Powerlink Revenue Determination 2013-17

Demand Forecast Review

Report to

Australian Energy Regulator

Public Version

Energy Market Consulting associates
NZIER Consulting

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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.

NZIER is also known for its long-established Quarterly Survey of Business Opinion and Quarterly Predictions.

Our aim is to be the premier centre of applied economic research in New Zealand. We pride ourselves on our reputation for independence and delivering quality analysis in the right form, and at the right time, for our clients. We ensure quality through teamwork on individual projects, critical review at internal seminars, and by peer review at various stages through a project by a senior staff member otherwise not involved in the project.

NZIER was established in 1958.

Authorship

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1 Introduction

1.1 Background

1. The Australian Energy Regulator (AER), in accordance with its responsibilities under the National Electricity Rules (NER), is required to conduct an assessment into the appropriate revenue to be obtained from provision of prescribed transmission services provided by Powerlink from 2012/13 to 2016/17 (the next regulatory control period, or RCP). The process that the AER is required to follow is described in chapter 6A of the NER.

2. This demand forecasting review is a review of the 2013-17 Revenue Proposal that Powerlink provided to the AER on 31 May 2011[1].

1.2 Scope and approach

1.2.1 AER scope and ToR

3. EMCa, in association with NZIER, was appointed by the AER as demand forecast consultant and was requested to undertake a review of the methods, inputs and data sources used by Powerlink in the energy, maximum demand and weather correction models that underpin its forecasts. Our assessment is to

[1] 2013-17 Powerlink Queensland Revenue Proposal (to AER), and including associated supporting information

assist the AER in forming an opinion on the forecast expenditure in Powerlink's revenue proposal, to the extent that this is influenced by forecast demand. In particular, we have regard to the methods used by Powerlink to develop maximum demand forecasts, which tend to drive a significant proportion of capital expenditure requirements.

4. The ToR for this work are attached in Appendix A.

5. As a result of work undertaken under the original TOR, we were asked by the AER to develop an alternative demand forecast. Our methodology and resulting proposed forecast are included in this report. This forecast is intended to assist the AER in considering Powerlink's proposed capital expenditure requirements (capex).

1.2.2 Framework for assessment

6. The approach taken to forecasting needs to suit the particular purpose and a sound understanding of the forecasting methodologies is essential to the integrity of any review. We have also drawn on the substantial body of international literature about electricity demand forecasting to guide our overall approach, which is principle driven as follows:

- Driven by sound regulatory, economic and industry practices – drawing on an understanding of regulatory requirements, electricity transmission planning industry practices, and "sensible" and current economic forecasting practices;
- Data driven – allowing us to provide advice to the AER based on objective analysis;
- Robust – subject to appropriate statistical tests and checked by a back-casting process. At the same time, we have run limited scenario analysis to take into account the impact of particular changes that may occur through the regulatory period.

1.2.3 Assessment criteria

7. Our first step is the identification of the criteria against which to assess the reasonableness of Powerlink's forecasts. The principles guide our thinking here, while the National Electricity Rules direct the high level regulatory requirements. Our assessment criteria are set out as follows:

- NER requirements – directed by legislation;
- NZIER assessment principles – our core framework;
- Powerlink strategic approach, including its network planning criteria and business criteria;
- Industry practices – evidence and experience;

- Market requirements – treatment of distributor and major load forecasts.

8. In setting out these criteria we are mindful that our role is to assess the reasonableness of the forecast from a top-down perspective and, as/if required, to advise on adjustments to the forecast proposed by Powerlink from this perspective. Our role was not to develop a demand forecast from first principles. Accordingly, we have made trade-offs (materiality, scale and nature of risks and the like) in order to make an assessment that is appropriate to the purpose for which it is to be used.

1.2.4 Process & our approach

9. To conduct our assessment we undertook the following process steps:

- Reviewed Powerlink's overall approach to demand forecasting, especially how this is implemented in its demand methodologies;
- Considered the suitability of the forecast method selected by Powerlink with respect to the term of the forecast and the alternatives available;
- Reviewed previous demand forecasts by Powerlink as a backdrop to this assessment, identifying and reviewing changes and comparing to industry practices as required;
- Undertook a detailed analysis of the structural nature of Powerlink's demand models, how the models take and use data and the factors that have been included in its analysis;
- Conducted econometric analysis to test Powerlink's forecasts, using core electricity demand drivers;
- Reviewed the weather normalisation approach and how this has been applied by Powerlink to the regional differences in Queensland;
- Reviewed Powerlink's approach to the translation of connection point peak demand forecasts into regional and state peak demands;
- Conducted a review of the inputs to Powerlink's forecast (data, data sources and assumptions) at an aggregate level and at a regional level.

1.2.5 Data sources

10. In assessing the reasonableness of the forecast we drew on a number of data sources:

a. Powerlink regulatory documents, principally as follows:
   - Revenue proposal 2013-2017 (public);
   - Powerlink 2010 demand forecasts (2011 – 2020) (confidential, as used for 2013-2017 revenue proposal);

- Powerlink demand and energy forecasting description and methodology (2011);
- ROAM Consulting report: Generation Scenarios for 2012 Revenue reset Application (confidential, provided by Powerlink);
- Information and data provided by Powerlink in response to requests;
- Other regulatory data (eg: NIEIR economic and electricity forecasts);

b. Powerlink company data

- Annual Planning reports, Annual reports, Statement of Intent;

c. NZIER own sourced data for in-house testing;

d. Queensland economic, demographic and other data. We used own sourced independent data in our testing of Powerlink's forecasts and drew on internal data from other demand forecast reviews where appropriate.

11. We wish to acknowledge the assistance that Powerlink provided with this review. This assistance was of a highly professional nature, as evidenced in the course of on-site meetings and by Powerlink's prompt and open provision to us of supporting information and responses to queries.

1.3 Our qualifications

12. 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.

13. Paul Sell is the Director of Energy Market Consulting associates Pty Ltd, based in Sydney. Paul is an energy economist with 30 years' experience, specialising in electricity and gas markets, with major experience advising on structural reforms and resulting regulatory regimes and markets in the Australian electricity sector, commencing in the early 1990s. His experience includes producing demand and expenditure forecasts, policy advice, regulatory analyses and business analyses in relation to electricity transmission and/or distribution networks in jurisdictions including Victoria, Western Australia, Queensland, New Zealand, Ontario and in the Philippines. Paul was previously a Vice President in the global professional firm Capgemini and a Partner in Ernst & Young consulting. Paul holds an honours degree in economics, specialising in Operations Research.

14. David is a consulting economist of 15 years. Prior to that, David's commercial experience was in business economics in technology firms, holding senior corporate and operational roles in Telecom New Zealand. He has considerable experience with demand analysis and especially with forecasting. As a

consulting economist he has current experience with regulatory economics having advised the NZ Commerce Commission for two years and has very recently advised on electricity transmission projects in New Zealand. The NZIER staff working on this review with David have experience in electricity transmission load forecasting and econometrics. David has two Masters degrees.

1.4 Structure of this report

15. We present our findings and recommendations in section 2.

16. In section 3 we describe Powerlink's approach to preparing its demand forecast, and the forecast that Powerlink has proposed as part of its Revenue Proposal. This description is based on information provided to AER as part of Powerlink's Proposal, together with information provided by Powerlink in response to our requests, and information and explanations provided by Powerlink at our on-site meetings.

17. We provide our assessment in section 4. This includes an assessment of Powerlink's forecasting performance, its forecasting framework and methodology (disaggregated into component parts) and an assessment of the demand forecast Powerlink has proposed to AER.

18. In section 5 we describe our assessment of an alternative forecast that we consider will better meet the revenue determination requirements of the AER.

19. Some further background information and references are provided in annexures.

20. This public version of the report has been redacted in accordance with advice from AER.

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2 Key Findings and Overall Assessment

2.1 Headline findings

21. We consider that the demand forecasts that Powerlink has proposed for its 2013-17 Revenue Proposal, should not be accepted. We consider that the forecasts overstate the initial “starting point” by overstating a “step increase” from the most recent peak demand, even after allowing for a cooler recent summer and the effects of the 2010/11 cyclone and severe flooding in Queensland, and that they overstate the subsequent demand growth rate.

22. The reasons why we have formed this view are as follows:

a. Powerlink’s current forecast uses 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, as previous over-stated forecasts;

b. Powerlink has (in its 2011 APR) already reduced its forecast from that proposed in its Revenue Proposal, particularly in the early years of the forecast, and its 2011 high-demand forecast represents what is in effect a series of one-year demand deferrals relative to the forecast in its revenue Proposal;

c. Powerlink’s approach taken to temperature correction appears to over-state that correction and also to distort the resulting forecast;

d. A range of structural changes is evident to us from our independent examination of data, including a declining demand growth rate and a declining “energy intensity” of demand growth with GSP and population. We do not see evidence that these have been taken into account;

e. The macro-economic forecasts used to drive the econometric forecast model appear to be towards the upper end of accepted forecast ranges;

f. We consider that the effects of recent and projected retail price changes have not been adequately accounted for;

g. We do not see evidence of the forecast accounting appropriately for the effects of the "two-speed economy" or of assessing forecast demands appropriately at sectoral level. Growth in the commercial component of the demand forecast used as a key input by Powerlink appears high and the effects of lower economic activity in the non-mining sectors appears not to have been fully accounted for;

h. We do not see evidence that we would find satisfactory, accounting for increasing embedded generation, distributed generation and energy efficiency measures[2].

2.2 Alternative forecast

23. We have undertaken an assessment to quantify the impact of the concerns expressed in our findings on the demand forecast proposed by Powerlink, and to recommend adjustments to provide a more appropriate forecast. Preparation of this alternative forecast did not involve a "blank page" approach; rather, we have undertaken an assessment to provide a forecast that we consider to be more appropriate than that proposed by Powerlink, and to address the more material concerns raised in our findings.

24. The resulting alternative forecast is presented below, and compared with Powerlink's proposed demand forecast. The graph in figure 1 shows the underlying "core" demand (i.e. excluding direct connected, mining and LNG loads) and the resulting aggregate demand forecast, compared with historical demands (actual, and as temperature corrected by Powerlink) and Powerlink's proposed forecast.

Table 1: *EMCa/NZIER alternative demand forecast*

MW

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Med Scenario 90% PoE	8,674	9,089	9,536	9,983	10,357	10,563
Med Scenario 50% PoE	**8,841**	**9,259**	**9,710**	**10,161**	**10,537**	**10,746**
Med Scenario 10% PoE	9,205	9,632	10,090	10,547	10,931	11,146

Source: EMCa NZIER

[2] These matters are partially addressed in NIEIR's 2011 forecast advice to Powerlink, but this is not the basis for Powerlink's Revenue Proposal forecast.

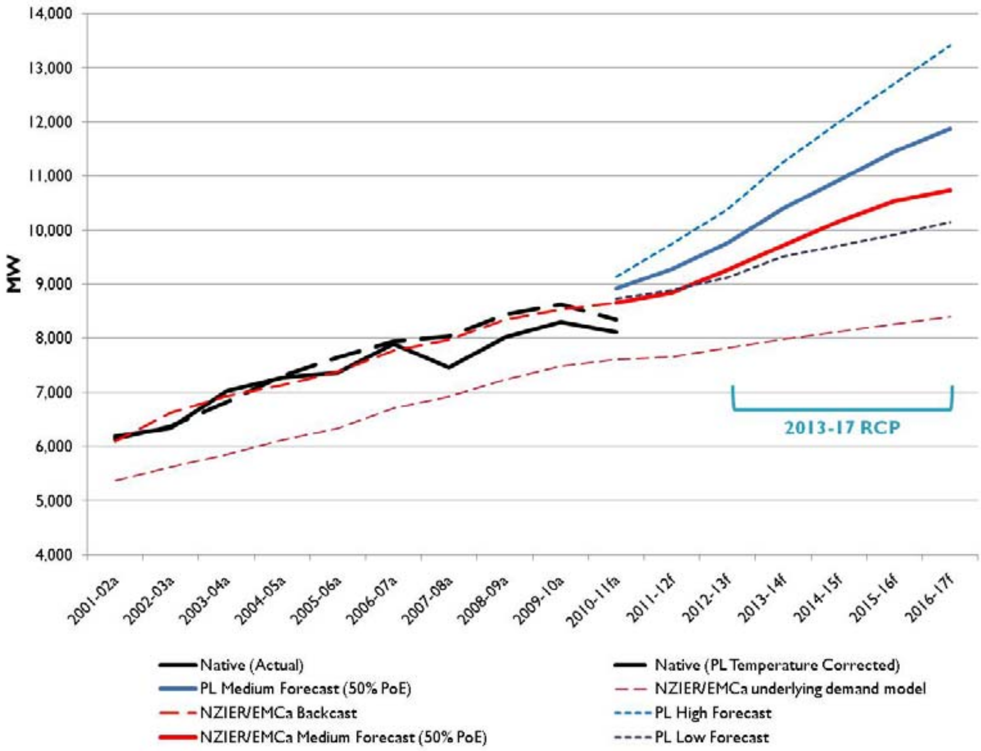
Table 2: *Proposed adjustments to Powerlink demand forecast*

MW

	2011/12		2012/13		2013/14		2014/15		2015/16		2016/17	
Med Scenario 90% PoE	-	318	-	378	-	554	-	630	-	763	-	974
Med Scenario 50% PoE	**-**	**439**	**-**	**506**	**-**	**690**	**-**	**769**	**-**	**910**	**-**	**1,131**
Med Scenario 10% PoE	-	548	-	620	-	817	-	903	-	1,053	-	1,291

Source: EMCa NZIER

Figure 1: *Alternative Queensland forecast summer peak demand*



Source: EMCa NZIER, and including comparison data from Powerlink

2.3 Recommendations

25. We recommend that the AER not accept the use of Powerlink's proposed demand forecast as a basis for determining a capex allowance in Powerlink's revenue determination.

26. We recommend that the AER adopt the alternative forecast that we have proposed in section 2.2 above. Specifically we recommend that our alternative forecast for a medium scenario, at 10% PoE temperature, should be used in place of Powerlink's medium forecast at 10%PoE, and that any other forecasts used for planning purposes should be similarly adjusted.

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3 Powerlink's forecasting process and proposed demand forecast

3.1 Introduction

27. In this section we outline the context for Powerlink's demand forecasts, and describe Powerlink's forecasting process and key aspects of its methodology. More detailed and specific aspects of Powerlink's methodology are described under the relevant sub-sections of our assessment, in section 4.

3.2 Purpose and use of Powerlink demand forecasts

3.2.1 Purpose and regulatory context

28. Powerlink prepares demand forecasts for a number of purposes. These include:

- preparing the regulatory Annual Planning Report (APR) – 10 year term;
- strategic studies for NEM planning purposes – up to 20 year term;
- internal network planning – various terms.

29. While the focus of Powerlink's APR is on the next 10 years, it is also used to forecast the next 5 years to meet regulatory requirements under the NER. Powerlink's (and other TNSPs) long term planning and forecasts are heavily supported by NIEIR[3], which prepares economic and electricity demand forecasts for the industry. NIEIR prepares the 20 year forecast that Powerlink provide to AEMO for interstate network planning in the NEM.

30. Powerlink prepares its demand forecast in accordance with Chapter 6A of the National Electricity Rules (Rules) and the AER's Electricity Transmission Network Service Providers Submission Guidelines. Powerlink records that

> *"during the next regulatory period, Queensland's transmission network will require continued investment to reliably meet the State's economic growth and to support a lower emissions National Electricity Market (NEM)".*[4]

31. Powerlink's demand forecast is updated annually and published on 30 June in its Annual Planning Report. The APR is prepared under the requirements of the NER as part of a transparent and public process that integrates distributor, major load and TNSP forecasts into national forecasts.

