Powerlink has provided this document to the AER in support of its Revenue Proposal

DEMAND AND ENERGY FORECASTING DESCRIPTION AND METHODOLOGY

Grid Planning			
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Document version:	1.0	Checked by:	P McCarthy, Principal Engineer, Regional Grid Planning
Date of current issue:	June 2010	Approved by:	T Miller, Manager, Network Development

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1 EXECUTIVE SUMMARY

Powerlink Queensland produces a robust demand and energy forecast each year through a "Bottom Up / Top Down " approach. This approach combines global drivers with detailed customer information to deliver a forecast against which future network behaviour can be assessed.

- The methodology contained in this document focuses on summer demand forecasts as this is the primary driver for network augmentation.
- The forecasting approach meets with a number of key measures consistent with industry best practice.
- Demand forecasting is done to standard weather conditions.
- Demand and energy forecasting is done to a range of economic outlooks.
- Forecasting method appropriate for Queensland's diverse load and weather patterns.
- Bottom up / top down approach.
- Strong focus on understanding customers so that the forecast reflects the timing and location of future growth.
- Weather and diversity correction used to establish the demand starting point. This includes an S-Curve approach for South East Queensland.
- Mining and Resource loads scrutinized to ensure that where they have been included they are reasonable and counted only once.
- Uses independent econometric modelling to validate the forecast.
- Review to ensure the forecast is both reasonable and consistent with available information.
- Through the application of coincidence factors, a suite of forecasts is produced at different levels in the network, with different inclusions for a range of purposes.

2 INTRODUCTION

2.1 Why Powerlink does load forecasting

As a Transmission network Service provider, Powerlink is obligated to develop an annual demand forecast in accordance with NER 5.6.1. In addition, under the provisions of NER 5.6.2A, Powerlink is required to set out its latest demand forecast in its Annual Planning Report which must be published by 30 June each year. Powerlink is also required to analyse the expected future operation of its transmission network (NER 5.6.2). In undertaking the analyses, the demand forecasts are incorporated into detailed models of the network which are used to simulate future network performance and identify future limitations and to assess possible augmentations. Powerlink provides these annual forecasts to the Australian Energy Market Operator (AEMO) in late May for their inclusion in the Electricity Statement of Opportunities (ESOO), required under NER 3.13.3. The most recent forecast is also used in regulatory submission to the Australian Energy Regulator (AER).

As the annual peak demand across Queensland occurs during the summer period, it is summer demand that drives network augmentation requirements. Energy consumption does not drive network augmentations. Because of the importance of summer maximum demand on network investments, forecasting of this quantity is of prime importance. This document outlines the methodology employed in forecasting maximum summer demand. While energy does not drive investment in transmission, it is nevertheless forecasted and reported. The methodology is akin to demand forecasting and is described in Section 6 of this document.

2.2 Industry Best Practice

Load forecasting involves the use of mathematical models to assist in the forward projection process. These models typically take into account the key drivers of electrical demand. These key drivers are quantities which in themselves can be forecast into the future. The models calibrate the relationships of the key drivers against historical outcomes to provide a robust basis for projection of electrical demand into the future. The key drivers (and hence demand forecasts) may also be disaggregated on a sectoral basis. While load forecasting methodologies are varied and subject to ongoing development, a number of recurring qualities of the process have emerged as identifying best industry practice in load forecasting.

In terms of load forecasting methodologies best practice could encompass:

- Undertaking separate spatial level forecasts (bottom up) and econometric (top down) system wide forecasts and then reconciling the two forecasts;
- Taking into account a wealth of key drivers of load such as weather, major loads, air conditioning loads and economic growth;
- Developing sufficiently comprehensive mathematical models for the load forecasting process to ensure good fit and correlation with historical data; and
- Incorporating the key policy impacts from federal and state energy and greenhouse policies that are likely to prevail for the duration of the forecast period;
- The process should be transparent and repeatable.

Powerlink Queensland's forecasting methodology meets the five best practice items raised above. Powerlink own load forecasting models are subject to all of the relevant diagnostic checks. In terms of the spatial forecast both ENERGEX and ERGON use statistical forecasting models. NIEIR also uses econometric models as part its forecast process. Again, the standard model tests, error statistics, and backcasting have been applied to these models.

2.3 Forecasting to Standard Weather

Weather, and in particular temperature, has a significant influence on demand. Because weather variability cannot be forecast, Powerlink forecasts are based on standard weather conditions. In particular, Powerlink forecasts demand to 10%, 50% and 90% Probability of Exceedence (PoE) conditions. 10% PoE weather conditions will drive demand to levels expected to be exceeded once in ten years, 50% PoE weather conditions will drive demand to levels expected to be exceeded once in two years, referred to as standard conditions, while 90% PoE weather conditions will drive demand to levels expected to be exceeded in nine out of every ten years.

