Appendix P – System Demand Forecasting for AA3

September 2011

westernpower

Access Arrangement Information for the period 1 July 2012 to 30 June 2017 (AAI)

System Forecasting Input for AA3

21/9/2010

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1 SWIS System Electrical Load Demand

1.1 System Forecasting Methodology

This section provides an overview of the peak load demand forecasting that Western Power undertakes each year. Western Power performs seasonal zone substation[1] and system forecasts. The summer forecasting starts in April after the summer peak whereas winter forecasting starts in September. Majority of the substations have their maximum demand take place in summer. There are only approximately 10 substations in SWIS that demonstrate winter peaking. They are the substations in south west of Western Australia where the electrical demand from the heating appliances is more prevalent than from the air conditioners during summer.

Two sets of forecasts are compiled for every substation each summer and then again each winter for with winter peaking substations. The first is based on historical substation maximum demand. The other is based on historical substation demand at system peak time. The substation peak load demand forecast is essential to ensure the substation has sufficient capacity to cater for maximum load demand that each substation supplies. The forecast based on system peak time is used to produce the overall SWIS load demand forecast and is used in system load flow studies.

The forecasting process is the same for both summer and winter. It begins by determining the date, time and value, of each of the substation maximum demand and system peak demand. Western Power utilises the load demand and assets ratings from the following sources; Process Information (PI), Transmission Rating Information System (TRIS) and Transmission Plant Management System (TPMS) for the purposes of producing load demand forecasts. Any dubious data and temporary transfers that may have been performed coincidently with the peak time are manually eliminated to avoid them from skewing the historical trend. The temporary transfers are performed to ease the demand pressure on certain parts of the system and may be related to faults on the network. They do not represent load growth or load reduction of the substations.

The rest of the forecasting process is performed in the Western Power substation forecasting tool, OPAL. The forecasting process includes determining:

1. Underlying load growth;
2. Spatial time series adjusted for temporary transfers;
3. Effective incorporation of expected economic activities; and
4. Historic Variance Adjustment Factors – Probability of Exceedance (PoE)

Each of these aspects will be explained in detail in the following sections.

[1] The term "substation" is used interchangeably to describe zone substation in this document.

1.1.1 Underlying Load Growth

Western Power has recorded the historical peak load demand values for all of the zone substations found within the SWIS network. This historical peak load demand data can date back as far as 14 years depending on the commissioning date of each substation. In order to determine each additional years new peak demand value, seasonal half hourly demand intervals are plotted for every substation to determine the correct yearly peak value. These peak demand values are then adjusted for load transfers and major new block loads. (Covered in Sections 1.1.2, and 1.1.3) Using regression analysis a prediction model is fitted to the historical data, which minimizes the distance between the actual and predicted peak demand values (in megawatts); this methodology is called least squared regression analysis. This model is then used to forecast the underlying growth on the majority of the substations in the SWIS network. Please note that customer substations and substations with less then 3 years of historical data are excluded from this process. For these substations knowledge of specific customer and local economic activity are used to determine the expected growth on these substations.

1.1.2 Spatial time series adjusted for temporary transfers

Two types of electrical load transfer can be identified that can effect yearly peak demand point's namely permanent transfers and temporary transfers. The permanent load transfers are usually planned and are performed to reduce the electrical load demand of a feeders or substations in order to address their capacity constraints. In these instances networks are permanently reconfigured.

The temporary transfers can be planned or unplanned. They are carried out to momentarily ease the pressure on the feeders or substations that are under significant load demand pressure. They are also performed to relocate the load temporarily from feeders that are under fault, or sections of feeders that require to be switched off for field operation purposes.

The temporary transfers are sometimes performed coincidently at the substation peak times during summer when the system is under enormous load demand pressure. The temporary network configuration is reverted to normal configuration when the pressure is eased. The transfers therefore do no represent load growth or load reduction in the concerned substations but simply a temporary emergency mitigation.

The transfers may significantly increase or reduce the substation peak values, and skew the historical regression line. Western Power corrects these values early at the data review stage.

1.1.3 Economic activities incorporated into spatial forecasts effectively

Western Power obtains the most up-to-date information on economic activity due to customer activity for each of its substation supply areas from the following three major sources:

1. Design Quotation Application (DQA)[2] information recorded in Distribution Quotation Management (DQM) System,

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[2] A DQA is a form that a customer must submit to Western Power for new installation and power upgrade. The DQAs are recorded in Design Quotation Management (DQM) system.

2. network access requests from major project proponents[3] ;and
3. consultations with various State and Local Government Authorities (LGA's), private developers and regional stakeholders.

The underlying growth trend produced using least squared regression analysis (covered in 2.2.1) determines the historical level of demand from ongoing economic activities. The impact of expected changes in consumption of large individual loads "block loads" also needs to be considered. A block load is annual peak demand from an individual customer that exceeds the historical underlying demand growth in the area. The substation forecast is the sum of the underlying demand forecast and the block load demand forecast.

Through consultation with relevant stakeholders Western Power requires that a reasonable probability exists to justify the inclusion of a proposed change to a block load in the load demand forecast. Differing levels of certainty determines whether a project is applied to either the central or high scenarios. The central scenario includes block loads that have been identified as having a high likelihood of proceeding while the high scenario includes block loads in the central scenario plus a number of loads with lesser likelihood of proceeding. These two scenarios assist Western Power in understanding the potential risk that may occur in different areas of the network and allows us to create plans to manage this risk.

As all loads supplied from a substation do not peak simultaneously, individual maximum demands for each block load can not simplistically be summated at the substation level. Western Power has developed standard diversification factors based on the type of industry expected to be connected. Diversity factors simulate the impact that a major new load is likely to have on the electrical network at the time of system and substation peaks. Since, the substation and system can peak at different times Western Power uses different diversify factors which take this into account. Apart from determining the likelihood of new projects going ahead the period over which a new load is expected to come on line is also accounted for in the block load take-up rate profile.

1.1.4 Historical Variance Adjustment – Probability of Exceedance (POE)

Western Power adjusts its base forecast by applying a Probability of Exceedance (POE) adjustment in order to account for the inherent variation found in the historical peak load demand data. The identified underlying trend represents a 5 in 10 year event 50 POE while the POE adjustment factor equates this to a 1 in 10 year event 10 POE. (IE one out of the next 10 years is likely to exceed the forecast) To calculate POE values Western Power uses prediction intervals which are an estimate of an interval in which future observations will fall, with a certain probability, given what has been observed historically.

The following formula is used by Western Power to calculate its 10 POE forecast. Where the probability of X_{n+1} falling in a given interval is:

$$\Pr\left(\overline{X}_n - T_a S_n\sqrt{1+(1/n)} \le X_{n+1} \le \overline{X}_n + T_a S_n\sqrt{1+(1/n)}\right) = p$$

[3] The network access requests are major applications Western Power receives that are over 5 million dollars in value and are individually looked after by Access Solutions.

Where T_a is the $100((1 + p)/2)^{th}$ percentile of Student's t-distribution with n − 1 degrees of freedom. Therefore the 10 POE forecast is the upper endpoints of the following prediction interval,

$$\overline{X}_n \pm T_a S_n \sqrt{1 + (1/n)}$$

The two most important benefits of using this approach is that it adjusts for the number of historical observations and it also accounts for the inherent year over year variability of those observations. For example if Western Power only has 5 years of historical peak load demand data for a particular substation then we would obtain a larger POE adjustment factor then for a substation with 15 years of historical data. Similarly the larger the historical year over year variability of the peak load demands, the larger the POE adjustment factor. These two key benefits are made possible because the calculation for the prediction interval is based on a student t distribution.

Once the 10 POE forecast is calculated, identified block loads are incorporated into the forecast as described in Section 1.1.3. This enables Western Power to correctly state that we consistently forecasts to a 1 in 10 year peak load demand event.

Figure 1: Historical Variance Adjusted Forecasting Example provides a simple example of the forecasts which Western Power produces. Please note that this example has not incorporated block loads or load transfers. The red line represents the 10 POE forecast, the blue line is the 50 POE forecast and the green line is the 90 POE forecast. It is Western Powers stated practice that future transmission system and network augmentation options are to be planned to 10 POE forecast. [4]

[4] Transmission Planning Guidelines

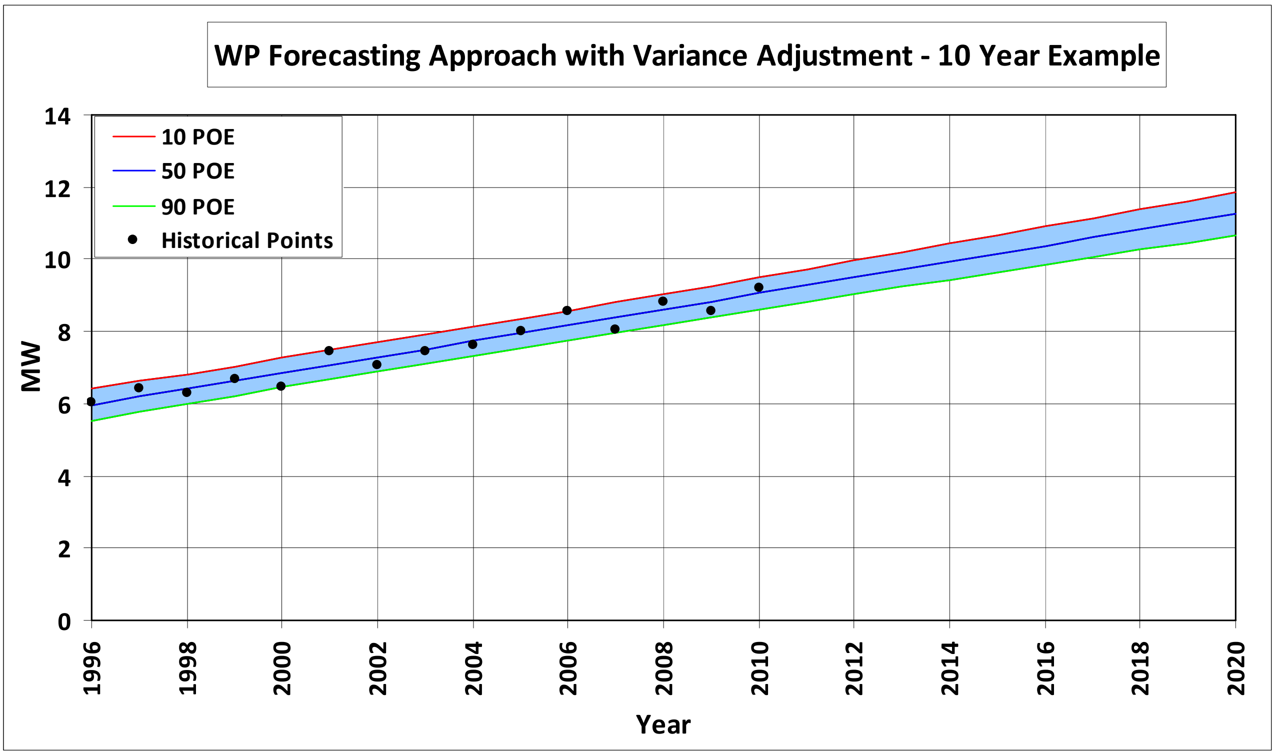

Figure 1: Historical Variance Adjusted Forecasting Example

Western Power recognizes that multiple factors cause peak load demand at the substation and system level and the interaction and combinations of these factors occurring simultaneously results in the peak yearly load demand. These factors include but are not limited to; day of week, public holiday, production behavior of major industrial/mining loads, consecutive hot days, random affects of residential consumer behavior, and temperature.

