Draft Regional Electricity Demand Projections Review

Background

Part F of the Electricity Governance Rules 2003 requires the Electricity Commission to publish demand forecasts as part of the grid planning assumptions. A national demand forecast has been developed and published by the Commission. Grid planning requires forecasts at a regional level in order to assess transmission requirements for servicing potential demand across geographical locations in New Zealand. This paper outlines the process the Commission undertook in order to assess and select an approach for projecting regional and grid exit point demand, and compares the Commission's results with those obtained using Transpower's allocation methodology.

Process

There are many alternative methods for forecasting at a regional level. The Commission tested a number of different methodologies with the goal of settling on an approach that produces forecasts that are:

- consistent with the national level model forecasts;
- consistent with historical regional growth patterns;
- stable when small changes are made to the model assumptions;
- based on a sound conceptual approach; and
- simple to explain.

Various allocation models were built in MATLAB using the national level demand forecasting model as a base. The results of each approach were assessed and, where issues were found, other alternative approaches tried.

Region definition

Each regional model produces forecasts of total energy use at each grid exit point by using a multi-stage allocation. Demand is initially forecast for a geographical area, and is then broken down to each grid exit point (GXP). The initial geographical allocations are done at either a 'regional' level or at an Electric Power Board level.

The old Electric Power Boards (EPB) are a useful level of aggregation as they provides an approximate grouping of demand supplied though each local area network.

The high level 'regions' used in the models are determined by the configuration of the transmission grid rather than by the normal regional council boundaries. In most areas there is no difference in these definitions, but there are a small number of exceptions where grid exit points are defined as being in regions different to those they are normally associated with. Appendix D contains a list of grid exit points for each transmission region.

Data availability

The methods used in the models were heavily constrained by the data available at a regional level. Historical and forecast population data at an Electric Power Board level was obtained from Statistics New Zealand. NZIER produce forecasts and estimates of historical GDP at a regional level. Historical grid exit point meter data is available, however a breakdown of the type of end use (residential vs. commercial for example) is not currently available at other than a national level.

General projection methods

Where the data allowed, the major demand sectors (Residential, Commercial/Light Industrial and Heavy Industrial) were allocated separately to the regions.

Heavy Industrial load was treated the same way in each of the models. The projection for Heavy Industrial load at a national level was based on a simple continuation of recent growth trends. The forecasts at a regional level were based on an apportionment of this projected growth in proportion to the existing heavy industrial loads in each area.

Forecast embedded generation and local lines losses were both spread in proportion to the total load (excluding heavy industrial) in each region.

The main focus of the various models was therefore on assessing allocation methods for Residential and Commercial/Light Industrial demand. Two main methods were used in the various models.

The majority of the models tested, spread total demand using a driver of some sort (such as forecast population or GDP relative to the national total) to allocate the growth across the various regions.

A number of the models used the alternative approach of projecting demand for each of the individual regions based on historical demand trends (a simple time series approach). The region forecasts were then scaled to match the national total.

The models outlined below have been split into their different industry sectors to aid comparison. The testing process involved a number of combinations and mixes of the sector models as part of the development process.

Model descriptions and results

The regional model descriptions below have been grouped into consumer sectors for comparison purposes. The MATLAB script files are organised slightly differently in that similar allocation methods used for separate sectors are contained within the same script.

Residential Demand Allocation Models

Model 1 : Basic Regional Allocation

Total residential forecast demand was allocated to Electric Power Board Level based on the forecast population in the EPB as a proportion of the forecast national population. The forecasts were then allocated to the individual GXPs within each

EPB on the basis of recent demand at the GXP as a proportion of total demand within the EPB.

Critique : The basic allocation approach ignores historical demand levels with the consequence that there are significant jumps at most of the regions and grid exit points at the transition between historical data and the forecasts.

Model 2 : Incremental Regional Allocation

Residential demand was split into two components in an attempt to identify and allocate changes in demand usage associated with the existing population base, and demand changes associated with changes in total population. The national demand model was run using an assumption of zero future population growth. The annual difference in demand between the normal forecast and the zero-population forecast was allocated to Electric Power Board Level based on the forecast change in population in the EPB as a proportion of the change in forecast national population. The zero-population increase in demand each year was allocated based on total population in each EPB compared to total nation population.
This approach required an estimate to be made of historical residential demand at each EPB. Due to lack of data the national proportion of residential demand to total demand was assumed for all EPBs.

The forecasts were then allocated to the individual GXPs within each EPB on the basis of recent demand at the GXP as a proportion of total demand within the EPB.

Critique : The approach requires an arbitrary split of residential and commercial industrial usage at a regional and EPB level. The allocation of changes in residential demand based on changes in EPB population produces distorted results near the end of the forecasting period due to population movements across regions being large relative to the small national changes in population.