This approach is important given the variability of summers in Queensland. Since 2007/08, summers in Queensland have lacked periods of sustained hot weather typically associated with peak demand. As such demand corrections to standard temperature (50% PoE) over this time have been upwards. However, in six of the seven years prior, demand correction to standard temperature was downwards, indicating hotter summers than standard. As an example, the 2003/04 corrected maximum demand was 302MW below the actual maximum demand. Forecasting to standard temperatures presents forecasts on a consistent basis and ensures that planning of network investment can be undertaken in a way that takes account of weather variability.

2.4 Forecasting to a range of economic outlooks

Powerlink's demand forecast is carried out for three different economic outlooks, high, medium and low. These economic outlooks are developed by an external consultant and set the range over which the forecast can be expected to follow. The medium economic outlook represents the most likely outcome over the outlook period while the high and low outlooks provide the upper and lower 10% bands over the forecast period.

2.5 How Queensland's Demand Differs from other states in the NEM

Queensland's electrical demand differs from other states in the NEM in a number of respects. Recognising these differences and taking them into account when compiling the Queensland forecast is essential. There are two significant differences between Queensland's demand and energy forecast when compared to the other states in the NEM.
The first is that only 60% of Queensland's load is near the state capital with the rest of the load being geographically diverse and hence subject to very different weather conditions. Hence the state maximum demand is less than the sum of the regional demands. The importance of recognising this particular aspect of the Queensland demand is that historic trends are showing that there is a slowly changing average diversity between the areas. The forecasting methodology is based on analysing top down data at this geographic area level.
The second major difference is the large proportion of resource driven (mining) load that is connected to the Queensland transmission network. This load can follow different growth patterns and be less predictable than residential and commercial load trends. Understanding our major customers and where necessary, assessing the industry they are in are both important factors. It is also important that Queensland specific economic drivers are employed in assessing future electrical demand growth in this state.

2.6 Powerlink's Approach to forecasting - Bottom Up / Top Down

Powerlink's approach to forecasting takes into account the characteristics of Queensland electrical demand described in the previous section. In particular understanding drivers behind resource customers from a number of perspectives (local and macro-economic) is crucial. Furthermore, building the forecast to reflect geographic diversity with differing weather patterns is essential when combining demands into a state forecast. For these reasons, Powerlink uses a "Bottom Up / Top Down" approach to forecasting as described below.

Each NSP (distributor) and registered participant (direct connect customer) is required to provide Powerlink with its ten year forecast under clause 5.6.1 of the National Electricity Rules. Powerlink, as a TNSP, is required to publish the forecasts submitted in accordance with the above provisions under the provisions of Clause 5.6.2A of the NER. In publishing these forecasts, Powerlink uses the participant information to construct a single statewide[1] coincident forecast for demand and energy. In combining the participant forecasts, Powerlink also undertakes a top down demand forecast based on econometric models derived by independent third party expert consultants. This top down approach provides a "second opinion" reasonableness check against the bottom-up outcomes. The NER provides for adjustment of participant provided forecasts under Clause 5.6.1(d) which could arise from this calibration process.

The key inputs to Powerlink's forecasting process are shown in Figure 1 .

[1] Statewide refers to networks connected to the NEM and excludes isolated networks not supplied from the Powerlink Transmission network.