Western Power recognises that temperature has a significant impact on electricity demand. It is clearly and well understood that temperature has a very significant affect on 'general' load demand and is well correlated as can be seen in Figure 2: 2009 Load Generation Variance vs. Temperature. Clearly, as the temperature increases so does the amount of load generation. [5] However, the affect that temperature has on 'peak' load demand is not as well correlated. From Figure 2 it is also clearly evident that in 2009 the hottest day of the year was not the peak load demand day. In fact in 2009 the third hottest day of the year was the peak load demand day as can be seen in Table 1: Characteristics of Historic Peak Load Demand Days. Additionally, Figure 2: 2009 Load Generation Variance vs. Temperature also demonstrates the extreme range of generation demand that the SWIS network can experience per degree. Take for example the range of generation (~2600 MW to ~3700 MW) experienced at 38 degrees, clearly the day of the week played any important part in this demand. (Sunday vs. Wednesday) In addition, random consumer behavior can have a significant affect on the generation demand as can be seen by examining the range of generation demands on Saturdays, at 36 degrees. (~2300 MW to 3000 MW)

[5] 2009 Temperate Data obtain from BOM and 2009 generation data obtain from Western Power

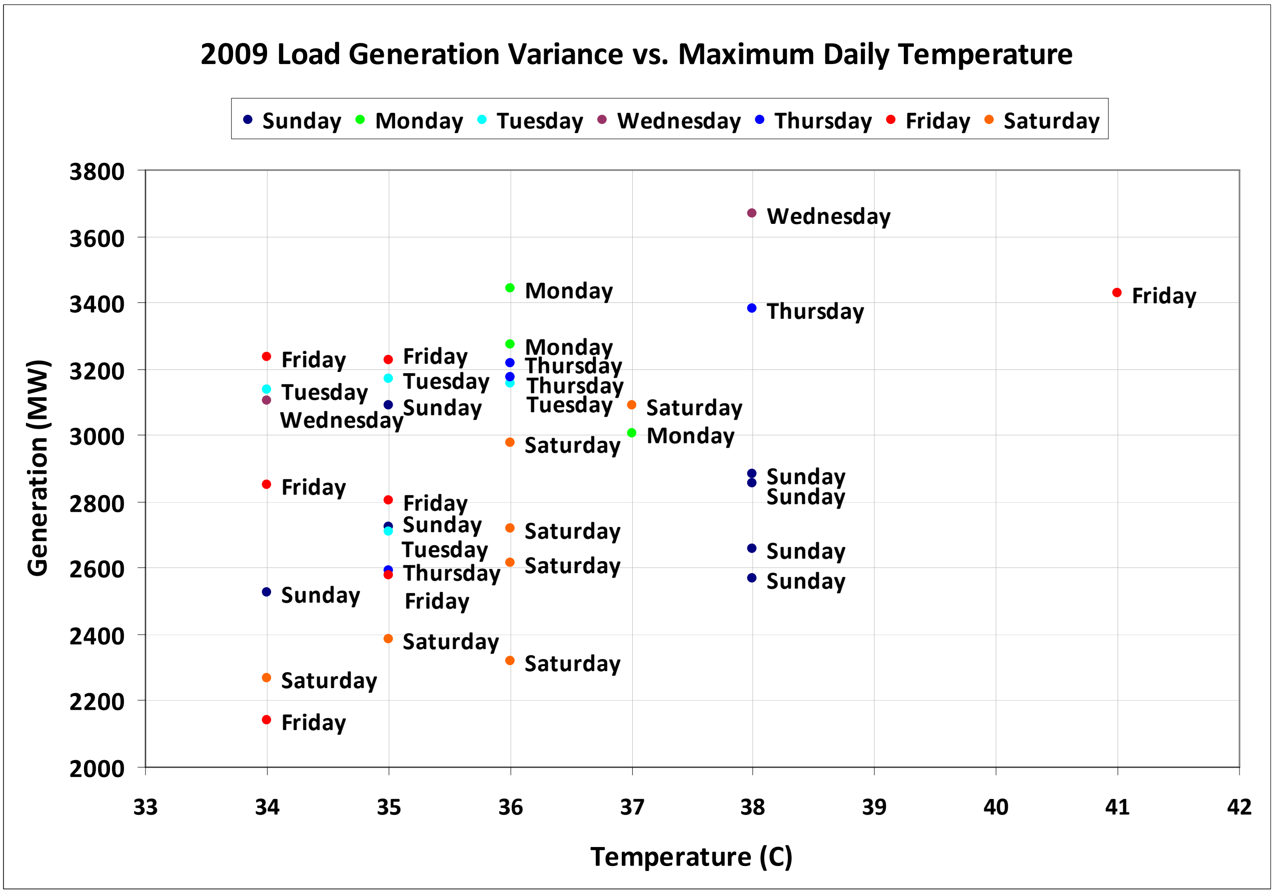

Figure 2: 2009 Load Generation Variance vs. Temperature

Additionally, Table 1: Characteristics of Historic Peak Load Demand Days displays the day that the peak load demand occurred dating back to 1999. It displays the day time high temperature, the overnight low temperature, the day of the week, and the number of days that were hotter in that year. From the table it is evident that the day time high temperature varied significantly through out the years from 36.1 to 41.7 degrees, the overnight low varied from 20.2 to 27.3 degrees, and the peaks pre-dominantly occurred from Tuesday to Thursday. Additionally, it was only in 2005 and 2007 that the peak load demand occurred on the hottest day of the year. Table 1: Characteristics of Historic Peak Load Demand Days demonstrates how the historical peak load demand on the SWIS network has been the result of a combination of factors occurring simultaneously.

Table 1: Characteristics of Historic Peak Load Demand Days

Peak Load Demand (MW)	Date	Maximum Daily Temperature	Minimum Overnight Temperature	Mean Daily Temperature	Number of Hotter Days	Day of Week
2019	8/02/1999	38.1	23.9	31.0	3	Monday
2263	8/03/2000	37.6	25.4	31.5	4	Wednesday
2299	6/03/2001	37.8	21.2	29.5	5	Tuesday
2216	31/01/2002	36.1	22.3	29.2	4	Thursday
2491	10/03/2003	40.1	23.9	32.0	3	Monday
2760	17/02/2004	40.1	27.3	33.7	3	Tuesday
2834	15/02/2005	41.1	22.8	32.0	0	Tuesday
2856	7/03/2006	36.4	20.2	28.3	6	Tuesday
3201	7/03/2007	41.7	21.6	31.7	0	Wednesday
3238	11/02/2008	37.1	23.9	30.5	9	Monday
3341	11/02/2009	38.4	24.9	31.7	3	Wednesday
3639	25/02/2010	40.8	24.5	32.7	3	Thursday

By applying Western Powers POE approach, it is our view that it is more fitting to adjust for all of the variability caused by the interaction of these factors, rather than just a temperature adjustment. It is therefore out of place to apply a POE approach to simply the weather component of the maximum load demand. Instead an all inclusive POE approach should consider all factors that contribute to the peak load demand and all of these factors and their interplay with one another need to be statistically accounted for in the POE adjustment.

1.2 Model Validation of Accuracy and Unbiasedness

As part of the AA3 submission Western Power examined the robustness and accuracy of its new forecasting methodology. Western Power applied its new forecasting approach to the historic peak load demand data that was used in 2008 and 2009 to produce the substation peak load forecasts for those respective years. Based on the original 2008 and 2009 data Western Power re-ran the forecasts with the original assumptions about economic developments (block loads) and transfers. The objective of the analysis was to measure how well the new methodology predicted the actual peak load demands in 2009 and 2010. It was also used to measure whether there was a statistically significant difference between Western Powers predicted forecast based on 2008 & 2009 data and the actual peak load demand, based on actual 2009 & 2010 data.

Western Power now produces a probabilistic load demand forecast as seen in Figure 3: Probabilistic Forecasting Intervals, which adjusts its 50 POE forecast to account for all of the historic variance and the number of observations that are available for each substation. Therefore based on this we would expect that in any year 10% of the substations in the SWIS would exceed the 10 POE forecast and 90% would be less then the 10 POE forecast. Western Power applied this approach to 253 separate historic forecasts and then compared the forecasted value to the actual. From the 2008 data, a forecasted 2009 and 2010 value was compared against the actual 2009 and 2010 data. Additionally, from the 2009 data a forecasted 2010 value was compared against the actual 2010 value. The results can be seen in Figure 4: Forecasting Methodology Validation . Of the 253 separate forecasts 33 or 13% of them were greater than the 10 POE forecasts, where we were expecting 26 or 10%. Additionally, 87% were below the 10 POE forecasts where we were expecting 90% to lie.

These results are very close to what we were expecting to see and further underpin the robustness to our new approach.

The second check was to determine whether there was a significant difference between the forecasted load demand and the actual load demand. To do this a two sample t-test was used at a 5% level of significance (industry standard). A two sample t-test, tests whether the forecasted peak load is significantly different then the actual peak load. The results indicate there was not a statistically significant difference (p value=0.58) between Western Powers forecasted peak load demand and the actual peak load demand.

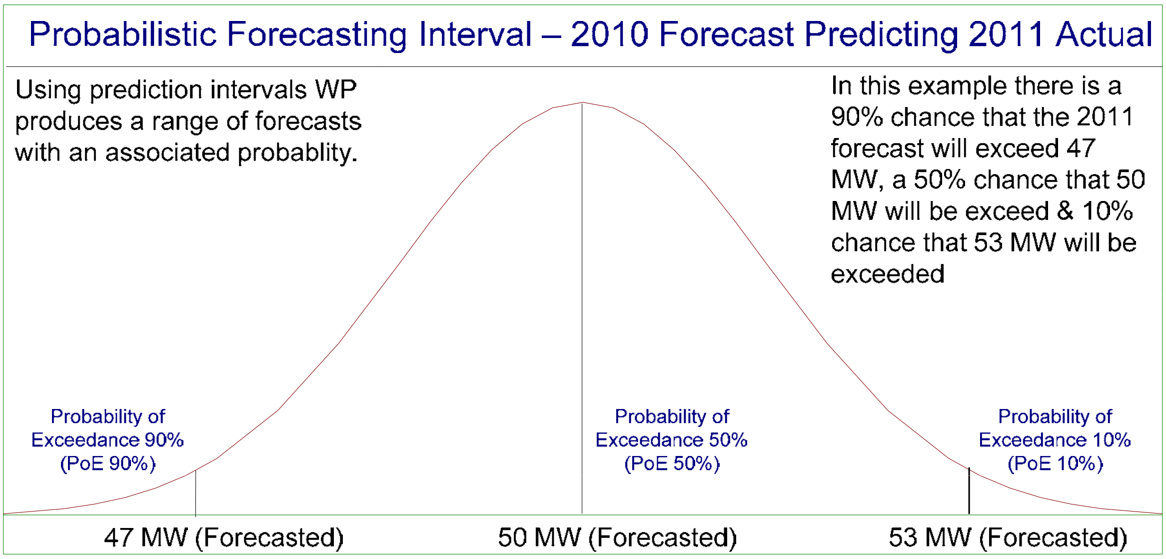

Figure 3: Probabilistic Forecasting Intervals

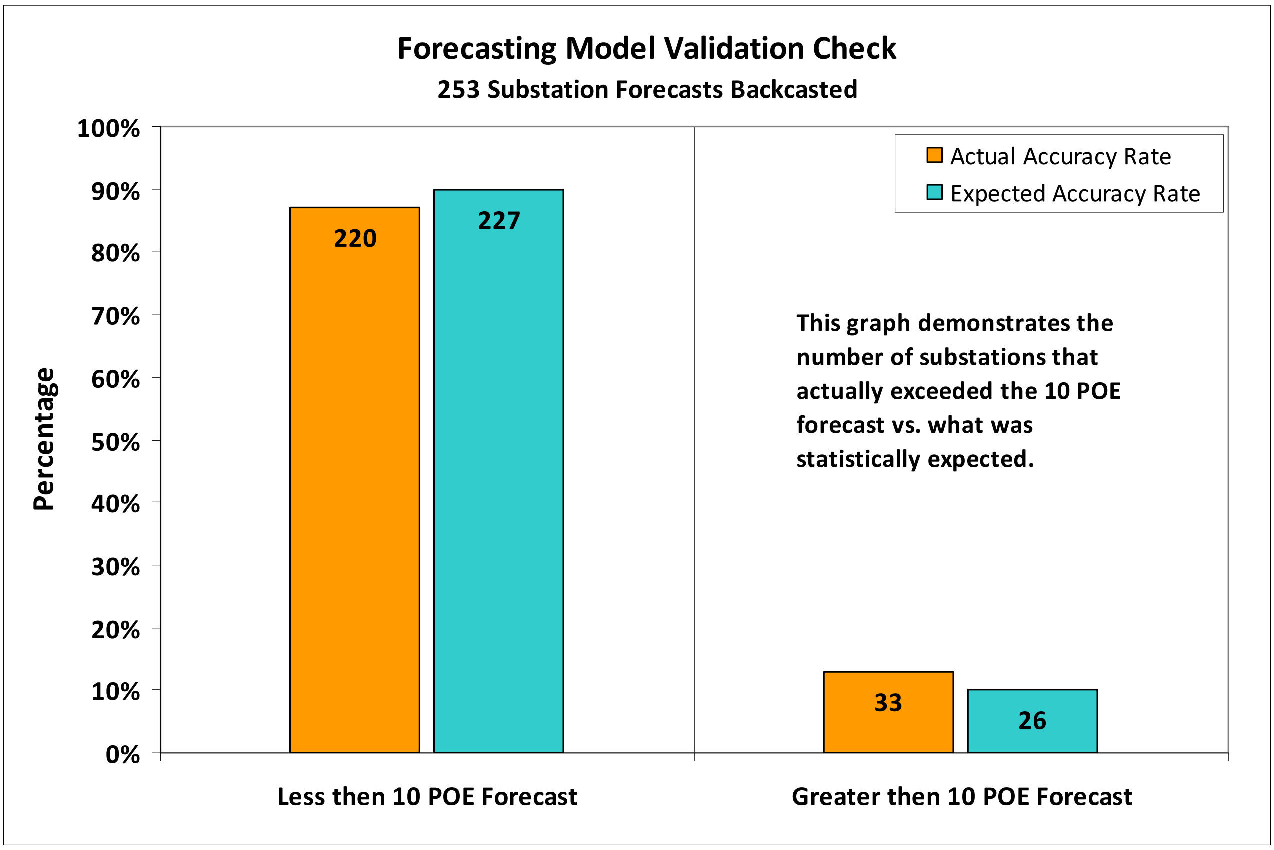

Figure 4: Forecasting Methodology Validation

Figure 5: 2010 Predicted vs. 2010 Actual provides the reader with a visual demonstration of the new Probabilistic forecast that Western Power produces. The blue bar represents the range of each forecast per substation (between 10 & 90 POE) and the red point is the actual 2010 peak load for the substation. Please note how the range of the forecast varies depending on each substation number of observations and historic variance as discussed. Also note that the actual load (red dot) is not always within the forecasted range, as previously discussed. Around 10% should fall to the left, 80% should fall within the range, and 10% should fall to the right. It is Western Power's view that this model validation process clearly demonstrates the robustness and accuracy of our new forecasting approach.

