



T R A N S P O W E R

HVDC Grid Upgrade Project

Proposal

Attachment C

Covec Report on South Island Demand

Doc reference: Inter-island HVDC Pole 1 Replacement
Investigation/DC/Consult/Covec Report

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South Island Electricity Load Growth

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Introduction

As part of an evaluation process for upgrades to the HVDC link, Transpower needs to understand how fast demand in the South Island is likely to grow. This is an important input into the analysis because load on the link depends on the supply/demand balance in the South Island relative to the North Island.

Selecting Variables to Drive the Forecast

A debate has occurred over the appropriate way to model and forecast demand, with the relevance of population as the driver of forecasts being questioned. In this report, we investigate the performance of a wider range of variables in models that *explain* historic demand in the South Island. However it needs to be understood that while the ability to explain history is important, it is not the sole criterion for designing a forecasting model. One additionally needs to consider the ability of the model to actually generate reliable forecasts.

To explain this point more clearly, consider a simple model of the following form

$$D_t = \alpha + \beta X_{t-1} + \varepsilon_t$$

where D_t is demand in period t , X_{t-1} is a variable observed in the previous time period ($t-1$) and thought to influence demand, α and β are parameters to be estimate and ε_t is a random error term.

If this model explains the history of demand well, future demand can be predicted one period ahead with relative ease. If a and b represent the estimates of α and β , the predicted demand in period $t+1$ is simply

$$D_{t+1} = a + bX_t$$

The key point is that we already know X_t , which drives the forecast of D_{t+1} . If we want to forecast demand any further ahead, we also need to forecast the driving variable X . Errors in the forecasts of X are a potentially important source of errors in forecasts of demand. Thus, when selecting a variable to drive a forecasting model, confidence in *forecasts* of that variable are a relevant consideration.

Our Empirical Analysis

We investigated the empirical relevance of three potential drivers for forecasts of South Island demand:¹

- Population;
- Economic activity measures; and
- Dairy sector indicators.

Population is obviously a factor contributing to residential demand, though household numbers and electricity usage per household are also likely to matter. In the absence of reliable time-series information that would address these composition issues, we used aggregate population. Statistics New Zealand publishes sub-national population forecasts, which are not error-free but are at least widely understood.

The best known measure of economic activity is real GDP. This is potentially a useful explanatory variable, though again there are compositional factors that could be relevant (eg shifts away from manufacturing and towards commercial services). A further difficulty is that sub-national GDP estimates are not available over an adequate time-span. Statistics New Zealand has only published sub-national estimates of nominal GDP for the years 2000-03 inclusive,² but this is too short a time-series to be useful.

We therefore considered two options as indicators of economic activity in the South Island: national real GDP, and the economic activity index published by the National Bank (which we annualized by averaging across quarters).³ Figure 1 shows that these variables are highly correlated; their linear correlation is 99.5%.⁴

There are several dairy industry indicators available for the South Island including:

- Cow numbers
- Litres of milk
- Kilograms of milk solids.

All potential measures have in excess of a 99% correlation with cow numbers, which is the variable we used.

Finally, we need a measure of demand for electricity. The two options are total withdrawals from the grid, and peak withdrawals from the grid. We used the variables contained in Meridian's letter to Transpower dated 25 February 2008. Both variables are available for the period 1997-2007 inclusive. They have a linear correlation of 96% over this time period.

¹ We only considered publicly available data for inclusion in the models.

² This was an experimental project. While the experiment was successful we understand that continuation of the series was not resourced. Further information is available at <http://www.stats.govt.nz/analytical-reports/regional-gross-domestic-product.htm>.

³ <http://www.nationalbank.co.nz/economics/regional/default.aspx>

⁴ Over the short period for which sub-national *nominal* GDP is available, it is highly correlated with both these measures: 99% with the NBNZ series, and 98% with national real GDP.