3.2.2 Powerlink interpretation and application of regulatory forecasting requirements

32. The quality, reliability and security of supply of prescribed transmission services supplied by Powerlink are established in the NER, in Powerlink's Transmission Authority and in customer connection agreements. Powerlink is the sole holder of a Transmission Authority in Queensland, which authorises it, under the Queensland Electricity Act 1994, to operate a high voltage transmission network in the eastern part of Queensland. A salient feature of the arrangements in Queensland is that Powerlink has mandated reliability obligations. Section 34 of The Queensland Electricity Act, provides that a Transmission Authority holder has a responsibility to:

> *"...ensure, as far as technically and economically practicable, that the transmission network is operated with enough capacity (and, if necessary, augmented or extended to provide enough capacity) to provide network services to persons authorised to connect to the network or take electricity from the network "* [5]

[3] NIEIR is a research and forecasting organisation based in Melbourne. In this report we reference the NIEIR 2010 forecast report to Powerlink, and which we understand was used as the basis for Powerlink's Revenue Proposal, unless we specifically state that we reference the equivalent 2011 report (which was provided subsequent to the Revenue Proposal).

[4] Section 2.1 Powerlink revenue reset proposal.

[5] Section 3.2 Powerlink revenue reset proposal.

3.2.3 Forecasting principles

We have reviewed a range of demand forecast methodology documentation provided to us by Powerlink and have discussed this methodology and associated processes with Powerlink personnel on-site. We consider that the Powerlink staff and management involved with demand forecasting have recognition of the drivers for demand forecasting, the need to represent uncertainty and the sources of that uncertainty. In particular, this includes recognition of issues such as the effects of long-term economic and population drivers, changes in utilisation profiles (for example air conditioner uptake and usage patterns) and temperature – in particular hot and humid days occurring in sequence.

We were not provided a "statement of principles" or similar that would formally recognise the purpose of the forecast or a set of guiding principles that would help to prioritise the matters of greatest importance and the most appropriate methods, time-horizon and scope for the demand forecasting process. We[6] have previously assisted an electricity transmission utility in establishing such a framework and, in section 4, we provide our assessment of Powerlink's demand forecasting framework against a set of such principles.

3.2.4 Powerlink business objectives

33. Powerlink's business objectives from its Statement of Corporate Intent are summarised as follows:

   a. Develop the grid to meet reliability standards as Queensland's load grows;

   b. Deliver a rate of return on investments at least equal to that implicit in the WACC determined by the regulator;

   c. Maintain an "investment grade" credit rating;

   d. Retain leadership as the most cost effective TNSP in the NEM;

   e. Do all this safely (public & employees);

   f. Attract and retain the necessary skills and capabilities.

34. From our review of documentation as well as our interaction with Powerlink personnel we consider that Powerlink's planning and forecasting approach is orientated towards the technical and operational side of the business to meet its mandated obligations of network security and reliability, as per its business objectives. Powerlink's use of demand forecasts in network planning appears consistent with normal industry practice in this regard.

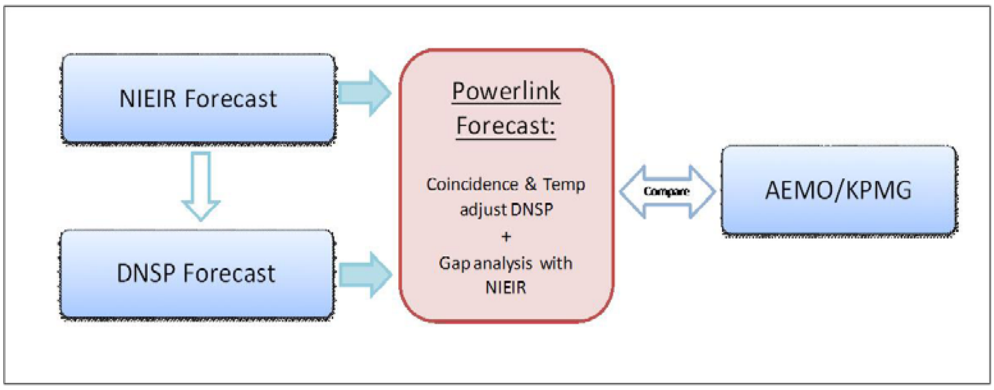
3.3 Powerlink methodology for forecasting

35. Powerlink's approach to forecasting takes into account the characteristics of Queensland electricity demand, reflecting geographic diversity with differing weather

[6] Advice by NZIER

patterns is essential when combining demands into a state forecast. For these reasons, Powerlink uses a "Bottom Up / Top Down" approach to forecasting as shown in the diagram below. [7]

Figure 2: *Powerlink demand forecasting process*



Source: NZIER (from description by Powerlink)

36. Under clause 5.6.1 of the NER, each distributor and direct connect customer is required to provide Powerlink with its ten year connection point demand forecast while Powerlink, as a TNSP, is required under the provisions of Clause 5.6.2A to publish the forecasts submitted. Powerlink uses these "bottom up" inputs to construct its state-wide coincident forecast for customer energy and demand at the connection point level. These forecasts are produced for 10%, 50% and 90% PoE, representing probabilities essentially related to maximum summer temperatures[8]. These forecasts are prepared for what we understand to be a medium growth scenario.

37. Powerlink engages NIEIR to undertake a "top down" demand forecast based on econometric models and this provides Powerlink with Low, Medium and High growth forecasts of peak demands. The NIEIR forecast is prepared for Powerlink at a state level while for the distributors we understand that NIEIR produces forecasts at a regional level.[9] We understand that the distributors use the NIEIR-sourced regional forecasts as top-down input to their connection point-level demand forecasts, which are passed to Powerlink as the connection point-level inputs to its forecasting process, as described in the previous paragraph.

[7] As per Powerlink Demand and Forecasting Policy.

[8] As previously stated, it is the 10%PoE forecast that drives capex but for presentational reasons it is logical for Powerlink to present the 50% PoE forecast, and then to develop its 10%POE forecast from this.

[9] We understand that the regions correspond to the previous regional electricity boards but are not the same as the temperature "regions" used later in this report. We expect that the distributors would themselves undertake a reconciliation between the NIEIR regional forecasts provided to them and their expectations of demand growth at each connection point.

38. Powerlink makes a series of adjustments to the connection point forecasts of demand that it receives from the distributors to allow for "regional peak energy coincidence" that is built into the NIEIR forecast. By way of overview, we understand that Powerlink takes inputs of regional demand and calculates the relationship between the connection point peak and the state peak (i.e. coincidence of peak demand) using historical data from each connection point. This relationship is then used to calculate the Queensland state coincident maximum demand forecast (for "native load" at 50% PoE).

39. Powerlink estimates a temperature adjustment to its demand forecast, in order to provide a demand forecast with a PoE of 10%. Powerlink has assessed the normalised temperatures for each region and its 50% PoE forecast assumes these normalised temperatures. In order to provide a "one-in-ten year" demand forecast for capex planning purposes, Powerlink has assessed 10% PoE temperatures for each region and, using a relationship that it has developed between temperature and demand[10], Powerlink produces a resulting 10% PoE demand forecast.

40. As an example, Powerlink has assessed an average summer temperature benchmark of 30 degrees for the Brisbane area (SEQ) based on its assessment that this is the long-term "maximum daily average" summer temperature[11], and has similarly assessed that the 10% PoE temperature is 32.2 degrees. Using the demand adjustment relationship that it developed, Powerlink determines 10% PoE demand forecast for SEQ assuming 32.2 degree daily maximum average temperatures.

41. Finally, for capex planning purposes an allowance is made for embedded generation using a trend method, to produce a forecast of "delivered demand". The maximum customer demand forecast is further adjusted for transmission losses so as to determine generator "sent out" demands, which are relevant in load flow analysis.

3.4 NIEIR forecasting process

42. Powerlink outsources to NIEIR the process of developing mathematical models to derive the relationship between key drivers and historical electricity demand for Queensland, and then projecting that relationship into the future using forecasts of the key drivers.

43. The NIEIR methodology takes data from ABARE on electricity sales (GWh) by sectors (residential, commercial etc) and uses its own industry model and projections of demand drivers to forecast energy consumption. NIEIR states that its models use a range of drivers, including prices, output by sector and real incomes while also taking into account weather conditions to produce energy forecasts by region.

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[10] This relationship is assessed in section 4.6

[11] Powerlink assesses the normalised temperature as the historical average of annual maxima of daily maximum average temperatures (i.e. the average of the daily maximum and minimum temperatures).

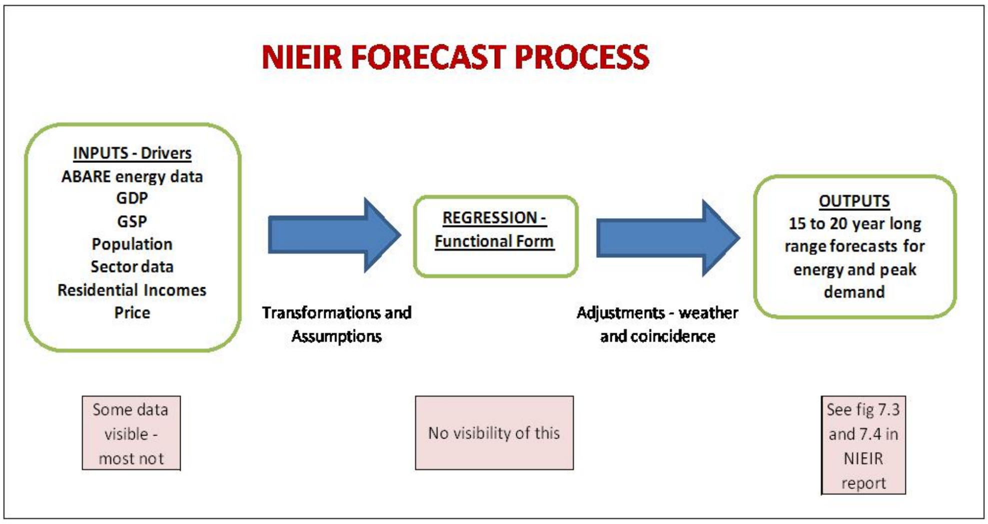
44. In 2010 NIEIR was required to develop maximum demand forecasts by region for Powerlink and it is these forecasts that we understand were used as the basis for Powerlink's regulatory demand forecast[12]. NIEIR used detailed historical demand data from Powerlink to calculate the coincident peaks in each region which were then fitted to the Queensland state maximum demand.

45. We are informed that the historical data provided to NIEIR as the basis for its models was "temperature-adjusted" data provided by Powerlink. This data was adjusted by Powerlink using the methodology described in the previous sub-section for determining its 10% PoE forecast; that is, the actual peak demands for each year were adjusted upwards or downwards depending on whether the actual temperatures were above or below Powerlink's assessed standard temperature benchmark for each region[13].

46. NIEIR also disaggregates its forecasts for the DNSPs to estimate the non-coincident demand peaks for Queensland regions, and these forecasts are separate (though clearly related as we discuss above) inputs into Powerlink's forecasts.

47. The following diagram illustrates what we understand to be the NIEIR forecasting process. While we were provided with descriptive material, which includes some input and output data, we were not provided with a copy of the NIEIR model and, accordingly, we do not have visibility of the form of that model or of the relevant statistical tests that would demonstrate its fit to explanatory variables.

Figure 3 : *NIEIR demand forecasting process*



Source: NZIER (from description by Powerlink)

[12] It is unclear whether these peak demand (MW) forecasts are determined using a model specifically developed for this purpose, or are derived from energy (GWh) forecasts using load factor assumptions

[13] We note that, as a result of Powerlink's methodology, the historical temperature-adjusted maximum demands differ, for example, between its 2010 and 2011 APRs.

3.5 Powerlink econometric model

48. Powerlink also worked with KPMG to produce an independent top down econometric forecast as a "cross check" on the main forecasts (RHS of figure 2). KPMG provided input data on causal drivers (GSP, mining index, population and prices) while Powerlink provided historical data on energy consumption and maximum demand. We understand that the demand inputs were Powerlink's temperature-adjusted historical demands, as provided to NIEIR for its modelling.

49. Powerlink's model forecasts energy consumption in the first instance. It then calculates the historical load factor relationship between energy consumption (GWh) and peak demand (MW) and converts the energy forecasts to peak demand forecasts using the calculated load factors.

50. The results of this modelling were provided to us by Powerlink along with the time series of input data used in the forecast process.

3.5.1 Model interactions

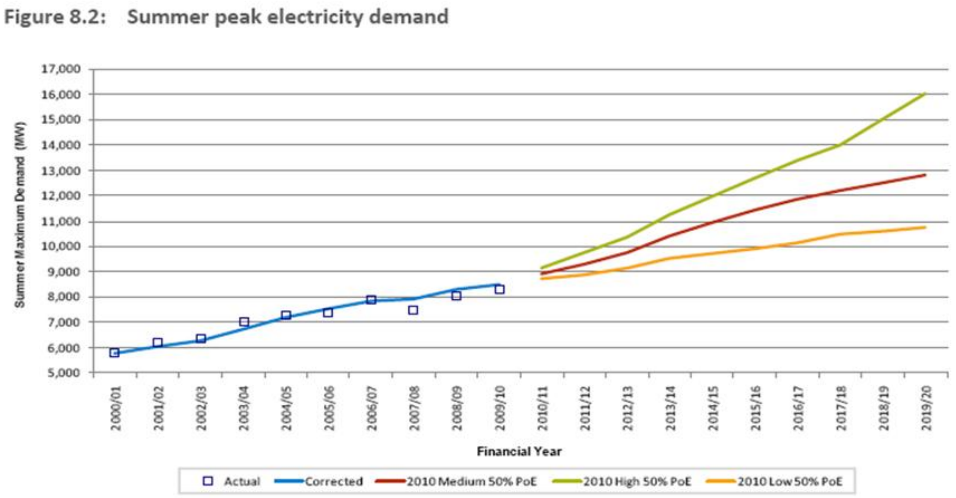
51. The NIEIR econometric modelling develops 20-year forecasts of energy and maximum demand, using historical data provided by Powerlink along with its own sourced data on drivers of electricity demand. To this forecast NIEIR adds its forecast of direct connected industrial loads, which are later cross checked by Powerlink. NIEIR provides the resulting forecast to Powerlink, who compare it to the sum of the forecast inputs received from the distributors and from its own direct connect customers. (LHS of figure 2).

52. Powerlink has informed us that it uses the NIEIR model as its "default" forecast but makes adjustments to this where it considers the difference between the forecasts from the two sources is unacceptable. Powerlink reports that recently the two forecast sources have been within 2% overall.

3.6 Powerlink's proposed forecast

53. Powerlink presents its proposed peak demand forecast for the 2013-17 RCP (as per its Revenue Proposal) as shown in figure 4 and tables 3 and 4.

Figure 4 *: Powerlink demand forecast (summer peak demand)*



Source: Annual Planning Report, Powerlink

Table 3*: Powerlink demand forecast (low, medium and high growth at 50% PoE temperature)*

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
High Scenario 50% PoE	9,738	10,384	11,245	11,992	12,714	13,404
Med Scenario 50% PoE	**9,280**	**9,765**	**10,400**	**10,930**	**11,447**	**11,877**
Low Scenario 50% PoE	8,890	9,129	9,516	9,714	9,909	10,148

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

54. For capex planning purposes, Powerlink uses a higher set of forecasts which is based on the above forecast but with a 10% temperature PoE, as described in section 3.3.

Table 4*: Powerlink demand forecast (medium growth at 10%, 50% & 90% PoE temperature)*

MW

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Med Scenario 90% PoE	8,992	9,467	10,090	10,613	11,120	11,537
Med Scenario 50% PoE	9,280	9,765	10,400	10,930	11,447	11,877
Med Scenario 10% PoE	9,753	10,252	10,907	11,450	11,984	12,437

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

4 Review of Powerlink's demand forecast and forecasting methodology

4.1 Introduction

55. In this section we describe and assess the various aspects of Powerlink's demand forecasting methodology, and its proposed forecast for revenue determination purposes.