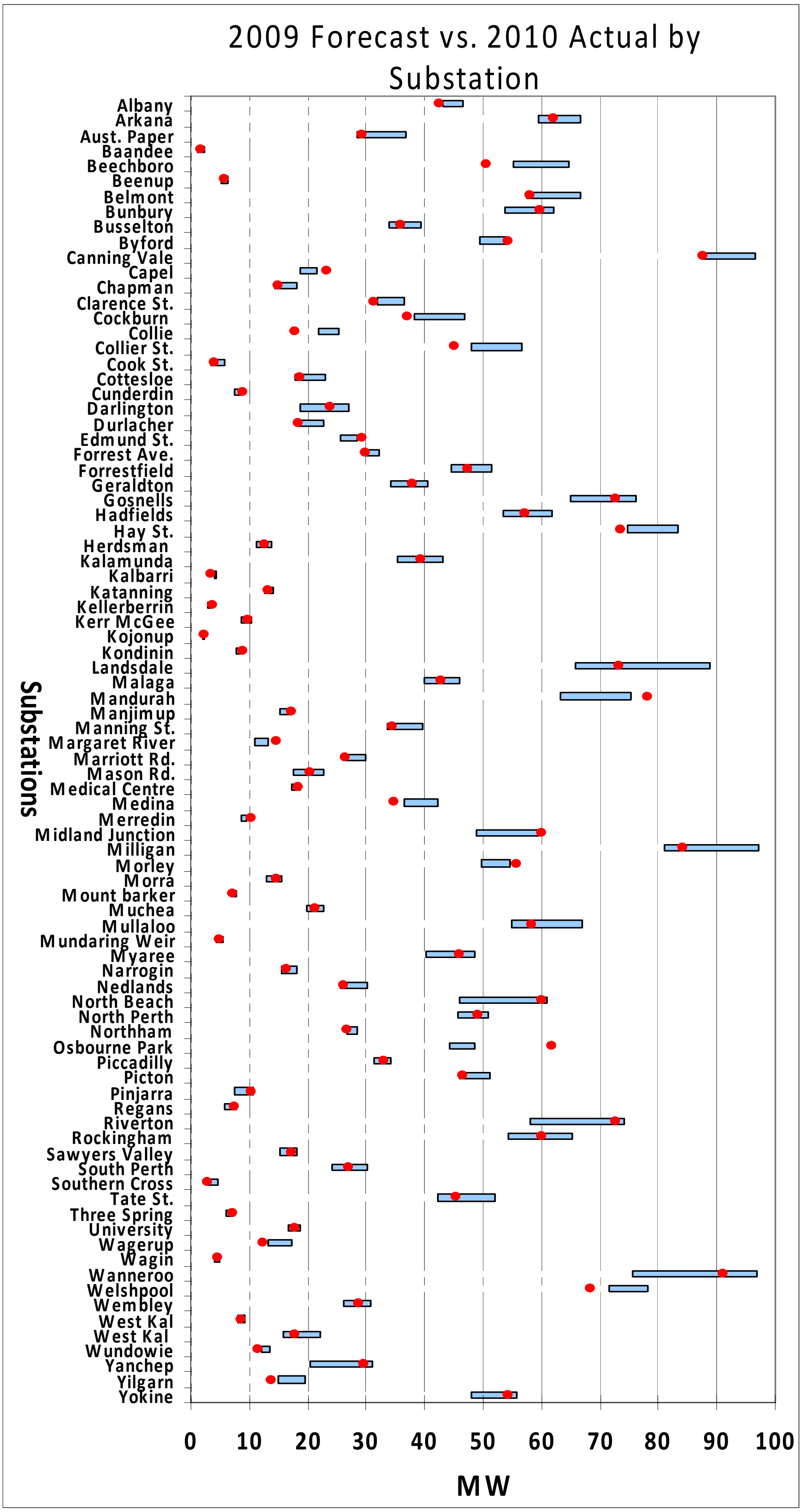

Figure 5: 2010 Predicted vs. 2010 Actual

1.3 Transparency and repeatability through effective documentation

As stated in Western Power System Forecasting Section Operating manual, the general requirements of the forecasting process include ensuring control of load forecast amendments, and information identification and traceability. The requirements help to achieve transparency and repeatability of the forecasting process.

The control of load forecast amendments, such as substation ratings, changes in inclusion or exclusion of potential loads from previous years and load transfers, are achieved by recording the changes in relevant sections of Western Powers forecasting software called Opal.

All forecasting information and output are to be recorded in Network Planning and Developments Information Capital Management system to provide an easily searchable listing of all branch documents.

All load forecasts are required to include a Quality Control Plan (QCP) as well. The purpose of the Quality Control Plan is to provide an audit record of each task that contributes to or needs to be considered when producing any forecasting study or analysis or report. Each task description may refer to one or more QCPs. They must be dated and signed when completed.

1.4 SWIS Network 2010 Load Demand Forecast

Western Power Overall SWIS Peak Load Demand Forecast has always been the summation of substation forecasts based on substation demand at system peak. The practice is regarded as a bottom up approach.

In 2010, Western Power applied POE adjustments to all of its substation forecasts. Every substation has a 10 & 50 POE line based on historical substation maximum demand, as well as the 10 & 50 POE line based on historical substation demand at system peak time. The central and high block load scenarios are also developed to consider a range of possible load demand growth. A 50 POE trend line that incorporates central scenario economic activity is referred to as central 50 POE trend line. Likewise, a 50 POE trend line that incorporates the high scenario is referred to as 'high 50 POE' line. Every substation has a different POE adjustment factor since the POE adjustment factors are based on the number of historical observations and the inherent yearly historical variance of those observations.

To calculate the POE adjustment at the system level, Western Power develops 50 POE and 10 POE trend line that are specific to the system, based on system historical observations and yearly variance of those observations. It would be incorrect to summate all of the individual central 10 POE substation forecasts as this would overestimate the system forecast by over adjusting for historical variance.

The WP load forecast high 10 POE is a collective sum of high 50 POE substation forecast (based on demand at system peak time) plus the difference between 50 & 10 POE trend lines of the historical system peak demand. As covered in 2.2.3, the high scenario includes those loads in the central forecast plus a number of loads with lesser likelihood of proceeding. Table 3: Projects in central and high scenarios shows the major block loads in Western Powers high and central forecast. The difference between the two scenarios in the 2010 forecasts is the inclusion of block loads that have a lesser likelihood of proceeding.

Figure 6: 2010 SWIS Load Demand Forecasts, shows Western Power's 2010 SWIS peak load demand forecast. Table 2: 2010 WP Load Demand Forecast provides, the forecasted load values associated with the SWIS Peak Load Demand forecast.

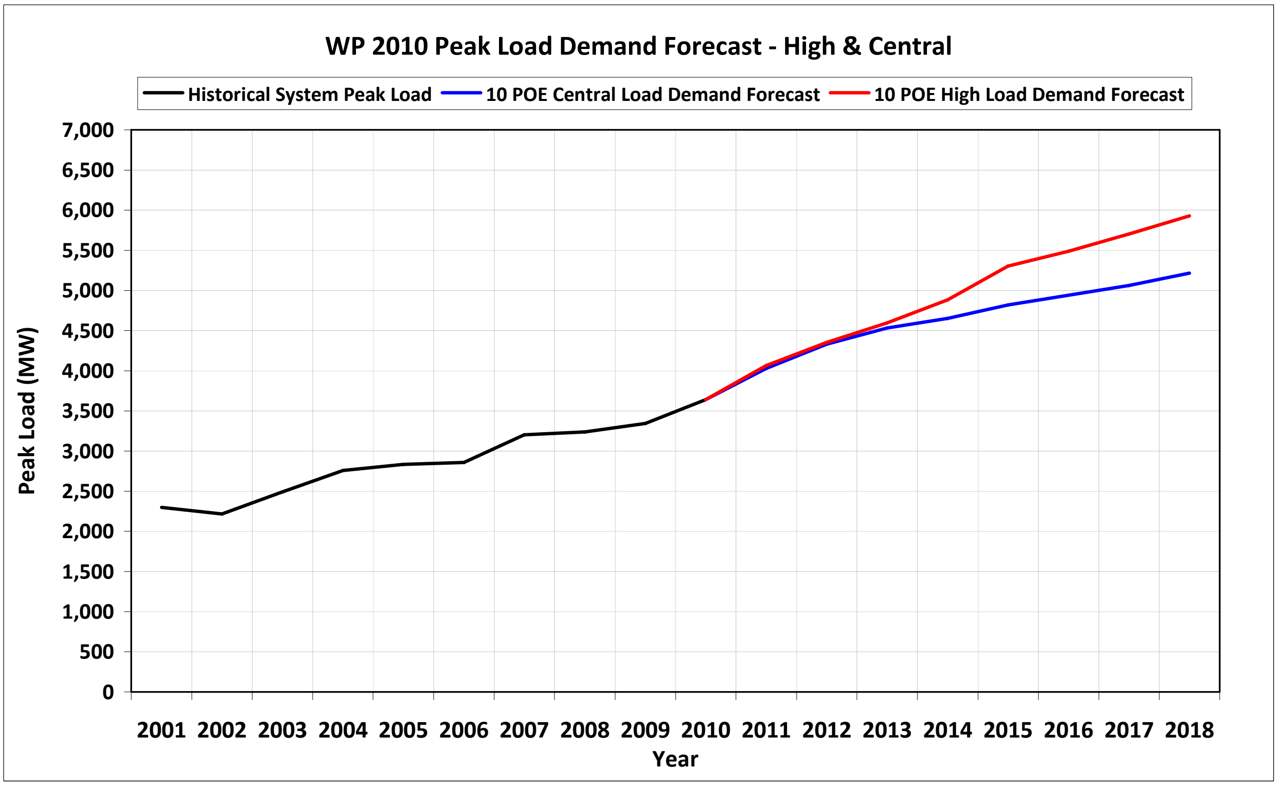

Figure 6: 2010 SWIS Load Demand Forecasts

Table 2: 2010 WP Load Demand Forecast

WP Historic Load	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Peak Load Demand	2019	2263	2299	2216	2491	2760	2834	2856	3201	3238	3341	3639
WP Load Demand Forecast	2011	2012	2013	2014	2015	2016	2017	2018				
10 POE Central Forecast	4027	4332	4531	4654	4822	4940	5061	5216				
10 POE High Forecast	4065	4354	4598	4884	5302	5490	5705	5931				

Table 3: Projects in central and high scenarios

Western Powers Major Block Loads (Diversified) Projects (over 20MW)	Central Forecast Year	Central Forecast MW	High Forecast Year	High Forecast MW
Port and Pumping facilities for Grange Resources -SDN	-	-	2015	20
Southern Seawater Desal Plant Stage 1 & 2 & 3	2011	16	2011	31
	2012	15	2016	31
	2018	31	-	-
Simcoa 3rd & 4th furnace expansion project	2012	24.3	2012	24.3
	-	-	2016	24.3
Asia Iron Ltd's. - Extension Hill Mine Site	-	-	2014	112.5
Gindalbie Stage 1.1	2012	86	2012	86
Gindalbie Stage 1.2	2013	23	2013	23
Gindalbie Stage 2.1	-	-	2014	27
Gindalbie Stage 2.2	-	-	2015	45
Gindalbie Stage 2.3	-	-	2017	45
Gindalbie Stage 2.4	-	-	2018	45
Port of Oakajee Stage 1	2014	27	2014	27
Port of Oakajee Stage 2	-	-	2018	15
Oakajee Industrial Estate Heavy (Smelter)	-	-	2017	28
	-	-	2018	30
Grange Resources mine	-	-	2015	160

Western Power compared its forecasts against IMO's, for sanity and accuracy check. This is covered in Section 4: IMO/NIEIR System Electrical Load Demand. The IMO's forecasts are produced using the top-down approach. The primary factors in their forecasts are the macro economic drivers, and temperature correction.

In addition to comparing to the IMO, Western Power studied a number of macro level drivers of load demand. They include Gross State Product (GSP), population growth, air conditioner penetration, government policy intervention and the CPRS. The aim of the study is to determine if these factors have been accounted for in the POE trends described in 2.2.3. If any of these factor's growth rates are forecasted to significantly increase or decrease during the AA3 regulatory period then Western Power would adjust its SWIS Load Demand forecast to take this into account. The following chapter describes the study in detail.

2 Macro level drivers of demand

2.1 Introduction

This section considers some of the underlying drivers of maximum demand, and focuses on the historical behaviour of these underlying drivers as well as assessing their forecasted growth rates during the AA3 regulatory period. The following key drivers were investigated and assessed by Western Power.