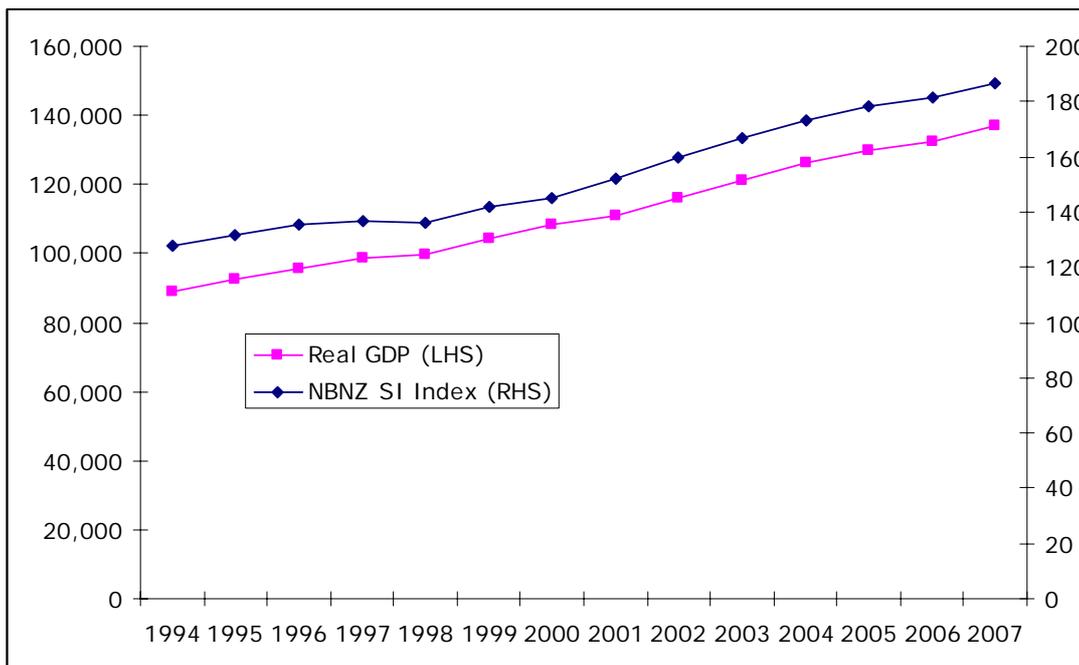


Figure 1 Nationwide Real GDP and South Island Economic Activity

Before modelling, it is useful to inspect the data, most of which are plotted in Figure 2. This shows steady and reasonably smooth growth in all variables except cow numbers which experienced something of a surge beginning in 2001.