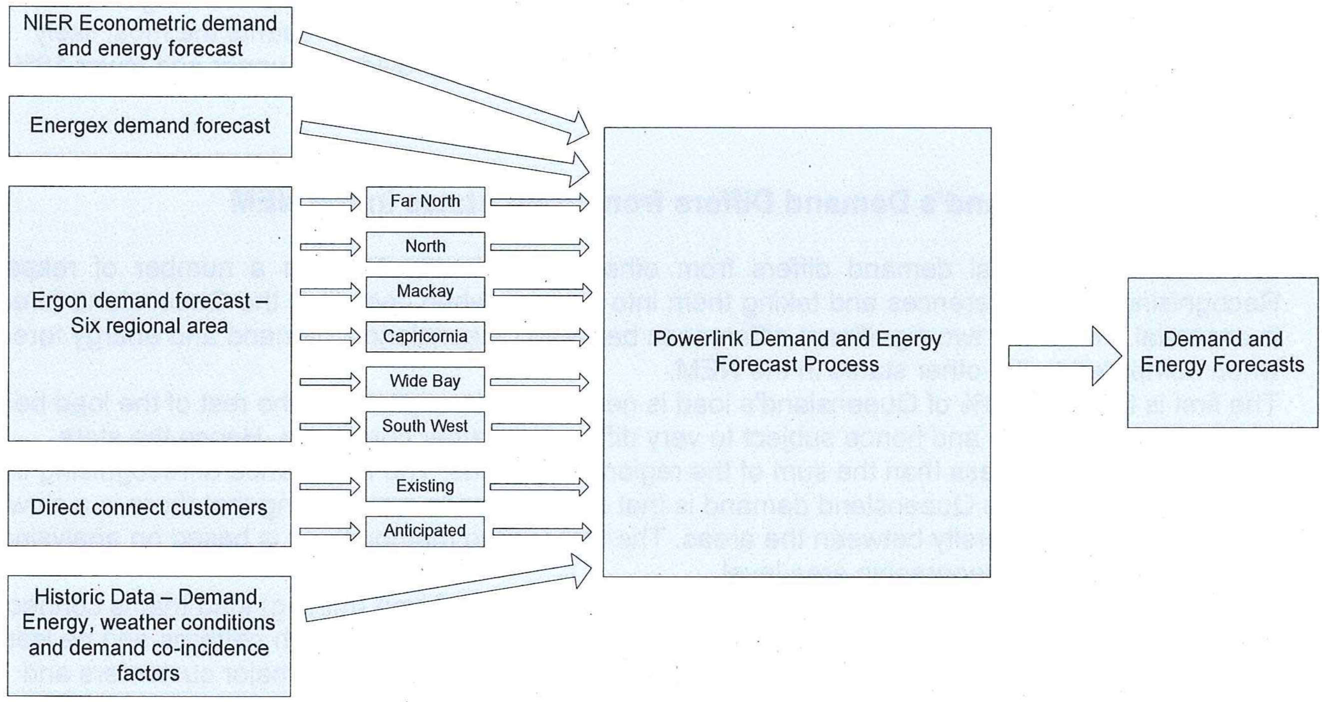

Figure 1: Inputs to the Demand & Energy Forecasts

3 BOTTOM UP FORECAST

The demand forecast is a multidimensional data set. It contains detail on where loads are and where future changes will occur at many levels of detail (refer to Figure 1). The various levels and location of data are linked by a range of specific factors. These locational details are an essential part of the forecast needed to determine the nature and timing of future network augmentations. They are directly related to individual customer activity and cannot be captured through econometric top-down forecasts. Therefore, Powerlink develops a "bottom up" forecast through discussion with its customers as required under the NER sections 5.6.1 and 5.6.2.

3.1 Customer Review

3.1.1 Energex and Ergon Demand and Energy Forecast

ENERGEX and Ergon Energy provide an annual ten year forecast each year (around late November). These forecasts are put together through both econometric forecasting techniques and detailed customer knowledge. In developing the econometric forecasts both ENERGEX and Ergon Energy work with experienced consultants to develop a top down view.

The ENERGEX forecast demand is supplied at both 50% and 10% PoE for the medium economic growth outlook. This forecast is supplied at a number of levels including all of ENERGEX combined, connection points, bulk supply points and zone substation demands at the time of ENERGEX's peak for both summer and winter for the coming decade. Spatial forecasting is used to develop the zone substation forecasts, from which the other forecasts are built. ENERGEX also build a demand management strategy into their forecast.

The Ergon Energy forecast demand is supplied at 50% PoE for the medium economic growth outlook for the coming decade. This forecast is for connection and bulk supply point demands at the time of summer peak demand for each of the six subareas within Ergon – Far North, North, Mackay, Capricorn, Wide Bay and South West. This forecast includes assumptions regarding Ergon major customers within each of these subareas.

3.1.2 Direct Connect Customers

Existing customers that connect directly to Powerlink's network are required to supply an annual ten year forecast for summer demand. These customers supply their annual forecasts at the time of their own peak. Forecasts are supplied for a medium (most likely) economic outlook and for a high economic outlook.

Powerlink also undertakes an assessment of proposed major industrial developments expected to connect directly to Powerlink's network. This assessment is based on discussions with possible new load proponents as well as considering high level drivers that would impact on the types of load being considered.

3.1.3 Reviewing Customer Data

Customer forecasts are compared to those supplied in previous years and checked for significant changes. Where significant changes are identified, reasons are sought from the customer to explain why the changes have taken place.

3.1.4 Combined Customer Forecasts Through Coincidence factors

ENERGEX supply demand forecasts at the time of ENERGEX peak. Customers who connect directly to Powerlink's network supply demand forecasts at the time of their own peak. Ergon Energy group their demand forecasts into six areas and supply demand forecasts at the time of area peak. Therefore to combine these individual demand forecasts into a state forecast requires co-incidence factors that scale the demands to what they would be at the time of state peak.

Historic data is collected and analysed to determine the co-incidence factors for each connection and bulk supply point. Co-incidence factors are the ratio of an individual load at the time of state peak to its own individual peak. Given Queensland's geographic diversity, coincidence factors are typically lower for the Powerlink network compared to other National Electricity Market TNSPs.

Co-incidence factors are not applicable for energy forecasts.

Once the coincidence factors have been calculated, then a Bottom Up state forecast can be calculated from the Customer demand forecasts (Ergon, Energex and Direct connection customers). This forecast is then modified to account for non-scheduled embedded generation and to align the starting point described in the following sections.

3.2 Assess Non-Scheduled Embedded Generation

In order to develop its bottom up forecast, Powerlink must correct the demand forecasts supplied from customers to take account of embedded non-scheduled generation.