- Gross State Product (GSP);
- Air conditioners penetration;
- Population growth;
- Policy interventions and the CPRS

Western Power recognizes that a significant change in the forecasted future growth rates of any of these key drivers, when compared to their historical behaviour, would affect Western Power's forecasting accuracy. Therefore, Western Power assessed the forecast of each one of these key drivers to their historical behaviour. The forecasts were obtained from the following independent sources;

- NIEIR & Department of Treasury & Finance (DTF) for the Gross State Product (GSP) forecast;
- Department of Climate Change and Energy Efficiency; Consultation Regulatory Impact Statement: Minimum Energy Performance Standards for Air Conditioners: 2011;
- Australian Bureau of Statistics (ABS) & WA Tomorrow for the Population forecast;

2.2 Gross State Product (GSP)

The demand for electricity is driven to a significant extent by economic growth. Therefore a sound understanding of the drivers of that growth on both the distribution and transmission network is essential for producing a robust and accurate forecast. For this reason Western Power assessed two independent GSP forecasts, one from the NIEIR (Statement of Opportunities July 2010) and one from DTF (2009/2010), to evaluate whether their future growth was significantly different from the historic growth obtained from the ABS.

Western Power assessed the forecasted GSP values across a few different measurements to test whether future growth is expected to exceed historic growth. The first measure that Western Power investigated was the historic and future average growth rates. Table 4: Average GSP Growth Rate both Historic & Forecasted, shows the historic GSP growth rates from the ABS and the forecasted growth rates from DTF and the NIEIR. Over the past 10 years the average GSP growth rate has been 4.08% compared to an expected growth rate from DTF of 4.00% and 4.11% from the IMO. Figure 8: Year over Year GSP Growth Rates - Historic & Forecasted shows these growth rates dating back to 1991. Clearly these values do not differ significantly from their historical trend. Additionally, Figure 7 shows that there is little variation in the future forecasted GSP growth figures in absolute terms as compared to the ABS historical figures. To further test that the forecasted GSP growth rates are not significantly different then the historic rates, Western Power used a two sample t-test. This test statistically assesses whether the future average growth rate is significantly different from the past rate. At a 5% level of significance the t-test also confirmed that there is not a significant difference between the forecasted GSP growth rate and historic GSP growth rate.

Therefore it is Western Powers view that no adjustment be made to the 2010 SWIS peak load demand forecast can be justified due to major changes in Gross State Product. All of the historic variance caused by GSP will be accounted for using the new POE methodology.

Table 4: Average GSP Growth Rate both Historic & Forecasted

Year Over Year Average GSP Growth Rates	
	Forecasted & Historic GSP Growth Rates
NIEIR Central Economic Growth - Forecast	4.11%
DTF Economic Growth Rate - Forecast	4.00%
ABS 10 Year Historic Growth Rate	4.08%
ABS 20 Year Historic Growth Rate	4.28%

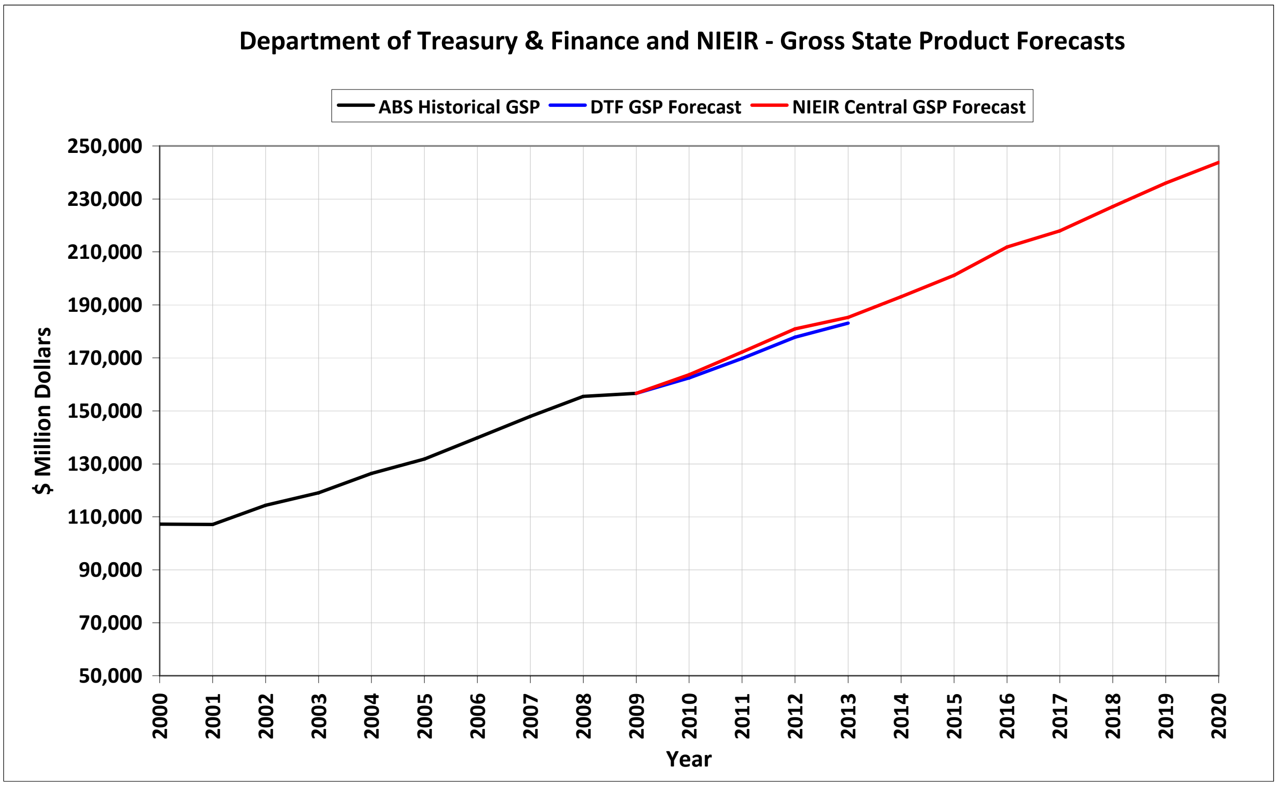

Figure 7: DTF and NIEIR GSP Forecasts

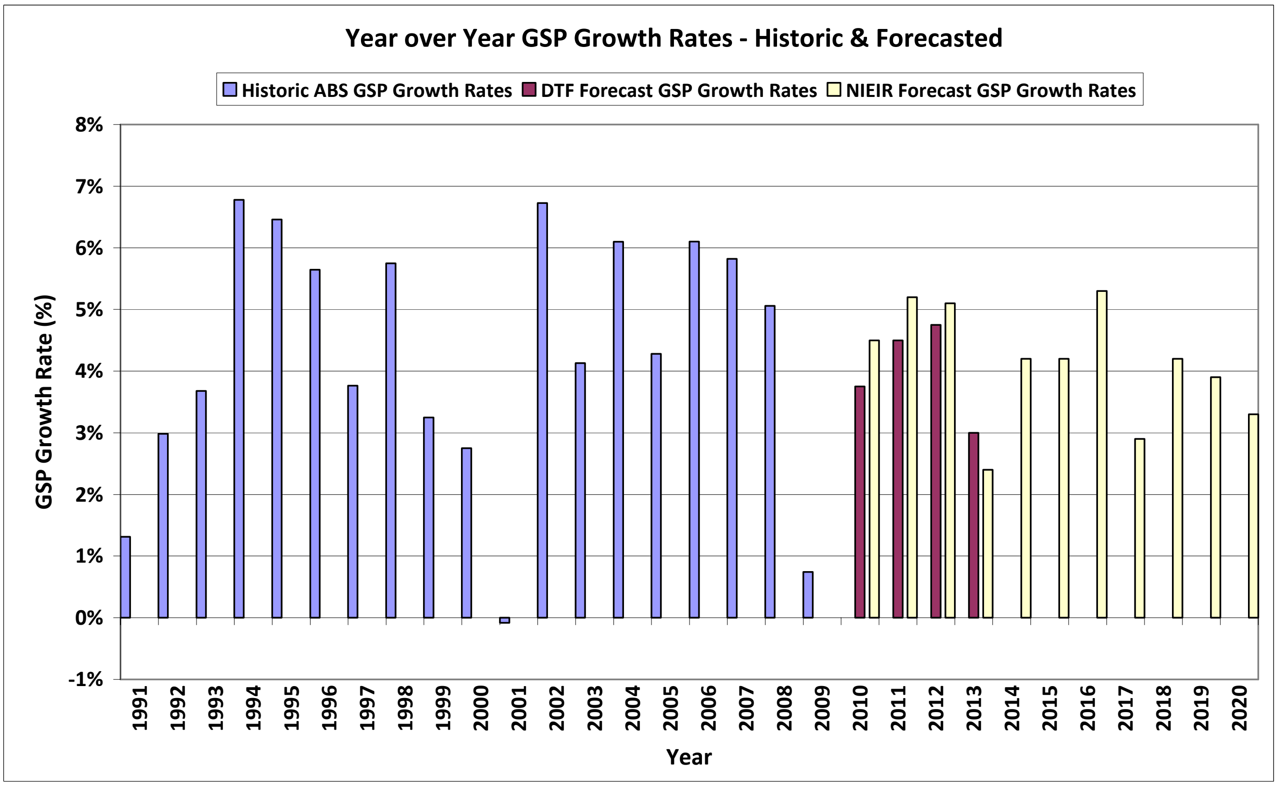

Figure 8: Year over Year GSP Growth Rates - Historic & Forecasted

2.3 Air Conditioners

The use of air conditioning systems on extreme summer days has a significant impact on peak electricity demand in Western Australia. The growth in load demand from air conditioning systems is essentially a function of growth in the number and size of new households and increases in the market ownership/penetration levels of air conditioning systems.

The market ownership of air conditioners in Western Australia has increased dramatically in the last 10 years (5.0% p.a.) as shown in Figure 10: WA Air Condition Market Penetration Levels. However, according to Department of Climate Change and Energy Efficiency this trend is not expected to continue as the market penetration levels begin to saturate (~75% market saturation) as shown in Figure 10: WA Air Condition Market Penetration Levels. Therefore, Western Power is expecting that the historically high market penetration rates of air conditions will slow during the AA3 regulatory period as the market reaches saturation.

Additionally, Western Power obtained the average floor area of new houses in Western Australia as shown in Figure 11: Average Annual Floor Area of New Houses in Western Australia. Figure 11 demonstrates that the average area of new houses has increased 8.1% in the last 8 years for Western Australia and Western Power expects this trend to continue. Furthermore, Western Power expects the forecasted households in the SWIS network will remain relatively unchanged from their historical trend and growth to continue at its historical rate.

The growth in load demand from air conditioners is a function of air conditioner market penetration levels and the number and size of households. During the AA3 regulatory period the market penetration rate of air conditioners is expected to come closer to saturation, however the size of households is expected to increase, while the number of new households is expected to remain relatively constant. It is therefore Western Power's view that in all likelihood the increases in housing size will more then likely offset the decline in air conditioner penetration levels; as such no change to the SWIS Peak Load Demand forecast can be justified.

It is also important to note that the majority of air condition load in the network comes from single phase air conditioner systems which are pre-dominantly found in residential and light commercial dwellings. The forecast and market share of different types of air conditioning systems, was obtained from the Department of Climate Change and Energy Efficiency and can be found in Figure 12: Forecast of Air Conditioner Type for Western Australia. Since the majority of peak load demand is caused by residential air conditioning systems as seen in Figure 12, Western Power did not specifically investigate other types of air conditioning systems.

