INFRASTRUCTURE EVIDENCE BASE

Scenario/Trends Analysis

February 2014

NATIONAL INFRASTRUCTURE UNIT

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SCENARIO/TRENDS ANALYSIS

A Discussion Document by National Infrastructure Unit

February 2014

The government committed to a number of actions to give effect to the vision and guiding principles that underpin the 2011 National Infrastructure Plan. A core group of these actions relate to building an evidence base to better understand:

- the **pressures** that place future demand on our infrastructure (scenario modelling workstream)
- the current **state** of our infrastructure (performance indicators, resilience and capital intentions), and
- the **response** to changes in the state and pressures on our infrastructure (an upcoming suite of initiatives).

This publication supports the first action (above) by summarising the outcomes of the investigation into future pressures placing demand on our infrastructure for a range of plausible scenarios.

Objective

The purpose of the scenario modelling workstream is to answer the following key questions regarding infrastructure:

- What are the future drivers of demand?
- Based on these drivers, what are the plausible alternative scenarios for future demand?
- What are the implications from a cross-sector, whole of New Zealand viewpoint?

Methodology

The scenario modelling workstream commenced in May 2013, with the National Infrastructure Unit (NIU) identifying major trends already noted by infrastructure sectors. Workshops were held with stakeholders to discuss these trends and to consider what scenarios would be of most value for the NIU to develop.

Further consideration has led to NIU using the following methodology to undertake the scenario modelling exercise:

1. Conduct a preliminary desktop review to gather existing trend data from infrastructure sectors
2. Hold a series of workshops across New Zealand to solicit input on key trends and possible scenarios for consideration
3. Conduct an in-depth review of trend data for key drivers of demand
4. Using the key drivers of demand that have been identified, create three cross-sector, whole of NZ scenarios that represent alternate views of future demand
5. For each scenario (central, upside and downside), analyse the future implications for NZ infrastructure using existing sector data
6. Consult with stakeholders to test the scenarios and outcomes of the analysis – and revise accordingly
7. Produce a clear and concise report summarising the scenario modelling outcomes as part of the evidence base

N.B. NIU is not producing any modelling itself, but using sector data and scenarios.

Scenario modelling in the context of supply and demand

New Zealand's demand for infrastructure is constantly changing. In this publication, we develop three alternative scenarios of the future and then rely on existing modelling (by each sector) to translate these scenarios into expected infrastructure demand.

The supply-side response to future demand is outside the scope of this publication. Instead, the way in which we respond to future pressures is addressed through other NIU workstreams (e.g. demand management, capital intentions plan) and will be a key focus of our work over the coming year.

SCENARIO/TRENDS ANALYSIS

Scenarios, forecasting and the strategic planning process

Gazing into the crystal ball of New Zealand's infrastructure is an inherently hazy endeavour. We cannot, with absolute clarity, predict the location and timing of our infrastructure investment needs over the next 50 years. We can, however, ensure that we have the correct processes and systems in place to effectively inform our decision making.

In that context, strategic planning relies (in part) on two related, but distinct, processes for understanding our future requirements – namely, scenario planning and forecasting. The New Zealand Transport Agency (NZTA) defines these techniques in the following way:

- **Scenarios** – an alternative set of possible futures. Scenarios say what might happen given a set of observed mega-trends. Scenarios do not predict the future; rather they help to guide our decisions using a qualitative view of what may lie ahead.
- **Forecasts** – a quantitative view of the future (either singular or alternative). Forecasting relies on trends and other input variables to predict a best estimate of what lies ahead.

The trends and scenario modelling described in this document represents somewhat of a hybrid approach. First, we build a set of scenarios that describe alternative views of the future (a central scenario, an upside scenario and a downside scenario). Then, to the extent that data is available, we make use of forecasts and projections that align with our scenarios in order to develop the evidence base that provides a quantitative range of future infrastructure demand.

Box 1. Scenario modelling in New Zealand

There are several government agencies in New Zealand that use scenario modelling as a planning tool. In this investigation, the NIU draws upon existing scenario data published by these agencies rather than producing new modelling. Accordingly, the NIU acknowledges the scenario modelling work completed by the following agencies:

- **NZTA** – NZTA have a well-established programme to analyse mega-trends and construct scenarios to inform their strategic planning process. NZTA's scenario planning is a continuously evolving process.
- **MoT** – the Ministry of Transport also uses scenario modelling and has been working with NZTA (in collaboration with NZIER) to develop a long term transport demand model. In addition, a Future Freight Scenarios study is underway and should be published in early 2014: http://www.transport.govt.nz/research/nationalfreightdemandsstudy/
- **MBIE** – The MBIE energy modelling team periodically updates a range of scenarios regarding energy demand, supply and generation: http://www.med.govt.nz/sectors-industries/energy/energy-modelling/modelling
- We are also grateful for the input and comments received from a wide range of stakeholders – including numerous government agencies, private sector entities and academic institutions.

Other notable scenario modelling initiatives

Scenario modelling is used by numerous companies, governments and institutes around the world. Two notable initiatives (of many) are referenced below to provide a broader, international perspective:

- **Shell** – An early adopter of scenario planning. An extensive set of Shell's scenario publications and guidance can be found here: http://www.shell.com/global/future-energy/scenarios.html
- **International Energy Agency** – IEA use scenarios to investigate and model various alternative futures regarding energy and technology: http://www.iea.org/publications/scenariosandprojections/

Infrastructure and the driving forces of change

We have grouped the major trends affecting infrastructure demand into four categories: population, economy, technology and resources. The table below shows the variables with potential to exert the greatest influence on our infrastructure requirements based on NIU's analysis:

Table 1: Key drivers of change

1) Population	2) Economy	3) Technology	4) Resources
Total population Age profile Regional distribution	Demand for commodities Service sector growth Heavy industry decline Funding constraints	Intelligent networks Technology-driven behaviour change	Water quantity and quality Carbon price & emission limits Climate change impacts Oil / gas discovery & price movements

Source: NZTA mega-trends study (2012), Treasury analysis

The influence of any one driver of change (e.g. technology) cannot be entirely isolated from another (e.g. economy). Nor can these drivers of change be neatly separated into domestic and international components. Rather, a frequently reoccurring theme in this study is one of interdependence – between New Zealand and the global economy, between the key drivers of change and between our infrastructure sectors.

The relationship between infrastructure and each of the key drivers of change – population, economy, technology and resources – is discussed in more detail below.

1. Population

The number, age profile and spatial distribution of our population correlates strongly with the assets and networks that underpin our society – from schools and hospitals to water services, transport links and energy supply. Whether the population grows or declines, gets older or younger – and in which locations these changes occur – can have a widespread impact on future infrastructure investment requirements.

Whereas aggregate demand is important for some sectors (e.g. electricity, which has a national grid), local population is important for other sectors (e.g. water, where networks tend to be more localised).

Population trends: the central scenario (business as usual)

A summary of recent population projections by Statistics New Zealand (national, regional and age profile) is shown below:

Figure 1: Total population

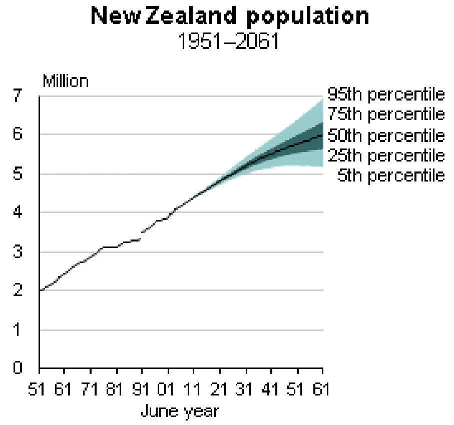


Figure 2: Age distribution

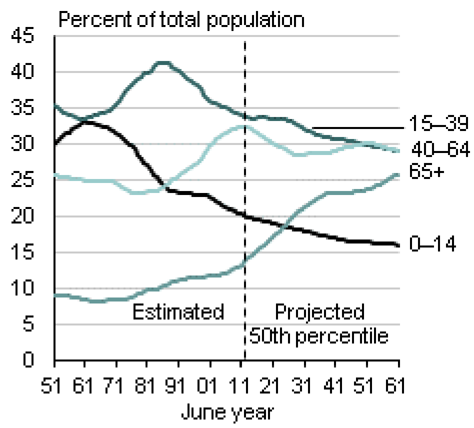
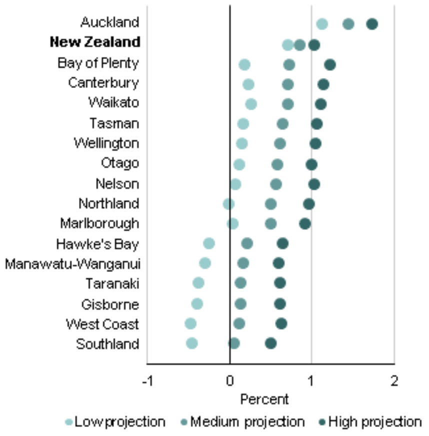


Figure 3: Regional growth



Source: Statistics New Zealand (2012)

By 2061, the population is estimated to increase from 4.5 million (2013) to 6.0 million based on the medium projection (i.e. the 50th percentile probability).

In the medium projection, the proportion of population aged 65+ (14% in 2012) is estimated to be 26% in 2061. Consequently, the rate of growth is projected to slow as our population ages.

Statistics New Zealand projects that 50 territorial authority areas will have fewer children in 2031 than in 2011 and 17 territorial authority areas will have less people outright by 2031 (although all regions are expected to grow over this time).

Urbanisation of our population is projected to continue, with the highest growth occurring in Auckland (reaching almost 2 million inhabitants by 2031 in the medium projection).

Key uncertainties: upside and downside factors

Key population uncertainties that may affect our infrastructure requirements include:

- **Total population** – ranging from 5.2 million in 2061 (low estimate) to 7.0 million (high estimate)
- **Ageing** – all projections show an increase in age. However, some uncertainty exists in the fertility rate and migration levels, and
- **Regional shifts** – the degree to which population consolidates in urban centres (especially the upper half of the North Island) will affect the size and location of some infrastructure.

Scenario development

Taking into account the business as usual estimates and key uncertainties, the potential future scenarios (as they relate to population) are summarised below:

Table 2: Population variables for each scenario

Driver of change	Central Scenario	Upside Scenario	Downside Scenario
Total population	6.0 million by 2061	7.0 million by 2061	5.2 million by 2061 (decline after 2051)
Age profile	Steady ageing	Slower ageing (high fertility & migration)	Accelerated ageing (low fertility & migration)
Regional distribution	Steady urban growth at rural expense	High urban growth and rural decline	Urban growth is constrained, rural growth static to declining

Source: Treasury analysis

2. Economy

The changing landscape of the New Zealand economy – and its interaction with the global economy – influences the type, location and amount of infrastructure that is required to enable our prosperity. In return, resilient, efficient and coordinated infrastructure networks are vital to a well-running economy.

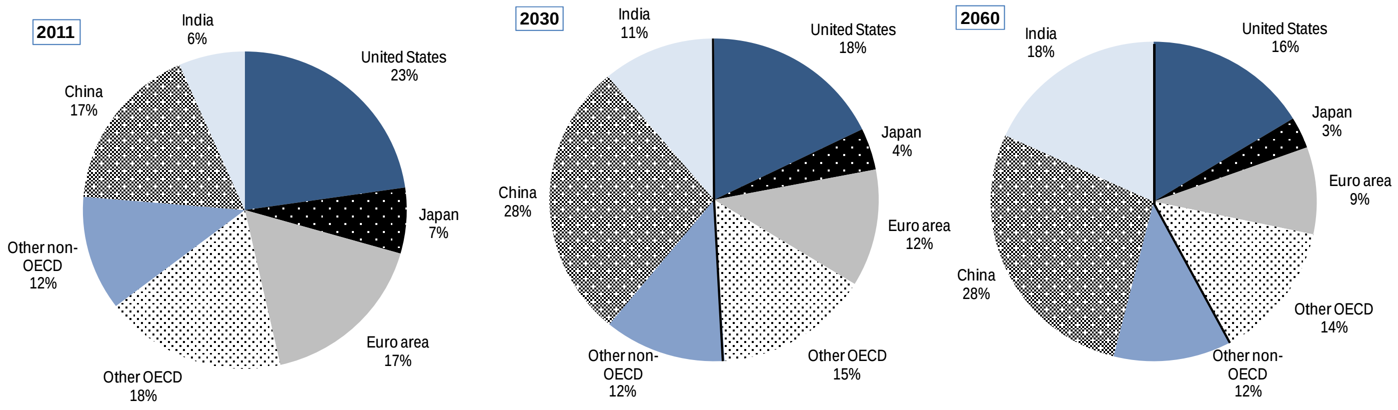
As a small nation with an open market, trade is an essential component of New Zealand's economy through the export of goods and services and the import of raw materials and capital equipment. Maintaining a stable and transparent regulatory environment is also a key factor in encouraging both foreign and domestic investment in our country.

Our reliance on trade makes clear the critical role that our ports and airports play in linking New Zealand to the world. Similarly, our telecommunications infrastructure plays a supporting role in connecting us, socially and economically, to our neighbours in the Pacific and around the world.

Domestically, we depend on road and rail networks for the movement of goods and people. We also depend on reliable supplies of water, energy and social infrastructure to support our residents, communities and businesses. In addition, the efficiency with which these services are provided indirectly affects our global competitiveness.

Key economic trends

Taking a broad view of recent trends, the geographic context of the world economy is changing with the advent of the 'Asian century'. For example, China and India are projected to double their combined share of global GDP in the next 50 years, from 23% in 2011 to 46% in 2060 (OECD, 2012).



Source: OECD (2012)

The influence of China, in particular, on New Zealand's economy has grown in recent years. In 2008, China overtook the United States to become New Zealand's second largest trading partner after Australia (New Zealand Treasury, 2013). The projected rise in wealth, living standards and changing dietary tastes in China has implications for New Zealand in terms of our export commodities (e.g. dairy, meat, forestry) and our export services (e.g. tourism, education). A sustained increase in commodity demand will likely create a need for investment in our productive water infrastructure, freight networks and supporting infrastructure.