The load supplied by the transmission system is the customer (or native) load plus distribution losses minus non-scheduled embedded generation. This means that a forecast of non-scheduled embedded generation needs to be added to the customer demand forecast to produce a native or underlying demand forecast. The econometric models produced as a validation (described later) are produced on the same (native) basis.

The forecast of the embedded generation is based on historic data associated with non-scheduled embedded generation which is assessed to form a view of future generation behaviour. The impact of this generation is then built into the bottom-up forecast to enable extraction of either a "Delivered Forecast" or a "Native Forecast". The native forecast is higher than the delivered forecast, as it assumes embedded non-scheduled generation is off to reflect the underlying customer load.

3.3 Losses and auxiliary services

3.4 Establish the Starting Point

Following each summer, Powerlink reviews recorded demands and corrects them to standard (50% PoE) weather conditions. An important input to this process is the state weather and diversity corrected peak demands for the last ten years. Powerlink's demand forecast is set up to align with both the econometric forecast and the trend of (historic) weather and diversity corrected peak demands.

Powerlink uses weather and diversity corrected demand rather than actual demand to establish the trend for the demand forecast to ensure it is not unduly influenced by mild or extreme summers. It also ensures that differing (historic) contributions from different parts of the state (at the time of state peak) are smoothed over time to establish the starting point. The methodology used to temperature and diversity correct historic demands is described below.

3.4.1 Weather and Diversity Correcting Historic Demands

Compared to other states in the National Electricity Market (NEM), Queensland's load distribution is decentralised, with greater than 40% outside the south east corner of the State. A significant amount of Queensland's load growth is industrial, scattered across the State, with an emphasis on the mining industry. Diversity in Queensland is greater than other NEM TNSP's due to larger geographic area, however weather correction is typically less extreme than other NEM TNSP's as the load is less sensitive to weather

The loads connected to Powerlink's network are divided into five groups. The first four represent geographic areas of Queensland with diverse load and weather patterns. The fifth group represents large customers who connect directly to Powerlink's network and are generally temperature insensitive. Diverse load and weather patterns across the State require load forecasting methods be applied to these five load groups to account for both weather and diversity.

The four geographic areas are North, Central, South East and South West and are shown diagrammatically below in Figure 2. Different temperature recording stations from the Bureau of Meteorology are used to standardise the loads within these four geographic areas.