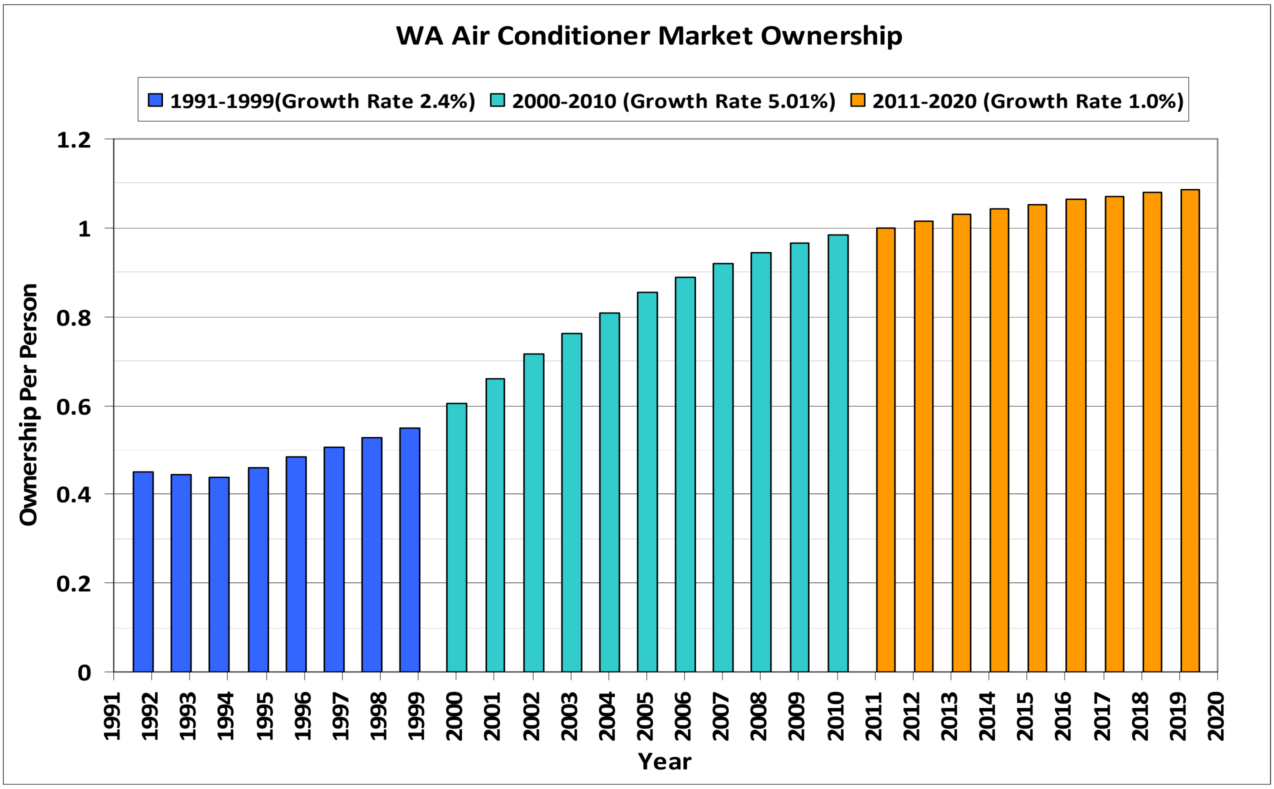

Figure 9: Western Australia Air Conditioner Market Ownership

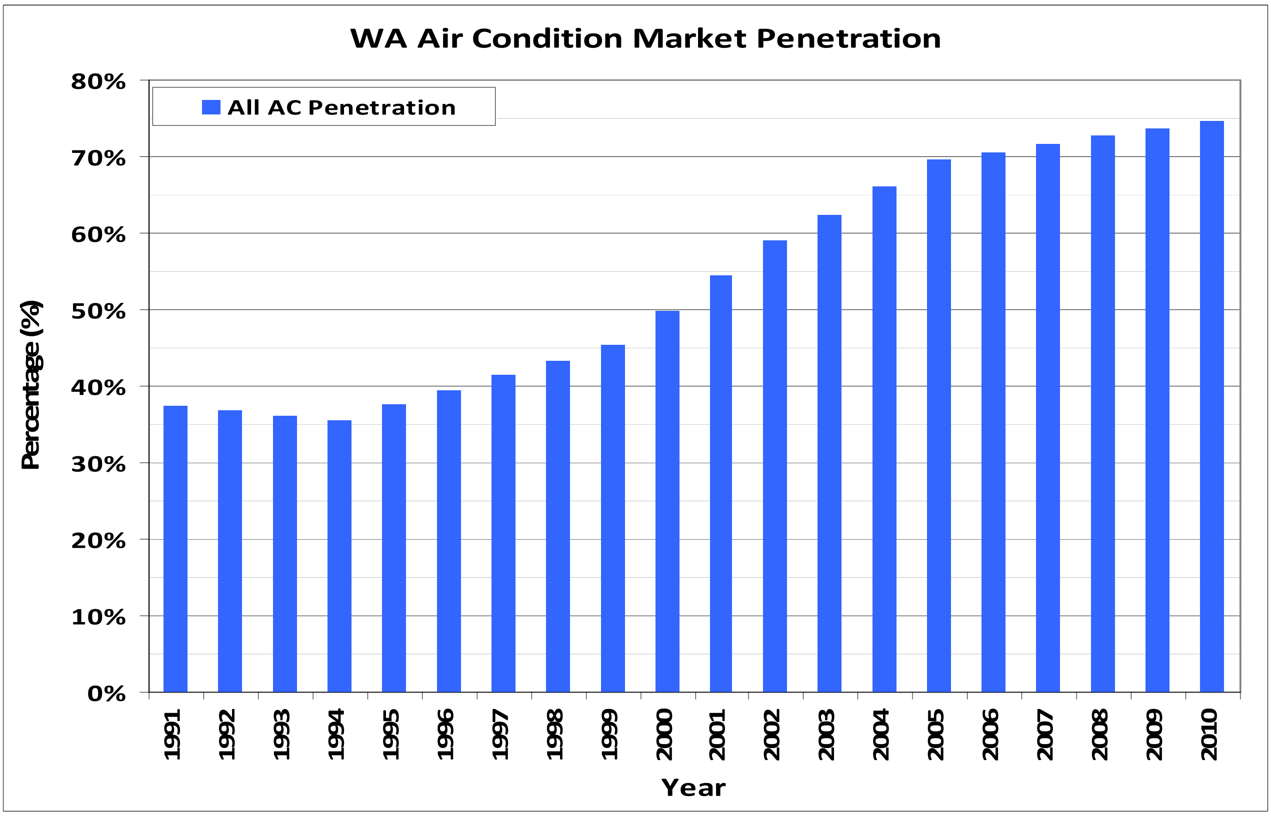

Figure 10: WA Air Condition Market Penetration Levels

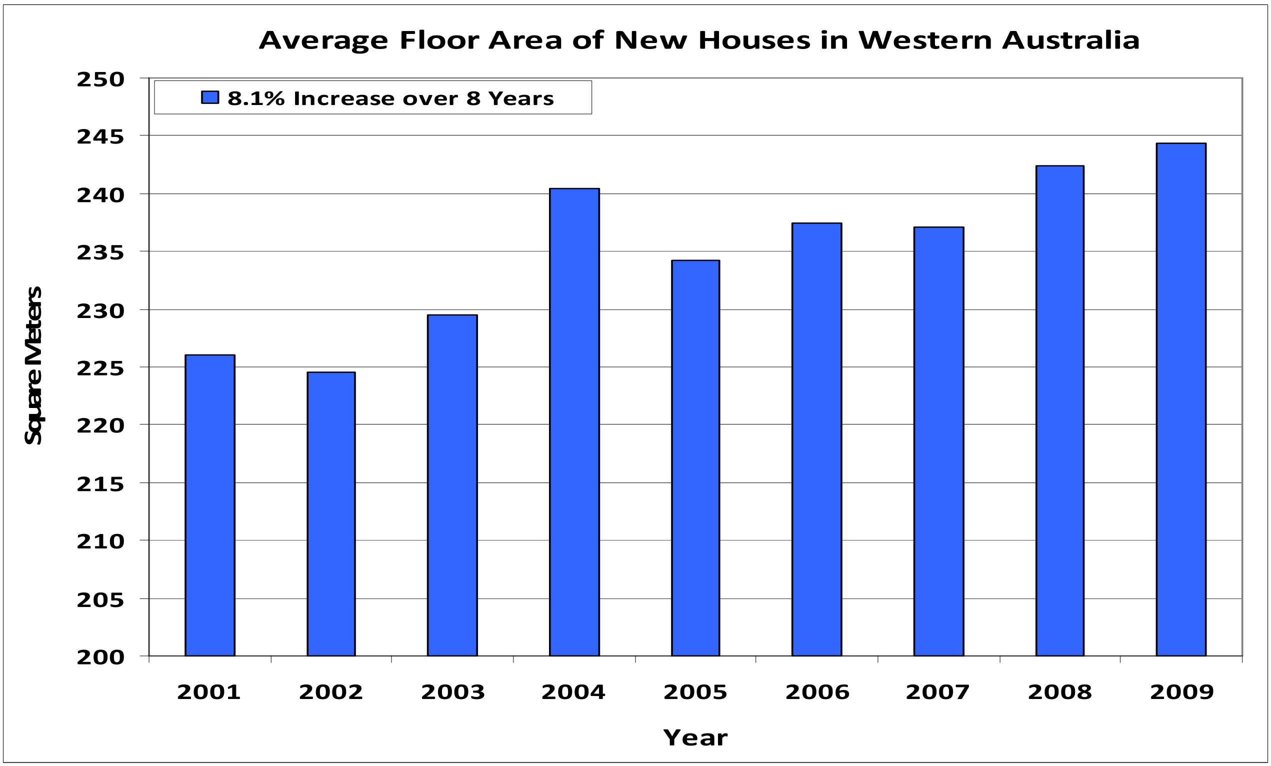

Figure 11: Average Annual Floor Area of New Houses in Western Australia

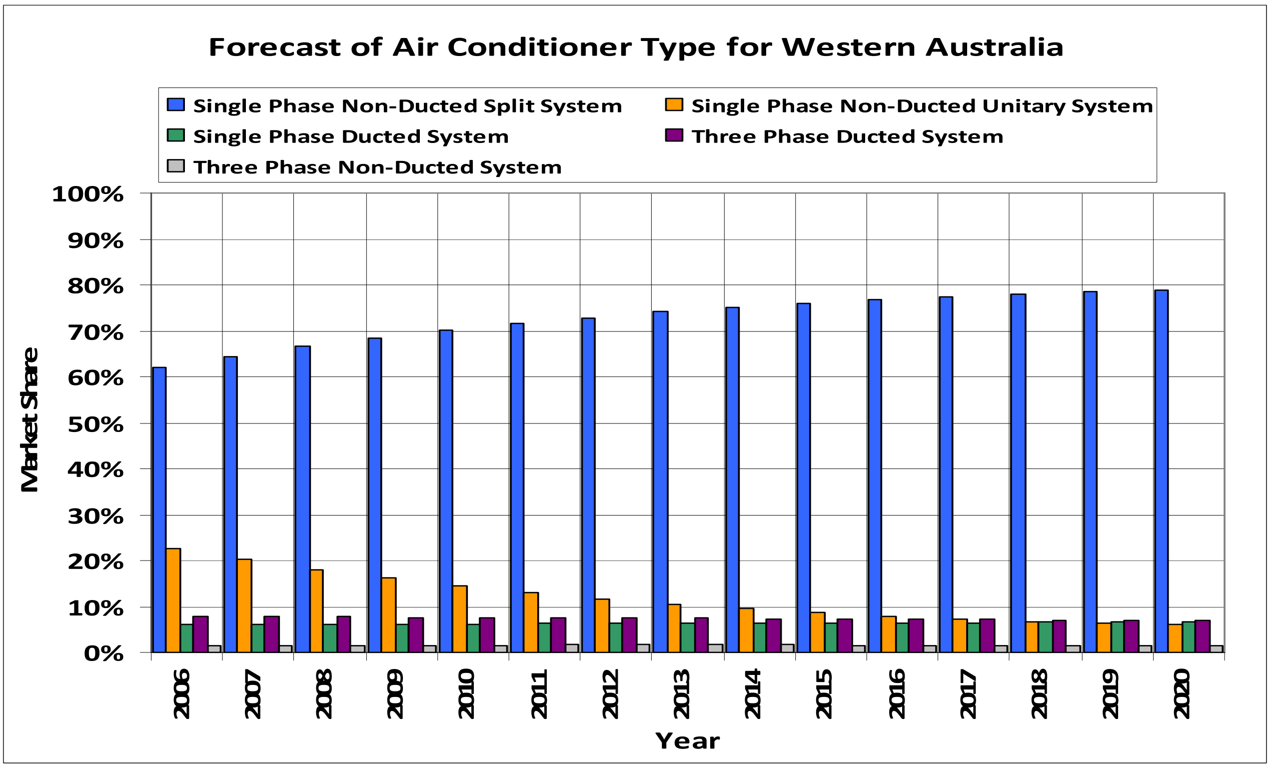

Figure 12: Forecast of Air Conditioner Type for Western Australia

Data source: Department of Climate Change and Energy Efficiency, Consultation Regulatory Impact Statement: Minimum Energy Performance Standards for Air Conditioners: 2011

2.4 Population

Population is one of the major drivers of electricity demand. Western Power therefore assessed the population forecasts from two different sources, namely Australia Bureau of Statistics (ABS) and Department of Planning Western Australia. ABS produced three population projections covering period from 2008 to 2056. Series B assumes current levels of fertility, mortality, net overseas migration and net interstate migration, whereas Series A and Series C are based on high and low assumptions for each of these variables respectively. Department of Planning produced WA Tomorrow – Population projections in 2005 for period 2004 to 2031. The forecast is based on anticipated changes to natural increase, immigration and interstate and intrastate migration. These forecasts are provided in Figure 13: Western Australia Historical and future population growth.

WA Tomorrow 2009/10 population projection forecast is significantly lower than the ABS 2008/09 historical data. The projection for the next ten years is also much more pessimistic than the ABS projections. This could be due to the fact that the projection was produced in 2005 and it did not take into account of the recent changes.

The historical growth of the population for the past 10 years is 2.14% per annum. According to the ABS central projection which is the Series B, the average growth per annum in the next 10 years is 2.10% per annum. That is, the future trend is not going to be much different from the past. Therefore it is western Power's view that no adjustment to the current SWIS peak load demand forecast is required. All of the historical variance caused by population has been accounted for using the new POE methodology.

