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Relative long-term demand risk between electricity and gas networks

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Concept has undertaken a wide range of assignments, providing advice on market design and development issues, forecasting services, technical evaluations, regulatory analysis, and expert evidence.

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1 Introduction / overview

Concept has been asked to comment on whether gas network businesses face fundamentally greater risks than electricity network businesses.

We have interpreted this as whether the demand for gas network services is inherently more uncertain (particularly with respect to downside risk) than the demand for electricity network services.

In this, it is necessary to distinguish between two different dimensions for the demand for network services: [1]

- Firstly, the average demand per customer can vary, either MWh volume and/or peak MW.
- Secondly, the number of customers connected to the network may vary. Such variation can be driven by changes in population, but they can also be driven by customers choosing to 'defect' from the network and not take any network services.

If the average MWh and/or peak MW demand per customer changes then, subject to any regulatory constraints, the network company can address any potential short-term revenue impacts by altering their tariffs (either the level and/or the structure).

However, such re-setting of tariffs will be constrained if the consequent price reached a level where customers could achieve their energy services via alternative means than through network delivery, and thus decided to defect from the grid.

Accordingly, it is considered that the risk of network defection is the most significant fundamental risk affecting network companies. While it is clearly influenced by variations in per-customer demand, the principal factor which will drive the risk of network defection is if there are feasible alternatives for the provision of <u>all</u> the energy services which customers require.

Using this framework, it is considered that gas networks do face a fundamentally greater demand risk than electricity networks because gas is a discretionary fuel for the vast majority of gas consumers, whereas electricity is more of an essential service.

In other words, the majority of gas consumers have feasible fuel and technology alternatives to provide the service for which they currently use gas as an input. For many of the most significant uses of gas, the economics of gas versus alternatives has the potential to move against gas, giving rise to the potential for significant demand defection in the long-term and associated network stranding.

Conversely, for a significant proportion of the uses for which consumers use electricity (e.g. lighting, whiteware, computing, entertainment systems, etc.) there are no feasible non-electricity alternatives.

Section 2 provides analysis of the relative economics of gas versus other fuels for the main uses of gas, and highlights that gas faces significant competition from alternative fuels for most of its main uses. The experience of the Queensland gas networks is used as an illustration of how this competition can result in significant gas network defection if the relative gas/electricity economics move materially against gas.

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[1] It is also useful to distinguish between short-term variations in demand driven by the weather, and long-term changes in the underlying drivers of demand (population, GDP, technology change, etc.). Although weather can drive material year-to-year variations in demand, it is considered that the fundamental risk for network demand is driven by changes in these long-term underlying drivers. It is this long-term risk which is the principal focus of this note.

This section also concludes that the different breakdowns of consumer segments for gas distribution and gas transmission networks may mean that the relative demand risk could also be different between the two networks.

Section 3 presents some analysis which indicates that the discretionary nature of gas versus the 'essential' nature of electricity has been reflected in rates of customer connection/disconnection to the respective networks.

All the above is not to say that electricity networks might not face stranding risk in the future. However, the nature of the risk is different to that for gas. Thus, while gas networks face stranding risk from being substituted by alternative fuels, the risk to electricity networks come from consumers potentially generating their *own* electricity using technologies such as photovoltaics and batteries.

This may reduce the volume of electricity flowing across electricity networks and, ultimately, could raise the threat of customers disconnecting from the grid altogether. However, section 4 sets out some qualitative analysis which suggests that the electricity grid defection stranding risk from such technologies is likely to be substantially less than that faced by gas networks.