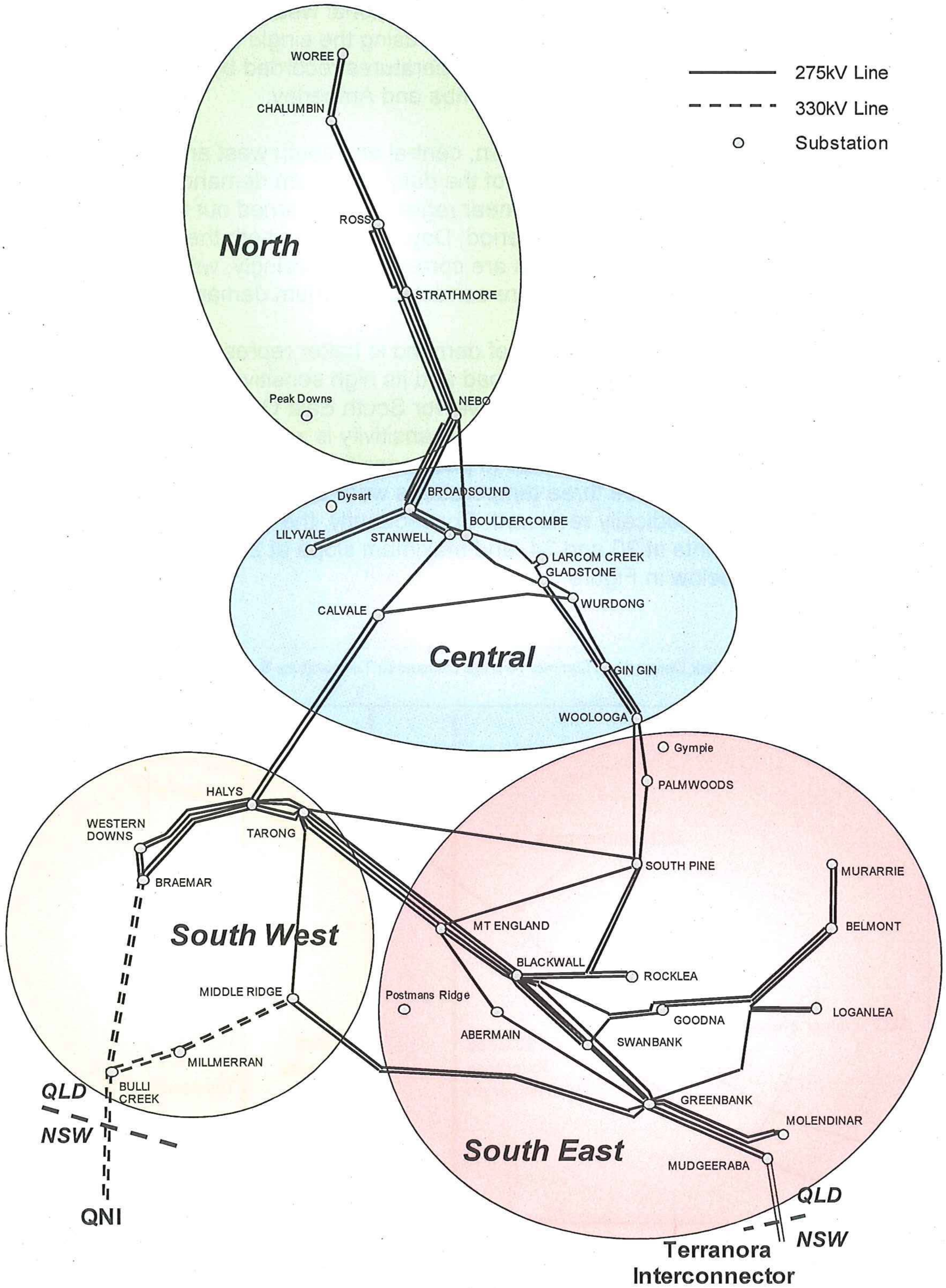

Figure 2: Temperature Regions

While there are many factors that can influence demand within each of these areas, temperature has been used as the major contributing factor for variations over a given season. In particular average daily temperature ((max+min)/2) has consistently provided good correlation with demand. Increased use of air-conditioning in recent years has strengthened the basis for this approach. While attempts have been made to factor in additional weather variables (such as humidity), the fit has been found to be less reliable than using the single temperature variable. Demands in these four areas are studied against temperatures recorded by the Bureau of Meteorology at Townsville, Rockhampton, Toowoomba and Amberley.

Temperature sensitivity of demand for the northern, central and south west areas can be satisfactorily reflected through linear regression of the daily maximum demands against daily average temperatures on working weekdays. Linear regression is carried out for all working days in a season, excluding the Christmas holiday period. Days that are in both the highest sixteen demands of a season, and hottest sixteen days are corrected accordingly, with the highest corrected demand being the season temperature corrected maximum demand for the area.

South East Queensland temperature sensitivity of demand is better represented through a non-linear relationship. This is due to the size of the load and its high sensitivity to temperature. Consequently, Powerlink has developed an 'S-Curve' for South East Queensland summer demands. This assumes that demand to temperature sensitivity is zero on a cool summer day with an average temperature of 20°C, increases to peak sensitivity at 27°C, and then saturates back to zero sensitivity at 34°C. These three temperatures were arrived at through the analysis on 11 years of data and are periodically reviewed. Consequently, the curve can be defined by a cubic function with turning points at 20 and 34, and maximum slope at 27. The 'S-Curve' for summer 2009/10 is shown below in Figure 3.