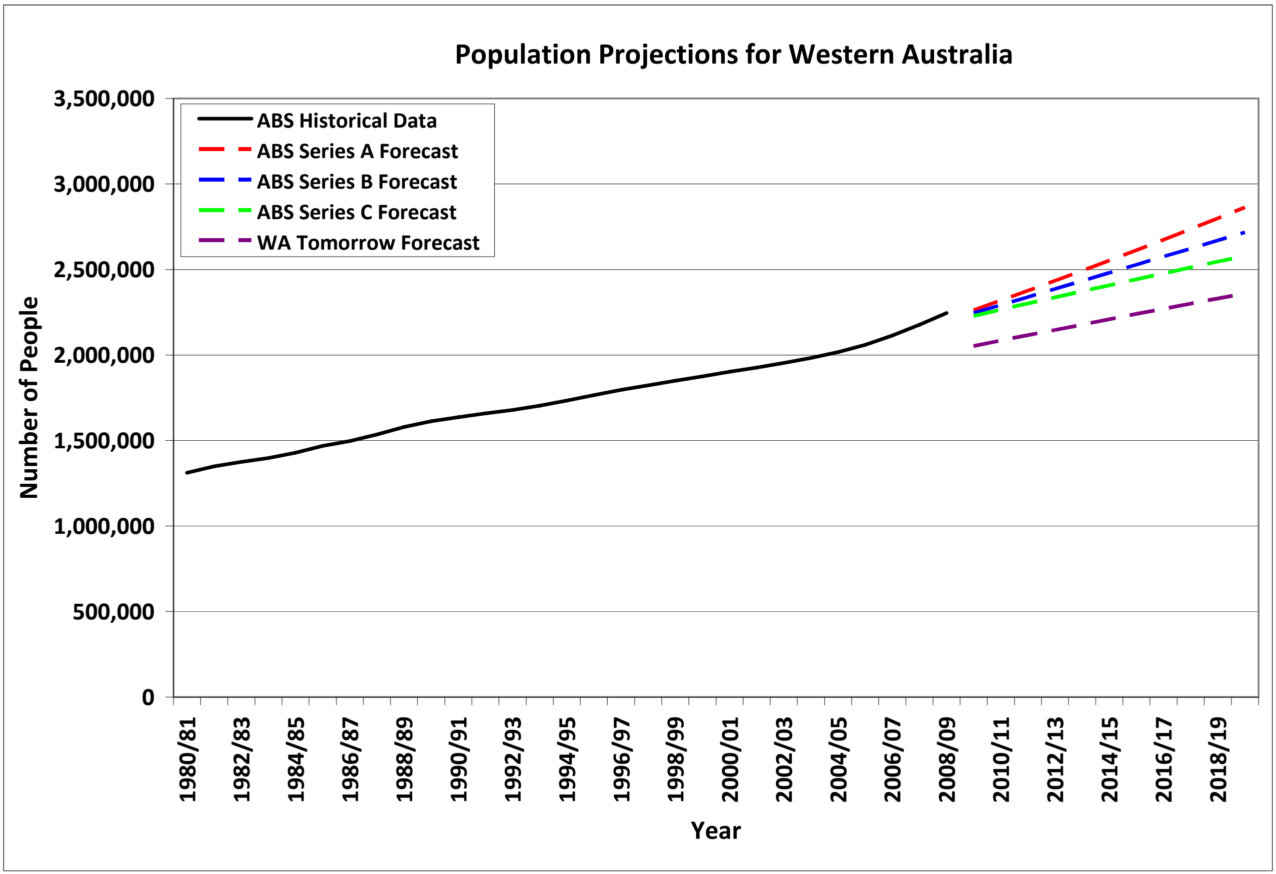

Figure 13: Western Australia Historical and future population growth

Table 5: Historical and projected average population growth

Scenario	Average Growth (Persons pa)
ABS 10 Year Historic Growth	39532
ASB Series A Future Grwoth	60055
ASB Series B Future Grwoth	47147
ASB Series C Future Grwoth	35007
WA Tomorrow Future Growth	30704

2.5 Policy interventions and CPRS

In the "Victorian Electricity Distribution Price Review", ACIL Tasman studied the impact of a number of energy efficiency policies and the Carbon Pollution Reduction Scheme (CPRS) would have on the maximum electricity demand.

The policies studied were introduced by Australian and Victorian Governments. They include Mandatory Energy Performance Standards (MEPS) for lighting and air conditioning, Standby Power, insulation target, photovoltaic's, hot water initiatives, Advanced Metering Infrastructures or smart meters.

ACIL Tasman considers the impact of the policy interventions and CPRS on the maximum electricity demand to be negligible, at least for the Victorian Regulatory Period from 2010/11 to 2015/16. ACIL Tasman recommends that the maximum load demand forecasts to disregard the impact of all of the policies and CPRS.

In Western Australia, without evidence to the contrary Western Power considers the effect of the policy intervention and CPRS to be similar to that in Victoria. The maximum electricity demand forecasts therefore do not take into account the impact of policy interventions and CPRS.

2.6 Macro Level Driver's of Demand Conclusion

This section considered some of the significant underlying drivers of maximum demand. This section focused on the historical behaviour of these underlying drivers as well as assessing their forecasted growth rates during the AA3 regulatory period. The following key drivers were investigated and assessed by Western Power.

- Gross State Product (GSP);
- Air conditioners penetration;
- Population growth;
- Policy interventions and the CPRS

All of these key driver's forecasts were obtained from a reputable and independent source, to determine if their forecasted growth rate was expected to be significantly difference from their historic growth rate. In the case, that there was a significant difference Western Power would include this difference as a manual change in the overall load demand forecast.

In all cases it was found that the future forecasts of each one of these components of maximum demand was not expected to be significantly different then their historic behavior. Therefore no adjustment to the overall load demand forecast could be justified. Additionally, since the new POE adjustment factor accounts for all the historic variance recorded in the model, any marginal increase or decrease of any one of these individual components would be accounted for.

3 IMO/NIEIR System Electrical Load Demand

The Independent Market Operator (IMO) in Western Australia publishes a Statement of Opportunities Report (SOO) on an annual basis.

The SOO provides information to current and potential participants in the Wholesale Electricity Market, relating particularly to generation investment opportunities. An integral part of the SOO is a forecast of peak demand and electricity consumption for the SWIS. Although the focus for the IMO is on the first three years of the forecast period, the included forecasts extend for ten years to 2020/21. The generation demand forecasts and gross state product forecasts, included in the SOO are prepared for the IMO by the National Institute of Economic and Industry Research (NIEIR). For the remainder of the document all forecasts will be referred to as NIEIR's forecasts.

Every year Western Power compares its bottom-up system forecast with NIEIR's to ensure that it is reasonable and sensible. In 2010, NIEIR's system forecasts are considerably higher than Western Powers (not including approximately 5% for network losses). After consultations with the IMO, the differences between the two forecasts are well understood and will be covered in Section 3.3 and 3.4. Section 3.2 provides the comparison between NIEIR's forecasts and Western Power's forecast.

3.1 Historical Forecasting Accuracy WP & NIEIR

This section examines the historical accuracy rates of both Western Power and NIEIR. Western Power obtained in the Statement of Opportunities from the IMO dating back to 2006 to determine how well NIEIR's 50 POE Summer Maximum Demand forecast with expected economic growth, predicted the actual values in the subsequence years. Additionally, Western Power undertook the same excise using forecasts produced by Western Power dating back to 2006. It should be noted that prior to 2010 Western Power forecasts were produced using an ad hoc temperature offset adjustment methodology. This offset simply adjusted the regression line to intersect the highest peak historical load on each substation. It was assumed that this peak load on each substation was cause by temperature. From 2010 onwards Western Power began using the POE variance adjustment methodology which was described in Section 1.1.4 .

It should also be noted that NIEIR forecasts Generation Load while Western Power forecasts Load Demand so a direct comparison in this Section is not available, however in Sections 3.2 - 3.4 network losses have been removed from NIEIR's forecast[6] so a direct comparison is possible.

Figure 14: Historical Western Power Forecasting Accuracy Rate and Table 6: Western Power's Historic Temperature Adjusted Forecasts vs. Actual Load Demand shows how well Western Power's forecasts in 2006 to 2009 line up against the actual values from 2007 to 2010. Table 6 further shows the average forecasting error that Western Power had in each year from its Temperature offset adjusted Central Forecast vs. the Actual Load Demand. Across all forecasting years Western Power was over forecasting on average by 191 MW.

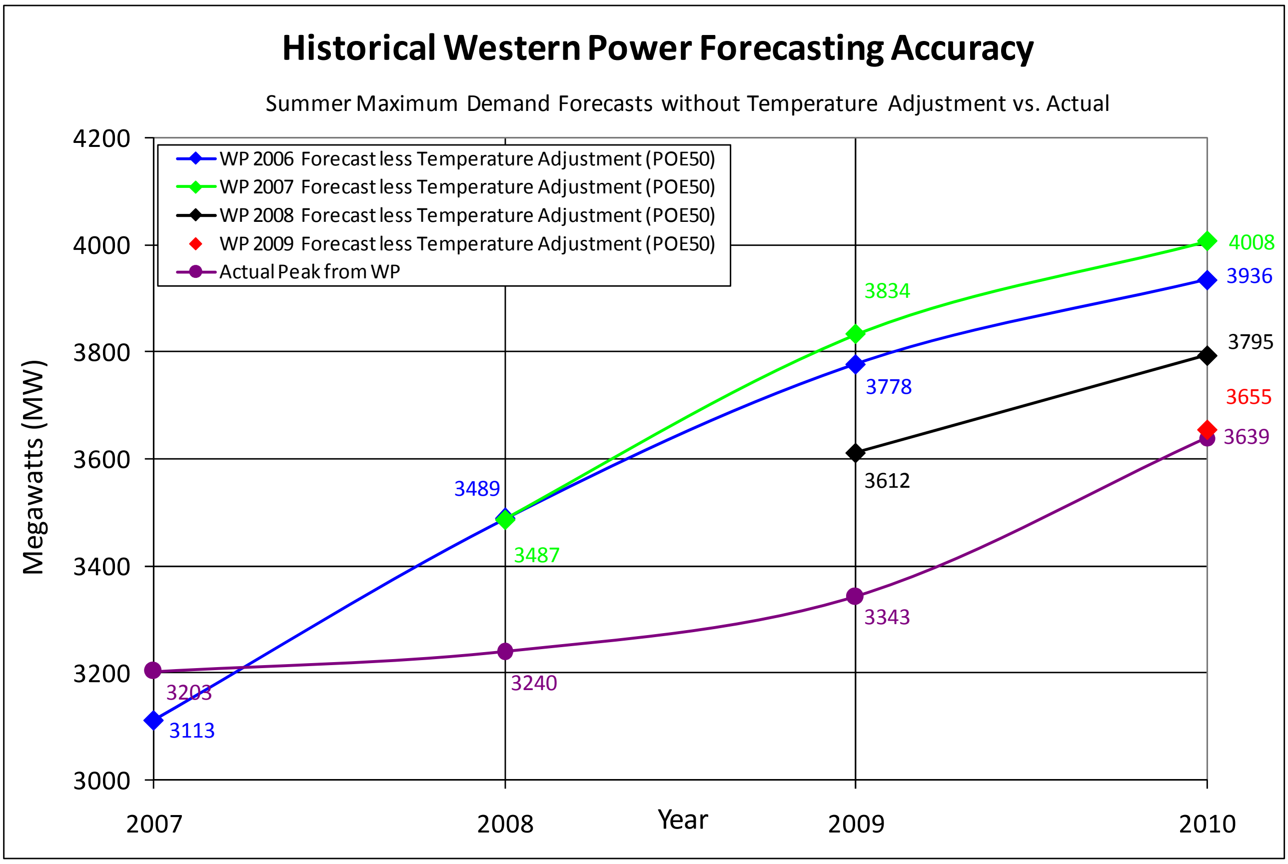

Figure 14: Historical Western Power Forecasting Accuracy Rate

Table 6: Western Power's Historic Temperature Adjusted Forecasts vs. Actual Load Demand

Western Power's Historic Temperature Adjusted Forecasts				
Year	2007	2008	2009	2010
Actual Peak Load Demand (MW)	3203	3240	3343	3639
2006 WP Forecast	3113	3489	3778	3936
2007 WP Forecast		3487	3834	4008
2008 WP Forecast			3612	3795
2009 WP Forecast				3655
Difference Forecasted - Actual				
2006 WP Forecast	-90	248	435	296
2007 WP Forecast		247	491	368
2008 WP Forecast			269	155
2009 WP Forecast				16
Average Forecasting Over Adjustment	-90	248	398	209

Figure 15: Historical NIEIR's Forecasting Accuracy Rate and Table 7: NIEIR's Historic 50 POE Expected Economic Growth Forecasts vs. Actual Generation Demand shows how well NIEIR's forecasts in 2006 to 2009 line up against the actual values from 2007 to 2010.

Table 7 further shows the average forecasting error that NIEIR had in each year from its 50 POE Expected Economic Growth Forecast vs. the Actual Generation Demand. Across all forecasting years NIEIR was over forecasting on average by 93 MW.