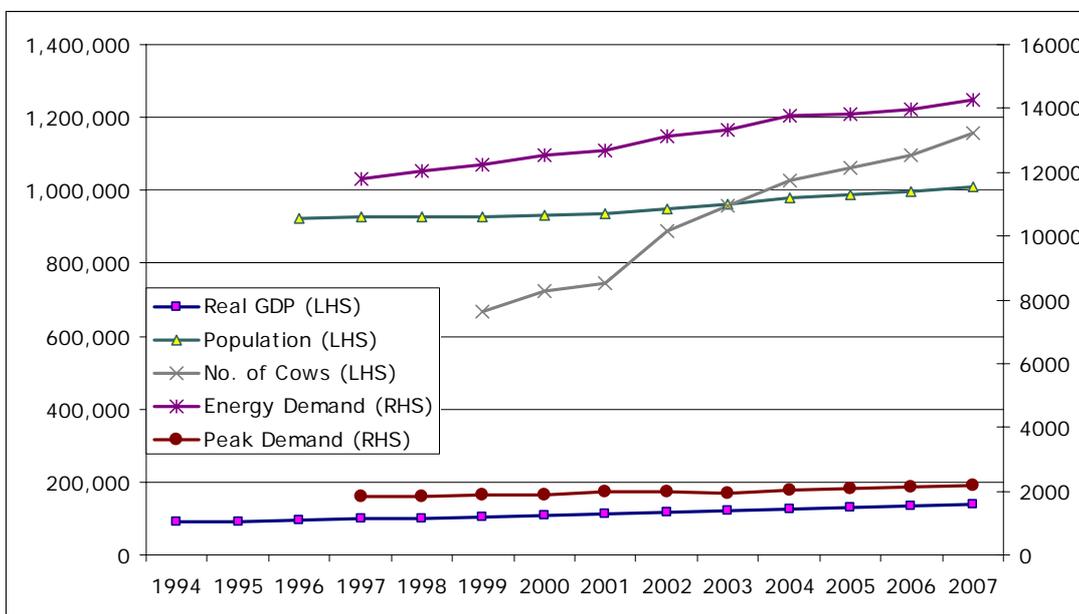


Figure 2 SI Electricity Demand and Potential Explanatory Variables

Dairy Growth

We investigated the growth of dairy-related electricity demand in the South Island. There is relatively little information on the medium- and longer-term outlook for this industry. However it is clear that most of the industry's growth over recent years has occurred in the South Island.

The vast majority of New Zealand's milk production is exported; it is supplied to factories on a seasonal basis, with the winter months being the off-season. This is likely to explain the relatively modest growth in peak demand relative to South Island cow numbers over the last decade apparent in Figure 2.

There are no official forecasts of South Island dairy industry growth. However data are available on dairy cow numbers by region back to the 1998/99 season. Selected years for South Island regions are shown in Table 1 with compound average annual growth rates over the whole period and the most recent three years.

Table 1 Cow Numbers by South Island Region 1999-2007 (Source: Livestock Improvement⁵)

Region	1999	2004	2007	CAGR (99-04)	CAGR (04-07)
Nelson/Marlborough	78571	85505	81309	1.7%	-1.7%
West Coast	80787	115548	127581	7.4%	3.4%
Canterbury	226494	376697	467061	10.7%	7.4%
Otago	112577	146768	160884	5.4%	3.1%
Southland	170323	300821	318482	12.0%	1.9%
South Island	668752	1025339	1155317	8.9%	4.1%

It is clear from these data that dairy growth has slowed markedly in the South Island. Two factors are mostly likely to be contributing to this slow-down:

- Bidding up of prices for land suitable for conversion to dairy due to greater awareness on both sides of the relevant markets; and
- Constraints on the availability of water for irrigation.

Competition for water has become intense in Canterbury, where recent (2004-07) dairy growth has been strongest. There is evidence that water is now a serious constraint on dairy industry growth in the eastern parts of the South Island. Two reports are relevant.

The Business Council for Sustainable Development has recently circulated maps⁶ showing that large parts of Canterbury and Otago have allocated more water than is available. Figure 3 shows the NZBCSD estimates for surface water. Red indicates that more than 100% of the available surface water has been allocated; grey areas are ones for which no data are available. For groundwater, NZBCSD estimates that Canterbury has more than five aquifers that are in excess of 75% allocated.⁷

⁵ http://www.lic.co.nz/lic_19981999_New_Zealand_Dairy_Statistics.cfm

⁶ <http://www.nzbcscd.org.nz/story.asp?StoryID=891>

⁷ Note that because demand for water varies over time, it is possible to survive with more than 100% allocated provided that savings made from lower off-peak demand more than compensate for excess draw-offs during peak periods. There are also a range of difficult measurement issues involved. Nevertheless, these data do indicate severe stress on the water resource.

