INFRASTRUCTURE EVIDENCE BASE 2015 Refresh

Energy Sector

March 2015

NATIONAL INFRASTRUCTURE UNIT

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EVIDENCE BASE

Energy Sector

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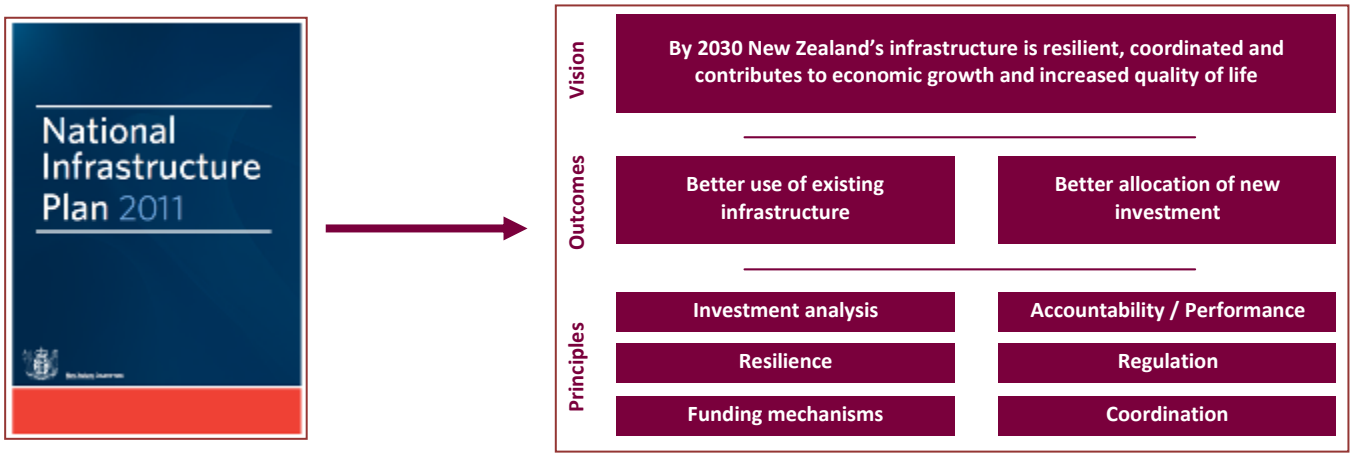
Introduction

Infrastructure is a crucial part of the New Zealand economy. It supports the day to day activities of New Zealanders, helps to improve living standards for all, and can be a driver for economic growth. As such, it is vital it is managed as well as possible. The National Infrastructure Plan 2011 sets out a long term vision for New Zealand's infrastructure and seeks to provide a common direction for how we plan, fund, build and use all economic and social infrastructure.



A significant constraint identified in the National Infrastructure Plan 2011 was the lack of information about asset condition and performance to allow more informed decisions and efficient and effective investment. A key part of the National Infrastructure Unit's (NIU) work programme over the past two years has been to develop a more robust Evidence Base to address this constraint. In particular, publishing the Evidence Base enables a discussion identifying the significant issues for New Zealand infrastructure and options to respond to these. Discussion of these will underpin the NIU's work programme over 2014, through to the release of the next National Infrastructure Plan in 2015.

The Evidence Base draws together work on performance indicators (the current state of the infrastructure), scenario and trend analysis (the future pressures or drivers of demand), the national resilience picture, and the first 10-year Capital Intentions Plan (what is known about indicative future spend).

This document forms the substantive component of the Evidence Base for the energy sector, defined by NIU as covering the production, transmission, distribution and availability for use of electricity, gas, oil and coal. Renewable thermal fuels (eg. biomass) are not currently included. It follows from the overview document, which can be found on the NIU's website. It draws information from the performance indicators, scenario and trend analysis, and resilience assessment.

Where data has been provided, this is publically available information, and has been provided with permission of the information owner.

EVIDENCE BASE 2015: ENERGY SECTOR

Overview messages

The overall condition of the New Zealand energy system is seen as good; quality is generally above targets, with sufficient service availability and adequate management. However there are challenges for each of the electricity, gas, oil and coal systems together with their interdependencies. There is a need to better understand desired customer levels of service so that both the supply and demand sides can strive towards acceptable levels of performance underpinned by investment that strengthens system resilience. The collapse of coal prices and more recently oil prices also present challenges in regards to asset renewals and investment.

In electricity, the generation mix is changing with a continued increase in geothermal, while the role of thermal (coal and gas) is transitioning from base-load and mid-merit to peaking generation. Appropriate plant and fuel supply contracts will be key to meeting the flexibility requirements of the electricity market in future. New Zealand's high renewable electricity component provides unique benefits and market opportunities compared to other countries.

Recent investments in the national grid (Transpower) now provide significant capacity margins in most areas but there is a need to remain cognisant of shifting electricity supply and demand throughout the country. Supply reliability of electricity distributors demonstrated an improving trend through 2008–13 with deterioration in 2014 due to the impact of large events. These external large events appear to be getting larger and causing greater loss of supply. Supply reliability varies widely between distributors, with some having a significantly larger number of interruptions and a significantly longer duration of interruptions.

In addition, the outlook for electricity distribution businesses is challenging due to a variety of reasons. These include a dynamic and changing market, with increasing level of investment uncertainty going forwards; ageing assets; consumers' increasing supply quality expectations; and emerging technologies such as household scale photovoltaic (solar) generation, which may reduce demand projections. Adapting to technology changes and shifting focus to customer control and managing demand will be crucial in responding to these challenges. Opportunities exist with smart grid initiatives to further enhance service delivery and use.

In oil, although there is little infrastructure redundancy built into the system with 70 percent of the petroleum fuel consumed in New Zealand each year processed by a single refinery, New Zealand has options for responding to domestic supply emergencies affecting supply pinch points. Storage capacity in the South Island is reported to be reaching capacity, and further investment may be required to avoid supply-side risk if demand grows or older infrastructure is not maintained. Due to the quality of New Zealand's crude oil production it is largely exported with very little processed onshore. Standards across the oil system are in accordance with international best practice.

Gas transmission capacity, including into Auckland, is generally considered to be sufficient for short-to-medium term supply/demand scenarios. The next step-change in investment is likely to be associated with a significant new gas find. At times Liquefied Petroleum Gas (LPG) has been intermittently exported in relatively small quantities but otherwise all gas is consumed onshore. Production is from numerous fields with distribution by pipeline in the North Island and various LPG networks in the South Island. LPG distribution is also via coastal tanker, rail and road.

Coal supply is critical to a range of domestic, industrial and institutional uses with supply and demand largely determined by commercial arrangements. Supply chains necessarily require stockpiling at both the supply and demand end. Road transport is the main option for domestic supply with the Midland rail line being a critical component for the coking coal export trade. An issue is quality and reliability of thermal coal meeting various end-user specifications.

Energy from geothermal and biomass sources also make a sizeable contribution to industrial process heat at some sites.

There are opportunities relating to energy efficiency and demand side management to improve utilisation of energy infrastructure.

Context

The energy sector comprises large scale network assets including 12,000km of high voltage transmission lines, 150,000km of electricity distribution lines, 2,500km of high pressure gas transmission pipelines and 16,800km of regional gas distribution systems. New Zealand's only oil refinery produces around 70 percent of the fuel consumed in New Zealand each year, and a single pipeline carries over 30 percent of national fuel demand from the refinery to Auckland. Coal is a critical fuel for industrial purposes and for heating accommodation and service buildings such as health and education facilities.

EVIDENCE BASE 2015: ENERGY SECTOR

For both electricity and gas, New Zealand is self sufficient in terms of production and supply, whereas for oil it is almost completely dependent on imports. Electricity generated is substantially from renewable sources and for the balance is dependent on gas and coal supplies which tend to be subject to ongoing supply uncertainty. For coal, New Zealand is largely self sufficient for domestic demand but at times has imported for electricity generation and process energy purposes.

The majority of energy companies are privately owned and operated. The electricity transmission, some electricity distribution businesses and gas pipeline businesses are subject to Commerce Commission price-quality regulation. There is also regulatory oversight through the Electricity Authority and the Gas Industry Company.