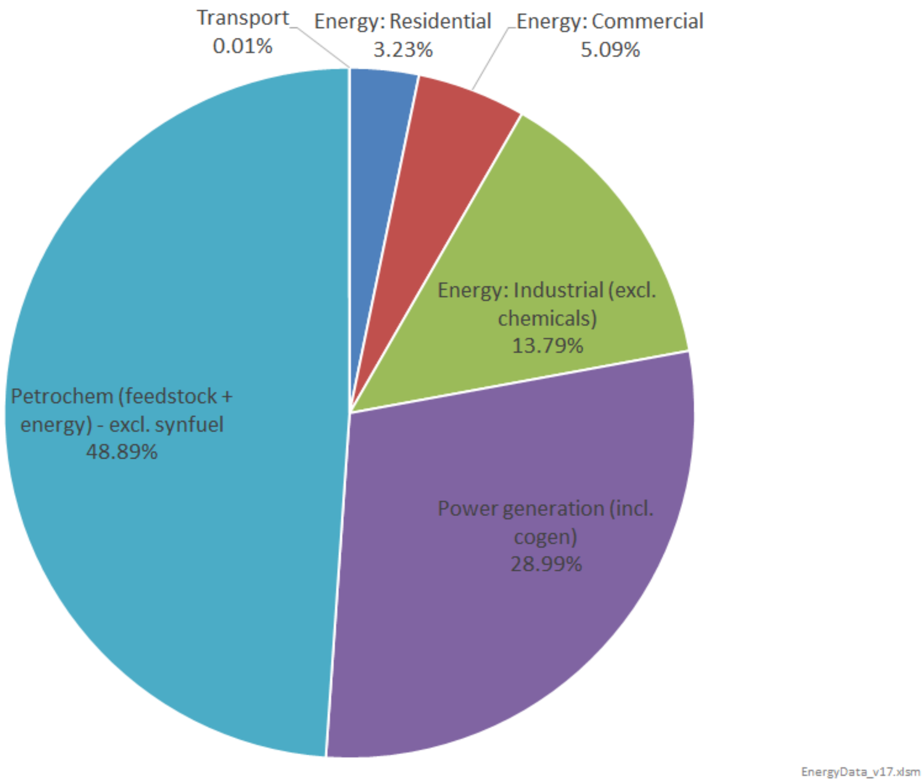
2 Consideration of gas network stranding risk

2.1 The economics of gas versus alternatives

Figure 1 illustrates that gas in New Zealand is used for three main purposes:

- As a feedstock for making petrochemical products such as methanol and urea;
- As a fuel for power generation; and
- As a fuel for heating energy for residential, commercial and industrial consumers.

Figure 1: Breakdown of New Zealand gas consumption for 2014



Source: Concept analysis using MBIE data

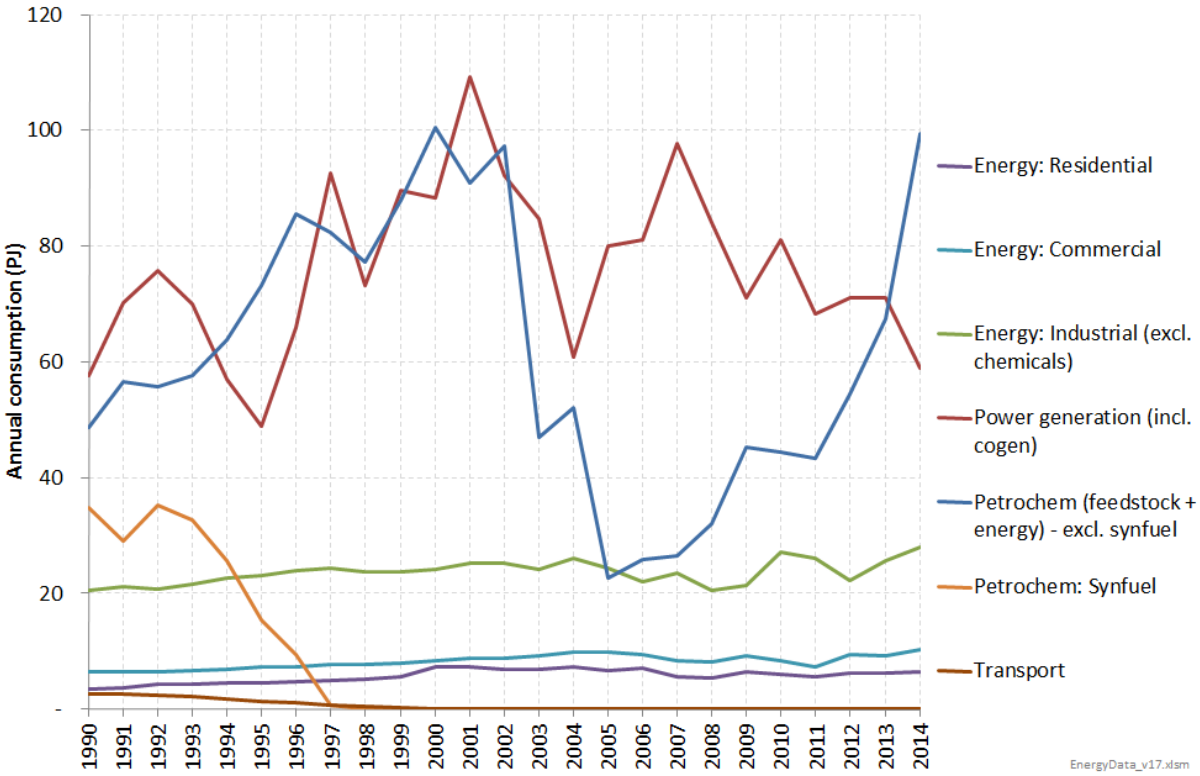
This section of the report considers the economics of these different uses, and their implications in terms of gas network demand risk.