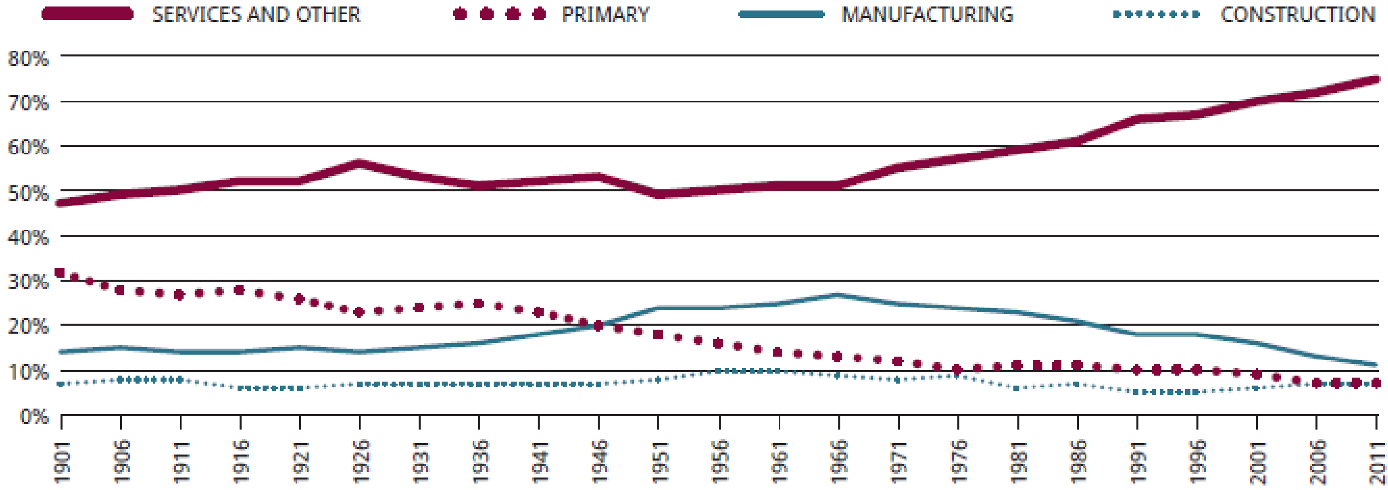
More immediately, the world economy continues to be plagued by uncertainty in the aftermath of the global financial crisis. The recovery has been uneven, with little to no growth in Europe, a moderate recovery in the United States and mixed results in the other advanced economies – with persistent upside and downside uncertainties projected to remain (OECD, 2013).

Turning toward the domestic economy, regional data paints a highly segmented picture. The Regional Economic Activity report (Ministry of Business, Innovation & Employment, 2013) shows:

- A divergence between overall economic activity (dominated by urban areas, especially Auckland) and export activity (dominated by the primary sector in rural areas), and
- Distinct regional activities, impacted by different trends and with different implications for infrastructure. Key statistics from the MBIE Regional Economic Activity report include:
  - Half of New Zealand's professional services workers live in Auckland and another 20% live in Wellington
  - The majority of our forestry industry is located north of Taupo
  - Over half of our petrol is processed at Marsden Point in Northland
  - Waikato (in particular) and increasingly Canterbury and Southland are key dairying regions
  - Sheep and beef farming is concentrated in the Manawatu-Wanganui, Canterbury and Otago regions, and
  - Mining is concentrated in the areas of the West Coast and the Coromandel.

The trend toward urbanisation of our population is mirrored by the trend of an increasing share of employment in the service sector:

Figure 4: Employment shares by industry (1901 to 2011)



Source: MBIE Regional Economic Activity Report 2013 (based on Stats NZ and NZIER data)

Key uncertainties: upside and downside factors

Key economic uncertainties that may affect our infrastructure requirements include:

- **Demand for commodities** –the increasing income and wealth of emerging economies has led to an increased demand for commodities. The degree to which the appetite for agricultural commodities is sustained will have a significant impact on New Zealand.
- **Service sector expansion** – the service sector as a share of New Zealand's employment has been increasing since the 1960s. The extent to which this trend continues (or regresses) is linked with the urbanisation of our population.
- **Heavy industry growth** – The future of heavy industry (e.g. wood processing, aluminium smelting) is uncertain – demand (or lack thereof) from these sectors can have a major impact on electricity demand (among other sectors).
- **Funding constraints** – events which lead to rising public debt levels may constrain our ability to build and maintain infrastructure. Low incomes and/or high infrastructure expenditure may similarly constrain consumer ability to pay.

Scenario development

Taking into account the business as usual estimates and key uncertainties, the potential future scenarios (as they relate to the economy) are summarised below:

Table 3: Economic variables for each scenario

Driver of change	Central Scenario*	Upside Scenario	Downside Scenario
Demand for commodities	Export volume growth at long-term trend rate	Rapid increase and sustained long-term demand for dairy, wool, meat, seafood	Decline in commodity export volumes and/or prices
Service sector expansion	Continued steady increase (esp. Auckland)	Rapid growth (Auckland-centric)	Decline or slow growth in services
Heavy industry (e.g. aluminium, wood processing)	Continued slow decline of most heavy industries	Return to peak demands	Rapid decline of heavy industry – individually or collectively
Funding constraints	Manageable public and private debt, consumer ability to pay	Low public and private debt, high incomes / consumer ability to pay	High public and private debt, low incomes / consumer ability to pay

Source: Treasury analysis. Note: The Central Scenario assumes national GDP growth in line with the Treasury's 2013 Statement on the Long Term Fiscal Position.

3. Technology

Innovation and technology drive productivity improvement and are the key enablers of long-run economic growth in New Zealand[1]. Although forecasting productivity improvement is fraught with difficulty, the last two decades have seen a proliferation of technology and innovation worldwide. How these new technologies are integrated into our industries, our behaviours and – indeed – into our infrastructure, may play a large part in determining future infrastructure needs.

Changes in technology may impact our future infrastructure requirements by:

- Creating demand for technology infrastructure itself (e.g. Ultra Fast Broadband)
- Altering demand and/or investment requirements by: influencing behaviours (e.g. smart meters), increasing asset performance and utilisation (e.g. intelligent networks), or adopting current design and operation methodologies when renewing century-old infrastructure, and
- Changing the structure and location of our industries (e.g. teleworking, online retail).

Most notably, through the Ultra Fast Broadband (UFB) initiative, the government has committed to installing a fibre network that will be available to 75% of New Zealanders by 2020 – a multi-billion dollar investment in new infrastructure. Combined with the Rural Broadband Initiative (RBI), the government estimates that 97.8% of New Zealand's population will have access to these schemes.

The UFB network and increased speed of mobile networks (i.e. 4G) may also enable an increase in teleworking. The resulting decrease in demand on our transport networks (during peak commuting hours) would create infrastructure savings, although it is difficult to ascertain the extent to which better, faster communication links will catalyse this behaviour.

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1 In telecommunications, the bulk of technology innovation takes place outside of New Zealand with the result that sector profitability is key to accessing those innovations for use in NZ.

Finally, the age of technology has the potential to change the entire structure of some industries – for example, forcing shopping centres and CBD retail precincts to focus on service-related activities rather than trading in products. This becomes relevant in an infrastructure sense when considering the impact on our transport networks. Although overall demand may not change, the altered patterns and timing of vehicle movements may have new, location-specific implications.

Box 2. Intelligent networks – making better use of existing infrastructure

Intelligent networks combine information and communication technology with hard assets (e.g. roads or power assets).

What is an intelligent network?

An intelligent network is one that:

- Can monitor performance, remotely sense asset condition, assess availability of the network, monitor utilisation and communicate this information to both users and managers of the network
- Can be embedded with new infrastructure or installed retroactively
- Is site-specific or system-wide

In essence, an intelligent network transforms ‘dumb’ assets into ‘smart’ assets and drives networks to work harder and perform better. The potential value offered by intelligent networks can be categorised in four ways:

- **Exploit existing capacity** by creating networks that can actively manage peak demands (defer the need for upgrades) or by removing the need to design assets for worst case scenarios (reduce the size of future upgrades)
- **Extend asset lives** through targeted, cost-effective condition monitoring and performance reporting
- **Reduce operating costs** – for example by deploying leak detection technologies combined with predictive analytics that reduce leakage, reactive maintenance and energy usage in water networks, and
- **Mitigate the risk of failure** by harnessing real-time data that enables informed decision making in both the short and long term.

Despite the potential benefits offered by intelligent networks, this is an emerging field with outcomes in some areas that are still uncertain. As with all infrastructure, the benefits must therefore be weighed against the costs of deployment.

One noteworthy initiative in the realm of intelligent networks is the Ministry of Transport’s Intelligent Transport Systems action plan. Currently under consultation, this plan aims to capitalise on technological opportunities available in the transport sector (http://www.transport.govt.nz/ourwork/intelligenttransportsystems/).

Key uncertainties: upside and downside factors

Key technology demand uncertainties that may affect our infrastructure requirements include:

- **Emergence of intelligent networks** – integration of sensors, communication links, data analytics and control mechanisms with our infrastructure assets could greatly improve efficiency and utilisation. However, the timeframe for these developments is uncertain and the effectiveness – on a large scale – is still to be proven.
- **Technology-driven behaviour change** – technology has the potential to empower residents to control their timing and quantity of infrastructure consumption (e.g. smart energy meters, increase in telecommuting).
- **Adoption rates** – the rate at which New Zealand residents and businesses adopt the applications and services enabled by new technologies is one determinant in the timing of technology-based societal shifts.

Scenario development

Taking into account the business as usual estimates and key uncertainties, the potential future scenarios (as they relate to technology) are summarised below:

Table 4: Technology variables for each scenario

Driver of change	Central Scenario	Upside Scenario*	Downside Scenario*
Emergence of intelligent networks	Gradual integration of technology with assets	Slow integration of technology with assets	Rapid integration of technology with assets
Technology-driven behaviour change	As projected UFB take-up and 4G / 5G mobile demand	Slow adoption of UFB and low 4G / 5G mobile network usage	Rapid adoption of UFB and high 4G / 5G mobile network usage

Source: Treasury analysis. Note: The upside scenario relates to high infrastructure demand (viewed as low technology usage) – and the reverse for the downside scenario. Demand for technology infrastructure itself is taken as a by-product of these changes.

4. Resources

Resource availability can be both a constraint and an enabler for our economy. For example, 47% of the world population is projected to live in areas of high water stress by 2030 (OECD, 2008). If this trend continues, New Zealand will be well placed to leverage our relatively bountiful water resources to produce water-intensive agricultural commodities for export to drier and less fertile parts of the world. Nonetheless, domestic demand for fresh water may arise from multiple sources – agricultural, urban, recreational, environmental and cultural – driving a need for mutually beneficial solutions where localised water scarcity emerges in New Zealand.

Sitting alongside water quantity as a key driver of change is the water quality in our lakes and rivers. Changes in market or societal expectations in managing water quality may emerge through pathways such as consumer preferences based on environmental accreditations, regulations or environmental limits. At the same time, demand for our agricultural commodities (especially from grazed animals[2]) may focus more attention on ways to achieve good water quality outcomes for all sectors of society.

Constraints in other resources, such as emissions limits and carbon pricing, may present both risks and opportunities for New Zealand. Similarly, a changing climate – whether more frequent floods and droughts, increasing temperatures, higher sea levels or changing patterns and locations of rainfall – presents us with risks (domestically) and opportunities (if we are less severely affected at the margins than other regions of the world).

Apart from water and climate, oil and gas are also important resources that can drive a change in infrastructure demand. Almost 40% of our consumer energy is used for transport – and oil accounts for approximately 98% of our transport fuel.

Separate to fuel for the transport system (which is mainly imported), the discovery of new oil and gas reserves within New Zealand may create high demand for infrastructure.

[2] It is expected that agricultural land will be used to generate the highest and best value over time. At present, the trend is toward producing animal proteins – which can increase contaminant loading in waterways in the absence of appropriate management techniques (whether infrastructure-based or non-infrastructure solutions). However, it should be noted that intensified land use may in fact shift over time to activities that do not place as much pressure on water quality as does animal grazing (aided by irrigation infrastructure which improves water supply reliability and enables a wider range of land use including annual crop-based uses).

Box 3. Climate change impacts in New Zealand

The Ministry for the Environment (MfE) projects the likely climate change impacts in New Zealand to be:

- higher temperatures, more in the North Island than the South, (but still likely to be less than the global average)
- rising sea levels
- more frequent extreme weather events such as droughts (especially in the east of New Zealand) and floods
- a change in rainfall patterns - higher rainfall in the west and less in the east.

The MfE lists the following potential positive and negative effects from the changing climate:

- agricultural productivity is expected to increase in some areas but there is the risk of drought and spreading pests and diseases. It is likely that there would be costs associated with changing land-use activities to suit a new climate
- people are likely to enjoy the benefits of warmer winters with fewer frosts, but hotter summers will bring increased risks of heat stress and subtropical diseases
- forests and vegetation may grow faster, but native ecosystems could be invaded by exotic species
- drier conditions in some areas are likely to be coupled with the risk of more frequent extreme events such as floods, droughts and storms
- rising sea levels will increase the risk of erosion and saltwater intrusion, increasing the need for coastal protection
- snowlines and glaciers are expected to retreat and change water flows in major South Island rivers.

Source: Ministry for the Environment (http://www.mfe.govt.nz/issues/climate/about/impacts.html)

Key uncertainties: upside and downside factors

Key uncertainties regarding resources that may affect our infrastructure requirements include:

- **Carbon price and emissions limits** – a high carbon price – if it eventuates – is likely to reduce energy usage.
- **Climate change impacts** – the rate at which the sea level rises will have varying impacts on our low-lying, coastal infrastructure, and an increasing prevalence of droughts will threaten the productivity of our agricultural sector.
- **Water quantity and quality** – global water scarcity may be beneficial given our relatively high availability of renewable water resources (although domestic water scarcity is likely to exist in some areas). Increasing demand and expectations for both water quantity and water quality may lead to competition between agricultural, environmental, recreational and cultural sectors for both abstraction and discharge rights.
- **Oil / gas discovery** – much of our oil and gas infrastructure is based in Taranaki. A major discovery elsewhere (if it requires onshore processing) may create significant demand for new infrastructure. Similarly, a major new discovery in Taranaki would increase the pressure on infrastructure that is already in high demand. On the other hand, declining domestic gas production may shift the focus to infrastructure required for increased energy importation.