There are multiple interdependencies with other sectors, such as transport, and a growing reliance on telecommunications and data flows.

What do we have?

Electricity

There are over 200 power stations connected to the national grid, and around 75 to 80 percent of New Zealand's electricity is generated from renewable sources including hydro (≈58 percent), geothermal (≈16 percent) and wind (≈5 percent). There is a considerable range of asset types, locations, sizes and ages with this diversity being of considerable value.

Electricity supply is dependent on thermal generation units fuelled predominantly by gas, but also coal and diesel.

Electricity is transmitted throughout New Zealand via a national transmission grid comprising approximately 12,000km of high voltage lines owned and operated by Transpower, a state-owned enterprise. This capacity has been significantly upgraded over recent years.

There are 29 local electricity distribution businesses (EDB's) under a range of ownership models, connecting customers with the national transmission grid. The 150,000km of distribution lines and related assets are valued at a regulated Asset Base level of $10 billion with a projected 10 year investment of $8.6 billion. All regions in New Zealand are covered and EDB's often have major customers within their networks. There is some embedded generation and industrial cogeneration at the network level and an increasing number of generators at the customer level.

Gas

Natural gas is extracted from fields in the Taranaki area, and existing infrastructure is focused on delivering gas from there to North Island markets. At around 13.5 years, the country's reserves-to-production ratio compares well internationally. There are ongoing high levels of investment in oil and gas.

Gas is the source of fuel for approximately 20 percent of New Zealand's electricity supply. It is otherwise transmitted and distributed for direct use through the North Island with the most significant customer being Methanex in Taranaki, where natural gas is converted to methanol, largely for export.

Gas is reticulated to 260,000 customers (residential and business). While gas is a discretionary fuel for households, large gas users are highly reliant on distributed natural gas primarily for process heat purposes. Residential use is generally for space heating, water heating and cooking. Most gas transmission and distribution pipes are buried and were installed prior to 1986, with 60 to 80 year operating lives.

Gas Distributors – Physical Characteristics

DISTRIBUTOR	NETWORK LENGTH (KM)	REGION	CONNECTIONS	PROPORTION OF CONNECTIONS (PERCENT)	DENSITY (CUSTOMERS/KM)
Vector (30 June 2014)	10,623	Northland, Greater Auckland, Waikato, Bay of Plenty (including Rotorua, Taupo), Gisborne, Kapiti	159,738	58.0	15.0
Powerco (30 Sept 2014)	5,738	Greater Wellington, Hawke's Bay, Manawatu, Horewhenua, Taranaki	102,794	37.3	17.9
GasNet (30 Jun 2014)	657	Wanganui, Rangitikei	12,812	4.7	19.5
Nova [1]	100	Wellington, Porirua, Hutt Valley, Hastings, Hawera, Papakura, Manukau City	Not known	Not known	Not known
Total	17,018 [2]		275,344	100	16.2

Source: Gas Industry Information Disclosures pursuant to Gas Distribution Disclosure Determination 2012 (specifically Schedule 9c)

[1] Under Part 4 of the Commerce Act 1986, Nova Gas is not subject to the Disclosure Regulations and does not otherwise publish information about its distribution networks. The Commerce Commission Gas Control Enquiry, Final Report, November 2004, records the length of Nova's Distribution Network as 100km as at June 2003.

[2] Total of open access networks only. Excludes Nova.

Liquefied Petroleum Gas (LPG) is discussed in the following section.

Oil

Oil is extracted from 18 fields onshore and offshore Taranaki, and almost all is exported due to its relatively high quality. Apart from international oil ticket contracts purchased to ensure compliance with International Energy Agency (IEA) obligations[1], the oil sector is entirely owned and operated by the private sector.

Imported crude oil is processed at the Marsden Point Oil Refinery which produces around 70 percent of the 8.5 billion litres of fuel consumed in New Zealand each year. A single pipeline carries around 35 percent of total product fuel volumes from the refinery to Auckland, and the remainder is transported by two ships to a network of ten coastal terminals.

The largest storage facility is in South Auckland, and approximately 35 percent of New Zealand's liquid fuel consumption passes through it each year.

At service stations, old single skin steel tanks have been replaced since the 1980's with modern, longer life tanks, including wrapped steel, single skin fibreglass and most recently double skinned fibreglass tanks. Some sites still need to upgrade tankage over the next five years and these will occur where economically viable.

In New Zealand, LPG is generally categorised under oil and for consistency this document retains the same approach. LPG is distributed as bottled gas or to local distribution networks such as in Christchurch. LPG is now priced at international rates. The LPG Association represents all major LPG producers/retailers in New Zealand.

Coal

New Zealand has known in-ground coal resources exceeding 15 billion tonnes, more than half of which is potentially recoverable. New Zealand's largest coal resource is lignite in Southland and Central Otago and is also one of the most challenging resources to be

[1] All countries that are members of the IEA are obliged to maintain a minimum of 90 days net oil stocks. Oil however can be held in other IEA countries if both governments agree that this oil is held for IEA compliance purposes by the owner of an oil ticket contract for that purpose.

brought into commercial use. There are also substantial resources of sub-bituminous coal in both islands, and a lesser amount of high-quality bituminous coal on the West Coast of the South Island, suitable for the international coking coal market.

Over 93 percent of all production is of bituminous and sub-bituminous coals. Although lignite makes up 80 percent of national coal resources, lignite production in 2013 represented only 6 percent of total production, mostly as a consequence of its high moisture content and distance from the main centres of energy demand.

Coal production is centred on the Waikato (mainly for several major industrial users and the Huntly power station), the West Coast (for export and for South Island industrial markets), and Otago/Southland (mainly for local industrial markets).

Is it where it needs to be?

Electricity

Electricity generation has a diversity of assets and system control functions, ensuring very high service availability. In electricity distribution, an obligation to supply rural communities ensures almost 100 percent availability across NEW ZEALAND. In a few instances it is proving cost effective in rural supply to provide stand-alone systems. Elsewhere there are an increasing number of customers installing generation such as stand-by diesel generators, wind turbines and photovoltaic panels (PV) leading to distribution companies, in particular, to improve management of their systems.

Changing land use due to New Zealand's international success in milk protein markets has developed new land use energy requirements as less energy intensive sheep and beef farming is replaced with heavy electricity demand irrigation schemes and dairy sheds. This has created demand which requires extending and strengthening the existing distribution networks and has required increased capacity investment upstream for core distribution assets and further to the Transmission assets.

Gas

There is good coverage of the North Island for gas distribution. However if not in close proximity to adequate network capacity the costs of new infrastructure to access it are very high. Major industrial consumers such as Methanex and New Zealand Steel, are generally well served, providing a baseload of demand. Storage capacity within the pipelines ("line pack") meets intra-day fluctuations in demand. Concerns in recent years around gas pipeline capacity north of Huntly have been addressed by a combination of market changes (especially reduced baseload gas-fired generation) and improved industry arrangements.

Oil

There are currently no known issues with oil availability, although there are some concerns with storage capacity at certain regional locations and reduction of service in remote areas and on tourist routes.

The South Island has a number of discrete LPG networks and otherwise bottled LPG is available throughout the country.

