Powerlink Revenue Determination 2013-17

Review of Revised Demand Forecast

Report to

Australian Energy Regulator

Public Version

Energy Market Consulting associates
NZIER

FINAL 18th April 2012

This report has been prepared to assist the Australian Energy Regulator (AER) with its determination of the appropriate revenues to be applied to the prescribed transmission services of Powerlink from 1 July 2012 to 30 June 2017. The AER's determination is conducted in accordance with its responsibilities under the National Electricity Rules (NER).

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About EMCa

Energy Market Consulting associates (EMCa) is a niche firm, established in 2002 and specialising in the policy, strategy, implementation and operation of energy markets and related access and regulatory arrangements. Its Director, Paul Sell, is an energy economist and previous Partner in Ernst & Young and Vice President of Cap Gemini Ernst & Young (now Capgemini). Paul has advised on the establishment and operation of energy markets and on matters such as electricity network open access, pricing and regulation and forecasts for over 30 years.

About NZIER

NZIER is a specialist consulting firm that uses applied economic research and analysis to provide a wide range of strategic advice to clients in the public and private sectors, throughout New Zealand and Australia, and further afield.

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NZIER was established in 1958.

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1 Introduction and background

1.1 Introduction

1. Under the National Electricity Rules, the Australian Energy Regulator (AER) is required to assess whether the revised regulatory proposal from Powerlink represents a reasonable expectation of demand for the 2013 – 2017 regulatory period. The AER asked EMCa/NZIER to conduct an assessment and to provide advice regarding Powerlink's revised demand forecast.

1.2 Background context for this report

2. In May 2011 Powerlink lodged a regulatory proposal for the 2013-17 regulatory period, which was subject to review by the AER. This proposal was based on a demand forecast of 11,877 MW by 2016/17. Based on advice from EMCa/NZIER', the AER adopted a 1,131 MW lower alternative forecast in its November 2011 Draft Decision.

3. Powerlink lodged its Revised Revenue Proposal (RRP) in January 2012, with a revised medium demand forecast ending 413 MW lower than its original forecast, but 718 MW higher than the AER's Draft Decision.

4. This report presents our assessment of Powerlink's revised demand forecast and of a revised alternative demand forecast that we propose for use by the AER in its final decision.

1.3 Our approach to this assessment

5. In conducting our assessment of Powerlink's revised demand forecast we followed a process that is similar to our 2011 demand forecast review and alternative forecast:

   a. We reviewed Powerlink's approach to the revised demand forecast, examining any differences from Powerlink's initial approach that we assessed in 2011 and taking account of any additional information provided by Powerlink;

b. We reviewed the structural nature of the demand forecasting method that Powerlink has relied on, to the extent to which this was made available to us, as well as a check model that Powerlink provided along with its RRP;

c. We conducted our own econometric analysis to test Powerlink's forecast and a range of alternative approaches, including different model forms and using independently sourced data on explanatory variables.

1.4 Our qualifications

6. Our review of Powerlink's regulatory demand forecast and this report have been prepared by Paul Sell of EMCa and David Boles de Boer of NZIER. We make the assessments in this report based on our training as economists and our experience as regulatory economists, including forecasting experience in the electricity and utilities sector.

1.5 Structure of this report

7. In section 2, we present our findings from our assessment of Powerlink's revised demand forecast, our revised alternative forecast and our recommendations for their use by AER.

8. In section 3 we describe Powerlink's revised demand forecast approach and its revised demand forecast, comparing it with Powerlink's initial demand forecast and the AER's draft decision.

9. In section 4 we provide our assessment of Powerlink's revised forecast, including our review and assessment of its revised forecast methodology, historical data and projections for input variables, together with the econometric analysis that we have used both in assessing Powerlink's forecast and in determining an alternative demand forecast.

10. In section 5 we present a revised alternative demand forecast that supersedes the alternative demand forecast that we provided in 2011. We have prepared this forecast following our consideration of matters raised by Powerlink in its RRP response to the draft decision, and taking account of up-to-date information.

2 Key findings and overall assessment

2.1 Headline findings

11. We consider that Powerlink's revised demand forecasts for the 2013-17 regulatory period are not reasonable and should not be accepted as the basis for determining Powerlink's capex requirements. The main reasons why we have formed this view are as follows:

a. We consider that Powerlink's revised forecast suffers from the same deficiencies of approach that we described in our 6th September 2011 report, and which have led to previous overstated forecasts for many years[1]. It is based on what is essentially the same process, the same methodologies, updated but similarly-derived assumptions and the same parties assisting and producing the majority of the content of the forecast;

b. We consider that the specification of the Powerlink check model in terms of energy (GWh) rather than peak demand (MW), the lack of a temperature correction, and the use of an exogenous load factor projection are significant weaknesses when compared with a model specification that forecasts peak demand directly;

c. The historical input variables data used by Powerlink (i.e. the GSP and electricity prices series) are from third-party sources, their derivation cannot be independently verified and the price series does not correlate well with official sources;

d. The projections of inputs to Powerlink's check model appear to be towards the upper end of an accepted range for these projections and they differ from those used by Powerlink's advisor, NIEIR, in producing the forecast that Powerlink has relied on for its proposed RRP demand forecast.

[1] Ibid, page 15, figure 6

12. Each of these factors contributes to a demand forecast that we consider to be unreasonably high.

13. We continue to have concerns with the process whereby Powerlink relies on an external party whose model, input data and the specific projections used to provide the forecast are not available for scrutiny by any party, including Powerlink itself. We note that the RRP forecast has a lower starting point and a significantly higher growth rate than the DNSPs' most recent connection point forecast, which Powerlink has pro-rated to match the NIEIR forecast.

14. We consider that the application of the "10% PoE" adjustment by Powerlink is satisfactory, though towards the upper end of what we consider reasonable. We also consider the use of GSP and price as key forecasting model determinants to be reasonable, as is the use of average temperature as an explanatory variable for maximum demand.

2.2 Revised alternative forecast

2.2.1 Basis for our revised alternative forecast

15. The AER asked EMCa/NZIER to update the alternative forecast that we provided in 2011, and in doing so to consider matters raised by Powerlink in its RRP.

16. For the update we developed a Queensland state forecasting model for underlying load[2] that uses GSP, price and temperature as explanatory variables to directly forecast peak demand in MW. It uses publically-available official historical series for GSP and electricity price and uses peak demand and temperature data supplied by Powerlink. The model provides a good back-cast fit to historical peak demand data[3].

17. For input projections we use the most up-to-date GSP forecast from the Queensland Treasury (January 2012), retail price rates of increase that we derived in 2011 and average projected temperatures from Powerlink's historical data. The GSP projections we use are effectively an update on those used by ACIL Tasman in its December 2011 advice to Powerlink, while the retail price growth rate that we derived for the period is similar to that presented by NIEIR in its 2011 demand forecast update report to Powerlink.

18. We add Powerlink's forecasts of demands for its major customers to our forecast for underlying (DNSP) demand, in the same way that Powerlink combines such forecasts with NIEIR's forecast for underlying DNSP demand.

19. We have used average daily temperatures on peak demand days as one of our regression variables, as proposed by Powerlink, and we have determined the 10% PoE forecast using the same relative adjustment as Powerlink.

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[2] i.e. excluding major direct customers

[3] See figure 1

2.2.2 The revised alternative forecast

20. Our 50% PoE revised alternative forecast is 22 MW higher in 2016/17 than the alternative forecast that we advised in 2011 but tracks considerably lower in the early years, reflecting continuing current flat demand, low short-term economic growth and the impact of retail electricity price increases. Regardless, our forecast is still above what appears to be the peak demand for the 2011/12 summer[4]. Our 10%PoE revised alternative forecast, which is used for capex budgeting purposes, is 737 MW lower than Powerlink's "medium" RRP forecast by 2016/17 and this is 46 MW below Powerlink's "low" RRP forecast for this period.

Table 1: EMCa/NZIER medium alternative forecast (2011) and revised medium alternative forecast (2012)

MW

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Alt forecast 50% PoE (2011)	8,841	9,259	9,711	10,161	10,537	10,746
Revised Alt Forecast 50% PoE	**8,447**	**8,869**	**9,421**	**9,862**	**10,425**	**10,768**
Revised Alt Forcastl 10% PoE	8,867	9,306	9,871	10,326	10,905	11,262

Source: EMCa/NZIER

Table 2: Proposed adjustments to Powerlink revised demand forecast (2012)

MW

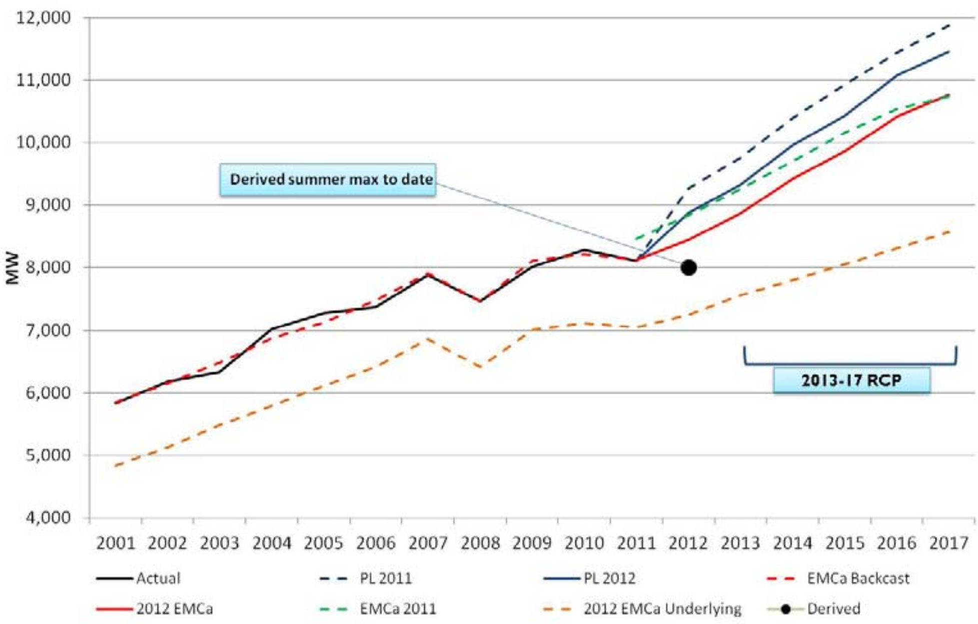
	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Reg Proposal 50% PoE (2011)	439	506	689	769	910	1,131
Revised Proposal 50% PoE	430	462	541	572	660	696
Revised Proposal 10% PoE	455	489	572	605	698	737

Source: EMCa/NZIER

21. The revised alternative forecast is shown on the following graph, and compared with Powerlink's RRP forecast, EMCa/NZIER's 2011 alternative forecast and Powerlink's initial RP forecast. The model back-cast is compared with actual demand and underlying (DNSP) load is shown separately from aggregate demand (which includes major direct customers).

[4] We have derived a provisional figure based on data provided by Powerlink in response to an information request

Figure 1: Powerlink medium demand forecast - Native MW, 50% PoE - 2012



Source: EMCa/NZIER, and including comparison data from Powerlink

2.2.3 Comparison of forecasts

22. The following table summarises demand forecasts for 2016/2017, comprising Powerlink's initial forecast, the forecast adopted by the AER for its Draft Decision, Powerlink's Revised Forecast and the Revised Alternative Forecast that we now propose.

Table 3: Demand forecasts for Powerlink 2012/13 – 2016/17 (MW)

MW

	2016/17
Powerlink Reg Proposal 50% PoE (2011)	11,877
AER Draft Dtermination (2011)	10,746
Powerlink Revised Proposal 50% PoE	11,464
NZIER Revised Alternative Forecast 50% PoE	10,768

Source: EMCa/NZIER

2.3 Our opinion

23. We consider that the demand forecast that is presented by Powerlink in its Revised Revenue Proposal is not a reasonable forecast and we recommend that AER not accept it as a basis for determining a capex allowance in Powerlink's revenue determination.

24. We recommend that the AER adopts the revised alternative forecast that we propose in section 2.2.2. Specifically we recommend that our revised alternative forecast for a medium scenario at 10%PoE temperature (as shown in table 1) should be used in place of Powerlink's medium forecast at 10% PoE, and that any other forecasts used for planning forecasts should be similarly adjusted.

3 Powerlink's revised demand forecast

3.1 Introduction

25. In this section we describe Powerlink's forecasting process and methodology, and the revised demand forecast provided in its RRP. To the extent that Powerlink's forecasting process is the same as in its initial RP (which is largely the case), the description of that methodology is not duplicated here.

3.2 Powerlink's forecast process and methodology

26. As with its original revenue proposal, Powerlink has relied on a demand forecast provided by NIEIR for its overall state-wide forecast for underlying (DNSP) demand. Powerlink has adjusted connection point forecasts provided to it by DNSPs, on a pro-rata basis, to match NIEIR's state-wide coincident forecast for such demand. Powerlink has then added its own forecasts for its main direct-connect customers, to produce an aggregate peak demand forecast.

27. This process appears to be the same as Powerlink used in developing its initial RP demand forecast. The NIEIR process used to determine its updated forecast also appears to be materially as we described in our 2011 Review.

28. In its RRP Powerlink also provided the AER with a check model and accompanying data that was used to calibrate this model[5]. The model shows a methodology based on forecasting energy consumption (GWh) from historical consumption, using

[5] Powerlink has claimed confidentiality for this model

wholesale price and GSP as explanatory variables in a regression model. The energy forecast produced by this model is then converted to peak demand using an assumed load factor relationship between energy consumption (GWh) and peak demand (MW), with the load factor being a Powerlink projection. The final adjustment is for assumed increases in distributed generation from solar photovoltaic sources.

29. We have confirmed that no temperature correction is made in this check model.

30. The Powerlink check model, is shown below[6]:

[C-I-C]

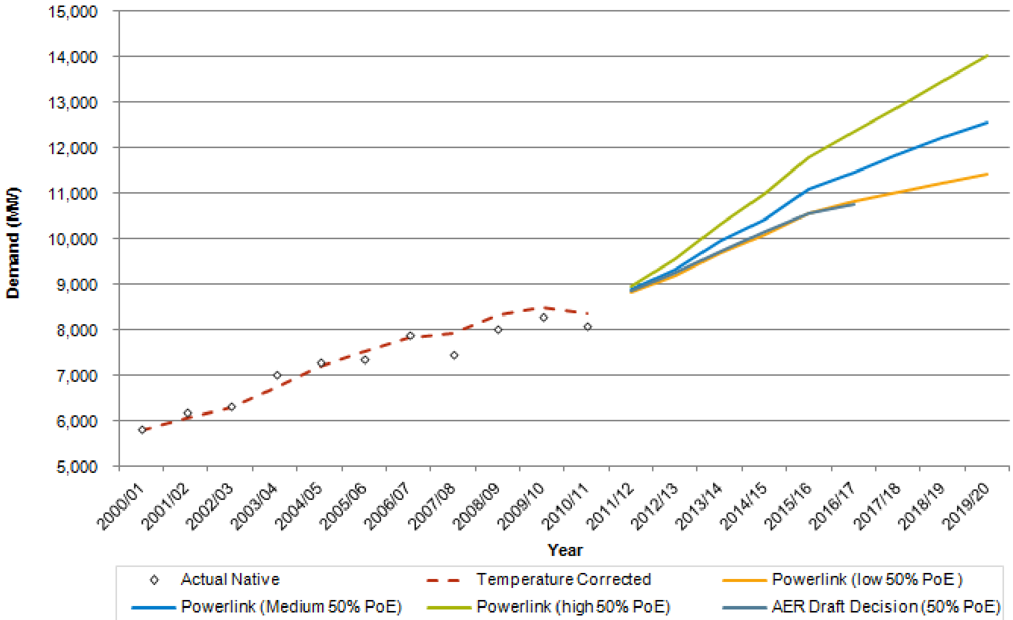
31. The forecast of 2016/17 underlying DNSP peak demand from the check model is 90 MW less than that derived from the updated NIEIR demand forecast that Powerlink has relied on in its RRP.