Scenario development

Taking into account the business as usual estimates and key uncertainties, the potential future scenarios (as they relate to resources) are summarised below:

Table 5: Resources variables for each scenario

Driver of change	Central Scenario	Upside Scenario	Downside Scenario
Carbon price & emission limits	$25/tonne carbon price (from MBIE scenarios)	$0/tonne carbon price (from MBIE scenarios)	$100/tonne carbon price (from MBIE scenarios)
Climate change impacts	Climate change as per Intergovernmental Panel on Climate Change projections	Rapid sea rise, increase in rainfall variability and extreme events	Low sea level rise, small change in frequency of events (drought / flood)
Water quantity and quality	Gradual increase in water scarcity and market or societal expectations for water quality	Rapid increase in water scarcity and market or societal expectations for water quality	Static or decreasing scarcity and low market or societal expectations for water quality
Oil / gas discovery	Business as usual oil / gas discovery	Significant oil / gas discovery (especially, but not limited to, regions other than Taranaki)	Little to no discovery of new, commercially viable oil / gas reserves in NZ

Source: Treasury analysis

Infrastructure and interdependency – current and future trends

With a collective value well in excess of $100 billion, New Zealand's infrastructure networks are vast and complex. Although frequently viewed as isolated sectors, our infrastructure is increasingly comprised of a series of interconnected systems.

For example, the energy sector relies upon process water for heating and cooling (or directly, for hydro generation). On the other hand, energy is an essential input enabling the distribution of potable water and treatment of wastewater. Taking another view, the geographic proximity of infrastructure networks often creates an intrinsic linkage (e.g. water pipelines installed underneath roads).

The trend of increasing interdependency is a double-edged sword. The integration of information and communication technology with hard infrastructure shows great promise in increasing the efficiency and effectiveness of service provision. However, interconnectedness can elevate risk exposure – where failure in one network can quickly propagate through other infrastructure networks.

In terms of scenario modelling, it is important to understand the current and future trends that link our infrastructure networks. The need is particularly acute in the context of:

- A trend toward convergence of our networks (particularly with information and communication technology being used in other sectors), and
- Long lives of many assets that create infrequent opportunities for change (i.e. to leverage the positive forces of interdependence – or to mitigate the risks).

The following diagram shows current interdependencies and future opportunities and trends in the connectedness of our infrastructure.

Infrastructure Interdependencies

Legend
Current interdependencies
Future interdependencies

Relies Upon Other Sectors For...

TRANSPORT	• Transport is highly reliant on hydrocarbons from energy sector • (Some) public transport relies on electricity to operate *• Electricity is required for electric vehicle charging* *• New fuel sources (or a changing mix) may create new dependencies*	• Stormwater management provides flood protection for transport assets	• Communication systems enable transport networks ops & planning • Smart transport systems reliant on advanced communication capability *• Congestion charging & dynamic prices rely on communications links* *• Self-driving cars require a dedicated spectrum*	
• Transport sector imports and distributes fuels • Transport and energy assets are frequently co-located	**ENERGY**	• Process water (e.g. cooling) required for some energy generation • Hydro power is reliant on the availability of water resources *• Wastewater as an energy resource* *• Energy recovery in water distribution (e.g. mini-hydro)*	• Control and communication systems for energy infrastructure *• Networked energy systems have increasing cyber security needs*	• Social assets consume - and pay for - electricity
• Transport provides the means to move waste by-products • Roads and water pipelines are frequently co-located • Transport moves goods and services critical to the productive water sector	• A significant amount of electricity is required to distribute and treat water • 30% of household energy use is for water heating • Energy by-products have potential to contaminate groundwater	**WATER**	• Communication systems assist the operation & planning of water systems • Civil defence systems (e.g. tsunami warning) rely on telemetry & comms *• Smart water meters and intelligent networks rely on communication links*	• Social assets consume - and pay for - water services
• Transport and telecommunication networks are frequently co-located	• National grid and telecommunications infrastructure are frequently co-located • Electricity is required to maintain operable communication networks	• Stormwater management provides flood protection for telecom assets	**TELECOMMUNICATIONS**	• Social assets consume - and pay for - telecommunication services
• Transport links provide access to social infrastructure	• Energy provision is an essential need for health care, schools, etc	• Water provision is an essential need for health care, schools, etc	• Control and communication systems for buildings • Emergency communications networks link hospitals / ambulances to people	**SOCIAL INFRASTRUCTURE**

Central Scenario: Implications for our infrastructure

The central scenario reflects the current trends and best estimates for key drivers of change that will affect future infrastructure investment requirements. This does not mean that the central scenario should be viewed as destiny, nor is it the NIU's expectation of what will happen. Rather, the purpose of scenario modelling is to contemplate alternate futures during strategic planning. To that end, the three scenarios (central, upside and downside) should be considered as a body of evidence, rather than as separable components.

Key drivers of change in the central scenario

Population

- Sustained population growth - reaching 6 million people by 2061
- An ageing population, with 24% aged 65+ (up from 14% in 2012)
- Increasing urbanisation results in a continued shift to main centres

Economy

- Commodity export volume growth continues at long-term trend rates
- Continued steady increase in urban-based service sectors; slow decline of most heavy industries
- Prudent and manageable debt levels

Technology

- Gradual integration of technology with assets
- UFB take-up occurs in line with projections
- 4G (and, in the future, 5G) mobile demand is in line with best estimates

Resources

- Medium carbon price ($25 / tonne)
- Climate change as per IPCC projections, increasing water scarcity and pressure on water quality
- 'Business as usual' oil / gas discovery in New Zealand

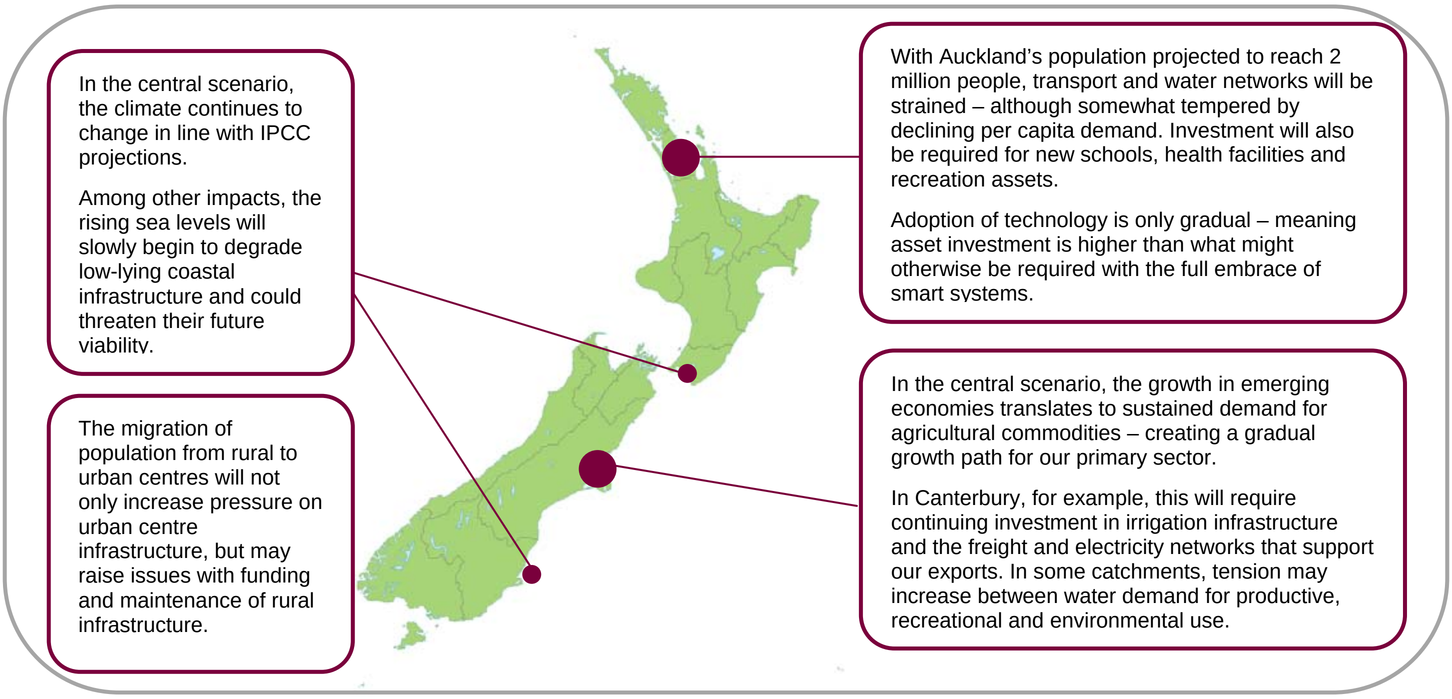
A description of the central scenario

The central scenario is characterised by a continuing trend of population movement to urban centres, especially in the upper North Island. Conversely, targeted growth in rural areas is provided by demand for agricultural and other primary sector products.

This translates, in infrastructure terms, to increasing demand on transport, water, telecommunications and social infrastructure in major urban centres and regional investment requirements in freight networks and productive water infrastructure. In the central scenario, the aggregate demand for energy and telecommunications infrastructure also continues to increase in line with GDP projections.

SCENARIO/TRENDS ANALYSIS

The key spatial implications for our infrastructure are shown in the diagram below (note: the diagram is not exhaustive and focuses only on selected major trends):



Interdependencies in the central scenario

Key changes in the interdependence of our infrastructure sectors include:

- Continued gradual convergence of our networks, and
- Regional interdependencies will strengthen – induced by the increasing segmentation of the economy between the primarily urban-based service sector and the rural primary sector.

The central scenario assumes gradual adoption of most technology rather than rapid uptake, although increased demand for services such as mobile will be aligned with increasing population in urban centres. In this case, ICT infrastructure will likewise only gradually continue its integration into water, transport, energy and social assets.

Box 4. Taking a cross-sector, whole of New Zealand perspective

Our infrastructure networks are both national and local. The degree to which a network is affected by national trends versus local impacts determines how the drivers of change (population, economy, technology, resources) manifest themselves as future infrastructure demand.

In general, our electricity network has a nationwide reach and is influenced by national trends in the aggregate. In contrast, our water networks and social infrastructure tend to be more localised and are highly affected by regional trends. Our transport and telecommunications networks are somewhere in between – with significant local influences, but flowing through a nationally connected system.

In reviewing the existing projections and scenario planning, two sectors stand out for the work they have already undertaken to understand future demands: the energy sector and the transport sector, both of whom have completed extensive investigations and modelling. Also, although much of the data is privately held, we believe the telecommunications sector has a firm understanding of future pressures.

Although demand forecasts do exist in the water and social sectors, it is more difficult to find comprehensive and consistent projections bridging the local and national levels. The modelling in these sectors also does not always consider scenarios created from the entire suite of fundamental drivers (population, economy, technology, resources).

Sector-by-sector discussion

Energy

Our energy infrastructure is spread across three separate, but interconnected segments: electricity, oil and gas. The electricity network consists of more than 100 generation sources, many of which are located in remote areas and connected to urban centres via the national grid. Both natural gas and oil are extracted from the Taranaki region, with the oil mainly exported while gas is used domestically. Crude oil, on the other hand, is imported and processed at Marsden Point Refinery – which supplies all of the country's aviation fuel, 80% of our diesel and about 50% of our petrol (among other products).

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

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.

The Energy 'Reference Scenario' (2011) and Electricity 'Mixed Renewables' (2013) scenario developed by MBIE are roughly equivalent to the central scenario defined here. In general, these scenarios assume:

- GDP growth by sector will occur according to NZIER mid-level forecasts (at a national level this equates to approximately 2% per annum growth to 2030)[3]

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[3] Although the NIU prefers to use Treasury GDP projections, we make use of existing scenario modelling for this publication – which, in the case of the energy sector, is based (in part) on NZIER GDP projections. The NZIER data estimates that New Zealand's real GDP will be about 50% higher in 2030 than in 2011. In contrast, the Treasury's 2013 Long Term Fiscal Model estimates a real GDP increase of 57% between 2011 and 2030. For the purpose of scenario modelling, we consider this to be within the bounds of uncertainty in the context of future infrastructure requirements.

- Population will grow according to the Stats NZ medium projection (in line with our central scenario assumption)
- An emissions price of $25 per tonne of carbon dioxide (in line with our central scenario assumption)
- Gas discovery occurs according to the Oil and Gas simulation model ('business as usual' in our central scenario). International oil prices increase according to NYMEX futures and IEA projections, and
- No significant changes in electricity demand from heavy industries.

In the Transmission Tomorrow publication, Transpower analysed nine different scenarios. Four of these were developed specifically by Transpower to test various parameters relating to the national grid. The remaining five are taken from scenarios set out in the Electricity Commission's 2008 Statement of Opportunities. In our central scenario discussion that follows, we draw upon the most likely trends that emerge collectively from the nine Transpower scenarios.

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 will grow on average by 1.1% per annum through 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[4]
- There is an ongoing need for the backbone grid from Roxburgh to Otahuhu and its capacity will need to increase over time
- 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 required in geothermal plants (with its share of electricity generation projected to grow from 14% in 2012 to between 21% and 29% 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. A sufficient level of exploration is expected to ensure supply is available to meet demand
- 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.

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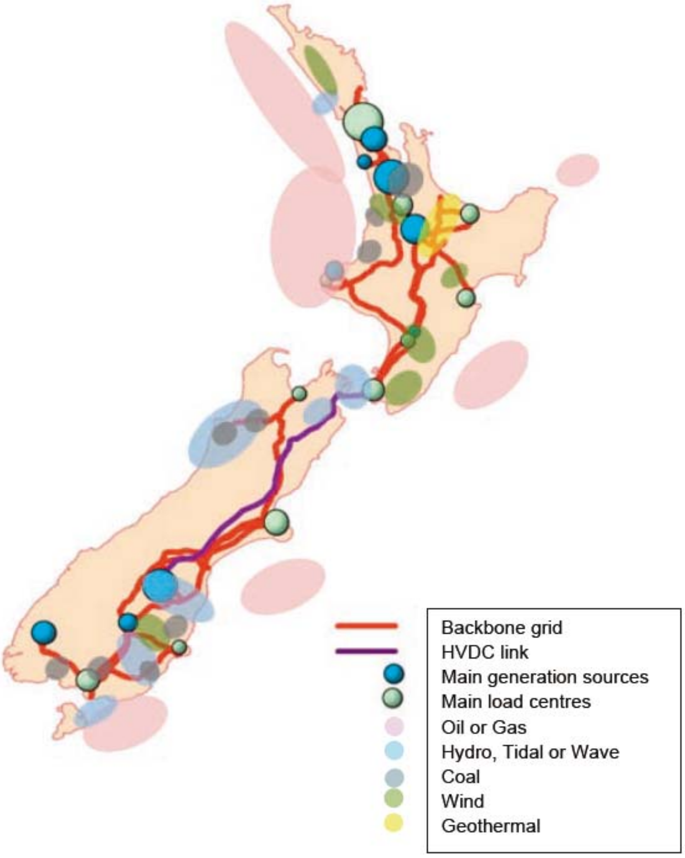
[4] Where new irrigation systems are gravity fed, potential exists for a decrease in energy use if they replace groundwater pumping solutions.