2.1.1 Petrochemical demand

Although petrochemical demand is the largest user of gas in New Zealand, it is considered that it is the sector with the greatest long-term demand volatility. This is not because alternative fuels may displace gas, but because New Zealand may be displaced as a location for manufacturing the petrochemical products. Such an outcome could occur if New Zealand wholesale gas prices rise materially in relation to overseas locations. This could happen if there was limited future upstream exploration success.

Figure 2 below shows that this volatility has been seen historically as New Zealand's upstream gas position has moved between situations of relative surplus and scarcity.

Figure 2: Historical changes in demand for key gas using segments



That said, petrochemical demand contributes relatively little to gas transmission network revenues due to the close-to-wellhead location of production facilities. Accordingly, although it exhibits significant demand risk, its small contribution to gas transmission revenues (and zero contribution to gas distribution revenues) means that in itself it is not a major factor driving gas network risk.

2.1.2 Power generation demand

Power generation demand is considered the next most volatile demand segment in New Zealand – as has been seen historically in Figure 2 above. Although a significant amount of the apparent volatility shown in Figure 2 is due to year-to-year variation in hydro generation, there is a more significant underlying volatility driven by the relative economics of gas-fired versus renewable generation for meeting a growth in demand.

After a period during the '90s and early 2000s where combined-cycle gas turbines were the cheapest new-build option, the pendulum has swung and now wind and geothermal plant are the cheapest new-build options for New Zealand. This relative competitive positioning for *baseload* power stations, is likely to persist with the result that no new baseload gas-fired power stations are likely to be built, and more existing ones are likely to retire (as has been the case for Otahuhu B and Southdown).

The italicisation of "baseload" is to indicate that gas-fired power stations are likely to remain the most competitive option for meeting *peaking* electricity demand. Accordingly, it is likely that we will continue to see new peaking gas-fired stations built going into the future. However, such new peaking stations are likely to be built close to well-head and thus are unlikely to contribute much to gas transmission network revenues (and zero to gas distribution revenues).

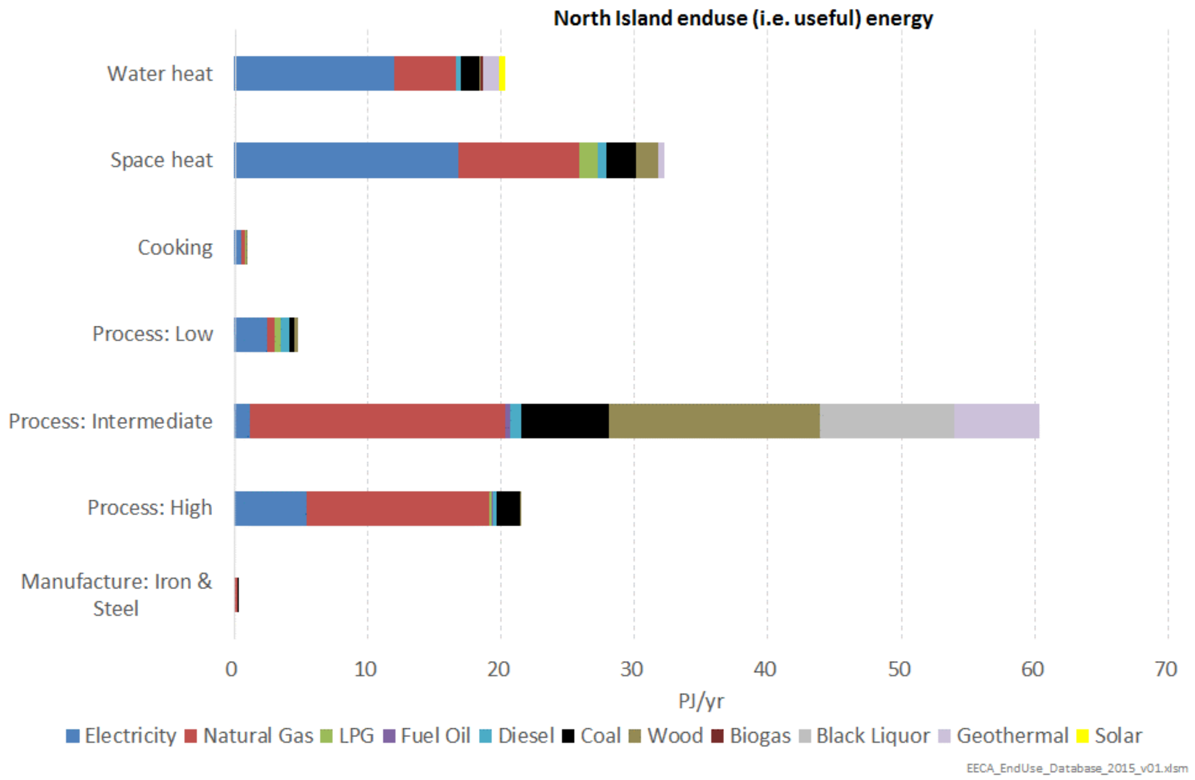
Therefore, the only gas network with continued exposure to power generation demand is the Maui gas transmission pipeline in relation to gas-fired generation at the Northern end of the pipeline – the e3p CCGT, and as a potential location for new peakers.