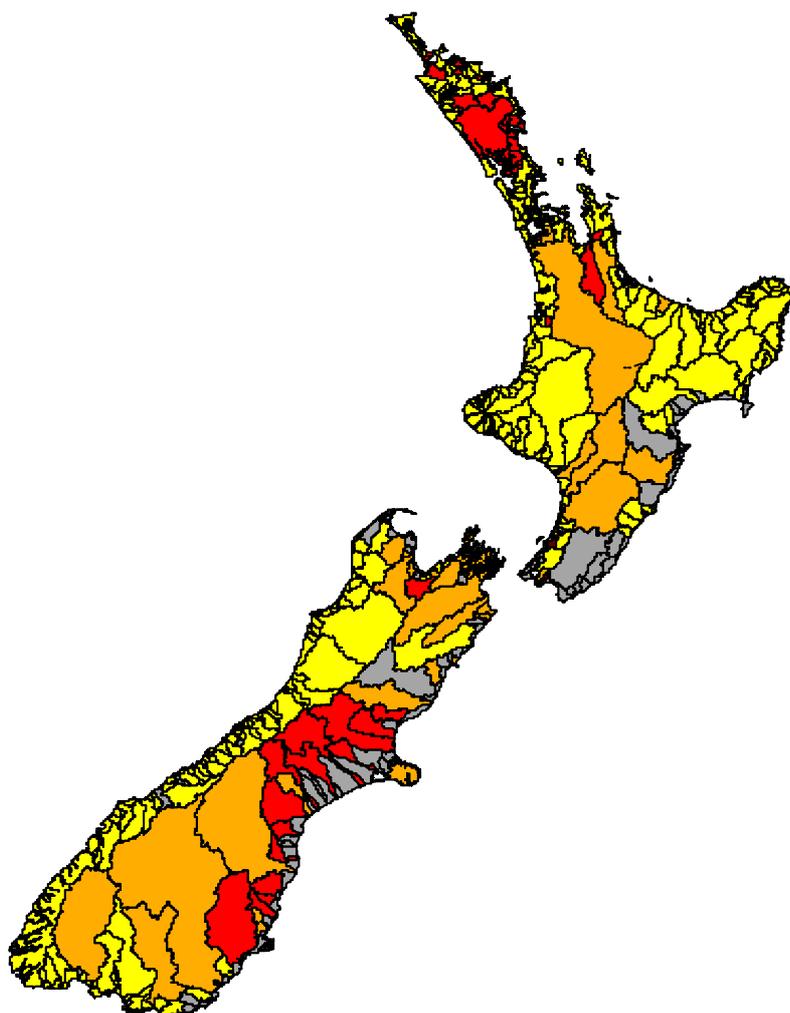


Figure 3 Surface Water Allocation Shares (Source NZBCSD)

It is clear that irrigation is the primary reason for this situation. The Ministry for the Environment commissioned a survey of water resources in 2006. It reported that 77% of all water use in New Zealand is for irrigation, and that two thirds of that is used in Canterbury.⁸

In summary, there is clear evidence that the growth rate of the dairy industry in the South Island has slowed markedly. While we cannot be certain what has caused this slowdown, it is very clear that competition for scarce water resources has intensified, and that it will only become more difficult in the future to obtain additional water for irrigation. We therefore consider that it would be unwise to expect a continuation of historic rates of growth in the South Island dairy industry.

⁸ Snapshot of Water Allocation in New Zealand, Ministry for the Environment, November 2006. <http://www.mfe.govt.nz/publications/water/water-allocation-snapshot-nov06/index.html>

A second relevant issue is the dairy industry’s demand for electricity. There appears to be a trend towards increased use of bio-energy, which is likely to constrain the dairy industry’s demand for electricity, whatever the scale of the industry. However it is also likely to serve non-dairy demand. Bio-energy plants on quite large scales are under development around Timaru (municipal waste) and Balclutha (meat processing waste).⁹

Similar systems are being installed on dairy farms. For example, Natural Systems Ltd (rated the most exciting environmental technology company in New Zealand by the National Business Review, March 2008) recently installed a digester on a LandCorp dairy farm in North Canterbury recently, saving 35% of the energy previously purchased to run the milking shed.¹⁰ Electricity prices are only one of the drivers for this type of substitution: it also helps farmers manage environmental contamination. As a result, this activity is expected to grow over time.

Population Growth

Statistics New Zealand data show that over the recent past (2001-07), the population of the South Island has been growing at a rate of 1.3% per annum. Statistics New Zealand is projecting this growth to slow markedly, to an annual rate of one half of one percent over the period out to 2031.¹¹ We note in passing that the North Island population growth rate is also expected to decline, but from a higher base (1.6%) and by a lesser amount (the medium forecast is growth of 0.9%).