56. In section 4.2 we describe, as background, previous forecasts that Powerlink has produced and we review the performance of these previous forecasts.

57. In section 4.3 we suggest an indicative set of governance principles for demand forecasting (as introduced in section 3) and assess Powerlink's demand forecasting framework in relation to these principles.

58. In section 4.4 to 4.7, we address specific aspects of the methodology that Powerlink uses to produce its forecasts, comprising our assessment of:

- Overall methodology and models used;
- Regional demand forecasting;
- Temperature adjustments;
- Inputs and assumptions.

59. We then complete this section 4 by describing our assessment of Powerlink's proposed demand forecast and summarising our findings on the different aspects of that forecast.

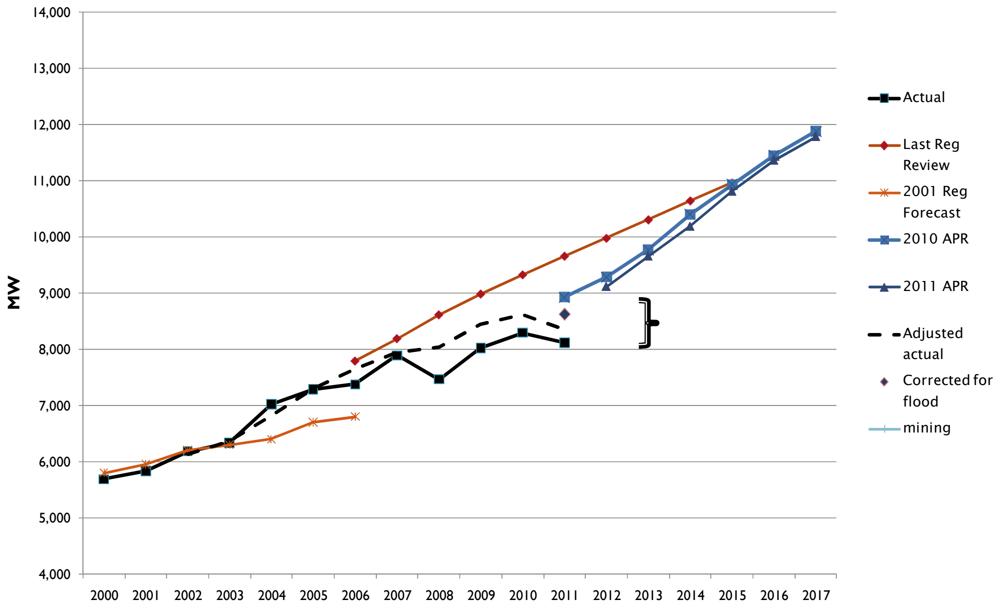
4.2 Powerlink's demand forecasting performance

4.2.1 Current forecast in context of previous regulatory forecasts

60. The following chart shows the maximum demand forecasts from the 2001 and 2006 Powerlink revenue determinations, the maximum demand since that time (actual and as adjusted by Powerlink), Powerlink's proposed medium demand forecast for the next RCP (which is based on Powerlink's 2010 APR) and Powerlink's most recent (i.e. 2011) APR forecast.

61. The graph shows that the RCP forecast demand would require a considerable step increase from current levels followed by a growth path that would exceed the underlying growth path experienced over the past ten years. This is so even taking account of the "one-off" adjustment that Powerlink has proposed (in its 2011 APR) to account for the effects of the 2011 floods and cyclone and which lead Powerlink to propose a "temperature and flood/cyclone-corrected" normalised demand of approximately 8,620 MW for that year in place of the native actual demand of 8,109 MW.

Figure 5 *: Powerlink regulatory peak demand*



Source: EMCa NZIER analysis of Powerlink data

4.2.2 Historical forecasting accuracy

62. We have reviewed Powerlink's performance in forecasting demand, since 2004. The graph below shows the successive forecasts published in Powerlink's APR since 2004 (with forecasts commencing from 2005/06) and compares these with Powerlink's actual peak demands and with Powerlink's own assessment of the weather-corrected peak demands.

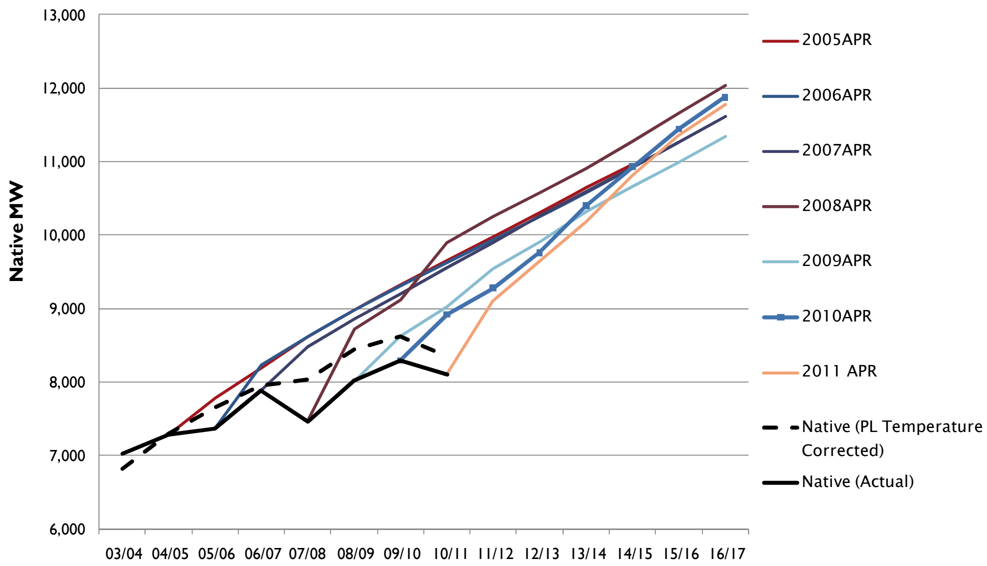
63. It can be seen that all forecasts from 2004 onwards have over-forecast demand. The forecasts have all commenced with significant first-year step increases followed by high

growth paths and each of these has considerably over-estimated the peak demands that have eventuated.

64. Each of the previous forecasts has also over-forecast Powerlink's temperature-adjusted actual demand by, in most cases, several hundred MW.

65. It should be noted that the 10% POE forecast used for capital investment purposes also allows for a further temperature variability buffer that is currently around 450MW so that, even if actual demand had exceeded forecast demand by up to around 450MW, Powerlink would be expected to have been able to meet that demand, under its investment planning criteria.

Figure 6 *: Powerlink forecast performance*



Source: EMCa NZIER

66. Powerlink's demand forecast in its 2013-17 revenue proposal continues the past trend of forecasting a significant first-year step up, combined with a growth trend that again exceeds past growth rates.

4.3 Assessment by reference to forecasting principles

4.3.1 Indicative forecasting principles

67. Electricity demand forecasting plays a key role in the effective planning and operation of a power system. These forecasts can be short, medium or long term. Forecasting from several months to years ahead is an integral process in scheduling new transmission facilities. An overestimate will result in the waste of investment, while an underestimate will result in insufficient transmission capacity to meet the demand.

68. When used for regulatory purposes (as per the current review) an overestimate of demand can lead to an over-estimate of required revenue, resulting in unnecessary price rises for consumers, while an under-estimate may constrain the ability of the business to make the necessary investments (should they be required) to meet future load.

69. We consider it essential that any forecast is developed under a set of design principles, in the same way that a set of principles or policy directs how business strategy and planning are developed. Part of our[14] recent review of Transpower's demand forecasting (the equivalent TNSP in New Zealand) was to assess whether the following forecast principles were appropriate and whether Transpower's forecasts were consistent with these (or other appropriate) principles, as follows:

   a. **accurately representing uncertainty** – the forecast must describe the range of possible outcomes, rather than having an unrealistic expectation of pinpoint accuracy;

   b. **fit for purpose** – the forecast must be prepared and presented in a form that is suitable for grid planning activities;

   c. **stable** – the forecast should not change unduly from year to year, and should not be excessively sensitive to any one input parameter;

   d. **seasonal** – the forecast must accurately represent seasonal trends, to the extent possible given available information.

70. In addition to these four design principles, there are principles generally observed in forecasting, for example, that the forecast should be based on sound economic practices, it should be validated and transparent.

4.3.2 Assessment against principles

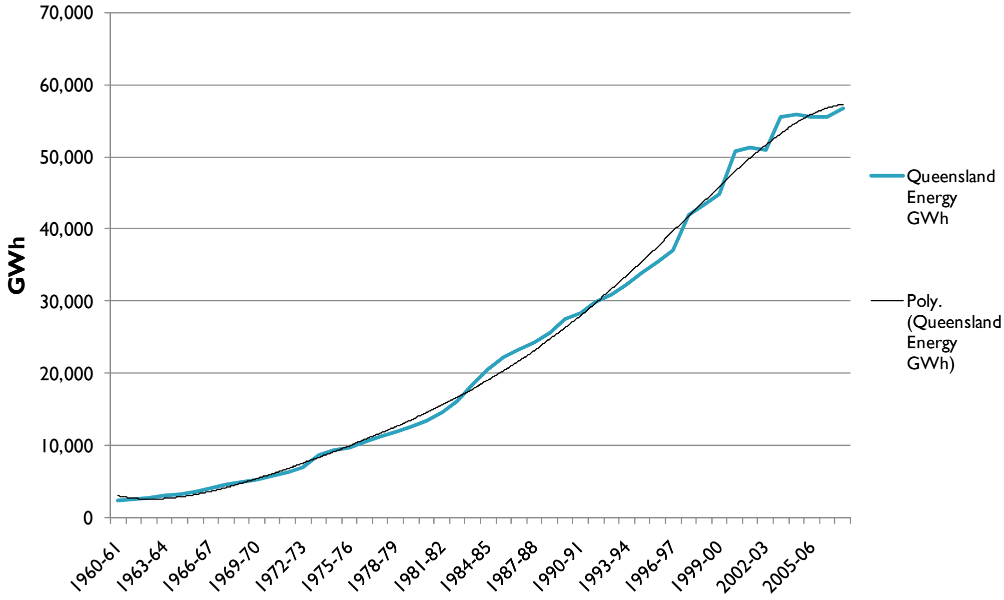
71. In regards to principles that we would expect to see demonstrated, we offer the following observations.

Accurately representing uncertainty

72. Figure 6 below shows a steady growth in the Queensland energy consumption track from 1960 through to the late 1990s after when it shows material year on year variations. This change represents an increase in risks for Powerlink. This would indicate the importance of preparing forecasts under a number of approaches and using different start points to test the range of possible outcomes. There is a range of approaches, including simulation approaches and a further critical examination of sensitivity to and variability in underlying assumptions, that could be used to improve forecasting under these circumstances.

[14] Review by NZIER

Figure 7 : *Queensland energy consumption 1960 - 2008*



Source: ABARE and NZIER

Fit for purpose

73. We have concerns that Powerlink has adopted a one size fits all forecasting approach. Powerlink's demand forecast seems to be used for a variety of purposes, such as annual planning, short and long term grid investment planning, operational planning, tariff determination and long term strategic planning, as well as planning for the purposes of meeting this regulatory requirement. These are different purposes with different time and spatial dimensions, and may also have different, sometimes conflicting, requirements in terms of the accuracy of the forecasts. These purposes may require different demand drivers and require different modelling techniques.

74. At the regional level, there are significant variations in electricity demand growth driven by specific local load requirements (mining, gas and the like) and Powerlink's demand forecasting approach takes account of these through the bottom-up process as required under the NER. For the purpose of long term grid investment planning, econometric factors and structural changes need to be identified and anticipated: for example, changes in sectoral and regional contributions to GSP, long-term regional economic patterns, changing energy intensity (with GSP and/ or population), air conditioner deployment and saturation effects, changing awareness of and drivers for energy efficiency including TOU and peak demand tariffs, distributed generation including small-scale wind and local solar and views on electric vehicles and their impact. To take account of these factors may require different forecasting models.

Stability

75. Validation of demand forecasts is an essential principle when uncertainty and risks are rising. We have concerns that the circularity of both input and output data in the NIEIR/Powerlink process does not appear to be externally validated and that the KPMG/AEMO forecast provides only limited validation. We have seen no evidence that

Powerlink has systematically reviewed its past forecasting performance or has attempted to rectify the deficiencies that are evident.

76. Powerlink's successive annual forecasts are not stable, with almost an annual "deferral" evident in the short term, but tending to converge in the long term to a similar demand level that represents an ever-increasing stretch from the current actual demand level. Improved forecasting would lead to more stable capital investment planning and would reduce planning effort required to develop solutions that are subsequently found not to be required, deferred or significantly modified as the actual situation emerges.

Seasonality

77. Powerlink's forecasting process takes into account seasonal variations and adjusts for temperature variation and allows for uncertain temperature outcomes and their impact. We have concerns about the methods used for this adjustment, and we assess this aspect of the methods used later in this section.

4.3.3 Findings on Powerlink's forecasting governance and principles

78. Powerlink's approach to forecasting appears to be consistent with its regulatory requirements and has been adapted to support its probabilistic scenario-based capex planning approach.

79. It appears that Powerlink has not established a framework, nor a platform of design principles, to guide its regulatory forecasting approach. Of particular concern is that there does not appear to be recognition that its forecasts have been consistently biased upwards for the past five years without governance processes being invoked to address this.

4.4 Assessment of Powerlink's overall forecast methodology & models

80. NZIER's survey of current demand forecasting methodologies is set out in Annex 2. In brief, when reviewing the relationship between electricity demand and causal drivers, best practices suggest that there are three aspects to consider – the ***explanatory variables*** modelled as drivers of electricity demand, the ***functional form*** modelled as representing the relationship between electricity demand and these drivers, and the ***time period*** over which this relationship is derived from historical data. In assessing Powerlink's methodology we use these best practices, our forecasting principles and our judgements about Powerlink's methodology compared to other demand forecast reviews that we have undertaken.

4.4.1 Reliance on NIEIR forecasts

81. Powerlink is highly reliant on the NIEIR demand forecasts as input when preparing its 2013 - 17 demand forecasts, either as direct input or indirectly via the distributors' connection point forecasts. Apart from the adjustments that Powerlink make to the DNSP inputs (and which are stated as being "minor") the core demand forecast uses

only NIEIR input data. We have concerns that there appears to be a circularity in the preparation of the forecasts caused by the same data being used (i.e. temperature adjusted data provided by Powerlink to NIEIR and NIEIR inputs to Powerlink and to DNSP's) in both the top down and the bottom up aspects of Powerlink's methodology. Unsurprisingly, the NIEIR and the DNSP forecasts are very close to each other, though Powerlink has cited this, erroneously in our view, as evidence of "a good track record with forecast reliability".

82. We were provided with NIEIR documents for two years, describing its forecasting approach and its year-by-year forecasts[15]. We were not provided access to the NIEIR model itself, or to a description of its functional form, explanatory variables, model fit parameters or backcasting results. We are satisfied that an econometric approach is appropriate for long term forecasting. However we are concerned that the methodology does not have a specified purpose; the NIEIR output forecast is used for a range of purposes, as described earlier, and 5-year forecasts of 10% POE maximum demands are only a small subset of the outputs provided, not its core focus. A shorter term forecast such as is required for the 2013-17 revenue reset, may well need to consider alternative techniques that better reflect near term conditions of the explanatory variables.

4.4.2 Changing structural relationships

83. Our examination of the long term trend with Queensland energy consumption suggests a changing relationship between energy and drivers may have occurred during the last 10 years and that this may continue to change in the future. This has implications for the use of GSP and other macro economic variables for both short and long term forecasts, and which implicitly assume a static relationship between the variables and energy consumption. Our experience with the analysis of longer term trends with these explanatory variables has revealed that the relationships change over time especially when there are shifts in economic conditions, consumer behaviours and or sustained changes in real prices.