3.3 Powerlink's proposed forecast

32. Powerlink presents its revised peak demand forecast for the 2013-17 RCP (as per its Revised Revenue Proposal) as shown in figure 2 and in tables 4 and 5. Powerlink's revised demand forecast (at 50% PoE) is 413 MW lower than its original 2011 forecast, but 718 MW higher than the AER's 2011 Draft Decision.

[6] Extracted from RRP page 67 (redacted in public version)

Figure 2 : Powerlink revised demand forecast 2012



Source: Revised Revenue Proposal, Powerlink (Figure 6.12, pg 80)

Table 4: Powerlink demand forecast (low, medium and high growth at 50% PoE)

MW

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Revised Proposal High	8,960	9,539	10,314	10,973	11,777	12,344
Revised Proposal Medium	8,877	9,331	9,962	10,434	11,085	11,464
Revised Proposal Low	8,826	9,186	9,689	10,072	10,566	10,810

Source: EMCa/NZIER (from Powerlink data in 2010 APR)

33. For capex planning purposes, Powerlink uses a higher set of forecasts which is based on the above forecast but with a 10% temperature PoE. At 11,999 MW, Powerlink's 10% PoE medium forecast is 438 MW less than its initial RP forecast but 853 MW higher than the AER's draft decision.

Table 5: Powerlink revised forecast (med growth) at 10% and 50% PoE and comparison with initial regulatory proposal

MW

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Reg Proposal 50% PoE (2011)	9,280	9,765	10,400	10,930	11,447	11,877
Revised Proposal 50% PoE	8,877	9,331	9,962	10,434	11,085	11,464
Revised Proposal 10% PoE	9,322	9,795	10,443	10,931	11,603	11,999

Source: EMCa/NZIER (from Powerlink data RRP, NIEIR Update)

4 Assessment of Powerlink's revised forecast

4.1 Introduction

34. We have assessed Powerlink's revised forecast by assessing its forecasting process, methodology, modelling and assumptions.

35. As is described in the previous section, Powerlink's overall forecasting process and methodology is essentially as we reviewed in 2011. We have reviewed our previous findings in the light of the response in Powerlink's RRP and we remain of the view that there are deficiencies in its forecasting process and methodologies that are detracting from its ability to provide reasonable demand forecasts[7]. This aspect of our review is not repeated here, however in Annex 3 we have responded to some general issues raised by Powerlink and some of these relate to its forecasting process and methodology.

36. In section 4.2 we describe our assessment of Powerlink's revised demand forecast. We first sought to assess the changes that Powerlink had made from its initial RP demand forecast to the RRP revised demand forecast. The remainder of this assessment follows a similar pattern to our previous assessment, examining the methodology, modelling and input assumptions that Powerlink has used.

37. Since we tested a range of sensitivities in forming our alternative forecast, we also tested the sensitivity of Powerlink's check model to changes in assumptions for the projected values of its inputs (that is, GSP, price and projected load factor). These sensitivities are reported in section 4.3. We used our own modelling as part of the assessment of the Powerlink model, therefore there are some aspects of this review

[7] See sections 4.2, 4.3, 4.4 and 4.5 of our 2011 Review

that refer to the alternative forecast presented in section 5. It is important to note, however, that we did not produce an alternative forecast before assessing Powerlink's forecast. Rather, our review of the reasonableness of Powerlink's forecast draws on the same wide exploration of the influence of and reasonableness of model forms and data series that we also used in determining our alternative forecast.

38. Section 4.4 presents our assessment of Powerlink's 10% PoE adjustment and in section 4.5 we present the findings for our assessment of the reasonableness of Powerlink's forecast, which we make based on our assessment of each of the contributing factors presented in this section 4.

4.2 Assessment of Powerlink's RRP forecast

4.2.1 Methodology for assessment

39. In the first instance, we sought to review the changes that Powerlink has made in updating its demand forecast since its initial RP (i.e., reduced by 413 MW), and the reasons for those changes. We describe this assessment in section 4.2.2 (though it was limited by a lack of information).

40. Powerlink distinguishes between demands by major customers and the underlying demand from Queensland households and commercial premises. We reviewed this split and the data used for the respective components of its forecast as described in section 4.2.3.

41. As part of the RRP Powerlink provided an internally produced "check model" for its forecast of underlying demand (i.e. excluding demands for major customers). While noting that the check model uses different input assumptions and produces a different (lower) forecast than the NIEIR forecast that Powerlink has relied on in its RRP, this check model nevertheless provided us with a transparent model form and a set of variables that were capable of review. At our meeting with Powerlink on 15th March, Powerlink acknowledged that our assessment of its demand forecast should be carried out by reference to this check model, for reasons of transparency.

42. Our review of this check model, including our review of input variables and input projections, is described in sections 4.2.4, 4.2.5 and 4.2.6. In brief, we conducted our assessment by:

a. Examining and assessing the reasonableness of the form of the underlying model – that is, its structure and the choice of input variables;

b. Examining and assessing the historical data series used to calibrate the model; and

c. Assessing the projections for these series that were used to determine the load forecast.

43. In its RRP Powerlink drew attention to the fact that the EMCa/NZIER alternative demand forecast was determined using a top-down approach, whereas Powerlink's forecasts were also informed by DNSPs' forecasts for individual connection points. For the RRP assessment we were provided with the DNSPs' connection point forecasts and Powerlink's reconciliation of these, adjusting for coincidence and to reconcile to its top-down NIEIR forecast. We comment on our review of this part of Powerlink's methodology in section 4.2.7.

4.2.2 Assessment of changes to Powerlink's forecast

44. On page 51 of its revised revenue proposal, Powerlink describes its forecasting process:

> *"Powerlink has adopted a revised demand forecast to take into account the latest information available from the National … (NIEIR)… , in particular the use of the latest economic outlooks for Queensland and the recent commitment of additional new customers connecting directly to Powerlink's network".*

45. These revisions resulted in a forecast demand reduction of 413 MW in 2017 compared to Powerlink's 2011 revenue proposal[8]. To determine why the forecast had reduced, we asked Powerlink (as in 2011) to provide the NIEIR model form and associated input data, as well as a breakdown of the underlying demand separate from the individual major loads.

46. We were provided with the individual major load and detailed connection point components of the forecast, which allowed us to reconcile the "underlying" and "major load" components of the historical series and of the forecast. This also confirmed that the "underlying" component of the forecast is determined directly from NIEIR's advice – it is NIEIR's forecast.

47. However Powerlink reiterated that it was unable to provide the NIEIR model form; that is, to identify the specific input variables used by NIEIR and how they are mathematically combined to produce the demand forecast. Without this, the way in which the large volume of data presented in NIEIR's report is used, is not transparent and therefore its role in the demand forecast is unknown. Commentary on this data is therefore of limited use and cannot be used to inform conclusions on the NIEIR forecasts. It appears that the NIEIR model form and specific data inputs have not been provided for review by any other party, including Powerlink itself.

48. As an observation, the GSP projection in NIEIR's updated forecast is higher than the projections reported in its 2010 report[9]. Taken in isolation, this would tend to suggest that NIEIR's demand forecast should be greater than that used in Powerlink's RP. However it appears that other factors have driven the lower demand forecast now provided.

49. We also note that in its forecast NIEIR now includes an increasing level of load that is provided by photovoltaic systems (i.e. solar PV) and Powerlink has allowed for this impact in its check model. We have taken NIEIR's projection for PV into account in our assessment of Powerlink's demand forecast and have used this projection and its associated adjustment to demand, in producing our alternative forecast.

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[8] The reduction of 413 MW is for the medium scenario at 50% PoE in 2017, compared to the 2011 regulatory proposal of the same scenario.

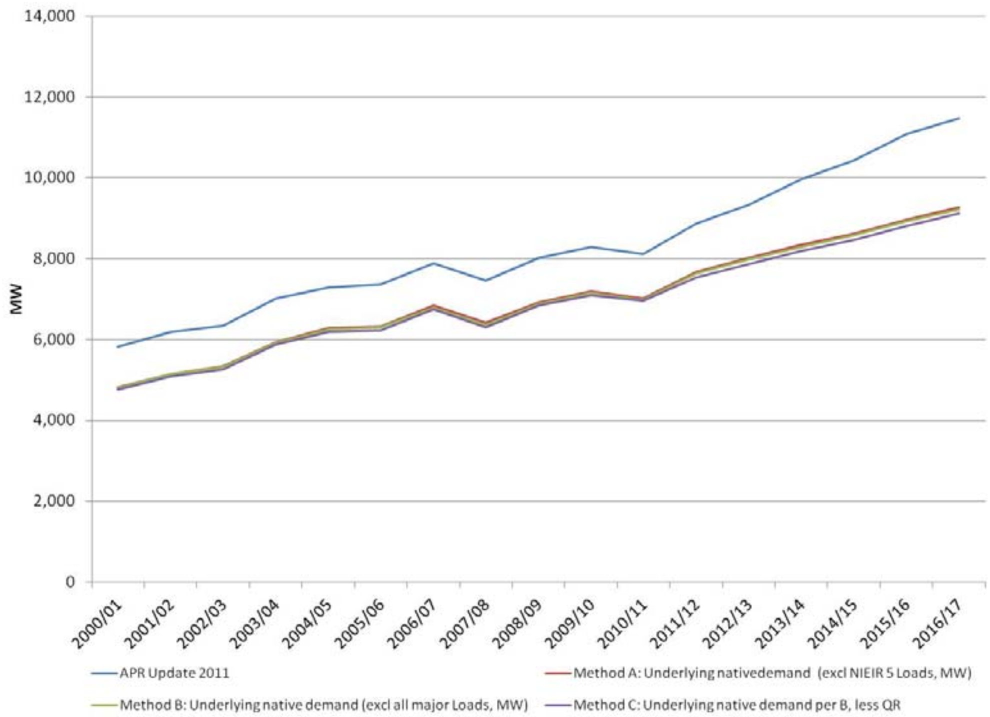
[9] NIEIR did not report on their price forecast in their 2010 advice to Powerlink.

4.2.3 Approaches to forecasting demand for major customers and for underlying demand

50. We agree with the approach whereby Powerlink uses a forecast of underlying demand for DNSP loads, to which it adds its own forecast of demand from large direct connected industrial customers. We also endorse Powerlink's development and presentation of a transparent and simple "check model" to independently forecast underlying DNSP demand[10].

51. Powerlink's historical data and forecasts for the two components comprising "underlying" demand and "major customer" demand are shown in figure 3.

Figure 3: Powerlink revised demand forecast 2012 – Underlying demand and major customer demand



Source: EMCa from Powerlink data.

52. We had slight concerns with the 2011 application of this process in that we were unable to confirm that the historical definitions of "underlying" demand and "major loads" were entirely consistent with the forecasting process in which specific major load forecasts were provided to us to be "added back". We were unable at that time to discount the possibility of some double counting. Extensive historical data supplied with the revised proposal, and from subsequent information requests, enabled our

[10] We have concerns about using input projections in this model that differ from those used by NIER, and which we cover in section 4.2.6.

reconciliation of Powerlink DNSP historical connection point demand data with our top down derived underlying demand (native demand less major industrials) and allowed us to apply different definitions of “major industrial” load to estimate the materiality of potential double-counting[11].

53. In this process we found a slight discrepancy in data provided by Powerlink for 2005/06, though we don’t consider this to be material. We also found some slight discrepancies compared with the calculations we had conducted in 2011. We corrected these but again their effect is small.

54. In our 2011 assessment, our review of the process whereby Powerlink forecasts its major loads led us to the view that this component of its forecasts is reasonable. Powerlink has used the same process for its RRP, and has updated its forecasts to take account of more recent information for these loads. We remain satisfied with this process and we consider that this component of Powerlink’s forecast is reasonable.

4.2.4 Underlying demand – Assessment of model form

Powerlink check model

55. As previously noted, Powerlink’s check model was provided to us and we were invited to form our view of reasonableness of Powerlink’s forecasts on the basis of our assessment of this check model, the associated historical and projected input variables and the resulting forecast. Powerlink provided us with the model in an Excel workbook, which contained the associated data.

56. Powerlink’s check model is shown mathematically in section 3.2. This model first forecasts Queensland energy consumption (GWh) from historical data on energy consumption, regressed against GSP and electricity prices. Powerlink then converts the resulting energy forecast into a peak demand forecast (MW), using an assumed future load factor.

57. Powerlink used (and provided) an historical GSP series and associated projection from Deloitte Access Economics, and a historical electricity price series (and associated projection) from KPMG. Powerlink used its own projection of future annual load factor.

58. Powerlink’s check model as provided produces a 2016/17 medium forecast for underlying load of 9,184 MW, which is 90 MW less than the NIEIR forecast of 9,274 MW for the equivalent component load that Powerlink has used in its RRP forecast.

Assessment of the impact of Powerlink’s model form on its forecast

59. For our initial assessment of the impact of Powerlink’s model form on the resulting forecast, we prepared two “direct” peak demand test models using the same historical GSP and electricity price data that Powerlink used in its check model. In one of these

[11] Powerlink’s definition varies slightly from NIEIR’s definition; however this is recognised by Powerlink, which adjusts its forecast accordingly. Another slightly different definition of “major load” data was provided to us in 2011. The different definitions that can be applied are shown in figure 3.

test models we added peak day temperature as an explanatory variable and in the other we used Powerlink's historical and projected load factor as an explanatory variable[12].

60. Using the load factor conversion, Powerlink's check model provides the following peak demand forecast, compared to forecasting peak demand directly using a temperature variable or a load factor variable.

Table 6: Comparisons on model form (for underlying demand) – Powerlink energy check model (energy basis) and direct peak demand test model

MW

	GSP	Price	Variable	2016/17
PL Check Model (Gwh)	Deloitte	KPMG	Load factor	9,184
Direct peak demand test model (MW)	Deloitte	KPMG	Temperature	9,328
Direct peak demand test model (MW)	Deloitte	KPMG	Load factor	9,277

Source: Powerlink, Deloitte, KPMG

61. The effect of each approach on 2017 demand MW is small which suggests to us that the mechanics of the energy to demand conversion process may produce a reasonable result for a given set of input variables.

62. In the table below we first use a different set of input projections (for GSP and price) to show the impact of these projections alone on the demand forecast.

63. We then developed a recalibrated version of the Powerlink form of the model, using ABS historical data for GSP and Queensland price as the explanatory variables in calibrating the model. The form of this model is in both cases the same as Powerlink's model and the input projections for GSP and price are as on the first line of the table.