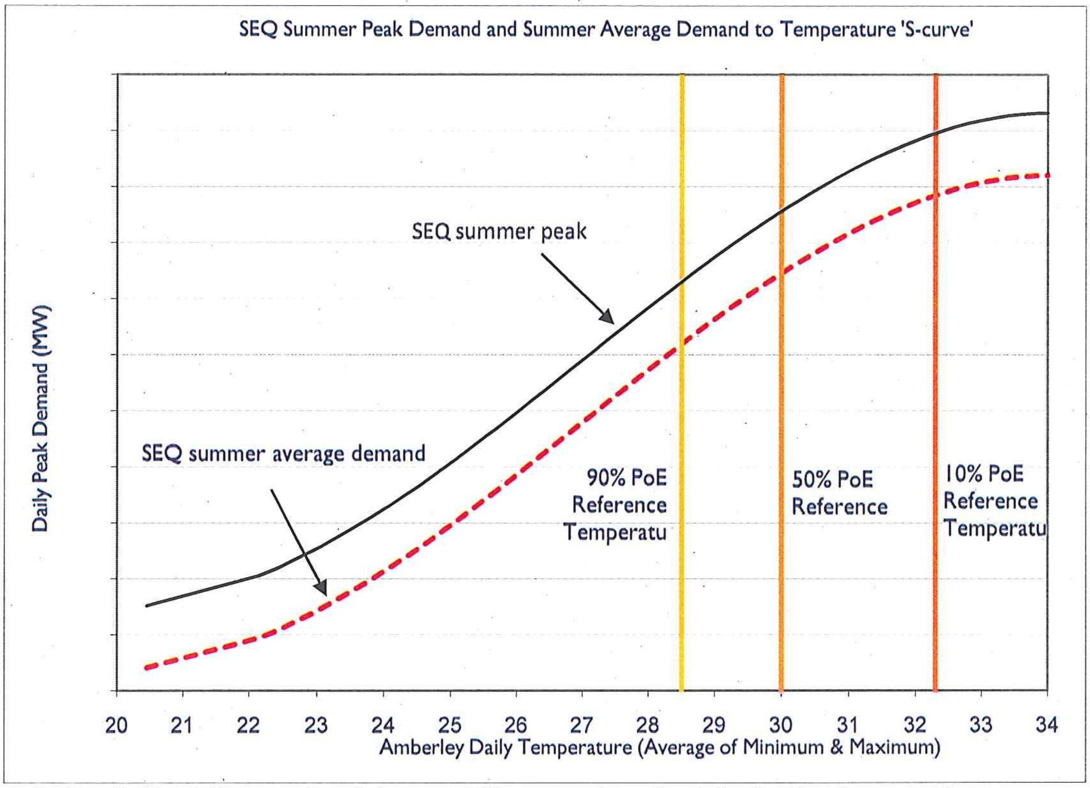

Figure 3: South East Queensland demand 'S-curves' against Amberley temperature

Following this analysis, a temperature corrected maximum demand is obtained for each of the geographic areas. The actual maximum demand is taken for the group representing industrial loads that connect directly to Powerlink's network.

In order to combine these demands into a corrected state demand, coincidence factors need to be determined. The coincidence factors are based on a ten year rolling average of historic data, with the most recent summer representing the last year. Coincidence factors for this purpose are calculated as follows.

For each of the last ten summers, for each of the load groups a coincidence factor is determined. In the each area, this factor is equal to the actual area demand at the time of actual state demand peak divided by the actual area demand peak. A ten year rolling average is then calculated for each of these load groups, resulting in a single coincidence factor for each.

These five co-incidence factors are then used to combine corrected demands for the five load groups to give a state corrected demand. This is done by multiplying each of the corrected demands by its corresponding coincidence factor and then summing to give the state total.

4 TOP DOWN FORECAST

4.1 Independent Econometric Modelling

Powerlink engages an independent third party expert to undertake a high level economic forecast. In recent years, Powerlink has engaged NIEIR to undertake the modelling. NIEIR have developed an energy demand and production model which is an integral part of NIEIR's Institute Multi-purpose model (IMP model). Because the econometric modelling is undertaken by an independentant party, Powerlink is able to undertake a due diligence by making comparisons are made between the Powerlink Bottom-up forecast and NIEIR's top down model with differences discussed and resolved.

NIEIR's comprehensive econometric model, known as IMP, model contains a number of sub-models to undertake the macro-economic and forecasting functions as set out in Figure 4.

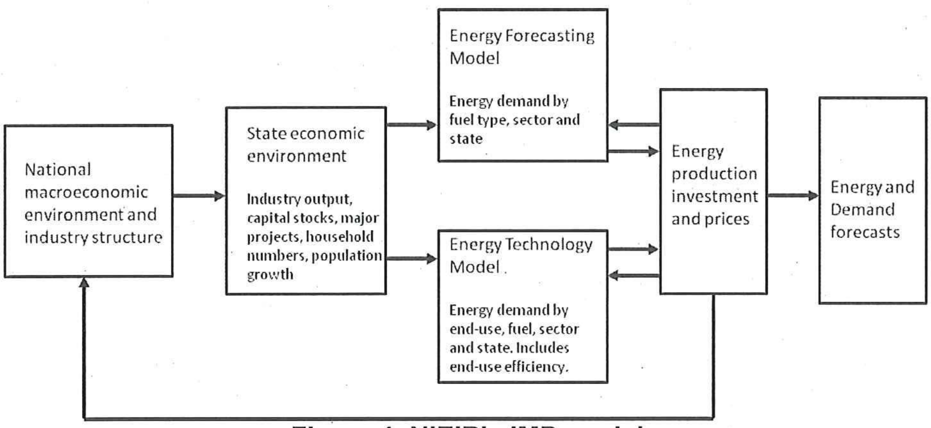

Figure 4: NIEIR's IMP model

NIEIR's forecast looks out ten years for energy and summer and winter demand. It is supplied at 10%, 50%, and 90% PoE for demand and low, medium and high economic outlooks for demand and energy.

NIEIR have been doing this work for a number of years and have established a good track record with forecast reliability. This is evidenced by the small level of adjustment Powerlink is required to undertake in fitting the bottom-up forecast within the top-down forecast envelope.

NIEIR review and model state, national and global drivers that impact on future electricity usage in Queensland. These include but are not limited to the following;

- International and Australian economic growth outlook,
- Queensland's and regional economic growth prospects and outlook,
- Population trends and projections,
- Impact of carbon pricing,
- Price sensitivity,
- Air-conditioning and demand sensitivity to temperature for each geographic area,
- Demand side management,
- Resource developments and associated infrastructure needs.

4.2 Treatment of Mining and Industrial Loads

Powerlink has several major customers that connect directly to its transmission network. These existing customers generally have flat demand forecasts under the medium economic outlook with some growth under the high economic outlook. Powerlink separates these customer forecasts out from the NIEIR's forecast and applies a customised approach for these particular subset of loads. This approach typically has minimal impact on the top down forecast, but is considered appropriate on the basis that these large customers are well aware of their own future plans which in turn should improve the quality of the forecast..

