic prices. Specifically, the Ukraine conflict increased domestic prices by 30% for petrol, 92% for jet fuel, and 58% for diesel.

Table 13: Ukraine conflict price rises

International price two months before the invasion (US$/bbl)		Price peak* (US$/bbl)	Increase	Increase in domestic prices (NZ $/l)	Increase to consumer	Time to reduce increase by 50%
Oil Price	74.76	121.57	63%	n/a		8 weeks
Petrol Price	87.72	156.81	79%	0.77	30%	4 weeks
Diesel Price	84.17	181.41	116%	1.08	58%	21 weeks
Jet Fuel Price	82.78	170.01	105%	0.84	92%**	13 weeks

Source: Envisory/Castalia analysis

*Note: * Peak prices were in early to mid-June 2022, about 3 1/2 months after the invasion. **There is no retail price for jet fuel, so a small margin is assumed to calculate the increase (no GST assumed)*

North Asian disruption could lead to price hikes nearly double those observed during the Ukraine crisis

When evaluating the potential price impact of fuel disruptions in North Asia, we anticipate a considerably larger increase than the one driven by the Ukraine conflict. Specifically, our analysis suggests that a North Asian disruption could lead to price hikes nearly double those observed during the Ukraine crisis: approximately 60% for petrol, 184% for jet fuel, and 116% for diesel.

First, unlike North Asian countries, Russia is not a direct supplier of refined fuels to New Zealand. The price increases in New Zealand during the Ukraine crisis stemmed from a ripple effect in the international market rather than a disruption in direct supply. In contrast, a North Asian disruption would impact New Zealand's direct suppliers, likely creating a sharper and more immediate price increase. Additionally, North Asian countries export more refined fuels today relative to Russia's exports prior to the war, meaning a supply shock in North Asia would put even more upward pressure on international fuel prices. [56]

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[55] "The EU and the UK banned the seaborne imports of crude oil on December 5, 2022, by far the biggest step to date to cut off the fossil fuel export revenue that is funding and enabling Russia's barbaric invasion of Ukraine. Imports of refined oil products from Russia were allowed until February 5, 2023." CREA, Available at: https://energyandcleanair.org/russia-sanction-tracker/

[56] https://www.worldstopexports.com/refined-oil-exports-by-country/

Furthermore, other international examples related to oil disruption also show that oil prices and, as a result, the prices of refined fuels can increase significantly. For example, oil production dropped significantly during the Iranian Revolution in 1979, causing oil prices to rise from US$13 per barrel to US$32 per barrel.[57] The New Zealand Government began reducing petrol demand in response with the "carless days schemes". The US Invasion of Iraq and its build-up in 2003 reduced Iraq's oil production and caused increased speculation in the oil markets.[58] [59] Another example is the 1973 oil crisis, which saw the Organization of Arab Petroleum Exporting Countries cut oil supply to countries supporting Israel during the Yom Kippur War. As a result, oil prices rose from US$3 to US$20 per barrel.[60]

Estimating average price increase to account for initial price surge and gradual decline

We also considered the time impact of the price increase. Initially, we expect prices to rise sharply, but over time, coordinated international release of emergency stocks and fuel companies will manage the supply chain reallocation, causing prices to decrease. We anticipate it will take roughly the same amount of time for prices to decline to 50% of their peak value as it did during the Ukraine conflict. Similarly, a comparable timeframe is expected for prices to return to pre-disruption levels. To account for this price fluctuation, we assume an average price increase instead of a peak price. This approach provides a more balanced view and avoids overestimating the impact of the price rise.

Economic impact of fuel shortage and higher prices

The economic impact of higher fuel prices and diesel and jet shortages would likely result in a GDP reduction of approximately NZ$2.0 billion or 0.72% of GDP. Table 14 summarises the economic impact of fuel supply disruptions, including the effects of price increases and shortages in diesel and jet fuel.

Table 14: Summary of economic impact of international supply disruption

Event severity	Fuel type	GDP impact, NZD million	GDP impact, %
Disruption to 50% of New Zealand's fuel supply	Petrol/ Diesel	1,565	0.56%
	Jet	456	0.16%
	Total	**2,021**	**0.72%**

As fuel prices rise, households and businesses are expected to cut back on petrol and diesel consumption. This demand reduction would help alleviate potential shortages, leaving petrol supplies unaffected but resulting in a diesel shortage of around 2.6% and 3.4% in jet shortage over the 64-day analysis period.

[57] Ministry of Culture and Heritage, 1979 – Key Events, available at: https://nzhistory.govt.nz/culture/the-1970s/1979

[58] Strategic Insights, Volume II, Issue 4 (April 2003), Oil Prices and the Iraq War: Market Interpretations of Military Developments, available at: https://ciaotest.cc.columbia.edu/olj/si/si_2_4/si_2_4_lor01.pdf

[59] New Zealand Herald (May 2008), Iraq invasion 'trebled cost of oil', available at: https://www.nzherald.co.nz/business/iraq-invasion-trebled-cost-of-oil/ZLWOHMPSWZIXMBDC3BFHDRZMAE/?c_id=590&objectid=10512421

[60] Ministry of Culture and Heritage, 1979 – Key Events, available at: https://nzhistory.govt.nz/culture/the-1970s/1979

Higher fuel prices and shortages are expected to significantly impact the economy by straining household budgets and disrupting business operations. For households, rising fuel costs will reduce disposable income as a larger share of budgets is allocated to essential fuel expenses, leaving less for other goods and services. Additionally, reduced mobility caused by lower petrol consumption will further dampen consumer spending on non-essential items.

On the business side, a physical diesel shortage could limit the operational capacity of some commercial sectors, placing financial and operational strain on businesses. Additionally, high fuel prices will raise operating costs, especially in fuel-intensive industries like transportation, logistics, and manufacturing. These increased expenses could lead to lower profit margins and reduced competitiveness, as companies must either absorb the higher costs or pass them on to consumers, resulting in higher fuel prices. Furthermore, higher fuel prices may result in workforce cuts or wage freezes, particularly in transportation sectors, contributing to higher unemployment or wage stagnation.

This combination of reduced consumer purchasing power and operational constraints would weaken overall economic activity. The total economic impact of petrol and diesel fuel shortages and increased prices could result in a GDP decrease of about 0.56% or around NZ$1.56 billion.

Jet fuel demand is expected to remain steady in the short term, as airlines would initially absorb higher fuel costs to maintain flight schedules. Over time, these costs would likely shift to consumers through increased ticket prices, potentially leading to a decrease in air travel and impacting tourism. This will reduce travel demand, particularly in the tourism sector.

Additionally, given that higher prices for jet fuel would not decrease the demand for fuel, this is expected to lead to some fuel shortages. However, we expect that the direct impact on GDP will be limited. First, the airlines would likely adjust operations to manage disruptions effectively. Second, as the supply disruption affects not only New Zealand but other parts of the world, global travel demand may soften. Overall, we estimate that jet fuel disruption would add further economic strain of about 0.16% or NZ$0.46 billion.

7.2.2 New Zealand-based logistics disruption

A New Zealand-based logistics disruption refers to events that impact the distribution of fuel to where the customer requires it. These can relate to anything from road outages/slips to the loss of a major terminal or critical infrastructure. Our analysis shows that these events can cost New Zealand's economy around NZ$2.4 billion or 0.85% of GDP.

Domestic logistics disruption will cause physical fuel shortage, but no price increase

Unlike international supply disruptions, the primary impact of logistics disruptions on economic activity comes from physical fuel shortages rather than price changes. Fuel prices are expected to remain stable, with fuel companies absorbing the costs, as seen during the 2017 RAP disruption event and based on the consultation with fuel companies. Overall, different disruption scenarios would result in different fuel shortages, as shown in Table 15.

Table 15: Fuel shortage summary under different scenarios

	unit	Short-term disruption at WIRI, or for RAP (8 days cover)	Long-term disruption at WIRI (or RAP)	Long-term disruption at MPT	Long-term disruption at Wellington	Long-term disruption at Christchurch
Disruption period	days	14	60	66	60	60
Petrol/Diesel	kl	7,000	70,460	161,620	35,179	51,393
Jet fuel	kl	4,020	144,900	147,560	-	-

Economic impact of fuel shortages

The economic impact of petrol, diesel and jet fuel shortages would likely result in a GDP reduction of around NZ$2.4 billion, or 0.85% of GDP. Table 16 summarises the economic impact of fuel supply disruptions under different scenarios.

Table 16: GDP impact under different scenarios

Scenario	Fuel type	GDP impact, NZD million	GDP impact, %
Short term disruption at WIRI, or for RAP	Petrol and diesel	92	0.03%
	Jet fuel	25	0.01%
Long term disruption at WIRI (or RAP)	Petrol and diesel	948	0.34%
	Jet fuel	170	0.06%
Long term disruption at MPT	Petrol and diesel	2,236	0.79%
	Jet fuel	169	0.06%
Long term disruption at Wellington	Petrol and diesel	468	0.17%
Long term disruption at Christchurch	Petrol and diesel	687	0.24%

Impact of RAP and Wiri terminal disruptions depends on the duration of the disruption. The RAP pipeline supplies multiple fuel types to the Wiri fuel terminal in South Auckland, with fuel pumped in controlled batches typically taking around a day. All fuels will be impacted by short or long-term disruptions. The main economic burden would fall on Auckland, with other regions in New Zealand experiencing less impact. A long-term disruption at Wiri or RAP could lead to GDP losses exceeding NZ$1.12 billion, or around 0.40% of the national GDP.

Marsden Point disruptions would result in a high economic impact. As the largest import location, Marsden Point plays a critical role in fuel supply, making any disruption here highly consequential for the economy. Marsden Point disruption could affect all fuel types, potentially leading to GDP losses of up to NZ$2.4 billion, or 0.85% of GDP, with ground fuel shortages contributing the most to this impact.

Impact of long-term disruption regional impacts: Wellington and Christchurch are limited to ground fuels. Disruptions at Wellington or Christchurch would primarily affect petrol and diesel supplies, with an estimated economic impact of up to NZ$687 million, or 0.24% of GDP. However, these disruptions would not affect fuel types like jet fuel and thus have a more limited effect than disruptions at MPT.

The economic impact of petrol shortages is likely to be lower than the forecasted levels presented in Table 16. Many petrol consumers have many options for changing behaviour that will have modest impacts on economic activity. For instance, many petrol consumers can often use public transportation or car sharing, switch to active modes of transport, and many consumers can reduce transport activity for a short period (such as working from home). It is difficult to model all these behavioural changes and avoid making incorrect assumptions. Therefore, our results above show the likely maximum costs of disruption to the petrol supply.

7.2.3 Supplementary input-output model to cross-check the results

The results of an alternative I-O analysis, which we used to strengthen our econometric model, show a close alignment between the two approaches. For example, in the long-term disruption scenario at MPR, our econometric model estimates a potential GDP loss of 0.85%, while the I-O analysis suggests a similar impact of around 1%.

Appendix D provides more detail on the methodology used for I-O analysis.

8.0 Mitigation options

This section reviews mitigation options available to improve New Zealand's fuel security and assesses their impact. While we review several mitigation options, we note that slow-moving 'natural' changes, such as the transition of New Zealand's vehicle fleet to EVs and alternative fuels, are already steadily enhancing the country's fuel security.

8.1 Reestablishing the Marsden Point Refinery

The Marsden Point oil refinery (MPR) was closed in March 2022 after a 60-year history of processing crude to make fuel for the New Zealand petroleum fuels market. In the period before closing, it supplied around 70% of New Zealand's refined fuels, with the balance imported from international markets.

The MPR competed in a global market where refineries are getting larger and more sophisticated in the range of products produced. Modern Asian refineries are five to ten times larger than MPR, with a greater capacity to upgrade a wide range of lower-value crude into higher-value products. They often have associated petrochemical facilities, meaning their income is not entirely dependent on the volatile margins associated with producing transport fuels.

Refining margins are volatile and cyclical. Small changes in global capacity utilisation can shift margins between strong and weak. Refineries are vulnerable when margins are weak unless they are integrated into a larger business or have other income streams. Smaller refineries – like MPR - at the end of the supply chain without economies of scale are particularly vulnerable.

Refining margins plunged at the end of 2019 due to excess global refinery capacity. This was compounded by COVID responses, reducing demand for refined fuels globally in 2020. The MPR income fell below the contractual Floor level (which triggered set payments from customers), but the company still struggled to cover its operating costs even after simplifying its operation. Fuel companies could import refined fuels more cheaply, meaning the high cost of MPR fuels made them uncompetitive. These conditions were expected to continue, leading to the strategic decision to shut down and convert the site to an import terminal. The International Energy Agency stated in its 2022 World Energy Outlook that under its announced pledges scenario "more than half of current refining capacity faces the risk of lower utilisation or closure by 2050, and there are few new capacity additions after projects under construction come online."

Reestablishing MPR would be a major undertaking for New Zealand in terms of time, new commercial arrangements and financial cost. In summary:

- The financial cost of reestablishing the MPR would be substantial. Our review of global benchmarks for refinery construction costs suggests the costs would range from NZ$5.9-16.1 billion (US$3.7-10.1 billion) before considering unique aspects of the MPR site that would likely reduce these costs. Channel Infrastructure's Worley Report estimates that the capital cost of the recommissioning project is estimated at a P50 to P90 range of NZ$4.9 billion to NZ$7.3 billion with an order of accuracy of -20% / + 50%. This will increase should the biorefinery currently under consideration be developed on the existing refinery site.
- The Worley Report estimates design, engineering and construction would take at least six years.
- Significant Government support or other intervention would be necessary. Channel Infrastructure shareholders have rejected reestablishment, and fuel company customers would require significant commercial inducement to switch back their supply chains to

buy refined fuels from MPR. Recovering these costs from consumers would require a material increase in fuel prices.

- Refinery margins are volatile and are unlikely to cover the operating costs of MPR at lower points of the cycle. A reestablished refinery would need income protection when margins fell below certain levels.
- Reestablishing MPR would reduce New Zealand's dependency on imported refined fuels. However, New Zealand would shift to dependence on crude imports. By the early 2030s, indigenous production could only supply, at most, less than 5% of the MPR feed. It may be less than that given New Zealand indigenous production is not well matched to the crude requirement of the MPR.
- Reestablishing MPR could provide more resilience by better managing fuel quality issues. However, that benefit is offset by the risk that MPR becomes a single point of failure risk.
- Stockholding will increase should MPR be reestablished, providing more in-country resilience. Some of that gap has been mitigated through refined fuel stocks increasing since the MPR closure, along with the implementation of minimum stock obligations from January 2025. We calculate the net benefit of increased useable stock (accounting for increased heel and minimum operational stock) would be 180 ML versus import product stock following the implementation of the MSO.
- Reestablishing MPR would lead to some local employment benefits, with higher-skilled, higher-paying jobs. New Zealand may also benefit from improved resilience to economic shocks as the balance of payments would improve because the cost of imported crude is less than the cost of imported refined fuels.
- Reestablishing MPR would increase New Zealand's greenhouse gas emissions due to refining operations. In 2019, Refining New Zealand reported 4,329 tonnes of SO_2 emissions in total and 206kg of CO_2 emissions per tonne of product.

Channel Infrastructure is also working with other parties looking to develop alternative fuel manufacturing facilities at Marsden Point, some of which would use decommissioned equipment from the MPR. If developed, these conflict with the ability to reestablish the MPR as it was prior to its closure.

8.2 Additional stocks (and tanks)

Stocks provide time for the disruption event to be managed by maintaining supply to customers while supply chains are rearranged or repaired. The MSO will be in place from January 2025 which should result in New Zealand's average stock holding being several days higher than the MSO in order to provide companies operating flexibility while ensuring compliance with the MSO.

We consider the following additional stocks:

- Addition of jet fuel storage capacity at Wiri/JUHI (in line with recommendations of the RAP Inquiry or higher levels);
- The announced additional jet fuel storage capacity at Marsden Point will be available from Q1 2027 (this will help meet higher stock levels required as demand increases), and
- A possible addition of seven days of diesel stocks and/or increasing the MSO for diesel to 28 days.

Petrol has the highest MSO, and our analysis shows stocks are well above this level on average. The cover is sufficient for the scenarios evaluated, and easing demand means petrol storage could be rationalised over the next decade.

We do not assess additional stock holdings above those listed, although Channel Infrastructure noted they have another 400 ML of decommissioned storage tanks that could be used to store more fuels if upgraded and converted to be suitable for refined fuel storage.

During this study, MBIE was consulting with stakeholders on:

- The appropriate level of jet fuel stock holding at or near Auckland Airport;
- Increasing diesel stocks and the options for how that increase could be done.

This study assesses the impact of these changes but does not cover the specific issues covered in the consultation process.

Feedback from consultations highlighted that while holding more jet fuel at Auckland Airport would be a useful resilience measure, the current JUHI footprint is fully utilised, and the long-term location of the JUHI remains unclear. Auckland Airport needs to resolve the future JUHI location before suppliers can plan additional storage, a second (or larger) pipeline from Wiri and greater backup capacity to receive fuel via truck.

8.3 Additional logistics options

Onshore mitigations to increase domestic supply reliance are centred around trucking resources, either through additional trucking capacity or increasing availably of closer logistics alternatives for secondary supply, thus reducing the distribution task. We discuss these options below although only additional trucking is analysed in the economic analysis.

8.3.1 Pool of contingency trucks

For each long-term domestic disruption case, the ultimate solution is the introduction of new trucking capacity (and drivers) to cover the larger distribution task of hauling fuel from other terminals. The consultations for the previous studies identified that imported trucks would begin to arrive a month after the disruption event, taking another month for the full complement of vehicles to be imported. During this period, we would expect the process of acquiring drivers (including the transfer of drivers from Australia) and training and qualifying them to occur.

Table 17 summarises the additional trucking resources that would be required to mitigate a long-term petrol and diesel disruption for an event at each of the assessed locations. These figures are based on fully deploying underutilised and spare trucks already in New Zealand, plus overloading the trucks to carry fuel at the volumetric capacity rather than limiting this to the legal road limits.

Table 17: Additional trucks required

Location	Marsden Point	Wiri Terminal	Wellington	Lyttelton
Imported trucks	31	11	13	31

A pool of contingency trucks (and drivers) already onshore would help reduce the impact and duration of any disruption. For example, 10 reserve trucks would enable ~ 90% of the normal petrol and diesel demand to be re-established within two weeks (likely quicker) in the Wiri outage scenario. Full restoration of supply would be possible within a month.

Holding a pool of contingency trucks would provide a good mitigation option. However, there is a risk of this being undermined if companies were to optimise their trucking fleet due to this new contingency resource now being available for disruption events.

In the consultations, Z Energy highlighted the importance of fuel companies having sufficient trucking resources to cover disruption events and suggested that:

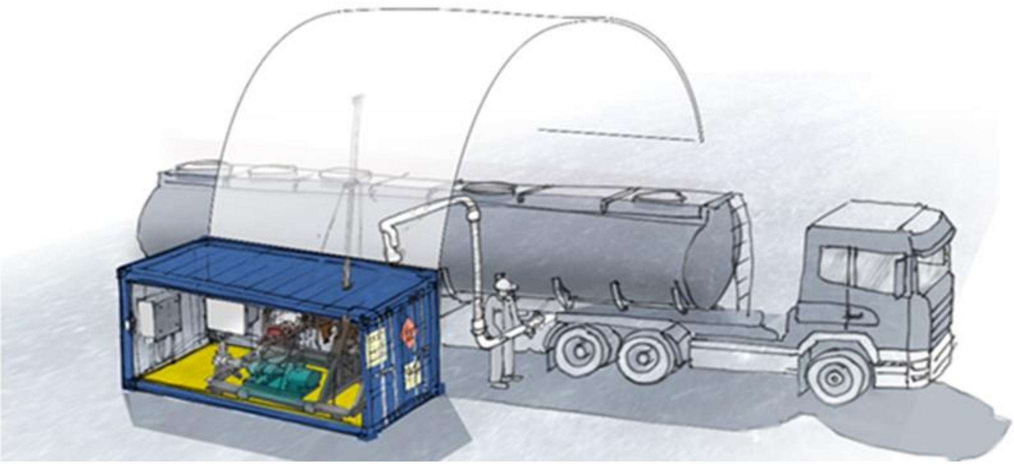
"fuel companies should provide assurances of their ability to respond to a significant disruption scenario, including maintaining sufficient distribution capacity via their trucking fleet".[61]

The advantage of having fuel companies and distributors hold sufficient trucks is that this will ensure the fleet is kept in a serviceable condition, be ready to deploy more quickly than if there was a pool of stored trucks, and allow companies to fully optimise how these assets would be used.

8.3.2 Alternative supply options for jet fuel

There are no practicable supply alternatives for getting jet fuel to Auckland Airport in the event of disruption to Marsden Point, Wiri Terminal or the RAP. In the 2020 report[62] Channel Infrastructure (Refining NZ at that time) proposed the idea of a skid-mounted container discharge facility. The concept (Figure 19) was for this facility to be temporarily located at the Auckland port, with a ship alongside acting as the jet fuel storage system.

Figure 19: Temporary jet fuel loading concept



At that time, there were unresolved questions about how this might work in practice, and the concept had not progressed.

In 2020, Timaru Oil Services Limited sought resource consent to build a new terminal with jet fuel storage at Tauranga, which would provide an alternative supply route to Auckland Airport via trucking. However, this consent was declined in 2021 due to objections from neighbouring properties and that the amenity and cultural effects were not acceptable to be community[63].

[61] Z Energy's House View | Aotearoa New Zealand's fuel security and resilience | October 2024

[62] Fuel Security and Fuel Stockholding Costs and Benefits 2020 | for MBIE | Hale & Twomey

[63] Resource Consent Declined for New Jet Fuel Storage Facility in Mount Maunganui

In a long-term Wiri Terminal outage, we assume a temporary truck loading facility would be set up at Marsden Point (or Mount Manganui), which would allow 800kl[64] of jet fuel per day (around 20% of normal demand) to be trucked to the Airport. Depending on the alternative supply location, this would require 10 to 13 jet fuel-enabled trucks to haul the fuel.