64. The result of using the different input projections is to reduce the demand forecast from 9,184 MW to 8,799 MW, a decrease of 385 MW. However recalibrating the model parameters using official ABS historical series leads to a decrease of a further 230 MW in the forecast demand.

[12] We used the actual load factor and not the temperature-corrected load factor, since year-on-year variations in load factor reflect variations in peak demand, and peak demand is considered by Powerlink and by ourselves to be largely temperature-driven. Our review of Powerlinks temperature based adjustments to the load factor can be seen in table 9 and Annex 2.

Table 7: Powerlink check model for underlying demand – recalibrated and with alternative input projections

MW

	GSP	Price	Variable	2016/17
PL Check model with alternative input projections	Deloitte/QLD T	KPMG/EMCA	Load factor	8,799
Recalibration of PL Check Model (Gwh)	ABS/QLD	ABS/EMCa	PL Load factor	8,569
Direct peak demand test model (MW)	ABS/QLD	ABS/EMCa	Temperature	8,578

Source: Powerlink

65. The demand forecast with the recalibrated version of Powerlink's check model is similar to the result of 8,578MW that we obtain from our revised alternative model (presented in section 5), which is calibrated and projected using this same data (i.e. ABS/Qld Treasury for GSP and ABS/EMCa forecast for price indexing).[13]

Literature on peak demand forecasting models

66. There is considerable literature on high level forecasting models of electricity demand concerning both forecasting process and the modelling approaches that can be employed. We are aware that other TNSPs in Australia use a similar approach to Powerlink but we hold the view that a more robust forecast should result from forecasting peak demand directly from explanatory variables. We refer to recent work by Professor Rob Hyndman and others in support of our view.

67. Hyndman reviewed Transpower's demand forecasting methods in 2011 and expressed the views that

> *".. if the half hourly national demand data is available, then why not model it directly. There are several well developed models for modelling half hourly demand directly"*[14]

68. In that same report Hyndman also expresses concern regarding the absence of weather based covariates in the Transpower forecasting,

> *"In many parts of the world temperature variation is the biggest contributor to variation in electricity demand"*

69. Another recent work by Rob Hyndman was the methodology for long term forecasting that was published in a 2009 paper he wrote with Shu Fan. That work describes an approach to directly modelling peak demand from both annual and half hourly data, using a range of demographic, economic and metrological related variables[15].

[13] For internal consistency reasons the regression model must be calibrated with the historical data series that complements the projection.

[14] Refer Rob J Hyndman – Review of Transpower's electricity demand forecasting. Sept 2011.

[15] Hyndman and Fan 2009.

70. We note that Powerlink's "energy forecast" based indirect approach also tends not to support the inclusion of temperature in the model specification, since annual energy use is much less affected by the peak temperature than peak demand itself. We have concerns for a model form for forecasting peak demand that omits temperature and we find it surprising that Powerlink has chosen a model form that does so, especially given the considerable attention that was afforded this subject in Powerlink's original RP, and more recently in its RRP and by its advisors. We consider that Powerlink's separate adjustment of its observed load factor data may be acting as a surrogate for temperature in this process, and we return to this later.

Assessment of coefficients

71. The size and nature of the coefficients in a regression analysis are key to the assessment of the form of the model. Given Powerlink's model form, it is important to remember that the coefficients in its check model relate to energy consumption rather than to peak demand. The use of a log-log model is good practice as this captures the multiplicative effect of the variables, which allows changes to be directly related to changes in demand. It also means that the coefficients can be directly interpreted as demand elasticities.

72. The following coefficients are observed in the Powerlink model, and are compared with the coefficients in the revised alternative model that we present in section 5.

Table 8: Coefficients on explanatory variables

	Powerlink energy model	EMCa/NZIER peak demand model
GSP coefficient	[C-I-C]	1.055664
Price coefficient		-0.140483
Average temperature		0.232398

Source: EMCa/NZIER, Powerlink

73. There are many reference studies regarding the elasticity of energy consumption, by sector, by regions and in many countries. While we are aware that AEMO has a view regarding peak demand elasticity, there are few reference studies of the relationship between price and peak demand. The ACIL Tasman report to Powerlink of January 2012 cites a number of studies of energy elasticities that describe a wide range of elasticities (residential: -0.1 to -0.7 and commercial: 0.0 to more than -1.0).

The RAND Corporation published a report in 2005 on a detailed study conducted in the US where they examined energy intensity for electricity and gas and estimated price elasticities for energy consumption by sector and by regions of the US. This is a very informative work as it not only provides a detailed view of elasticities but also how they vary over time by region - hot southern states and cooler northern states for example. The RAND study reported similar elasticity results - for example it quotes a short run price elasticity for energy consumption of -0.35 to -0.5 for residential and up to -0.6 for the long run. The report estimates commercial elasticities above -1.0 in some regions. Many elasticity studies quote a likely range as between -0.2 to -0.4, which accords with our experience.

74. The price elasticity for energy consumption of [C-I-C] in Powerlink's check model is much lower than we would expect, and is matched by a GSP elasticity that (at [C-I-C]) is also much less than the value of around unity that we would expect and which is seen in our alternative model specification. We consider that the price elasticity of peak demand of -0.14 in our revised alternative forecasting model is well within the expected range and would be consistent with an energy price elasticity of -0.28 if one was to accept AEMO's view that demand elasticities are around half of energy elasticities. We have also assessed the coefficient on temperature in our peak demand model, and we consider this too to be plausible (see section 5 and annex 1).

75. The Powerlink check model coefficients result in a model that is less sensitive to changes in price or GSP that would be expected, and we find that the forecast demand that arises from the model is driven strongly by the assumed load factor that is used to derive the peak demand forecast from the primary model's energy consumption forecast.

Impact of Powerlink's peak demand "temperature correction" process

76. The load factor to convert energy to demand uses the observed historical relationship between these two to predict the future demand, though with one major adjustment. Rather than use the actual data on peak demand, Powerlink uses its historical temperature adjusted peak demand to smooth the load factor path over time and to project a smoothed curve into the future. The temperature adjustment process was covered in our earlier report, however we make the following comments in relation to the load factor assumption that we now see in Powerlink's check model, and its role in the demand forecast produced by Powerlink's check model:

    a. For clarity, Powerlink temperature-adjusts only the peak demand data; it does not adjust the historical energy data which retains a "real" relationship with price and GSP. The effects of temperature adjustments that Powerlink makes are therefore inherent in its historical load factor as the following table describes. The smoothing process in the load factor is in direct proportion to the difference between historic native demand and temperature adjusted demand, though with a reverse sign in front of the percentage adjustment, as would be expected[16].

[16] When the actual temperature is below "PoE 50% average" Powerlink adjust the native MW demand upwards using a calculation of demand sensitivity to temperature, which is reflected in a decreasing load factor. We discuss this further in Annex 2.

Table 9: Powerlink historical temperature corrections to peak demands and temperature-corrected load factors

	Load F Correction	Load F Correction	Temperature Correction	Temperature Correction
		%	MW	%
2000/01	- 0.004	-0.6%	-58	-1.0%
2001/02	0.006	0.9%	-48	-0.8%
2002/03	- 0.004	-0.6%	32	0.5%
2003/04	0.022	3.5%	-202	-2.9%
2004/05	- 0.002	-0.3%	16	0.2%
2005/06	- 0.027	-4.2%	276	3.7%
2006/07	- 0.005	-0.9%	61	0.8%
2007/08	- 0.056	-8.4%	568	7.6%
2008/09	- 0.036	-5.7%	418	5.2%
2009/10	- 0.026	-4.3%	328	4.0%
2010/11	- 0.014	-2.3%	241	3.0%

Source: Powelrink

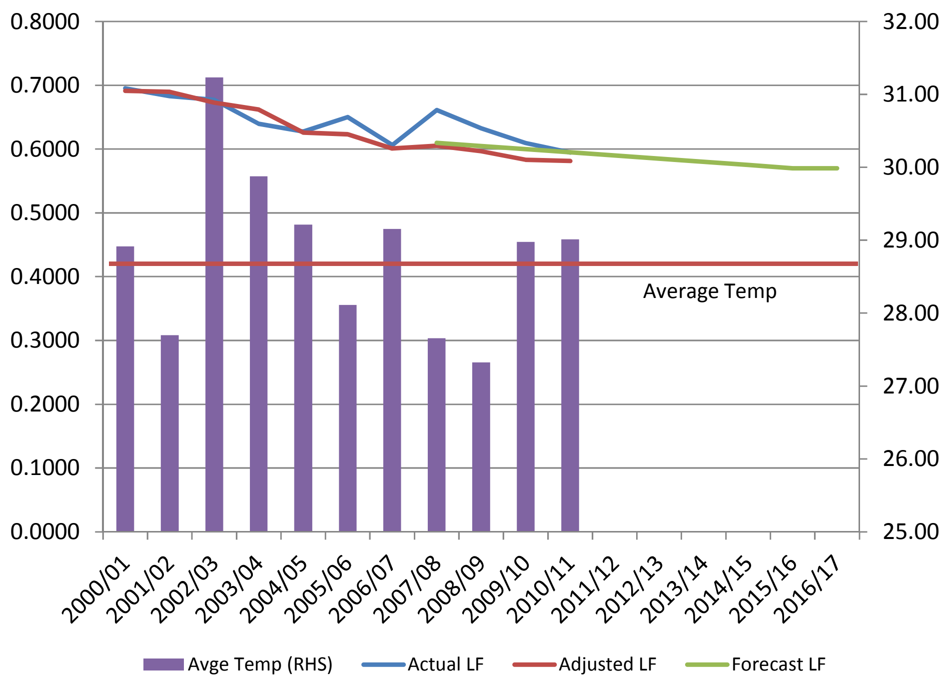
b. Powerlink uses the adjusted / smoothed load factor to project the future load factor. To the extent that there are issues with the temperature adjustment that Powerlink applies to correct its historical maximum demands, then these will indirectly affect Powerlink's load factor forecast. From the table above, it can be seen that in the past four years Powerlink has adjusted its peak demands upwards by amounts ranging from 241 MW to 568 MW. The average adjustment over the eleven years of historical data is an upwards adjustment of 148 MW and the Load factor has been adjusted downwards by an average of 2.1%.

c. Further, because Powerlink has made such significant upwards adjustments in the most recent four to six years, this considerably influences the apparent rate of peak demand growth over what is only an eleven year series. We would expect a model based on such data to project this higher rate of growth (as well as higher starting point) to produce a significantly higher forecast.

d. From our enquiries it appears that Powerlink's load factor forecast is not formally derived, although it "takes account of" factors that we would expect, such as a levelling of the decline in load factor that has occurred over the past ten years, as air conditioner penetration starts to saturate and appliances become more efficient. Powerlink does not appear to use an analytical basis for projecting the load factor but estimates its "glide path" into the future. In Powerlink's model specification, the peak demand forecast is directly impacted by changes to the projected load factor; that is a 1% decrease in the load factor increases peak demand by 1%.

77. While we have not conducted formal analysis of the projected load factor (and which is not required under a direct peak demand forecasting approach), we can observe from the chart of Queensland data below that less aggressive temperature correction and the associated correction to load factor could plausibly see this levelling out at or even slightly above 0.60, rather than the end-of-period projection of 0.57 that Powerlink has used. A change such as this would reduce the end forecast by over 400 MW.

Figure 4: Powerlink historical and projected load factor (raw and as-corrected by Powerlink) vs. Temperature on peak day ((max + min)/2) C



Source: EMCa, from Powerlink data

Conclusions from our assessment of model form

78. In conclusion, we observe that Powerlink's check model can produce a forecast that is repeatable given its specific input variables, but we consider that the model form has deficiencies which are likely to contribute to a poor forecast record.

79. A forecasting model for peak demand should ideally reflect the direct causal relationship between explanatory variables and peak demand. Powerlink's use of only two variables (GSP and price) to forecast energy results in the load factor having to represent the balance of the unidentified explanatory variables[17]. This places significant weight on the accuracy of the load factor projection in order to provide a reasonable forecast of demand and we have concerns with the way in which this important input parameter has been projected[18]. The absence of a specific temperature variable in the Powerlink check model form is especially concerning given that Powerlink has previously argued that temperature is widely recognised as having a major influence on electricity peak demand in Queensland.

[17] We have included a table in the appendix C which sets out a schedule of variables that are described by NIEIR as used for electricity forecasting though as we state here it is unclear how they are used.

[18] Figure 13 in the ACIL Tasman Assessment of Load Forecast Methodology and Results describes an 11 year load factor in Queensland that has significant variation. The trend line they draw through it has a poor fit which confirms our caution with the use of a constant load factor value (that is forecast at 0.57 in the check model).

80. We have determined that if Powerlink's check model was to be recalibrated using the same (official historical) data then, with the same input projections for the same explanatory variables, it produces a similar demand forecast to that which we obtain from using a model form that directly forecasts peak demand. This forecast is, however, 615 MW less than Powerlink's check model as presented and 705 MW less than the NIEIR forecast of 9,274 MW that Powerlink has used for the underlying demand component of its RRP forecast.

81. In the next section we therefore turn our focus to the assessment of explanatory variables.

4.2.5 Assessment of explanatory variables used in forecasting underlying demand

Explanatory variables for energy consumption

82. As previously discussed, in its check model Powerlink has used historical GSP and electricity price series as explanatory variables to forecast energy consumption[19]. In conducting this revised assessment we have explored the use of the following variables in our own regression model:

a. GSP

b. Population

c. Price

d. Temperature.

83. Because of the short time series that give rise to issues with multi-collinearity, and as with our analysis for our 2011 review, we find an unsatisfactory outcome from attempting to use both GSP and population in a regression. It was, and remains, unclear what explanatory variables Powerlink's forecasts from NIEIR rely on since a large range of variables, including population and GSP, is presented in the NIEIR demand forecast report. With this significant concern in mind, we were therefore unable in our 2011 review to form an opinion on the suitability or otherwise of explanatory variables that Powerlink (through NIEIR) had used.

84. For the RRP, Powerlink's check model provides a transparent basis for our assessment of reasonableness. We therefore conducted analysis to confirm Powerlink's choice of explanatory variables and we were able to establish satisfactory relationships between GSP and price as explanatory variables for energy consumption. While arguments can be made for using population or other factors, we did not find that substituting population for GSP provided a superior outcome.

[19] There are many reference regarding explanatory variables for energy demand – the RAND report we cite here covers a wide range of variables.

85. On this basis we consider that Powerlink's choice of explanatory variables (i.e. Queensland state GSP and the electricity price) is reasonable as a basis for forecasting energy consumption.

Explanatory variables for peak demand

86. Following on from our initial concerns about Powerlink's model form, we also explored the use of similar explanatory variables for use in forecasting peak demand directly.

87. The relationship between GSP and *peak demand* is less straight forward than with energy consumption. NZIER (2004) questioned whether there might be macro-economic explanatory variables available other than GSP that would better reflect the influence of income or standard of living on residential peak demand and of output or revenue on commercial and industrial demand.[20] Household numbers and composition are also often used when forecasting peak demand and in Australia the use of an air-conditioner penetration index has been used as a variable[21].