Figure 5: Location of potential future energy generation resources



Source: Transmission Tomorrow: Enduring Grid (Transpower, 2011)

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:

Figure 6: Grid level electricity demand by scenario

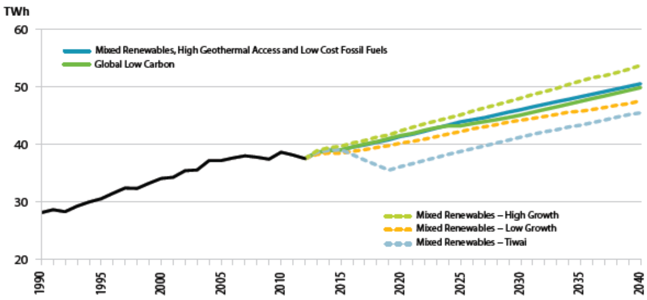
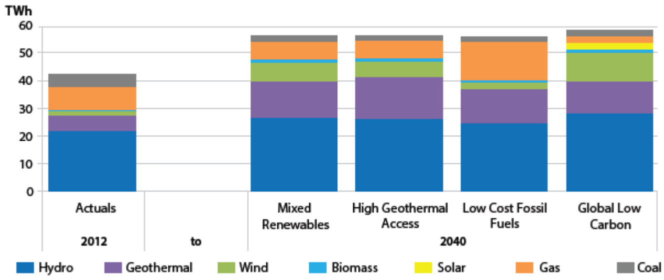


Figure 7: Electricity generation by scenario



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

Transport

The demands placed on our transport infrastructure in the central scenario can be separated into freight movements (export and domestic) and household travel (including tourism). In this analysis, we draw upon information from the National Freight Demands Study[5] (2008), published outputs from the land transport demand model[6] (Stephenson & Zheng, 2013) and supporting data from NZTA and the Ministry of Transport.

The National Freight Demands study relies upon population projections, GDP forecasts and individual commodity forecasts. Population projections are based on Stats NZ medium projections and are in alignment with our central scenario assumptions. National GDP forecasts are based on an average of 2% per year GDP growth. Although this does not align exactly with current Treasury projections, we consider it to be within an acceptable range for the purpose of modelling the central scenario. Finally, our central scenario does not include specific forecasts for individual commodities. However, the National Freight Demands Study uses trends and best estimates in this regard which, although based on pre-GFC optimism, we consider to be in the general spirit of the central scenario.

Key implications for our transport infrastructure as reported in the National Freight Demands Study include:

- From 2006 to 2031, the number of freight tonnes lifted (and tonne-kms transported) is expected to increase by 70% to 75%. Freight growth will be in both basic commodities (typically transported short distances) and sophisticated products (longer distances)
- Rail freight demand is projected to increase by 70% between 2006 and 2031 – with its modal share remaining approximately the same over that period
- Coastal shipping is projected to reach 8.5 to 9.0 million tonnes by 2031 – approximately double the level in 2006 (this is driven in part by planned expansion of the Marsden Point refinery)
- Substantial growth in traffic generation is forecast for Waikato with an increase in forestry and dairy traffic as well as increased movement of aggregates to serve both Waikato and Auckland. Canterbury is also forecast to experience high growth in traffic generation due to an increase in dairy production
- Auckland is projected to have the highest growth in terms of traffic that is attracted to the region – reflecting the movement of primary products from Northland and Waikato.

At the household level, transport demand is affected by demographic shifts, economic changes and fuel prices (among other factors). The land transport demand model developed by NZIER contains an extensive range of inputs that allow various scenarios to be modelled. The base case modelled by NZIER relies upon the following assumptions:

- **Macroeconomic** – generally based on long-run historical averages and best estimates (e.g. an oil price of $300 in 30 years, roughly aligned with the IEA's World Energy Outlook projection published in 2012)
- **Industry** – industry GDP is a function of total GDP, but with shares modelled using a VAR
- **Technology** – gradual improvements in fuel economy (0.2% per annum) and various assumptions on the share of alternative fuels used by vehicles
- **Price and income responsiveness** – base case assumptions linking travel behaviour to changes income or the cost of travel

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[5] The Ministry of Transport commissioned Deloitte to carry out an update of the National Freight Demand study and to undertake a Future Freight Scenarios study. Each of these studies may provide an improved outlook on future transport demands. The reader is referred to the Ministry of Transport website (http://www.transport.govt.nz/research/nationalfreightdemandsstudy/), where these reports will be published upon their completion (expected to be in 2014).

[6] Several agencies are working with NZIER to undertake further demand modelling across the transport modes (completion date unknown).

- **Regional dimensions** – GDP and industries are included by region, as are other variables such as household incomes, freight demand, etc, and
- **Tax rates** – assumed to grow in line with inflation.

From the NZIER report produced for NZTA, the key implications for our infrastructure in the base case include:

- Household travel demand is projected to grow nationally by 1.0% per annum over the next 30 years, although the kilometres travelled per vehicle is projected to decline
- Two-thirds of travel demand growth is due to population growth. Regionally, this translates to increased pressure on transport networks in our urban centres, and
- Public transport demand is projected to grow by 0.95% per annum over the next 30 years. The public transport share of travel is projected to gradually decline over time (as incomes grow, enabling private vehicle use).

Graphs of selected results are shown below:

Figure 8: Growth in travel demand (passenger-kilometres)

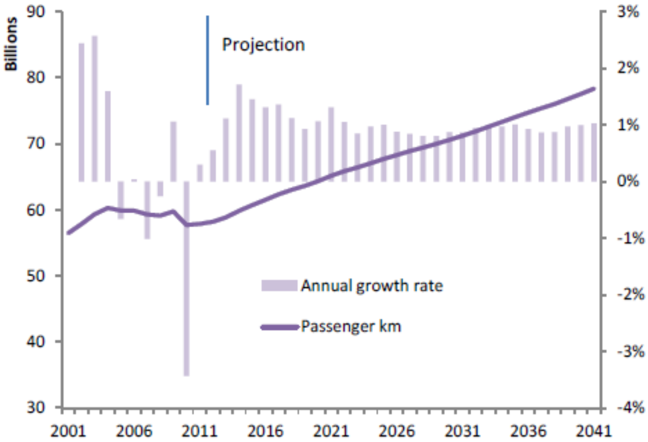
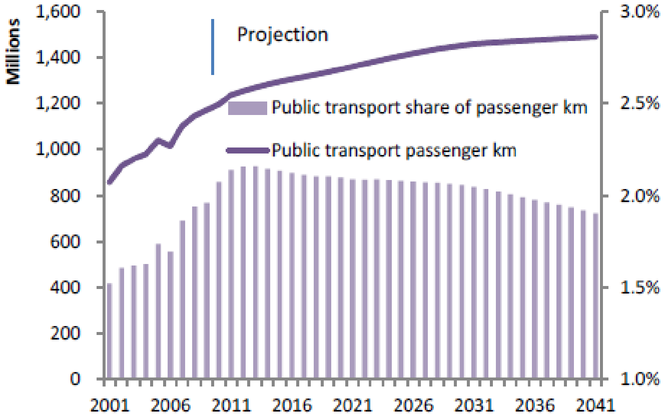


Figure 9: Growth in public transport demand (passenger-kms)



Source: National Long-Term Land Transport Demand Model, NZIER and NZTA (2013)[7]

Water

Although water, as a resource, is governed by a natural and interconnected cycle, we generally consider our water infrastructure in two separate categories: urban water and productive water. At present, the availability of data, projections and modelling for our water infrastructure is inconsistent and fragmented[8]. Accordingly, it is difficult to develop an informed view of future infrastructure requirements at a regional and national level[9]. Instead, we focus on readily available indicators of future demand such as irrigation projections (for productive water) and demand for water in Auckland and Wellington (for urban water).

[7] The information provided by NZIER information provides an indication of structural trends and underlying demand pressures only, and deliberately exclude policy/supply-side initiatives.

[8] Local authorities are taking steps toward improvement in this regard (e.g. LGNZ 3 Waters project and the establishment of a Centre of Excellence).

[9] In part, this also reflects the localised nature of water infrastructure, where a national picture may not show the nuanced requirements of individual Councils and communities.

Productive Water

In the central scenario, global demand for commodities is assumed to increase as the world population grows, incomes rise and consumer preferences change. Developing countries are driving a structural shift in commodity demand. A recent Reserve Bank report (Sullivan & Aldridge, 2011) describes this phenomenon:

> *Growth in food demand is fastest in the early stages of a country's development. As countries become wealthier, consumer preferences switch from merely more food, to higher nutrient food. So in the initial stages of development a country may consume higher quantities of rice, but as wealth continues to grow, other grains, such as wheat, become more popular, and then dairy and meat become larger parts of the national diet. Eventually food demand becomes dictated more by population growth than income growth.*

This trend is especially evident in Asia where it appears that incomes still have much room to rise. Sullivan & Aldridge (2011) cite a comparison of China with Taiwan to illustrate this point (data collated by Nomura Global Economics):

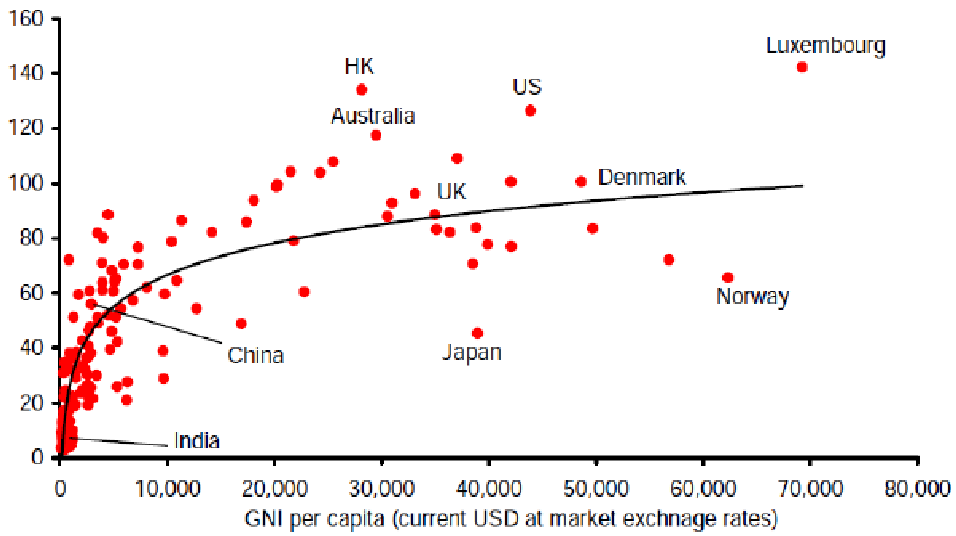
Table 6: Average per capita annual food consumption (kilograms)

Period	GNI per capita (USD)	Grain	Vegetables	Meat	Milk	Fruit
Taiwan						
1975	979	162	110	27	15	55
1980	2,394	134	130	43	25	70
1985	3,368	110	103	56	32	112
1990	8,325	102	93	63	43	132
1995	13,103	100	102	73	59	137
China						
2000	934	265	132	39	3	46
2005	1,734	376	168	48	11	62
2008	3,427	444	171	42	15	65

Source: Taiwan Council of Agriculture, China Statistical Yearbook and Nomura Global Economics (cited in Sullivan & Aldridge, 2011)

Similarly, per capita meat consumption correlates closely with per capita income around the world:

Figure 10: Per capita livestock meat consumption (kg / year)



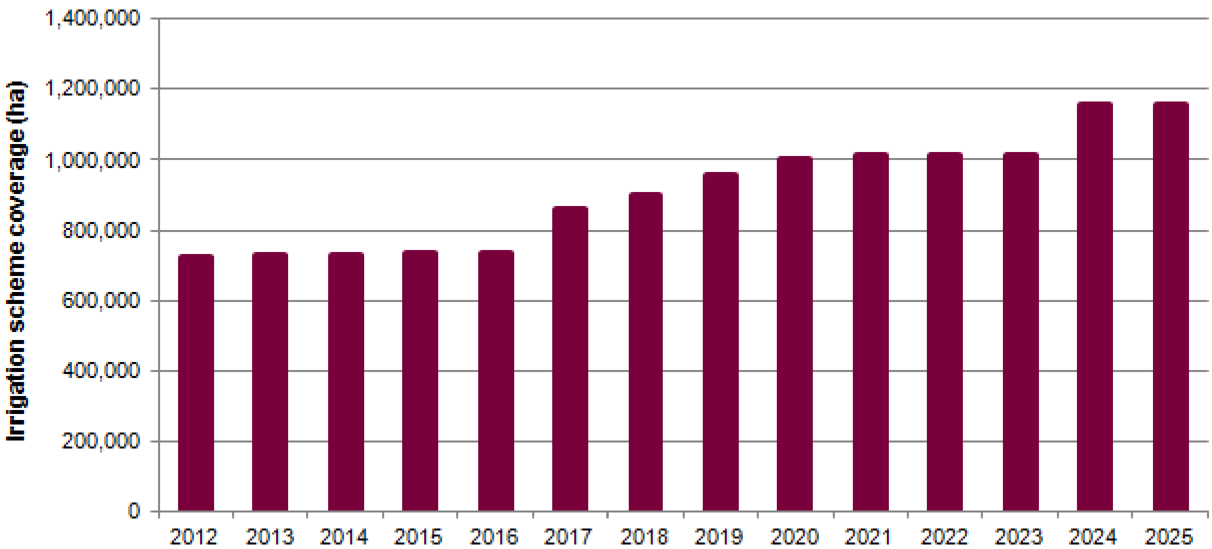
Source: FAO, World Bank and Nomura Global Economics (cited in Sullivan & Aldridge, 2011)

Based on this data, the central scenario assumes that global economic growth, and Asian growth in particular, will bolster demand for proteins from New Zealand. This trend will be facilitated by both our geographic proximity to Asia and our relative abundance of water which gives us a comparative advantage in agricultural commodities markets. Although rapid growth in prices and demand is unlikely to continue unabated, the medium term outlook is expected to be strong.