Having a plan to quickly establish an alternative supply of jet fuel to Auckland Airport from another terminal would be sensible in maximising disruption response outcomes. Potential plans could include establishing (or even having in place) a jet fuel loading gantry at Marsden Point, quickly emptying and converting a tank at Mount Maunganui for receiving jet fuel, and ensuring there are sufficient jet fuel-enabled trucks in the fleet to haul jet fuel from these alternative locations.

8.3.3 Rail supply from Marsden Point

Once the rail spur to Marsden Point is in place, another supply resilience option would be rail (via isotainers) from Marsden Point to shift fuel in the event of a disruption to Wiri Terminal or RAP. This option would require the ability to load the isotainers at Marsden Point efficiently, get these to the rail head, and unloading capability, either into a day tank or for loading directly into trucks via a loading gantry. Isotainers could supply petrol, diesel or jet fuel.

A typical isotainer can hold around 22.5kl, and assuming each could be loaded in 30 – 45 minutes, a single loading bay might be able to load 800 kl to 1,000 kl of fuel each day into 36 to 48 isotainers. The key issue, other than having the isotainer infrastructure in place, would be the speed at which sufficient isotainers could be sourced in the event of a disruption.

We note that some events (e.g. natural disasters) could take out the rail link as well as the pipeline.

8.4 Biofuels, renewable or low carbon refinery

A refinery producing petroleum fuel substitutes/replacements from local feedstock could provide a useful component of New Zealand's fuel security. There have been a variety of options explored in the past, up to the scale of Z Energy's 20 million litre/year biodiesel plant (now permanently closed). Several options could be considered in New Zealand, some of which are already under investigation. These include:

- A biorefinery consuming locally sourced oils and fats and turning that into renewable fuel[65], primarily renewable diesel and/or sustainable aviation fuel (SAF)
- A gasification to liquid fuel plant with waste or woody biomass feed, with the primary aim of SAF and/or renewable diesel production[66]
- A refinery producing SAF from renewable energy (electricity) by generating hydrogen and then combining it with CO_2 to produce a liquid fuel (referred to as e-SAF).

All these options are being investigated in New Zealand, including a biorefinery[67] and an e-SAF[68] facility at Marsden Point. This study evaluates the fuel security benefits of a biorefinery processing

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[64] Physical testing showed the JUHI could receive 800kl of jet fuel via truck daily.

[65] Most significant investments in biorefineries now use hydrogenation processes (more like normal refineries) to produce a 'drop-in' fuel that is similar to conventional petroleum fuel. This removes the need for blending as with earlier fuels such as biodiesel.

[66] This technology was the basis of a significant portion of Air New Zealand's roadmap to 50% SAF by 2050

[67] https://channelnz.com/biorefinery-proposed-at-marsden-point-energy-precinct/

[68] https://channelnz.com/production-of-sustainable-aviation-fuel-at-marsden-point-progresses-to-the-next-phase/

local sources of fats and oils to renewable fuels. This is the method used for most of the commercial renewable fuels available globally (excluding ethanol).

Other processing options using local feedstocks or energy should have a similar security benefit for the same scale although, as they are at an earlier phase of development, they are likely to be more expensive than we estimate for a biorefinery.

There is little detail available on the recently announced biorefinery (other than the involvement of Qantas suggests SAF production will be an option, and the use of the former refinery equipment would mean a hydrogenation process[69]), so we assume a typical biorefinery based on the likely feedstock availability in New Zealand.

The basis of the biorefinery analysed for this fuel security study (noting the proposed biorefinery may be different) is:

- Throughput: 200,000 tonnes per year (240 million litre/year or ~ 5,000 bbl/day) as that relates to what we understand about suitable feed availability in New Zealand.
- Feed: oils and fats.[70]
- Yield of renewable diesel/SAF: ~90%. Depending on the sophistication of the plant, there is the ability to swing so diesel could be maximised (i.e. 90% yield) with no SAF or, if maximising SAF (with the right technology), up to 50% SAF with 40% diesel. That is there will always be some renewable diesel produced even if maximising SAF production.
- The balance of the yield is gases or naphtha (some could be used for renewable LPG). The naphtha is likely to have more value as a feed for bioplastic plants rather than for upgrading into petrol and the gases may be used as fuel for the process.

Such a plant could therefore produce between:

- SAF (jet fuel) range: 0 ML (if renewable diesel maximised) to 125 ML - 0-7% of NZ demand
- Renewable diesel range 95 ML (when maximising SAF) to 220 ML (when maximising renewable diesel) - 2.5%-5.7% of NZ demand.

For comparison, the e-SAF facility under investigation for locating at Channel Infrastructure is expected to produce 60 ML, a little over 3% of New Zealand's jet fuel demand.

There is little specific information on the cost of biorefineries, although refineries with hydrogenation have similarities to conventional refinery costing. For a refinery of this scale, we use the information that we earlier calculated for refineries but assume the cost will be in the top half of the range. This gives a capital cost range of US$320-425 million (NZ$530-710 million). We compared the value/cost of the biofuel relative to convention petroleum fuel to analyse the bio refinery's economic cost rather than directly considering the capital cost of the investment (this assumes the capital cost is recovered within the price of biofuel).

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[69] Fuel and the processes used must be approved for use in commercial aviation (comply with ASTM D7566). As of July 2023, 11 conversion processes for SAF production have been approved, and 11 other conversion processes were being evaluated. Two of the approved processes use oils and fats (not including co-processing options).

[70] The preference is for used oils and animal fats feed rather than vegetable oils as these result in a better total lifecycle emissions reduction compared to fossil fuel (80-90% emissions reduction).

8.5 Refinery to process indigenous crude and condensate

A refinery capable of processing indigenous crude either on a continuous or emergency basis would be very different to the Marsden Point Refinery. It would be substantially smaller (<5% of the scale of MPR) and sized to match the expected production. It would only use simple processes (e.g. distillation) possibly only producing one or two products. These sorts of refineries are known as Modular or Mini refineries[71].

Modular refineries are so-called as they are collections of prefabricated units designed specifically for the crude stream(s) they will process. They are:

- Typically sized in the 1,000 to 30,000 bbls/day range;
- Require a lot less land and associated facilities (for the smaller end of the scale);
- Have prefabricated modular units for different refining processes with additional modules included depending on the complexity of the fuels produced;
- Are scalable by adding additional modules;
- Often focused on diesel production as that is the simplest fuel to refine if aiming for simplified operation;
- Petrol production requires more complex processing to meet specifications, which increases complexity and cost; and
- Most often located in countries with land-based crude oil production where there is economic justification to process crude oil locally rather than transfer it to a port, ship it to a refinery, and then ship it back again as a refined fuel.

Modular refineries are most common in Africa.

At its simplest, a modular refinery is only a distillation unit module. Additional modules are required to produce petrol, jet fuel and diesel suitable for the market use (module for each fuel).

A modular refinery may be better located in Taranaki where New Zealand indigenous production is located. Marsden Point would be an option with an additional shipping cost, and there may be a cost saving with associated infrastructure available there. There is likely to be no synergy with existing refinery equipment on site due to the vastly different scales.

There is little cost information available on modular refineries, although promoters indicate costs that are much lower than those of a conventional refinery if scaled down to the same size. The indicated costs may only be for the most basic distillation unit and not include the more sophisticated units required to produce on-spec fuels or the related utilities, which make up a significant portion of a refinery's cost[72].

New Zealand crude and condensate production

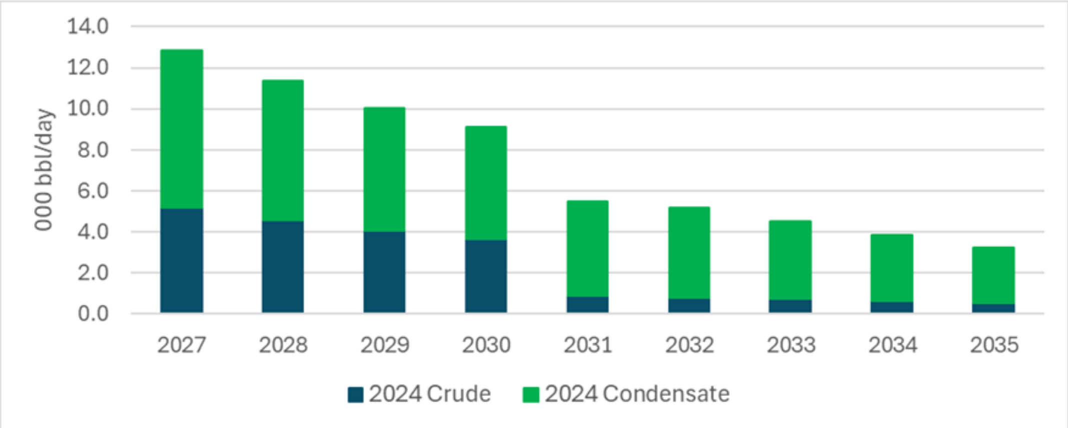
Domestic crude and condensate production is falling and forecast (Figure 20) to be in rapid decline by the time an indigenous refinery could be in place (likely at least four years). Most of the crude (shown until 2030) is Maari, which is offshore, so it may not be relied upon for a domestic refinery (it is far more complex to have the ability to import crude for such a refinery) and may not be in

[71] VFuels is an example of a company providing modular refineries (https://www.vfuels.com/what-we-do)

[72] A 2020 modular refinery notes financing of US$35 million for phase one, which includes 5,000 bbl of distillation. (https://www.nsenergybusiness.com/projects/waltersmith-modular-refinery/?cf-view)

production for a much longer following the commissioning of a domestic refinery. Figure 20 shows the current outlook for indigenous crude and condensate production through to 2035.

Figure 20: Forecast of domestic crude and condensate production[73]



Possible modular refinery details

The production profile illustrates that any modular refinery will need to focus on condensate processing to provide an ongoing security benefit. Based on the available feed, a size of around 5,000bbl/day (typical for a modular refinery) would be most appropriate, although even that might be more than the production level by the mid-2030s.

Domestic security will benefit primarily from the ability to produce diesel, which is essential for economic activity. This conflicts with the quality of the feedstock. Condensate is very low in the middle distillate cuts that are used to produce diesel (only 15-30%). Most of the material is lighter including gases and light naphtha, which is not particularly suitable for petrol manufacturing. This material is normally sold as a condensate feed for petrochemical manufacture as that is where it has the most value.

The producers of domestic crude and condensate have contracts for the sale of their production. Establishing a refinery for indigenous crude (even if only used in an emergency) would require producers to break those contracts or have the ability to do so in an emergency.

An indigenous refinery is not expected to be economic as only a small portion of saleable product would be produced, with the rest exported at a lower value. Therefore it would be regarded as a contingency should New Zealand be isolated from international markets. It is not normally economic to turn a refinery off and on, but as this would be a contingency option, test running for a short period each year to ensure operational feasibility is likely to be the most cost effective way to ensure readiness is maintained.

In summary, we expect a refinery processing indigenous crude and condensate would:

- Be sized around 5,000 bbls/day based on the outlook for indigenous production;
- Focus on mainly lighter condensate feed;

[73] Based on the 2024 Reserves Outlook published by MBIE

- Not be economical in normal circumstances, so would be designed and commissioned for emergency use;
- With the necessary modules produce around 750 - 1,500 bbl/day of diesel (120-240,000 litres/day), which is 1-2% of New Zealand's daily demand;
- An additional petrol module (likely to increase the capital cost significantly) may produce a similar amount of petrol, although it would be difficult to meet petrol specifications so may not provide resilience benefit;
- The jet fuel portion of the feed is very small, so it would not be worthwhile including a jet fuel module given its quality requirements, and any jet fuel production would reduce diesel volumes; and
- The balance of feed (about 80% of the intake) would still be exported as it would not be suitable for further processing (largely too light). Some could be used as fuel for the process.

Obtaining consent for a modular refinery would be required, although limited operational times may ease that somewhat. Siting the refinery close to existing petroleum infrastructure, (e.g. near the Omata Tank Farm outside New Plymouth), would provide the ability to leverage those assets and avoid duplication.

The few costs provided are in the US$10's of million for a 5,000 bbl refinery, but as noted, this is unrealistic against normal refining costs and unlikely to produce suitable specification fuels. Some of the difference is that no residue upgrading facilities are needed, although we expect that once the associated infrastructure and related costs are included, the total will climb. Based on an analysis of normal refining costs from our report on reestablishing the Marsden Point Refinery, the cost could be in the US$190-425 million range, which is a much larger amount. For this analysis, we assume the refinery would produce diesel only, simplifying operation and therefore be lower than the range above. A range of US$100-200 million is assumed. Operating costs (to keep the plant in a state of readiness and for occasional test operation) could be NZ$10-15 million/year.

8.6 Supply diversity

New Zealand has a diverse range of suppliers, with five countries each supplying more than 5% of one of the main transport fuels. South Korea and Singapore are the main suppliers, as they have the region's largest export-focused refineries. We discussed the diversity of supply as a resilience measure during the consultation, and companies said this was a consideration when securing supply. Analysis of the import flows over the past three years shows significant variation in fuel flows from different countries over time, with many different refineries supplying fuel.

There are large export refining centres to the west of New Zealand (India and the Middle East) and the east (US Gulf Coast). Fuel from European refineries also flows into the region when there is an economic incentive. Traders constantly monitor the prices between the major regions, and if price differentials cover the cost of shipping, they will often move fuel significant distances to capture that value.

New Zealand could consider forcing suppliers to increase supply diversity by requiring them to secure some (e.g. at least 10%) of their supply from outside the immediate Asia-Pacific region (i.e., from India, the Middle East, and/or the USA). This would come at a cost, and it may be difficult for smaller companies to comply, as they normally term their supply for a period with a single supplier.

The cost varies depending on market movement between the different refining centres and the cost of shipping. We estimate it would increase the fuel supply cost by US$2.5 - 4.5/bbl (NZ 2.6 - 4.7 cpl) for those deliveries. Requiring this diversity on at least 10% of New Zealand's fuel imports increases the import cost by NZ$23 - 41 million per year, which would be passed on to consumers.

We question whether the strategy would provide much value as these flows will happen anyway if there is an economic driver. There may be benefits from establishing supply relationships in those refining centres, although the multinational companies operating in New Zealand already have these relationships within their trading operations.

With no identifiable benefit, this option is not analysed in the cost benefit section.

8.7 International Arrangements/Agreements

New Zealand mitigates its risks to fuel supplies, as well as other critical needs, through international multilateral and bilateral agreements. The global geopolitical environment is changing, although countries continue to work together to plan for and manage critical supply chains. During the consultation, the following relevant work in this area was highlighted.

- The Indo-Pacific Economic Framework for Prosperity[74]. This is a grouping of 14 Indo-Pacific countries developing a future-focused economic cooperation framework covering a range of priority economic and trade issues. The key drivers for the Framework development are:

  > "*deterioration in the geopolitical environment in the region, critical weaknesses in regional production and supply chains highlighted in the early stages of the pandemic, and a growing sense that technology, trade and investment flows needed to underpin regional response to climate change*."[75]

  The framework's brief covers all critical supply chains, as many countries are as dependent on New Zealand's exports as we are on others. The grouping includes all of New Zealand's major fuel suppliers (Singapore, South Korea, Japan, Malaysia) and the countries we would look to if there were fuel supply disruptions in Asia (India and the United States).

- Enhanced Partnership (EP) with Singapore. The EP with Singapore, established in 2019, continues to be developed. The countries announced adding a sixth pillar on "Supply Chains and Connectivity" to the Enhanced Partnership during the New Zealand Prime Minister's visit to Singapore in April 2024:

  > "*Under the pillar, the Prime Ministers agreed to launch negotiations for an Agreement on Trade in Essential Supplies. The Agreement builds on the close cooperation on the Singapore-New Zealand Declaration on Trade in Essential Goods for Combating the COVID-19 Pandemic and aims at a higher level of ambition for a stronger bilateral supply chain relationship. The Agreement will become part of the Singapore-New Zealand Closer Economic Partnership.*"[76]

  Singapore is the centre of refined fuel trade in the Asia-Pacific and one of New Zealand's most critical fuel suppliers.

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[74] https://www.mfat.govt.nz/en/trade/free-trade-agreements/free-trade-agreements-under-negotiation/indo-pacific-economic-framework-for-prosperity

[75] Indo-Pacific Economic Framework for Prosperity, National Interest Analysis, MFAT

[76] https://www.mfa.gov.sg/Newsroom/Press-Statements-Transcripts-and-Photos/2024/04/Official-Visit-of-the-Prime-Minister-of-New-Zealand

The Government's continued engagement with regional trading partner countries and these frameworks and partnerships are appropriate approaches to managing fuel supply risk (along with other supply chain risks) by avoiding isolation from our normal trading partners. New Zealand is also a member of the IEA. The IEA has been operating for 50 years and provides the mechanism for coordinated response to fuel-specific scenarios. Expansion to include associate members in the response actions is helping offset the declining portion of IEA members' global oil consumption.

We note these as appropriate responses for the Government to help manage supply chain risks but we do not analyse this in the cost/benefit analysis.

8.8 Accelerated energy transition

New Zealand could reduce fuel security risks by accelerating the transition to non-fossil fuel transport technology such as EVs.

The New Zealand economy is transitioning to renewable energy sources and reducing reliance on imported fossil fuels. The transition to alternative technologies and fuels, such as EVs, HFCs, and biofuels, mitigates potential fuel disruptions by reducing overall dependence on conventional fossil fuels. Broader market trends and technological advancements drive this transition and it is already occurring without requiring additional intervention or costs. However, if the government is considering spending resources on fuel security measures, it could consider accelerating this energy transition. Achieving this would likely require subsidies, and the Government would need to determine a funding mechanism. Potential options include taxes or a fuel surcharge on fuel. These would require careful policy design to avoid subsidising consumers who were already going to transition and avoid distributional impacts.

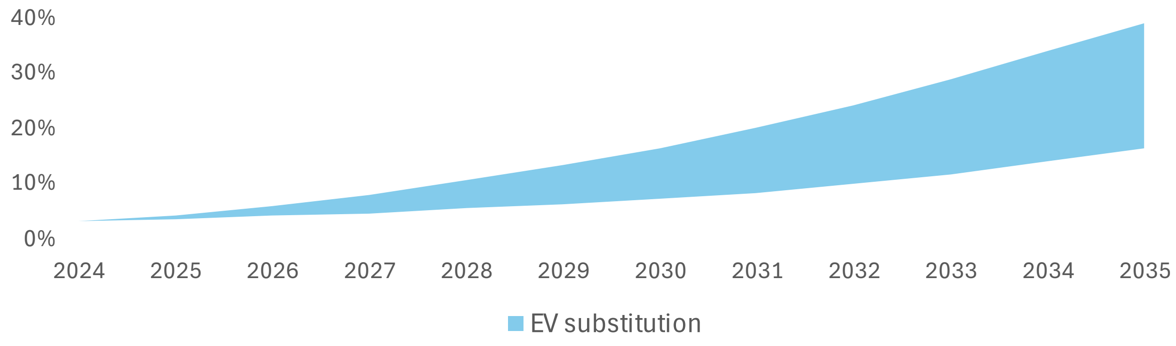
The ongoing transition to renewable technologies will affect petrol, diesel, and jet fuel consumption differently. Each group of fuel type users have different technological options to transition to renewable energy sources. Envisory, Castalia and Climate Change Commission (CCC) have independently forecast the consumption trends for non-fossil energy supplies for traditional petrol, diesel and jet fuel users (Section 5.0). In the following subsections we discuss and present forecasts for the transition to non-fossil energy sources (before any mitigation intervention is considered):

- Petrol users forecast to transition to EVs
- Diesel users forecast to transition to other vehicle and fuel types
- Jet fuel users have challenges in identifying substitutes.

Petrol users will transition fastest to substitute energy sources

Light passenger and commercial vehicles currently consume about 83% of petrol imports. Light vehicles are already shifting to battery electric vehicles (EVs). Castalia and Envisory's modelling shows that as EV adoption continues, the transportation sector could reduce its petrol consumption by up to 40% (Figure 21). As a result, over time, the risks to fuel security will decrease because New Zealand light vehicle users will become less reliant on imported fossil fuels.

Figure 21: Forecast petrol market non-fossil fuel supply, %



Diesel users have relatively fewer substitutes, but some transition is expected

We expect between 11% and 35% of diesel in the transportation sector to be replaced by 2035 with alternative fuel sources. The transportation sector accounts for over 70% of total diesel consumption. Technological options to transition diesel users include light vehicle EVs, medium truck EVs, and hydrogen fuel cell (HFC) heavy trucks.[77]

Furthermore, up to 6% of current diesel demand could be feasibly replaced with biofuel. Seadra Energy and stakeholders like Qantas and ANZ are investigating the development of a biorefinery at Marsden Point, which will have the potential to produce renewable diesel, SAF, and hydrogen.[78] The biorefinery may be capable of swinging production between renewable diesel and SAF, and if diesel is maximised, this could be 90% of the production capacity. We model a refinery (based on feedstock availability) that could produce ~6% of New Zealand's diesel demand, although a larger refinery may produce closer to 10%. This substitution represents a critical step in scaling renewable fuel production.

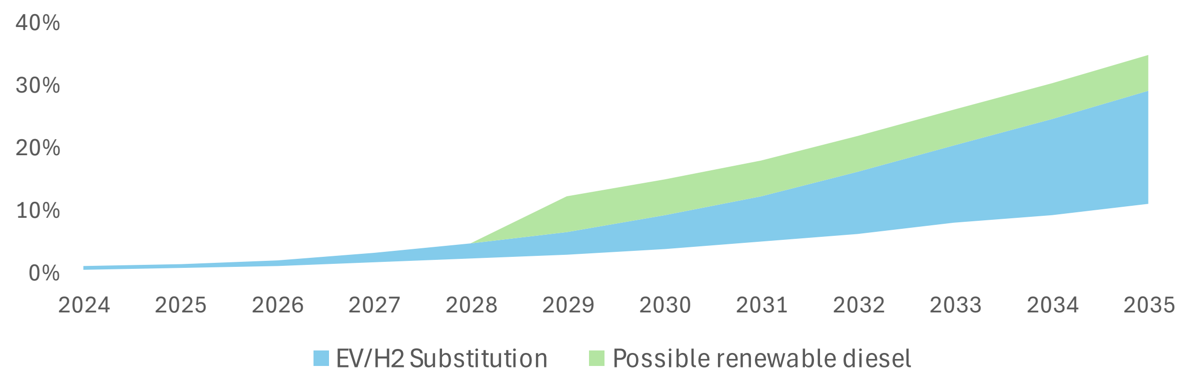
[77] We assume heavy trucks will transition to HFC instead of EV technologies because HFC is generally more suitable for long-haul, heavy freight tasks. We note that EECA's Low Emissions Heavy Vehicle Fund currently provides funding for specific "heavy" EV trucks, which—except for one model (EVC61)—are too light to be considered "heavy trucks" in this Study. This Study classifies trucks over 30 tonnes in mass as "heavy trucks," which is consistent with how the Climate Change Commission's "heavy trucks."