Regression Models

When these variables are used in regression modelling, a large set of regression models can be estimated. Four such models are reported in Table 2, all of which explain energy demand. To illustrate the impact of different variables, we have erred on the side of over-fitting these models, which is why some of the P-values exceed 10%. All variables are specified in levels and the models were estimated by Ordinary Least Squares.

Table 2 Regression Models Explaining Energy (MWh) Demand

	Model 1		Model 2		Model 3		Model 4	
	Coef	P-value	Coef	P-value	Coef	P-value	Coef	P-value
Population	0.026	0.000			-0.006	0.177		
GDP			0.062	0.000	0.075	0.000	0.029	0.114
Cows							0.002	0.090
Constant	-11871	0.001	5816	0.000	9739	0.006	7910	0.000
R Squared	0.929		0.991		0.993		0.994	
DW P-value	0.000		0.249		0.549		0.759	

⁹ <http://tinyurl.com/6hwsnm>

¹⁰ <http://www.naturalsystems.co.nz/BioGenCool.html>

¹¹ These figures were obtained from the latest information available at <http://www.stats.govt.nz/people/population/default.htm>

In all cases, the National Bank’s indicator of economic activity in the South Island was eliminated due to being insignificant; models in which this replaced GDP were inferior to models using GDP alone. Note also that South Island cow numbers are only available from 1999, so model 4 was estimated with two fewer observations than Models 1 to 3.

Of this set, we would prefer model 2 because it has no coefficients that are negative or insignificant and it has an acceptable Durbin Watson statistic (DW).¹²

Table 3 Regression Models Explaining Peak Demand (MW)

	Model 1		Model 2		Model 3		Model 4	
	Coef	P-value	Coef	P-value	Coef	P-value	Coef	P-value
Population	0.003	0.000			-8E-04	0.651		
GDP			0.008	0.000	0.009	0.029	0.022	0.027
Cows							-9E-04	0.106
Constant	-1346	0.011	1010	0.000	1539	0.211	186.3	0.709
R Squared	0.871		0.93		0.932		0.926	
DW P-value	0.025		0.137		0.055		0.604	

Table 3 shows models explaining peak demand. The patterns are very similar to the energy demand models. Population alone results in a negative constant and strong positive autocorrelation. Models 3 and 4 have negative and insignificant coefficients. So again, GDP alone appears to offer the best explanation of history.

We conducted a few experiments using the first difference of energy and peak demand and other variables, but the resulting models had very poor fits.

In the limited time available it was not possible to explore this line of work further; further experimentation may yield better results.

Conclusions

Based on the above relatively limited research, we have reached several conclusions.

First, South Island population and national GDP are both correlated with demand for electricity in the South Island. There are also strong theoretical/logical rationales for believing that they influence demand. However they are also correlated with each other, so it is relatively difficult to construct a regression model in which both are significant.

Expansion of the dairy industry in the South Island is also a driver of electricity demand. Cow numbers are strongly correlated with electricity demand. However for similar reasons, it is difficult to construct a model in which cow numbers and either of the other variables are both significant.

¹² The DW P-values are based on tests for positive autocorrelation. Values less than 5% or 10% imply autocorrelation is present (which is undesirable).

In our view, these variables (or others designed to better measure the same effects) are the main factors that influence South Island load. Since they are so highly correlated with each other, it follows that for practical purposes one needs to choose one of them. This need not be a once-and-for-all choice however: cross-checks will be useful as a sanity check on forecasts.

Of the three variables available, population is the only one for which predictions are published. It is highly attractive for that reason. Based on this position, we expect the recent strong load growth in the South Island to moderate over the medium to long-term. Some corroborating evidence is available from constraints on the growth of dairying due to competition for water resources, and substitution towards alternative energy sources by dairy farmers, agricultural processors and others. The latter substitution is likely to be driven by a combination of price and environmental sensitivity.

Overall, we consider that the most likely scenario is that recent strong growth in electricity demand in the South Island demand will not continue.