88. Peak demand is also influenced by other factors with temperature most important here, though time lags are also acknowledged as relevant to a number of explanatory variables, price in particular. The choice of explanatory variables is not cut and dry and it is the combination that provides the best fit when validated against historical actual demand.[22]

89. In our 2011 review of Powerlink regulatory proposal we developed a simple linear regression model using price, peak day maximum temperature and population to assess an alternative peak demand forecast. While at that time we tested a number of different model forms including the use of GSP and time lagged variables, that particular combination of variables best met our selection criteria.

90. With better transparency over Powerlink's revised check model inputs we are satisfied that the use of GSP and price is a reasonable approach, including for forecasting peak demand, however we are of the view that it is essential that a temperature variable is included.

91. As noted previously, we consider that Powerlink's methodology indirectly takes account of temperature and its influence on peak demand through its adjustment of historical load factor, though this solely influences the projected load factor and the historical load factor is not directly used in Powerlink's regression model. As a consequence we have assessed Powerlink's methodology and forecast on the basis that the explanatory variables it uses in forecasting peak demand effectively comprise GSP, price and a temperature-related correction. We consider this choice of explanatory variables to be reasonable, while noting our assessment of the different "model form" in which these variables are used (as described in the previous section).

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[20] RAND Corporation report on the Price Elasticity of Demand for Energy (2005) which describes regression testing of residential and commercial sectors electricity demand using 10 variables, none of which were GSP.

[21] Refer Hyndman and Fan (2010).

[22] The Hyndman and Fan forecasting report provides a good description of the process for selecting which variables to include, or not, in a log based regression model.

4.2.6 Assessment of projections for explanatory variables (GSP and price)

The role of historical data series and data projections

92. Historical data series for the chosen explanatory variables are required to calibrate the regression models, that is, to determine the constant and variable coefficients in the model. Projections from those same series, or potentially from different sources, are required to form the demand projections from those models.

93. We assembled and assessed a range of data series, including the series that Powerlink used in its check model and the series used by NIEIR for the same variables that Powerlink uses in its model[23].

Available historical data and projections - GSP

94. The November 2011 NIEIR forecast update that Powerlink has relied on for its RRP demand forecast uses NIEIR's own GSP data, that is, NIEIR's record of historical actuals and NIEIR's projection.

95. Powerlink's check model uses GSP data (history and projection) sourced from Deloitte Access Economics (Deloitte).

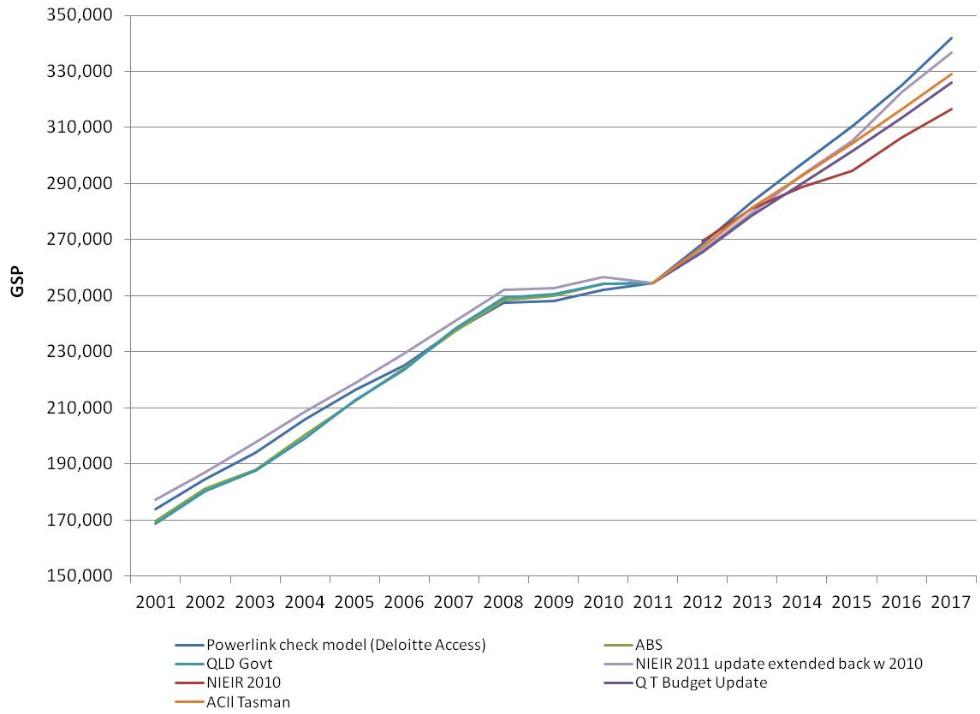
96. For assessment purposes, we sourced official government historical GSP data from the ABS and from Queensland Treasury, and GSP projections from the Queensland Treasury, the latest such projections being from its January 2012 Budget update[24].

97. We have standardised the historical data around the 2011 year for comparison purposes and to enable each series to be directly used for sensitivity testing in a regression model (whether Powerlink's model or in our alternative model presented in the next section). The following chart presents this data, along with NIEIR's 2010 GSP projection which was used in producing Powerlink's initial RP demand forecast.

[23] Other data series documented by NIEIR were not assessed because it is unclear how, and in some cases even if, they are used in forming NIEIR's demand forecast. Variables presented in NIEIR's report are listed in Annex 2.

[24] ACIL Tasman also used the QLD Treasury budget forecast for GSP in its advice to Powerlink, the latest data available to ACIL at that time being Treasury's July 2011 budget projection.

Figure 5: Powerlink revised demand forecast 2012 – comparison of GSP



Source: NIEIR, ACIL Tasman, ABS, Qld Treasury, Powerlink.

98. Of note from this chart are:

a. ABS and Queensland Treasury historical data is very similar, as we would expect given that it is government-sourced data[25];

b. Deloitte and NIEIR 2011 historical data has a slightly different trending compared with the official data, with the NIEIR historical data appearing not to take account of year-on-year variations that are evident in the official statistics;

c. Deloitte and NIEIR's 2011 projections are higher than the Queensland Treasury's projections, which are in turn higher than projections based off NIEIR's 2010 projected growth rates;

d. ACIL Tasman used June 2011 Queensland Treasury Budget projections, which are in the mid-range;

e. The Queensland Treasury January 2012 budget projections are also in the mid range, and represent the most up-to-date the projections we have reviewed.

Available historical data and projections – electricity price

99. In its November 2011 forecast update NIEIR provided to Powerlink a series of electricity prices for residential, business and for total consumers. These show limited historical data, together with a projection. The "business" price series is low,

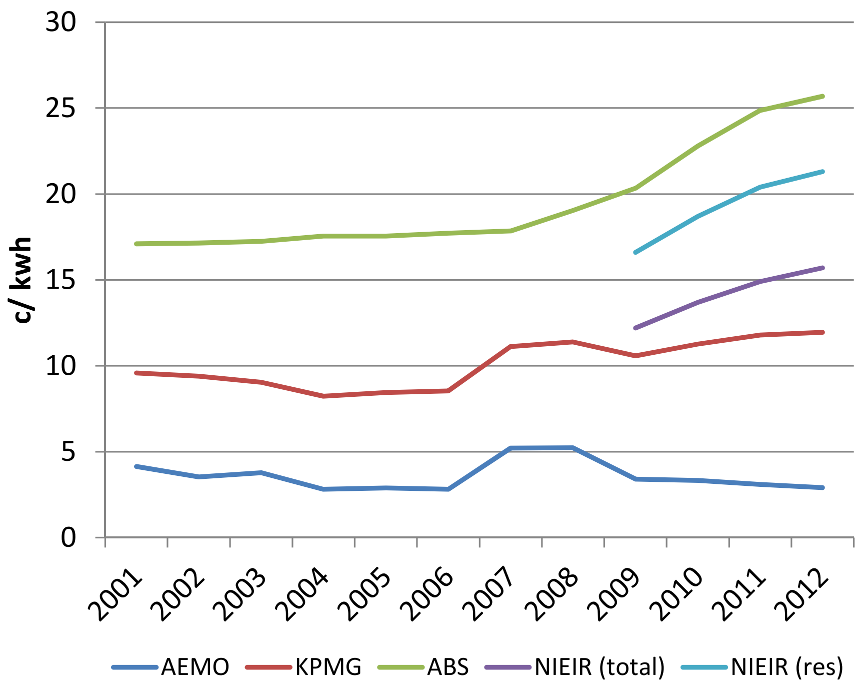
[25] We note that there are different ways in which GSP can be measured. We have used chain volume method data, converted into real (current dollar) terms where required

suggesting to us that it is heavily weighted by the low prices for electricity paid by large industry. It is not clear how NIEIR has produced these price series or how they are used in NIEIR's demand forecast.

100. In its check model, Powerlink uses a historical price series with associated price projection from KPMG. We observe that this data is approximately half the level of both the NIEIR residential price series and the ABS (Brisbane) price series. Given the relationship that we observe between this price series and average spot market wholesale prices from AEMO (in the chart below) we believe that the KPMG price series may represent the average of spot prices from the wholesale market with an assumed mark-up for network prices and retail margins. From its overall trend, by comparison with official series, it may also be expressed in nominal dollars rather than in real terms. If these assumptions are correct, then this would not be an appropriate series to represent real movements in retail prices which consumers pay, and we observe a very different historical pattern from that shown in the ABS historical series for electricity prices in Brisbane.

101. On the other hand, NIEIR's historical data (though only available for four years) shows a similar growth trend to the ABS official series[26].

Figure 6: Price data series (c/kwh)



Source: AEMO, KPMG, ABS, NIEIR

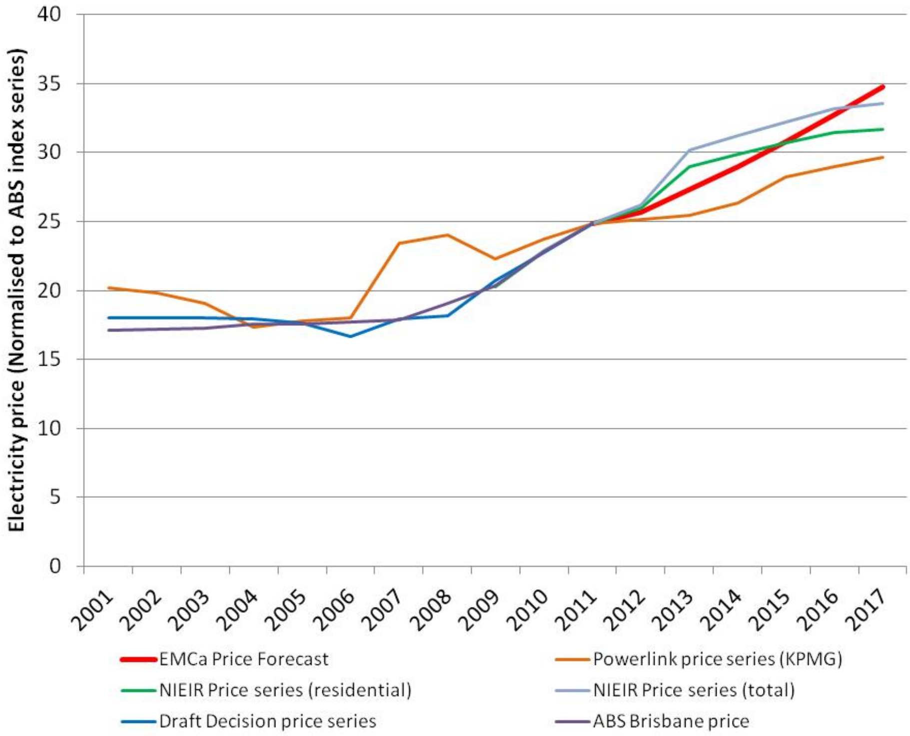
102. In developing our alternative demand forecast as part of our 2011 review of Powerlink's initial RP, we developed a historical retail price series from data presented

[26] The different level of each series is not a concern, since it is growth trends and fluctuations that influence the model. Calibration of the model can be from an index or an average price.

in reports by ROAM consulting, Powerlink's advisers on generation planting scenarios. We also developed a retail price projection based on QCA retail determinations (for the near term) and, beyond that, taking account of the AER's determination for Queensland distribution network prices and KPMG's underlying wholesale price projection. We have reviewed the derivation of this series, and we consider it to be still valid.

103. In the same way as with GSP we are faced with multiple historical and projected price series and we have standardised them through 2011 for comparison of the impact each price series would have in a regression and for assessing the reasonableness of the basis for Powerlink's forecast.

Figure 7: Powerlink revised demand forecast 2012 – comparison of price data



Source: EMCa, NIEIR, ABS, Powerlink.

104. Of note from this chart are:

a. KPMG's price series has anomalies in 2007 and 2008 that, as above, are assumed to reflect historical spot wholesale price fluctuations in those years but which are not reflective of retail price movements;

b. KPMG's price series has a low projection compared to all others;

c. The NIEIR series only extends back to 2009 and appears to include only residential and large industrial prices which are weighted together. NIEIR's projection is for the "total" price to increase at a greater rate than the residential price. NIEIR's projections also show a step increase in 2013;

d. Our 2011 historical price series is very close to the historical ABS price index for Brisbane;

e. Our 2011 projected price growth is similar in aggregate over the period to NIEIR's projected total price growth. In our projection, we did not seek to model the "shape" of the price projection but, rather, smoothed the assumed annual price growth to the end-point that we had derived. For this reason, our price forecast is lower than NIEIR's over much of the period, but slightly higher by the end of the period.

Assessment of projections for explanatory variables

105. We are concerned that Powerlink has used the KPMG historical price series to calibrate its regression model. The model would be inaccurate to the extent that it would seek to "explain" changes in energy consumption in years 2007 and 2008 by reference to supposed high electricity prices that did not exist as retail prices that consumers pay, and similarly would seek to explain an effect from a supposed decrease in prices in 2009 that did not take place. In short, we would expect the regression model to be materially inaccurate as a predictor because of this.

106. With regards to projections, we are concerned that Powerlink has used data that is at the upper end of the range for GSP and at the lower end of the range for price, both of which would tend to bias the forecast upwards.

107. It is difficult to accept the reasoning for Powerlink to use forecasts for GSP and price that differ from those of its adviser, NIEIR. Powerlink has calibrated a check model that purports to explain energy consumption in terms of GSP and price. We understand that NIEIR's demand forecast also takes account of GSP and price. In producing a check model, one would expect it to provide a similar though not identical result to the, presumably, more sophisticated NIEIR model, for the same set of inputs. Instead, we find that the check model, which in any case as presented produces a forecast 90 MW below the NIEIR forecast, produces a forecast that is 319 MW below NIEIR's forecast when it is re-run using the same GSP and price growth projections as NIEIR. In other words, it does not provide a reasonable validation of NIEIR's forecast.

Table 10: Powerlink revised forecast for underlying demand – check models validation

MW

	GSP	Price	Load Factor	2016/17
NIEIR update - Base Case	NIEIR	NIEIR	?	9,274
PL Check Model	NIEIR	NIEIR	Powerlink	8,955
PL Check Model	QLD T	KPMG	Powerlink	8,862

Source: EMCa from Powerlink & NIEIR data.