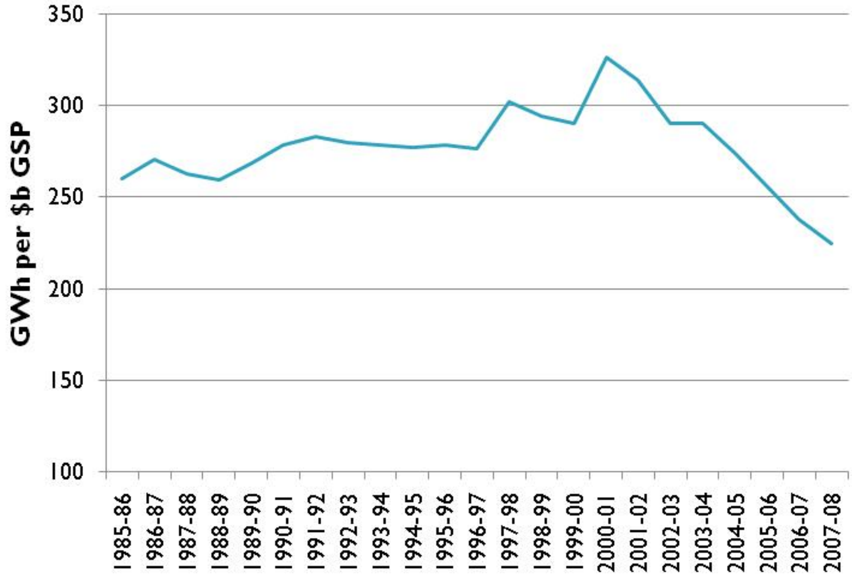
84. Where the explanatory variables are themselves forecasts, it is best practice to prepare an output forecast that uses a randomisation of the input parameters to describe the range of possible demand forecasts. We recently reviewed the forecast methodology of an electricity distributor in New Zealand using this approach to test the variability of the resulting forecasts.

85. To illustrate this point, we point to recent volatility in energy consumption in Queensland (see figure 6). We also flag the following results, which show a structural change in the relationship between Queensland energy demand and GSP and population respectively, that appears to have occurred around 2000/01: in both cases, energy demand growth has reduced as a function of GSP and of population. In descriptive

[15] Long run economic and electricity load forecasts for the Queensland Electricity Network, NIEIR (June 2010 and June 2011)

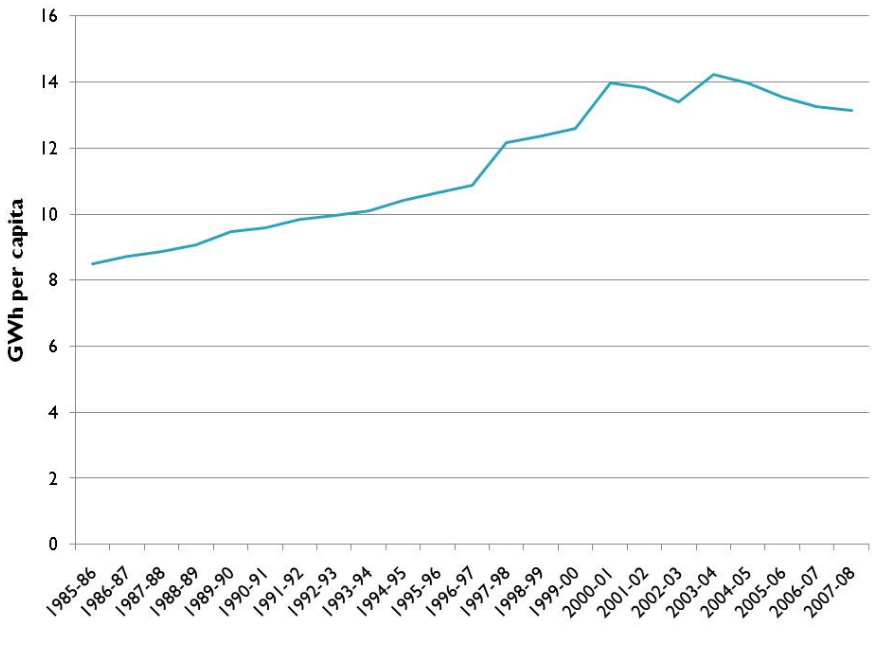
material that we have been provided, we have not seen recognition of these effects in calibrating econometric models for currently-proposed forecasts and, if not accounted for, these factors would lead to an over-forecast such as we observe.

Figure 8 *: Queensland energy demand divergence- Economic demand*



Source: NZIER, ABARE, ABS

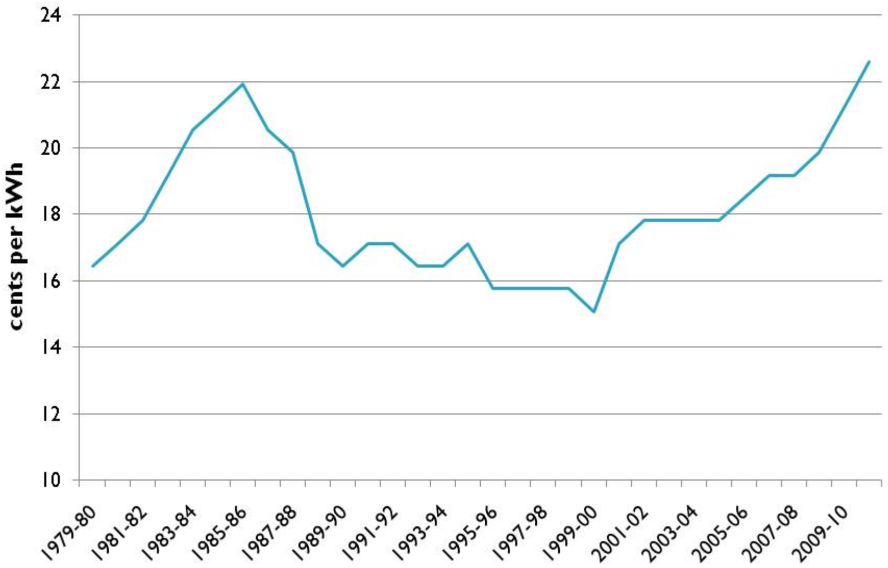
Figure 9 *: Queensland energy demand divergence – demographic demand*



Source: NZIER, ABARE, ABS

86. The following chart shows the trend in rising real retail prices that started in 2000 and has continued throughout the 2000's.

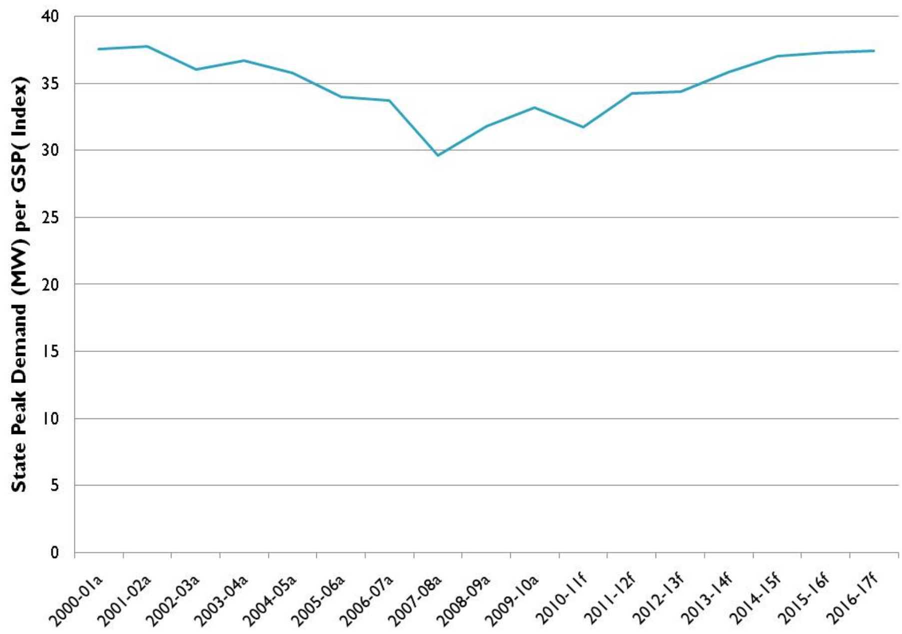
Figure 10 *: Queensland energy demand divergence - real retail price*



Source: ROAM/NZIER

87. Using the ratio of demand per unit of GSP, the following chart describes the same declining historical trend in peak demand growth. This can be contrasted with the reverse trend change that is implied in Powerlink's proposed forecast.

Figure 11 *: Queensland Energy demand divergence - GSP*



Source: NZIER/Powerlink

4.4.3 Findings on methodology

88. Powerlink relies on NIEIR demand forecasts as the key input to its 2013-17 demand forecasts. We are concerned that the use of NIEIR's work is a "one size fits all" approach in which NIEIR's forecasts are used for a range of purposes, including energy and demand forecasts over a range of periods and with levels of granularity ranging from connection point level up to overall state demand.

89. We consider that a focus on the need, for regulatory capex determination purposes, to forecast peak summer demands, by region, for the five-year RCP and taking proper account of temperature-driven demand variability, would lead Powerlink to consider refinements to its methodology. These refinements would include closer review of changes in structural relationships.

90. We also have concerns that there appears to be circularity in the methodology with NIEIR-based forecasts used in both the top down and the bottom up forecasts, reducing the opportunity for independent validation.

91. Our findings on further specific aspects of the methodology are recorded below.

4.5 Assessment of Powerlink's approach to regional demand forecasting

4.5.1 Significance of regional demand

92. For capital expenditure planning purposes, it is essential for Powerlink to have a good understanding of the regional distribution of its demand (and generation scenarios). Powerlink does this by producing forecasts at a regional level.

93. In its Revenue Proposal Powerlink describes significant differences between Queensland's demand and energy patterns when compared to the other states in the NEM. The main difference is that in Queensland only 60% of the load is near the state capital with the rest of the load being geographically and sectorally diverse and hence subject to very different weather conditions and other drivers, in different parts of the state. The state maximum demand is somewhat less than the sum of the regional demands and Powerlink reports that there is a slowly changing diversity between the regions.

4.5.2 Powerlink approach to regional demand forecasts

94. Powerlink derives regional demand forecasts from the demand and energy forecasts that are supplied to it by the DNSPs and direct connect customers. The DNSPs provide demand forecasts for each connection point, which can then be aggregated to each of the regions which correspond to the previous electricity boards (7 in total), to which Powerlink make adjustments based on analysis of the regional maximum demand relative to the time of the state demand (the coincident peak). Powerlink uses historical data to estimate the relationship between the peaks (i.e. their peak diversity) and also to allow for any changes to demand at the connection-point level that are forecast by the DNSPs.

95. NIEIR undertakes a similar process when preparing its demand forecasts, disaggregating its core state demand into regional demand by coincidence factors that it calculates from historical data provided by Powerlink. Powerlink compares its coincidence adjustments with those from NIEIR and reconciles any differences.

96. NIEIR also uses Powerlink supplied historical demand data to estimate the regions' own peak demand (the non-coincident peak) by establishing (using linear regression) the relationship between such maximum demands and average daily temperatures for each region. NIEIR suggests that this approach also provides a useful diagnostic for the state maximum demand calculations.

4.5.3 Assessment of regional forecasts

97. We are of the view that Powerlink's approach to forecasting regional demands is reasonable, noting that it is regional / connection-point demand forecasts that drive the load flow models that Powerlink use to establish the needs for specific network augmentations. We consider it appropriate that a bottom-up approach drives the regional forecasts and that these are then squared with state-wide forecasts, rather than the regional forecasts being developed by disaggregating the state-wide forecasts.[16]

98. Our main cause for concern is that the bottom-up and top-down forecasts trace back to a single source, so that there is limited opportunity for independent verification.

99. While we do not have cause for concern, we consider that it would be worth monitoring the issue of changes to regional diversity over time, which Powerlink has noted. A better understanding of this may allow Powerlink to forecast changes to these relationships and which may lead to more accurate forecasts aggregated from the regional forecasts.

4.5.4 Findings on regional demand

100. Powerlink's approach appears reasonable in terms of its requirement to provide a network to meet demand at the regional level, and appears to take appropriate account of demand coincidence and diversity and regional differences in demand growth, being built up from connection point forecasts (as required under the NER).

101. As an observation, we consider that the use of historical data to calculate future demand coincidence factors for each region assuming static relationships may not be appropriate in the presence of volatility in demand. The potential future relationships between regional demand peaks and state peak could be explored through randomisation or scenario modelling.

[16] We reviewed the regional connection point peak demand forecasts, including direct connect loads, and confirmed that the sum of the connection point demand forecasts at state peak provided by Powerlink equals Powerlink's state-wide coincident demand forecast

4.6 Assessment of Powerlink's approach to temperature correction

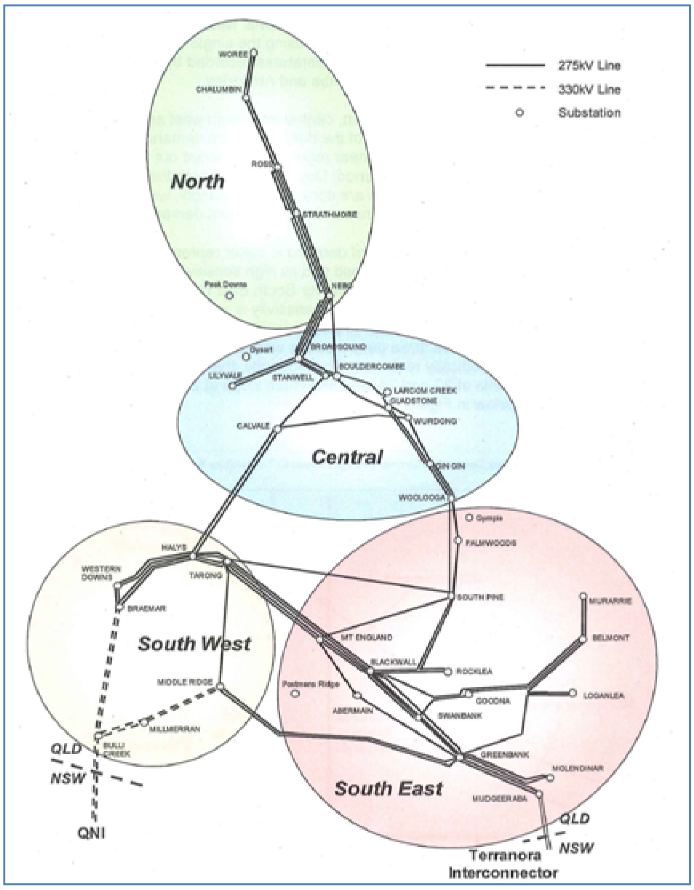
4.6.1 Justification for temperature adjustments

102. Powerlink uses weather and diversity corrected demand rather than actual demand to establish both the start point and the trend for the demand forecast. Powerlink undertakes this correction to ensure the forecast is not unduly influenced by mild or extreme summers when peak demand occurs. Powerlink indicates that this also ensures that (historic) demand contributions from different parts of the state (at the time of state peak) are smoothed over time to establish the starting point. Powerlink sets its demand forecast to align with both the econometric forecast and the trend of (historic) weather and diversity corrected peak demands, which are corrected to the standard PoE 50% temperatures.

4.6.2 Powerlink approach to temperature adjustments

103. To account for both weather and diversity load forecasting Powerlink uses average daily temperature ((max+min)/2) because it has identified this parameter as consistently providing a good correlation with peak demand. While attempts have been made to factor in additional weather variables (such as humidity), they have found the fit to be less reliable than using the single average temperature variable.