Along with commodity-based water demand in the central scenario comes a gradual increase in demand for recreational and environmental benefits. Combined with climate change predictions, this will drive the need for reliable infrastructure to store and distribute alpine-sourced water to take the pressure off groundwater and coastal rain-fed rivers along the east coast of both islands.

The following graph estimates our total area of irrigated land over the next 10 years based on existing proposals. Whether these proposals proceed, or are supplemented by even more schemes, depends on the continued strength of global agricultural commodity demand and the availability of water sources.

Figure 11: Existing, planned and proposed irrigation schemes in New Zealand



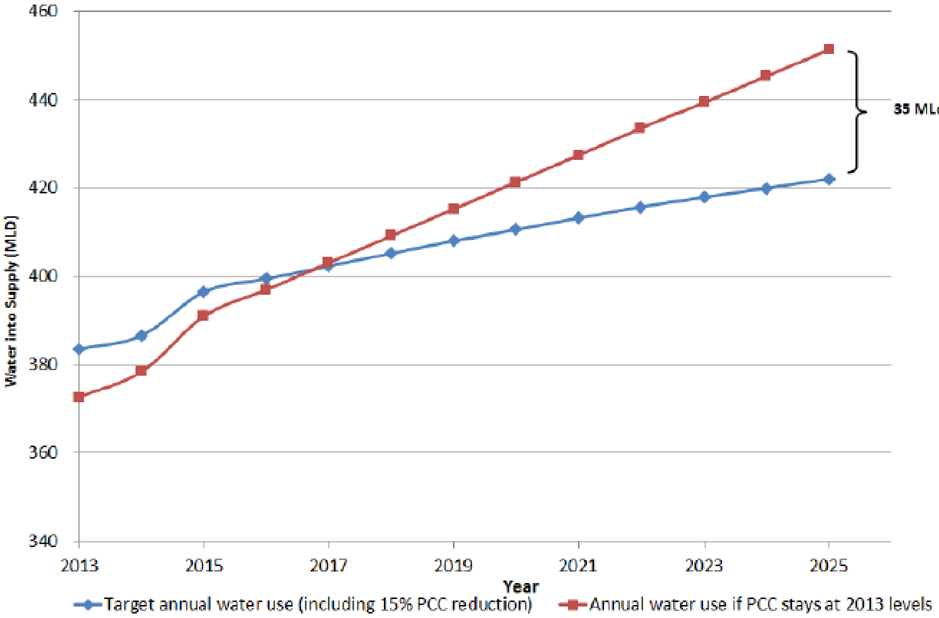
Source: ANZ, MPI, Irrigation NZ and Treasury analysis (2013)

Finally, at the same time that we face high demand for our commodities (especially animal proteins), the intensification of grazed animal land uses in New Zealand will keep the spotlight on water quality in the coming years. The convergence of environmental, social, cultural and economic interests will likely drive the need for new infrastructure, technology and management practices to maintain or improve the health of our waterways. The government is currently investigating a number of reforms to ensure the quality and quantity of our fresh water meets the needs of stakeholders.

Urban Water

As with the productive water sector, our urban water sector is similarly expected to face substantial demand pressure in the future. With both high population growth and relatively modest water resource availability, Auckland makes a good case study for understanding the substantial investment that may be required in the absence of other solutions. Watercare's most recent demand management plan demonstrates the scale of the challenge:

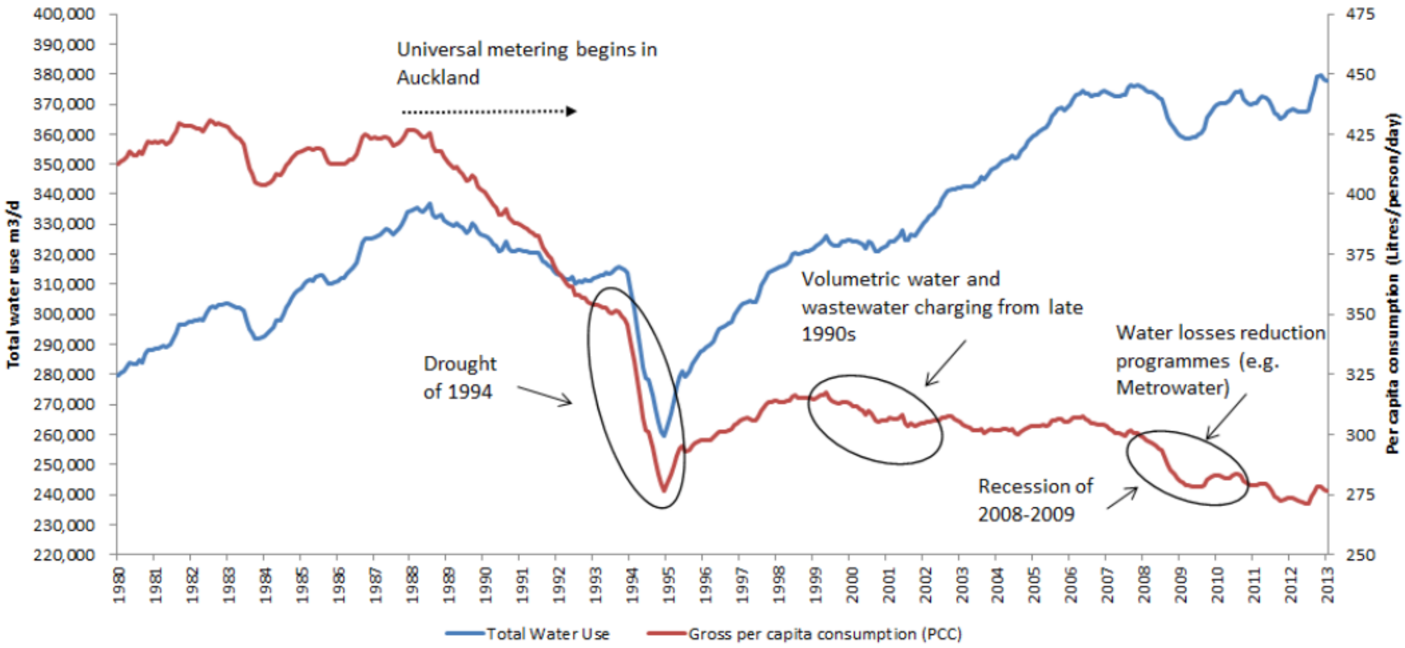
Figure 12: Demand for water in Auckland



Source: Auckland Regional Water Demand Management Plan (Watercare, 2013)

Although demand management and/or supply-side responses are outside the remit of this publication, it is interesting to note the encouraging path that Auckland's water sector has taken over the last three decades. Despite an 85% growth in population from 1980 to 2013, Auckland's water demand grew by only 35% during this period – thanks in large part to per capita consumption dropping from over 400 litres / person / day to approximately 275 litres / person / day.

Figure 13: Historical water use in Auckland



Source: Auckland Regional Water Demand Management Plan (Watercare, 2013)

Apart from water demand, the urban water sector also faces pressure to ensure water quality meets acceptable standards – both for potable supply and for the discharge of wastewater and stormwater to the receiving environment. For the smaller potable water suppliers, compliance deadlines to meet obligations in the Health (Drinking Water) Amendment Act 2007 are staggered from 2013 to 2016. For wastewater discharge quality, the government is currently investigating a number of reforms for fresh water management. The level of investment that may be required in the urban water sector is dependent, in part, on the level of standards to be met and also by the existing standard of water quality that is being achieved.

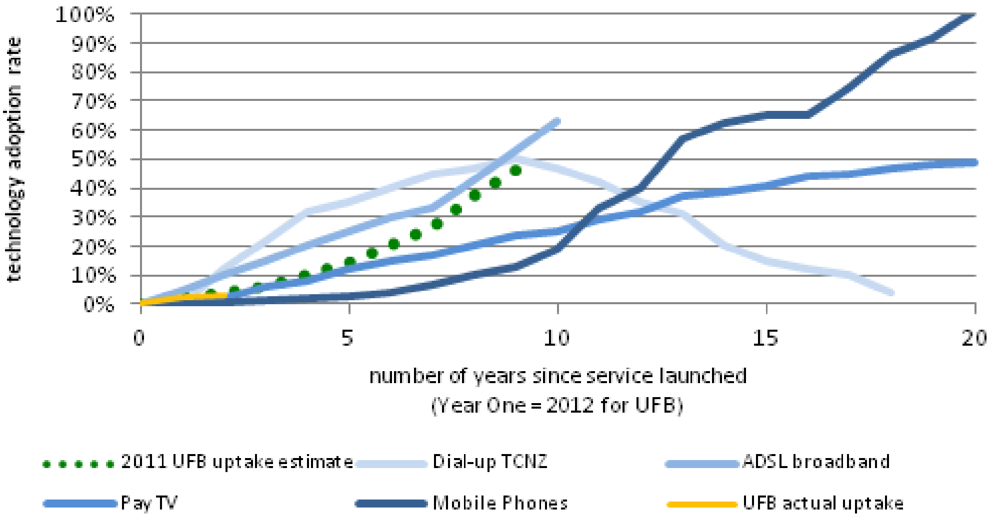
Both level of demand and ability to meet the investment required will be dependent on population, which in this scenario suggests divesting difficulties between rural and urban centres as population migrates from one to the other.

Telecommunications

The key driver of telecommunications infrastructure is data demand. Rather than being linked directly to supply side technology or network change, data demand is most immediately driven by customers adopting and using new services and applications – such as for e-commerce, online entertainment, and digital methods of providing education or health services.

In the central scenario, the UFB network (in tandem with the RBI) will be progressively developed by 2020, with nearly 98% of our population having access to faster broadband by this time. UFB uptake will also begin to change consumer patterns with concomitant impact on our physical infrastructure requirements. To provide some context for the UFB initiative, a recent graph produced by MBIE shows adoption rates in New Zealand for various technologies:

Figure 14: Technology uptake rates in New Zealand



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

Along with the UFB initiative, the recent 700 MHz 4G spectrum auction in New Zealand is a key step in the roll-out of fourth generation networks by telecommunications providers. The auction conditions were designed to make 4G coverage available to 90% of our population within 5 years. While it is difficult to project the demand in New Zealand, Cisco estimates that global mobile data traffic will increase 13-fold between 2012 and 2017 (Cisco, 2013). The same report projects that 4G connections will comprise 10% of total mobile connections and account for 45% of total traffic.

Demand in the telecommunications sector is expected to have both an urban and rural strand. The increasing urbanisation of our population will drive the need for new or upgraded towers in Auckland (for example) to cater for mobile voice and data demand. At the same time, demand for broadband in rural areas is expected to strengthen as 3G and 4G / LTE wireless options become available.

As the UFB network is developed and as mobile data traffic increases, the central scenario assumes that the burden placed on the copper network will reduce. The central scenario assumes that technology, in general, will enable future infrastructure demand. In that context, demand for telecommunications infrastructure occurs primarily through the adoption by consumers of content and applications supported by the UFB network and 4G mobile networks.

Social infrastructure

Social infrastructure is most directly impacted by demographic change, which forms the main part of this discussion. The increased use of technology, although it shows promise for better utilising social assets, is expected to become only gradually more integrated over time in the central scenario – causing relatively minor overall impacts.

Education

Demand for education infrastructure is influenced by fertility rates, migration levels and retention rates. In this analysis, we rely upon Ministry of Education school roll forecasts for primary and secondary schools (National School Roll Projections: 2011 Update). The medium scenario in the school roll projections aligns with the medium population growth assumed in our central scenario.

Figure 15: Primary school roll projections to 2030

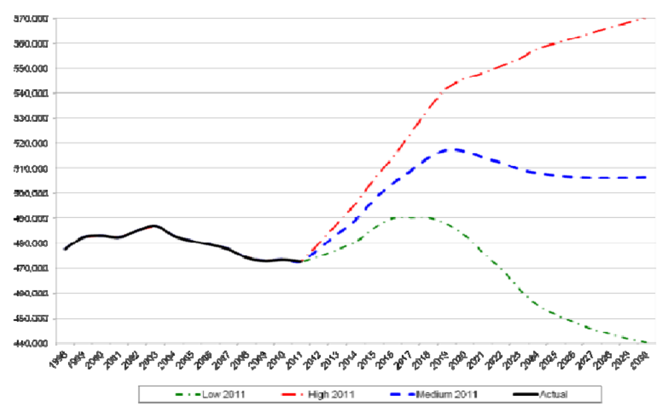
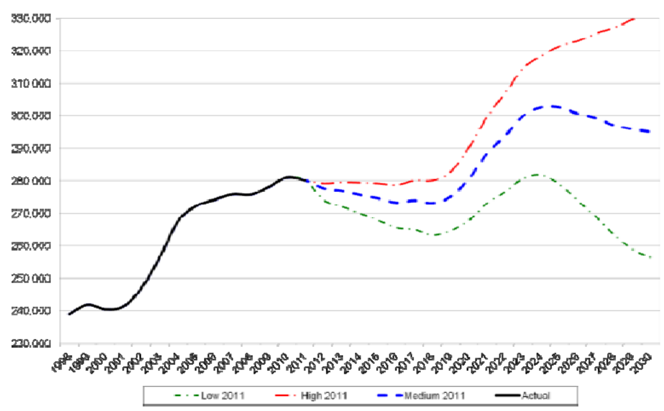


Figure 16: Secondary school roll projections to 2030



Source: Ministry of Education (2011)

In the central scenario, the total school roll is projected to peak in 2024 at approximately 810,000 full-time equivalents (from 755,000 in 2012). After 2024, the school roll is expected to diminish which is consistent with the general trend of an ageing population.

However, considering the school roll projections at a national level masks the substantial variation that is expected to occur at a regional and local level. For example, based on Stats NZ medium projections from 2011 to 2031, the population aged 0 to 14 in the Ruapehu district will decline by 36% while in the Selwyn district it will increase by 30%. Overall, 50 of 67 territorial authorities will have fewer children in 2031 than they had in 2011. These changes will have direct implications as to whether new schools are required and whether existing schools need to be upgraded or rationalised.