Model 3 : National average MWH per person

Total residential demand at an EPB level is estimated by calculating the forecast national average MWH per person and using forecast EPB population to project demand for each EPB. The forecasts were then allocated to the individual GXPs within each EPB on the basis of recent demand at the GXP as a proportion of total demand within the EPB.

Critique : This approach ignores existing regional differences in demand intensity.

Model 4 : Incremental based on EPB MWH per person

Change in residential demand at an EPB level is estimated by projecting EPB demand per person on the basis on estimated historical residential demand. The same balance of commercial and residential demand has been assumed at all EPBs. A minimum growth of 0% in demand per person was set for projection purposes. Forecast EPB demand was calculated using projected population figures, and the resulting forecasts scaled to the national total. The forecasts were then allocated to the individual GXPs within each EPB on the basis of recent demand at the GXP as a proportion of total demand within the EPB.

Critique : This model was developed as a variation on one of the combined models outlined below . It requires an arbitrary estimate of historical domestic demand at an EPB level and produces forecasts weighted heavily towards high population growth areas.

Commercial / Light Industrial Demand Allocation Models

Model 1 : Basic Regional Allocation

Commercial/Light Industrial Demand : Total annual commercial and light industrial demand was allocated to each broad region based on forecast regional GDP as a proportion of forecast national GDP. The resulting regional demand was allocated to GXPs within the region on the basis of recent demand at the GXP as a proportion of total demand with the region.

Critique : The basic allocation approach ignores historical demand levels with the consequence that there are significant jumps at most of the regions and grid exit points at the transition between historical data and the forecasts. The breakdown below the regional level for the commercial/light industrial demand results in the same growth rates for all GXPs within a region.

Model 2 : Incremental Regional Allocation based on change in GDP

Commercial/Light Industrial Demand : The annual change in commercial and light industrial demand was allocated to each broad region based on the change in regional GDP as a proportion of the change in national GDP. The resulting regional demand was allocated to GXPs within the region on the basis of recent demand at the GXP as a proportion of total demand with the region.

Critique : Requires an arbitrary split of historical residential and commercial industrial usage at a regional and EPB level. As above, the breakdown below the regional level for the commercial/light industrial demand results in the same growth rates for all GXPs within a region.

Model 3: Incremental Regional Allocation based on GDP / demand

Recent GDP / demand per region was used to project annual changes in demand within each region based on forecast GDP with the resulting projections being scaled to the national total. Regional demand was then allocated directly to GXP based on recent demand at the GXPs as a proportion of total regional demand.

Critique : The breakdown below the regional level for the commercial/light industrial demand results in the same growth rates for all GXPs within a region. Bases forecast allocation on estimated balance of residential and commercial / light industrial demand. Forecast regional growth appears to be high compared to historical regional rates.

Model 4: Incremental Regional Allocation based on GDP / demand II

The ratio of recent GDP / demand per region was used to project annual changes in demand within each region based on forecast GDP. The resulting projections were scaled to the national total. Regional demand was then allocated to EPBs based on estimated historical trends in commercial / light industrial demand per person (scaled to the region total) then to GXP based on recent demand. A variant on this model was also tested using different regional GDP scaling to improve Monte-Carlo modelling behaviour.

Critique : Improves the demand balance within each region but the forecasts are still based on an estimated balance of residential and commercial / light industrial demand (over-forecasts high population areas such as Auckland). The secondary allocation to EPB from regions makes some approximations as some EPBs straddle regions.

Combined Residential and Commercial / Light Industrial Demand Allocation Models

Model 1 : EPB allocation based on MWH per person trend

The historical trend in demand per person was calculated for each EPB and used to project demand at each EPB based on forecast population. The individual totals were then scaled to maintain consistency with the national forecasts. The resulting forecasts were allocated to the individual GXPs within each EPB on the basis of recent demand at the GXP as a proportion of total demand within the EPB.

Critique : This approach could not be consistently applied to all EPBs because of individual changes that resulted in unusual trends in some cases (the introduction of significant embedded resulting in a significant downward trend in the historical data). The approach also resulted in some step jumps in some EPBs.

Model 2 : EPB allocation based on recent MWH per person

Recent demand per person was calculated for each EPB and used to project demand at each EPB based on forecast population. The individual totals were then scaled to maintain consistency with the national forecasts. The resulting forecasts were allocated to the individual GXPs within each EPB on the basis of recent demand at the GXP as a proportion of total demand within the EPB.

Critique : This model produces distorted results in later years due to the changes within the EPBs being large relative to the small changes in the national population .