For more details, please see EECA, Low Emissions Heavy Vehicle Fund, available at: https://www.eeca.govt.nz/co-funding-and-support/products/low-emissions-heavy-vehicle-fund/

For more details, please see Climate Change Commission (2021), Reducing emissions from transport, buildings urban form, available at: https://www.climatecommission.govt.nz/public/Evidence-21/Evidence-CH-6-reducing-emissions-transport-buildings.pdf

[78] Channel Infrastructure, 2024, Biorefinery proposed at Marsden Point Energy Precinct. Available at: https://channelnz.com/biorefinery-proposed-at-marsden-point-energy-precinct/#:~:text=Seadra's%20existing%20option%20to%20purchase,ultimately%20decide%20to%20not%20proceed

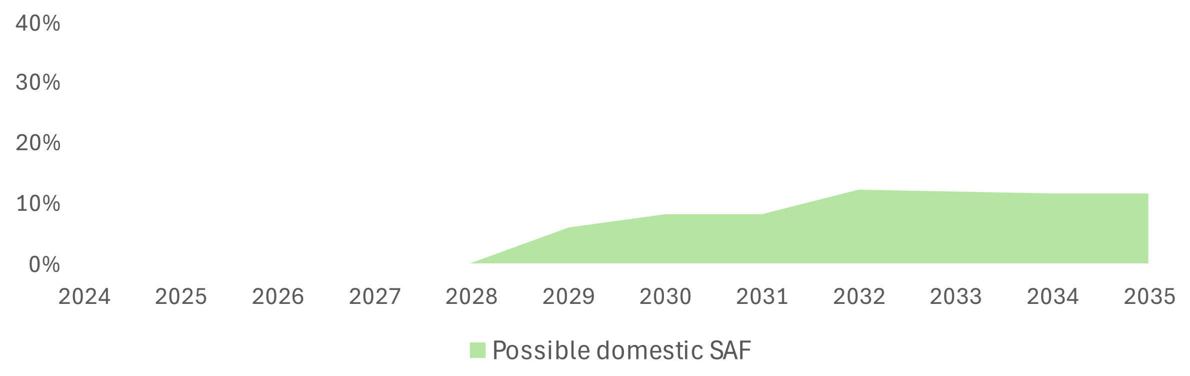
Figure 22: Forecast diesel transport market non-fossil fuel supply, %



Jet fuel users face significant challenge to substitute with alternative energy sources or technologies

Replacing jet fuel with alternative energy sources poses a more significant challenge due to the higher cost, limited production capacity and aviation fuel requirements.[79] Nonetheless, several sustainable aviation fuel options are under consideration at a scale that could potentially replace up to 12% of the country's jet fuel demand through to 2035, as detailed in Figure 23. Note that the biorefinery could not produce the SAF assumed here while maximising renewable diesel production, as assumed above.

Figure 23: Forecast jet fuel market non-fossil fuel supply, %



To accelerate the ongoing transition to EVs/HFCs and biofuels, the government can implement a range of financial incentives and policy measures. The Government would need to determine a funding mechanism. Potential options include offering subsidies, tax credits, renewable fuel certificates, or rebates for purchasing EVs, HFCs, and biofuels would lower the price of non-fossil fuel alternatives relative to fossil fuel options. These would require careful policy design to avoid subsidising consumers who were already going to transition and avoid distributional impacts.

We discuss this in more detail in the next section and Appendix E.

[79] Environment + Energy Leader. 2024. Air New Zealand retreats from 2030 emissions target, citing operational hurdles. Available at: https://www.environmentenergyleader.com/stories/air-new-zealand-retreats-from-2030-emissions-target-citing-operational-hurdles,44942

9.0 Cost Benefit Analysis (CBA) of mitigation options

The identified mitigation options all have varying costs and different impacts on fuel security. Some options have well-defined implementation pathways with clear costs and benefits. Other options require further research or may offer limited advantages.

We have closely evaluated the options with clearly defined feasibility, costs, and potential benefits. These include:

- Reestablishing Marsden Point refinery
- Increasing jet fuel and diesel storage capacity
- Expanding trucking capacity to alleviate petrol and diesel disruptions from infrastructure failure
- Investing in biofuels, renewable fuels, or low-carbon refineries
- Developing a refinery to process indigenous crude and condensate
- Accelerated transition to zero-emission road vehicles (Accelerated Transition).[80]

We evaluated the options using a combination of quantitative and qualitative measures. We quantified the annual costs of each option. We then quantified the benefits of each option in terms of additional fuel volume. Finally, we qualitatively scored the options according to their overall effectiveness in mitigating different fuel disruption scenarios. However, since no single option can fully eliminate fuel shortages, improving New Zealand's fuel security will likely require a combination of these measures rather than reliance on one solution.

In the following sections, we outline the analysis according to:

- Costs of each option on an annual basis
- Benefits of each option in terms of usefulness of the volumes of fuel for resilience.

Costs - Annual costs

The annual cost of each option is calculated as a marginal cost relative to the status quo. This includes expenses for:

- Infrastructure investments, such as a new refinery, additional storage tanks, or new trucks.
    - For infrastructure-related options, we estimate marginal costs based on the additional annualised capital and operating expenses required to implement and sustain these measures.
- Any government incentive or subsidy to encourage biofuel adoption or accelerate the transition to EVs.

[80] IEA's "10-Point Plan to Cut Oil Use" recommends several actions that mitigate the economic impact of fuel distribution disruptions by reducing fuel demand, including "make public transport cheaper and incentivise micro-mobility, walking and cycling" (Action 6). These actions can be effective options for fuel security, but are out of the scope of this study. For more details, see: IEA (2022), A 10-Point Plan to Cut Oil Use, available at: https://iea.blob.core.windows.net/assets/c5043064-58b7-4066-b1e9-68d7d9203fe9/A10-PointPlantoCutOilUse.pdf

- For government incentive-related costs, we estimate the funding required to reduce the price gap between alternative fuels and conventional fuels or between EVs and internal combustion engine (ICE) vehicles. For example, the estimated cost of accelerating the transition to EVs reflects the marginal cost of making EV ownership financially comparable to ICE vehicles on a total cost of ownership basis. This would require lowering EV costs sooner than currently forecast to ensure that new vehicles added to the fleet are EVs. Achieving this would likely require subsidies, with the Government needing to determine a funding mechanism—potential options include taxes or a fuel surcharge on fuel. Similarly, the estimated marginal cost of increasing biofuel adoption represents the effective subsidy needed to bring biofuel prices in line with diesel or jet prices.

Overall, the costs associated with each option are primarily economic, and the burden will ultimately fall on the New Zealand economy. These costs may be reflected in different ways—either through government subsidies (a burden on taxpayers) or by consumers paying higher fuel prices, because fuel companies or producers pass investment costs onto fuel consumers.

Benefits - Volume usefulness

The benefits of each mitigation option are measured by its volume usefulness—the amount of fuel it adds to improve fuel resilience, adjusted by its scenario usefulness score, which reflects how effectively it addresses different disruption types and whether it only provides a one off benefit (additional inventory holdings can only be used once in a disruption event) or a continuous benefit (transition permanently reduces fossil fuel dependence).

The Appendix E provides details on the scoring system.

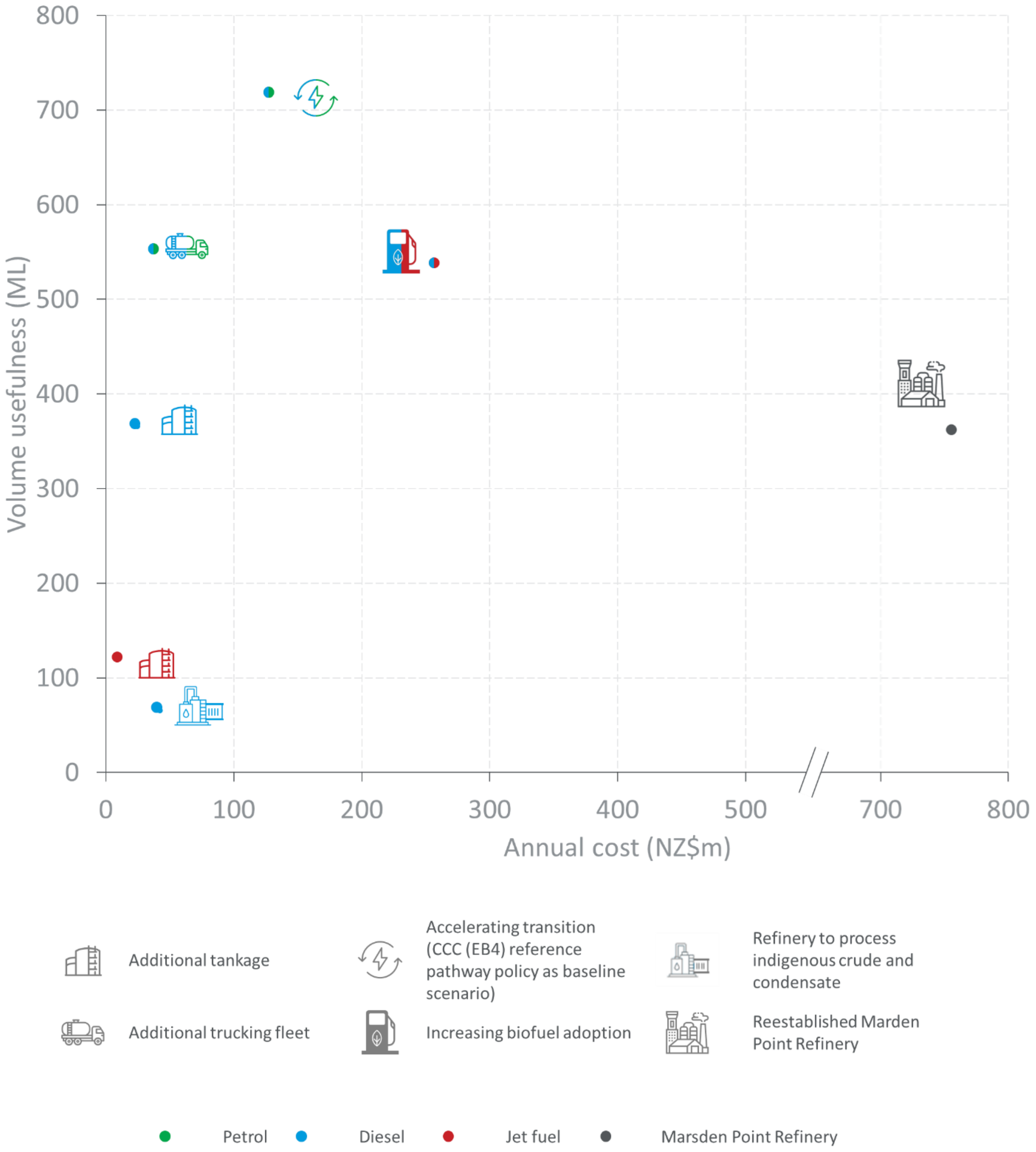
Comparing and evaluating mitigation options

We carried out the analysis in three steps:

- **Step 1**: we estimate an annual cost to provide a certain amount of fuel resilience (measured in ML)
- **Step 2**: we assign a qualitative score to each option according to cost, volume mitigation potential and effectiveness in addressing the fuel security scenarios
- **Step 3**: we grouped the options according to their scores in steps 1 and 2 to guide policymakers on the most effective options.

For **step 1**, We compare all mitigation options based on their volume usefulness (ML) and annual cost (NZ$ million), as shown in Figure 24. The most effective options provide high fuel resilience at a lower cost, while less effective options either have high costs or contribute relatively little to mitigating fuel disruptions. For example, additional trucking capacity is estimated to provide the highest volume mitigation usefulness for diesel and petrol combined at a relatively low cost. In contrast, building a modular refinery to process indigenous crude and condensate offers limited fuel volume benefits at a much higher cost.

Figure 24: Comparison of different mitigation options based on volume usefulness (ML) and annual cost (NZ$ million) [81]



For **step 2**, we developed a scoring chart that allows to evaluate different fuel security mitigation options based on three key criteria:

- **Annual cost** – financial burden associated with implementing each option.
- **Volume mitigation potential** – the maximum amount of fuel each option could contribute to improving resilience, regardless of the disruption scenario.

[81] Mitigation costs are provided in 2024 dollars.

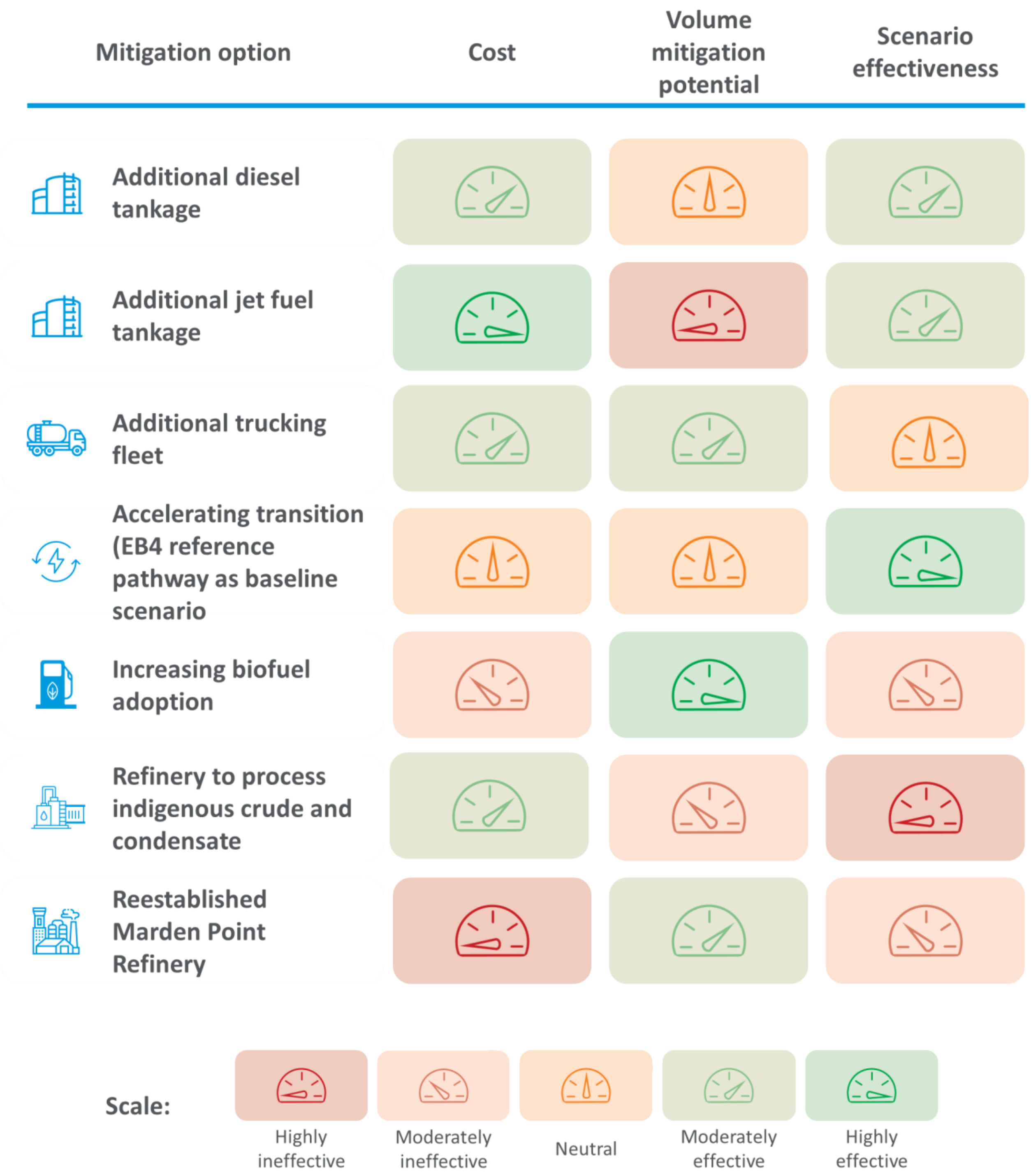
- **Scenario effectiveness** – how well each option addresses different fuel disruption scenarios. It is a total score assigned across all disruption scenarios.

Each criterion is rated using a scale from 1 (least effective) to 5 (most effective), where:

- Red (1-2): Low effectiveness, high cost, or low fuel volume
- Orange (3): Moderate cost, fuel volume or effectiveness
- Green (4-5): High effectiveness, low cost, or significant fuel volume contribution.

For example, Figure 25 shows that the mitigation option of an additional trucking fleet scores high across all criteria. On the other hand, while accelerated transition scores high based on cost and scenario effectiveness, it has a low score on the immediate volume mitigation potential. This is because, the additional fuel volume it provides each year is limited.

Figure 25: Evaluation of mitigation options



Finally, in **step 3**, based on the results of the analysis above, we grouped the mitigation options into three categories: most effective and cost-efficient, moderately effective and cost-efficient, and least effective or high cost. In each group, we divided mitigation options by fuel type. We also discuss the potential trade-offs and limitations associated with each approach.

Appendix E sets out the more details on the scoring system to determine volume usefulness and in-depth analysis of the individual fuel security options.

Most effective and cost-efficient options

Diesel and petrol

- *Expanding trucking capacity to more quickly alleviate petrol and diesel disruption following infrastructure failure*
    - Annual cost: Low (~$38M)
    - Volume usefulness: Highest (~552 ML)
    - Effectiveness: Expanding trucking capacity is a cost-effective solution for mitigating fuel disruptions, with a low annual cost and high-volume usefulness. The introduction of additional trucks and drivers ensures fuel can be hauled from alternative terminals, addressing supply shortages. Additionally, the fuel companies holding sufficient trucking resources offer the advantage of maintaining serviceable fleets, ensuring rapid deployment, and optimising asset use. As a result, this option can significantly improve fuel distribution flexibility, making it one of the most effective mitigation strategies for supply chain disruptions.

- *Increasing diesel storage capacity - Diesel*
    - Annual cost: Low (~$24M)
    - Volume usefulness: High (~336 ML)
    - Effectiveness: Expanding fuel storage capacity for diesel by adding seven 12 ML tanks[82] (approximately 7 days additional stock) provides a buffer in the event of a fuel disruption at a lower cost.
    - Limitation: The effectiveness of this mitigation option for domestic supply disruptions is dependent on the location of the storage. Supply disruptions can happen at different points in the system—ports, pipelines, or specific regions. If storage is too concentrated in one area, it may not be useful when a disruption occurs elsewhere.
- *Accelerated transition to zero-emission road vehicles (Accelerated Transition)*
    - Annual cost: Low (~$129M)
    - Volume usefulness: Moderate (~719ML)
    - Effectiveness: This strategy enhances long-term fuel security by reducing reliance on fossil fuels. At a moderate cost, it provides ongoing support to mitigate fuel supply risks.
    - Limitation: Further analysis is needed to identify the most effective measures to accelerate the shift to EVs/HFCs (e.g., subsidies, tax incentives) and to estimate the associated costs. Cost estimates in this analysis rely on recent data comparing ICE vehicles with EVs/HFCs, but rapid technological developments may lead to significant cost changes.

[82] A 12 ML tank was costed as this represents a large tank for most fuel terminals and is of a size where economics of scale are achieved versus smaller tanks. Channel Infrastructure uses larger tanks both due to the size of the former crude oil tanks available and the larger scale of storage relative to most other terminals.

Jet fuel

- *Increasing jet fuel storage capacity - Jet*
  - Annual cost: Low (~$8M)
  - Volume usefulness: Moderate (~121 ML)
  - Effectiveness: Adding two 12 ML tanks would extend jet fuel storage by four days, creating a reliable buffer against disruptions at a low cost.
  - Limitation: The current JUHI footprint is fully utilised, and the long-term location of the JUHI remains unclear. As with additional diesel storage, the effectiveness of this option depends on the storage location, which impacts accessibility and distribution efficiency.

Moderately effective and cost-efficient options

Diesel and jet fuel

- *Investing in biofuels, renewable fuels, or low-carbon refineries*
  - Annual cost: High (~257$M)
  - Volume usefulness: High (~ 537ML)
  - Effectiveness: Biofuels can significantly contribute to fuel resilience, particularly for diesel and jet fuel. For example, a biorefinery could supply ~6% of normal diesel demand (higher if the refinery capacity is larger), extending the time inventories would last.
  - As a result, while it has a high cost, its high usefulness makes it a strong mitigation option.
  - Limitation: There is significant uncertainty around the costs of investing in biofuels and biorefineries. Our analysis relies on currently available data regarding the marginal cost of SAF and biodiesel relative to conventional jet fuel and diesel. However, these cost margins may fluctuate due to technological advancements and market dynamics. Additionally, production costs could decline over time as the industry scales up. Thus, further analysis is needed to refine cost estimates and assess the financial feasibility of large-scale biofuel adoption.

Least effective or high-cost options

- *Developing a refinery to process indigenous crude and condensate - diesel only*
  - Annual cost: Low (~42$M)
  - Volume usefulness: Low (~66 ML)
  - Effectiveness: While the refinery is relatively low-cost, it is driven by the assumption that the refinery will be idle and only used in an emergency. When operating a refinery processing indigenous crude and condensate could supply only 1-2% of the diesel demand.
- *Reestablishing Marsden Point refinery - all types of fuel*
  - Annual cost: Highest (~$756M)
  - Volume usefulness: Moderate (~360 ML)
  - Effectiveness: This option provides minimal improvement in fuel resilience compared to its cost, making it one of the least efficient strategies.