As part of its normal business Powerlink is in discussions with a number of customers that may connect load in the future. Powerlink review these proposals to determine how much of this potential load is likely to proceed. The size and nature of this proposed load is discussed with NIEIR to determine what (if any) has already been included within their forecast. If necessary Powerlink will correct the "top down" forecast to better allow for these proposals. The only place where this was done in the 2010 APR forecast is in the Surat Basin where new LNG pumping load, coal mining load and supporting load is proposed. This addition was undertaken on the basis of imminent new growth identified outside the area generally forecast.

Ergon Energy, also have mining and industrial customers who connect or may connect to their network. These customers are also included with NIEIR's top down forecast. Powerlink review these forecasts with Ergon to ensure that customer forecasts are reasonable, consistent with NIEIR and counted only once.

5 PUTTING IT TOGETHER

5.1 Compare and reconcile Growth rates

The bottom up forecast described earlier incorporates all customer demand forecasts, accounting for embedded non-scheduled generation and establishing a starting point that lines up with history. Appropriate temperature correction and diversity factors are also employed when combining the loads.

The top down forecast supplied by NIEIR is put through a range of high level checks to ensure consistency with previous years and other available data. It is also adjusted as necessary to ensure that directly connected industrial and mining loads are based on the best information and are counted once and once only.

The top down forecast is then overlaid on the bottom up forecast and the differences are compared. One area that is reviewed is how are the two forecasts are tracking at the end of ten years. Where they are close (within 2%) then the top down forecast is regarded as validating the customer forecast. Adjustments are made to the customer forecast to bring it into line over ten years. This is then the final forecast. Where more significant (greater than 2%) variations are observed more reconciliation is performed. This generally involves the following tasks.

Task 1. Communicating with NIEIR, Energex and Ergon to understand the differences in the annual growth rates between the two forecasts.

Task 2. NIEIR, Energex and/or Ergon to re-examine and modify their demand forecasts if appropriate based on the outcomes of the discussions.

Task 3. If there is still any difference in the annual growth rates after Task 2, then the annual growth rates in the bottom-up forecast are modified so that the cumulative growth over the forecast period is consistent to the top-down forecast.

The adjustments required to annual growth through this process is normally very minor as the customers generally rely on the same underlying economic, population and other trends and further forecasts used by NIEIR to develop the top-down forecast.

5.2 Forecast suite

Annual state peak demand forecasts are produced for 10%, 50% and 90% PoE (probability of exceedance) levels. These correspond to the level of peak demand that would expect to be exceeded once in ten, once in two and nine in ten years respectively. These different PoE levels relate to the temperatures across the state at the time of peak demand. The 50% forecast is the "standard" forecast produced through the methodology described. 10% and 90% PoE forecasts are obtained by application of implied ratios from the NIEIR forecast. Ratios for directly connected customers are unity as they are considered relatively temperature insensitive.

Demand and energy forecasts are also developed for three economic growth outlooks – high, medium and low with medium considered the most likely. The medium forecast is the "standard" forecast produced through the methodology described so far. High and low forecasts are obtained by application of implied ratios from the NIEIR forecast.

In addition to compiling the forecast for state peak, forecasts are prepared for various "levels" of the network, using co-incidence factors based on historic averages. The levels in the network where forecasts are required are shown in Figure 5.

Another variation of the demand forecast is based on the treatment of embedded non-scheduled generation. The "delivered from grid" forecast assumes these generators are on while the "native" or underlying forecast assumes they are off. The native forecast is the one developed through econometric modelling as it considers all load connect within the networks. The delivered forecast is used to analyse the transmission network as it reflects the load that has to be supplied.

The forecasts are also produced on an "As Scheduled" basis to AEMO for inclusion in their ESOO and as an input to their analysis.