108. Noting that the Deloitte Access Economics GSP forecast used by Powerlink is above the NIEIR forecast and considerably above Queensland Treasury forecasts, including the forecast used by ACIL Tasman in its advice to Powerlink, we consider that this too is driving Powerlink's check model forecast above the reasonable range. Re-running Powerlink's check model with Queensland Treasury's most up-to-date GSP forecast, for example (but retaining Powerlink's use of the KPMG price forecast) reduces the forecast produced by this model from 9,184 MW to 8,862 MW, a decrease of 322 MW in the check model and 412 MW below Powerlink's RRP forecast.

109. We have a preference to source both historical data series and projections from an official primary source. In considering the different series available, we have formed the view that the official ABS series for historical GSP and for Brisbane electricity prices, the January 2012 Queensland Treasury GSP forecast and our retail price forecast (with a similar growth rate to NIEIR's) are the most suitable points of

reference against which to assess the reasonableness of Powerlink's forecast. We find that a combination of the historical data and the projections used by Powerlink for its explanatory variables produces a material upward bias to the demand forecast produced by Powerlink's check model.

110. In section 5, we develop our proposed alternative forecast using the historical and projected data series referred to above.

4.2.7 Reconciliation with DNSP forecasts

111. In data that Powerlink has provided to us from information requests under the current (RRP) review, we observed that Powerlink had pro-rated the most recent connection point forecasts that DNSPs' had provided (for the 2011 APR), such that the sum of DNSP forecasts exactly matched the "top-down" NIEIR forecast for these loads. This involved a 3.3% pro rata reduction to the DNSPs' connection point forecasts in 2012, declining to materially no adjustment by 2016/17, and then reversing to an increase of 3.8% by 2021.

112. We understand from discussion with Powerlink that, as part of the APR process, Powerlink liaises with DNSP representatives and through this process seeks to make adjustments at the individual connection point level to approximate the top-down forecast. Powerlink explained that it had made pro-rata adjustments as a matter of expediency for its RRP, since this was taking place outside of the APR process.

113. EMCa considers this process of pro-rata adjustment of connection point forecasts to be reasonable for the purposes of the RRP.

4.3 Powerlink demand check model sensitivities

4.3.1 Powerlink check model sensitivities

114. We used the Powerlink check model to evaluate the sensitivity of the revised demand forecast produced from this model, to different input assumptions. Some of these sensitivities were reported in section 4.2.6, but the table below lists a more complete set of results from the different permutations of projections for GSP, price and load factor. In each case, the Powerlink check model used is identical (i.e. as reported in the RRP) and, for clarity, we have normalised the various input projections to 2011 so that they can be substituted in the model on a comparable basis[27].

115. Our base line for this comparison of demand forecasts is the NIEIR DNSP forecast that Powerlink has relied on for its RRP demand forecast.

[27] The range of sensitivity test of the Powerlink check model is limited by the simple model form and the use of only two explanatory variables.

Table 11: Powerlink revised forecast for underlying demand – check models sensitivity tests

MW

	GSP	Price	Load Factor	2016/17
NIEIR update/ PL RRP Forecast	NIEIR	NIEIR	?	9,274
PL Check Model	NIEIR	NIEIR	Powerlink	8,955
PL Check Model	Deloittes	NIEIR	Powerlink	9,131
PL Check Model (as presented)	Deloittes	KPMG	Powerlink	9,184
PL Check Model	Deloittes	EMCa	Powerlink	9,119
PL Check Model	QLD T	EMCa	Powerlink	8,799
PL Check Model	QLD T	KPMG	Powerlink	8,862
PL Check Model	Deloittes	KPMG	Forecast = 0.60	8,718

Source: EMCa from Powerlink & NIEIR data. (RRP forecast ex NIEIR and Powerlink check model as presented, are highlighted)

116. Of note from the table are:

a. Powerlink's check model is relatively sensitive to GSP forecasts – for example the use of Deloittes' GSP data results in a 2017 forecast that is 322 MW higher than using the QLD Treasury GSP forecast;

b. The Powerlink model is not especially sensitive to different price data;

c. As reported previously, Powerlink's check model with NIEIR GSP and price projections produces a demand forecast that is 319 MW less than NIEIR's forecast;

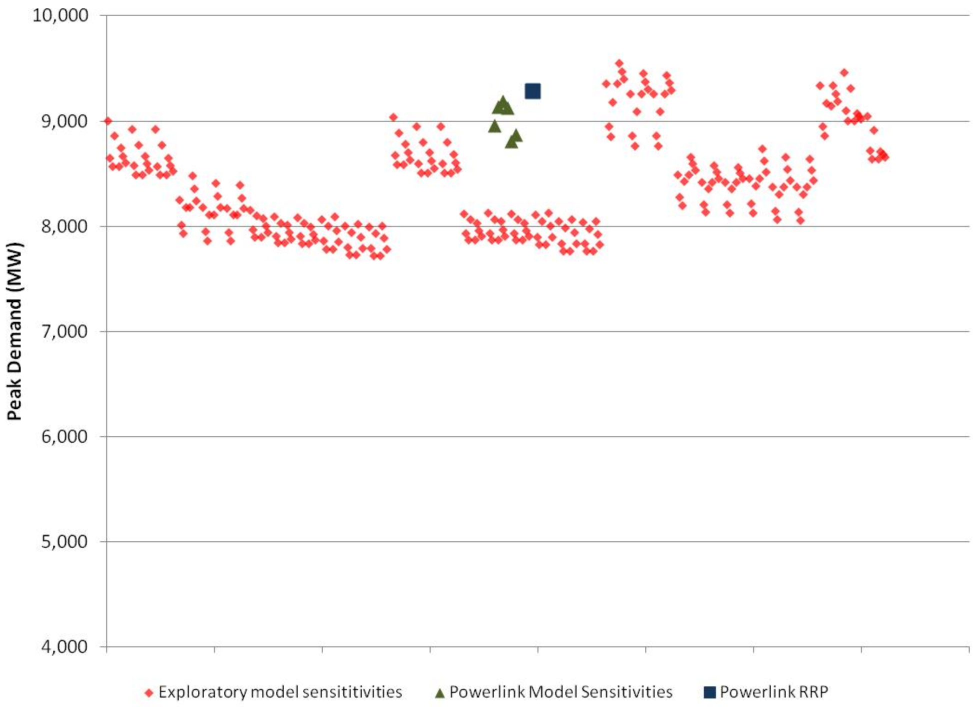
d. Powerlink's (NIEIR) RRP forecast is above the range of all other permutations of input data.

4.3.2 Sensitivity of results from exploratory EMCa/NZIER modelling

117. As previously described, EMCa/NZIER explored a wide range of model forms, historical input data and input projections as part of the process of assessing Powerlink's forecast and (subsequently) in developing an alternative forecast.

118. In the following diagram, we have shown the results from a set of such model/data combinations. This includes models calibrated using different combinations of GSP, price, population and temperature, with and without lags on some variables, with different historical data series and different projections. These are shown by way of the red diamond shapes, while the data from Table 11 Powerlink model sensitivities is shown as green triangles. Powerlink's RRP forecast (based on NIEIR's underlying demand forecast) is shown as a dark blue square.

Figure 8: Powerlink underlying demand forecasts for 2016/17 – comparison of Powerlink sensitivities and EMCa exploratory assessment model results



Source: EMCa from Powerlink & NIEIR data.

119. For clarity, the scatter plot shows the 2016/17 peak demand (MW) that resulted from the scenario and sensitivity testing that we conducted as part of our wide-ranging exploratory analysis to test the reasonableness of Powerlink's forecast. The exploratory model sensitivities represent the outputs both from changes to the model form (how it takes and uses data) and from using different projections for price and GSP. Also included (for sensitivity testing only) are scenarios such as using Powerlink's temperature adjusted historical MW data in the regression, using a load factor in place of average temperature and lagging the price and GSP variables.

120. The results of changes to the model form cause the cluster effect that is observed in this chart while the range of the points in each cluster represents changes to the projections of each input variable.

121. The results below 8,000 MW come from variations to the model that include lagged variables. These models provided some plausible forecasts but most had unacceptable regression statistics. The forecasts at and above 9,000 MW resulted from changes to the model to take in Deloitte and KPMG data with and without lags to examine these effects. Aside from our reluctance to use these data for reasons explained elsewhere in this report, these analyses also resulted in regressions with unacceptable statistics.

122. The remainder of the outputs (in the 8,000 to 9,000 MW range) include a variety of model forms, some of which provide good statistics while others do not, and include some runs with data that we did not regard as suitably robust. The modelling results that provided our recommended alternative forecast come from the cluster to the left of the Powerlink model results (in red).

4.4 PoE 10% adjustment

123. An adjustment is required to a 50% PoE demand forecast in order to derive a 10% PoE forecast, which is the accepted basis for capex expansion planning. Powerlink determines this adjustment so as to reflect the 10% (and 90%) PoE temperatures by calculating the sensitivity, by region, of the peak demand load to temperatures using regression, with the resulting coefficients determining the adjustment (in MW per degree C), as follows;

Table 12: Observed temperature sensitivity of daily peak demands

Table A.2 Observed temperature sensitivity of daily peak demands

	Demand change dependence on average daily temperature (MW per °C) (1)			
	South East (2)	South West	Northern non-industrial	Central non-industrial
Summer				
2001/02	72	5.0	28	14
2002/03	69	7.0	32	18
2003/04	115	8.6	37	18
2004/05	147	9.0	33	19
2005/06	162	11.1	40	24
2006/07	160	12.0	46	24
2007/08	154	11.2	50	19
2008/09	196	11.6	46	25
2009/10	168	14.5	41	20
2010/11	152	11.3	28	19

Source: Powerlink APR

124. Reference PoE temperatures are provided by NIEIR, who make allowances for warming trends, while Powerlink sources the MW data for the regression calculations and determines the forecast demand, as shown in table 13. This indicates a 10% PoE forecast that is 535 MW more than the 50% PoE forecast, by 2016/17.

Table 13: Powerlink's RRP medium forecasts, at 10%, 50% and 90% PoE

MW

Year	Medium		
	10%	50%	90%
2011/12	9,322	8,877	8,609
2012/13	9,795	9,331	9,052
2013/14	10,443	9,962	9,671
2014/15	10,931	10,434	10,133
2015/16	11,603	11,085	10,773
2016/17	11,999	11,464	11,141

Source: Powerlink

125. We consider that Powerlink's methodology for deriving its 10% PoE forecasts is reasonable. We conducted our own assessment of the results of this process, using actual peak-day temperatures from the Powerlink supplied 11 years of data. We undertook our own regressions which confirmed the increasing SEQ temperature sensitivity that Powerlink has observed.

126. Our calculations indicated the need for an adjustment of 445 MW (to the 2016/17 forecast), using the demand model presented in section 5. In part this is lower than

Powerlink's adjustment because the corresponding 50% PoE demand forecast is lower than Powerlink's and, if we applied Powerlink's percentage increase to the lower 50% PoE demand forecast then the resulting adjustment is 495 MW. While Powerlink's adjustment is 50 MW higher, we have formed the view that Powerlink's adjustment is within reasonable bounds of what we would expect.

127. In summary, therefore, we consider that Powerlink's 10% PoE adjustment to its 50% PoE forecast, is reasonable.

4.5 Findings from our assessment of Powerlink's revised demand forecast

4.5.1 Results of our assessment

128. We endorse Powerlink's use of updated input from NIEIR to account for changes in the (nearly) 2 years that have elapsed since the 2010 APR formed the input to Powerlink's original 2011 demand forecast. We also endorse Powerlink's development (for the RRP) of a check model and associated data that has enabled our review of the basis for its demand forecast.

129. Based on our review of Powerlink's process, we consider that Powerlink's forecasts for its major customer demands are reasonable.

130. We have reviewed Powerlink's derivation of a 10% PoE forecast from its 50% PoE forecast. This is slightly above our expectation, but on balance we consider that the relative size of Powerlink's adjustment is reasonable.

131. We have concerns with Powerlink's revised forecast of underlying demand. The check model that Powerlink provided produces a demand forecast that is 90 MW less than its RRP forecast, which is obtained from NIEIR. This difference in itself would not concern us; however the check model produces this result only by using a projection of GSP that is materially higher than NIEIR's and a price projection that is lower than NIEIR's. When we re-run the check model using NIEIR's input projections, it produces a demand forecast that is 319 MW lower than NIEIR's and we consider this to be a material difference.

132. We have reviewed the historical data that Powerlink's check model is calibrated from and we consider that the price data used is not appropriate for this purpose, as it appears not to reflect historical movements in retail prices that consumers pay. The historical GSP data also differs from official (ABS) series, though we do not deem this to be significant.

133. We have concerns about the input projections used, in that the GSP forecast is materially higher than the latest forecast from the Queensland Treasury and the price forecast is lower than NIEIR's (and which has similar growth over the period of the RCP to our own retail price forecast).

134. We have concerns about the form of the model that Powerlink has used, which produces a forecast of peak demand by indirect means, by first forecasting energy (GWh) and then adjusting this with a load factor forecast that is in turn extrapolated from historical peak demands that have been increased for recent years by the separate temperature correction applied by Powerlink. Powerlink choose not to use

the direct method of forecasting peak demand from a broader set of explanatory variables, including temperature.

135. We have tested the materiality of each of these concerns. Taken together, we consider that they are leading to a material over-statement of future underlying demand.

4.5.2 Recommendation

136. We consider that the demand forecast that is presented by Powerlink in its Revised Revenue Proposal is not a reasonable forecast and we recommend that AER not accept it as a basis for determining a capex allowance in Powerlink's revenue determination.

5 Revised Alternative forecast

5.1 Introduction

137. Following our assessment that Powerlink's RRP forecast is not reasonable, we have developed a revised alternative forecast.

138. For this update, we use the same overall process as for our 2011 alternative forecast; that is we identify and forecast the underlying load separately from the forecast of major industrial and mining loads, for which we use Powerlink's forecast. Consistent with our assessment in the previous section, we have focused on developing a suitable model form, calibrated with suitable historical data and projected with suitable input projections for the explanatory variables. We have tested this model for stability and for the reasonableness of its coefficients.

5.2 Approach used in developing alternative forecast for underlying demand

5.2.1 Overall approach

139. Consistent with Hyndman,[28] we use the same three stage methodology that was used in our 2011 alternative forecast to develop an alternative forecast for underlying demand:

a. Stage 1 – Using historical data on demand and explanatory variables *develop statistical models* for annual peak demand;

[28] Refer Hyndman and Fan (2010)

b. Stage 2 - Using the models from stage 1, and projections of the explanatory variables used in the models, prepare *forecasts of peak demand* out to 2017;

c. Stage 3 - *Evaluate the resulting forecasts* by testing model sensitivity to changes in both inputs and model form and thereby obtain a suite of forecasts that reasonably reflect uncertainty.

140. Throughout this process, we attempted to use the same methods as Powerlink, to the extent that we were satisfied that these were reasonable. Following extensive exploration of alternatives, we used the same primary explanatory variables in our model (GSP and price), the same PV forecast, and the same factor to adjust from the 50% PoE forecast to the 10% PoE forecast. We did not use the same model form, nor an exogenous forecast of load factor, and we used different historical data series and projections. We used Powerlink's data for historical peak demands and associated temperatures.