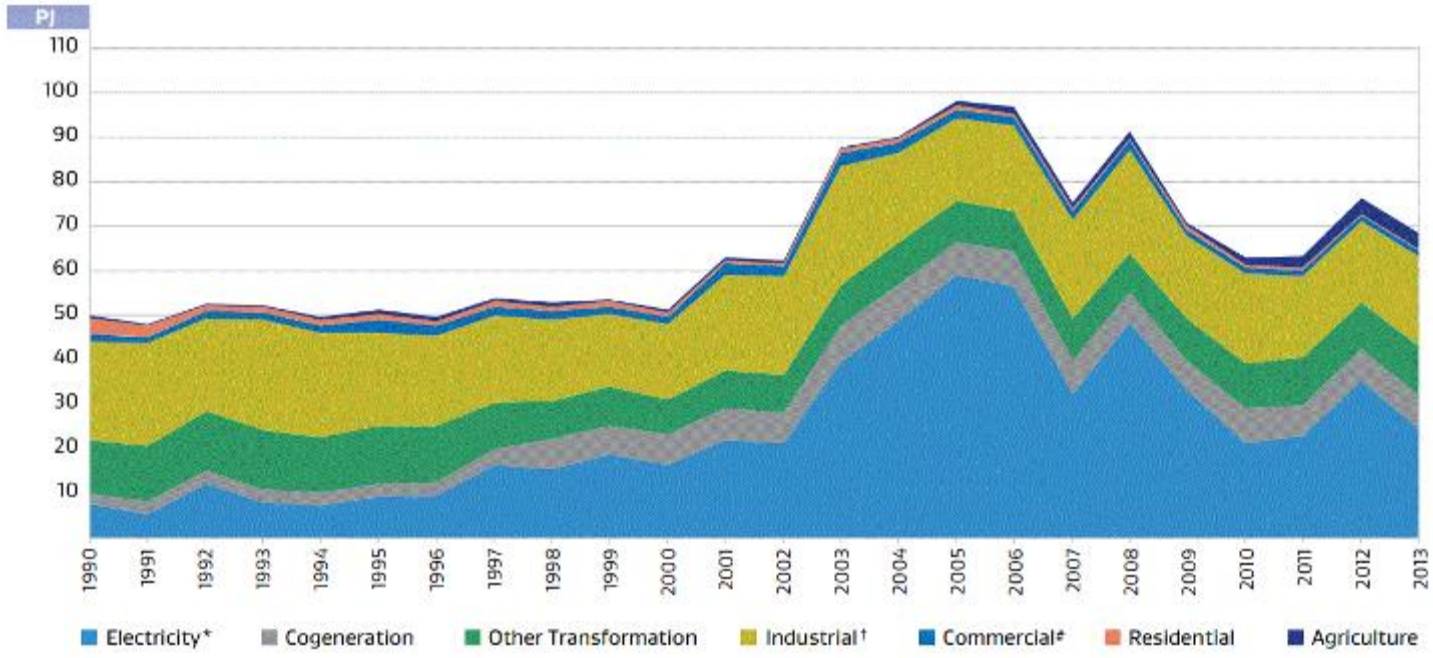
Coal

Due to the low energy density, coal production and use is very dependent on transport availability through rail and road options and, for export/import options, on port facilities. Export coal is highly dependent on KiwiRail and port export facilities. Domestic industrial coal is mostly transported by road and has little dependency on rail.

Most of New Zealand's premium bituminous coal is exported as high-quality coking coal for steel making. The rail link between the West Coast and Christchurch Port facilities has managed to accommodate export volumes despite damage following the Canterbury earthquakes.

Electricity generation accounts for the largest amount of domestic coal use. Industrial coal use is primarily for steel, cement, lime and plaster, meat, dairy, and other food processing, wool, timber, pulp and paper products. Commercial coal use is mainly for heating accommodation and service buildings in central and local government, hospitals, rest homes and educational institutions. A small amount of coal is used by the agricultural (mainly horticulture), transport and residential sectors.

Total Coal Consumption by Sector



The coal market is dominated by a few suppliers. There are constraints from domestic regulations regarding sulphur content and associated emissions from high sulphur coals. A further constraint is the location of coal resources compared with the user. Industrial demand in the South Island is increasing, driven mainly by the dairy sector, and there are issues arising from the general decrease in coal quality, in particular high sulphur, higher ash and the quality requirements of the existing boilers.

The coal sector is under a mix of state and private operators. There is one State-Owned operator, Solid Energy, producing most of New Zealand's coal and the rest are private operators, both private and listed.

There are a number of challenges or risks, including; global commodity prices, RMA provisions, possible increases in the carbon price, evolving international climate change response commitments and the ongoing need to ensure supply of coal meets the expectations of industry and other consumers.

What quality is it?

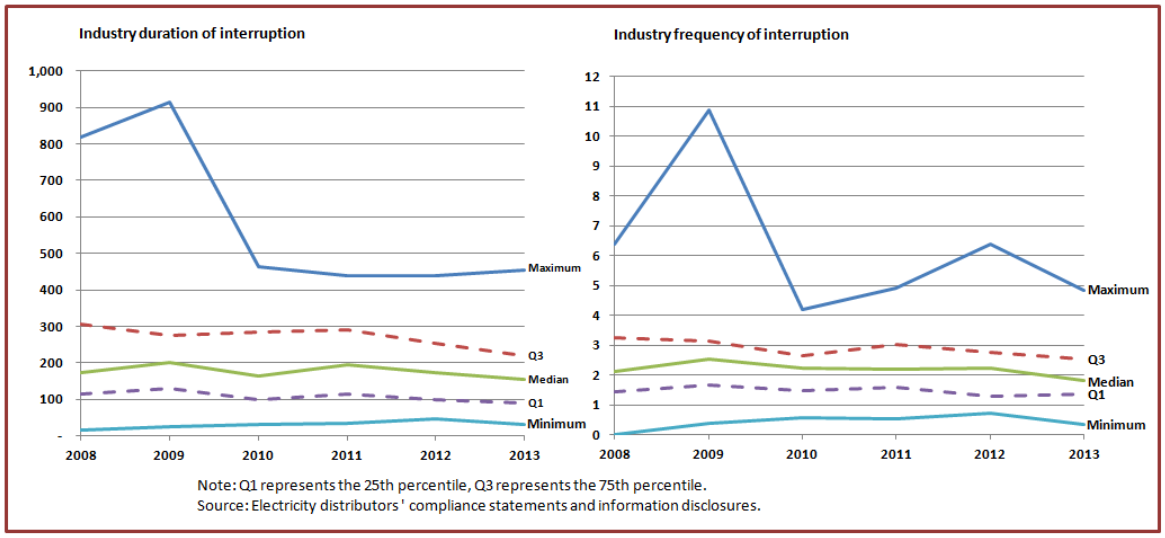
The overall quality and service availability appear good in this sector.

Electricity

In electricity, forced outages for the generation, transmission and distribution are mostly below target maximums and availability is above targets; however, there are known vulnerabilities to hazards, such as wind and storm events as well as earthquakes. There is an on-going need to upgrade components to meet international standards and ensure operational capability. However, overall asset condition is assessed as good.

It is recognised that many industrial users can not tolerate outages – even if disruptions are below their targets. If there has been a disturbance that causes a user's plant or equipment to stop, this can cause several hours of downtime to get their plant operational again, even if the disturbance is only for a few seconds and restored quickly.

Distribution assets have a broad age range, and condition is generally good. Asset Management Plans are provided as a regulated requirement and part of the information disclosure on how the price and quality decisions are currently balanced for consumers' current levels of service. The average reliability of the distribution industry overall improved to 2013 then dropped back in 2014, as reported by the Commerce Commission (Electricity distributors' performance from 2008 to 2014), but it varies widely between distributors. Some distributors had a significantly larger number of outages, and a significantly longer duration of outages than others. Each EDB is dealing with significant regional variations in topography, population density and resilience of the communities they are delivering to.



Note: Q1 represents the 25th percentile, Q3 represents the 75th percentile.
Source: Electricity distributors ' compliance statements and information disclosures.

Delivered power quality is becoming an increasing issue with reducing tolerance of appliances and customers able to monitor power quality. Generally, distribution networks rely on 1970/80's technology, which will struggle to transition to much more active networks with distributed generation, smart meters, electric vehicles and other changes.

In transmission, Transpower's Asset Management Plans and Strategies were the subject of independent review in 2010 resulting in a range of recommendations primarily related to achieving compliance with PAS55 standards. Transpower gained PAS55 certification in 2014. It is understood a number of distribution companies are working towards certification.

Under Part 4 of the Commerce Act 1986, the Commerce Commission sets information disclosure requirements for the 29 EDB's and Transpower, as well as price-quality paths for 17 of the EDB's and Transpower. Disclosures include condition, quality, capacity and asset management plan information, and can be found on the Commerce Commission's website.

Gas

The "New Zealand Gas Story" issued by the GIC in February 2013 (available on their website) notes: "overall processing facilities' operational reliability record is strong".