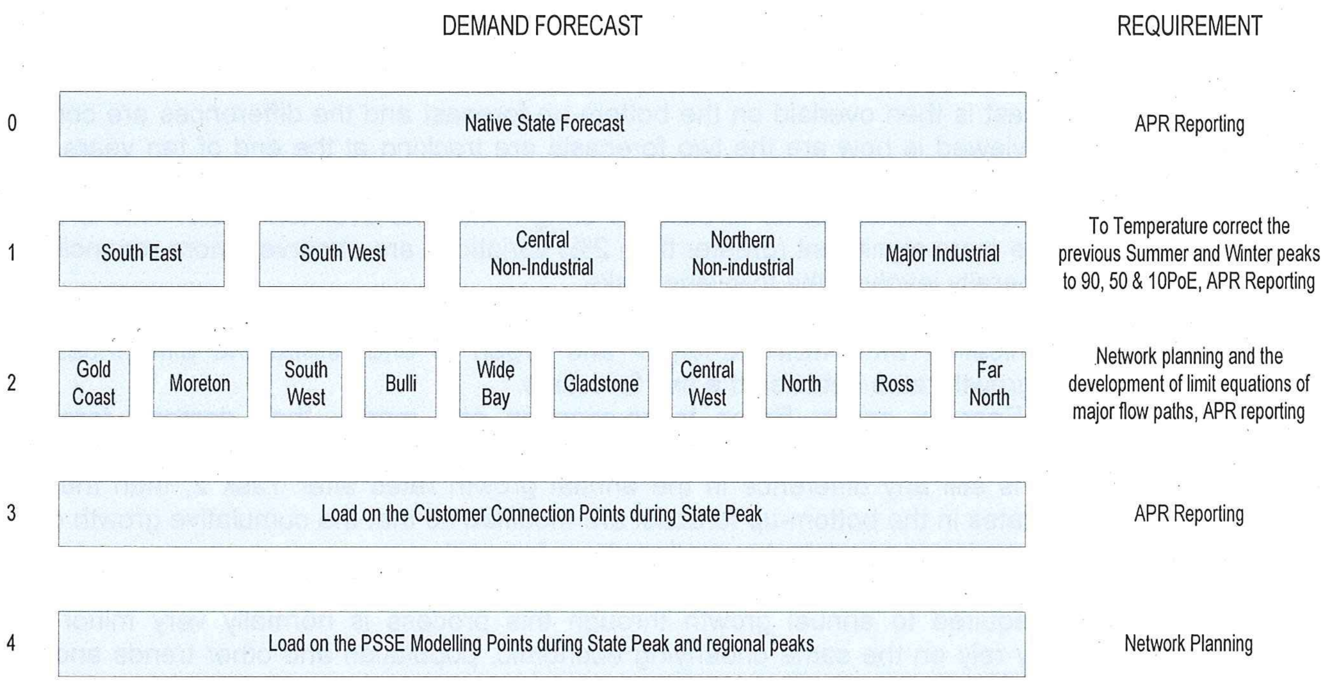

Figure 5: Types of Demand Forecasts

5.3 Checks and Balances

Powerlink undertakes a number of reviews, checks and balances to ensure that its demand forecast is reasonable and consistent with a range of information available. These checks include.

5.3.1 Starting Points

The starting point is corrected to line up with the historic weather and diversity corrected trend every year. Details of how this is done are given in section 3.3. In particular, the use of an "S – Curve" to model the sensitivity of demand in South East Queensland to temperature allows Powerlink to make better predictions along this non-linear relationship.

5.3.2 Responding to Change

In response to correcting the starting point and economic drivers (such as the global financial crisis), Powerlink's forecast for 2011/12 demand has dropped around 7% from the 2007 to the 2010 APR.

5.3.3 Comparisons to Previous Years

When customer forecasts are received comparisons to previous years are made at every load point. Where significant differences occur, Powerlink discusses these with the customer to understand the reason for the change and where necessary question or alter the change.

5.3.4 Checks with Major Loads

Powerlink looks at the forecasts supplied by major customers that connect directly to its network and seeks to understand what is behind them. Generally they are flat and consistent with history. Where new major loads are to connect directly to Powerlink's network, Powerlink will carefully consider the information behind the customer's forecast and form a view on what the future loading will be. Some potential and quite significant loads may be excluded as a result of this screening process.

For both existing and new loads that connect directly to Powerlink's network, Powerlink works closely with its econometric forecaster NIEIR to understand what has and has not been included within their forecast. Only then does Powerlink establish a "top down" forecast that includes directly connected loads once and only once.

5.3.5 Working Closely with Customers

In addition to working closely with customers that connect directly to its network, Powerlink works closely with both ENEGEX and Ergon Energy to understand what feeds into and drives their demand forecasts.

5.3.6 Household Survey

Powerlink takes part every year with Ergon Energy and ENERGEX in a household survey on electricity usage. One important output of this is a better understanding of air conditioner usage and the extent of penetration and saturation on the network. These patterns are reviewed against the review of temperature sensitivity each year. In addition to delivering an increased understanding they help guide thinking as to where these sensitivities are likely to head.

6 ENERGY FORECAST

In addition to its summer and winter demand forecasts, Powerlink produce an energy forecast that is published in its Annual Planning Report each year by June 30.

While it is only the summer demands drive network augmentation, energy is used in establishing transmission pricing.

Powerlink develops its energy forecast by following a similar bottom up / top down approach to that used for demand forecasting. There are however a couple of key differences that make it easier. As energy typically measures the total usage over a month, season or a year, it does not vary as much as demand with day to day temperatures. Temperature correction of annual energy is usually relatively minor and is not relevant for major customers. Individual customer energy forecasts can simply be added to develop a bottom up forecast.

Like demand forecasting, Powerlink's energy forecasts,

- Have a starting point that is consistent with history;
- Use econometric modelling provided by NIEIR as a check;

Energy forecasts are supplied for low, medium and high economic outlooks. Like demand they are also produced for "as delivered" from the network and as "native" which is increased by the amount of embedded non-scheduled generation.

7 AUTHORISATION

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4/4/2011

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