5.2.2 Consideration of model form

141. Rather than forecasting peak demand via energy usage and a load factor as per Powerlink and ACIL Tasman, we prefer to forecast peak demand directly from the selected explanatory variables for stages 1 and 2. The literature on electricity forecasting includes a number of respected sources on this methodology[29]. This direct method has several advantages, including that:

a. The model is calibrated using coefficients that reflect the elasticity of peak demand directly, rather than elasticities for energy consumption, which tend to differ (as is noted by ACIL Tasman in its report to Powerlink);

b. The sensitivity of peak demand to temperature can be determined directly as part of the same modelling process by which coefficients are determined for other variables;

c. This method obviates the need for a separate forecast of load factor, which is a material and critical parameter in converting an energy forecast to a peak demand forecast.

142. For this revised assessment we developed models of raw demand using linear regression (in the same way as 2011) but also logarithmic demand from natural log regressions. We did this for three reasons:

a. Firstly, we needed to assess the Powerlink check model, which uses a log form approach; and

b. Secondly we wished to assess whether a log form model produces a better fit to the historical data than the linear form we used in 2011; and

c. This form facilitates comparison of elasticities in model selection.

[29] Refer Hyndman and Fan (2010), McSharry et al (2005) and Weron (2006) for guidance on forecasting demand directly into MW.

143. We developed a single state-wide model, consistent with Powerlink's check model approach.

5.2.3 Explanatory variables for underlying demand model

144. We tested a wide range of explanatory variables, including GSP, population, electricity prices, temperatures and "dummy" variables for "unique" conditions such as in 2008 (GFC) and 2011 (floods). We tested a range of combinations of more than 20 potential explanatory variables. As noted previously, we sought to use the same methods as Powerlink where possible, and in this regard we were satisfied with the use of GSP and electricity price as the main model variables. Consistent with our earlier discussion of forecasting approach, we prefer to use a temperature variable in the forecast model in the same manner as in our 2011 model.

145. In figure 8 (in section 4.3.2) we showed a range of results from this exploratory testing process. In each case we assessed the suitability of the model, including the regression statistics and the suitability of the input data, to form our view as to the preferred model. A number of potentially acceptable models provided forecasts in a similar range, around 8,600 MW (by 2016/17).

146. After reviewing the various sources available for historical data and projections we settled on the following combination of explanatory variables.

Table 14: Explanatory variables

Dependent variable: MW	Historical native demand series from Powerlink, from which we subtracted selected major loads to get an underlying native peak demand (equivalent to NIEIR definition of "DNSP" demand).
Explanatory variable: Price	ABS (Brisbane) historical electricity price index. We projected this using the growth rates that we developed in 2011 (and which we reviewed and confirmed as being reasonable).
Explanatory variable: GSP	ABS historical GSP data (chain volume measured) and forecast from Qld Treasury mid-year 2011/12 (ie: January 2012 budget update).
Explanatory variable: Temperature	Regionally weighted average peak day temperatures developed from Powerlink supplied daily max and min temperature historical data for the day of each historical state peak demand, with the forecast temperature being the state weighted average of the historical data that Powerlink provided.

Source: EMCa/NZIER

147. We settled on a log-log model using this data, and with no lagged variables. The resulting model and regression statistics are shown in the following table. This model projects an underlying demand for 2016/17 of 8,578 MW, which compares with NIEIR's forecast of 9,274 MW and Powerlink's check model forecast of 9,184 MW.

Table 15: EMCa/NZIER revised alternative forecast – regression model

Dependent Variable: LOG(MWQLDMETHA)				
Method: Least Squares				
Date: 02/22/12 Time: 22:25				
Sample (adjusted): 2001 2011				
Included observations: 11 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	- 4.610963	1.110629	- 4.151668	0.006000
LOG(ELECTRICITYPRICEABS)	- 0.140483	0.082523	- 1.702352	0.139600
LOG(GSPABS)	1.055664	0.076051	13.881030	-
LOG(TMPAVGMINMAX)	0.232398	0.190571	1.219483	0.268400
DUMMY_08	- 0.094630	0.025005	- 3.784471	0.009100
R-squared	0.9856	Mean dependent var		8.7246
Adjusted R-squared	0.9761	S.D. dependent var		0.1355
S.E. of regression	0.0210	Akaike info criterion		- 4.5889
Sum squared resid	0.0026	Schwarz criterion		- 4.4081
Log likelihood	30.2392	Hannan-Quinn criter.		- 4.7029
F-statistic	102.8984	Durbin-Watson stat		2.5430

Source: EMCA/NZIER

5.2.4 Assessment of model

148. We are satisfied that the combination of explanatory variables in this model meets our selection criteria as well as our (and AER's) assessment principles. The temperature variable is present with a credible coefficient.[30] Likewise the price coefficient has a credible coefficient at -0.14 against peak demand. This is well above the low level seen in Powerlink's energy consumption check model and represents the increased sensitivity to price that has been visible in Queensland for several years now. The GSP coefficient is also higher than in Powerlink's check model and is at a level we would expect to see for an economically active state like Queensland. We include a dummy variable to capture the one-off effect of the GFC impacts in 2008.

149. The conventional R-square tests for this model are satisfactory; however we prefer the probability test to guide our views on model stability. Despite there being only 4 variables and 11 years of data, we are satisfied with the p-test statistics for this model.

150. We tested our model for stability and robustness. Because there are only 11 years of historical data and, consequently, limited degrees of freedom, we consider that great care must be taken in attempting to draw conclusions on model stability from out-of-sample testing that excessively shortens the in-sample calibration range. While it appears from our reading of the RRP that Powerlink may hold a different view on this matter, we did conduct one and two year stability tests on our model using the ex-ante

[30] We describe our evaluation of temperature trends and adjustments in Appendix B

and ex-post forecasting process proposed by Hyndman. This testing showed a good forecasting performance by the model[31].

5.2.5 10% PoE capital budgeting forecast

151. We re-analysed the historical relationship between temperature and demand and this essentially confirmed the relationships that we had found in our 2011 analysis[32]. Like Powerlink, we find that there has been a strongly increasing demand sensitivity to temperature over the past decade and we consider it reasonable to project, as Powerlink has, using the most recent sensitivity rather than the whole-period historical average.

152. As described in section 4.4, we accepted the process that Powerlink has followed. However using three checks of reasonableness, we do get lower results.

153. If we use a linear relationship that we have derived from Powerlink's data on mean daily peak temperatures (i.e. (max+min)/2)) then the implied adjustment for 2016/17 is 445 MW[33] rather than the 495 MW that Powerlink's relativities imply (after scaling for our lower 50% PoE demand forecast). If we use a linear relationship that we have derived from Powerlink's data on maximum temperatures (as opposed to mean daily temperatures) then the resulting adjustment for 2016/17 would be 360 MW. If an S-curve relationship was assumed to hold for SEQ then, using Powerlink's S-curve, the adjustment for the dominant and most temperature sensitive region, SEQ, is about 300 MW[34], which would be broadly consistent with the 360 MW finding for the whole state, as above.

154. Elsewhere we have questioned the validity of the S-curve, and we recognise arguments both for and against including overnight minimum temperatures in the adjustment. On balance therefore we have made an adjustment which represents Powerlink's 10% PoE adjustment, scaled to our lower 50% PoE demand; that is, an adjustment of 495 MW by 2016/17 above our 50% PoE forecast..

[31] As part of our assessment we sought to replicate out-of-sample testing that Powerlink conducted on its model and on what Powerlink considered to be a version of the model we used in 2011. We found that Powerlink's application of the technique did not produce statistically meaningful results. We also note that, because energy consumption is more stable year-on-year than peak demand, an energy model will appear to be more stable. Also, because Powerlink's model has very low coefficients as noted above, it will give the appearance of stability because it is closer to a 'trend line" than a model with higher coefficients. Test results such as these however do not lead to a conclusion that such a model is preferred.

[32] See annex 1

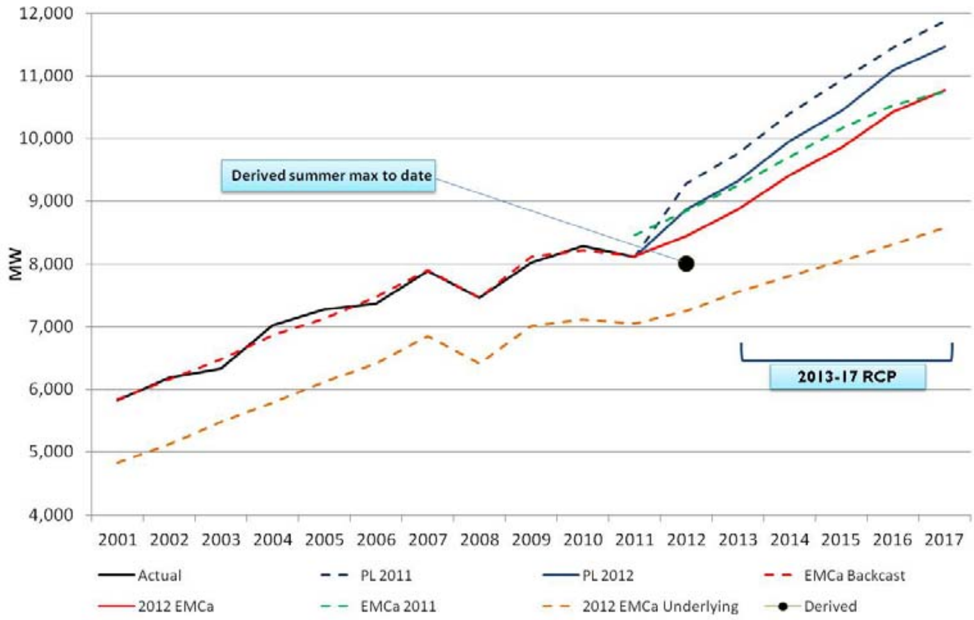
[33] As reported in section 4.4

[34] Taking a temperature difference from 30.0 degrees to 32.3 degrees for SEQ, as per table A.2 of the Powerlink 2011 APR

5.3 Resulting forecast

155. The following chart shows the underlying demand resulting from this approach as well as our overall forecast using Powerlink forecast of major loads. The back-cast from the model and a comparison with our 2011 alternative forecast and Powerlink revised forecast are also included.

Figure 9: Powerlink and EMCa/NZIER revised demand forecasts (2012) and comparison with 2011 forecasts



Source: EMCa/NZIER

156. The following tables set out our recommended alternative demand forecasts. These tables compare our current (revised alternative) forecast with our 2011 alternative forecast, and show the forecast at 50%PoE and 10% PoE levels.

Table 16: Powerlink's demand forecasts (2011 and revised 2012)

MW

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Reg Proposal 50% PoE (2011)	9,280	9,765	10,400	10,930	11,447	11,877
Revised Proposal 50% PoE	8,877	9,331	9,962	10,434	11,085	11,464
Revised Proposal 10% PoE	9,322	9,795	10,443	10,931	11,603	11,999

Table 17: EMCa/NZIER alternative demand forecasts (2011 and revised 2012)

MW

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Alt forecast 50% PoE (2011)	8,841	9,259	9,711	10,161	10,537	10,746
Revised Alt Forecast 50% PoE	**8,447**	**8,869**	**9,421**	**9,862**	**10,425**	**10,768**
Revised Alt Forcastl 10% PoE	8,867	9,306	9,871	10,326	10,905	11,262

Source: EMCa/NZIER

Table 18: Differences between Powerlink and EMCa/NZIER revised demand forecasts

MW

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Reg Proposal 50% PoE (2011)	439	506	689	769	910	1,131
Revised Proposal 50% PoE	430	462	541	572	660	696
Revised Proposal 10% PoE	455	489	572	605	698	737

Source: Powerlink/EMCa

5.4 EMCa/NZIER model sensitivities

157. Consistent with our forecasting approach and in the same manner as for our review of the Powerlink forecast and methodology, we tested a range of variations to the model form and inputs to identify a suite of possible forecasts. These sensitivity tests are conducted at underlying DNSP demand level.

158. Table 19 describes a range of what we consider to be credible forecasts from *different combinations of inputs* to the EMCa/NZIER model. These forecasts are all materially lower that the NIEIR Base Case forecast at DNSP level and are within a narrow range. We also prepared these forecasts with maximum temperature replacing average temperature in the model, and excluding the "2008" dummy variable, and found that the difference in resulting forecast was not material.

Table 19: EMCA/NZIER 2012 Alternative Forecast Model - Sensitivity to alternative input data and projections

MW

	GSP	Price	Temp	2016/17
NIEIR update - Base Case	NIEIR	NIEIR	?	9,274
EMCa/NZIER Model 2012	ABS/QLD T	ABS/EMCa	avge temp	8,578
EMCa/NZIER Model 2012	QLD T	ABS/EMCa	avge temp	8,560
EMCa/NZIER Model 2012	QLD T	NIEIR	avge temp	8,601
EMCa/NZIER Model 2012	ABS/QLD T	NIEIR	avge temp	8,622
EMCa/NZIER Model 2012	Deloitte	KPMG	avge temp	9,328
EMCa/NZIER Model 2012	ABS/QLD T	ABS/EMCa	load factor	8,569
PL Check Model	ABS/QLD T	ABS/EMCa	PL Load factor	8,569
EMCa/NZIER Model 2012	Deloitte	KPMG	load factor	9,277

Source: EMCa/NZIER

159. Table 20 describes a range of forecasts that result from using *different model forms*. We include these results for completeness however most of these forecasts do not meet our credibility criteria and are not considered as plausible forecasts.

Table 20: EMCa/NZIER 2012 Revised alternative forecast model – Sensitivity to alternative model forms

MW

	GSP	Price	Temp	Model Form	2016/17
EMCa/NZIER Model 2012	ABS/QLD T	ABS/EMCa	avge temp	log linear, 2008 dummy	8,578
EMCa/NZIER Model 2012	ABS/QLD T	ABS/EMCa	avge temp	log linear, 1 off 2011 adjust	8,999
EMCa/NZIER Model 2012	ABS/QLD T	ABS/EMCa	avge temp	log linear, no 2008 dummy	8,631
EMCa/NZIER Model 2012	ABS/QLD T	ABS/EMCa	avge temp	log linear, ex ante 2011	8,676
EMCa/NZIER Model 2012	ABS/QLD T	ABS/EMCa	avge temp	log linear, ex ante 2010/11	7,828
EMCa/NZIER Model 2012	ABS/QLD T	ABS/EMCa	nil	log linear, temp adj MW	9,338

Source: EMCa/NZIER

160. The forecasts were rejected mostly because of unstable coefficients (for instance too much variation in the coefficient or the sign of the price coefficient went from negative to positive), or because we consider the model form simply lacks credibility. The second scenario shown in table 20 is an example of this, where a separate adjustment is made to the 2011 MW in the model to compensate for the weather, despite GSP and temperature variable reflecting the weather impact already.

161. The calibration using temperature-adjusted peak demand (last scenario shown on table 20) is likewise not considered credible, because it is based on an adjustment of the key input variable (peak demand) that is made outside of the model rather than as part of the regression process. We have separately addressed the way in which we consider this has "over-corrected" for recent lower temperatures[35]. This correction has considerably increased the apparent peak demand growth rate, and a log model effectively extrapolates this higher growth rate into the future leading to a multiplicative increase in the end-forecast[36].