2.1.3 Energy demand for residential, commercial and industrial users

Figure 3 below shows that heating 'Energy' use is dominated by three main sub-applications:

- Space heating
- Water heating
- Process heat – i.e. raising heat for an industrial process. This in turn is split into three main sub-categories:
  - Low-temperature (<100°C) process heat
  - Intermediate-temperature (100-300°C) process heat
  - High-temperature (>300°C) process heat

Figure 3: Breakdown of fuel shares for end-uses where gas is an option



Source: Concept analysis using EECA Energy End-use Database data

Figure 3 also provides another key insight: For all these main applications bar one (high-temperature process heat), gas is the minority fuel meeting consumers' requirements. In other words, there are significant alternatives other than gas for the provision of the heating service.

The key implication from this is that there could be significant demand defection risk away from gas to these alternative fuels if the economics of gas versus alternatives were to move away from gas.

Concept has recently done some analysis for Gas Industry Co looking at such economics, and arrived at the following conclusions:

- ***Space heating:*** Gas space heating faces the greatest competitive pressure, with electric resistance heating being more cost effective for small heating loads, and the economics of gas being fairly evenly balanced against alternatives such as heat pumps or wood burners for medium to large heating loads. This is reflected in significant growth in heat pump sales, and anecdotal evidence of gas space heating being displaced by heat pumps.

- ***Water heating:*** 'Instant' gas water heating is generally competitive against electric cylinders and (even more so) against heat pumps and solar water heaters. However, the economics of gas water heating are influenced by whether a household has gas for space heating as well (and thus whether the fixed charges of gas supply will count solely against water heating), and thus the long-term competitiveness of gas water heating could be affected by gas' relative success in the space heating market.
- ***Process heat:*** Gas is strongly competitive for the provision of industrial process heat – much more so than its relative competitiveness for space and water heating. In significant part this relates to the fact that heat pump technology is not well suited to raising steam to the high temperatures required for process heat. Accordingly, the main alternatives are combustion fuels such as coal, biomass and diesel – all of which suffer from either high boiler capital and/or high fuel costs relative to gas except in a few specific situations (e.g. forestry processing facilities with 'free' on-site biomass fuel, or existing coal boilers for large industrial plant located 'at the coal mouth').

In summary, the analysis suggests that while gas demand to supply industrial process heat looks relatively secure, the same could not be said for space and water heating if gas prices were to rise significantly and/or the cost of electricity heating options were to fall significantly.