Figure 12 *: Queensland temperature regions*

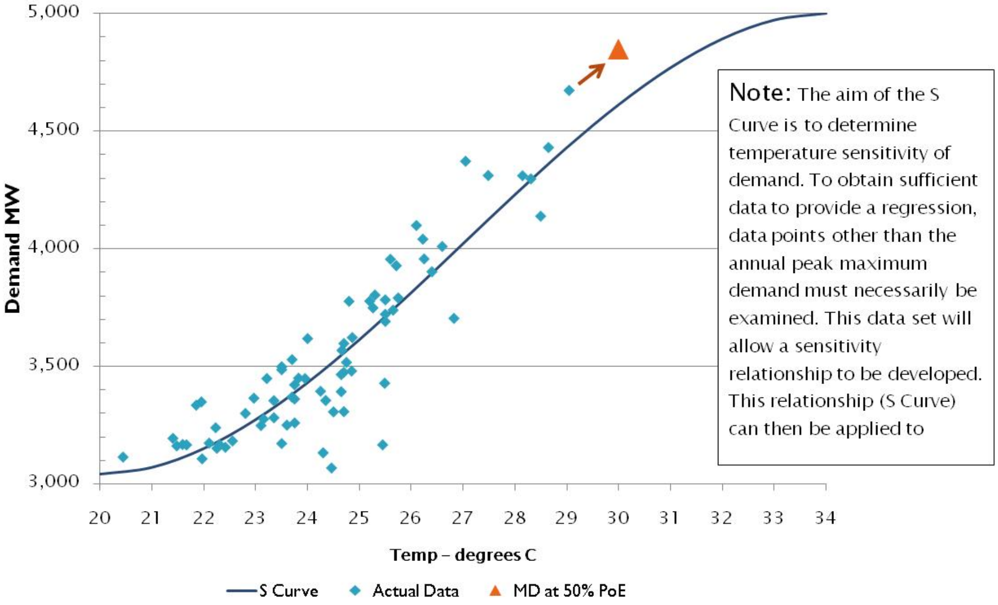


Source: NZIER, Powerlink

104. Powerlink proposes that temperature sensitivity of demand for the northern, central and south west temperature regions can be satisfactorily defined using linear regression of the daily maximum demand against daily average temperatures on working weekdays. Linear regression is carried out for all working days in both summer and winter, excluding the Christmas holiday period. Days that are in both the highest sixteen demands of a season, and hottest sixteen days are corrected accordingly, with the highest corrected demand being the season temperature corrected maximum demand for that region.

105. Powerlink proposes that South East Queensland temperature sensitivity of demand is better represented through a nonlinear relationship due to the size of the load and this area's high sensitivity to temperature. Its SEQ "S-curve" assumes that demand to temperature sensitivity is zero on a cool summer day (average temperature 20°C), then increases to be at peak sensitivity at 27°C, and then saturates back to zero sensitivity at 34°C. Powerlink informed us that the S-curve relationship was arrived at through Powerlink's analysis of year 2010 temperature and demand data. Powerlink describes the curve as a cubic function with turning points at 20 and 34, and maximum slope at 27. Powerlink's 'S-Curve' relationship for summer 2010, and which we understand was the basis on which Powerlink 'temperature-corrected" historical data, is shown below.

Figure 13: *SEQ temperature S-curve - 2010*



Source: Powerlink, NZIER

106. Having determined regional peak (temperature adjusted) demand Powerlink then uses coincidence factors to merge the peak demands into a state total. Powerlink also calculates the demand adjustments that are required to account for the important PoE=10% and (though of less significance) 90% temperatures using NIEIR analysis of historical temperature statistics.

Table 5: *NIEIR PoE temperatures by region*

Table 4.6 Queensland average daily temperature percentiles by distribution area – summer and winter[1]

Distribution area	10th percentile	50th percentile	90th percentile
Summer	[redacted]	[C-I-C]	
FNQEB			
NORQEB[2]			
MEB[2]			
CAPELEC[2]			
WBBEB[2]			
SWP[2]			
ENERGEX[2]			
Winter			
FNQEB[2]			
NORQEB[2]			
MEB[2]			
CAPELEC[2]			
WBBEB			
SWP			
ENERGEX			

Source: NZIER from NIEIR data

107. In calculating temperature correction adjustments in its demand forecasts for each region and for the state, NIEIR uses 50 years of summer and winter temperature data to determine the temperatures that will exceed each of the PoE's 10%, 50% and 90%. We note however [C-I-C] [redacted]

4.6.3 Assessment of Powerlink's temperature adjustments

108. Powerlink's temperature adjustments are a very important factor in its Revenue Proposal because it determines both the start point for the forecast and the adjustments to the trend in regional (and state) demand, and are also used to derive the 10% PoE forecast used for capex planning purposes from the 50% baseline forecast. Using the coefficients from its regional regressions to remove the impacts of temperature variations on peak demand, Powerlink adjusts the historical actual demand up or down to correspond to the standard PoE=50% temperature. We refer to the output from this process as "temperature adjusted actual demand". We have concerns with this process.

109. Our first concern is with the use of daily average temperature (max + min)/2 as the standard temperature in the adjustment calculation, because we are of the view that average temperatures may not reflect the full impact on demand compared to maximum temperatures. We conducted a number of tests on the max and (max+min)/2 temperatures and while in some regions the R^2 results were mixed, the max temperatures generally had a better R^2. From a statistical perspective we are also concerned by the dampening effect that the averaging process has on outliers (which impact R^2).

110. We acknowledge effects from preceding overnight temperatures and from sequential hot days. Nevertheless we do not consider it reasonable to provide the same weighting to the overnight minimum as to the daytime maximum temperature and our statistical tests did not give reason to believe otherwise. We are also persuaded by the use of max temperature in two recent temperature adjustment studies that we identified.

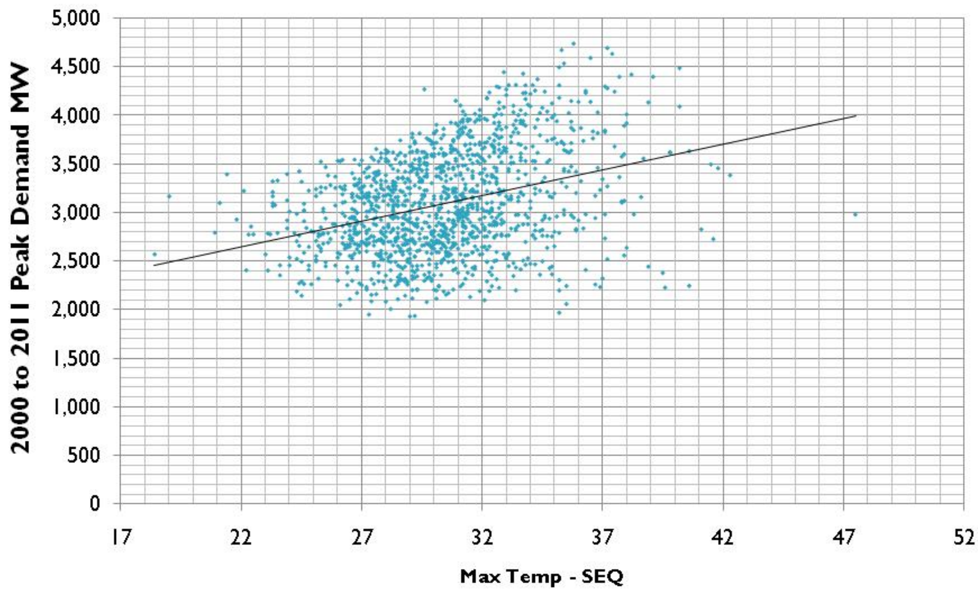
111. We were also concerned that the use of an S curve rather than a linear relationship introduces an asymmetric adjustment. This can be illustrated by consideration of the S curve in figure 13: it can be seen that a 'downwards' adjustment for a greater-than average temperature (e.g. >30 degrees) will be made at the "flatter" end of the S curve and therefore will be less than an upwards adjustment from a cooler summer temperature.

112. Figure 14 shows the relationship between peak demand and daily average temperature for SEQ over summers from 2000 to 2011, using Powerlink data, and provides a different picture from the S-curve approach used by Powerlink and presented in figure 13.

113. We tested the fit of a linear relationship and an S-curve "cubic" function on the 11 years of SEQ temperature and demand data provided. We were concerned by Powerlink's assumption of 20 degree and 34 degree lower and upper bounds to the S-curve, something which the data itself did not reveal and which has a significant effect on the shape of the curve. For this reason, also because it does not provide a clearly improved fit, and because it leads to an asymmetry on the adjustment which biases it upwards, we were not persuaded that an S curve for SEQ provides a more suitable adjustment than the linear relationship used by Powerlink to adjust for temperature in other regions.

114. We also identify what appears to be a stronger relationship between energy consumption and average temperature than there is with peak demand, which presents as being more sensitive to maximum temperatures.[17] Again, this relationship was tested and confirmed in the work we undertook to determine an alternative forecast.

Figure 14 : *Peak daily demand as a function of maximum temperature*

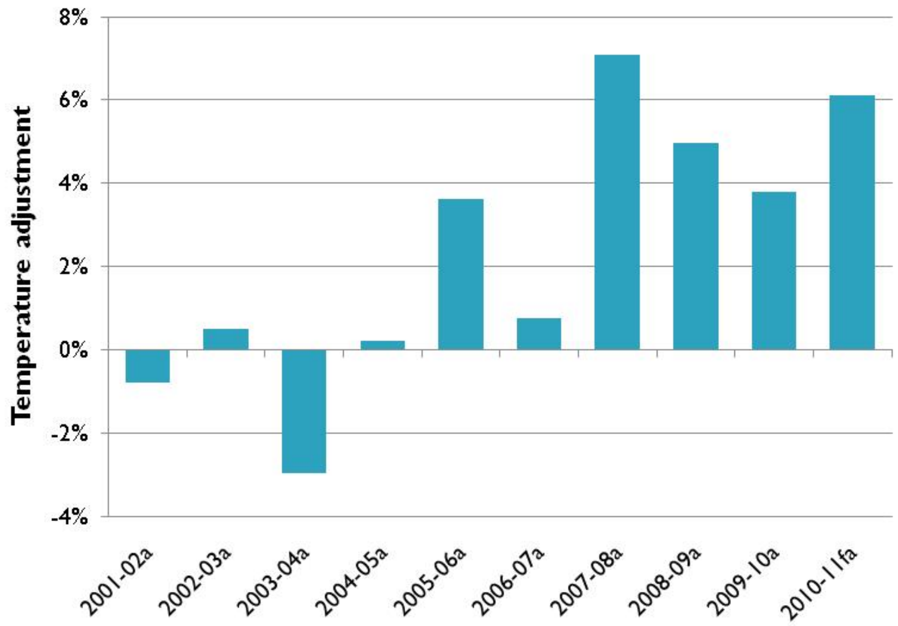


Source: NZIER, Powerlink

115. The impact of this matter on the forecast results can be seen from our later alternative forecasts as significant. Powerlink's forecast start point is adjusted according to whether the actual temperature is above or below the standard PoE=50% temperature and the "temperature smoothed" historic demand becomes vital in the econometric analysis that drives forecast results. Because the actual temperatures (especially in Brisbane) have been below "standard" for a few years now, the use of these temperatures in combination with the S-curve results in a larger upward adjustment for the start point of the demand forecast than would the use of a simple linear relationship. Figure 15 illustrates the adjustments that have resulted from Powerlink's temperature adjustment method.

[17] We conducted a basic regression with temperature and the GWh linear trend line. The fit of max temperature with the raw consumption and peak demand data was better than with (min+max)/2. This result is based on the probability/t-statistic applied to the variable in the simple regression. The fit is better for peak than consumption, but better under annual percentage changes and levels than the (min+max)/2 relationship.

Figure 15*: Powerlink temperature adjustments*



Source: NZIER & NIEIR

116. Our test results also indicate that for Queensland state (not just for Brisbane) the relationship between energy and temperature is significant and that energy sensitivity to temperature has been materially growing over recent years. We describe these sensitivities in more detail in section 5, which describes our proposed alternative forecast.

4.6.4 Findings on weather and coincidence adjustments

117. The temperature and diversity adjustments are a significant factor in Powerlink's Revenue Proposal where they are dominant in setting the start point for both the APR and the regulatory submission demand forecasts. We have significant concerns with the temperature adjustments:

a. We consider it preferable to use actual demands to calibrate forecasting models rather than "temperature-corrected" data and as we describe later, our analysis finds a better fit to actual data. We note that Powerlink's temperature corrections have changed over time, so that historical corrected data tends not to be stable. This issue can be seen from successive APRs where corrected "actuals" are restated based on actual temperature corrections for that year;

b. From our review we consider it preferable to use a relationship between peak demand and maximum daily temperatures than with average daily temperatures and, again, our analysis shows a better fit;

c. The "S" curve, used for temperature correction and for determining the 10%POE capex planning forecast from the base 50% POE demand forecast, results in biased temperature adjustments and requires re-calibration. In the absence of satisfactory evidence to the contrary, we prefer use of a simple linear relationship.

118. We do not have material concerns with the coincidence adjustments, while noting the observation under "regional demand" in section 4.5.4.

4.7 Assessment of Powerlink forecast inputs and assumptions

119. Powerlink uses a range of data inputs when preparing its demand forecast, however, most of the data that goes into preparing the forecasts is sourced from, and used by, the DNSPs or by NIEIR. By this we mean that Powerlink receives mostly "completed" regional forecasts from the DNSPs and from its direct-connected load customers, as well as a complete state forecast from NIEIR. The DNSP forecasts use regional forecasts from NIEIR, which is the common denominator and source of the most significant input data and assumptions.

120. We were provided access to Energex, NIEIR and Powerlink high level forecasts and data sources but were not provided access to enable review of the Ergon forecasts.

4.7.1 Powerlink use of input data and assumptions

121. The *Energex* regulatory proposal indicates that it uses the following data as inputs to its forecasts:

- Population changes that affect their customer numbers and locations. (from NIEIR);
- GSP changes that affect customer spending patterns and capacity. (from NIEIR);
- Climate conditions – especially temperatures (from NIEIR and EDSD);
- Directly connected demand and energy loads (own data).

122. Price effects are not explicitly considered but are considered to be implicit in the NIEIR forecast that is provided to the DNSPs.

123. Powerlink makes very limited direct use of data in preparation of its regulatory demand forecast:

- Historical regional coincidence data to transform DNSP forecasts into a state coincident peak demand (own data);
- Direct connect industrial demand (from customers);
- NIEIR forecasts to compare to DNSPs' adjusted forecasts (from NIEIR);
- Historical temperature data to adjust actual demand to "standard" (from Qld Met Service).

124. It appears that retail price effects are not explicitly considered by Powerlink but are understood to be implicit in the NIEIR forecast[18].

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[18] NIEIR has forecast [C-I-C] while the Queensland Energy Minister has indicated that he expects prices to continue to rise by an average 10% per year on the

125. As described earlier, Powerlink prepares an econometric forecast using KPMG-supplied economic variables as well as its own input data as a cross check of the NIEIR forecast.

126. As a matter of good forecasting practice DNSPs, Powerlink and NIEIR are each required to make assumptions about a number of key matters in the preparation of their forecasts. Significant among the assumptions are:

- the need to identify and forecast input demand drivers – economic and population growth are significant here;
- projections of the retail price of electricity;
- how the relationship between the demand drivers and electricity consumption may change in the future;
- the extent to which weather conditions will track as they have in the past;
- the outlook for growth in various industrial sectors;
- changes in household characteristics and usage patterns.

127. We have determined that a number of these assumptions are accommodated in the low-medium-high scenarios of economic and population outcomes in the future. For example NIEIR takes a view of the most likely path of the explanatory variables and then determines low and high scenarios with associated probabilities for the various inputs, and which then determines a range of possible outcomes.