In gas transmission, assets are well maintained, reaching international standards under health and safety regulations. These regulations include requirements for management plans to address pipeline risks, including those created by challenging geologies along North Island transmission routes. Transmission from Taranaki is dominantly via the Maui pipeline and otherwise via Vector's pipeline network. The Maui Gas Outage of 2011 has highlighted risks for transmission pipelines that have had high levels of reliability for over 30 years. Review of the Maui gas outage by Worley Parsons concluded that the risks are acceptable and that alternatives exist for all but the most extreme events. Integrity management protocols offer assurance of asset life.

A large number of acts, regulations, standards, codes of practice and guidelines governing the quality of gas sector installations as well as the quality of the natural gas being distributed and used apply to the overall gas sector. Health and safety is an important element of these. Foremost among these is the Gas Act 1992 and the amendments of 2004 together with the Gas Regulations 1993. The sector therefore meets relatively stringent delivered gas quality requirements and networks are designed and operated to high standards.

Commerce Commission information disclosure requirements, which are similar to those for EDB's, provide information on gas pipeline reliability.

Oil

The oil sector must meet stringent and comprehensive fuel quality standards in particular to meet international standards as required by vehicle and aircraft manufacturers. In order to achieve this, the sector has a range of operational, monitoring, testing and reporting procedures in place. Under the Consumer Guarantees Act, goods that are normally bought for personal use must be of an acceptable quality, "fit for purpose", free of minor defects and safe. These guarantees apply to fuel purchased for private use. Under the Fair Trading Act, companies cannot misrepresent the qualities of a product they sell, so all fuel must be correctly labelled such as "Unleaded 91".

Regulations governing important properties of petrol and diesel for protecting consumers and the environment are the Engine Fuel Specifications Regulations 2008 (Regulations). These regulations describe the most important performance properties of fuel, such as the octane number, and specify limits for components that could cause harm to you, your vehicle or the environment. These components include aromatics, lead and sulphur.

Under the national fuel quality monitoring scheme, Trading Standards (part of the Ministry of Business, Innovation and Employment), organises testing of petrol and diesel samples to ensure oil companies are complying with the regulations. Testing under the scheme concentrates on the fuel's most critical properties, such as octane number, benzene level, contaminants, aromatics, water in diesel, and sulphur content. Motorists fund the fuel quality monitoring scheme through the petroleum fuels monitoring levy (PFML).

The delivered quality of oil is therefore very high and the liquid fuel delivery system, including operation and maintenance, must be to high standards particularly for health and safety reasons.

Coal

The quality of service delivery for coal is dependent on transportation links nationally (largely by rail) and locally (by road). Customers require coal of certain specifications to meet local regulatory requirements and to suit the end use technology available.

The types of coal transported range from low grade lignites to high grade bituminous coals and necessarily meet commercial specifications. Generally the timeliness of delivery is the key parameter and supply chains have stockpiles at source and delivery point to manage continuous extraction and use with batch delivery chains.

With the limited number of suppliers, and the constraints imposed by plant and regulatory requirements, customers often have very limited choices.

What Capacity is it at?

Considering energy in general, the small size of the New Zealand market leads to relatively dynamic supply and demand balances with susceptibility to step-changes in demand. The contribution one company can make is material. As the service sector contribution to GDP increases, the correlation of energy demand growth to GDP growth appears to be declining.

Electricity

Electricity generation appears to have appropriate headroom capacity available, with a range of options to meet changing demand over time and "N-1 contingency" to accommodate short term unplanned plant outages (N-1 refers to the system at all times being able to manage should the biggest single risk occur).

However, the generation mix may not be appropriate in the future, particularly with the decommissioning of thermal capacity. Thermal generation plays a key role by providing support at times of low hydro inflows, low wind generation and supporting seasonal demand profiles (e.g. high demand in the winter when hydro inflows are low). This role is also contingent on securing flexibility in gas supply

contracts to accommodate such variations in demand, an issue which is partially addressed by the Ahuroa gas storage facility, but is implicitly at odds with gas producers' desires for constant production.

Electricity transmission and distribution capacity is under regular information disclosure through Asset Management Plan processes and other performance requirements to the market (Electricity Authority) and competition (Commerce Commission) regulators. The Transmission and 17 of the 29 distribution businesses are price and quality controlled with their expenditure regulated through price and quality control regimes under the Commerce Act which can alter actual capital and operational spend allowances and timing of these from the schedules disclosed in businesses investment Plans. The Electricity Authority is an independent Crown entity responsible for the efficient operation of the electricity market with oversight of the system from generation through to customer service. Transpower publishes an Annual Planning Report which details the status of all projects that Transpower considers possible over the next 15 years. The latest is 2014, and the report ensures a transparent and comprehensive understanding including generation assumptions and distribution network assumptions, and more particularly provides assurance at a national and regional level of sufficient capacity.

An issue that needs to be considered is the gap between peak and trough demand. An increasing gap may lead to increasing price differentials on a daily basis, and the sector will need to consider opportunities to better manage peaks in order to delay capacity investment and gain better use of existing assets. From an infrastructure perspective, there is an emerging issue of possible divergence between volumes of electricity transmitted and peak demand. This creates a new gap, where revenue from kWh (electricity volume) pricing is creating a short fall for infrastructure investment (renewals and peak demand management).

A demand side market is emerging, supported by a number of recent initiatives in the wholesale electricity market. Capacity can in part be addressed by demand-side management.

Gas

There is confidence in on-going gas supply, with the presence of Methanex in the market being a good indicator of the overall situation (currently operating its three production trains). The number of gas fields, reserves levels, and high levels of upstream investment mean that gas supply capacity is now more certain than it was 10 years ago. Much of the reserves increments have come from existing fields using new technologies. However, lead times to develop new fields mean that there is growing concern that the next significant new opportunity has not yet been identified. However, the continuing relatively low oil prices are likely to act as a disincentive for exploration and development investment. The narrow and declining domestic gas market is also a barrier to development.

Gas transmission pipelines generally have good capacity, including ability to handle peak demand, for the foreseeable future; unless, or until, investment is driven by major new supply or load.

Work is underway through the Gas Transmission Investment Programme to address long-term transmission capacity and pricing issues. The Gas Industry Company (GIC) is active in advancing this matter.

Methanex has returned to operation of its three methanol trains, demand otherwise is generally flat to declining, in line with other developed countries, such as the UK, where gas demand is understood to have dropped 20 percent. Efforts are being applied to improve oil and gas reserves data to alleviate uncertainty in future supplies and encourage access to these supplies. Should substantial reserves of gas be accessed above current demand levels, there are a number of options available, including the possibilities of CNG (Compressed Natural Gas) for use in the transport fleet, LNG (Liquefied Natural Gas) for export, and additional Methanol production. It is possible that increased reserves may support growth in demand in these areas.

Oil

Oil production and processing have no known capacity issues within New Zealand. Private sector incentives and investments are aligned to optimise capacity supply and access economically recoverable resources. However, with refiners closing in Australia, crude production is having to be shipped further afield, increasing pressure to enable larger export tankers to operate, which would require infrastructure upgrades at Port Taranaki.

For supply, almost all oil is imported either as crude or product and delivered through ports throughout New Zealand. Storage facilities exist at various points in the supply chain. Within New Zealand, the distribution comprises some aged assets which are being de-mobilised, and opportunities exist to improve efficiency and supply chains. Refining NZ is a publicly listed company covering all

New Zealand's refining capacity and also distribution capacity via the Refinery to Auckland pipeline (RAP), and annual shareholder reporting provides a good measure of capacity and performance. The refinery will generally maximise production to its capacity, with the balance provided by international markets.

Petrol consumption continues to drop (42 percent to 41 percent of total demand in 2012) with diesel continuing to rise (42 percent to 44 percent of total demand in 2012). This follows trends in other developed countries.

Coal

The coal sector faces challenges in justifying up front capital investment in opening both underground and opencast mines. Strong environmental controls are applied in terms of consenting, health and safety, and labour regulations.

There is headroom to transport increased volumes with no known critical capacity pinchpoints.

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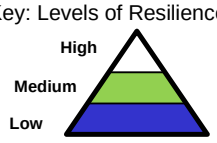
How resilient is it?