Justice

As with education infrastructure, assets in the justice system are closely linked to population. The Ministry of Justice reports that the most influential factors affecting justice forecasts are (Justice Sector Forecasts 2012-2022):

- Number entering the courts system (the single most significant variable)
- Proportion of people remanded in custody
- Average time spent on custodial remand, and
- Proportion of imposed sentence served in custody (excluding remand).

These variables are not explicitly included in our central scenario assumptions. However, the Ministry of Justice forecast is based on the Stats NZ medium population projection, which is consistent with the central scenario we have developed. Graphs from the Ministry of Justice study are reproduced below:

Figure 17: Prison population forecast to 2022

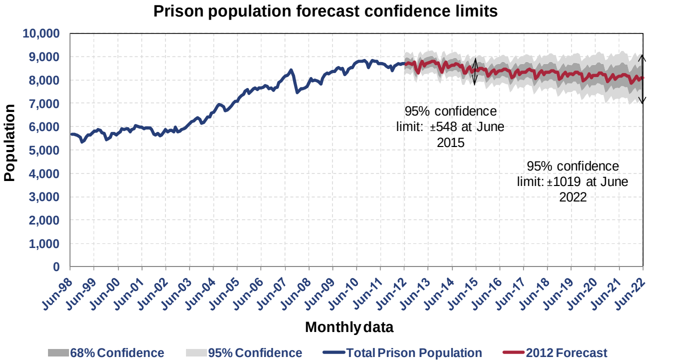
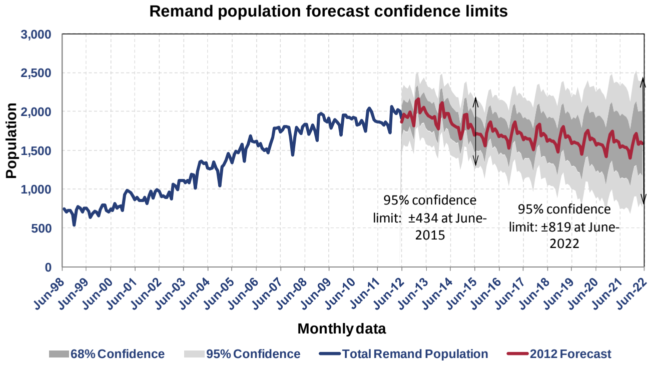


Figure 18: Total remand population to 2022



Source: Ministry of Justice (2012)

In general, the national trend is for decreased demand in our justice system. However, this is likely to vary by region. Although the trend may be downward overall, no further analysis has been conducted for this exercise and it is possible that urban areas experiencing high growth will see an increase in demand for justice-related infrastructure – against the national trend.

Health

Demand in the health sector is related to demographics (population growth, age cohorts), income effects and health sector productivity. The central scenario assumes a business as usual trend with respect to income and productivity, with the most tangible link to health infrastructure demand being demographic change.

As with all social infrastructure, future demand will be subject to significant regional variation in the central scenario with urban centres (especially Auckland) experiencing high population growth which will place pressure on health infrastructure. Similarly, our maturing population will place high demand on aged care facilities and assessment, treatment and rehabilitation (AT&R) services.

Upside Scenario: Implications for our infrastructure

The upside scenario reflects trends in key drivers of change that result in high investment requirements for New Zealand's infrastructure. Where projections or modelling results are available, we consider the implications for our infrastructure in the upside scenario by discussing specific deviations relative to the central scenario for each sector.

As with the other scenarios, the upside scenario does not represent the NIU's expectation of the future and we do not provide comment on the likelihood of all of the high demand factors (listed below) coinciding. Instead, this scenario should be viewed as a possible upper bound for infrastructure demand.

Key drivers of change in the upside scenario

Population

- High population growth - reaching 7 million people by 2061
- Slower than projected ageing (high fertility & high inward migration)
- Higher than projected urban growth, and accelerated rural decline

Economy

- Rapid increase and sustained demand for dairy, wool, meat, etc
- Rapid growth in service sector (Auckland-centric); return to peak heavy industry demand
- Low debt levels, high incomes

Technology

- Slow integration of technology with assets
- UFB take-up is slower than currently projected
- 4G (and, in the future, 5G) mobile demand is lower than estimated

Resources

- Low / no carbon price ($0 / tonne)
- Rapid sea level rise, sharp increase in extreme climate events, substantial pressure on water quantity & quality
- Significant oil / gas discovery in New Zealand

A description of the upside scenario

The upside scenario is based on the highest level of population growth, accompanied by consolidation of population in our urban centres. Many of the rural areas decline in population as the trend toward a service-oriented economy continues. However, the upside scenario also assumes both a return to peak heavy industry demand (e.g. processing of wood and metals) and an emerging economy-fuelled boom in our agricultural exports.

This translates, in infrastructure terms, to soaring demand for transport, water and social infrastructure in major urban centres, and similarly high demands placed on water resources, productive water infrastructure and all transport modes used for distribution and export. Although demand related to primary sector growth is high in rural areas, population decline in the rural centres results in underutilised or 'stranded' assets that are no longer needed.

In the upside scenario, the high aggregate demand for energy brings forward the need for investment in new sources of generation and increases the need to augment our energy distribution infrastructure – especially in areas where heavy industry is located.

Finally, the upside scenario assumes that climate change will occur more rapidly than IPCC projections. From a spatial perspective, this has implications for our coastal areas where our land erodes more quickly, assets begin to deteriorate more rapidly and low-lying communities (and their infrastructure networks) are threatened.

Moving inland, higher rainfall in the west of country brings both benefits and risks, while less rainfall may reduce water supply reliability in areas such as Canterbury (rain on the west will provide more water into large rivers, but supply will be more variable).

Interdependencies in the upside scenario

The upside scenario is characterised by a slow or limited trend in the convergence of our networks. The low adoption rate of new technology in this scenario means that infrastructure productivity gains are not realised to the extent that they could be.

Sector-by-sector discussion

Transport

A limited set of stochastic results from the long term demand model have been published by NZTA and NZIER. Of the results that have been published, demand uncertainty is due mainly to price and income variations. Graphs that show a possible range of demand for vehicle travel and public transport usage are reproduced below:

Figure 19: Public transport demand (stochastic estimate)

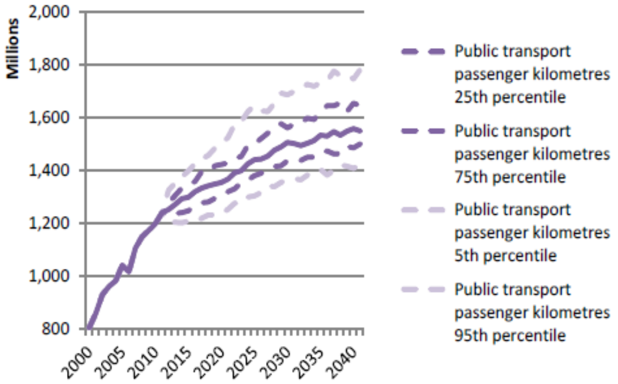
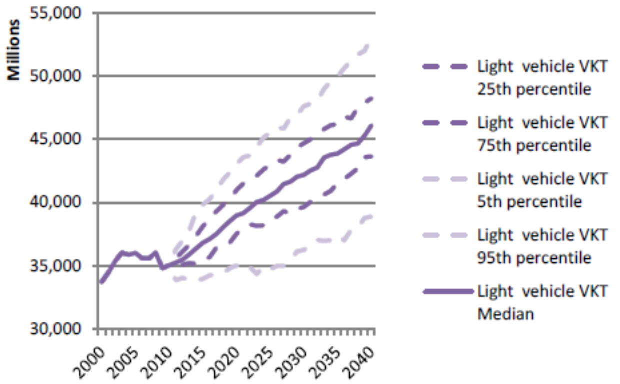


Figure 20: Vehicle kilometres travelled (stochastic estimate)



Source: National Long-Term Land Transport Demand Model, NZIER and NZTA (2013)

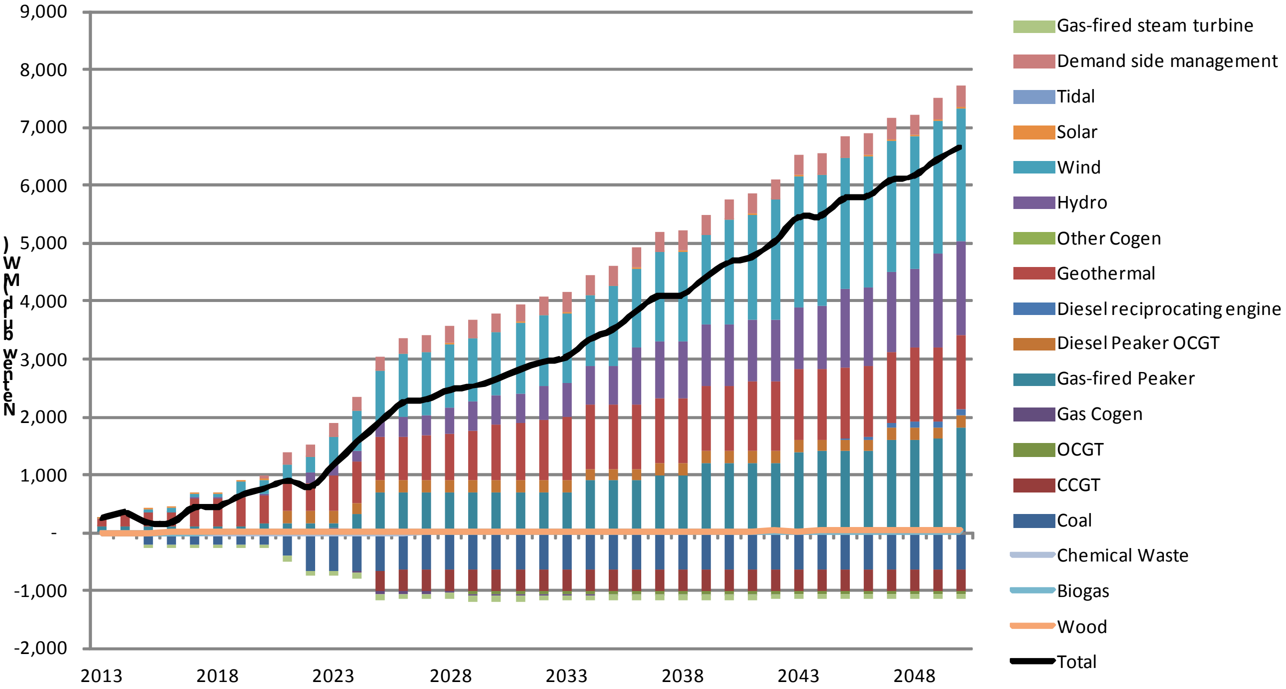
When compared to the central scenario (50th percentile), the modelled equivalent to the upside scenario (95th percentile) shows an approximately 15% increase in both public transport demand and light vehicle kilometres travelled. This translates into a need to construct new roads, upgrade existing roads and develop new public transport options in line with demand estimates. However, the need for new assets will be highly regionalised and is likely to be concentrated in urban centres.

Although quantitative modelling of freight demand is not available for the upside scenario, we estimate that the pressures placed on road, rail, port and airport infrastructure will increase in line with economic growth. Latent capacity in these networks will be absorbed (to varying degrees) and existing pinch points will intensify.

Energy

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.

Figure 21: New build by fuel type in the high demand (upside) scenario



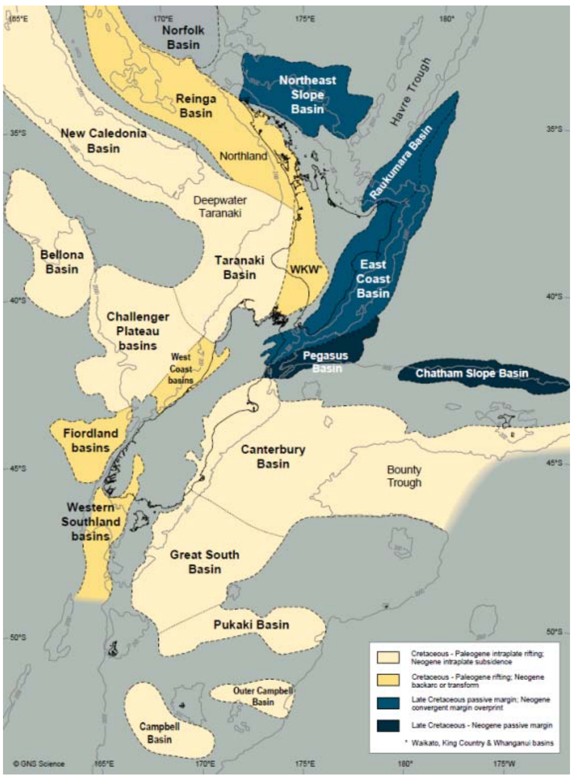
Source: Ministry of Business, Innovation & Employment, Treasury analysis

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 has the potential to create high demand for new pipelines and supporting infrastructure – especially if the new find is developed for the domestic market, rather than for offshore processing and distribution.

Similarly, 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.



Source: NZ Petroleum & Minerals

Box 5. Heavy 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, 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% from its peak (MBIE, 2013). More recently, the future of aluminium production in New Zealand has been called into question. With about 15% 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 heavy industry – on the upside or the downside.