5.5 Assessment against AER guidelines

162. The guidance for our assessment of the RRP is the forecasting and assessment principles that we discussed in our 2011 report to the AER. We are aware that the AER has presented a set of forecasting guidelines to an ENA Working Group and we have discussed the "best practice" approach in this material with both Powerlink and the AER. We provide a brief assessment of our process and methodology against the relevant AER forecasting guidelines. Most of these guidelines overlap with or are subsets of our own forecasting principles and we include comments accordingly.

Table 21: Assessment of EMCa/NZIER approach against AER guidelines

AER Guidelines	Our Approach to the Powerlink RRP Review
Accuracy & unbiasedness	The alternative forecast model results from a wide exploration of factors driving demand, and is evidence-driven. The data series are neither at the low nor high extremes of series that are available and the resulting demand forecast is similarly not at the extreme end of the range of resulting forecasts. The model provides a sound back-cast and reflects well recent history, in which demand has been influenced by a combination of slow GSP growth, higher prices and cooler temperatures. Our approach is to maintain accuracy and minimise bias by using evidence to inform our analysis as opposed to using subjective assessments.

[35] See annex 1

[36] For clarification, Powerlink has not used temperature-adjusted peak demand in its check model. We tested this option because, as we observe in section 4, Powerlink's check model involves a projection from a temperature-corrected load factor and we consider that this is contributing to the over-estimation of its forecast. As expected, this model provides a significantly higher forecast than a model which incorporates the effects of temperature directly.

Transparency and repeatability	This is a subset of our robustness principle which is driven through sound economic and forecasting practices. Powerlink's RRP forecast is not transparent and its basis has not been made available for review. EMCa's 2011 model was made available to Powerlink for its review and, similarly, our current alternative forecast model is included in this report. Our proposed alternative model is calibrated off official published statistics. The model can be re-created from this data. The resulting forecast is not dissimilar to the alternative demand forecast prepared in 2011 with the common theme being that it is a direct forecast of peak demand based on unadjusted explanatory data.
Incorporate key drivers	We have tested more than 50 combinations of demand drivers through the two stages of assessing Powerlink's forecast and developing an alternative forecast. We are satisfied that the drivers that we are using are an appropriate combination for this forecast. For our 2011 forecast we used price, population and temperature after testing a wider set of variables while for this 2012 revision we selected price, GSP and temperature, along with a dummy variable to compensate for the 2008 GFC impact. This combination delivers a stable forecast and the key drivers are the same as Powerlink maintains.
Validate and test model	We have conducted scenario testing on both ours and Powerlink's models to identify a plausible range of forecasts. Many of the possible forecast outcomes are presented in this report to make transparent the forecast range considered. As well as using different inputs to test the model we use back-casting to identify the fit of the model to actual historic data and use ex ante reliability testing. We have undertaken such testing, taking due account of the relatively short time series of data that is available.
Accurate and consistent forecasts at different levels	Underlying forecasts of demand were developed in 2011 using both Queensland state and regional level data with a detailed reconciliation between each of the top down and the bottom up. Data availability restricted this process for 2012 however we were able to analyse and reconcile to our satisfaction the connection point demand statistics with both the NIEIR and the check model forecasts and with DNSPs' 2011 APR connection point forecasts, in the same way as Powerlink has in its RRP. Part of this process was to identify any possible double counting of demand and thereby maintain accuracy and avoid any bias.
Use latest information	For our 2011 work, our 2012 review of the Powerlink RRP, and the preparation of our alternative forecast, we sought out the latest information and cross checked data by comparative analysis (such as normalisation) to ensure its fitness for purpose. We have used most recent available statistics for GSP and price data for our 2012 analysis. Through sensitivity testing, we identified the factors that matter (notably, GSP and price) and focused particularly on these variables.
Reconcile top and bottom forecasts	We reconciled the top-down forecast with the bottom up DNSP forecasts, separate from the major loads, to ensure that we understood past and future connection point loads and to avoid double counting in either ours or Powerlink's forecasts.
Use appropriate input assumptions	As above, we tested a wide range of inputs and selected the set that best met our selection criteria and that delivered a stable forecast. We conducted sensitivity testing to cross check the impact of the different data series available to us.

Source: EMCa/NZIER

5.6 High and low range for forecast

163. We have developed indicative high and low demand forecasts, based on sensitivity testing of key variables in our revised alternative forecast model. This testing showed that the impact of realistic changes to price in the outer years would have minimal impact on the forecast. We are mindful that the QCA has set price changes for 2012 and will be releasing its 2013 decision on price changes soon so that any price upside/downside to the medium forecast will apply beyond 2014. Further, that the AER has set distribution network prices to 2015.

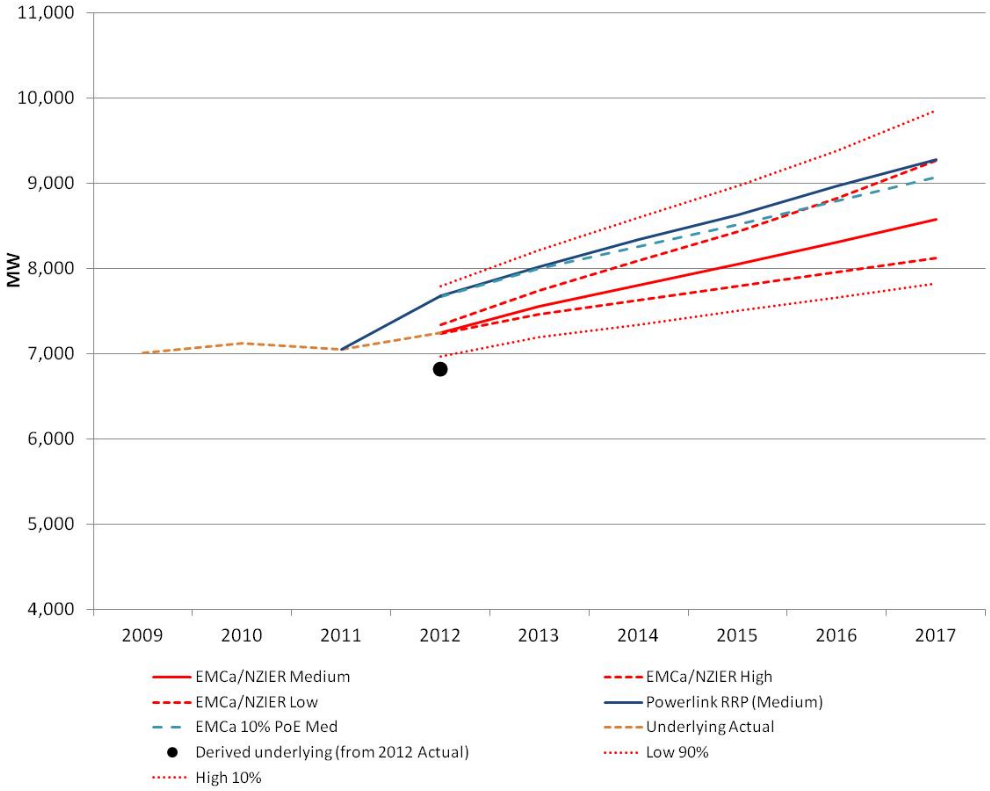
164. For GSP our tests showed that different scenarios would have a more significant impact. With our review of the GSP projections in Powerlink's check model in mind, we determined to use the Deloitte GSP growth path to 2017 as our high scenario base case and to supplement it with an additional 0.5% pa upside increment of GSP growth.

165. For the downside from lower GSP growth, we assumed a significant slowdown of 1% below Queensland Treasury's forecast.

166. The following graph shows the results of our assessment of high and low 5-year demand forecasts, together with the upper and lower temperature-related fluctuations. That is, the outer bounds represent the 90% PoE lower demand forecast and the 10% PoE high demand forecast respectively. The derived 2011/12 year to date approximation to underlying peak demand is also shown on the graph[37].

[37] For clarity, the 2011/12 demand point has not been used in estimating the demand forecast as this is recent data that was provided to us prior to verification.

Figure 10: EMCa/NZIER alternative forecast of underlying demand, with high and low forecast ranges (MW)



Source: EMCA/NZIER

5.7 Recommendation

167. We recommend that the AER adopts the revised alternative forecast that we propose in section 2.2.2 (and duplicated in section 5.3). Specifically we recommend that our revised alternative forecast for a medium scenario at 10% PoE temperature (as shown in table 1) should be used in place of Powerlink's medium forecast at 10% PoE, and that any other forecasts used for planning forecasts should be similarly adjusted.

A. Annexures

Annex 1: Temperature sensitivity analysis

168. We have described in the body of this report the importance of the temperature based adjustments that Powerlink makes to native peak demand to compensate for temperatures that are different from the historical average 50% PoE peak-day temperature. Powerlink derives the sensitivity relationship (MW per degree) by linear regression in each region except SEQ where Powerlink uses an "S-curve". Powerlink's assumed 50% PoE temperatures are as follows (sourced from 2011 APR). It is correction to these 50% long-term average temperatures that gives rise to the temperature adjusted historical peak demand that we included in our sensitivity testing of the regression model and that appeared as an outlier in our comparison of scenarios[38].

Table 22: Powerlink temperature adjustment assumptions (for 10% PoE adjustment)

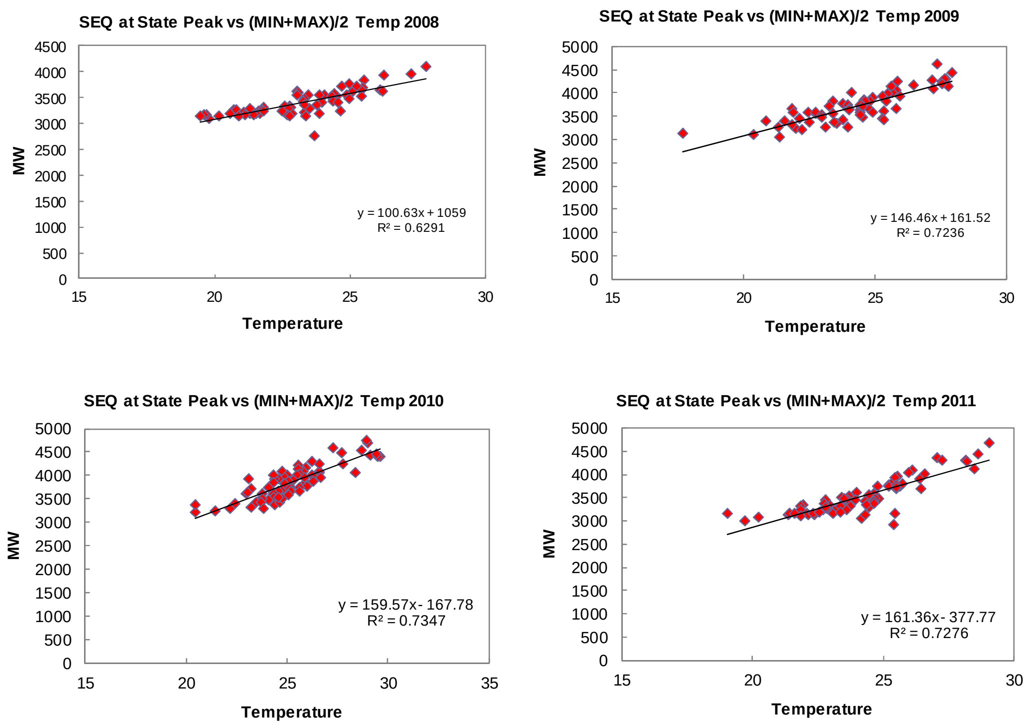
	Summer	
	10% PoE	50% PoE
Townsville for northern non-industrial native load (2)	32.7	31.0
Rockhampton for central non-industrial native load	33.2	32.0
Toowoomba for south west native load	30.2	28.0
Archerfield (Brisbane) for south east native load – winter only (3)	–	–
Amberley (Brisbane) for south east native load – summer only (3)	32.3	30.0

Source: Powerlink APR 2011, figure A.1

169. As in 2011, we analysed the eleven years of SEQ data provided by Powerlink both separately and together (with appropriate adjustments in the latter case, and as per our 2011 analysis, for inter-year effects). The results of this analysis for the past four years of data are shown in figure 11 below. We found a satisfactory linear demand/temperature relationship and no evidence to support the proposition that an S-curve might better fit the relationship. The coefficients are also similar to what Powerlink has found from the same data (around 160 MW/degree in the past two years).

38 See section 4.3.2 and section 5.4

Figure 11: EMCa/NZIER analysis of temperature / demand relationship (SEQ, years 2008 to 2011)



Source: EMCa/NZIER analysis from Powerlink data

170. Powerlink has provided us with the formula for its S-curve from its 2011 APR, which is as follows.

Table 23: Powerlink temperature correction S-curve for SEQ 2010-11

[C-I-C]

Source: Powerlink

171. We have used Powerlink's S-curve (as above) to compare the implied temperature sensitivity with the sensitivity from a linear model (using the coefficients as shown on the graphs in figure 11). We find that the S-curve gave a temperature sensitivity that would have ranged from 183 MW/degree to 196 MW/degree over the past 5 years, and which is considerably greater than the equivalent linear coefficients. We estimate that the S-curve approach would have adjusted temperatures upwards by 515 MW more than a linear correction (in aggregate) over the past 5 years.

172. The results for SEQ are also compared with Powerlink's total Queensland adjustments over this period, of 1,616 MW.

Table 24: Temperature adjustments – comparison between S-curve and linear adjustments (SEQ 2010-11)

				SEQ	SEQ	SEQ	SEQ	QLD
	Average Actual Temp SEQ	Powerlink 50% PoE temp SEQ	Temp adjustment C	MW per C (2011 S-curve)	S-curve adjustment	Linear adjustment	S-curve - Linear	Actual adjustment
2007	28.30	30.00	1.70	189	322	194	128	61
2008	27.80	30.00	2.20	193	425	218	207	568
2009	27.35	30.00	2.65	196	519	384	134	418
2010	29.00	30.00	1.00	183	183	159	24	328
2011	29.05	30.00	0.95	183	173	152	21	241
					1621	1107	515	1616
source:	Calc	PL APR	Calc	Calc	Calc	Calc	Calc	

Source: EMCa/NZIER analysis from Powerlink data

Annex 2: NIEIR forecasting variables

173. Powerlink's forecasting advisors, NIEIR, describe a range of variables that they take into account when preparing their energy and peak demand forecasts. We are unclear which variables are actually used and the way they are used in the forecasting process.