When considering the resilience of energy supplies, it is necessary to consider a range of attributes of resilience including: service delivery; adaptation; the community or users; responsibility; interdependencies; financial strength; continuity; and organisational performance. This encourages deliberations with users and greater transparency on the ability of energy systems to meet current and future needs in a comprehensive fashion, in order to achieve efficient and effective outcomes. Increased resilience is not necessarily achieved by greater investment and is often achieved by operational improvements.

There is increasing need to better articulate desired customer levels of service so that both supply and demand side can strive towards acceptable levels of resilience.

Key: Levels of Resilience



Electricity

With New Zealand's largely renewable electricity generation system and relatively limited hydro storage capacity, mainly in South Island catchments, there is vulnerability to low rainfall periods and a necessity to ensure sufficient generation capacity at all times. When hydro storage is being conserved, electricity flow will tend to reverse and be from the North to the South Island, and the (HVDC) transmission line from Benmore in the South Island to Haywards in the North Island is therefore a vital link.

	Resilience Expectation	Assessed Resilience	Desired Movement
Generation			
Individual Generator <300MW			–
Individual Generator >300MW			–
River Chain >300MW			–
Transmission			
66kV			↑
110kV			↑
220kV & >			↑
HVDC			–
Distribution			
Embedded generation			–
Distribution <11kV			–
Distribution 11kV			–
Distribution			↑
Retail			
Retail functionality			–
Customer Interface			↑

There is also vulnerability to windless days and the rate of change in wind generation. The volatility in wind generation has knock on effects in terms of requiring back up generation or load shedding to be available to the market at much shorter notice than the volatility experienced with hydro generation and with demand.

Growth in electricity demand is predominantly around Auckland, so over recent years transmission reinforcement from the south has been vital to ensure security of supply. This also translates to increased investment in the local distribution network, in this case the Vector network. Northland, being another net importer of electricity and having major industrial consumers such as the refinery, has been concerned for many years about supply risk. This is being partially alleviated by the same transmission upgrades and also regional generation developments.

As demonstrated by recent storm events in Wellington and Canterbury, in the electricity market risks to the distribution system and resilience are key considerations to reduce consequential economic and social losses associated with outages. The vulnerability of the "last kilometre" in parts of the system, the economic consequences of outage, and the duration of outage probably need increased attention. Largely for commercial reasons at this stage, some distribution companies are starting to deploy Remote Area Power Supplies (RAPS).

Vulnerability to external events are linked to vegetation management regulation and the ability to remove private trees adjacent to electrity line corridors. There is legislation in place which may need strengthening.

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Gas

In-built redundancy within critical supply chain elements and the industry's contingency management processes mean that unplanned interruptions of various durations, as occur from time to time, are rectified quickly and pass unnoticed by most other industry participants and consumers. Threats to the supply chain are reasonably understood, with the main hazards in respect of pipeline routing and facilities operation subject to statutory oversight/certification, regular monitoring, maintenance and/or mitigation works. MBIE published a study of gas disruption risk scenarios that concluded that current regulatory arrangements were appropriate. MBIE is currently considering submissions received.

This gas supply security assessment contributes to improving understanding of levels of resilience across the energy sector as mapped out in the assessment to the right made at a national level. As further evidence is developed, this tabulation will be refined and will be used to assist in prioritising efforts.

Gas	Resilience Expectation	Assessed Resilience	Desired Movement
Sources			
Gas Fields < X TJ/day			–
Gas Fields > X TJ/day			–
Imported LPG			–
Transmission			
Maui			–
Vector – to Huntly			–
Vector – Huntly to Auckland			–
Vector – National			–
Large Commercial			↑
Distribution			
Residential/small commercial			–
Large commercial			–
LPG Bottled			–
LPG Networked			–
Retail			
Retail functionality			–
Customer Interface			↑

Oil

New Zealand will remain highly vulnerable to international oil supply disruption and price. Through New Zealand's membership of the International Energy Agency (IEA), New Zealand is required to hold 90 days of stock effectively held through storage onshore and international arrangements where stock is held offshore. There are considerable Lifelines concerns about the inability of service stations to supply fuel during electricity outages and other emergency situations.

Oil	Resilience Expectations	Assessed Resilience	Desired Movement
International			
International supply ex Asia			↑
International supply ex elsewhere			↑
Refinery			
Refinery			–
Refinery to Auckland (RAP)			–
Wiri Terminal			↑
Coastal Distribution			–
Regional Storage			
Auckland, Wellington, **Christchurch**			↑
Elsewhere			–
Distribution			
Urban			–
Rural			–
Retail			
Retail – Individual sites			–
Retail – Area availability			↑
Customer Interface			↑

Coal

In-built redundancy within critical supply chain elements and the industry's stockpiling practices mean that unplanned interruptions of various durations, as occur from time to time, are usually rectified quickly and pass unnoticed by most consumers.

From time to time contractual arrangements may not offer long term assurance of supply. The domestic thermal coal market competes with the global market with imports from Indonesia for example occurring from time to time.

The financial status of some suppliers is of concern with potential for disruptions in supply.

Coal	Resilience Expectation	Assessed Resilience	Desired Movement
Sources			
Lignites			–
Sub-bituminous			–
Bituminous			–
Distribution			
Residential/small commercial			–
Large commercial			–
Large industrial			–
Export			–
Retail			
Retail functionality			–
Customer Interface			–

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What are we investing?

The energy sector has significant ongoing investment both to maintain existing facities and to invest in new.

In electricity there has been significant investment into the national grid which is now reducing as capacity margins are restored. The distribution sector will logically be required to make a similar capacity investment so that capacity margins between the national grid and consumers are also maintained. Investment in new generation, largely in wind and geothermal, has declined recently with the flattening in demand growth. Retirement of aging thermal plant is a current feature with associated demobilisation costs. Electricity distribution businesses continue to invest in asset renewals and capacity expansion in some regions, as well as exploring emerging smart technologies.

Gas investments are largely driven by petroleum and gas exploration as well as refurbishment of existing facilities to meet changed health and safety requirements. Exploration activities are showing signs of decline particularly as oil prices remain relatively low.

The oil refinery is making significant investments in improving efficiency and capacity. In oil distribution there is ongoing maintenance investment and some investment in new storage facilities.

There has been some investment and divestment in the coal supply system as sources increase or decline in importance. The most significant potential new investment is a new mining venture on the West Coast of the South Island by Bathurst Resources. This is expected to largely rely on existing national infrastructure. Bathurst has bought and developed production for the local South Island market but their flagship development is for export and is on hold due to low international coal prices. NZCC have recently consented and opened a new underground coal mine for export and other developers are looking at new production to meet demand in the South Island market.

A more complete assessment across the energy sector is yet to be made but current investment levels are considered reasonable and appropriate for the sector.

How productive is it?

The following is adapted from the document “Energy in New Zealand 2013” published by the Ministry of Business, Innovation and Employment. This document presents a range of energy sector performance indicators including energy intensity, emissions intensity, energy self-sufficiency and household energy affordability indicators.

Energy Intensity

Energy intensity is a measure of the energy used (in MJ) per unit of gross domestic product (GDP, in real 95/96 New Zealand dollars). It is influenced by both the composition of industry within the economy and improvements in energy efficiency. For a more detailed analysis of the drivers of energy use in New Zealand, readers are encouraged to read the report: *Changes in Energy Use – New Zealand, 1990–2012.*

Energy Intensity by Industry

Since 1990, the overall energy intensity of the economy has declined in real terms by an average rate of 1.4 percent per annum to 3.6 MJ per (95/96) dollar in 2012. The most significant factor in this almost 27 percent decline in energy intensity has been the rapid growth of the commercial sector (low energy intensity) relative to the industrial sector (high energy intensity). Energy intensity is not a good measure for economic growth. Better measures would be changes in GDP contribution or relative value of inputs to outputs of the energy sector compared to similar measures of productivity with peer countries. Efforts will be made to develop measures of economic productivity versus energy use. With these provisos the balance of this section is based on current energy intensity measures.