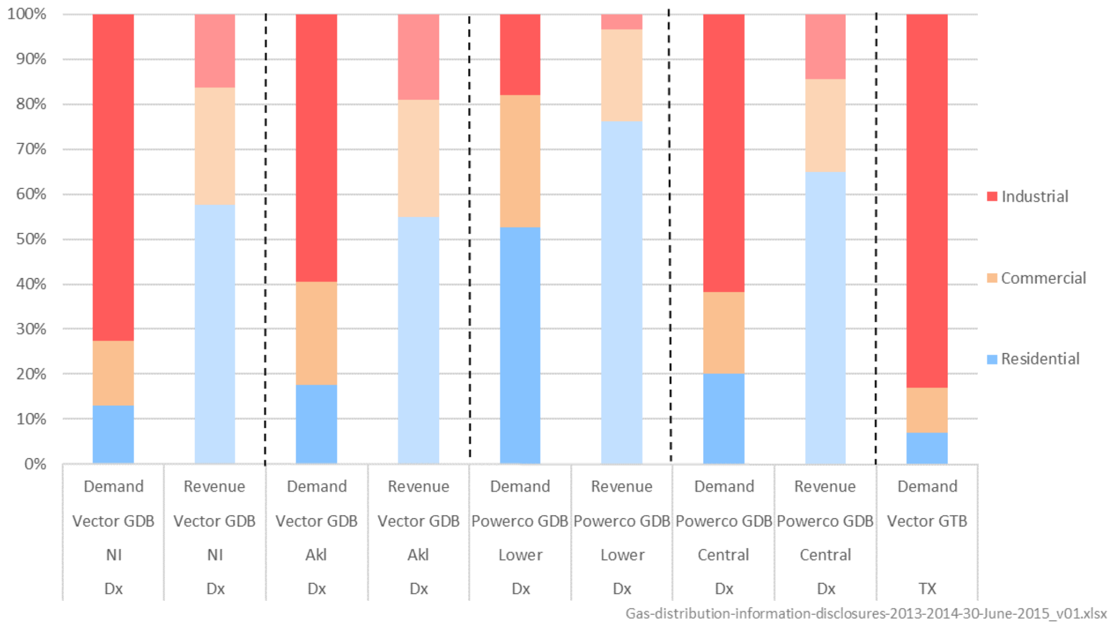
That said, the GIC analysis also shows that appliance capital costs are significant components of the lifetime costs of energy for space, water and process heating. This means that any defection away from gas is likely to be relatively slow, driven by the replacement cycle of capital appliances which can have lifetimes of 15 to 20 years. However, the corollary of this is that once a space or water heating customer has switched to another fuel, it becomes much harder to win them back.

Another implication from the above analysis, is that the relative competitiveness between these three key end-uses for gas may be reflected in different risks between gas transmission and gas distribution networks.

Specifically, because gas distribution networks' revenue is so heavily dominated by residential and commercial demand (as illustrated by Figure 4 below) – which in turn is dominated by the more at-risk uses of space and water heating (as illustrated by Figure 5 below) – the long-term risk faced by gas distribution networks is likely to be significantly greater than that faced by gas transmission networks which have a greater proportion of industrial process heat demand.

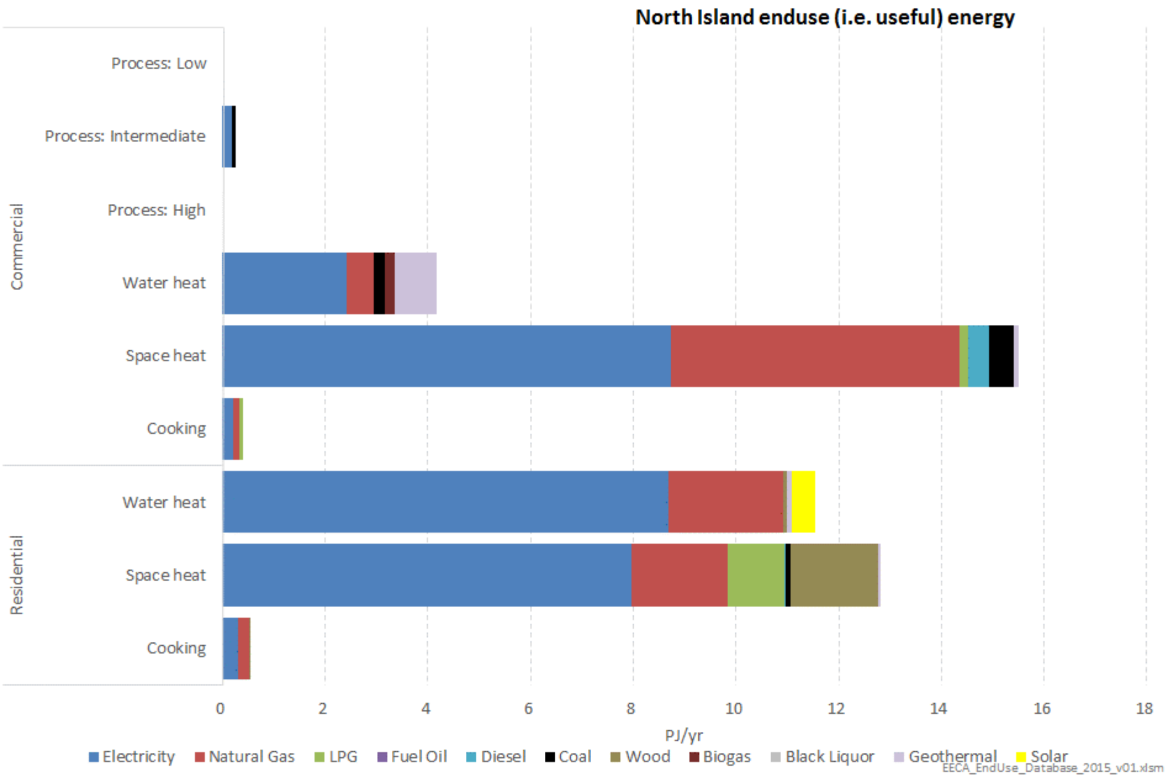
Indeed, it is hard to see how this could not be the case given that gas distribution networks have to get their gas from gas transmission networks. Therefore, if gas distribution networks exist, transmission networks must also, whereas it is feasible to see a future where gas transmission networks only exist to supply a relatively small number of very large directly-connected industrial consumers, even if gas distribution networks have substantially withered away.