128. What is material to the forecast results is that NIEIR is the common denominator and provides demand forecasts using its own data and its own forecasts for input assumptions. Without access to NIEIR's data inputs and to the functional form of its forecasting model, we are unable to form a view on the reasonableness of NIEIR's input assumptions or its modelling except by reviewing the resulting Powerlink forecasts (see section 4.2).

129. We also examined the analysis that Powerlink undertakes using KPMG's input data and for a number of reasons we are unable to use it when considering the reasonableness of the Powerlink forecast. Our concerns with this "benchmark" analysis are that few observations limit the robustness of the results and because it uses Powerlink adjusted energy consumption data there is no independent view on the trends with energy consumption or demand. We do not have reason to suggest that the results are invalid but rather that they are not a good fit with our assessment principles.

130. We therefore undertook some independent econometric testing to facilitate an understanding of causal factors that we would expect to see evidence of in the forecasts prepared by others. This "testing" of the explanatory drivers of peak demand contributed to our preparation of an alternative forecast.

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back of real price rises of 10% over the last 4 years. This aspect is explored further in our alternative forecast, which is described in section 5.

4.7.2 Assessment of NIEIR data and assumptions

131. We have reviewed the long range electricity forecasts that NIEIR prepared for Powerlink in 2010 and in 2011. While there is considerable data and explanation regarding inputs and process, the reports nevertheless do not provide us with an end-to-end view of the process, how particular data was used and the form and parameters of the model that it uses.

132. While we consider that the process as described is essentially "as expected", we identified the following issues.

Macro-economic factors

133. NIEIR refers to a range of macro-economic factors that are incorporated into its forecasting process. We have been able to review a number of these and provide our comments as follows.

GSP

134. NIEIR predicts economic growth [C-I-C] [redacted] Counter-views could be expressed that the Asian economies, and Australia, will experience inflation pressures which will slow growth and this may be exacerbated by the drag of continuing economic problems in many major countries. We also have concerns regarding [C-I-C] [redacted] and draw attention to the often-described "two-speed economy" in which lower growth may continue in the non-mining sectors.

135. [C-I-C] [redacted] therefore, to the extent that GSP is considered relevant, we consider it appropriate to base underlying forecasts for non-mining electricity demands on GSP forecasts that do not include the mining contribution to GSP, [C-I-C] [redacted]

136. [C-I-C] [redacted]

Figure 16 : *Forecasts of GDP growth rates*

[C-I-C] [redacted]

Interest rates

137. [C-I-C] [redacted]

Figure 17 : *NIEIR forecasts of domestic interest rates*

[C-I-C] [redacted]

CPI

138. [C-I-C] [redacted]

Figure 18 *: GDP and CPI*

[C-I-C]

Population growth

139. [C-I-C]

Exchange rate

140. NIEIR's 2010 forecast (on which Powerlink's submission demand forecast is based) assumes the following exchange rate forecast which is considerably below current levels and most current forecasts.

Figure 19 *: NIEIR 2010 Demand Forecasts Report to Powerlink*

[C-I-C]

Electricity usage drivers

Electricity prices

141. NIEIR has forecast [C-I-C] [redacted] while the Queensland Energy Minister has indicated that he expects retail prices to continue to rise by an average of 10% per year. Our preliminary analysis, of QCA's retail price determination process and the implications of the AER's determination for distribution prices over this period, suggest retail price rises are more likely to be at the level indicated by the Minister than those in NIEIR's forecast. This difference would have an impact on consumption, through price elasticity effects.

Air conditioning

142. Air conditioning ownership is described by Powerlink and NIEIR as remaining a significant driver of peak demand loads, especially in SEQ, over the forecast period. Powerlink estimates that 76% of Queensland households now have some form of air conditioning. [C-I-C] [redacted]

Figure 20 : *Estimated annual increase in Queensland summer temperature sensitive load at 10th percentile*

[C-I-C] [redacted]

143. This trend seems consistent with data which shows air conditioner ownership reaching saturation after a period of high growth. However maximum summer temperatures since 2005 have also been less than the long term average. Determining the relative impacts of declining air conditioner growth against a backdrop of lower summer temperatures is an important factor in forecasting peak demand in a "normal" summer.

Temperatures

144. [C-I-C] [redacted]

[C-I-C] [redacted]

Energy sector assumptions

145. As we have noted elsewhere in this report Powerlink adjusts peak demand forecasts from NIEIR for major loads based on its first hand understanding of major load customer forecasts. While we have visibility of these components of the demand forecasts we are not able to comment on the validity of the major customer forecasts.

Embedded generation

146. Forecasts of embedded generation are developed from historical actuals. Powerlink's primary focus in developing its demand forecasts is on "native" demand, which excludes embedded (local) generation and we concur that this is a more appropriate metric to forecast than delivered demand. However, in that it is delivered demand that Powerlink must meet, it is equally important that the forecast for embedded generation is realistic. This aspect of the forecasting process is not well-explained and we observe that while there has been material growth in embedded generation in the recent past, Powerlink's APR forecasts assume no further growth.

Distributed generation and energy conservation

147. Australia is introducing various renewable energy and efficiency initiatives, some of which will have the effect of reducing the need for centralised generation and consequent transmission requirements. [C-I-C] [redacted]

148. [C-I-C] [redacted] For these reasons it is unclear what assumptions, if any, have made with regards distributed generation and energy conservation initiatives in Powerlink's proposed forecast. From our experience in the sector, we would expect further considerable growth both in distributed generation and energy conservation and efficiency, particularly given the Federal Government's recently-announced programs. [C-I-C] [redacted]

Trend energy growth rates

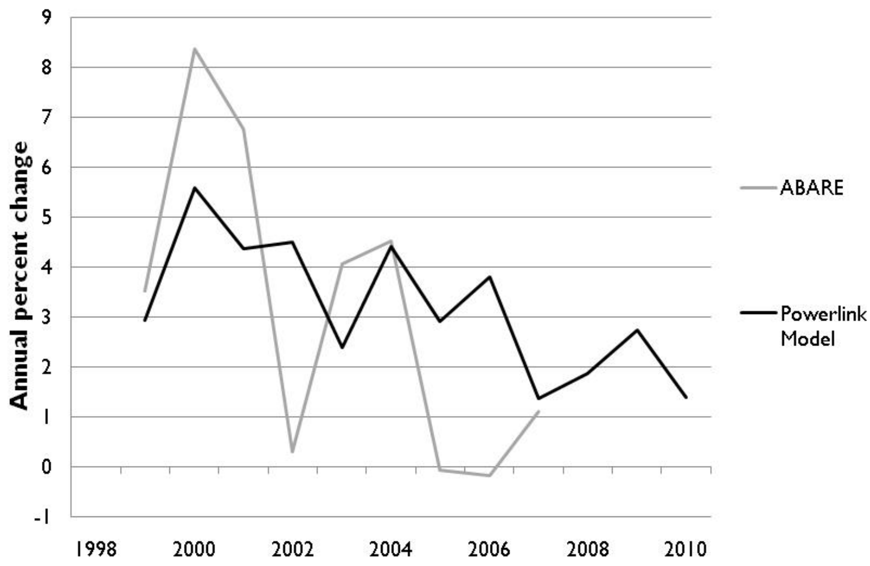
149. In Figure 21, we show the rate of growth in energy consumption (and in the case of the ABARE data, energy produced) and both show a clear downwards trend. Although the way in which NIEIR data is used in its model is not visible to us, we would expect from

19 [C-I-C] [redacted]

20 [C-I-C] [redacted]

the description we have been given that this declining trend is moderated by the temperature adjustment applied by Powerlink.

Figure 21 *: Growth in energy consumption*



Source: NZIER, ABARE, Powerlink

Sectoral contributions to growth

150. Our concern with the some aspects of the inputs and assumptions used in the forecasts resulted in a request to Powerlink for historical energy consumption data by sector. This data (figure 23) is helpful to identify where the demand changes have occurred and to consider the appropriateness of the input assumptions to future conditions in those sectors. This is especially relevant to sector contributions to GSP.

151. As expected, residential demand growth was steady until 2008 from when it has declined, while demand growth in both the commercial and large industrial sectors has fluctuated throughout this period. In terms of energy volume (GWh) the commercial sector accounts for 47% of total consumption.

152. Using this data as a backdrop, we reviewed the sectoral forecasts provided by NIEIR, as shown in figure 24. [C-I-C] [redacted]

Figure 22 *: GWh growth by sector*

[C-I-C]

Figure 23*: NIEIR energy forecast by sector*

[C-I-C]

4.7.3 Findings regarding data & assumptions

153. We consider that issues with data and input assumptions may be contributing to Powerlink's persistent over-forecasting in the past (relative to actual demand) and these issues appear to remain in the current forecasts. Our concerns are that:

a. the macro-economic forecasts may be too high, noting that they are high relative to the comparator forecast;

b. the effects of the "two-speed economy" does not appear to have been incorporated into forecasting, with the result that underlying (non-mining) load may be over-forecast. This appears particularly so for the commercial demand forecast;

c. increasing amounts of embedded generation, distributed (i.e. distributor-level) generation, energy conservation, saturation of air conditioning, and the evident declining trend demand growth rate, may have been insufficiently accounted for;

d. assumptions regarding retail price changes are not consistent with other forecasts and the impact of the price increases since 2000 appears to have been underestimated.

154. We have noted that these findings are based on our review of the primary source forecast documents, where we have sought to identify possible causes for the over-forecasting that is evident. Because we have not had access to Powerlink's or NIEIR's forecasting models, we have undertaken some further independent analysis to determine an alternative forecast.

4.8 Assessment of Powerlink 2013 – 2017 demand forecast

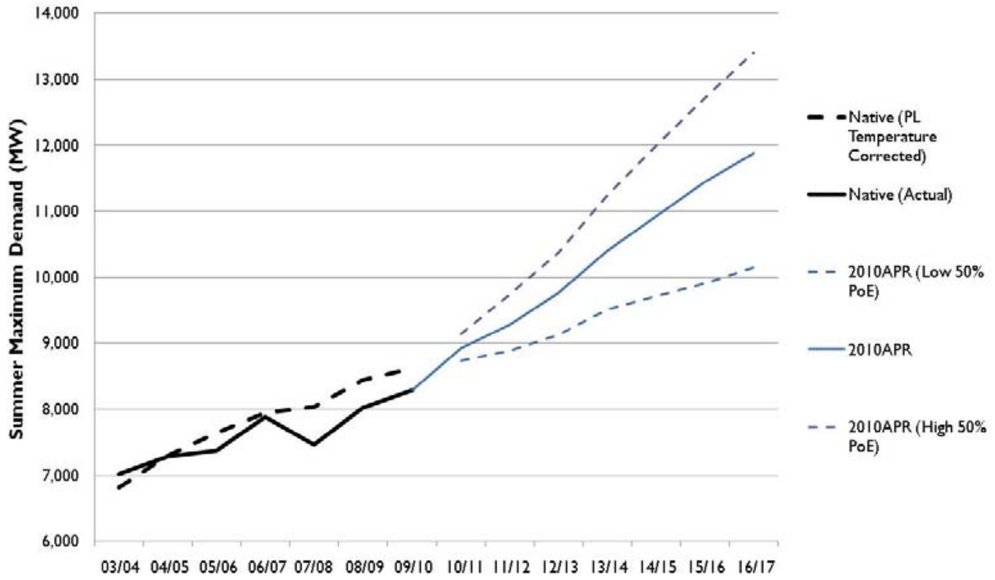
155. We set out here our assessment and findings regarding the demand forecasts that Powerlink has included in its 2013-17 Revenue Proposal. Our assessment is prepared on the basis of the review and analysis discussed in the previous sections of this report.

4.8.1 Powerlink forecasts

156. Powerlink uses the peak demand forecast from its 2010 APR as the basis for the capital expenditure (capex) forecast in its 2013-17 Revenue Proposal. Powerlink undertakes a low, medium and high forecast of "native load" and its base forecast uses a 50% PoE summer temperature. Powerlink uses this forecast as the basis to determine a "delivered" demand forecast which takes account of embedded generation and a "generation" forecast which takes account of transmission losses and generator "auxiliary" demands. Consistent with stated capital planning criteria, Powerlink derives a 10%PoE adjusted peak demand forecast, which is used for capex planning purposes so that its capex investment is planned to meet a "one-in-ten" summer in terms of summer maximum temperatures.

157. The figure and associated table below show Powerlink's actual and forecast peak demands, along with Powerlink's assessment of "temperature-corrected" historical demand.

Figure 24*: Queensland forecast summer demand*



Source: NZIER, Powerlink

Table 6*: Powerlink demand forecast*

MW

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
High Scenario 50% PoE	9,738	10,384	11,245	11,992	12,714	13,404
Med Scenario 50% PoE	**9,280**	**9,765**	**10,400**	**10,930**	**11,447**	**11,877**
Low Scenario 50% PoE	8,890	9,129	9,516	9,714	9,909	10,148

Source: NZIER, Powerlink

158. Recalling that Powerlink takes NIEIR forecasts as an input and makes adjustments to develop its own forecasts, we felt it useful to present the NIEIR forecasts in a similar format to identify where the adjustments take place. Powerlink appears to adjust the NIEIR forecast downwards in 2013 (and 2012, though this is not part of the forecast period), with substantial upwards adjustments in the remaining years, under all scenarios.

Table 7*: NIEIR 2010 demand forecast*

[C-I-C]

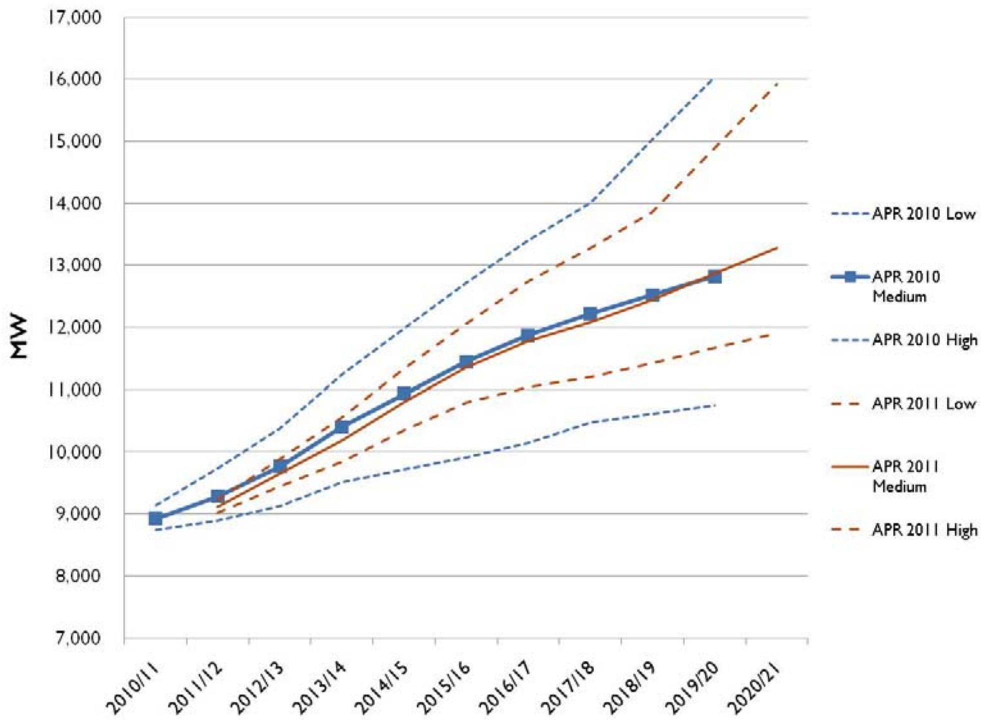
Table 8: *Difference between Powerlink 50% PoE demand forecast and NIEIR forecast*

[C-I-C]

159. In the 2010 medium growth scenario, Powerlink's peak demand growth is forecast to be around 4.2% per annum over the next 10 years.