Conclusion on cost-effective and useful strategies for enhancing fuel resilience

The most cost-effective strategies for enhancing fuel resilience are accelerating the transition to zero-emission vehicles, expanding trucking capacity and increasing diesel storage. These measures provide the highest resilience benefits at for the cost.

For jet fuel, increasing storage is the most cost-effective option. Investing in biofuels could also be viable for both jet fuel and diesel, but it requires further analysis and comes with higher costs.

In contrast, reestablishing Marsden Point Refinery or developing a new refinery for indigenous crude proved inefficient due to either high costs and/or limited effectiveness across all fuel types.

Appendix A Project Scope

Project objectives

The objectives for the Fuel Security Study and the Fuel Security Plan (which will be developed based on the findings of the study) are to:

- Identify and mitigate vulnerabilities in New Zealand's fuel supply chains.
- Enable us to minimise the impact of fuel disruption events on essential services and economic activity.
- Investigate how New Zealand could improve sovereign fuel resilience.
- Maintain availability of fuel at an affordable price.

The successful candidate will need to consider these objectives in the development of the study.

Project scope

MBIE is seeking a report to improve our understanding of New Zealand's fuel security requirements from now to 2035. We would like the following areas investigated:

Focus area	Description
Investigate the reopening of the Marsden Point oil refinery	What is required to reopen Marsden Point as a fully functional oil refinery as it was prior to its closure in 2022? How would it contribute to New Zealand's economy and sovereign fuel resilience?
Investigate the strategic importance of infrastructure at Marsden Point and the role it could play in underpinning New Zealand's fuel resilience	What is the strategic importance of infrastructure at Marsden Point (including pipeline infrastructure) for New Zealand's fuel resilience? In answering this question, the study should consider the comparative costs and benefits of: • an oil refinery at Marsden Point • an oil refinery at Marsden Point that can refine domestic crude • a low carbon fuel refinery • other fuel infrastructure at Marsden Point including the Marsden Point to Auckland Pipeline.
An understanding of the risks, impacts and mitigation measures of an extended fuel supply shortage	What are the risks of an extended fuel supply shortage and what would be the key likely impacts on New Zealand's economic activity? • The study should cover scenarios that impact fuel importation and distribution. • The study should look into the forecasted global refinery capacity, international fuel distribution networks and demand dynamics, and the likely impacts these may have on New Zealand's fuel supply. What mitigation measures could New Zealand take to minimise or prevent impacts of an international fuel supply shortage? • The study should include information on measures that could be taken now and in the future. • Each mitigation measure should be considered through a cost-benefit framework.
Understanding of potential domestic disruptions to fuel distribution	How is domestic fuel distribution vulnerable to disruption? • The study should investigate vulnerabilities of national infrastructure and supply chains. • The study should include how New Zealand could be impacted by transitional scenarios.

Mapping fuel consumption trends and how they could impact fuel security	How will changing fuel consumption trends impact New Zealand's fuel resilience? • There is existing modelling on New Zealand's changing fuel consumption trends. The study should assess the modelling assumptions and results and analyse what this means in the context of New Zealand's fuel resilience in the future.

To undertake this Fuel Security Study, engagement will be required with relevant stakeholders including (but not limited to):

- fuel importers
- fuel infrastructure owners and operators
- fuel distributors and suppliers (including regional companies)
- large fuel consumers and critical services (including transport and logistics services)
- low carbon fuel manufacturers and suppliers (including hydrogen and methanol companies).

There are existing reports related to this work which are available on MBIE's website including (but not limited to):

- *Refining NZ: Impact of Conversion to Fuels Terminal* (Hale & Twomey) March 2020
- *Fuel Security and Fuel Stockholding Costs and Benefits 2020* (Hale & Twomey) December 2020
- *Economics of Fuel Supply Disruptions and Mitigations* (M.E research) May 2019.

Desired supplier relationship

We will seek a collaborative relationship with the successful supplier. This includes regular project calls between MBIE and the supplier.

MBIE intends to enter a short-term, high-trust relationship with the potential supplier for this procurement. This relationship will involve regular, open communication between both parties and joint efforts for problem solving to ensure the best outcome for all.

Appendix B Consultations

The team (and/or MBIE) had consultation meetings with and/or received formal written feedback from the following companies, departments and ministries during the study.

- Air New Zealand
- Auckland Airport
- Board of Airline Representatives NZ (BARNZ)
- bp Oil New Zealand
- Channel Infrastructure NZ
- Commerce Commission
- Department of Prime Minister and Cabinet (DPMC)
- Gull New Zealand
- Health NZ
- MBIE Fuel Policy and Emergency response
- MBIE Trade and Supply Chain team
- Ministry of Foreign Affairs and Trade (MFAT)
- Ministry of Transport
- Mobil Oil New Zealand
- National Emergency Management Agency (NEMA)
- NZ Defence Force
- Seadra Consortium (Biorefinery at Marsden Point)
- Sustainability Council NZ
- Timaru Oil Services/Tasman Fuels
- Waitomo Group
- Z Energy.

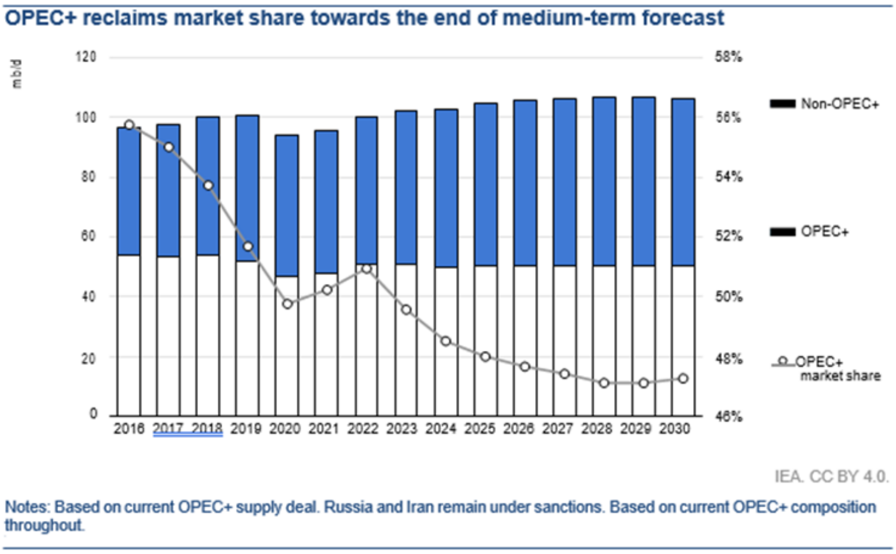
Several other companies and ministries were contacted, but no formal meetings or responses were received. Earlier feedback from recent related consultations (e.g. Minimum Stock Obligation Consultation) which included a wide range of stakeholders was also fed into the study.

Appendix C Global supply, demand and refining capacity outlook

International Fuel Demand and Supply

The International Energy Agency (IEA) expects rising world oil supply to surpass forecast demand from 2025 onwards, led by non-OPEC+ producers. Total supply capacity rises by 6 million barrels per day(mb/d) to nearly 113.8 mb/d by 2030.[83]

Figure 26: OPEC+ share of crude oil supply



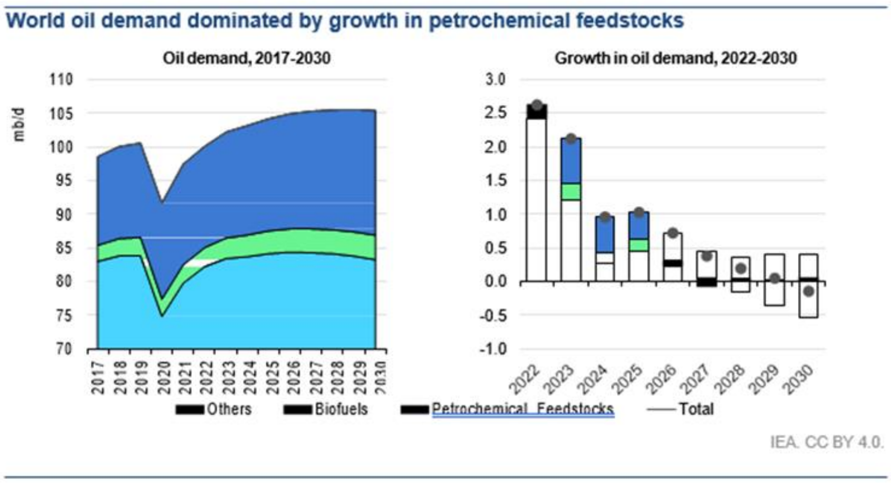
Source: IEA

The forecast supply is an abundant 8 mb/d above the projected global demand of 105.4 mb/d by 2030. Most of the demand growth is for petrochemicals production.[84]

[83] Includes natural gas liquids (NGLs) and biofuels. IEA Oil 2024, page 7

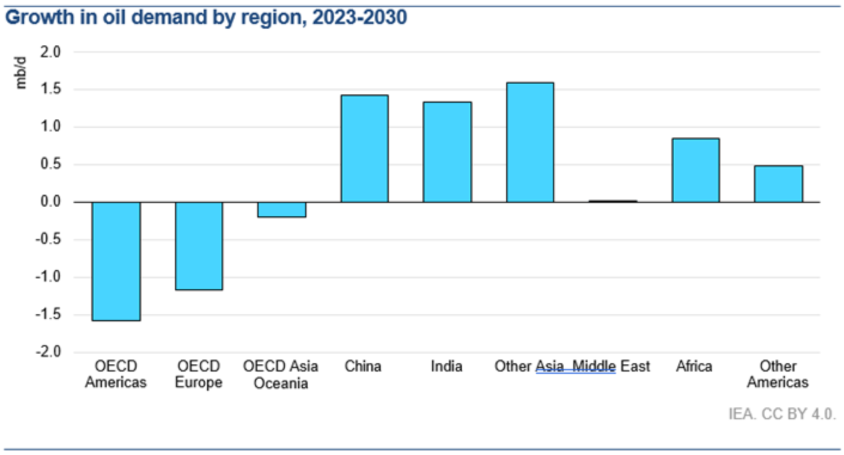
[84] IEA Oil 2024, page 7

Figure 27: World oil demand



New fuels demand is centred in Asia, led by China and India. Fuels demand in advanced economies is expected to fall by 3 mb/d between 2023 and 2030, while emerging and developing economies will increase use by a factor of 2.5. India is set to become a leading source of oil demand growth, averaging 4%-5% each year until 2037.[85]

Figure 28: Growth in demand by region



Supply/Demand dynamics and trade flows

Crude oil and refined fuels continue to move between regions depending on relative demand. Asia currently imports most crudes for processing from the Middle East but can switch to alternatives, including the Americas, if it is short.

The Middle East remains the top exporter of crude oil and refined fuels by 2030. Rising non-OPEC+ crude supply, sanctions on Russian crude exports and OPEC+ voluntary cuts push higher crude volumes from the Atlantic Basin to Asia-Pacific refiners to the end of the decade.[86]

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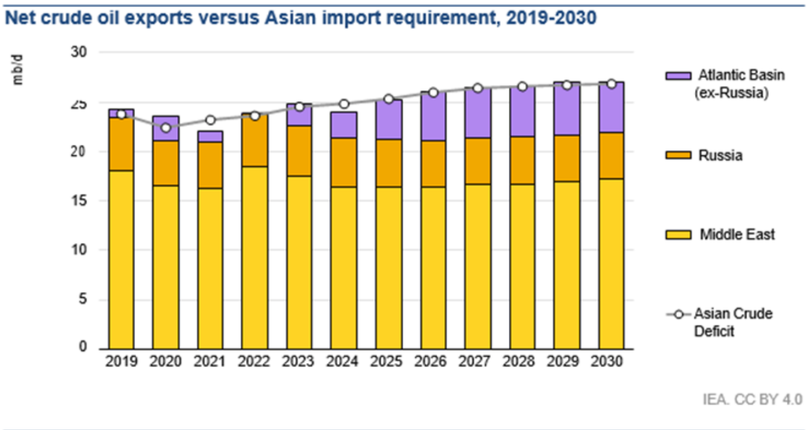
[85] U.S. Energy Information Administration, International Energy Outlook 2023, October 11, 2023

[86] International Energy Agency, Oil 2024, June 2024

Figure 29: Asian crude supply



Global and Asian refining outlooks

Total refinery capacity of almost 103,500 k/bd in 2023[87] is forecast to expand by 3.3 mb/d by 2030[88]. However, the range could be as wide as 2.6 mb/d and 4.9m b/d, based on the inherent uncertainty of all refinery projects.[89]

Most refinery capacity (54 mb/d) is currently in the Atlantic Basin (Americas, Europe (including Russia), and Africa), compared with 49 mb/d for the Middle East and Asia Pacific. This will swing after 2025, as the rationalisation of refining activity in the Atlantic Basin is offset by the growth of refining activity in China, India and the Middle East.

Table 18: List of Refinery projects planned by 2028 (capacity in barrels per day)[90]

Country	Refinery operator (site location)	Estimated crude distillation unit capacity	Estimated startup year	Capacity type
China	Yulong (Shanndog)	400,000	2025	New
China	Ningbo Daxie (Zhejiang)	120,000	2025	Expansion
China	Sinopec Zhenhai (Zhejiang)	250,000	2025	Expansion
China	Huajin Aramco (Liaoning)	300,000	2027	New
China	Sinopec Yueyang (Hunan)	40,000	2027	New
India	Indian Oil (Gujarat)	86,000	2025	Expansion
India	Indian Oil (Barauni)	60,000	2024	Expansion

[87] Energy Institute Statistical Review of World Energy 2024, accessed June 2024

[88] International Energy Agency, Oil 2024, June 2024

[89] US Energy Information Administration, Outlook on global refining to 2028, August 2024

[90] Table source: US Energy Information Administration, Outlook on global refining to 2028, August 2024. Data Source US EIA, Facts Global Energy, Bloomberg New Energy Finance, S&P Global

India	Indian Oil (Bongaigon)	37,000	2028	Expansion
India	Indian Oil (Guwahati)	4,000	2024	Expansion
India	Indian Oil (Panipat)	200,000	2027	Expansion
India	Hindustan Petroleum (Visakhapatnam)	150,000	2024	Expansion
India	Hindustan Petroleum (Barmer)	180,000	2026	New
India	Chennai Petroleum (Nagapattinam)	180,000	2027	New
India	Numaligarh Refinery Ltd (Assam)	120,000	2027	Expansion
India	Indian Oil (Paradip)	200,000	2027	Expansion
India	Ratnagari Refinery and Petrochemicals (Ratnagari)	1,200,000	2028	New
Bahrain	Bahrain Petroleum (Sitra)	110,000	2025	Expansion
Iran	National Iranian Oil Refining and Distribution Company (Bandar Abbas)	120,000	2025	Expansion
Iran	National Iranian Oil Refining and Distribution Company (South Adish, Siraf)	60,000	2025	New
Iraq	Iraqi Ministry of Oil (Haditha)	20,000	2024	Expansion
Jordan	Jordan Petroleum Company (Zarqa)	50,000	2027	Expansion
Oman	Oman Oil Company, Kuwait Petroleum International (Duqm)	17,000	2024	Expansion
Saudi Arabia	Saudi Aramco Total Refining and Petrochemical Company – SATORP (at Jubail)	40,000	2026	Expansion
Nigeria	Dangote Group (Lagos)	650,000	2024	New
Mexico	Pemex Olmeca Refinery (Dos Bocas)	340,000	2025	New

Issues driving the location, level and composition of world refining capacity include the global energy transition, a pivot of demand growth from the Atlantic Basin to Asian economies, and integration with petrochemicals production. The Middle East remains the top exporter of crude oil and refined fuels, and refinery capacity will expand by 630 kb/d by 2030. The US is set to have a substantial product surplus of around 5 mb/d. However, by 2030, the IEA expects Europe to develop a shortfall in diesel and jet fuel and the US to be short jet fuel only.[91] This may signal competition for some middle distillates beyond 2030.

Table 19: Energy Transition issues impacting refining capacity[92]

Issue	Comment	Capacity Impact
Integration with energy transition goals – unrefined fuels (NGLs and biofuels)	Demand for refined fuel is increasingly replaced by fuels that bypass the refinery. The supply of unrefined fuels, including fractionated NGLs and biofuels, increases by a combined 2.5 mb/d, 2023-2030, and captures about 75% of projected demand growth from refiners. Naphtha, LPG and ethane use climbs 3.7 mb/d for petrochemical refining and clean cooking.	Refinery closures or conversions
Integration with energy transition goals - EVs	Electric car sales neared 14 million in 2023 (nearly one in five cars sold), 95% of which were in China, Europe and the United States. Over half of recent new vehicles in China were electric. The IEA expects EVs to displace about 6 mb/d of petrol and diesel demand by 2030 and pressure refiners who favour petrol production for local use in advanced economies.	Refinery closures, upgrades or conversions
Supply and demand growth pivots from developed to emerging and developing economies	Oil demand in advanced economies declines, falling 3 mb/d 2023 - 2030, while demand from emerging and developing economies increases by a factor of 2.5, led by India and China. Clean energy technologies and high-speed rail (and EVs) blunt demand growth in China, but India's use of transport fossil fuels rises sharply. Significant demand growth will also come from emerging and developing economies in Asia.	Refinery expansion in Asia and India Contraction in developed economies
Shifting refined product slate to match demand shifts	Related to the energy transition, refiners must progressively modify their product output to meet divergent trends for distillates. Petrol demand falls while diesel and jet fuel demand rises. By 2030, the IEA expects Europe to develop a shortfall in diesel and jet fuel and the US to be short jet only, signalling potential global competition for some middle distillate.	Contraction for petrol Expansionary jet fuel
Integration with petrochemicals production	Investment shifts away from transport fuels processing to petrochemical integration and production, linked to the availability of NGL feedstocks.	Expansionary but not for transport fuels

[91] International Energy Agency, Oil 2024, June 2024

[92] US Energy Information Administration, Outlook on global refining to 2028, August 2024

Technology advances in traditional refining	Implementing new and efficient processing technology (e.g. catalysts) can improve yields and utilisation but needs investment.	Closure of weaker assets
Enhanced global fuel air quality and vehicle efficiency benchmarks	Meeting higher benchmarks typically requires more processing units. Some refineries expand to meet higher standards, particularly if there is government support.	Closure of weaker assets or selective upgrades

Likely impacts these may have on New Zealand's fuel supply

OECD Asia-Oceania (including New Zealand) is expected to continue to need around 1.2 mb/d of refined fuel imports over the forecast period.[93] Competition grows within the wider Asian region with other net fuel importers, particularly for jet fuel.

New Zealand's current main fuel suppliers are Singapore, South Korea, and Japan. The following refinery trends affect these trading centres/economies:

- South Korea has relatively stable domestic demand and will produce nearly 300 kb/d of transportation fuels by 2030. Continues to export.
- Japan's aging refineries struggle to compete internationally due to their lower scale and complexity compared to newer Asian refineries, e.g., the closure of the 120 kb/d Yamaguchi refinery in Q1 2024.
- Singapore. Hub for trade, storage, blending and distribution. New additions are petrochemical integrations or biofuels.

Crude is predominantly supplied to these refiners from the Middle East, but if Middle East is short, alternatives include the Americas.

- Middle East remains the largest global producer and exporter of crude and products and has increased refinery capacity East of Suez.

What about other producers/exporters of refined fuels as potential suppliers?

- Regional refiner/exporter India is set to become the world's largest source of oil demand growth, and it will also continue to export products.
- Reduced jet fuel exports from North America.
- European refining contracting.
- China continues to export certain transport fuels, subject to quotas.

[93] International Energy Agency, Oil 2024, June 2024

Appendix D Methodology for estimating the economic impact of fuel disruptions

The methodology for estimating the economic impact of fuel disruptions is based on estimates of the cost of physical fuel shortages and the impact of price changes on GDP.

We report GDP disruption costs in constant 2009 dollars, aligning with standard real GDP presentation practices. Conversions to and from real and nominal values rely on the RBNZ GDP deflator.[94]

Evaluating the cost of physical fuel shortages

Our model assumes that GDP output will decrease in response to reduced fuel consumption caused by physical fuel shortages. The impact on GDP depends on fuel type. For ground fuels (petrol, diesel), we produced regression models to estimate how GDP output responds to changes in consumption as an input. For jet fuel, we calculate the effect that fuel shortages have on the aviation services sector under the assumption that, in most cases, a fuel shortage results in delays of flows of goods and services—and, therefore, a delay in but not a loss of GDP.[95]

We use the energy-led growth hypothesis to determine the costs of fuel shortages

The methodology for estimating the economic impact of fuel shortages draws on the energy-led growth hypothesis. This hypothesis suggests that energy consumption is tightly linked to economic growth, with energy acting as a critical input across all economic sectors to drive and sustain growth.

The causal relationship between energy—particularly fossil fuel consumption—and economic performance has been widely studied.[96] Research supports the energy-led growth hypothesis, showing that fossil fuel consumption and economic performance may have a causal, mutually reinforcing relationship. Studies also indicate bi-directional causality between energy use and GDP

[94] Available at: https://www.rbnz.govt.nz/statistics/series/economic-indicators/prices

[95] For example, a jet fuel shortage may delay foreign tourist flows into New Zealand, but they should eventually enter New Zealand and contribute to exports, albeit at a later date.

[96] Although there is no clear consensus on whether energy consumption causes economic growth.

across various economies. Overall, energy consumption appears to drive economic growth either directly or through a two-way relationship with GDP.[97, 98, 99, 100, 101, 102]

To test the energy-led growth hypothesis for fuels, we produced a regression model to estimate how GDP output responds to changes in energy consumption as an input (the "Energy/GDP model"). Our statistical analysis identifies a strong correlation between ground fuel consumption and economic output. While this correlation does not imply that ground fuel consumption causes GDP, we apply the elasticities derived from our regression analysis to estimate potential GDP losses resulting from reduced ground fuel consumption. We do not extend this methodology to jet fuel consumption, as our analysis did not yield a statistically significant relationship in the expected direction.