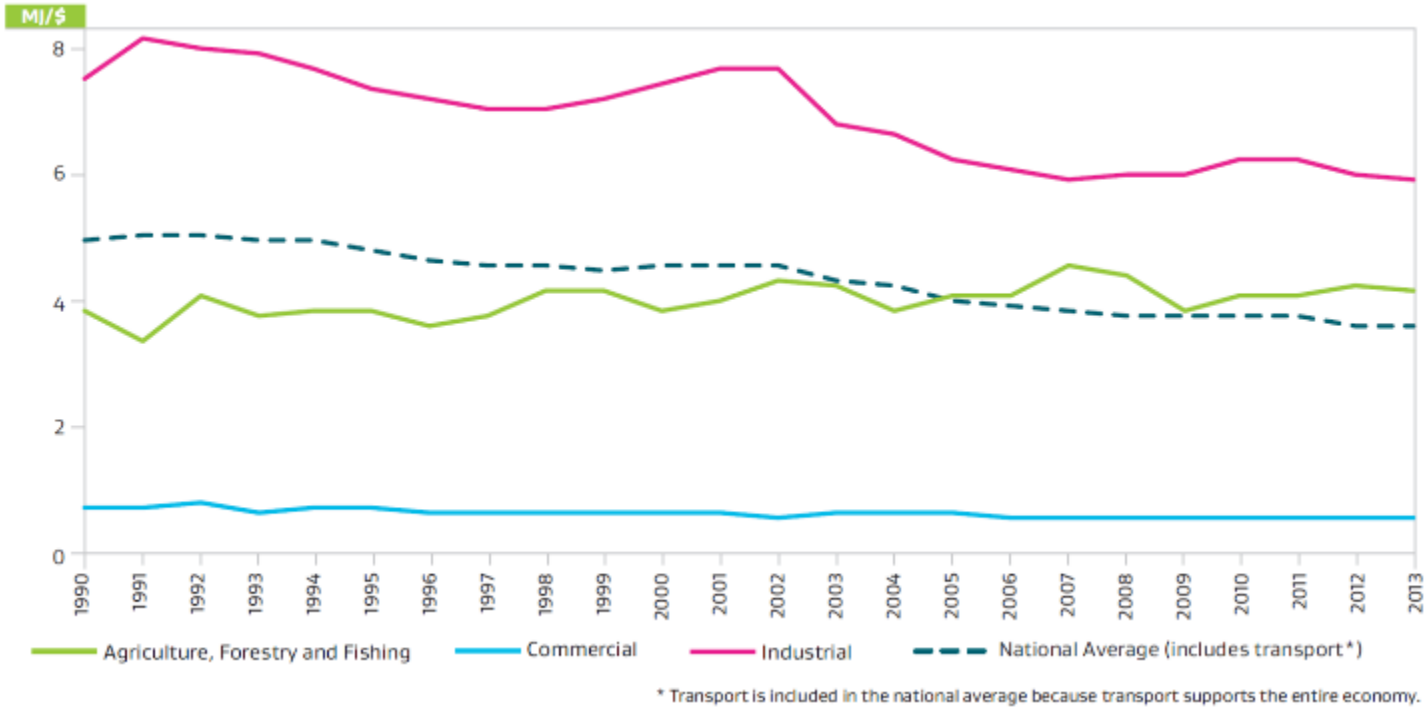
The figure below shows a time series of the energy intensity of industries within the New Zealand economy. In this chart, the dashed lines refer to individual industries, whereas the solid blue line is the average energy intensity of New Zealand. The individual industries within the New Zealand economy all showed decline in energy intensity since 1990. The agriculture, forestry and fishing sector’s

energy intensity has been relatively flat, but quite variable since 1990. The variability of the energy intensity is largely related to agricultural production volatility. The commercial sector is the least energy intensive sector at 0.6 MJ per dollar in 2012; this has declined steadily at a rate of 1.2 percent per annum since 1990. The energy intensity of the industrial sector (including chemical and metals manufacturing) has improved at an average rate of 1.0 percent per annum since 1990. It was relatively flat until 2002, when Methanex's Waitara Valley methanol production facility was mothballed. Industrial energy intensity increased in 2011, but has since fallen again in 2012. Factors affecting industrial energy use in 2012 included:

- Methanex restarting a second methanol production train at their Motunui plant in mid-2012 after signing a 10-year gas supply agreement with Todd Energy
- Production of aluminium at the Tiwai Point aluminium smelter was lower in 2012 than in 2011
- Production dropped in the wood, pulp and paper manufacturing sector.

Transport is New Zealand's most energy intensive sector, at 27 MJ per dollar in 2012. The energy intensity of transport has declined by 1.4 percent per annum since 1990.

Energy Intensity of New Zealand Industries



Source: Energy in New Zealand 2014 published by Ministry of Business, Innovation & Employment

How well are we managing it?

In general, there is a high level of information disclosure and oversight from MBIE, the Energy Efficiency and Conservation Authority (EECA), and Statistics New Zealand. Reporting obligations on many sector participants also contribute to high levels of transparency. MBIE has live energy information available on its website and regularly publishes the Energy in New Zealand (previously Energy Data File) and Energy Outlook: http://www.med.govt.nz/sectors-industries/energy/energy-modelling/publications/energy-in-new-zealand-02013

Electricity

Effective sector management is in place, but it is recognised that ongoing monitoring of arrangements is necessary to ensure that it is relevant and appropriate. Competition appears healthy in both the generation and retail markets. Electricity transmission and distribution is a monopoly market which is price and quality regulated.

Dominant in sector oversight are the Ministry of Business Innovation and Employment (MBIE) Infrastructure & Resource Markets; the Electricity Authority; the Commerce Commission for information disclosure and price-quality paths; and Transpower as System Operator.

The Electricity Authority (Authority) is an independent Crown entity responsible for the efficient operation of the New Zealand electricity market. Although independent, the Authority is required to have regard to Government Policy Statements and must pursue the statutory objective set for it in the Electricity Industry Act 2010 (Act) to promote competition in, reliable supply by, and the efficient operation of, the electricity industry for the long-term benefit of consumers.

Gas

Again, competition appears relatively healthy in this market and governance arrangements with a co-regulatory body are proving effective. There will always be tensions in gas supply due to the discrete nature of gas fields, their varying characteristics, relatively small New Zealand demand and the lumpy investment decisions on both the demand and supply side.

The Gas Industry Company (GIC) is the gas industry body, responsible for developing downstream industry governance arrangements that ensure gas (including natural gas and LPG) is delivered safely, efficiently and reliably to new and existing customers. The GIC is a special-purpose industry-owned company and co-regulator. It works closely with other regulatory bodies whose responsibilities also include the gas industry: Worksafe New Zealand for energy safety; MBIE for oversight of the co-regulatory model and consumer protection; and the Commerce Commission for information disclosure and price-quality paths. It is required to meet objectives in Part 4A of the Gas Act 1992 and Government Policy Statements. Its strategy is to optimise the gas industry's contribution to New Zealand.

For gas, as for electricity, technical, health and safety regulations are the responsibility of MBIE.

The New Zealand Petroleum and Minerals within MBIE has a role regulating upstream oil and gas activities.

The Gas Association (GANZ) represents companies and organisations in the gas sector involved in the transportation and trading of gas. GANZ represents interests across the major pipelines, networks, metering, and below the meter to equipment suppliers and installation. GANZ's prime focus is on the safety and technical aspects of the natural gas industry.

Oil

Appropriate sector management is in place but it is recognised that on-going monitoring of arrangements is necessary. MBIE has primary sector oversight at the government policy level and has recently led work on assessing oil security. This has resulted in Cabinet decisions on measures to improve domestic oil security and also confirmation of International Energy Agency (IEA) obligations for international security purposes. The Ministry of Civil Defence (MCDEM) oversees communication and coordination arrangements and readiness activities for oil supply during civil emergencies. International standard health, safety and environmental obligations lead

to high quality operations and management. Liquid fuel prices are substantially determined by international pricing and continuing price volatility is expected.

The oil refinery is a tolling facility with users able to direct source product from offshore markets or process crude through the refinery. It must therefore be price competitive. There is active competition in oil distribution and retailing with indications of rising distribution and retail margins. The total delivered price of liquid fuels is dominated by the international oil price component.