160. Bearing in mind that the 2010 APR was prepared more than a year ago, we compared the 2010 APR forecast, as used for the Revenue Proposal, with Powerlink's recently released 2011 APR. While the 2011 medium scenario commences lower than the 2010 forecast used for its Revenue Proposal, Powerlink forecasts a slightly higher growth rate such that it reaches a similar (though still slightly lower) level by 2016/17 (the last year of the RCP). The high demand forecast is notably less than in the 2010 APR with, in effect, a one-year deferral of the entire forecast. On the other hand, Powerlink forecasts a considerably higher "low" demand forecast. The resulting forecast range is much narrower than the range used in Powerlink's Revenue Proposal.

Figure 25 *: Comparison of Powerlink 2010 and 2011 APR*



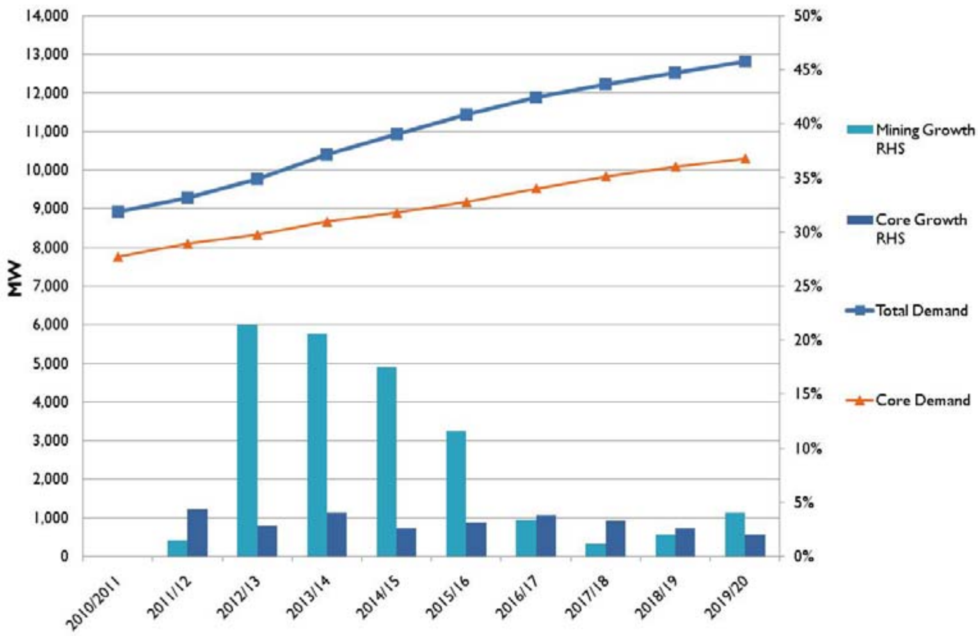
Source: NZIER, Powerlink

161. Using the 2010 APR, the forecast projects a 2010/11 demand of 8,924MW which is higher than the 2010/2011 actual of 8,109MW, Powerlink's "temperature-corrected" demand assessment of 8,350MW and Powerlink's "temperature and flood/cyclone corrected" peak demand assessment of 8,620MW.

162. The 2010 and 2011 APRs have medium forecast “start points” for the regulatory period (i.e. for 2012/13) of 9,765 and 9,653 MW respectively, both of which are more than 1,500MW more than the most recent actual (2010/11) of 8,109MW.

163. Mining and Industrial directly connected loads are an integral part of these forecasts and are reviewed directly with the customers by Powerlink who remove these loads from the NIEIR forecasts and replace them with its own view as described previously. The impact of this process on demand levels and demand growth in the forecast is shown in figure 26 below.

Figure 26 : *Peak demand forecast MW – excluding mining and direct connect*



Source: NZIER, Powerlink

4.8.2 Findings on Powerlink’s proposed demand forecasts

Background to our findings

164. As described in section 4.2.2, Powerlink’s demand forecast performance has been poor, with consistent over-forecasting of peak demand since 2005. In our assessment process, we have focused on attempting to determine likely reasons for this over-forecasting and on assessing whether there is good reason to believe that these issues are rectified in the current forecast.

165. We have made our analysis and assessment based on our experience with forecasting electricity demand, our experience with forecasting generally including demand forecasting in other sectors, our understanding of the electricity sector and particularly the transmission sector and previous experience with Queensland electricity sector transmission plans. We have assessed the material aspects of Powerlink’s approach to forecasting, the methodologies and processes it uses and the inputs employed.

Headline findings

166. On this basis, we consider that the demand forecasts that Powerlink has proposed for its 2013-17 Revenue Proposal, should not be accepted. We consider that the forecasts overstate the initial "starting point" by overstating a "step increase" from the most recent peak demand, even after allowing for a cooler recent summer and the effects of the 2010/11 cyclone and flooding, and that they also overstate the subsequent growth rate.

167. The reasons why we have formed this view are as follows:

a. Powerlink's current forecast uses 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, as previous over-stated forecasts;

b. Powerlink has (in its 2011 APR) already reduced its forecast from that proposed in its Revenue Proposal, particularly in the early years of the forecast, and its 2011 high-demand forecast represents what is in effect a series of one-year demand deferrals relative to the forecast in its revenue Proposal;

c. Powerlink's approach taken to temperature correction appears to over-state that correction and also to distort the resulting forecast;

d. A range of structural changes is evident to us from our independent examination of data, including a declining demand growth rate and a declining "energy intensity" of demand growth with GSP and population. We do not see evidence that these have been taken into account;

e. The macro-economic forecasts used to drive the econometric forecast model appear to be towards the upper end of accepted forecast ranges;

f. We consider that the effects of recent and projected retail price changes have not been adequately accounted for;

g. We do not see evidence of the forecast accounting appropriately for the effects of the "two-speed economy" or of assessing forecast demands appropriately at sectoral level. Growth in the commercial component of the demand forecast used as a key input by Powerlink appears high and the effects of lower economic activity in the non-mining sectors appears not to have been fully accounted for;

h. We do not see evidence that we would find satisfactory, accounting for increasing embedded generation, distributed generation and energy efficiency measures[21].

Assessment by reference to forecasting principles

168. While the approach that Powerlink takes to developing its forecasts is reasonably clearly described at an oveview level, we consider that Powerlink has not adopted a coherent and structured approach to the development and governance of its regulatory demand forecasting. In particular there is not a clear set of principles as to how

[21] These matters are partially addressed in NIEIR's 2011 forecast advice to Powerlink, but this is not the basis for Powerlink's Revenue Proposal forecast.

Powerlink interprets the NER and its obligations under its Queensland licence and thereby how it converts those regulatory requirements into an appropriate demand forecast for capex planning purposes.

169. We consider that revisions based on such principles would lead to improved forecasts for the 10% PoE peak demand forecast that is required for capex forecasting purposes for the Revenue Proposal. These forecasts are currently produced as part of a much larger process which produces a range of different forecasts (energy and peak demand) over a range of time periods.

Other observations

170. At the "process" level, we consider that the methodology used by Powerlink is broadly satisfactory and is in line with what we would expect. In particular, we consider that a top down / bottom up approach such as Powerlink uses, is broadly appropriate in reconciling macro effects with connection-point level forecasts.

171. A weakness in the approach as currently applied is that the adopted forecasts are essentially those prepared by NIEIR, whose approach (including its model and model parameters) is not transparent to other parties and it appears that Powerlink understands this modelling only at a general level. We consider that the input provided by the KPMG / AEMO process is not sufficient to redress this and to provide the necessary level of independent verification.

Conclusions on assessment of Powerlink forecast

172. We regard these matters as significant and, as agreed with AER, we have conducted analysis to support an alternative forecast that we consider will be more appropriate in determining Powerlink's proposed revenue. This is described in the following section.

5 Alternative Forecast

5.1 Description of our process

173. Our process for determining the alternative forecast was developed to identify peak demand in the core transmission network, separate from the impacts of direct connected industrial and mining loads. We prefer an approach of forecasting peak demand (MW) directly, provided a suitable model can be established, rather than indirectly (as Powerlink describes) from an energy (GWh) forecast converted to peak demand using load factor assumptions. Data was requested from, and supplied by, Powerlink to enable this approach.

174. We prepared alternative forecasts using three methods to identify a range of possible outcomes:

   a. Method 1 which used historical Queensland state level ***temperature adjusted*** demand data from Powerlink, regressed against a range of demand drivers to determine the goodness of fit and the coefficients of the drivers. The mining and industrial loads were then added to obtain a state total;

   b. Method 2 which used historical regional level ***unadjusted*** (native) peak demand data from Powerlink, regressed against the same range of demand drivers plus the coincident daily maximum temperatures for each of the regions. These outputs were added, along with the mining and industrial loads to identify a state wide total load;

   c. Method 3 which involved a "naïve" trend analysis using both Powerlink's historical native and temperature adjusted peak demand data.

175. As noted prior, we forecast the growth in core demand separate from the mining/industrial loads in all three methods to avoid duplication. We used Powerlink's mining forecasts here because Powerlink reported the process whereby it had consulted directly with these customers and we accepted that process.

176. There are strengths and weaknesses to any forecasting process, however we consider that the approaches chosen here meet our assessment principles and provide the AER with a robust alternative forecast. One potential area of weakness was the relatively

short time series of historical demand data that Powerlink was able to provide. In determining long term relationships it is preferable to use as long a technically valid time series as possible but, despite our reservations, the 11 years of data we used proved to be an acceptable input.

177. To identify and separate the impacts of temperature on native peak demand we again sought data from Powerlink to enable this analysis. To make allowance for the diversity of the Queensland environment we conducted this part of the analysis on the same temperature regions that Powerlink uses.

178. The daily temperature data sourced from Powerlink was compared to our own sourced data and analysed to identify:

a. The significance of recent temperature trends in Queensland;

b. The relationship between temperature and peak demand in all four of Powerlink's temperature regions over 11 years;

c. The 10%, 50% and 90% PoE maximum daily temperatures for all four regions.

179. To take account of the weather diversity in the state the analysis of daily temperature data was conducted for each of the four regions but, to ensure that the effects of both the intra and inter annual weather patterns are identified, the analysis was conducted on an annual basis as well. Because seasonal weather patterns within each year vary, as does the overall annual climate (temperatures), we prepared regressions of temperature to peak demand for each of the 11 years in each region (44 in total). This process identified the intra-year relationship of peak demand to temperature around the peak, and we derived the 10%PoE forecast from the econometric / trend based 50% PoE forecast, using this relationship.

180. From this data we also observed changes over time in the relationship between peak demand and associated daily maximum temperatures.

181. To identify impacts from trend changes in longer term economic and demographic drivers, we developed time series of retail price changes and a range of widely used economic and demographic demand drivers.[22]

182. The following demand drivers were tested in the regressions;

a. Queensland state GSP – historical data from ABS, checked against Queensland Treasury data, and forecast data from NIEIR;

b. Queensland population – historical and forecast data from ABS, checked against Queensland Treasury and KPMG;

[22] Recalling that we had concerns with double counting of economic drivers we assembled our historic data on drivers, we used Queensland state GSP without mining contributions in our testing as mining/industrial demand was added directly to the output of the regression results.

c. Retail price – historical data from ROAM report to Clean Energy Council March 2011 and forecast data from KPMG, AER and Queensland Competition Authority BRCI[23];

d. Regional temperature data from Powerlink.

183. Where possible alternative sources of data were identified to allow a cross check on data quality in the alternative forecast.

184. After considerable testing of different models, we excluded GSP on the basis that we found it had little explanatory power in the analysis[24].

185. We selected the functional form of the forecast model as linear regression for a number of reasons but mostly because, based on our experience, the relationships between drivers and peak electricity demand are usually reasonably straight forward at the level being analysed here. If we were building a ground up forecasting model we would likely use functional forms specific to each demand sector (residential, commercial etc).[25]

186. We noted, but did not incorporate, work done by NIEIR subsequent to its forecast used for Powerlink's revenue proposal on embedded / distributed generation (such as PV) and electric vehicles. Had we done so, the effect would have been a further reduction in the proposed demand forecast. We decided not to include these factors explicitly, on the grounds of materiality given the limited time to advise the AER. Also, it could be argued that some such factors are correlated with electricity prices, which we have included in our forecasting model.

187. In determining the methodology for our alternative forecast we wanted to ensure that we were able to reflect current best practices, especially with regards to the temperature adjustments to Queensland peak demand. We identified two recent publications that report on demand forecasting work in California and in Belgium. Both these papers include consideration of temperature adjustments with the California paper especially helpful to our analysis.

[23] This includes taking account of AER determinations for Queensland distribution network charges.

[24] Most likely, the factors influenced by GSP were covered by other variables, such as population

[25] We have undertaken more extensive demand forecast reviews at a detailed level and have considered a range of possible technical approaches to temperature corrections for regional forecasting of transmission loads.

5.2 Results

5.2.1 50% PoE forecasts – methods assessment

188. Our approach using the three forecasting methods described above resulted in the following peak summer MW demand for Queensland, including the add back of Powerlink's forecast of mining and industrial loads.

Table 9: *NZIER peak demand forecast – including mining and direct connect*

MW

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Method 1 - State Demand	8,792	9,196	9,631	10,064	10,421	10,609
Method 2 - Regional Demand	8,841	9,259	9,710	10,161	10,537	10,746
Method 3 - Trend line Demand	9,068	9,359	9,651	9,942	10,233	10,525
PL Demand - Medium growth	9,280	9,765	10,400	10,930	11,447	11,877

Source: EMCa/NZIER & Powerlink

189. While the three methods provide similar forecasts, albeit at a materially lower level than Powerlink, we considered the relative merits of each forecast as follows.

190. Methods 1 and 3 both take the temperature "corrections" applied by Powerlink in the past and use these as the basis for the projection. Method 2 takes the maximum regional temperatures from the last 11 years and, in the regression, relates these temperatures directly to demand without any separate adjustments.

191. Methods 1 and 3 also both use average Queensland state conditions (economic, demographic and climate) from the past and project them into the future; on the other hand, method 2 takes account of the regional differences in Queensland (in regards temperature, its relationship with demand and population growth). These regional differences are significant.

192. We prefer method 2 as a basis for our proposed alternative forecast because it:

   a. relates actual peak MW by region to population, retail prices and maximum temperature by region while making allowance for direct connect loads at regional level as well;

   b. eliminates the problematic separate temperature correction of historical actual native demand;

   c. takes retail price changes into account via a demonstrated historical relationship that shows plausible coefficients, and uses best available future retail price forecasts;

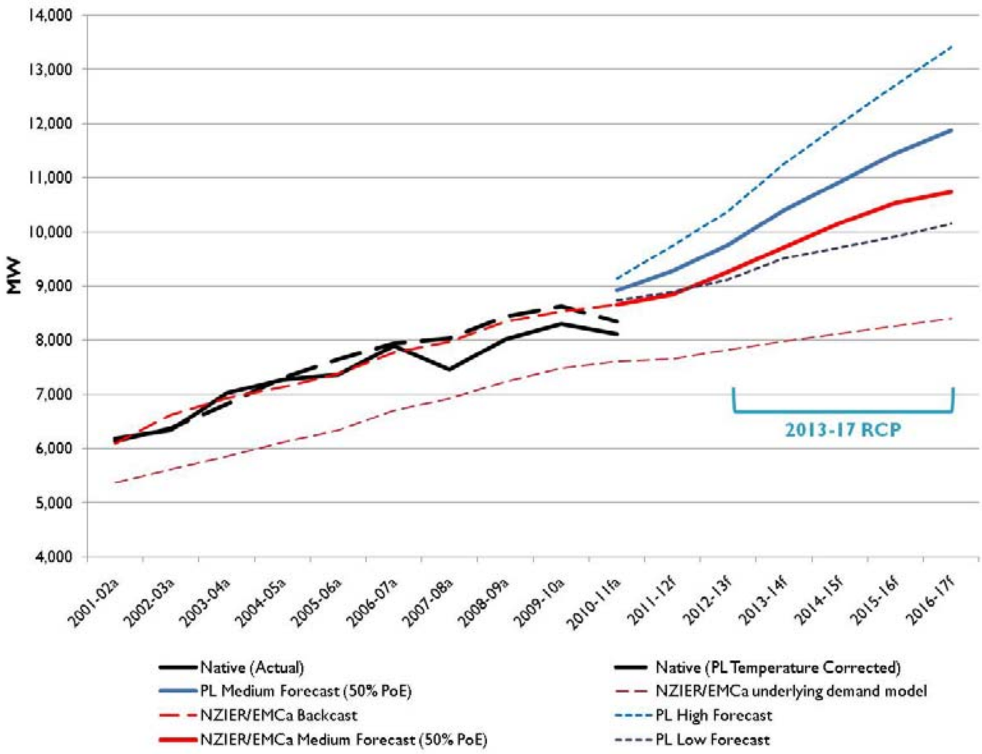
   d. incorporates the changes to the demand drivers (including temperature) directly into the regression model.