Model 3 : Incremental allocation based on average MWH per person

This approach calculates the national average MWH per person for each forecast year and forecasts the annual increase in demand at each EPB based on the projected annual increase in population. The resulting forecasts were allocated to the individual GXPs within each EPB on the basis of recent demand at the GXP as a proportion of total demand within the EPB.

Critique : This approach is based on population increases only, and ignores differences in energy intensity across the different areas.

Model 4 : Incremental allocation based on EPB trended MWH per person

This is a variation on Model 1 above with the MWH trend being capped at a minimum growth of 0% per year. The allocations are calculated based on annual changes in demand and annual changes in population rather than total population. The resulting EPB forecasts were allocated to the individual GXPs on the basis of recent demand at the GXP as a proportion of total demand within the relevant EPB.

Critique : This approach acknowledges the energy intensity differences between the regions, however the minimum growth cap is somewhat arbitrary (although it avoided issues associated with embedded generation).

Model 5 : Incremental allocation based on GDP

This model allocates annual changes in demand to each region based on annual changes in regional GDP. Demand is then allocated to EPBs within each region based on the trend in MWH per person at each EPB, scaled back to the region total. Demand is then allocated to the individual GXPs within each EPB on the basis of recent demand at the GXP as a proportion of total demand within the EPB.

Critique : This approach ignores differences in energy intensity between the regions with the result that some regions were projected to have high demand growth rates relative to GDP growth.

Model 6 : Allocation based on national MWH per person relative to base year

This is similar to model 3 above but replicates the process used by Transpower to calculate the allocation for their residential, commercial and light industrial demand to EPB level. Demand is allocated to EPB based on the change in the average MWH per person, and change in population with the EPB, relative to the last historical year. Demand is then allocated to the individual GXPs within each EPB on the basis of recent demand at the GXP as a proportion of total demand within the EPB.

Critique : As a purely population based approach this method weights growth toward those areas with high population growth, however it does not allow for possible growth differences in the mix of residential and industrial/commercial demand (discussed below).

Model 7 : Historical trend

The historical trend in each region is forecast forward based on historical meter data and scaled to the national totals. Demand is allocated to EPB based on the trend in average MWH per person at each EPB, scaled back to the region total. Demand is then allocated to the individual GXPs within each EPB on the basis of recent demand at the GXP as a proportion of total demand within the EPB.

Critique : This approach acknowledges differences in energy intensity trends between the regions although the secondary allocation to EPB from regions makes some approximations due to some EPBs straddling regions.

Heavy Industrial Demand Model

Total heavy industrial demand was allocated to individual direct connection GXPs based on recent demand at that GXP as a proportion of total load at all direct connect GXPs.

Critique : This approach assumes that the existing plant will grow at the same rate as they have over recent years. At a regional level this reflects the assumption that new heavy industrial load will trend to occur either at existing plant or in new plant within the same geographical region. This approach is believed to be more reasonable than the alternatives of either spreading the demand evenly over all points of supply or guessing where new load may appear.

Comparison with Transpower allocation methodology

Transpower's allocation methodology uses an approach where residential and light industrial and commercial demand is allocated to each EPB based on changes in the average national MWH per person for each year, and change in population with the EPB, relative to the last historical year. Demand is then allocated to the individual GXPs within each EPB on the basis of recent demand at the GXP as a proportion of total demand within the EPB.

This allocation approach allocates higher demand to those areas with higher population growth. Transpower's modelling does not explicitly allocate energy demand associated with direct connect loads to specific regions. To allow a comparison to be made between Transpower's and the Commission's allocation methodologies we have applied Transpower's methodology to the commercial and light industrial area combined with the Commission approach for the heavy industrial sector.

Future modelling requirements

The regional modelling developed to date forms a starting point for more detailed future regional modelling. The draft Commission approach produces relatively similar growth rates in each region, particularly when compared to the wide range of different regional growth rates produced by the Transpower allocation methodology.

Because the different methodologies produce very different regional level forecasts, we believe it is essential to get a better understanding of the demand types and historical growth patterns within each of the regional areas.

The current lack of publicly available information on the relative balance between the commercial/industrial load and the residential load in each region severely hampers the Commission's capability in this respect.

Data on commercial/industrial and residential loads used to be available in the Electric Power Board reports produced prior to the break up of the Electricity Division in the late 1980s. Since then, public information on consumptions types has been limited to national level aggregates.

The Commission is proposing to approach retailers to obtain data that would allow the split of commercial/industrial and residential load to be identified at a regional level. Ideally we would like to obtain this data for as large a historical period as possible to provide the best indication of any trends in each region, especially in light of the two “shortage” years in 2001 and 2003 complicating the picture of recent demand.