There are four major oil companies operating in the New Zealand market with healthy competition evident in the retail market, for example the availability of discounting through associations with supermarket chains and other loyalty programs. There are concerns around the reduction in the numbers of service stations predominantly in rural areas and along tourist routes.

Coal

The Coal Association of New Zealand operates through Straterra, the national organisation representing the mining and mineral sector. Straterra works with Government and the community, and promotes government and industry research investment to strengthen the industry's competitiveness and environmental acceptability.

Straterra is an active member of international organisations and research consortia to ensure current practices are internationally aligned and maintain awareness of technology development.

The regulatory environment primarily includes the Resource Management Act, the Crown Minerals Act, the Conservation Act, and Worksafe New Zealand for energy safety. Otherwise commercial arrangements between the parties, as well as global prices for coal dictate supply and demand.

What future trends and scenarios may impact energy infrastructure?

There are a range of trends impacting on the energy sector:

- WorkSafe Regulation – the hierarchy of controls can drive added cost into maintaining, replacing and operating energy infrastructure
- Electricity volumes are falling while demand keeps increasing, impacting through lower revenues for increasing investment requirements
- New Zealand is in a good strategic position (high levels of renewable generation) to take electricity into transport fleets.
- Oil and coal prices have been declining increasing uncertainty in investment markets.

As part of the development of the Evidence Base for New Zealand's infrastructure, the NIU has undertaken an investigation into future pressures placing demand on our infrastructure for a range of plausible scenarios: a central scenario (best estimate of future infrastructure demand), an upside scenario (high infrastructure demand) and a downside scenario (low infrastructure demand).

Each scenario has an associated set of projections of future infrastructure demand. The NIU has not produced any new models or forecasts in this regard. Rather, we rely upon existing sector forecasts where applicable and relevant. In the energy sector, our analysis primarily relies upon extensive modelling and forecasting completed by MBIE and Transpower.

The full results of our scenario modelling investigation have been published in a separate document available on the NIU website, but relevant extracts for the Energy sector are reproduced below.

Implications for energy infrastructure in the central scenario

The implications for our energy infrastructure in the central scenario are drawn primarily from modelling completed by MBIE (Energy Outlook: Reference Scenarios 2011, Energy Outlook: Insights 2013) and by Transpower (Transmission Tomorrow and Transmission Tomorrow: Enduring Grid).

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The key pressures in the central scenario are related to trends in peak load and base load (and the ratio between the two), spatial distribution of future demand and the mix of installed generation types.

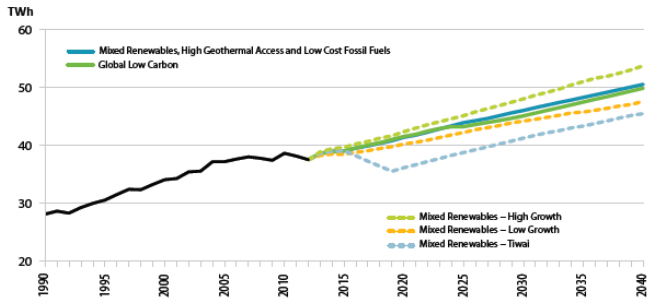
Based on the assumptions for the central scenario, the modelling completed by MBIE and Transpower suggests the following implications for our energy infrastructure:

- Electricity demand grows on average by 1.1 percent per annum through to 2040;
- Increased irrigation and the use of heat pumps will continue to boost summer energy demand. Irrigation, in particular, will increase the utilisation of the grid on the east coast of the South Island;
- Additional capacity for the regional connections to the backbone grid is less certain with more variation between scenarios. For the regional connections, newer technology options for better utilising the grid, such as extracting more capacity from the existing lines or the use of demand-side management, have added value;
- There is likely to be significant investment in geothermal plants (with their share of electricity generation projected to grow from 14 percent in 2012 to between 21 percent and 29 percent in 2040);
- Demand for wind power will increase modestly, although its relative cost in comparison to other electricity sources will continue to constrain its growth;
- Geothermal and wind power can make only a minimal contribution to meeting peak demand. As such, future investment will be necessary to establish flexible peaking capacity, demand management initiatives and/or energy storage options;
- Demand for gas is expected to remain relatively steady and will continue to come from price sensitive users such as petrochemical manufacturing facilities and power generators, as well as from other industrial, commercial and residential users. Assuming successful exploration, robust reserves and upstream investment would reasonably be expected to ensure supply matches demand for the short to medium term. There is concern that continuing relatively low oil prices may not support investment;
- Both the extraction and export of oil from Taranaki and the import of oil are expected to continue along current trends; and
- The central scenario incorporates high uncertainty (and relatively low impacts) from new technologies such as electric vehicles and household photovoltaic panels due to their cost differentials in comparison to other options.

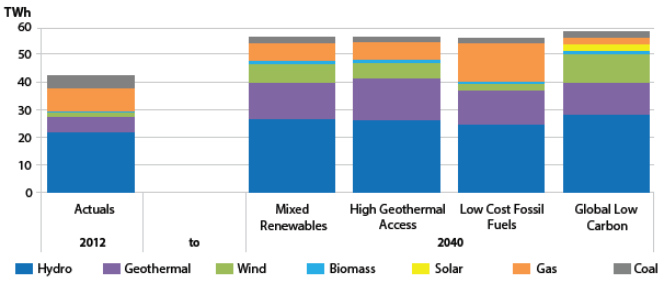
Further, Transpower's analysis found that the type, location, size and timing of generation development are the greatest sources of uncertainty. Generation development will occur in response to demand as well as the type of fuels that are available. With a substantial amount of energy generation resources potentially available in New Zealand, it is difficult to predict where and when this development might occur.

On balance, MBIE estimate that $14 billion in new generation investment will be needed by 2030. Estimates for electricity demand and generation are reproduced below:

Grid level electricity demand by scenario



Electricity generation by scenario



Source: Ministry of Business, Innovation & Employment (2013)

EVIDENCE BASE 2015: ENERGY SECTOR

Industry in New Zealand

With a relatively small population by global standards, demand on our infrastructure can be heavily influenced by industrial activities such as forestry, mining, and steel and aluminium processing. In New Zealand, these industries are concentrated in a small number of locations and in a small number of firms that are exposed to global markets. Forestry is concentrated in the north of the North Island, steel processing south-east of Auckland and aluminium processing in Southland. Accordingly, fluctuation in demand has the potential to occur at point sources and in discontinuous steps rather than gradual trends.