Figure 4: Demand and revenue split across consumer segments for gas pipelines[2]



Source: Concept analysis using Commerce Commission Disclosures

Figure 5: Breakdown of residential and commercial fuel shares for end-uses where gas is an option



Source: Concept analysis using EECA Energy End-use Database data

[2] Revenue decomposition data for Vector's gas transmission business is not readily available from public disclosures, hence only the demand decomposition data has been shown for the Vector gas Tx business.

2.2 Queensland is a live example of the stranding risk faced by gas networks

An example of the risk of gas network defection due to the discretionary nature of gas is being demonstrated in Queensland. There, rising gas prices, coupled with falling costs of electricity technologies (particularly reverse cycle air conditioners), are resulting in falling gas demand.

This has reached the point where the National Competition Council has decided that it is no longer necessary to regulate gas network prices, and instead move to a regime of light regulation – largely information disclosure. In reaching this decision the Council noted:

> "*The most significant constraint on market power associated with the Queensland Gas Distribution Network is the ability for end users to substitute other forms of energy – electricity and LPG. The Council acknowledges the precarious competitive position of gas in the areas served by the Queensland Gas Distribution Network*".[3]

Clearly, due to climatic factors, the relative position of gas as a fuel for Queensland consumers is going to be different for New Zealand consumers. Nonetheless, the differences are differences of degree, rather than fundamental nature. Accordingly, material shifts in the price of gas heating and/or electricity heating in New Zealand could, over the long term, result in similar outcomes to those currently being experienced in Queensland.

[3] "*Light Regulation of Envestra's Queensland Gas Distribution Network. Final Determination and Statement of Reasons*", National Competition Council, 5 November 2014

3 Analysis of gas and electricity connection statistics

The previous sections have set out analysis which suggests that:

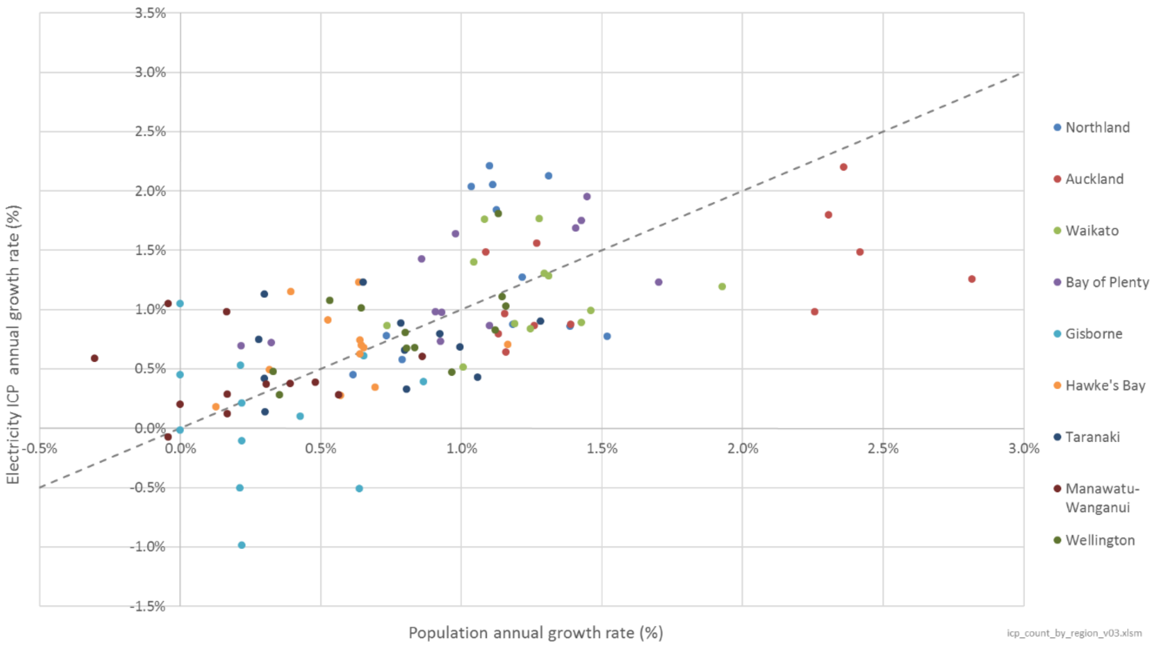
- gas is a discretionary fuel for the vast majority of gas consumers; whereas
- electricity is more of an essential service, with no practicable alternative than grid-supplied electricity for the majority of consumers.