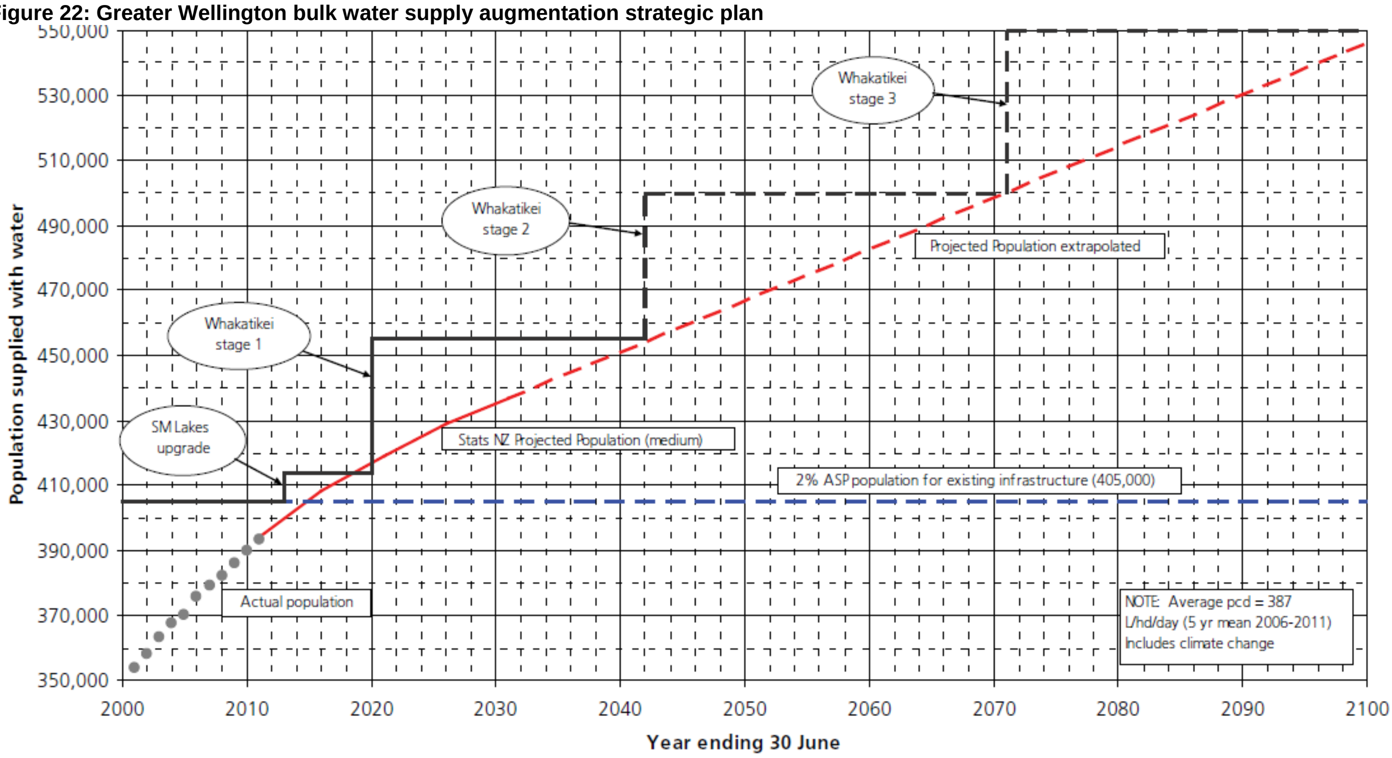
Water

Urban Water

The effect of the upside scenario on our urban water sector is expected to be driven in part by population. Taking Auckland as an example, the Stats NZ high population for the Auckland region by 2031 is nearly 8% above the medium projection. Although this may seem small at face value, the impact from a variation of this size cannot be underestimated – particularly when developing new sources of supply (or incentivising lower per capita demand) can be years in the making.

For example, Greater Wellington Water’s plan to ensure that sufficient capacity is available to meet demand is shown in the graph below (Greater Wellington Regional Council, 2012). In the event that population growth shifts from the Stats NZ medium projection to the high projection instead, augmentation of the system may be required much earlier than planned.

Figure 22: Greater Wellington bulk water supply augmentation strategic plan



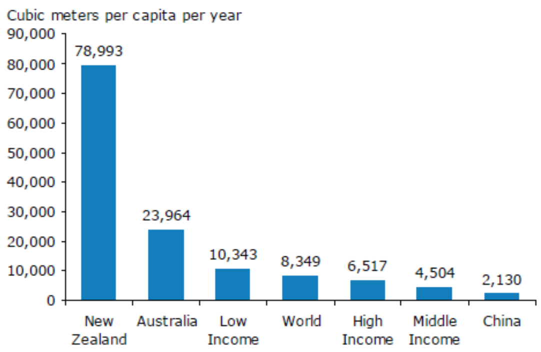
Source: Greater Wellington Water (Water Supply Asset Management Plan, 2012)

Productive Water

In the productive water sector, climate change, with projected impacts on rainfall and hydrology, will have a major impact on irrigation schemes. There will be regional differences in changes in rainfall, presenting localised challenges for those designing and managing irrigation schemes (Office of the Prime Minister's Chief Science Advisor, 2013). The same report also highlighted that changes in seasonal river flows and snow melt are likely.

The extent to which storage is available (or needed) for our irrigation schemes will be a key factor in the infrastructure response to climate change.

Figure 23: Global renewable water resources (2007)



Sources: ANZ, United Nations ESCAP

However, although climate change will stress our local resources to some extent, our relatively bountiful water resources in other regions may be a strategic advantage from a macro perspective[10]. Irrigation infrastructure can be used to collect allocated water from one catchment and apply it in another or several others. In the right circumstances, this can alleviate allocation pressure in catchments with scarcity and provide water for environmental flows and recreational pursuits.

[10] An increase in NZ population and higher incomes for New Zealanders may further increase the domestic demand for water (including environmental awareness and recreational uses). This will increase our requirements for water infrastructure and highlights the need for robust systems that allocate and manage water quantity and quality across the various sectors of our society (e.g. urban water, productive water, environmental flows).

Telecommunications

In the upside scenario, we assume that the UFB network (in tandem with the RBI) will continue to be progressively developed by 2020, but with adoption rates lower than expected. In general, the upside scenario assumes low demand for new technology, which is reflected in relatively higher demand for other assets (which have not leveraged productivity-enhancing technology improvements). However, this scenario does note the increased demand for services such as mobile which are aligned to population growth and migration, and expects increased demand in urban centres in particular.

With limited data and modelling publicly available, it is difficult to forecast the specific local, regional or national implications for our copper, mobile, fibre and other telecommunications assets in the upside scenario.

Social Infrastructure

Social infrastructure in the upside scenario is affected by high levels of population growth (in the urban centres) and decline (in rural centres). Key implications for each sector are noted below.

Education

Nationally, the combined primary and secondary school roll is projected by the Ministry of Education to be approximately 900,000 in 2030 under this scenario (where it is about 800,000 in the central scenario). Although the projections do not specifically note where these additional 100,000 students will be located, the associated Stats NZ population projections show a substantial increase in the upper North Island (and to a lesser extent, other major urban centres).

Justice

As with education infrastructure, the justice system will also be more heavily burdened in the upside scenario when compared to the central scenario. The forecast produced by the Ministry of Justice suggests the prison population may reach about 9,000 people in a high-demand environment (compared with 8,000 in the medium projection). This is essentially a flat prison population from the present day, rather than a declining population in the central scenario. Again, the spatial distribution of the impact is unknown but is expected to be primarily urban.

Health

In the upside scenario, the ageing of our population is slower than expected with high inward migration and high fertility rates. When compared to the central scenario, this is expected to increase the burden on maternity services and early childhood care – but will reduce the burden (in relative terms) on aged care facilities.

Downside Scenario: Implications for our infrastructure

The downside scenario reflects trends in key drivers of change that result in low investment requirements for New Zealand's infrastructure. Where projections or modelling results are available, we consider the implications for our infrastructure in the downside scenario by discussing specific deviations relative to the central scenario for each sector.

As with the other scenarios, the downside scenario does not represent the NIU's expectation of the future and we do not provide comment on the likelihood of all of the low demand factors (listed below) coinciding. Instead, this scenario should be viewed as a possible lower bound for infrastructure demand.

Key drivers of change in the downside scenario

Population

- Population reaches 5.2 million people by 2061 (declining after 2051 though)
- Higher than projected ageing of the population (low fertility & migration)
- Urban growth is constrained and rural centres are static or declining

Economy

- Decline in commodity export volumes and/or prices
- Decline or slow growth in services; rapid decline of heavy industry
- High public and private debt; low incomes / consumer ability to pay

Technology

- Rapid integration of technology with assets
- UFB take-up is much more rapid than current projections
- 4G (and, in the future, 5G) mobile demand exceeds best estimates

Resources

- High carbon price ($100 / tonne)
- Low sea level rise, little change in extreme event frequency, little to no pressure on water quantity & quality
- Limited discovery of commercially viable oil / gas reserves in NZ

A description of the downside scenario

The downside scenario is based on the lowest population projection and assumes a soft or declining world economy (particularly in developing countries). Urban growth is constrained and the population in rural centres is static or declining.

This translates, in infrastructure terms, to lower demand for transport, water and social infrastructure in major urban centres, and comparatively low demands placed on water resources, productive water infrastructure and freight transport modes. Rural infrastructure is underutilised due to both static or declining population and weak demand for goods produced by the primary sector.

In the downside scenario, the low aggregate demand for energy reduces the need for investment in new sources of generation and decreases the need to augment our energy distribution infrastructure – especially in areas where heavy industry is located.

Finally, the downside scenario assumes that climate change will occur more slowly than IPCC projections. From a spatial perspective, this extends the life of coastal assets – more than would be the case in the central scenario. In a similar vein, the regional effects of drought and flooding are also reduced.

Interdependencies in the downside scenario

In contrast to the other scenarios, the downside scenario assumes a warm embrace of new technology by our residents and rapid integration of information and communication systems in our infrastructure networks. In this scenario, the trend toward convergence of our infrastructure sectors accelerates and the potential for productivity gains are maximised.

The increase in interdependency manifests itself through better utilisation of existing assets and altered behaviours of our residents due to an increase in teleworking, e-commerce and consumer-centric demand management options.

Sector-by-sector discussion

Transport

As with the upside scenario, the same limited set of stochastic results from the long term demand model have been published by NZTA and NZIER. Graphs that show a possible range of demand for vehicle travel and public transport usage are again reproduced below:

Figure 24: Public transport demand (stochastic estimate)

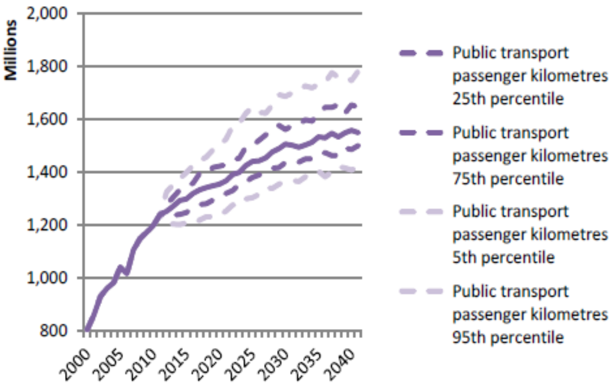
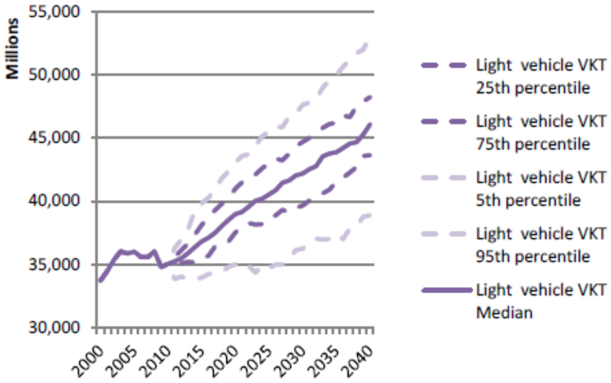


Figure 25: Vehicle kilometres travelled (stochastic estimate)

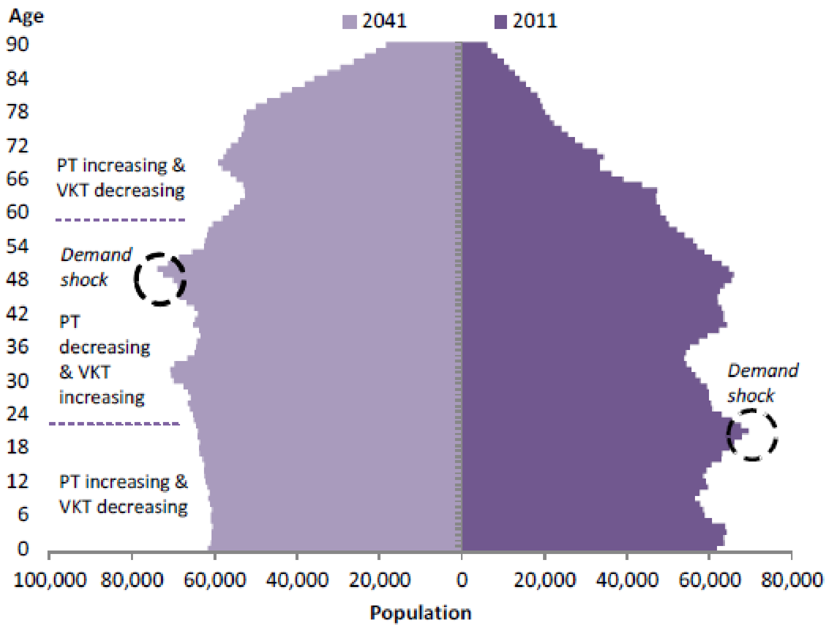


Source: National Long-Term Land Transport Demand Model, NZIER and NZTA (2013)

When compared to the central scenario (50^{th} percentile), the modelled equivalent to the downside scenario (25^{th} percentile) shows an approximately 10% reduction in public transport demand and 15% reduction in light vehicle kilometres travelled. The need to construct new roads, upgrade existing roads and develop new public transport options is accordingly diminished in this scenario.