Ground fuels - estimating GDP impacts of shortages

We present the methodology and results of our regression model, which analyses the elasticity of GDP with respect to fuel consumption. We find statistically significant results for ground fuels (petrol and diesel). These significant results imply a correlation between GDP and fuel consumption, but the model design does not establish a causative relationship.

However, we use the elasticities derived from the model to estimate the GDP losses of reduced ground fuel consumption.

Energy/GDP Model specification

Our model is specified as follows:

$$\Delta ln(GDP_t) = \beta_0 + \sum_k \lambda_k \times \Delta ln(GDP_{t-k}) + \sum_k \theta_k \times \Delta ln(Petrol_{t-k}) + \sum_k \sigma_k \times \Delta ln(Diesel_{t-k}) + \sum_k \omega_k \times \Delta ln(Jet\ Fuel_{t-k}) + \epsilon_t \Leftrightarrow$$

$$\Delta GDP_t = e^{\beta_0} \times \prod_k \Delta GDP_{t-k}{}^{\lambda_k} \times \prod_k \Delta Petrol_{t-k}{}^{\theta_k} \times \prod_k \Delta Diesel_{t-k}{}^{\sigma_k} \times \prod_k \Delta Jet_{t-k}{}^{\omega_k}$$

[97] John Asafu-Adjaye, Dominic Byrne, Maximiliano Alvarez found evidence of bi-directional causality between fossil fuel consumption and real GDP for developed exporters, developing exporters, and developed importers. Economic Growth, Fossil Fuel and Non-Fossil Consumption: A Pooled Mean Group Analysis using Proxies for Capital, Energy Economics (2016)

[98] David I. Stern found evidence of energy consumption causing GDP under the multivariate approach and using a quality-adjusted energy index. Energy and economic growth in the USA: A multivariate approach, Energy Economics, Volume 15, Issue 2 (1993)

[99] James D. Hamilton found that changes in oil prices causes changes in gross national product and unemployment. Oil and the Macroeconomy since World War II, The Journal of Political Economy, Vol. 91, No. 2, pp. 228-248 (1983)

[100] John Burbidge and Alan Harrison found that oil price rises generally have a contractionary effect on economic output. Testing for the Effects of Oil-Price Rises using Vector Autoregressions. International Economic Review, 25(2), 459–484 (1984)

[101] David I. Stern found that energy causes GDP either unidirectionally or possibly through a mutually causative relationship. A multivariate cointegration analysis of the role of energy in the US macroeconomy, Energy Economics, Volume 22, Issue 2 (2000)

[102] David I. Stern, Cutler J. Cleveland, Energy and Economic Growth, Rensselaer, Working Papers in Economics, Number 0410 (2004)

The Energy/GDP model uses naturally logged variables so that coefficients can be interpreted as elasticities. A full description of the model's variables and coefficients is presented in Table 20.

Table 20: Model variables

Variable name or coefficient	Description
GDP	Real GDP per capita
Petrol	Quarterly petrol consumption per capita
Diesel	Quarterly diesel consumption per capita
Jet fuel	Quarterly jet fuel consumption per capita
k	Number of quarterly lags (8)
β_0	Underlying growth rate factor
λ_k	Economic output elasticity with respect to previous economic output with k lag
θ_k	Economic output elasticity with respect to petrol consumption with k lag
σ_k	Economic output elasticity with respect to diesel consumption with k lag
ω_k	Economic output elasticity with respect to jet fuel consumption with k lag

Data

An overview of the data that we used to develop the Energy/GDP model is summarised in Table 21.

Table 21: Energy/GDP modelling data

Variable	Source	Note
Real GDP	Infoshare	Expenditure measure, chain volume, seasonally adjusted, Qrtly-Mar/Jun/Sep/Dec
Population	Stats NZ	Estimated Resident Population (Mean Quarter Ended), Qrtly-Mar/Jun/Sep/Dec
Petrol consumption	MBIE	Measured in millions of barrels per quarter
Diesel consumption	MBIE	Measured in millions of barrels per quarter
Jet fuel consumption	MBIE	Measured in millions of barrels per quarter

We seasonally adjusted the Petrol consumption, Diesel consumption, and Jet consumption data series.

The Energy/GDP model uses a first-differenced specification, to minimise bias due to autocorrelation, and thus avoid the risk of spurious regression. For example, instead of using petrol consumption per capita in 2002Q1, the model will calculate the difference between petrol consumption per capita in 2002Q1 and 2001Q4.

Programming and results

We used a distributed lag model to estimate the model coefficients in R. Our analysis showed a positive correlation between ground fuel consumption and real GDP. Figure 30 presents the model outputs.

Figure 30: Model output

```
Coefficients:
                           Estimate Std. Error t value Pr(>|t|)
(Intercept)               0.0034277  0.0026542   1.291   0.2036
L(GDP, 1:laglength)1     -0.1326319  0.1457462  -0.910   0.3680
L(GDP, 1:laglength)2     -0.0183016  0.1489839  -0.123   0.9028
L(GDP, 1:laglength)3     -0.1015088  0.1509065  -0.673   0.5048
L(GDP, 1:laglength)4     -0.2479625  0.1454619  -1.705   0.0956 .
L(GDP, 1:laglength)5      0.2686291  0.1526563   1.760   0.0857 .
L(GDP, 1:laglength)6      0.2806616  0.1637240   1.714   0.0939 .
L(GDP, 1:laglength)7     -0.0474223  0.1598908  -0.297   0.7682
L(GDP, 1:laglength)8     -0.1570684  0.1560332  -1.007   0.3199
L(Petrol, 1:laglength)1   0.1700905  0.0704443   2.415   0.0202 *
L(Petrol, 1:laglength)2   0.0992258  0.0785971   1.262   0.2137
L(Petrol, 1:laglength)3  -0.1126272  0.0800362  -1.407   0.1667
L(Petrol, 1:laglength)4  -0.1129339  0.0835944  -1.351   0.1839
L(Petrol, 1:laglength)5  -0.0788012  0.0805392  -0.978   0.3335
L(Petrol, 1:laglength)6  -0.0467497  0.0752145  -0.622   0.5376
L(Petrol, 1:laglength)7   0.0397888  0.0677093   0.588   0.5599
L(Petrol, 1:laglength)8  -0.0615067  0.0645328  -0.953   0.3460
L(Diesel, 1:laglength)1  -0.0048196  0.0513913  -0.094   0.9257
L(Diesel, 1:laglength)2   0.0267271  0.0534336   0.500   0.6195
L(Diesel, 1:laglength)3   0.1291490  0.0532343   2.426   0.0196 *
L(Diesel, 1:laglength)4   0.0754107  0.0562078   1.342   0.1869
L(Diesel, 1:laglength)5  -0.0132493  0.0538879  -0.246   0.8070
L(Diesel, 1:laglength)6  -0.0427578  0.0540497  -0.791   0.4333
L(Diesel, 1:laglength)7   0.0515639  0.0540720   0.954   0.3457
L(Diesel, 1:laglength)8   0.1203966  0.0479518   2.511   0.0160 *
L(Jet, 1:laglength)1     -0.0182704  0.0088453  -2.066   0.0451 *
L(Jet, 1:laglength)2     -0.0117942  0.0110681  -1.066   0.2927
L(Jet, 1:laglength)3      0.0085639  0.0118670   0.722   0.4745
L(Jet, 1:laglength)4      0.0265918  0.0113702   2.339   0.0242 *
L(Jet, 1:laglength)5      0.0200201  0.0103511   1.934   0.0599 .
L(Jet, 1:laglength)6      0.0140519  0.0100929   1.392   0.1712
L(Jet, 1:laglength)7      0.0051347  0.0093426   0.550   0.5855
L(Jet, 1:laglength)8     -0.0006805  0.0077229  -0.088   0.9302
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.007125 on 42 degrees of freedom
Multiple R-squared:  0.5528,     Adjusted R-squared:  0.2121
F-statistic: 1.622 on 32 and 42 DF,  p-value: 0.07049
```

Using ground fuel consumption to calculate changes in real GDP

We assume a constant elasticity between ground fuel consumption and GDP. Based on these assumptions, holding all other variables constant, we estimate the change in GDP as a result of a change in fuel consumption as:

$$\%\Delta GDP = 1 - \prod_k \frac{Petrol_t}{Petrol_{t-k}}^{\theta_k} \times \prod_k \frac{Diesel_t}{Diesel_{t-k}}^{\sigma_k}$$

Since we expect that economic impacts will be sustained within one year, we ignore significant coefficients for lags greater than 4.

Using input-output models to cross-check results

Since the regression model is not designed to determine the causative nature or magnitude of a fuel shortage on GDP, we developed an alternative input-output model to evaluate the economic impacts of a ground fuel shortage that supplements the regression model.

We assume that the economy sustains these losses over a relatively short period, whereby the usual input-output structure of the economy does not have enough time to adjust to reduced fuel supply. Therefore, each industry becomes perfectly dependent on transport services in the short term.

The input-output model assumes the economy sustains losses from reduced output from road- or rail-based transport service industries. These road- or rail-based transport service industries reduce output directly proportionally to the level of fuel shortage each experience. The level of fuel shortage is calculated by making assumptions on each industry's split of petrol and diesel consumption and applying estimated fuel shortages according to these assumed splits.

The input-output model is based on the most recent Input-Output Tables produced by Statistics NZ.[103] We identified the following transport industries as road- or rail-based transport service industries that will be directly affected by a fuel shortage, and present the "fuel usage split" for each[104]:

- Road transport freight services (10/90)
- Road passenger transport (10/90)
- Railway transport freight services (0/100)
- Railway passenger transport (0/100)
- Postal and courier services (0/100).

We calculate a reduction in transportation services used for each industry in the economy based on a weighted average of each road- or rail-based transport service industry "used." The input-output model assumes each industry reduces its total output directly proportionally to its reduction in road- or rail-based transport service industry usage.

We understand that a loss in total output does not translate directly into the same loss in GDP because GDP measures only the value-added portion of total output, not the entire economic activity, which includes intermediate inputs. According to New Zealand Statistics, New Zealand's total GDP in 2020 was approximately NZ$323 billion,[105] while total output was around NZ$615 billion. This means GDP accounts for about 50% of total output. As a result, we estimate that any change in total output is likely to lead to a smaller proportional change in GDP. Using this ratio, we estimate that if total output decreases by 2%, GDP would decline by roughly 1%.[106]

Jet fuels—estimating GDP impacts of shortages

Our methodology for estimating the impact of jet fuel shortages draws on an analysis of disruptions caused by the RAP pipeline rupture in 2017. Since neither the Government nor industry has publicly released a comprehensive financial or economic assessment of this event, we used available data on flight disruptions and the number of affected passengers. Supplementing this with further research on the economic impacts of flight disruptions on airlines and the broader economy, we estimate the potential effects of jet fuel shortages under various forecasted scenarios.

We calculate the effect that fuel shortages have on the aviation services sector under the assumption that, in most cases, a fuel shortage results in delays of flows of goods and services—

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[103] National accounts input-output tables: Year ended March 2020, Statistics NZ (2020), available at: https://www.stats.govt.nz/information-releases/national-accounts-input-output-tables-year-ended-march-2020/

[104] Presented as petrol/diesel.

[105] https://www.stats.govt.nz/information-releases/regional-gross-domestic-product-year-ended-march-2020#:~:text=New%20Zealand's%20total%20GDP%20was,percent%20for%20the%20South%20Island.

[106] This estimate is a simplified approximation based on historical GDP-to-output ratios. The actual impact on GDP depends on sector-specific effects, demand fluctuations, and economic multipliers. If high value-added industries experience a decline, GDP may fall by more than the estimated ratio. Conversely, if lower value-added industries are affected, GDP may decline by less.

and, therefore, a delay in but not a loss of GDP.[107] We do, however, assume that the aviation sector will sustain losses due to cancelled flights.

The rupture forced fuel suppliers to ration jet fuel supply to 30% of usual demand, disrupting 270 flights—meaning that they were cancelled, rescheduled, or required additional fuel stops. Airlines took on additional financial costs to rebalance loads, make additional stops, and transport fuel in empty planes.[108]

In our analysis, we assume that airline losses will be proportionate to the number of passengers impacted by the disruption. The following presents our assumptions and logic for estimating the number of passengers affected in each disruption scenario and the economic cost per passenger affected:

Passengers disrupted

We assume that the number of passengers disrupted will correspond directly to both the level and duration of fuel rationing imposed on airlines, referencing the estimated 30,340 passengers affected during the 2017 RAP pipeline disruption:

- **Baseline passenger impact:** We estimate that 30,340 passengers were affected by the 2017 RAP pipeline disruption. This estimate is based on passenger and aircraft movement data from Auckland International Airport Limited's (AIAL) Annual Report 2017,[109] with an average of 112 passengers per flight based on AIAL's 169,245 aircraft movements and 19,020,573 passengers moved, and 270 flights were disrupted
- **Rationing assumptions:** Fuel companies usually ration fuel supplies in a disruption scenario. We assume that the number of passengers affected is proportional to the rationing required and the number of days rationed in each disruption scenario. We set the 2017 RAP disruption scenario level and duration of rationing to an average of 42% and 9 days, respectively:
  - During the 2017 RAP pipeline disruption, airlines were restricted to 90% of fuel demand on 15 September, 30% of fuel demand from 16 September to 21 September, and 50% from 23 September to 24 September. This is a 42% rationing (weighted average by number of days) across 9 days.
- Therefore:
  - If a given disruption scenario requires 42% rationing across 18 days, we estimate that 60,680 passengers are disrupted (two times the 2017 RAP pipeline disruption)
  - If a given disruption scenario requires 21% rationing across 27 days, we estimate that 45,510 passengers will be disrupted (1.5 times the 2017 RAP pipeline disruption).
- The rationing level is the average daily volume of jet fuel that needs to be reduced to prevent a true shortage, divided by an assumed daily jet fuel consumption of 4,200kL/day.

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[107] For example, a jet fuel shortage may delay foreign tourist flows into New Zealand, but they should eventually enter New Zealand and contribute to exports, albeit at a later date.

[108] Government Inquiry into The Auckland Fuel Supply Disruption, Department of Internal Affairs (2019), available at: https://www.dia.govt.nz/diawebsite.nsf/Files/Inquiry-into-the-Auckland-Fuel-Supply-Disruption/$file/AFSD-Inquiry-Report-August-2019.pdf

[109] 2017 Financial Statements, Auckland International Airport Limited, available at: https://corporate.aucklandairport.co.nz/investors/results-and-reports

Table 22 presents the number of passengers disrupted for each scenario.

Table 22: Number of passengers disrupted for each scenario

	Short-term disruption at WIRI or for RAP (8 days cover)	Long-term disruption at WIRI (or RAP)	Long-term disruption at MPT	International supply disruption (50%)
Rationing required to prevent actual shortfall	34.5%	6.5%	7%	60%
Days disruption	14	66	66	6
Passengers disrupted	53,305	358,721	356,803	13,951

Economic cost per passenger disrupted

We estimated the disruption cost per passenger of NZ$400 per passenger affected based on an implied damage cost from the legal proceedings following the 2017 RAP pipeline disruption:

- Air New Zealand sued Z Energy for damages totalling NZ$4.1 million due to the 2017 pipeline rupture, having already settled on an amount with BP.[110] Assuming that Z Energy supplied Air New Zealand with 47% of its jet fuel,[111] we estimate that Air New Zealand sustained NZ$8.7 million in losses. This amounts to an airline cost of NZ$287 per passenger when spread across the estimated 30,340 passengers affected
- Passengers and other sectors of the economy, such as food, retail, and hospitality, sustain losses due to the disruption. We estimate that these costs are 39% of airline disruption costs, based on the proportion of "passenger costs" and "spillover costs" of total airline disruption costs sustained in Australia.[112] Therefore, the total economic costs of disruptions are NZ$474 per passenger affected.

Increased fuel prices reduce GDP

The estimated effect of higher fuel prices on GDP depends on price elasticity and consumer responses.

- For ground fuels, we estimate how consumer demand changes in response to price increases using own-price elasticity estimates. We then calculate the resulting GDP

[110] Air NZ seeks millions in damages from Z Energy after fuel pipeline damaged, Stuff NZ (2019), available at: https://www.stuff.co.nz/business/111178733/air-nz-seeks-millions-in-damages-from-z-energy-after-fuel-pipeline-damaged

[111] Plimmerton Rotary Presentation, Z Energy (2019), available at: https://cdn.fld.nz/uploads/sites/plimmertonrotary/files/PDFs/2019-2020/July-August/Z_Energy_9-7-19.pdf

[112] Airhelp estimated flights disruptions costed Australian airlines US$1.3-1.5 billion in 2022. This cost is broken down into: Airline costs (US$0.4-0.5 billion), passenger cost (US$0.3-0.4 billion), spillover cost (US$0.2 billion), cancellation cost (US$0.4 billion). We assume that the damages sustained by Air New Zealand fall under airline and cancellation costs. Spillover and passenger costs make up 39% of total costs. https://img.airhelp.com/Documents/AH_disruption_economic_cost.pdf?updatedAt=1695047330127

impact using the framework outlined in the previous subsection on GDP loss due to reduced fuel consumption.

- For jet fuel, research suggests that increased jet fuel prices reduce international air passenger travel as airfares rise in response.[113, 114] We model the effect that these jet fuel prices have on New Zealand's current account balance as fewer foreign tourists arrive in New Zealand and fewer New Zealand travellers leave.

Ground fuels: Own-price elasticity of fuel demand determines ground fuel consumption reduction

We estimated the own-price elasticity of ground fuels by replicating the methodology used by Motu.[115] We use the following model specification:

$$ln(Fuel_t) = \gamma_0 + \gamma_1 \times ln(FuelPrice_t) + \sum_k \gamma_k \times ln(FuelPrice_{t-k}) + \phi_0 \times ln(GDP_t) + \sum_k \phi_k \times ln(GDP_{t-k}) + \epsilon_t$$

We estimate an annual elasticity by taking the sum of significant "FuelPrice" coefficients.

The regression model uses a first-differenced specification (the data considers year-on-year changes rather than relative changes). For example, instead of using petrol consumption per capita in 2002Q1, the model will calculate the percentage difference[116] between petrol consumption per capita in 2002Q1 and 2001Q4.

Data for own-price elasticity model

We use quarterly data to build the own-price elasticity model. An overview of the data that we used to develop our price-elasticity model is summarised in Table 23.

[113] How do fuel use and emissions respond to price changes?, Bureau of Infrastructure, Transport and Regional Economics (2008), available at: https://www.bitre.gov.au/sites/default/files/other_006_bitre_briefing.pdf

[114] https://cedelft.eu/publications/price-elasticities-in-aviation-and-marine-shipping-literature-study/#:~:text=A%20likely%20figure%20for%20aviation,and%202.0%20for%20holiday%20flights.

[115] Domestic Transport Costs and Charges Annual Research, Motu Economic and Public Policy Research (2023), available at: https://www.transport.govt.nz/assets/Uploads/DTCC-Estimation-of-transport-related-elasticities_Oct2023-1.pdf

[116] Through natural logarithms of first differences.

Table 23: Database for price-elasticity model

Model variable name or coefficient	Description
$Fuel_t$	Fuel consumption per capita for quarter t. Fuel can be either petrol or diesel. Fuel consumption data is sourced from MBIE oil statistics.
$FuelPrice_t$	Real price of fuel per litre for quarter t. Fuel can be petrol or diesel. Real fuel price data is sourced from MBIE oil statistics.
GDP_t	Real GDP per capita for quarter t. Real GDP data is sourced from Stats NZ and Motu. Motu data was scaled to align with GDP(E) in 1987q2.[117]
$Population_t$	Population for quarter t

For each variable except for GDP, we adjusted the quarterly data for seasonality. GDP data did not require adjustment since chain volume and seasonally adjusted variants are readily available on Infoshare.[118]

Modelling results

We present the regression modelling results that inform our price elasticity assumptions for petrol and diesel demand. We assume a constant elasticity between ground fuel price and ground fuel demand.