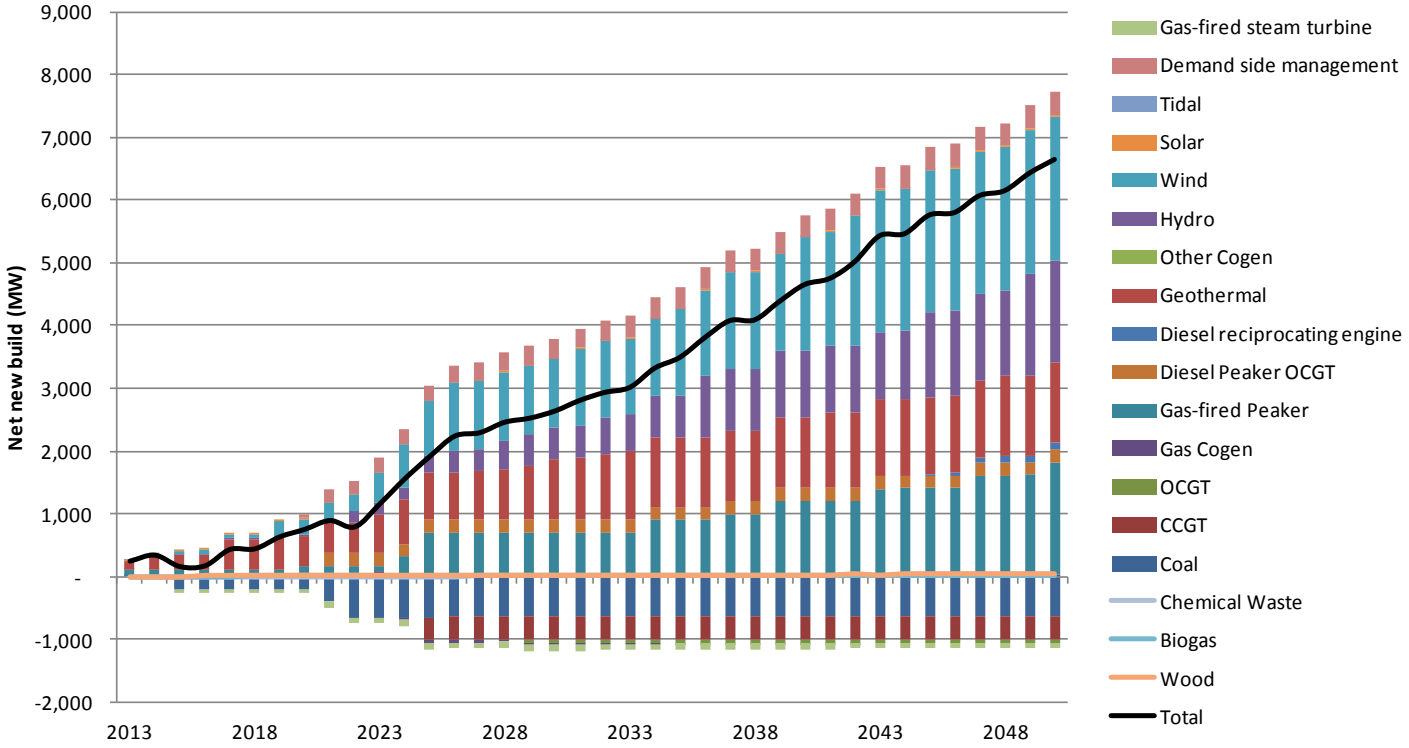
For example, since 2004, the wood processing industry's energy demand has declined rapidly by over 30 percent from its peak (MBIE, 2013). More recently, the future of aluminium production in New Zealand has been called into question. With about 15 percent of the country's electricity supply used by the Tiwai Point aluminium smelter, the potential impact on infrastructure is considerable.

Overall, we assume a gradual decline of heavy industry in New Zealand in the central scenario. The upside scenario assumes a return to peak demand, while the downside scenario assumes an accelerated decline of heavy industry. However, we do not speculate on the future of specific heavy industries. Nonetheless, careful infrastructure planning is required to ensure we are prepared for step changes in demand created by industry – on the upside or the downside.

Implications for energy infrastructure in the upside scenario

Modelling by MBIE (discussed in detail in the central scenario section) considers the impact of high energy demand driven by higher than expected population and economic growth. Based on MBIE's projections in the high demand scenario, the net new build for electricity generation is shown by fuel type in the graph below.

New build by fuel type in the high demand (upside) scenario



Source: Ministry of Business, Innovation & Employment, Treasury analysis

Source: NZ Petroleum & Minerals

Our upside scenario also considers the possible impacts emanating from the extensive oil and gas exploration that is underway in New Zealand. At present, New Zealand's gas production is located within the Taranaki region. Although Taranaki is comparatively well placed to support new oil and gas discoveries (of a certain magnitude), a non-Taranaki discovery worthy of development is likely to be substantial and the extracted product exported.

A large, new discovery in Taranaki would increase the pressure on existing infrastructure in the region, some of which is already nearing capacity. Deep water discoveries may also change the type of infrastructure that is required (e.g. to service floating liquefied natural gas operations rather than onshore processing).

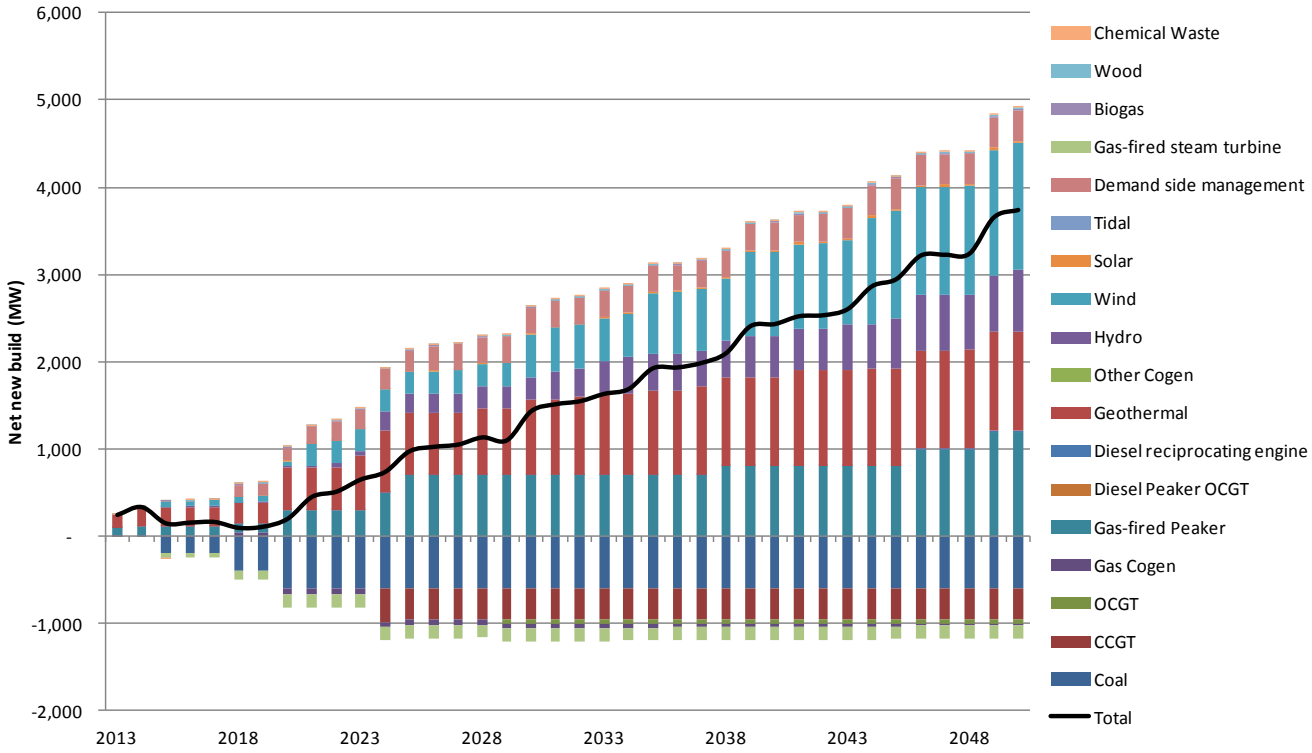
It is difficult to predict the location, timing and likelihood of a significant discovery. However, given the extent of New Zealand's petroleum basins, the probably of such an event occurring cannot be entirely discounted – especially with the current upswing in exploration activity.

Should a major oil or gas discovery occur, new or upgraded transport links, water infrastructure and social infrastructure will also be required to support the development – a clear example that demonstrates the interdependence of our infrastructure networks.

Implications for energy infrastructure in the downside scenario

Modelling by MBIE (discussed in detail in the central scenario section) considers the impact of low energy demand driven by lower than expected population and economic growth. Based on MBIE's projections in the low demand scenario, the net new build for electricity generation is shown by fuel type in the graph below.

New build by fuel type in the low demand (downside) scenario



Source: Ministry of Business, Innovation & Employment, Treasury analysis

As with most of the other sectors in the low demand scenario, the implications for our electricity infrastructure generally translate to a delay and reduction in size of new investment and underutilised or oversized assets.

In the oil and gas sectors, the downside scenario assumes few or no new discoveries (and/or policy changes that negatively impact exploration in New Zealand). In this case, production is expected to decline, which could lead to a gap between gas supply and demand, as well as underutilised oil export assets. At the same time, new infrastructure may be required to import energy to address the gap in gas supply and demand.

Sources

Electricity Information Disclosures. Suppliers of electricity lines services are subject to information disclosure regulations under Part 4 of the Commerce Act 1986. http://www.comcom.govt.nz/regulated-industries/electricity/

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