As our population ages in the downside scenario, it is interesting to note an expected increase in public transport demand by the elderly (and an increase in private vehicle usage for those who are ‘middle-aged’ – driven by relatively high income growth in this scenario). The following graph demonstrates this concept:

Figure 26: Demand impacts by age distribution

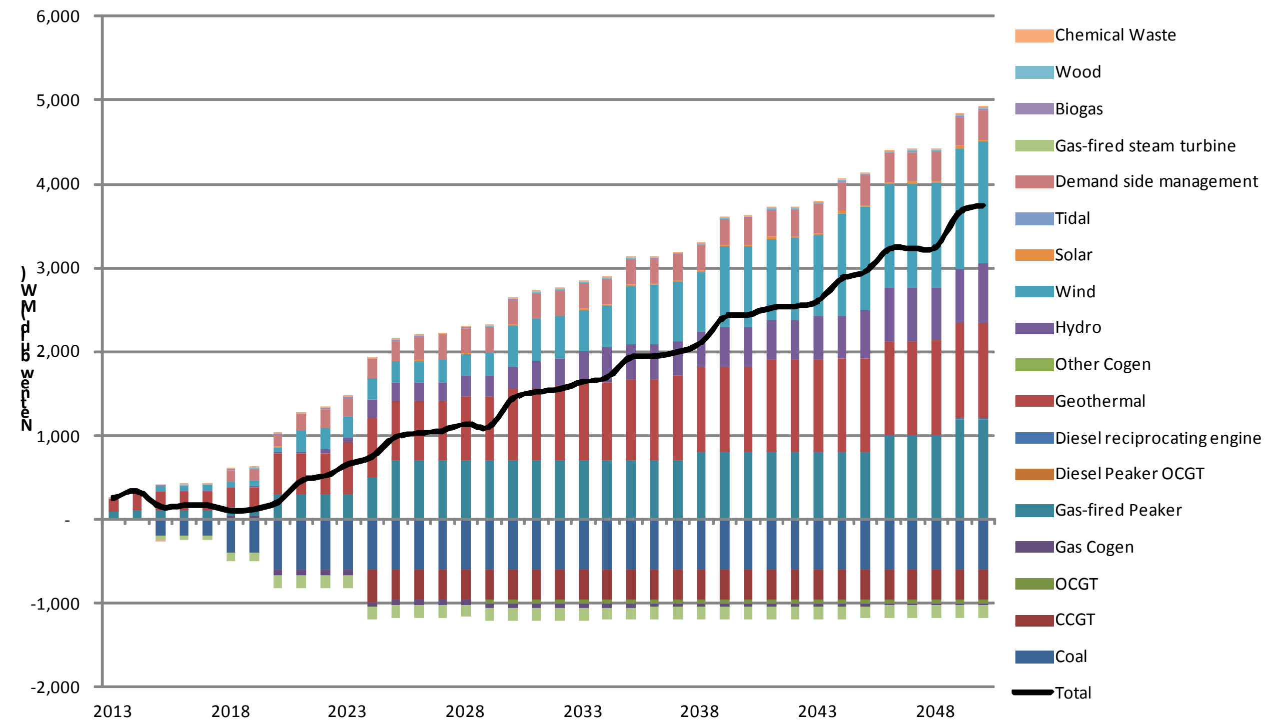


Source: National Long-Term Land Transport Demand Model, NZIER and NZTA (2013)

Energy

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.

Figure 27: 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 little to 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.

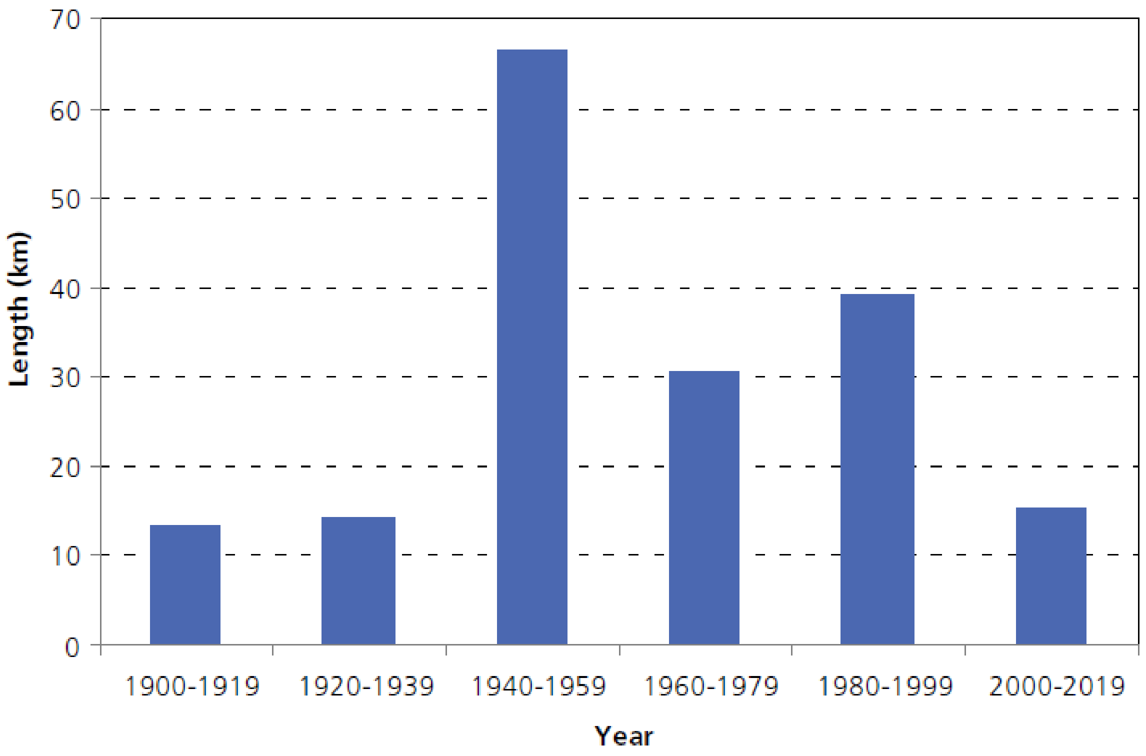
Water

Urban Water

As with the other scenarios, the effect of the downside scenario on our urban water sector is expected to be driven in large part by population. In this case, low population growth (and decline in some areas) will translate to lower requirements for new sources of supply and infrastructure upgrades. In rural areas that experience high population decline, the existing assets may in fact be significantly underutilised – with their operation and maintenance creating a burden on the remaining ratepayers.

In a similar vein, the downside scenario assumes that we have high public and private debt, lower incomes and a limited ability to pay by our ratepayers. In the medium to long term, this type of funding constraint could be exacerbated by the looming renewal of a substantial cohort of assets built in the mid-20th century. Although the average age and expected useful life of urban water assets varies across the country, Greater Wellington Water provides one example of the lumpy renewal liability faced by many councils in the next 30 to 50 years:

Figure 28: Length of distribution pipelines by year of construction (Greater Wellington Water)



Source: Greater Wellington Water (Water Supply Asset Management Plan, 2012)

Productive Water

Although climate change will be relatively ‘kind’ in the downside scenario, demand for productive water infrastructure will also be relatively low due to weak demand for our agricultural products.

Also, a proliferation of new technology, coupled with better information links through programs such as the Rural Broadband Initiative, will drive innovation and productivity in the agricultural sector. Low cost sensors for water, crops, livestock, weather and geospatial data will enable more efficient water use and better infrastructure management. Taken at face value, leveraging technology in the productive water sector would reduce or defer the need for capital upgrades. However, it should be noted that technology may in fact drive additional infrastructure investment – if, for example, better assets and more storage is required to ensure the water supply is reliable enough to make the technology investment worthwhile.

A recent report by CSIRO in Australia provided some insight into emerging technologies in the agricultural sector (Griffith, Heydon, Lefort, Taylor, Trotter, & Wark, 2013). These include:

- Integration of sensor data and related digital services into vertical supply chains to create efficiencies and innovation in processing, distribution and marketing
- The increasing focus by agribusiness companies on using digital services to optimise supply chains and complement their traditional focus on physical products and processes
- Biosecurity and food safety initiatives that will increasingly use agricultural sensor data for early detection and monitoring of incidents
- Growing consumer demand for information about food provenance that can be used to add value to food and provide more customer choice
- The development of tools and methodologies for biomass and carbon accounting that can be used for farm operations as well as emerging carbon markets
- Addressing the unmet demand from rural communities for better access to education, health and other social and communication services.

Source: CSIRO, Smart Farming: Leveraging the impact of broadband and the digital economy (2013)

Telecommunications

In the downside scenario, we assume that the UFB network (in tandem with the RBI) will continue to be progressively developed by 2020, but with adoption rates much higher than expected. In general, the downside scenario assumes high demand for new technology, which is reflected in relatively lower demand on other assets (where productivity-enhancing technologies have been leveraged). Although it also notes lower demand for services such as mobile which are aligned to population growth and mobility.

With limited data and modelling publicly available, it is difficult to forecast the specific local, regional or national implications for our copper, mobile, fibre and other telecommunications assets in the downside scenario. However, we assume that the aggregate demand will be relatively high for fibre and mobile in line with global trends.

It should also be noted that what we currently consider to be ‘ultra fast’ broadband will one day be ordinary by international standards. Although the timing of such a scenario is uncertain, the end result would be a need to upgrade our fibre networks to achieve faster speeds (or to invest in other technologies, whatever they may be).

Social Infrastructure

Social infrastructure in the downside scenario is affected by low projections for population growth (in the urban centres) and gradual decline (in rural centres). Key implications for each sector are noted below.

Education

Nationally, the combined primary and secondary school roll is projected by the Ministry of Education to be approximately 700,000 in 2030 under this scenario (where it is about 800,000 in the central scenario). The projections do not specifically note where this decline will occur.

Justice

As with education infrastructure, the justice system will also be less utilised in the downside scenario when compared to the central scenario. The forecast produced by the Ministry of Justice suggests the prison population may reach about 7,000 people in a low-demand environment (compared with 8,000 in the medium projection) – an acceleration of the trend toward a declining prison population. Again, the spatial distribution of the impact is unknown.

Health

In the downside scenario, the ageing of our population is higher than expected with low inward migration and low fertility rates. When compared to the central scenario, this is expected to decrease the burden on maternity services and early childhood care – but will substantially increase the burden on aged care facilities.

Summary

Concluding remarks

Pressure is placed on our infrastructure networks by four fundamental drivers of change: population, economy, technology and resources. While it is common to forecast a best estimate of demand, the future is inherently difficult to predict. The purpose of this publication, therefore, is to create a profile of future demand that encompasses a range of plausible upside and downside scenarios.

During our investigations, it became clear that the energy and transport sectors have both undertaken significant work in the area of scenario planning and demand modelling – based on the fundamental drivers of change, incorporating both spatial and temporal effects and considering the interdependencies between infrastructure sectors. Although the demands placed on energy and transport infrastructure are no less daunting, it is encouraging that systems appear to be in place to enable proactive management of these networks.

Although demand modelling has been undertaken within the water and social infrastructure sectors, it is more difficult to find published evidence that allows us to paint a joined-up picture at a local, regional and national level that includes both upside and downside scenarios. The same is true for telecommunications, where the sector is privatised and has not published forecasts or trend analysis.

Regardless of the sector, the future implications for our infrastructure are profound. In the upside scenario, population growth creates high demand on all aspects of our urban infrastructure and economic growth exacerbates this demand. Regional infrastructure requirements are commodity-driven in the main, creating demand for productive water infrastructure and transport links for distribution or export. Failure to manage these high levels of demand will inhibit the growth of our economy and restrain living standards from reaching a level they might otherwise have achieved.

On the contrary, the downside scenario creates, on balance, a low demand trajectory for our infrastructure. Although technology uptake is high (creating demand in the telecommunications sector), the other sectors are relatively unburdened due to low population growth, limited urbanisation and anaemic economic growth. In this case, continuing to augment our infrastructure networks in the long run may lead to an expensive mistake – resulting in early investment or, in the worst case, a network of stranded, underutilised and oversized assets that are costly to build and maintain.

Whether our future follows a low-demand path, a high-demand path or somewhere in between is unclear. But, the lesson to be learned is more obvious: it is essential that we have, both within and between our infrastructure sectors, a robust system in place that helps us to anticipate shifting patterns of demand and to respond appropriately.

Next steps

Having developed an evidence base that covers performance, trends and scenarios, resilience and capital intentions, our next step is to investigate the most appropriate ‘response’. In doing so, the NIU’s first action is to consult widely with each sector on the evidence base and what, if any, actions might be needed to address issues highlighted by it.

This initial scenario modelling investigation helps to provide an illuminating perspective on the nature of the response and conveys two clear messages – namely, that the response should seek to:

- Leverage the positive drivers of change (e.g. embrace cost-effective new technologies) and mitigate the negative drivers of change (e.g. develop and implement climate change adaptation plans), and
- Exploit the opportunities presented by interdependence (e.g. intelligent networks that improve asset utilisation), whilst simultaneously managing the risks of interdependence (e.g. resilience planning to protect against failure propagation).

Finally, the infrastructure response is not expected to be a static plan. Instead, the response must continuously evolve to address new evidence and shifting trends – whether global or domestic.

References

Alcatel-Lucent. (2012). Building the Benefits of Broadband: How New Zealand can increase the social and economic impacts of high-speed broadband.

Cisco. (2013). Cisco visual networking index: Global mobile data traffic forecast update, 2012-2017.

Frith, W., Mara, M., & Langford, J. (2012). Demand for transport services: Impact on networks of older persons' travel as the population of New Zealand ages. NZ Transport Agency Research Report 481.

Greater Wellington Regional Council. (2012). Water supply asset management plan.

Griffith, C., Heydon, G., Lefort, D. L., Taylor, K., Trotter, M., & Wark, T. (2013). Smart farming: Leveraging the impact of broadband and the digital economy. CSIRO and University of New England.

MBIE. (2011). Energy Outlook: Reference Scenarios and Sensitivity Analysis.

MBIE. (2013). New Zealand's Energy Outlook: Electricity Insight.

MfE. (n.d.). Climate change impacts in New Zealand. Retrieved November 5, 2013, from http://www.mfe.govt.nz/issues/climate/about/impacts.html

Ministry of Business, Innovation & Employment. (2013). Regional economic activity report.

Ministry of Education. (2011). National school roll projections: 2011 update.

Ministry of Justice. (2012). Justice sector forecasts 2012-2022.

New Zealand Treasury. (2013). New Zealand Economic and Financial Overview.

OECD. (2012). Looking to 2060: Long-term global growth prospects. France.

OECD. (2013). OECD Economic Outlook, Volume 2013 Issue 1.

OECD. (2008). OECD Environmental Outlook to 2030. Paris.

Office of the Prime Minister's Chief Science Advisor. (2013). New Zealand's changing climate and oceans: The impact of human activity and implications for the future.

Richard Paling Consulting. (2008). National freight demands study.

Statistics New Zealand. (2012). National population projections: 2011(base)–2061.

Statistics New Zealand. (2012). Subnational population projections : 2006(base)-2031 (October 2012 update).

Stephenson, J., & Zheng, L. (2013). National long-term land transport demand model (NZTA research report 520 undertaken by NZIER).

Sullivan, R., & Aldridge, T. (2011). The outlook for commodity prices and implications for New Zealand monetary policy. Reserve Bank of New Zealand.

Transpower. (2011). Transmission Tomorrow.

Transpower. (2011). Transmission Tomorrow: Enduring grid.

United Nations. (2009). The United Nations world water development report 3: Water in a changing world.

Watercare. (2013). Auckland regional water demand management plan 2013-2016.