Figure 31: Modelling results

```
Time series regression with "ts" data:
Start = 1975(2), End = 2019(4)

Call:
dynlm(formula = petrol ~ L(petrol_price, 0:4) + L(gdp, 0:4),
    data = quarterly_data, end = c(2019, 4))

Residuals:
      Min        1Q    Median        3Q       Max
-0.085867 -0.012158  0.002455  0.012900  0.067701

Coefficients:
                       Estimate Std. Error t value Pr(>|t|)
(Intercept)           -0.003246   0.001752  -1.853 0.065580 .
L(petrol_price, 0:4)0 -0.121947   0.036340  -3.356 0.000979 ***
L(petrol_price, 0:4)1 -0.002289   0.036566  -0.063 0.950155
L(petrol_price, 0:4)2 -0.084431   0.036512  -2.312 0.021967 *
L(petrol_price, 0:4)3  0.007894   0.036616   0.216 0.829571
L(petrol_price, 0:4)4  0.014534   0.035918   0.405 0.686256
L(gdp, 0:4)0           0.551489   0.145919   3.779 0.000218 ***
L(gdp, 0:4)1          -0.181228   0.143591  -1.262 0.208657
L(gdp, 0:4)2           0.042004   0.142826   0.294 0.769053
L(gdp, 0:4)3           0.216264   0.143957   1.502 0.134900
L(gdp, 0:4)4          -0.171858   0.145771  -1.179 0.240082
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.02325 on 168 degrees of freedom
Multiple R-squared:  0.1898,	Adjusted R-squared:  0.1416
F-statistic: 3.936 on 10 and 168 DF,  p-value: 7.813e-05
```

[117] Domestic Transport Costs and Charges Annual Research, Motu Economic and Public Policy Research (2023), available at: https://www.transport.govt.nz/assets/Uploads/DTCC-Estimation-of-transport-related-elasticities_Oct2023-1.pdf

[118] Table: Series, GDP(E), Chain volume, Seasonally adjusted, Total (Qrtly-Mar/Jun/Sep/Dec), Infoshare (retrieved October 2024).

```
Time series regression with "ts" data:
Start = 1975(2), End = 2019(4)

Call:
dynlm(formula = diesel ~ L(diesel_price, 0:4) + L(gdp, 0:4),
    data = quarterly_data, end = c(2019, 4))

Residuals:
     Min       1Q   Median       3Q      Max
-0.08164 -0.01197  0.00184  0.01331  0.07125

Coefficients:
                       Estimate Std. Error t value Pr(>|t|)
(Intercept)           -0.006203   0.001810  -3.426  0.00077 ***
L(diesel_price, 0:4)0 -0.043309   0.024074  -1.799  0.07382 .
L(diesel_price, 0:4)1 -0.001642   0.024780  -0.066  0.94725
L(diesel_price, 0:4)2 -0.055314   0.025181  -2.197  0.02942 *
L(diesel_price, 0:4)3  0.017427   0.024940   0.699  0.48568
L(diesel_price, 0:4)4  0.011493   0.023021   0.499  0.61828
L(gdp, 0:4)0           0.629637   0.151744   4.149 5.29e-05 ***
L(gdp, 0:4)1          -0.108246   0.149008  -0.726  0.46858
L(gdp, 0:4)2           0.072415   0.147940   0.489  0.62513
L(gdp, 0:4)3           0.217908   0.149519   1.457  0.14688
L(gdp, 0:4)4          -0.235051   0.151400  -1.553  0.12242
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.02406 on 168 degrees of freedom
Multiple R-squared:  0.1758,    Adjusted R-squared:  0.1267
F-statistic: 3.583 on 10 and 168 DF,  p-value: 0.0002486
```

Based on these assumptions, holding all other variables constant, we estimate the change in ground fuel consumption as a result of a change in ground fuel price as:

$$\%\Delta GroundFuel = 1 - \frac{GroundFuelPrice_{t+1}{}^{\gamma_1}}{GroundFuelPrice_t}$$

Ground fuels: Price increases reduce household consumption

We use own-price elasticities to estimate the increase in household petrol and diesel spending due to an international fuel price shock. We assume that the increase in household spending on ground fuels is equal to the first-order reduction in household economic consumption. We estimate this change in percentage terms as:

$$\%\Delta Spending = (1 + \%PriceIncrease)^{1+\gamma_1}$$

We apply the percentage increase in spending to an estimated household expenditure on petrol and diesel. This calculation combines the number of households in New Zealand, the weekly household expenditure on petrol and diesel from Stats NZ data, and our assumed duration of the price increase. Table 24 presents our assumptions.

Table 24: Price increase consumption impact assumptions

Assumption	Value	Source
Number of households	1,865,300	Stats NZ
Duration of price increase, days	60	-
Weekly household petrol spending, NZ$/week/household	53.90	Stats NZ
Weekly household diesel spending, NZ$/week/household	8	Stats NZ

Jet fuel: Rising jet fuel prices reduce net tourism travel

We base our GDP impact estimate from increased jet fuel prices on studies indicating that a 10% rise in jet fuel prices could result in a 2% decline in domestic passenger travel and a 6% drop in international travel.[119] This reduction in travel directly impacts tourism, decreasing GDP.

To calculate the net tourism loss, we use average spending per tourist. For inbound tourists, this is NZ$6,248 (2009 dollars), derived from 2019 travel service exports (NZ$12.0 billion)[120] divided by total arrivals (2,110,892).[121] Outbound tourists spend approximately NZ$1,794 each.

Assuming a 1% increase in jet fuel prices reduces international travel by 0.6%[122], we apply this rate to pre-COVID-19 passenger volumes (2,110,892 inbound, 3,098,493 outbound[123]) and multiply by average spending to estimate tourism's GDP impact.

[119] How do fuel use and emissions respond to price changes?, Bureau of Infrastructure, Transport and Regional Economics (2008), available at: https://www.bitre.gov.au/sites/default/files/other_006_bitre_briefing.pdf

[120] BPM6 Annual, Current account services (Annual-Mar), Infoshare (retrieved November 2024).

[121] Visitor arrivals by country of residence, age and visa type (Annual-Mar), Infoshare (retrieved November 2024).

[122] Assuming that a 10% increase in jet fuel prices results in a 6% decrease in international travel (footnote 119), following the same linear relationship.

[123] NZ-resident traveller departure totals (Annual-Mar), Infoshare (retrieved November 2024).

Appendix E Methodology for estimating and evaluating the cost and benefits of mitigation options

This appendix provides a detailed description of the methodology and assumptions for estimating the economic costs and benefits of all analysed mitigation options that could improve fuel security.

The six mitigation options set out below are:

- Reestablishing the Marsden Point refinery
- Adding tanks for fuel storage for diesel and jet fuel
- Adding trucks for fuel distribution
- Increasing biofuel production
- Refinery to process indigenous crude and condensate
- Accelerating the transition to fossil-fuel free vehicles

After outlining these six options we explain the scoring matrix used.

Reestablishing Marsden Point refinery

We established that at an annual cost of NZ$756 million, the reestablishing MPR can provide up to 180ML of fuel, including diesel, petrol and jet, as discussed below. The feasibility analysis for reestablishing MPR was outlined in detail in our Interim Report to MBIE.

The costs associated with Reestablishing MPR would be a major undertaking for New Zealand in terms of time, new commercial arrangements and financial cost. Our review of global benchmarks for refinery construction costs suggests the costs would range from NZ$5.9-16.1 billion (US$3.7-10.1 billion) before considering unique aspects of the MPR site that would likely reduce these costs. Channel Infrastructure's Worley Report estimates that the capital cost of the recommissioning project is estimated at a P50 to P90 range of NZ$4.9 billion to NZ$7.3 billion with an order of accuracy of -20% / + 50%. This will increase should the biorefinery currently under consideration be developed on the existing refinery site.

We used the cost estimates determined in the Worley Report to estimate the annualised costs of re-establishing the MPR. Our cost analysis shows that the financial cost would be around NZ$756 million.[124]

The volume that reestablished MPR could provide as mitigation during a disruption assumed to be equal to the increase in useful stock available when operating a refinery compared to a 100% import system.

[124] We used an 8% discount rate for all large-scale commercial mitigating options, in line with the latest Treasury guidance for commercial public sector discount rates for cost-benefit analysis with a time horizon under 30 years. (Discount Rates, The Treasury New Zealand (retrieved November 2024), available at: https://www.treasury.govt.nz/information-and-services/state-sector-leadership/guidance/reporting-financial/discount-rates)

Where applicable, the standard annuity and present value formulas apply the 8% discount rate. For trucking, we used a 12% discount rate, reflecting that most trucking businesses are smaller and unlikely to access lower-cost financing.

The 2020 Fuel Security and Fuel Stockholding Costs and Benefits report estimated the gross difference in stock levels between the two systems at 340KT. However, not all of this is useful:

- Some of it consists of heel stock due to the greater number of tanks required.
- A portion is intermediate stock, which certain minimums are required for refinery operations.
- Adjusting for these factors reduces the difference by 120KT.

Additionally, companies are now holding more stock for the 100% import supply than assumed in 2020, and with the implementation of the Minimum Stockholding Obligation (MSO) - which was not considered in 2020 - total stock holdings under a 100% import system increase to approximately 806KT.

This reduces the difference in useable inventories between the systems to just under 150KT or 180ML.

Additional tanks for fuel storage

We calculate the annualised cost of fuel tanks designed to store additional stock that can be accessed during a disruption scenario. These volumes are in addition to the existing storage volumes and any new storage that will be built to satisfy the Minimum Stock Obligation.

We do not calculate the cost of additional petrol tanks because our disruption modelling showed little to no need for additional petrol tank capacity once the Minimum Stock Obligation storage is binding.

Additional diesel storage

We established that at an annual cost of NZ$24.5 million, the additional diesel storage can provide up to 77ML of diesel, as discussed below.

Increasing diesel storage to cover seven days of diesel demand would require around seven additional diesel tanks. This is based on an annual diesel demand of over 4 billion litres, or a daily demand of over 11 ML, which totals just over 77 ML over a seven-day period. Given a useful tank capacity of 11 ML per tank, the required number of tanks to store this amount is approximately seven units.[125] This will allow the storage of a total of about 77ML of extra diesel that could be used during fuel disruption.

The annual cost per for a 12 ML tank is around NZ$3.9 million or NZ$24.5 million for seven tanks. Table 25 presents our additional diesel tank cost assumptions.

[125] As we costed a reasonably large tank (by normal terminal standards), we used multiples of this tank for larger volumes, as the volumes may be dispersed (multiple locations/tanks) and the size captures many of the benefits of scale.

Table 25: Additional diesel tank cost assumptions

Cost calculation component	Unit	Value
CAPEX[126]	NZ$'000/tank	14,618
Standby inventory cost	NZ$'000/tank	13,380
Land rental	NZ$'000/tank/year	910
OPEX	NZ$'000/tank	160
Total volume	ML	12
Available volume (total volume less heel)	ML	11
Useful life	years	20

Additional jet fuel storage

We calculated that at an annual cost of NZ$8 million, the additional jet fuel storage can provide up to 22ML of jet fuel, as discussed below.

Increasing jet fuel storage to cover four additional days of jet demand at Auckland Airport would require around two additional storage tanks. The annual jet fuel demand at Auckland Airport is over 1.5 billion litres, which translates to a daily demand of around 4ML. Over a four-day period, this totals 16.8ML. Given a useful tank volume of 11ML per tank, the required number of tanks to store this amount is approximately two units. This will allow the storage of a total of about 22ML of extra jet fuel that could be used during fuel disruption.

The annual cost for a 12 ML jet fuel tank costs approximately NZ$4.0 million or NZ$8.0 million for two tanks.[127] .Table 26 presents our additional jet fuel tank cost assumptions.

Table 26: Additional jet fuel tank cost assumptions

Cost calculation component	Unit	Value
CAPEX	NZ$'000/tank	15,714
Standby inventory cost	NZ$'000/tank	13,008
Land rental	NZ$'000/tank/year	910
OPEX	NZ$'000/tank/year	180
Total volume	ML	12
Available volume (total volume less heel)	ML	11
Useful life	years	20

[126] We assume that the cost of inventory stored in the tank is a capital expenditure.

[127] Includes the cost of standby stock, operational expenses, and rent. We assume that the 12ML tank will have a 1ML heel, so only 11ML of fuel will be available per tank at a given time. Appendix D presents our detailed cost assumptions.

Increasing fuel stock to cover 100% of the projected shortfall is redundant and is likely to introduce more risk

Increasing fuel stock further to cover 100% of the projected shortfall would come with a significant increase in annual costs and introduce additional risks. First, the infrastructure required to store large quantities of fuel safely must meet strict environmental and safety regulations. Excess fuel storage increases the risk of spills, fires, or other environmental hazards, making it a point of single failure. In the event of any disruption or malfunction, the consequences could be severe, with potential environmental and economic damage. Moreover, expanding storage capacity to this extent represents redundancy rather than true resilience. Investing in more storage may result in inefficiencies, as it would rarely be needed and could divert resources away from other, more effective mitigation measures. This reliance on extensive storage could lead to unnecessary costs.

Additional trucks for fuel distribution—estimating costs

We calculate the annualised cost of additional trucks needed to fully address the shortfall in our disruption scenarios. This capacity is in addition to the trucking investments made by fuel companies after the 2017 RAP disruption.

These trucks can haul both petrol and diesel. There is no difference in the cost of trucking petrol or diesel. We did not evaluate the cost of trucking jet fuel because trucks cannot meet the very high volumes to supply commercial aircraft outside of extreme emergency scenarios, and airlines would likely source fuel from other airports.

Overall, our estimates show that the additional trucking capacity can provide up to 147ML of diesel and petrol at an annual cost of NZ$38 million. These trucks incur an annual capital cost recovery factor, fuel, driver, and other operating costs, as shown in Table 27.

Table 27: Truck costs and additional capacity required for each disruption scenario

Cost component	Unit	Short-term disruption at WIRI or for RAP (8 days cover)	Long-term disruption at WIRI (or RAP)	Long-term disruption at MPT	Long-term disruption at Wellington	Long-term disruption at Christchurch
Additional truck cost	NZ$m per year	21.9	37.9	38.2	27.1	44.2
Financing	NZ$m per year	3.8	5.4	4.3	4.6	7.9
Operating	NZ$m per year	15.4	28.0	29.6	19.1	30.7
Margin	NZ$m per year	2.7	4.5	4.3	3.4	5.6
Shortfall reduction	ML/year	6.9	70.5	147.1	35.2	51.4
Additional truck units	Units	20	28	23	24	42

Increasing biofuel adoption

A biofuel refinery using local feedstock could enhance New Zealand's fuel security. We estimate that a biorefinery can provide up to 215ML of a mix of diesel and jet fuel at an annual cost of NZ$257 million.

The annual cost is driven by the price gap between conventional diesel and jet fuel and their biofuel alternatives, as biofuel production is typically more expensive than fossil fuels. This is based on the analysis of publicly available estimates of the cost of biofuel production in New Zealand. We assume this price difference represents the cost to New Zealand, which can be shared across multiple sectors. The Government might consider subsidies or tax exemptions, or businesses might accept lower profits, or consumers could pay a premium for biofuel-powered services over fossil fuel alternatives.

However, depending on the success of the currently planned biorefinery project in New Zealand, the marginal costs could be lower than our estimates. We understand that Seadra Energy Inc., alongside other consortium partners, plans to develop a biorefinery at Marsden Point. We have met with Seadra and Channel Infrastructure representatives to understand the proposal, however, we do not have access to Seadra's estimated biorefinery costs. Presumably, the Seadra consortium's proposal is based on the plant being economically viable, or it will have strategic value in lowering the cost of biofuel. Seadra's cost assumptions may be lower than our estimates from public information. Seadra could plan for technological innovations that lower the cost of refined biofuels, or may have access to lower cost feedstock. If the Seadra consortium's proposed biorefinery is successful, the marginal costs may be lower than our estimates.

To estimate this cost, we project the production of a potential biofuel facility and calculate the cost to achieve price parity with the fossil fuel incumbent for the facility's total production. We assume that the production facility will produce renewable diesel, which replaces diesel, and sustainable aviation fuel (SAF), which replaces jet fuel.

Increasing biofuel adoption by the equivalent of 200,000 tonnes per year of feedstock incurs an economic cost with a present value of NZ$1.9 billion over ten years. Since the biofuel refinery produces two fuel types, we calculate their mitigation costs separately:

- Renewable diesel: An estimated NZ$530 million in subsidy spending over ten years (in present value terms) would be required to ensure consumers used renewable diesel. This would equate to NZ$74 million per year. It would displace around 92ML of diesel consumption per year.
- SAF: Refining and achieving price parity for SAF with conventional jet fuel would require an estimated NZ$1.40 billion of subsidy spending[128] over ten years (in present value terms) or NZ$196 million per year. This would displace 124ML of jet fuel consumption per year.

To achieve a single datapoint that represents the cost and volume mitigation of a biorefinery's renewable diesel and SAF production, we took an average of the two biofuels' characteristics (mass density, energy density, cost differential). Using this calculation process, the biorefinery costs NZ$257 million per year and displaces 215ML of fossil fuel consumption.

[128] Costs borne by the Government as subsidies or tax exemptions, and/or premiums paid by consumers of renewable diesel.

Production assumptions for biofuel production

The following tables set out the assumed biofuel production facility production yield and other assumptions about production.

Table 28: Biofuel production facility assumptions

Component	Unit	Value
Feedstock throughput	Tonnes/year	200,000
Yield	%	90
Renewable diesel share of yield	%	44
SAF share of yield	%	56

Table 29: Biofuel production facility property assumptions

Component	Unit	Value	Fuel type
Mass density	Kg/m3	835	Renewable diesel
Energy density	% diesel energy density	96	Renewable diesel
Mass density	Kg/m3	808	Sustainable Aviation Fuel
Energy density	% jet fuel energy density	100	Sustainable Aviation Fuel

Calculating the cost to achieve biofuel parity

We forecast the cost of renewable diesel and sustainable aviation fuel to calculate the cost that the Government or users will need to offset to achieve biofuel parity. This cost differential is multiplied by the assumed production to estimate the annual social cost of increasing biofuel adoption. Forecasting the cost of biofuels is difficult. Based on current prices, we assumed that renewable diesel and SAF costs are around 1.75 times more than the cost of diesel and jet fuel per ML across the entire forecast period - from 2025 to 2035.[129] [130]

Refinery to process indigenous crude and condensate—estimating costs

Estimating the cost of a small refinery capable of processing indigenous crude is challenging due to the lack of precedent. We base our cost estimate on the capital cost of modular refineries, as they can be specifically designed to handle disruption scenarios. We estimate that a modular refinery can provide up to 66ML of diesel at an annual cost of NZ$42 million.

Modular refineries can process between 1,000 and 30,000 bbl/day and focus on diesel production due to its simpler production process compared to petrol.

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[129] Polytechnique Insights (2021), Biofuels, an alternative that is still too expensive, available at: https://www.polytechnique-insights.com/en/braincamps/planet/zero-carbon-aviation/biofuels-an-alternative-that-is-still-too-expensive/

[130] Radio New Zealand (2021), What is the real cost of a switch to biofuels?, available at: https://www.nzherald.co.nz/nz/what-is-the-real-cost-of-a-switch-to-biofuels/JVVCML3BVA3TEM7JZQMDZDXAJU/

We estimate the cost of a modular refinery with a 5,000 bbl/day capacity (based on projected Indigenous crude production) and assume a 20-year useful life. We also assume that the refinery would only operate at full capacity in an emergency; otherwise, it will largely be idle, apart from minimal annual generation required to maintain it.

We estimate the cost of the modular refinery by calculating the annuity required to cover its capital cost over its useful life and adding an annual operational cost required for annual generation. We assume a refining margin of zero because the modular refinery would operate during emergency situations and therefore would likely be compensated for costs only. Table 30 presents our cost assumptions for calculating the cost of locally refined diesel from indigenous crude.

Table 30: Cost assumptions of locally refined diesel from indigenous crude

Cost calculation component	Unit	Value	Note
Refinery capacity	Bbl/day	5,000	Crude oil barrels refinery per day
Refinery lifetime	Years	20	Castalia/Envisory assumption
Capital cost	NZ$m	265.5	Converted from US$150m estimate
Diesel output	L/day	180,000	Average of 120,000 and 240,000L/day estimate
OPEX	NZ$m/year	15	Required to run the plant intermittently to ensure it is fit to operate. Based on Envisory estimate
Refining margin	NZ$/bbl	0	Assumes the modular refinery will be compensated for costs only when run during an emergency

Accelerating Transition—estimating costs and benefits

As discussed in Section 8.8, New Zealand's road transportation sector is transitioning towards alternative technologies and fuels, such as EVs and HFCs. Broader market trends and technological advancements drive this transition, and it is already occurring without requiring additional intervention or costs. However, if the government is considering spending resources on fuel security measures, it could accelerate this energy transition. Achieving this would likely require subsidies, and the Government would need to determine a funding mechanism. Potential options include taxes or a fuel surcharge on petrol. These would require careful policy design to avoid subsidising consumers who were already going to transition and avoid distributional impacts.

We call this the Accelerated Transition. The cost of the Accelerated Transition is the cost of offsetting the premium of owning non-fossil-fuelled vehicles. We estimate that at an annual cost of around NZ$129 million, the Accelerated Transition can mitigate, on average, about 90ML.

Establishing the baseline and Accelerated Transition scenarios

Our analysis begins by establishing a baseline scenario, based on the Climate Change Commission's (CCC) projection for new vehicles entering the fleet under the Reference Pathway scenario from Emissions Budget 4 (EB4). This scenario reflects the current trajectory of transport emissions in New Zealand. For example, it assumes that by 2035, 66% of new light passenger vehicles (LPVs) will be EVs.

We assume higher fleet additions for each vehicle class in the Accelerated Transition. Using a straight-line ramp-up, we increase the share of zero-emission vehicles annually from current levels to 75% across all vehicle classes by 2035, except for heavy trucks. For heavy trucks, we assume the zero-carbon share will reach 50% by 2035, reflecting the slower development of hydrogen vehicle technology (and viable battery EVs).

To test the sensitivity of the modelling, we also apply the CCC's second emissions reduction plan (ERP2) forecast as an alternative BAU scenario.

Table 31: Proportion of zero-emissions vehicles entering New Zealand by vehicle class and scenario by 2035.

Vehicle class	CCC (EB4) Reference Pathway	CCC (ERP2) Baseline Pathway	Accelerated Transition
LPV New	64%	66%	75%
LPV Used	36%	22%	75%
LCV	44%	29%	75%
Motorcycles	46%	77%	75%
Buses	51%	91%	75%
Medium Trucks (under 30t GVM)	14%	11%	75%
Heavy Trucks (over 30t GVM)	15%	5%	50%

To understand the potential costs associated with the Accelerated Transition, we first calculated the volume of additional vehicles entering the fleet relative to the baseline scenario. Next, we calculated the delta between the TCO of the ICE vehicles and EV/HFCs for vehicles across six classes: light personal vehicles, light commercial vehicles, motorcycles, buses, medium trucks, and heavy trucks.

Estimating the annual volume of avoided fossil fuel

For each vehicle class, we modelled an increase in the proportion of EVs or HFCs vehicles entering the fleet. This gave an "ambitious" number of additional EV/HFC vehicles entering the fleet. For a given year and vehicle class, if this number is greater than baseline scenario, the additional zero-emission vehicle is considered an "Accelerated Transition policy-driven inflow". These policy-driven inflows represent additional zero-emission vehicles entering the fleet annually under the Accelerated Transition scenario—vehicles that, under normal conditions, would have been ICE petrol or diesel vehicles.

Initially, the policy will encourage more vehicles to enter the fleet, including LPVs, LCVs, and medium trucks. However, by 2033, only heavy vehicles will require subsidies, as shown in Figure 32 and Figure 33.