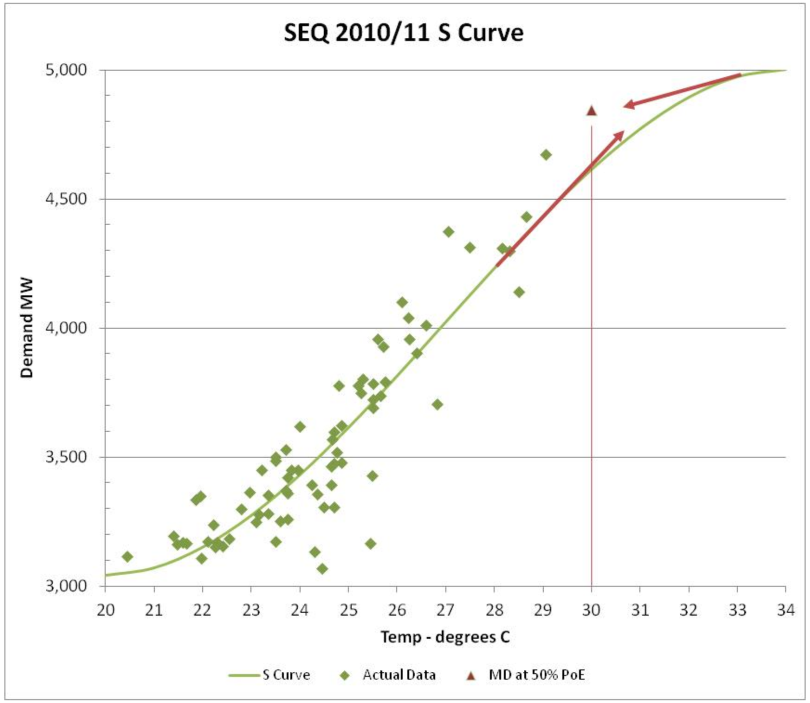
NIEIR forecast Variables
Population
Airconditioning use
GDP - Australia
GDP - World
GSP - Queensland
Final Demand - Queensland
Oil Prices
Inflation
Savings rate
Wage Levels
Balance of Payments
Exchange Rate
Interest Rates
Employment
Business investment
Housing investment
Mining growth

Annex 3: Response to other matters raised by Powerlink in its RRP

174. In the following table we respond to matters raised by Powerlink and its advisers in response to EMCa/NZIER's 2011 demand forecasting report. We note that our 2011 alternative forecasting model and associated data series were also provided to Powerlink by the AER, though we understand that this was not made available to Powerlink's advisers.

175. Matters of substance have been dealt with in the body of our report. The following table therefore responds to matters that have a peripheral or limited impact on the main purpose of the current work, which was to assess Powerlink's RRP demand forecast, and corrects apparent misunderstandings and incorrect assumptions made by Powerlink and its advisers. We have noted actions that we have taken, where relevant, in the current assessment and in this report.

No.	ISSUE NAME	WHO RAISED IT	ISSUE RAISED	RESPONSE	ACTION
1	Use of Average Temperatures	Powerlink - p52 RRP	References not cited	References were cited for studies that had used daily maximum temperature as the key variable.	None required
2	Use of Average Temperatures	Powerlink - p52 RRP	Use of average temperature for peak demand correction	We concur with Powerlink's view that overnight minimum temperatures tend to have an effect on subsequent-day peak demands. We remain unconvinced that overnight minimum temperatures have the same weight as the daytime maximum temperature, in influencing demand on a given day (and which is the effect of using a daily mean which Powerlink specifies as (max+min)/2) . For example, the ACIL Tasman analysis quoted in table 6.2 shows a better correlation with maximum temperature than with average temperature in 4 of the past 6 years, and materially the same in one other of those years. Other references that we have reviewed tend to give lower weightings to prior temperatures (including previous overnight, previous day maxima etc). Nevertheless we can achieve a satisfactory, if not optimal, correlation between peak demand and mean daily temperature, which Powerlink proposes. Moreover, Powerlink's RRP check model now shows that Powerlink does not use temperature-corrected historical peak demand as an input; rather, Powerlink's model uses non temperature corrected energy (GWh) data.	EMCa/NZIER 2012 model has been specified using mean daily temperature as an input variable.
3	Use of Average Temperatures	ACIL Tasman p20 to 25	Range of other temperature issues	ACIL Tasman conducted various analyses regarding the use of average temperature using historical data from SEQ to demonstrate that Powerlink's use of average temperature is valid. We are unclear about the data used and the inconclusive results of ACIL's analysis are consistent with our findings regarding the lack of evidence on this subject. By its very process averaging removes the	None required.

				outliers and delivers a better R-squared.	
4	S-curve	Powerlink RRP page 55 and ACIL Tasman report page 15 to 17.	S-curve relationship and direction of bias	Powerlink correctly notes (p55) the asymmetrical nature of the S-curve and states that it is justified because of the special nature of the demand to temperature relationship in SEQ. The purported evidence by ACIL Tasman of a downward bias is from a contrived and limited example that represents an incorrect comparison. The arrows on the chart below provide a simple line of sight on this matter – correction of demand on the basis of an S curve leads to greater upward correction in cooler years than corresponding downward corrections from hotter years.  	None required - Powerlink does not use temperature adjusted data in its check model and has advised that it does not provide temperature-adjusted data to NIEIR for use in its modelling. Indirectly, temperature correction affects Powerlink's "corrected" load factor which appears to be influencing Powerlink's projection of load factor, and which is an exogenous adjustment in Powerlink's forecasting method. This issue is addressed in our assessment of Powerlink's forecast.

5	S-curve	Powerlink RRP page 55 and ACIL Tasman report page 15 to 17.	S-curve relationship of demand to temperature	Powerlink's statement that there is a distinct S-curve relationship at the lower end of the curve, is indicative of the issue that we have raise since (to the extent this is believed to exist) it drives an S-curve levelling-off at the top end, which is where the demand adjustments are made. We have re-analysed the data and remain of the view that there is no satisfactory evidence to support an S-curve relationship.	None required. Impact as above
6	S-curve	Powerlink RRP page 55 and ACIL Tasman report page 15 to 17.	S-curve data presented as a single series	EMCa/NZIER undertook considerable analysis of the demand/temperature data provided by Powerlink, a summary of which was reported in our 2011 report, to look for evidence of the S-curve relationship claimed by Powerlink. This included analysing the data within each year, and also analysing the full data set. In the latter case, the data was normalised to adjust for demand growth year-on-year, in the manner that Powerlink suggests is necessary. Our analysis included a review of the data presented by Powerlink in Figure 6.2 of the RRP, and which does not show statistically valid evidence of a non-linear relationship of demand to temperature. We are unable to comment on other material on temperature as presented by ACIL Tasman or Powerlink without access to the underlying data that generates these outputs. The evidence presented in the RRP does not support the assertions made in this regard. EMCa/NZIER found evidence, as Powerlink state, of an increase in temperature sensitivity over the period, and we have taken this into account in our adjustment for the PoE 10% demand forecast.	EMCa/NZIER have used Powerlink's relationship between the PoE50% and PoE10% forecasts, to derive EMCa's PoE10% forecast. Temperature corrected peak demand data has not been used in Powerlink's check model, was not provided to NIEIR for use in its modelling, and we do not use it in determining our alternative forecast.

7	S-curve	Powerlink RRP page 56	Failing to adjust for temperature	EMCa/NZIER's demand forecast model corrects for temperature by incorporating temperature in the regression model. In this way the regression determines the impact of temperature on the same basis that it determines the impact of other explanatory variables. This is consistent with good practice and is preferred over approaches which seek to adjust for some explanatory variables outside of the model specification process.	EMCa/NZIER correct for temperature within the forecasting model.
8	Population	Powerlink RRP page 56	Using absolute population rather than growth rates	EMCa/NZIER's 2011 forecast model used absolute population, price and maximum temperature to forecast absolute peak demand in each year. Growth rates in peak demand in such a model are a function of growth rates in the explanatory variables. The implied criticism in the RRP seems to reflect a misunderstanding of the mathematics of such models.	None required.
9	Population	ACIL Tasman p26	NIEIR population projections provide an upward bias	NIEIR population projections are at a level above other predictions of Queensland population and have a higher growth rate. ABS growth projections average 2% to 2017 while NIEIR's 2012 projection average is 2.5%, up from 2.3% for the 2011 APR.	None required, as population is not used in Powerlink's RRP check model nor in our proposed alternative forecast which responds to the RRP.
10	Electricity Prices	Powerlink RRP page 57 - 58	Data sources for price result in forecasts that are unreasonabl e	EMCa/NZIER's 2011 forecast model used information from ROAM for historical price data. Independent data from ABS confirms the trend from that data series. EMCa/NZIER developed a retail price series for the purpose of this work.. We did not, as implied in the RRP, obtain a price projection from a solar power supplier. The retail price projection check series that we used in 2011 and again for the current review is based on wholesale price projections, QCA approved increases for retail prices and AER-approved increases for distribution network charges. This series has the correct components and produces end-of-period aggregate	None required.

				price growth that is similar to NIEIR's advice to Powerlink. Data from different sources has been combined in an appropriate manner.	
11	Electricity Prices	Powerlink RRP page 58	Price elasticity of demand is half that of energy	EMCa/NZIER is aware of the cited AEMO comment re demand elasticity. As noted in our report, the peak demand elasticity in our alternative model accords with this expectation, while the very low energy elasticity to price in Powerlink's check model is not consistent with the sources quoted by Powerlink (AEMO, ACIL Tasman, RAND Corporation).	Accounted for in our assessment
12	Price Elasticity	Powerlink RRP page 59	Flawed analysis predicts a high price elasticity	The range for short and long term price elasticity for energy found in the literature is very wide from 0 to -0.7 (see ACIL Tasman p36 for some references). We would expect to see energy price elasticity of between -0.2 and -0.4. The derived elasticity from our 2011 analysis was -0.34 for QLD and 0.21 for SEQ. Table 6 p36 of ACIL Tasman report shows NIEIR having apparently determined a positive price elasticity while the 2012 Powerlink check model shows a price coefficient of -0.08. The EMCa/NZIER 2012 alternative model has a demand elasticity of -0.14.	None required. Information is accounted for in our assessment.
13	GSP	Powerlink RRP page 60	AER fails to forecast the mining and resource boom in QLD	EMCa/NZIER has used Powerlink's data for projected mining and major customer load growth. The flow-on effect of this is reflected in Queensland's population growth (which was used as an explanatory variable in our 2011 analysis) and in GSP growth (which is used in our 2012 analysis, consistent with Powerlink's check model).	None required.
14	GSP	Powerlink RRP page 60	EMCa/NZIER failed to analyse NIEIR GSP	EMCa/NZIER has twice requested access to the form of NIEIR models and the detail of the inputs to the models but has not been provided access to that information. We understand that Powerlink does not have access to this information.	None required. Our assessment and revised forecast takes account of NIEIR information.

			data		
15	GSP	Powerlink RRP page 61-62	GSP is the dominant driver of MW demand	EMCa/NZIER tested the relationships between the variables and MW demand and considered that price, population, temperature and GSP all play a role in energy forecasting. GSP and population data has a very strong correlation, of .99, suggesting that either can be used for MW demand forecasts. For our 2011 analysis we were not provided with a model to assess the factors that had been used in determining Powerlink's forecast. Model specification using both population and GSP is difficult because of this colinearity. For the RRP, Powerlink provided its check model which used GSP and we have prepared an acceptable model using this variable.	None required. Our revised forecast uses GSP and other variables.
16	GSP	Powerlink RRP page 62-64	NIEIR understate GSP forecasts	EMCa/NZIER were not provided access to NIEIR data and models and were unable to examine inputs and assumptions to make a considered assessment of this and other matters.	None required. Our revised forecast uses GSP and other variables from independent sources.
17	Forecasting Performance	ACIL Tasman p55 and PL RRP p68	EMCa backcast performs poorly	Despite a short data history but in keeping with best practices, EMCa/NZIER use ex ante and ex post testing of the forecast of 1 and 2 years. Taking 4 years out of sample from a total 11 years is an inappropriate approach and merely reflects short term variances through that period. EMCa notes that graphs in the RRP (and Powerlink's consultant reports) which refer to the "EMCa model" are not in fact the EMCa model.	We have tested the EMCa/NZIER proposed model for stability and sensitivity using valid statistical techniques. The results are presented in the current report.
18	Forecasting Performance	Powerlink RRP p66	EMCa uses in sample backcasting only	In sample backcasting is a standard approach to model validation and serves to confirm the fit of the regression. EMCa conducted ex ante and ex post testing which takes out of sample actuals and compares these to the forecast data. The length of the data series is critical to the validity of this approach.	We have tested the EMCa/NZIER proposed model for stability and sensitivity using valid

					statistical techniques.
19	Forecasting Performance	Powerlink RRP p66 - 67	Powerlink check model backcasts better than EMCa	See our responses to issues 17 and 18 above. The large out of sample test that Powerlink undertakes is inappropriate. We also refer to our detailed review of this check model in the body of this report.	Assessment of Powerlink RRP check model and revised alternative EMCa/NZIER model is covered in the current report.
20	Quality of EMCa forecast model	Powerlink RRp p70-71	EMCa model is unsound	The models we have used for our assessments forecast MW direct from explanatory variables, which is best practice for energy and demand forecasting. The 2011 model used one set of variables (excluding GSP) while the 2012 model uses another set (including GSP). They deliver very similar forecasts and each meets selection criteria in its own right.	We have assessed methodology issues in some detail in the body of this report.
21	Quality of EMCa forecast model	Powerlink RRP p 71	EMCa model does not capture economic drivers	Powerlink and its advisors appear to consider GSP as the prime (and in effect the only) driver of peak demand. We accept the widely held view that GSP drives energy consumption but it is less clear that GSP is a better predictor of peak demand than other variables, such as population or numbers of households (at least for the residential sector). For the RRP, Powerlink provided its check model which used GSP and we have prepared an acceptable model using this variable.	The current analysis included extended analysis of alternative explanatory variables, the results of which are described in the current report.
22	Quality of EMCa forecast model	Powerlink RRP p 71	Biased relationship between population and demand	Figure 6.8 of the RRP purports to describe the results of analysis by ACIL Tasman of a population driven regression model before and after the economic slowdown following the 2008 GFC. The conclusions drawn in the report are invalid because it seems that the point being made is one of being able to forecast economic shocks from pre-GFC data, not of forecasting peak demand using population as a driver. We note that the 2008 GFC was not widely predicted.	No further action required.

23	Quality of EMCa forecast model	Powerlink RRP p 72	Unreasonable relationship between price and demand	The 2011 alternative model had a price elasticity of -0.3 and the revised alternative model has a price elasticity of -0.14. Both are within an acceptable range.	The assessment of price coefficients is covered in the current report.
24	Quality of EMCa forecast model	Powerlink RRP p 73	Max temperature coefficient fails to capture increasing sensitivity	The temperature coefficient in the regression model for 50% PoE forecasts is only relevant to the forecast insofar as forecast temperatures are assumed to vary from average historical temperatures. Our projection is based on the average of historical temperatures and we consider it unnecessary and somewhat heroic to attempt to include provision for a warming trend in a 5-year forecast. We observe that the temperature coefficient in the regression model is likely to be strongly influenced by the lower summer temperatures over the last 4 years, that is, more recent history of significant temperature sensitivity would have a greater influence on the coefficient than earlier periods in the data series For our 10% PoE forecast we have used the relationship determined by Powerlink.	Assessment of temperature impacts is covered in Annex 1 of this report.
25	Quality of EMCa forecast model	Powerlink RRP p 73	EMCa model backcasts poorly	This statement does not accord with valid analysis of the model. Please see our responses to issues 17 to 20.	Assessment of backcast results and model stability is covered in the current report.
26	Assessment of EMCa against principles	Powerlink RRP p 74	EMCa model fails to meet forecasting standards	This statement is not supported by valid analysis. Evidence was provided in the 2011 report, and further evidence is provided in the current report for the methods and explanatory variables. These accord with good industry practice, using official data series where possible and the models have been extensively tested.	None required. Evidence is provided in the current report.

Annex 4: References

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Weron, R. (2006). Modeling and Forecasting Electricity Loads and Prices, John Wiley & Sons, Ltd.