To examine whether this has been reflected in consumer decisions, analysis was undertaken to determine whether there is a discernible difference between population growth, and growth in the number of gas and electricity customers.

This analysis – which only looked at areas which have both gas and electricity to enable a 'like-for-like' comparison – is presented in Figure 6 and Figure 7 below.

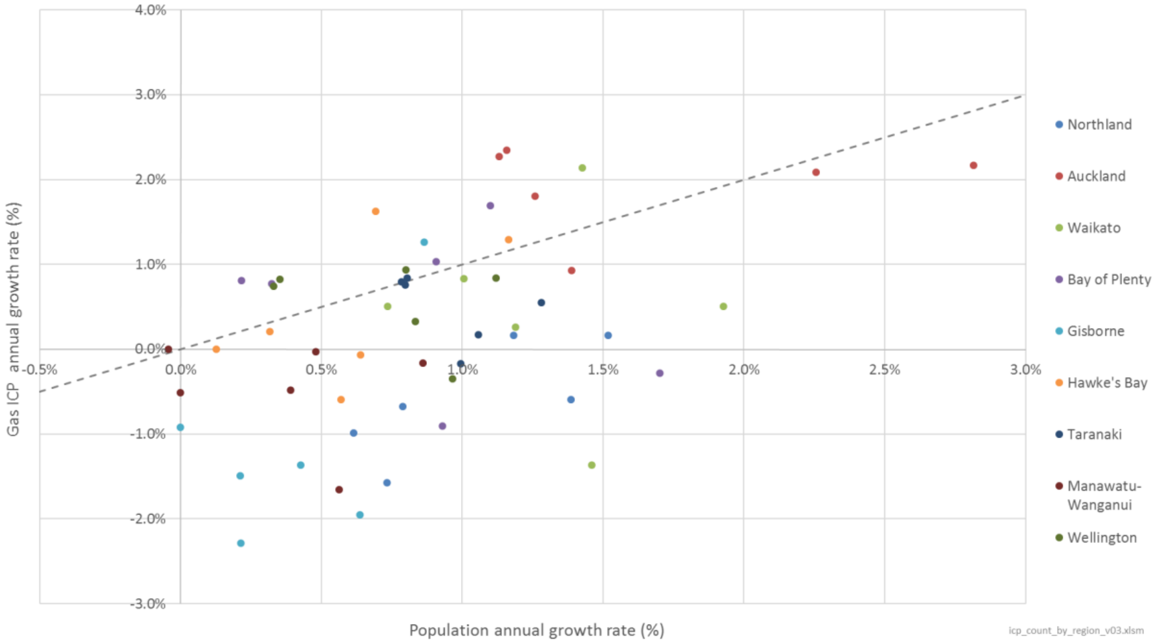
These plot the observed annual population growth rates against the observed annual change in electricity and gas customer numbers. For comparison a "45 degree" dotted line is shown, illustrating where the points should sit if there were a perfect correlation between population growth rates and electricity/gas customer number growth rates.

Figure 6: Correlation between population growth rates and electricity customer numbers (YE June 2004 to 2015)



Source: Concept analysis using NZStats population data and Electricity Authority electricity ICP data.

Figure 7: Correlation between population growth rates and gas customer numbers (YE June 2010 to 2015)



Source: Concept analysis using NZStats population count and GIC gas ICP data.

The key take-aways from this analysis are:

- There appears to be a much tighter correlation between electricity customer numbers and population growth than gas customer numbers and population growth.
- There are a material number of instances of gas customer numbers *falling* despite population rising, whereas there are very few such instances for electricity.[4]

All in all, this analysis appears to support the hypothesis that gas is discretionary whereas electricity is essential.

[4] All the instances for electricity customer numbers falling at times when population is rising are in one region: Gisborne. This is either suggestive of a significant change in demographics in terms of average people per household that hasn't been experienced in other New Zealand regions, or a possible issue with the accuracy of the Gisborne data.

4 Electricity network stranding risk arising from new technologies

The previous analysis has been based on the hypothesis that, unlike gas, a significant proportion of the uses for which consumers use electricity (e.g. lighting, whiteware, computing, entertainment systems, etc.) have no feasible non-electricity alternatives. These uses have become such a fundamental part of our everyday life that electricity is generally regarded as an essential service.