Figure 32: Total additional zero-emission vehicle inflows

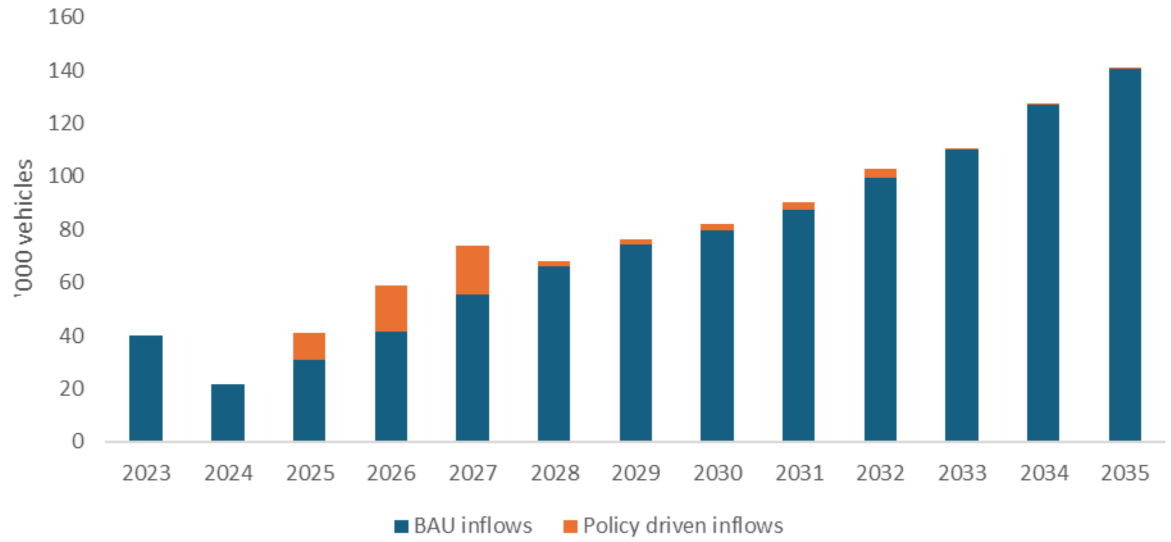
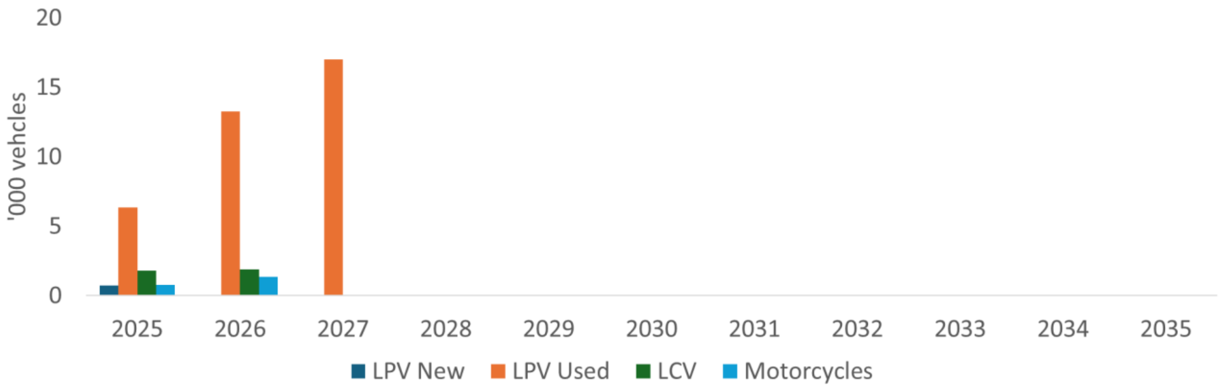
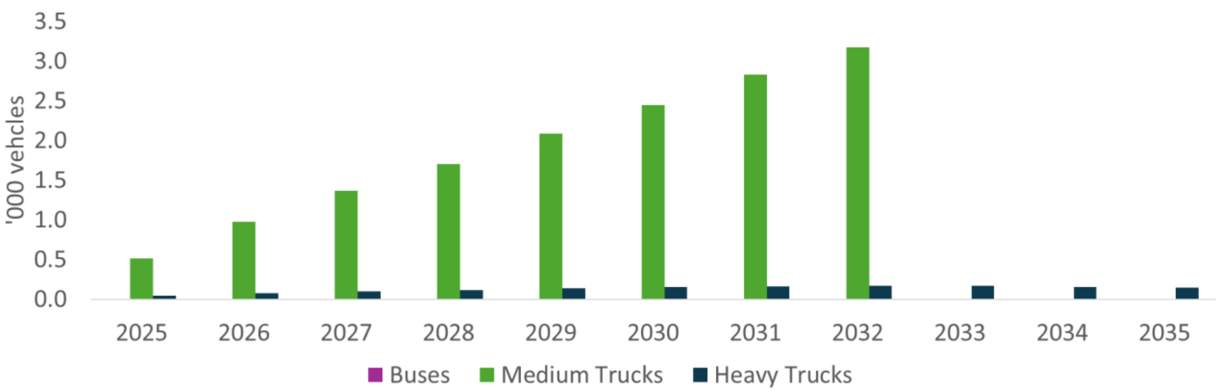


Figure 33: Policy-driven additional zero-carbon vehicles added to the fleet





Based on the calculated number of additional EV/HFC vehicles entering the fleet due to the policy intervention, we estimated the volume of fossil fuel avoided. This is the number of policy-driven vehicles multiplied by annual km travelled and fuel consumption. For example, in 2025, due to policy intervention, we assume that 40 new HFC trucks will enter the fleet. The average truck drives

58,600 km per year, with a fuel consumption of 0.56L/km; thus, annual diesel mitigation in 2025 is 1.3ML for this type of vehicle.

Figure 34 shows total fuel mitigation by fuel type. Overall, the Accelerated Transition is estimated to mitigate petrol volume demand until 2039 as more LPVs and LCVs are added to the fleet, but decreases to zero from 2037 to 2029 once the last cohort of petrol-consuming vehicles subsidised end their useful life. Diesel volume mitigated increases steadily until 2035, primarily driven by increasing medium and heavy truck fuel demand. However, diesel volume mitigated decreases from 2039 to 2046 as medium trucks end their useful life. By 2047, all medium trucks subsidised under "Accelerated Transition" are retired, leaving only heavy trucks. From 2047 onwards, diesel volume mitigated decreases as the last cohorts of heavy trucks subsidised end their useful life. In our analysis, we assumed an average volume mitigated (diesel and petrol combined) of 90ML.

Figure 34: Total vehicle lifetime fuel mitigated by fuel type

Cost associated with Accelerated Transition

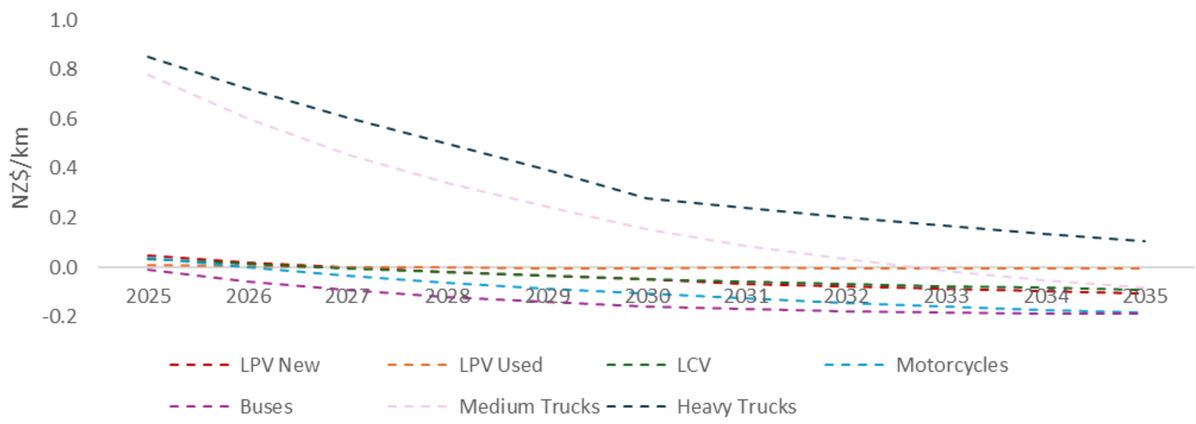
We calculate the lifetime TCO difference between ICE and EVs/HFC for each additional zero-emission vehicle introduced under the ambitious scenario. This difference represents the marginal cost to the New Zealand economy to bring forward these EV/HFC purchases.

For each vehicle class, we projected annual kilometres travelled and assumed a useful life and year of entry into the national fleet. These figures were used to estimate annualised costs of ownership and the cost of ownership per km, factoring in the discount rate. The TCO calculation considered the cost of capital expenditure (upfront purchase of a vehicle), repairs and maintenance, fuel/energy, charging and refill infrastructure (when applicable), and the Road User Charges (RUC).

We calculated TCO for both fuel types, adjusting costs based on the vehicle's entry year to reflect technological improvements. For all vehicle classes except heavy trucks, we calculated the TCO of an ICE (internal combustion engine) and its EV equivalent. However, for heavy trucks (the largest class of trucks over 30 tonnes in mass), we assume that battery-electric technology is not (yet) viable. Instead, we compare the TCO of an ICE and a hydrogen-powered heavy truck.[131]

Figure 35 visualises the cost of ownership premium per km of owning a zero-carbon vehicle compared to its ICE equivalent, or the "Zero carbon vehicle total cost of ownership differential." If a vehicle class achieves total cost of ownership parity with its ICE counterpart, the zero-carbon vehicle total cost of ownership differential is less than or equal to zero. At this point, the Government does not provide any support under the "Accelerating Transition" mitigation option. As shown in Figure 35, Light Passenger Vehicles (new or ICE), Light Commercial Vehicles (LCVs), Motorcycles and Buses will achieve TCO parity with their ICE equivalents by 2027. Medium trucks will achieve cost parity by 2033.

Figure 35: Zero carbon vehicle total cost of ownership differentials



Calculating the annual cost of the Accelerated Transition

We calculate the annual cost of the Accelerated Transition by multiplying an assumed additional zero-carbon fleet inflows per vehicle class, the lifetime kilometres travelled per vehicle class, and the TCO per km differential for each vehicle class.

Calculating an annual cost is complex since each vehicle class incurs a different annual cost according to its year of entry into the national fleet due to improving technologies, a different number of new zero-emission vehicles (for each class) enter the fleet each year, and each vehicle class has a different expected useful life. Each ICE vehicle class will, on average, consume a different level of petrol and diesel per km travelled and have a varying cost per ML of fossil fuel avoided. Therefore, we allocate the cost of future fuel demand by petrol or diesel according to vehicle class and fleet mileage for each vehicle class.

Finally, the annualised cost is calculated by converting each year's annual cost into an annuity over the useful life of each vehicle class. The annualised cost only applies when the TCO differential is greater than zero. We take an average of the annual cost from 2025 to 2035, ignoring years when

[131] We assume heavy trucks will transition to HFC instead of EV technologies because HFC is generally more suitable for long-haul, heavy freight tasks. We note that EECA's Low Emissions Heavy Vehicle Fund currently provides funding for specific "heavy" EV trucks, which—except for one model (EVC61)—are too light to be considered "heavy trucks" in this Study. This Study classifies trucks over 30 tonnes in mass as "heavy trucks," which is consistent with how the Climate Change Commission's "heavy trucks."

For more details, please see EECA, Low Emissions Heavy Vehicle Fund, available at: https://www.eeca.govt.nz/co-funding-and-support/products/low-emissions-heavy-vehicle-fund/

no subsidies are required. As seen in Figure 36 and Figure 37, annual cost is high at the start of the period but decreases towards the end of the period.

To determine an annual cost, we annualised the total cost spent between 2025 and 2035, which is estimated to be around NZ$129 million per year.

Figure 36: Total cost of Accelerated Transition policy

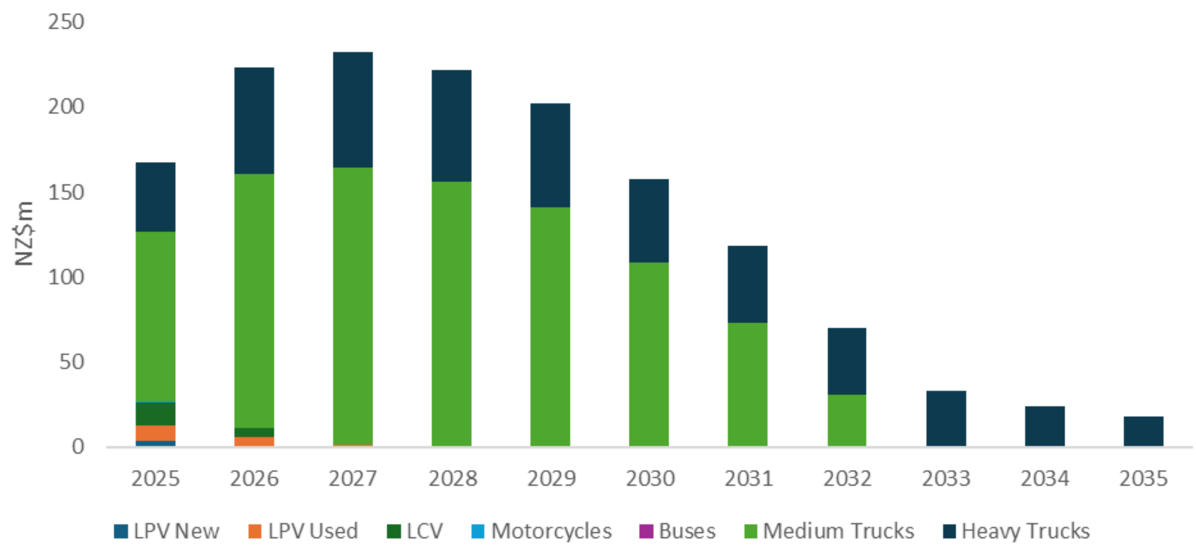
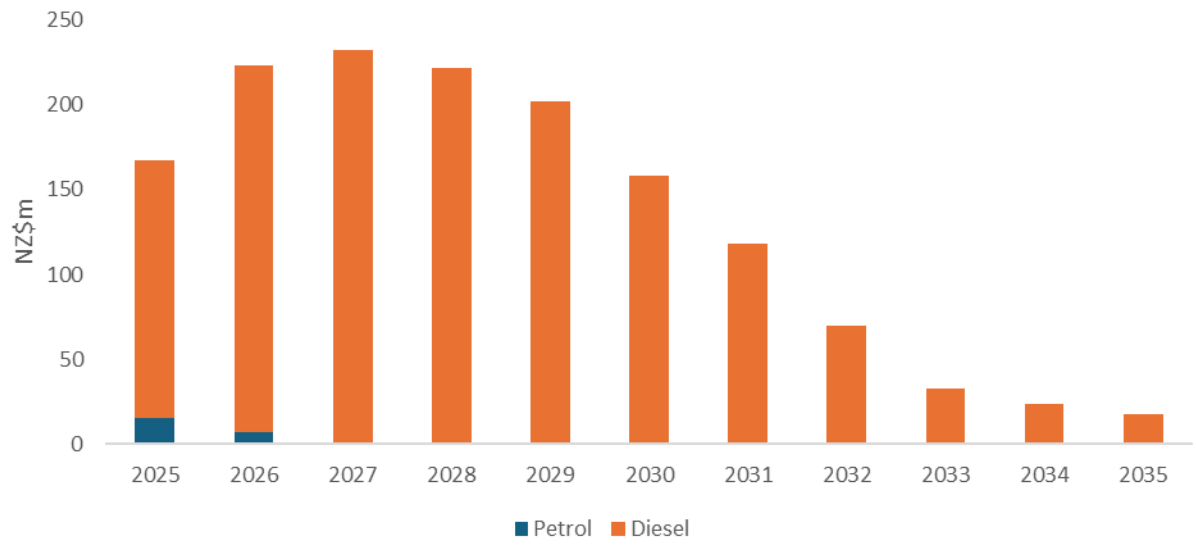


Figure 37: Total cost of Accelerated Transition policy by fuel type



Sensitivity analysis

To test the sensitivity of the results to different status quo assumptions, we ran an alternative model using the Ministry for the Environment's Second Emissions Reduction Plan (ERP2)'s "baseline" forecast as the BAU scenario. MBIE specifically requested this sensitivity testing. Accelerating Transition using ERP2's baseline costs NZ$144 million per year and mitigates 102ML of fuel consumption per year.

Accelerating Transition using ERP2's baseline as the BAU scenario is more expensive than using the EB4 reference scenario as the BAU scenario. This is because ERP2's baseline generally projects fewer zero-carbon vehicles entering the fleet by 2035, meaning more vehicles will require subsidies to support the transition.

The distribution of vehicles subsidised under Accelerating Transition differs depending on status quo assumptions. For example, Accelerating Transition using ERP2's baseline as the BAU scenario requires subsidising a more balanced proportion of used or new LPVs. This is because in 2025, ERP2's baseline projects that 11.1% and 11.4% of used and new LPVs that enter the fleet are EVs, while the EB4 reference pathway projects 5.6% and 17.9%, respectively. Therefore, using the EB4 reference pathway as the BAU scenario requires more aggressive subsidies to reach its targets for new LPVs and comparatively less aggressive subsidies for used LPVs.

Figure 38: Total annual cost of Accelerated Transition policy assuming ERP2 baseline as the BAU scenario

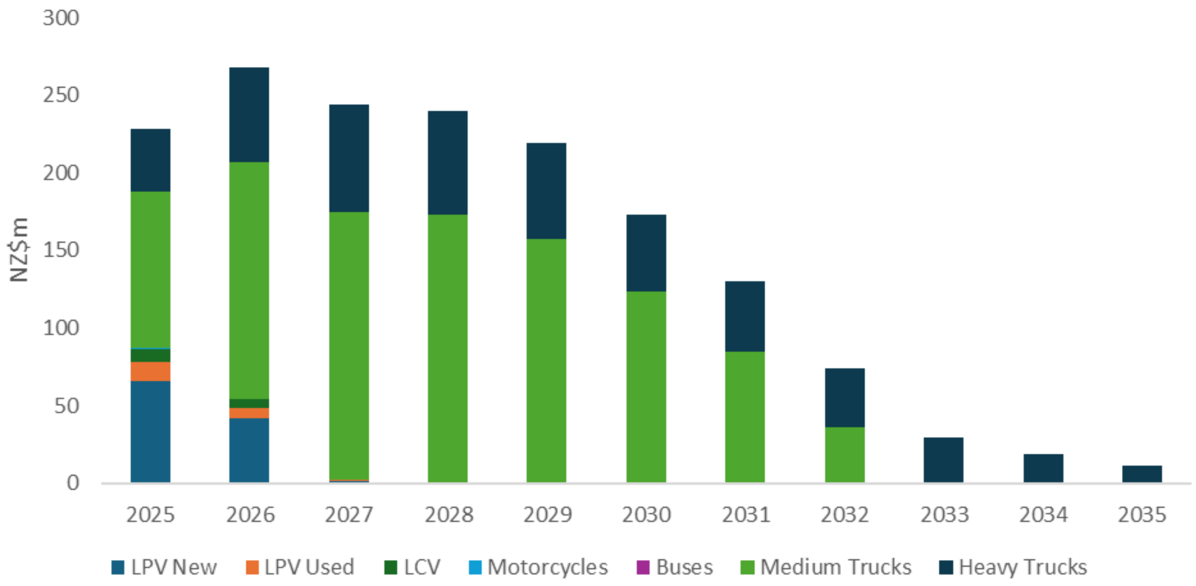


Figure 39: Total annual cost of Accelerated Transition policy assuming ERP2 baseline as the BAU scenario, by fuel type