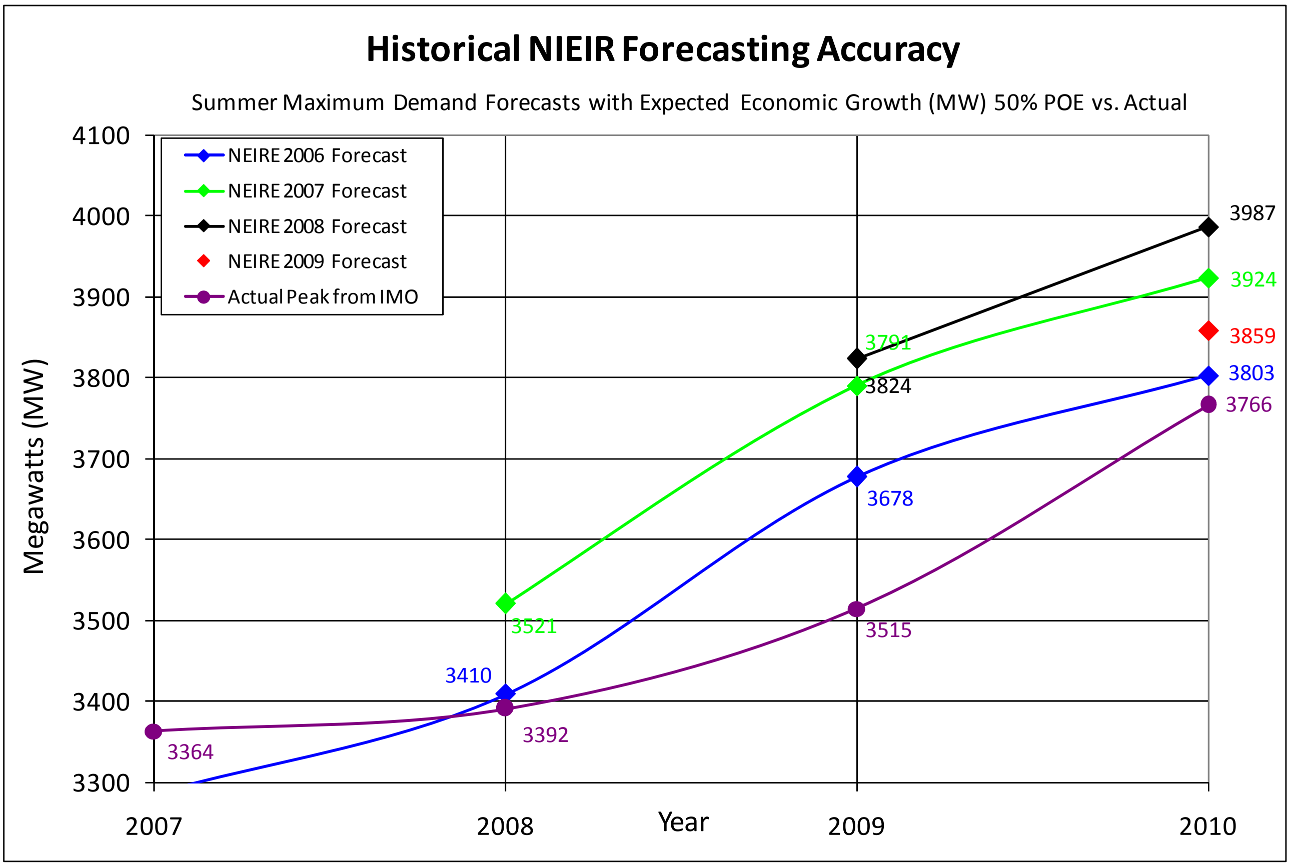

Figure 15: Historical NIEIR's Forecasting Accuracy Rate

Table 7: NIEIR's Historic 50 POE Expected Economic Growth Forecasts vs. Actual Generation Demand

NIEIR's Historic Forecasts (50 POE - Expected Economic Growth)				
Year	**2007**	**2008**	**2009**	**2010**
Actual Peak Load Demand (MW)	**3364**	**3392**	**3515**	**3766**
2006 NIEIR Forecast	**3287**	**3410**	**3678**	**3803**
2007 NIEIR Forecast		**3521**	**3791**	**3924**
2008 NIEIR Forecast			**3824**	**3987**
2009 NIEIR Forecast				**3859**
Difference Forecasted - Actual				
2006 NIEIR Forecast	**-77**	**18**	**163**	**37**
2007 NIEIR Forecast		**129**	**276**	**158**
2008 NIEIR Forecast			**309**	**221**
2009 NIEIR Forecast				**93**
Average Forecasting Over Adjustment	**-77**	**74**	**249**	**127**

It is clear from the above graphs and tables that both NIEIR and Western Power have historical been cautiously optimistic in their expectations about the amount of electricity and generation demand required within the SWIS network. As such, Western Power has decided to produce a high and central forecast which was detailed in Section 1.1.3, where Western Power includes any project not in the central forecast as contingency projects. Under this approach, capital funds would be requested if and when the projects actually proceeded. Additionally, due to the cautiously optimistic historic forecasts Western Power is more then comfortable including a 10 POE variance adjustment factor which is less then NIEIRs 10 POE temperature adjustment factor. Further details about the differences between NIEIRs 10 POE Temperature Adjustment and Western Power's 10 POE Variance Adjustment can be found in Section 3.4.

3.2 WP & NIEIR Forecast Comparison

Figure 16: Western Power and NIEIR forecasts, provides a comparison between Western Power's 10 POE High and Central Forecast and NIEIR's 10 POE Expected (Central) Economic Growth forecast minus network losses (~5%)[6]. From Figure 16 and Table 8: Comparison of WP High & Central 10 POE and NIEIR's 10 POE Expected Economic Growth Forecasts it is clear that there is a large difference between the IMO's 10 POE Expected (Central) Economic Growth forecast and Western Power's 10 POE Central Forecast, however this difference is significantly smaller when compared to Western Power's 10 POE High Forecast. After consultations with the IMO, the differences between the two forecasts are well understood and will be covered in the next sections.

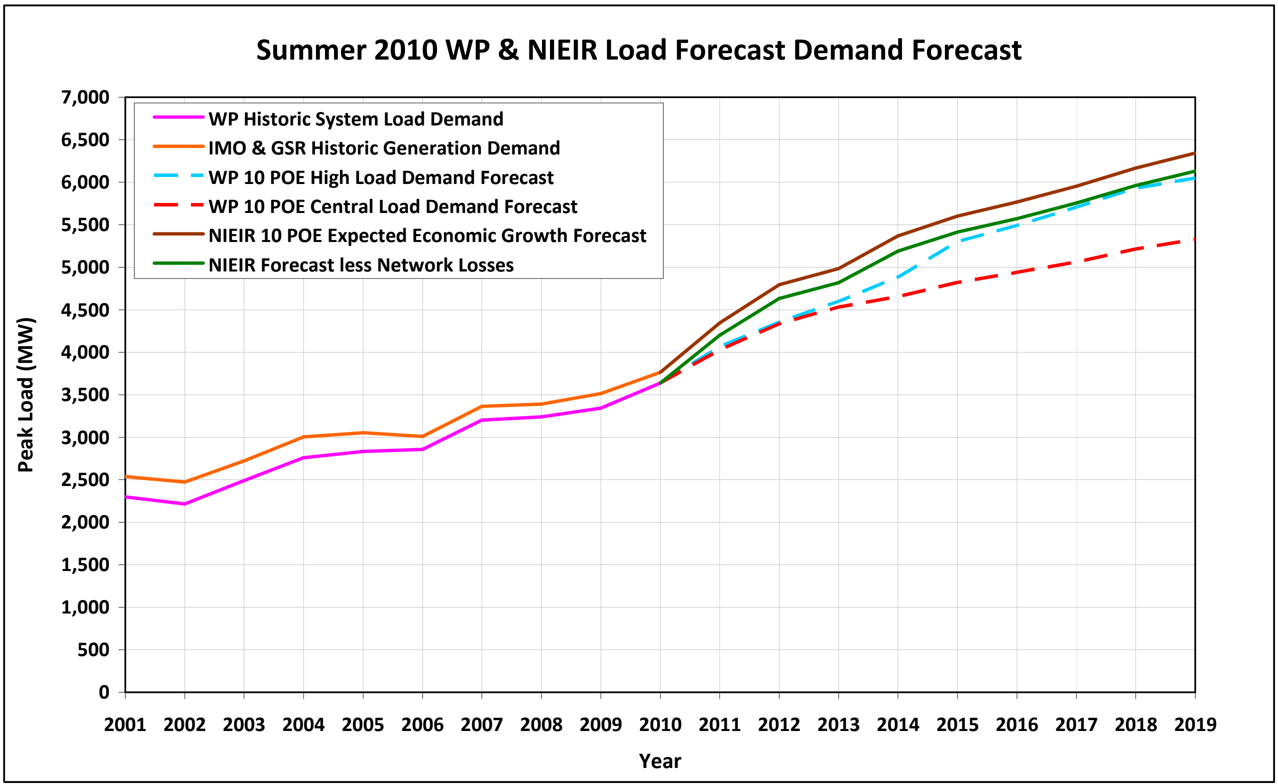

Figure 16: Western Power and NIEIR forecasts

[6] Network losses must be removed from the IMO forecast since they forecast generation demand and Western Power forecasts load demand. The difference of ~5% has shown to be the historical average losses between generation and demand.

Table 8: Comparison of WP High & Central 10 POE and NIEIR's 10 POE Expected Economic Growth Forecasts

Year	NIEIR 10 POE Expected Economic Growth Load Demand Forecast	WP 10 POE High Load Demand Forecast	WP 10 POE Central Load Demand Forecast
2010/11	4159	4065	4027
2011/12	4587	4354	4332
2012/13	4771	4598	4531
2013/14	5139	4884	4654
2014/15	5360	5302	4822
2015/16	5519	5490	4940
2016/17	5699	5705	5061
2017/18	5902	5931	5216
2018/19	6070	6048	5329

3.3 WP & NIEIR Differences between Block Load Assumptions

The first difference between NIEIR's and Western Powers forecasts are the assumptions around the timing of major development projects. An additional difference lies in the fact that Western Power uses diversified load demands while NIEIR uses non-diversified load demands. Table 9: Western Power's Assessment of Major Block Loads (Diversified) and Table 10: NIEIR's Assessment of Major Block Loads (Non-Diversified) provide a breakdown of the major projects and there expected load demand timing. From the tables it is clear that Western power has taken a more conservative approach to the probability of major new load proceeding than NIEIR. As noted above, the Western Power high growth scenario forecasts are more comparable with NIEIR's Excepted Economic growth scenario. The intention is to treat the potential loads that have not been included in the central forecast as contingency projects. Under this approach, capital funds would be requested if and when the projects actually proceeded.

Table 9: Western Power's Assessment of Major Block Loads (Diversified)

Western Powers Major Block Loads (Diversified) Projects (over 20MW)	Central Forecast Year	MW	High Forecast Year	MW
Port and Pumping facilities for Grange Resources -SDN	-	-	2015	20
Southern Seawater Desal Plant	2011	16	2011	31
Stage 1 & 2 & 3	2012	15	2016	31
	2018	31	-	-
Simcoa 3rd & 4th furnace expansion project	2012	24.3	2012	24.3
	-	-	2016	24.3
Asia Iron Ltd's. - Extension Hill Mine Site	-	-	2014	112.5
Gindalbie Stage 1.1	2012	86	2012	86
Gindalbie Stage 1.2	2013	23	2013	23
Gindalbie Stage 2.1	-	-	2014	27
Gindalbie Stage 2.2	-	-	2015	45
Gindalbie Stage 2.3	-	-	2017	45
Gindalbie Stage 2.4	-	-	2018	45
Port of Oakajee Stage 1	2014	27	2014	27
Port of Oakajee Stage 2	-	-	2018	15
Oakajee Industrial Estate Heavy (Smelter)	-	-	2017	28
	-	-	2018	30
Grange Resources mine	-	-	2015	160

Table 10: NIEIR's Assessment of Major Block Loads (Non-Diversified)

Projects	Low Year	Low MW	Central Year	Central MW	High Year	High MW
Southern Seawater Desalination Plant	2012	21	2012	21	2012	21
Stage 1 & 2 & 3	2020	44	2016	44	2016	44
	-	-	-	-	2020	67
Simcoa 3rd & 4th furnace expansion project	2011	12	2011	22	2011	22
	-	-	-	-	2019	44
Asia Iron Ltd's. - Extension Hill Mine Site	2014	100	2014	140	2014	140
Gindalbie Stage 1.1	2012	85	2012	95	2012	95
Gindalbie Stage 1.2	2014	100	2014	120	2014	120
Gindalbie Stage 2.1	-	-	-	-	2016	170
Gindalbie Stage 2.2	-	-	-	-	2017	220
Port of Oakajee Stage 1	2014	20	2014	30	2014	35
Grange Resources Mine	2015	60	2015	80	2014	80
Stage 1 & 2	-	-	-	-	2018	100

Although there are differences between NIEIR and Western Power regarding the timing and diversification of different projects, if we compare the forecasts based solely on underlying growth (50 POE) and the block loads we obtain a very similar 10 year forecast. Figure 17: Western Power and NIEIR 50 POE forecast provides a comparison between Western Powers 50 POE High & Central forecast and NIEIR's 50 POE High, Expected and Low Forecast and demonstrates the strong correlation between the two different forecasts. The principal cause of the differences between NIEIR and Western Power's forecasts comes from the methodology that we each use to adjust to a 10 POE forecast from a 50 POE forecast. This is the topic of Section 3.4