This appears to have been reflected in the analysis presented in section 3.

But this is not to say that electricity networks do not face their own unique future risks which could affect the demand for network services.

Whereas the risk for gas networks comes from being substituted for alternative fuels, the nature of the risk for electricity networks comes from consumers producing their *own* electricity on site rather than purchasing it from the grid.

Historically such risk has been extremely low due to the significant economies of scale associated with electricity generation. However, recent developments in technologies such as photovoltaics and batteries mean that it is becoming cheaper for some consumers to produce their own electricity rather than purchase it from the grid.

Not only will such developments reduce the volume of electricity flowing across electricity networks, ultimately they raise a potential risk of customers disconnecting from the grid altogether. Indeed, there has been much discussion in elements of the media about the so-called 'death spiral' for electricity networks as a result of PV-induced mass grid defection.

However, there are a number of factors to suggest that such technologies will not result in anywhere near the same type of stranding risk as faced by gas networks. Full discussion and analysis of such factors is outside the scope of this note but, in brief, the key factors are discussed qualitatively as follows.

Firstly, the economics of consumers using solar PV in order to disconnect from the grid do not currently stack up – at least from a public benefit perspective (more later). The significant seasonal variation in solar output – which is counter-seasonal to general demand patterns – and the potential for extended cloudy periods, means there is a need for significant amounts of battery and/or diesel genset back-up for when the sun is not shining. Neither of these back-up options are currently anywhere near cheap enough to justify full grid disconnection.[5] Similarly, solar PV itself is also currently at least twice as expensive as grid purchased electricity.

There would have to be significant cost reductions in all of these technologies (particularly batteries) in order for grid disconnection to start to become economic.

However, were battery costs to start to fall to the level where grid disconnection was to become cost-effective, it is almost certain that another technology – namely electric vehicles (EVs) – would have become economic sooner, and we would likely see large-scale uptake of EVs displacing internal combustion engine vehicles (ICEs).

The significant increase in electricity demand associated with charging an EV would mean it would become harder for a household to install enough PV panels to provide sufficient electricity – particularly during winter periods.

In other words, were consumers to disconnect from the grid in a world with low battery costs, they would be denying themselves access to another technology (namely EVs) whose cost savings would be even greater than the costs savings that could be achieved from grid defection.

[5] Large numbers of diesel gensets in an urban area may also create local environmental impacts including noise which could limit the extent of diesel backup-facilitated urban grid disconnection.

This dynamic points to another factor behind mass electricity grid defection being unlikely: namely that a large number of consumers don't have the physical capability to generate sufficient on-site power from PV to meet their requirements. Thus, apartment dwellers and other households with little suitable roofspace, plus large numbers of commercial and industrial consumers don't have sufficient space to install the quantity of PV panels required to meet their electricity requirements. And the economics of other micro-generation technologies (micro-wind, cogeneration, diesel generation) are not cost-competitive with grid generated electricity to facilitate such grid-defection by other means.

This means it is likely there will always be a significant proportion of consumers for whom grid-generated electricity is their only feasible option to meet their electricity requirements. A proportion which may grow if, as set out above, mass EV uptake were to occur.

This is not the case for gas where, particularly for distribution networks providing predominantly space and water heating, it is entirely feasible for consumers to switch to alternative technologies en-masse to meet their heating requirements without incurring major cost increases.

All the above is not to say that these new technologies won't result in some displacement of electricity network assets:

- It will increasingly be cost-effective to supply the electricity requirements for some remote rural consumers via local generation and so-called micro grids, rather than large distances of distribution network.
- The size of some assets may prove to be over-built as new technologies enable more dynamic peak control.[6]

However, although the average per customer demand (MWh and peak MW) may change – the revenue implications of which can be addressed by altering tariffs – the grid is likely to continue to be required for the vast majority of electricity consumers for the foreseeable future. Therefore, the risk of significant electricity grid defection is considered to be substantially less than that facing gas networks.

A final caveat to this, is that the above analysis considering electricity grid defection is entirely qualitative.

It should be noted that Concept will shortly embarking upon more detailed quantitative analysis of the above factors to determine whether this is indeed the case, or whether alternative scenarios could possibly result in significant stranding of electricity assets (e.g. a combination of a mass shift to gas / LPG / wood for space and water heating with significant falls in PV and batteries to meet the residual electricity needs).

[6] However, the economies of scale of electricity networks mean that the asset value of such stranding may not be directly proportional to the difference in peak demand.