193. We also consider that method 2 provides a result that was consistent with the "flood correction" that Powerlink attached to its 2011 actual peak demand. The back-cast results of the model are relatively close to (though generally less than) Powerlink's

temperature and flood-corrected historical demands and, because it is based off eleven years of historical demand, the need for consideration of a one-off "starting point" adjustment is avoided.

194. In short, we consider that method 2 provides a superior basis for forecasting, while noting that it is not inconsistent with either of the other methods. The proposed forecast is shown in the following graph, which also shows Powerlink's medium forecast. The graph shows the "underlying" demand model that we have produced (which excludes mining, LNG and direct-connected industrial loads) and the resulting total once these loads are "added back". We have also shown "backcast' results which can be compared with temperature-adjusted actual demands.

Figure 27 : *EMCa/NZIER and Powerlink peak demand forecasts compared (MW, 50% PoE)*



Source: EMCa NZIER

5.2.2 10% PoE forecast

195. An important part of our alternative forecast process was to identify the causal relationships between native peak demand and temperatures at regional level in a similar manner as did Powerlink but using daily maximum temperatures rather than daily averages. Our earlier testing, and our literature search on best practices, identified maximum temperatures as the more appropriate driver of peak demand.

196. To provide a 10% PoE temperature adjustment for decisions on capex allocations we;

a. identified a linear relationship for demand and maximum temperature in each of 11 years, across all regions, that had a better fit than other temperature choices[26];

b. examined the S-curve for SEQ and identified that a linear fit was better than a cubic curve, and that the S-curve biases the correction on the upwards side[27];

c. selected the highest coefficients by region from this analysis;

d. applied these coefficients regionally to core underlying loads, excluding mining and industrial.

197. This process resulted in PoE adjustments that were lower and with less spread than those identified by Powerlink, as can be seen by the smaller differential between our 10% PoE and 50% forecasts. The temperature sensitivity and PoE estimates that we found are as follows.

Table 10: *NZIER PoE and temp sensitivity by region*

	SEQ	SWQ	CQ	NQ
Sensitivity - MW	119.74	9.24	30.03	17.88
10% PoE oC	37.8	34.9	38.4	33.9
50% PoE oC	35.8	32.1	36.0	32.1
90% PoE oC	35.3	30.5	33.9	30.3

Source: EMCa NZIER

5.2.3 High and low demand forecasts

198. Powerlink uses high, medium and low demand forecasts to produce a range of capex scenarios in its probabilistic planning model. From our work reviewing Powerlink's capex forecast[28], we found that the resulting forecast from this process (for which Powerlink used 20 scenarios) was close to the capex forecast resulting from use of the medium demand forecast only. Therefore the presence of high and low demand forecasts, separately considered, does not appear to bias the capex forecast. Moreover our proposed "medium" demand forecast is closer to Powerlink's low demand forecast, for which Powerlink had already produced a capex forecast.

199. We therefore established that a medium demand forecast would suffice for the purposes of reviewing and, as required, proposing an adjustment to Powerlink's capex

[26] This is the 44 regressions that were described earlier.

[27] By its nature the function of the S curve is not linear and we have estimated that it results in a MW correction upwards, when temperatures are lower than normal, that is nearly twice the adjustment downwards of above-normal temperatures.

[28] EMCa in association with Strata Energy Consulting

forecast, while noting that this forecast needs to be based on a 10% PoE (one-in-ten year) assumed temperature.

5.2.4 Resulting forecasts

200. The following three tables describe the Powerlink medium scenario at 10%, 50% and 90% temperature PoE, the NZIER alternative forecast on the same basis and the differences between these two.

Table 11: *Powerlink peak demand forecasts*

MW

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Med Scenario 90% PoE	8,992	9,467	10,090	10,613	11,120	11,537
Med Scenario 50% PoE	9,280	9,765	10,400	10,930	11,447	11,877
Med Scenario 10% PoE	9,753	10,252	10,907	11,450	11,984	12,437

Source: Powerlink NZIER

Table 12: *EMCa / NZIER alternative peak demand forecasts*

MW

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Med Scenario 90% PoE	8,674	9,089	9,536	9,983	10,357	10,563
Med Scenario 50% PoE	**8,841**	**9,259**	**9,710**	**10,161**	**10,537**	**10,746**
Med Scenario 10% PoE	9,205	9,632	10,090	10,547	10,931	11,146

Source: EMCa NZIER

Table 13: *Differences between proposed alternative forecast and Powerlink forecast*

MW

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Med Scenario 90% PoE	- 318	- 378	- 554	- 630	- 763	- 974
Med Scenario 50% PoE	**- 439**	**- 506**	**- 690**	**- 769**	**- 910**	**- 1,131**
Med Scenario 10% PoE	- 548	- 620	- 817	- 903	- 1,053	- 1,291

Source: EMCa NZIER

5.3 Recommendations

201. We recommend that the AER adopts the alternative forecast that we have proposed in section 5.2 above. Specifically we recommend that our alternative forecast for a medium scenario, at 10% PoE temperature, should be used in place of Powerlink's medium forecast at 10%PoE, and that any other forecasts used for planning purposes should be similarly adjusted.

202. We consider that the alternative forecast provided here provides indications to alternative approaches that Powerlink could consider and further refine, for example, to the connection point level, with low and high demand variants and by further reviewing structural trends driving changes in consumers' energy usage patterns and trends in embedded / distributed generation.

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A. Annexure

Annex 1: Terms of Reference

Demand forecast methodology

203. Powerlink's energy, maximum demand and weather correction models are used to develop the demand forecast for its revenue proposal. The maximum demand forecast is used to determine the future capex requirements for the main system network.

204. The demand forecast consultant is required to review the demand forecast models applied by Powerlink to develop the demand forecasts published in Powerlink's Annual Planning Report 2010 and AEMO's 2010 Electricity Statement of opportunities.

205. The demand forecast consultant is required to review the reasonableness of the methods, inputs and data sources of the models as set out below.

Forecasting Methods

206. The demand forecast consultant must describe and comment on the reasonableness of Powerlink's energy, maximum demand forecast and weather correction models used to develop the demand forecasts, including the:

- functional form of the models;
- inter-relationships and interactions between the models;
- method that Powerlink uses to incorporate historic information;
- method that Powerlink uses to develop probability of exceedance (PoE) forecasts and low, medium and high growth forecasts.

207. The demand forecast consultant must describe and comment on the reasonableness of the changes to Powerlink's energy, maximum demand forecast and weather correction models between 2006 and 2010.

208. Where applicable, the demand forecast consultant must describe and comment on the reasonableness of the process that Powerlink uses to derive regional maximum demand forecasts from the QLD maximum demand forecast.

209. The demand forecast consultant must identify and comment on the reasonableness of any other relevant aspect of Powerlink's energy, maximum demand and weather correction models.

210. The demand forecast consultant is required to take into consideration any reports, documents or other views relevant to Powerlink's demand forecast models.

Inputs and data sources

211. The demand forecast consultant must identify and comment on the reasonableness of the inputs and assumptions in Powerlink's energy, maximum demand and weather correction models, including, but not limited to:

- real QLD gross product
- real interest rates
- Consumer Price Index

- residential population
- real price of electricity and real price of natural gas
- monthly electrical energy
- cooling and heating days
- air conditioner ownership
- half hourly loads and daily temperatures
- major energy loads
- scheduled generation, embedded generation and demand side participation
- distribution and transmission network losses

212. The demand forecast consultant must identify and comment on the reasonableness of the data sources used by Powerlink in its energy, maximum demand and weather correction models and evaluate whether Powerlink has used consistent data sources across its models.

Annex 2: Electricity Demand Forecasting

213. Methods available for forecasting electricity demand include:

a. trend method – extends the historical trend over time, without considering explanatory variables; does not reflect cause and effect; most suitable for short-run projections;

b. end use method – models the energy use patterns of various devices and systems (e.g, household electrical appliances) and aggregates across end uses and end users; incorporates device use rates, energy efficiency improvements and fuel substitution; most effective for new technologies and fuels, which lack time series data, but requires detailed data on each end use and can overlook behavioural responses of consumers;

c. econometric method – establishes causal relationships between electricity demand and various economic, demographic and climatic variables from statistical analysis of historical data; then uses these relationships and forecasts of explanatory variables to project future electricity demand; requires a consistent set of data over a long time period; any future change in relationships, such as due to economic shocks or government policy, must be built into the model explicitly;

d. time series method – uses econometric models in which the only explanatory variables are lagged electricity demand, on the assumption that future demand is related to past actual and expected demand, with adjustment for how actual past demand differed from expected; requires data over a long time period; does not reflect cause and effect; most suitable for short-run forecasts;

e. more advanced modelling methods such as neural networks, chaos analysis and fuzzy logic – develop mathematical or computational models to determine complex relationships between inputs and outputs or to find patterns in data and then simulate the structure and/or functional aspects of behaviour; often adaptive models that “learn” from the external or internal data they process and evolve accordingly; can produce more reliable and stable forecasts than more traditional modelling methods; still somewhat experimental, but increasingly used overseas for short–run forecasts; require expert skills and forecasts are not transparent to non-experts; have tended to be used more for short-run forecasting; and

f. hybrids of the above methods, such as combining econometric models with time series models or the end use approach.

214. A variation of the econometric method is the fuel share model. This approach forecasts total energy demand, as a first step, before dividing this total between different energy sources or “fuels”, one of which is electricity. A strength of this method is its explicit recognition of substitution between fuels according to relative fuel prices. A weakness is that it does not reflect the interdependence between price and quantity. Its sequential estimation procedure assumes that fuel prices are determined independently of both total energy demand and the distribution of demand by fuels, and that total energy demand is independent of fuel shares (Meetamehra, 2009). A rise in price may not only cause consumers to switch to another fuel, but cause a reduction in total energy demand. A fall in one fuel’s share of total energy demand is not necessarily matched by an equal and opposite rise in another fuel’s share.

215. In contrast, the econometric method assumes that relationships, such as between electricity demand and GDP, remain constant. This may not be valid where there is a significant shift in the composition of total energy demand, as NZIER (2005) finds there to have been in the mid to late 1970s and early 1980s in New Zealand. In focussing on shares, the fuel share approach can also overlook important drivers of the level of demand, such as demand for the end products produced using fuel inputs.

216. The econometric method is generally the most suitable method for long-run forecasting and is widely used in other countries, although with some variation in explanatory variables and functional forms. In New Zealand the Electricity Commission (EC) shortened the historical data series used for the commercial and industrial model to post 1986, to address the structural break in the relationship between electricity demand and GDP arising from change in the share of electricity in total energy demand. Estimates of energy demand equilibria in NZIER (2005) suggest that in New Zealand electricity demand is becoming increasingly de-linked from demand for other fuels and is converging towards a more stable equilibrium relative to GDP.

217. In viewing the relationship between electricity demand, GDP and population, there are three aspects to consider – the **explanatory variables** modelled as drivers of electricity demand, ***the functional form*** modelled as representing the relationship between electricity demand and these drivers, and ***the time period*** over which this relationship is derived from historical data.

Explanatory variables

218. Econometric modelling of electricity demand as a function of economic, social and demographic variables, as well as climatic factors, is a widespread approach in long-run forecasting of electricity demand. For example:

- Italy – GDP, population, GDP per capita (Bianco et al., 2009)
- France – climatic temperature and cloudiness, economic activity, price (sales offers) and season (whether on daylight saving time) (RTE, undated)
- Cyprus – number of customers, price and number of tourists (Egelioglu et al., 2001)
- Hong Kong – climatic variables (Yan, 1998) and GDP, deflated domestic exports, population and price (Fung and Tummala, 1993)
- Singapore – GDP, population and price (Liu et al., 1991)
- India – population and weather (Rajan and Jain, 1999) and
- Maryland, USA – per capita income, price and long-run elasticity of demand (Lakhani and Bumb, 1978).

219. GDP, population and price are commonly selected as the most significant explanatory variables. The variables adopted by the Electricity Commission in forecasting residential demand and commercial and industrial demand in New Zealand – GDP, population, households and price – reflect the strong empirical relationship between these drivers and electricity demand. The residential demand model originally included a climatic temperature adjustment, but this was removed in the 2006 review as it made the modelling more complex for a negligible impact on the long-run forecasts.

220. NZIER (2004) questions whether there might be explanatory variables available other than GDP that would better reflect the influence of income or standard of living on residential demand and of output or revenue on commercial and industrial demand. An advantage of GDP is the availability of historical data for as long as reliable data on electricity consumption have been available, whilst many other official data series are available from 1987 only. The Electricity Commission has, however, already shortened the time period of historical data used for the commercial and industrial model to since 1986, due to a structural break in the relationship between GDP and electricity demand. GDP appears slightly superior overall. In determining long-run relationships, it is preferable to use as long a time series as available, reliable and technically valid. GDP is therefore particularly useful for the residential model which still uses historical data back to 1974, which is not available for the alternative explanatory variables.

Functional form

221. There are a number of different functional forms, including linear, log, per capita, first differences and lagged dependent variable, however selecting the model that performed best inevitably involves some compromise, such as between goodness of fit, stability and robustness to the common problems of multicollinearity (correlation between explanatory variables), cointegration/non-stationarity (similar trends over time in explained and explanatory variables, which may be coincidental rather than directly causal) and autocorrelation (correlation between an explanatory variable's current and past values). The choice of functional form is also often constrained by the objective of simplicity and transparency of methodology.

222. Although a common model structure across the three demand sectors would further this simplicity, we recognise that no one model structure performs well for all three sectors. We do not consider the selected model structures so different as to impede understanding.

Time period

223. One of the questions that emerges from this review is whether the relationship between electricity demand, GDP, population and other drivers has changed over the time period of historical data used to derive the coefficients for forecasting future electricity demand. If so, different starting points in regression analysis of the historical data can result in different values of these coefficients and therefore different forecasts. If a significant structural break has occurred, the time period may need to be shortened, or time dummy variables introduced to reflect more accurately the more recent relationship.

B. Glossary

ABARE	Australian Bureau of Agricultural and Resource Economics (now ABARES: Australian Bureau of Agricultural and Resource Economics and Sciences)
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
APR	Annual Planning Review
DNSP	Distribution Network Service Provider
EMCa	Energy Market Consulting associates
GSP	Gross State Product
LNG	Liquified Natural Gas
NEM	National Electricity Market
NER	National Electricity Rules
NIEIR	National Institute of Economic and Industry Research
NZIER	NZIER Consulting
PoE	Probability of Exceedance
RCP	Regulatory Control Period
ROAM	ROAM Consulting
SEQ	South East Queensland
STPIS	Service Target Performance Incentive Scheme
Strata	Strata Energy Consulting

TNSP	Transmission Network Service Provider
TOR	Terms of Reference
WACC	Weighted average cost of capital