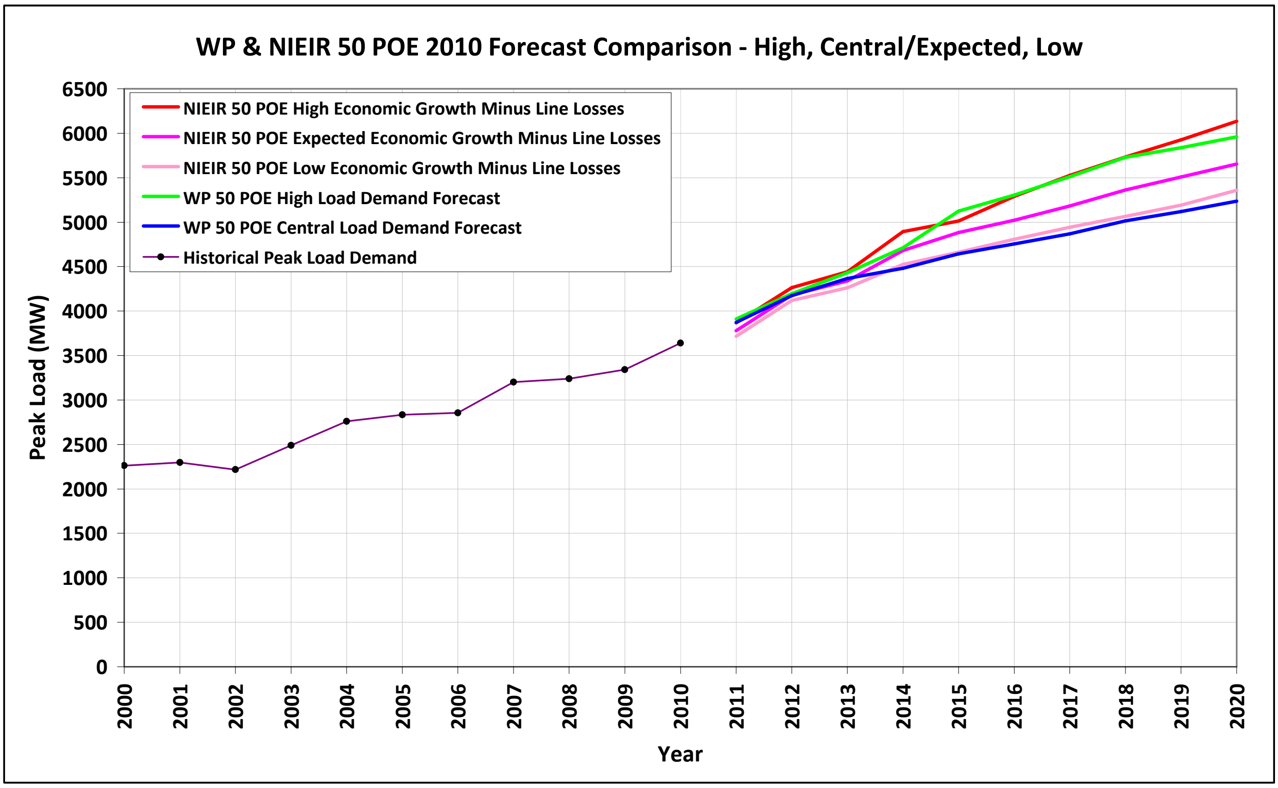

Figure 17: Western Power and NIEIR 50 POE forecast

3.4 WP & NIEIR Differences between Methodology

The most important difference between the NIEIR forecast and Western Power's forecast is the methodology used to adjust to a 10 POE forecast. Western Power's approach has been described in detail in Section 1.1.4. NIEIR uses a temperature adjustment POE approach in their methodology however at this time the exact manner in which they make this adjustment is not available.

Table 11: Western Power and NIEIR temperature adjusted forecasts provides a comparison between the POE temperature adjustment that NIEIR uses and the POE variability adjustment that Western Power uses. Figure 18: NIEIR Temperature Adjustment vs. Western Power's Variance Adjustment further demonstrates the large degree of differences between the two different methodologies. Effectively this difference in a 50 POE to a 10 POE adjustment equates to a 9.2% load demand increase using NIEIR's methodology as compared to a 3.9% increase using Western Power's methodology in the 2011 forecast year.

Additionally, as part of SKM/MMA's independent audit of Western Power's forecasting methodology SKM reviewed the 10 POE adjustment factor used by both Western Power and NIEIR. Their conclusions are as follows, "Our general conclusion based on construction of an independent temperature sensitivity model is that WPs projection understates the difference by approximately 50 MW and consequently we conclude that NIEIR overstates it by a greater amount. Lack of detail on the NIEIR approach prevents us from determining the causes of this but use of temperature sensitivity inappropriate to peak demand is the most likely factor." SKM further went on to state that, "the 50 MW difference (WP) in a base forecast of 4000 MW is considered not significant." Western Power recognizes that there are differences between out forecast and NIEIR's but are confident that our forecasts are appropriate to use for capacity expansion.

Table 11: Western Power and NIEIR temperature adjusted forecasts

Year	NIEIR 10 POE Expected Economic Growth	NIEIR 50 POE Expected Economic Growth	WP 10 POE Central Forecast	WP 50 POE Central Forecast	NIEIR Temperature Adjustment 50 POE to 10 POE	WP Variance Adjustment 50 POE to 10 POE
2010/11	4346	3979	4027	3874	367	154
2011/12	4793	4401	4332	4173	392	159
2012/13	4986	4569	4531	4366	417	165
2013/14	5370	4928	4654	4482	442	172
2014/15	5601	5140	4822	4643	461	178
2015/16	5767	5288	4940	4755	479	186
2016/17	5955	5453	5061	4867	502	193
2017/18	6168	5645	5216	5015	523	201
2018/19	6343	5799	5329	5120	544	209
2019/20	6517	5951	5454	5236	566	218

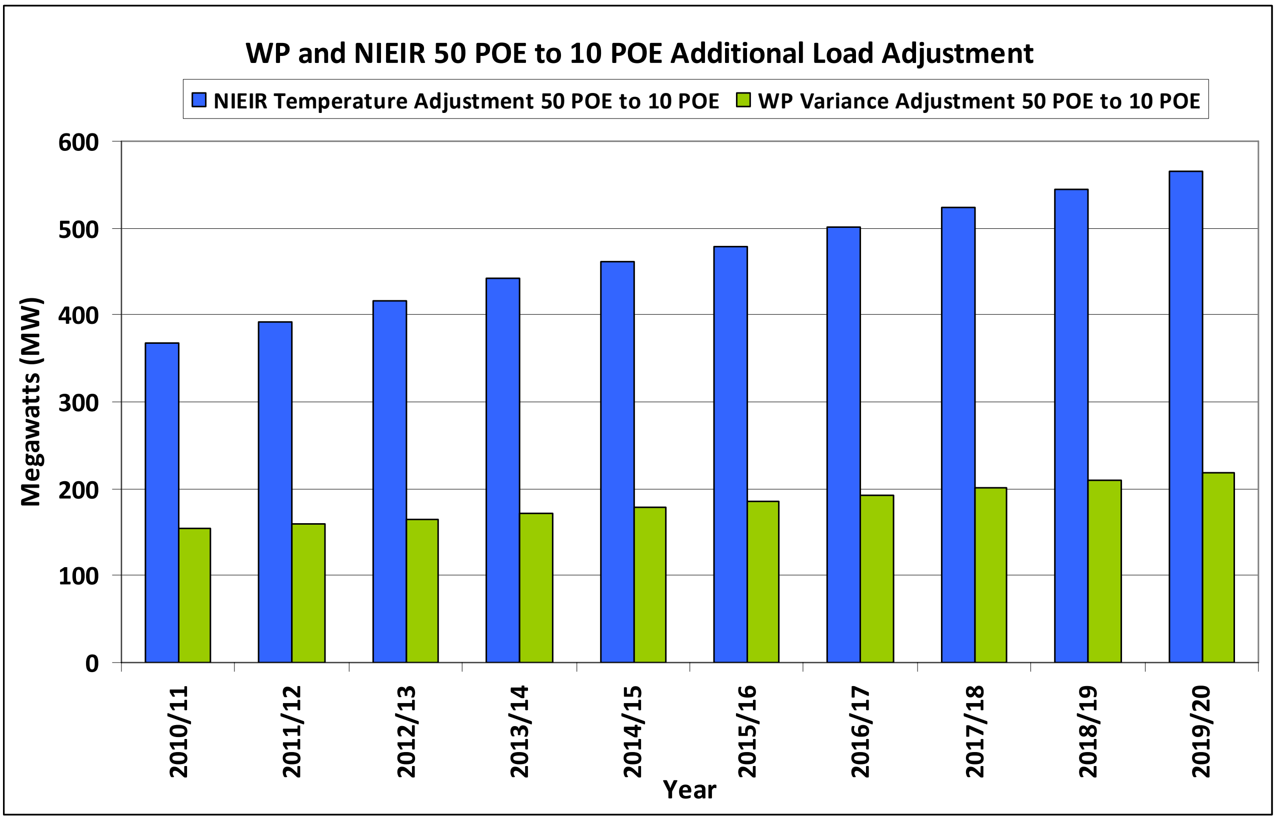

Figure 18: NIEIR Temperature Adjustment vs. Western Power's Variance Adjustment

4 SKM / MMA Review of WP's demand forecasting methodology

As part of Western Power's AA3 submission Sinclair Knight Merz was engaged to provide an independent review of Western Power's forecasting methodology. Section 4.1 presents their results and conclusions.

4.1 SKM / MMA Executive Summary

In preparation for Western Power's submission to the Economic Regulation Authority (ERA) for the proposed revisions to the access arrangement (for period AA3), Sinclair Knight Merz through its new division SKM MMA, was commissioned to provide an independent review of Western Power's demand forecasting methodology and forecasts for the electricity supply in the SWIS to assure stakeholders that the results, method and input assumptions are robust. SKM MMA's expertise in conducting network demand forecast reviews is based on staff industry experience and previous assignments that have involved reviews of forecasts prepared by almost all Australian network businesses. SKM has previously reviewed forecasts prepared by Western Power, ActewAGL, TransGrid and others. MMA has reviewed forecasts prepared by all of the network operators in New South Wales, Victoria, Queensland and South Australia; in all cases apart from Victoria on two or more occasions.

SKM MMA generally concludes that the forecasting methodology adopted by Western Power is comparable with good industry practice throughout Australia.

SKM MMA's key findings can be summarised:

- The suite of forecasting software (ForeSite) used by Western Power is perhaps the best integrated demand forecasting package that SKM MMA has reviewed;
- The process and practices used in accessing and processing input data are well established and technically sound;
- The treatment of load transfers and block loads (historical and forecast) is consistent with good industry practice;
- The calculation of trends in historic data and the forecast of future demands using regression analysis is technically sound;
- The forecasts produced by Western Power are robust and repeatable;
- Western Power does not explicitly weather correct the historic data. This is a key difference between the Western Power approach and typical industry practice; there is no evidence that this affects or biases the 50 POE demand forecasts.
- Western Power does not develop an econometric top-down demand forecast. Western Power has made a decision to utilise the IMO econometric forecast for comparison purposes;

- Western Power does prepare an alternate high economic growth scenario demand forecast but this is based on the same underlying growth trend as the base forecast, but with more optimistic assumptions regarding future block load development;
- Western Power's assessment of new block loads over the forecast period is more conservative (lower) than the IMO, resulting in a lower demand forecast than that included in the IMO's Statement of Opportunities;
- The treatment of new block loads and transmission losses account for much of the difference between the Western Power and the IMO 50 POE forecasts;
- The adjustment of the 50 POE forecast to provide a 10 POE forecast is based on a statistical analysis of the historic series and calculation of a Prediction Interval. This is another key difference between the Western Power approach and typical industry practice which normally uses temperature correction to estimate the demand under a 10 POE temperature condition. The impact of this difference is estimated to be an approximately 50 MW understatement of the 10 POE forecast which in the context of Western Power's peak demand of 4000 MW is considered not significant.

These findings are discussed in more detail in the body of this report.

SKM MMA also has some more theoretical concerns with Western Power's decision not to explicitly correct for weather on two grounds:

1) The assumption that in the historical figures any abnormal days are distributed evenly across the history – this may indeed be the current situation over recent years, but it is clear that a congregation of abnormal days can skew the trend curve – impacting 50 POE as well as 10 POE forecasts. SKM acknowledges that this has not affected the data used for the AA3 forecasts which therefore are not skewed but it could affect the approach in future;
2) The assumption that temperature dependence is reasonably constant (therefore represented in the historical series) –SKM MMA analysis suggests that the sensitivity of demand to temperature (MW/degree) appears to be changing – therefore the historic series may not capture future sensitivity. However our tests of an alternative approach that may address this proved inconclusive and in view of the small 50 MW understatement of the 10 POE forecast the alternative is not recommended.

SKM MMA believes that the methodology adopted by Western Power and the forecasts produced are technically sound, conservative and generally in line with good industry practice.

5 Appendix

Reference Document

DM # 7664662

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