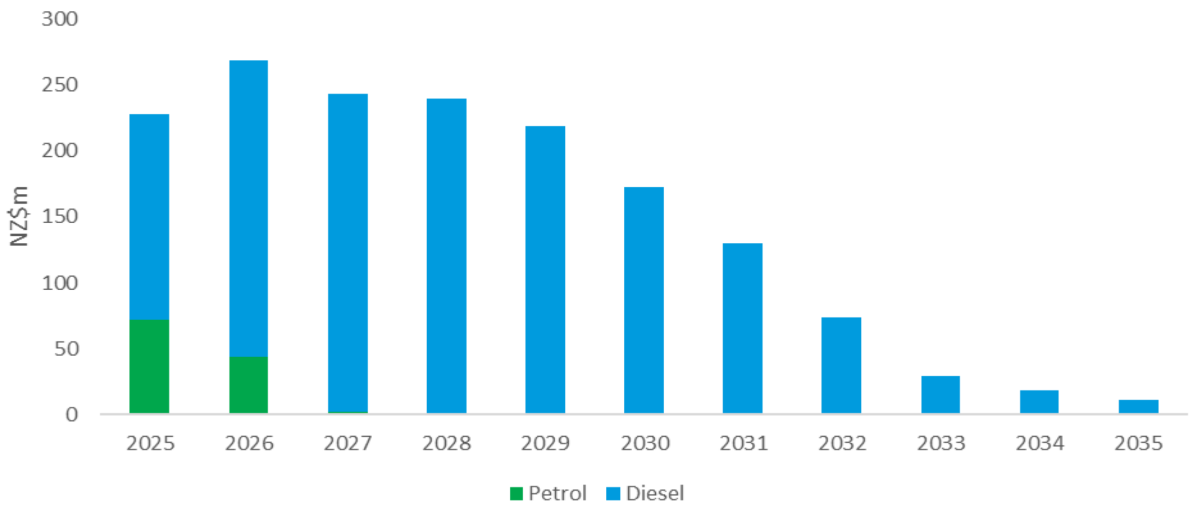
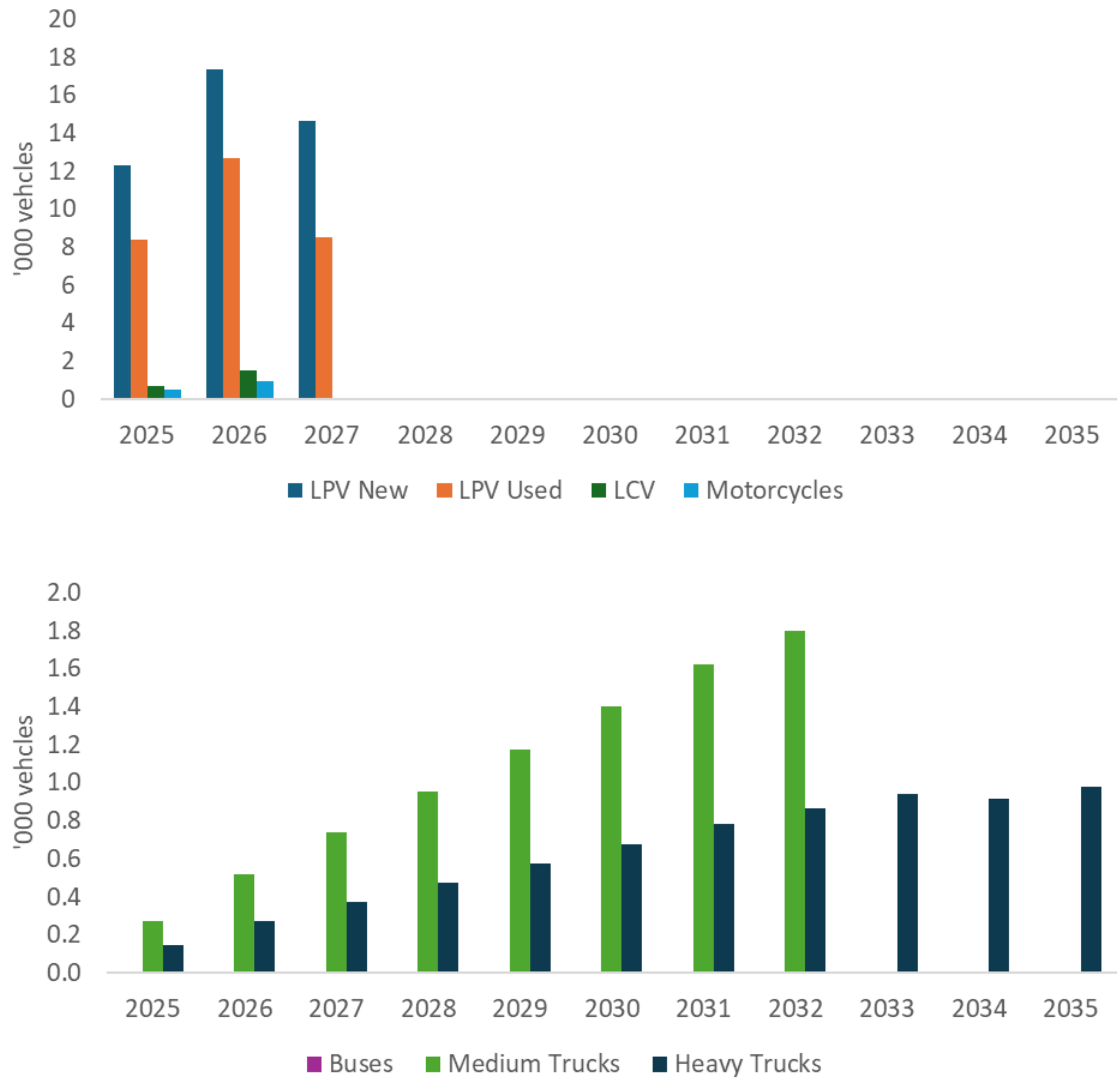


Figure 40: Additional zero-carbon vehicles added to the fleet assuming ERP2 baseline as the BAU scenario



The charts below compare the forecast number of zero-carbon vehicles entering the fleet between the EB4 reference and ERP2 baseline models. The ERP2 baseline projection is generally lower than the EB4 reference, so the cost of "Accelerating Transition" using ERP2 baseline as the BAU scenario is relatively higher as more zero carbon vehicles require subsidisation to achieve parity of total cost of ownership.

Figure 41: Forecast number of new EV LPVs entering the fleet under EB4 reference and ERP2 baseline pathways

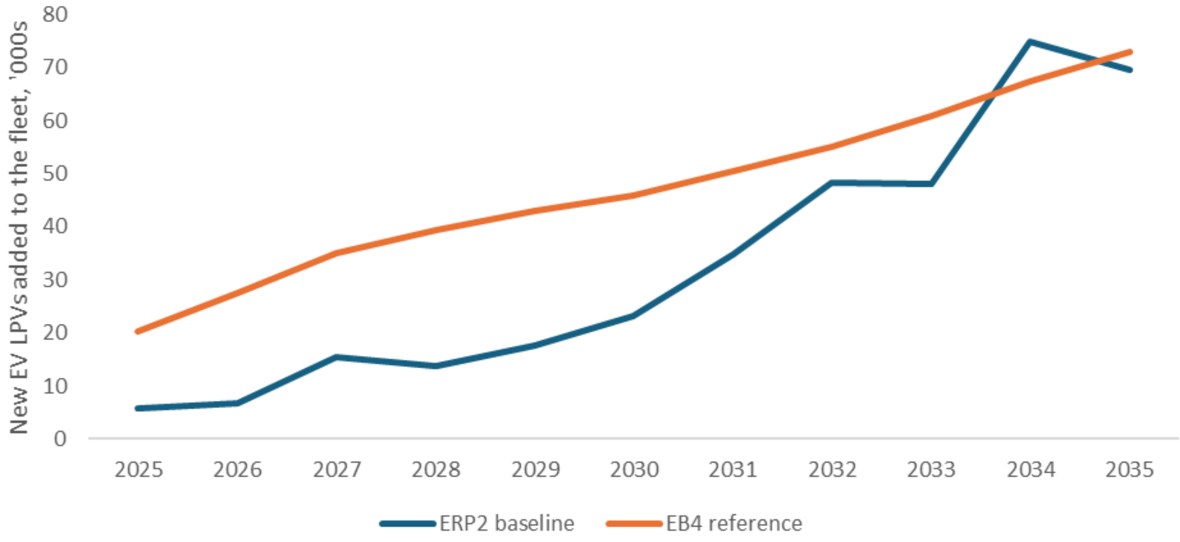


Figure 42: Forecast number of used EV LPVs entering the fleet under EB4 reference and ERP2 baseline pathways

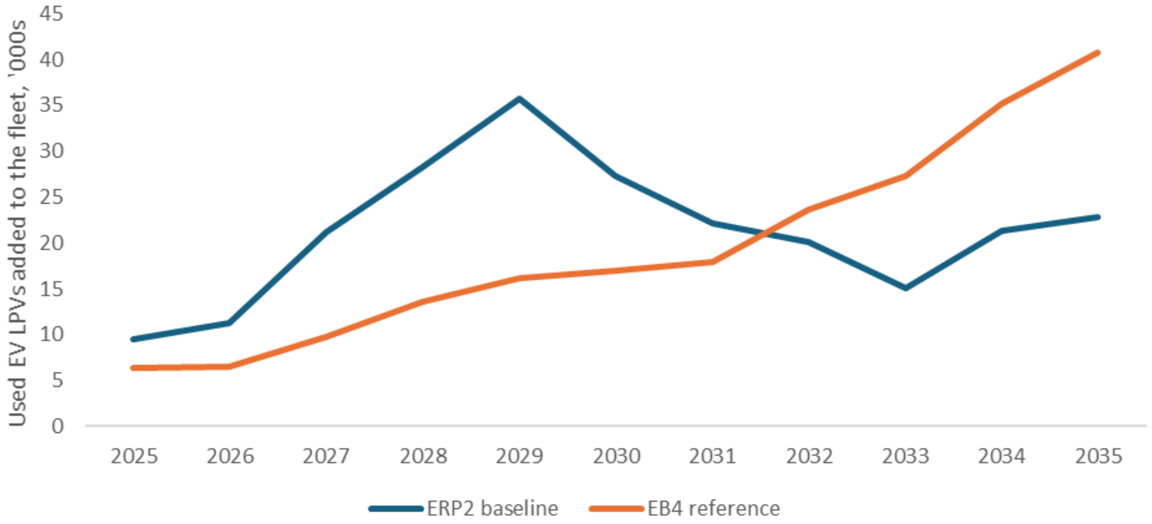


Figure 43: Forecast number of EV LCVs entering the fleet under EB4 reference and ERP2 baseline pathways

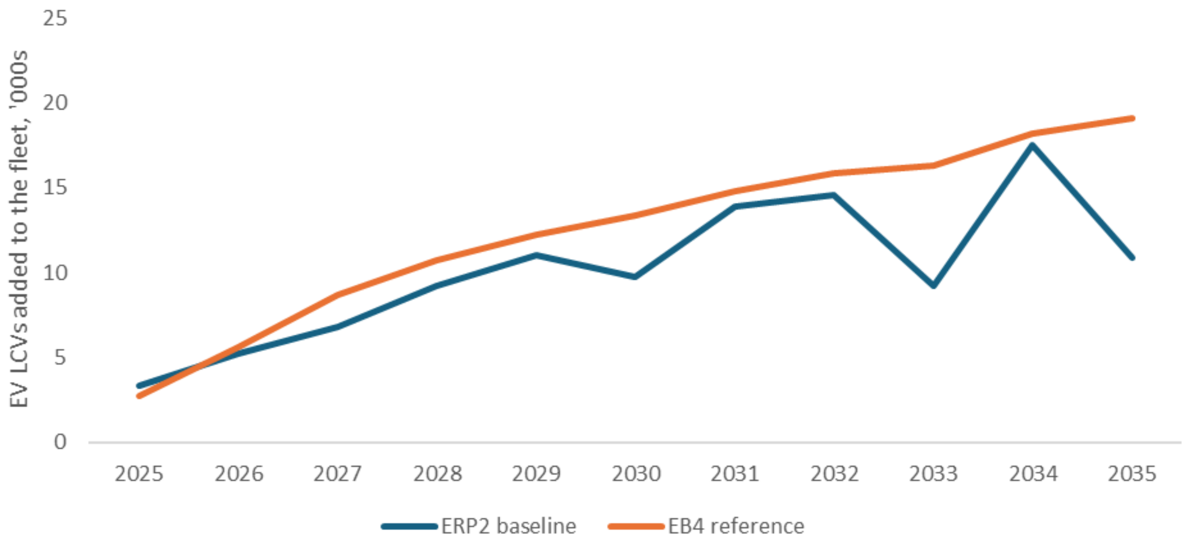


Figure 44: Forecast number of EV motorcycles entering the fleet under EB4 reference and ERP2 baseline pathways

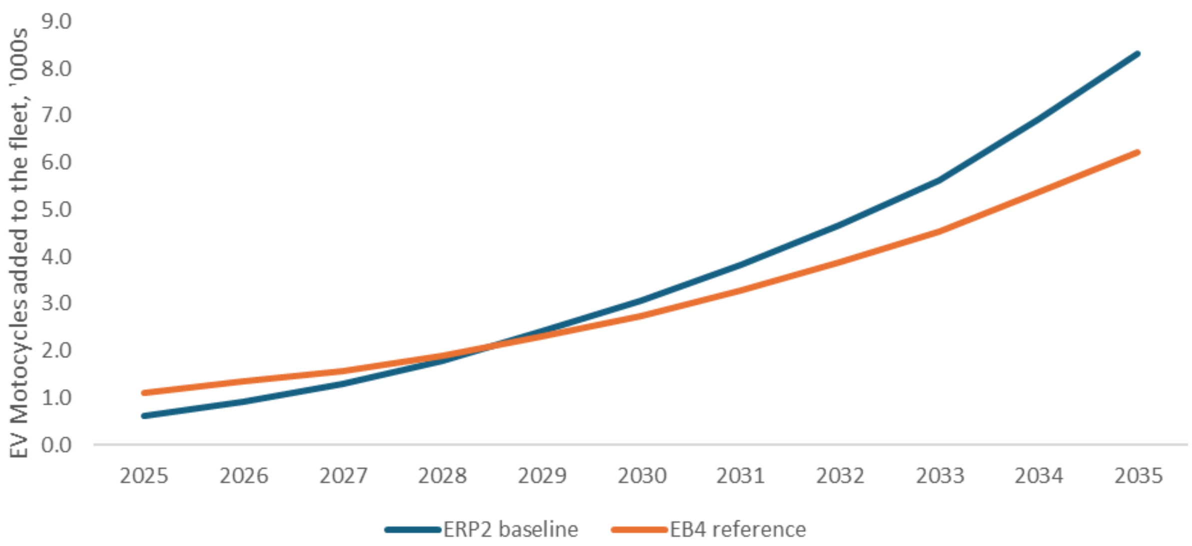


Figure 45: Forecast number of EV buses entering the fleet under EB4 reference and ERP2 baseline pathways

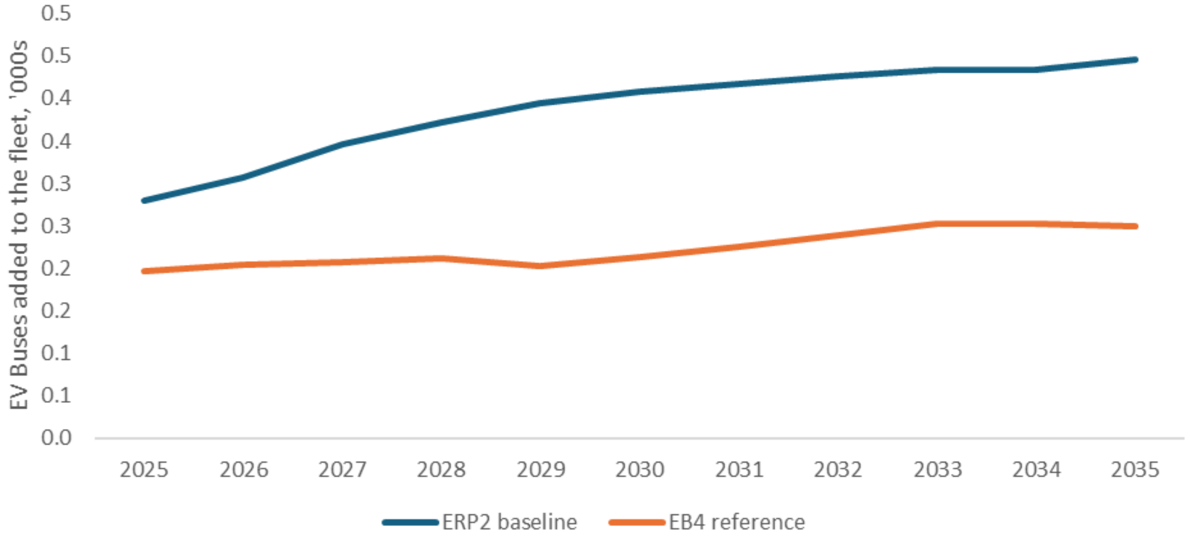


Figure 46: Forecast number of EV medium trucks entering the fleet under EB4 reference and ERP2 baseline pathways

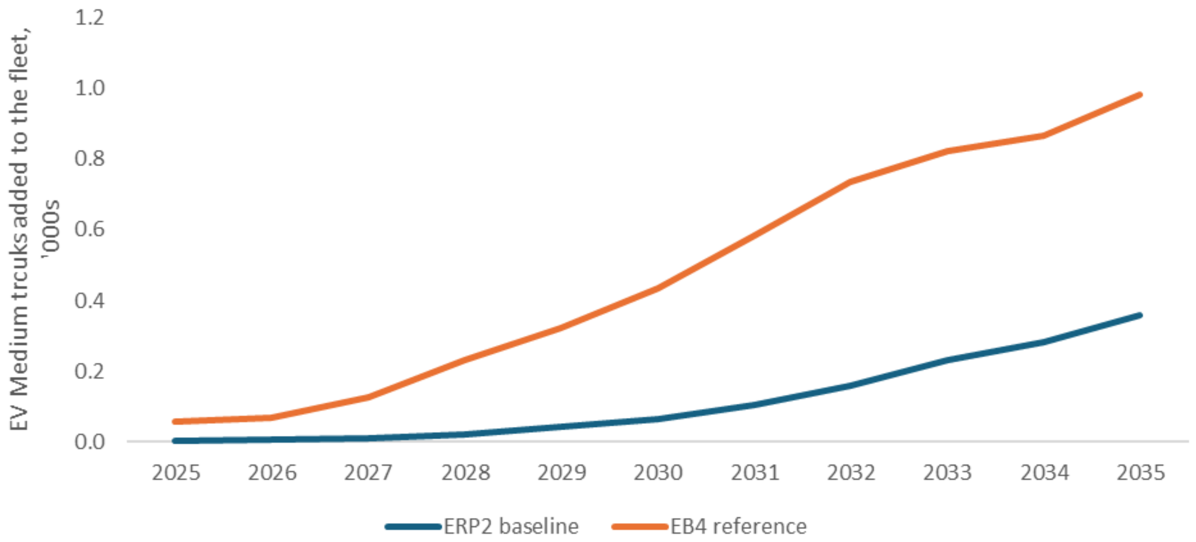
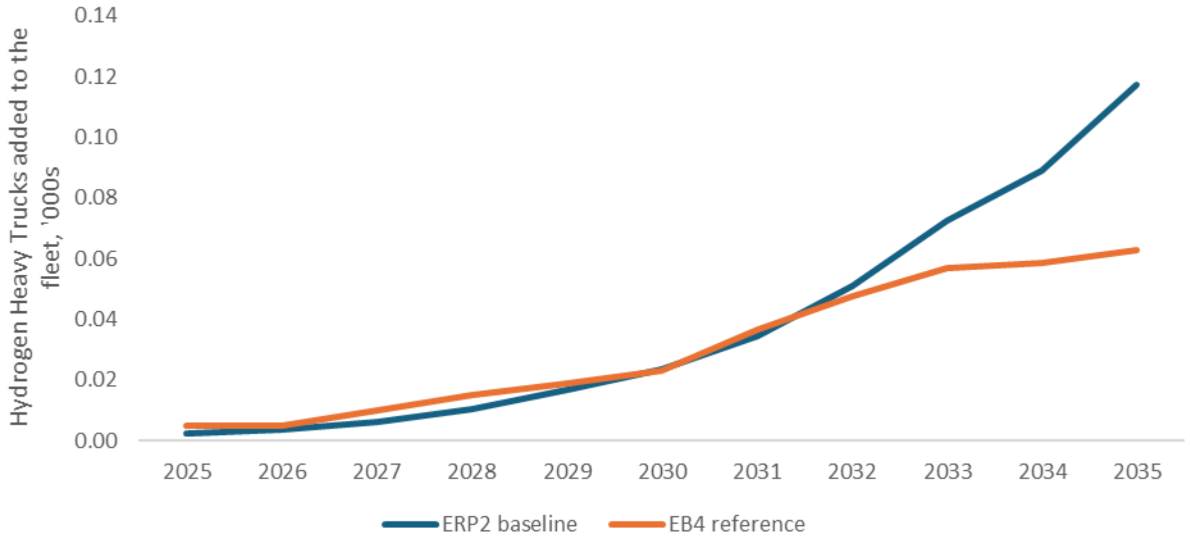


Figure 47: Forecast number of hydrogen heavy trucks entering the fleet under EB4 reference and ERP2 baseline pathways[132]



Scoring matrix to evaluate the mitigation options

We provide additional explanation of the scoring matrix used to evaluate the mitigation options. We estimate the volume of "usefulness" based on the following approach:

Step 1: We estimate the benefits of each mitigation option based on the volume of fuel it can contribute to improving fuel resilience. This is expressed as "Volume Mitigated", shown in Table 33. For example, installing seven additional tanks to expand diesel storage would add approximately 77 ML of diesel, available for use during a fuel disruption.

Step 2: Estimate scenario usefulness. Each mitigation option is assigned a scenario usefulness score from 0 to 1, indicating its effectiveness in addressing different disruption scenarios:

- 0 – No impact on fuel resilience
- 0.5 – Mitigation potential depends on stock location
- 0.75 – Supports fuel supply during disruptions
- 1.0 – Provides continuous improvement to fuel resilience.

Table 32 details the scores assigned to each option.

[132] Although ERP2 baseline projects a greater number of hydrogen heavy trucks enter the fleet compared to the EB4 baseline, Accelerating Transition assuming the ERP2 baseline as the BAU scenario subsidises more hydrogen heavy trucks. This is because the ERP2 baseline scenario projects that more heavy trucks (zero carbon or ICE) enter the fleet—for example, by 2035 the ERP2 baseline scenario projects that 420 heavy trucks will enter the fleet, while the EB4 reference pathway projects 2,200 vehicles will enter the fleet. This difference in scale makes the heavy truck subsidy for an Accelerated Transition more expensive assuming the ERP2 baseline.

Table 32: Mitigation options scoring effectiveness matrix

Disruption event/Mitigation Options	Domestic					International			
	Short term RAP/Wiri	Long term RAP/Wiri	Long term Marsden Point	Long term Wellington	Long term Christchurch	Minor (one ship or product quality)	Major disruption	Severe Disruption (no supply)	Scenario effectiveness score
Additional diesel stock	0.5	0.5	0.5	0.5	0.5	0.75	0.75	0.75	**4.75**
Jet Stock near Auckland Airport	0.75	0.75	0.75	0.5	0.5	0.75	0.75	0.75	**5.5**
Trucking - petrol/diesel	0.75	0.75	0.75	0.75	0.75	0	0	0	**3.75**
Transition - petrol/diesel	1	1	1	1	1	1	1	1	**8**
Biorefinery - average combined	0	0	0.5	0	0	0	1	1	**2.5**
Modular refinery processing indigenous crude	0	0	0	0	0	0	0	1	**1**
Reestablishing MPR	0	0	0.5	0	0	0.75	0.75	0	**2**

Step 3: Calculate volume usefulness. We calculate volume usefulness by multiplying the volume mitigated by its scenario usefulness score. The results are shown in Table 33.

Table 33: Volume usefulness

Mitigation Options	Annualised cost	Volume mitigated	Scenario effectiveness score	Volume usefulness
	NZ$ million	*ML*	*#*	*ML*
Additional diesel stock to cover 7 extra days of demand	24	77	4.75	366
Jet Stock near Auckland Airport to cover 4 extra days of demand	8	22	5.50	121
Additional trucking - petrol/diesel	38	147	3.75	552
Accelerated transition - petrol/diesel	129	90	8	719
Biorefinery - average combined jet/diesel	257	215	2.5	537
Modular refinery processing indigenous crude	42	66	1	66
Reestablishing MPR	756	180	2	360