Forecasting capital expenditure for the Queensland transmission grid – an approach to deal with a rapidly changing power system

Discussion Paper

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1 Abbreviations

Abbreviation	Definition
ACCC	Australian Competition and Consumer Commission
Capex	Capital expenditure which is part of the revenue building block
ERU	Electricity Reform Unit – the Queensland Interim Regulator
NEC	National Electricity Code
NECA	National Electricity Code Administrator Limited
NEM	National Electricity Market
NEMMCO	National Electricity Market Management Company Limited
QNI	Queensland – New South Wales Interconnector
TNSP	Transmission Network Service Provider
TUOS	Transmission Use of System charge

2 Introduction

Powerlink Queensland is currently preparing its application to the ACCC for its revenue cap determination for the period 2002 to 2007. The ACCC's principles for setting revenue, the accrual building block approach, include a mechanism for rolling the forecast capital expenditure into the regulatory asset base. Powerlink is required to produce a capital expenditure forecast as part of its formal submission to the ACCC in early 2001.

Producing such a capital expenditure forecast for anything beyond a 2 to 3 year period for the Queensland grid requires an innovative approach, given the changing generating patterns which will be superimposed on a relatively high demand growth in the State and a "tight" grid.

Powerlink has significant obligations to develop its network to meet the security and reliability standards of the National Electricity Code and has additional obligations under its transmission licence and the Queensland Electricity Act.

Thus, despite the forecasting challenges, the revenue caps determined by the ACCC must provide for sufficient capital expenditure to enable Powerlink to meet these obligations.

Powerlink faced the same challenges in providing a capital expenditure forecast for its recent final revenue determination by the Queensland Interim regulator (ERU) and developed an approach which was endorsed by ERU and its independent consultant, Arthur Andersen.

Powerlink believes that a refinement of that approach is the most appropriate approach for the ACCC to adopt in its revenue determination for Powerlink.

It should be noted that the capital expenditure forecasting process undertaken by the ACCC in its revenue cap decision **does not constitute approval for individual projects**. The aim of the forecasting process is to be as close as possible to the final actual outcome to avoid later price shocks to customers. Approval for individual projects is sought through a separate NEC process, which would involve the Regulatory Test.

2.1 The nature of the estimating challenge

In its *2000 Annual Planning Statement*, Powerlink noted that there was considerable uncertainty about the development of the transmission grid beyond 2002. The primary cause of this uncertainty is the commissioning of significant amounts of committed new generating capacity (and QNI) between 2001 and 2004, and the impacts this new capacity will have on the existing generation pattern. The major “unknown”, in terms of grid development, is which specific plant will be impacted and when. This will be influenced by the bidding strategies of all generators (including NSW).

There is also considerable uncertainty on the generation side beyond 2004; with the combination of the Energy Policy and mooted gas developments also likely to impact on the established generation pattern at that time. Against this uncertainty, is the relative certainty of continued demand growth on an already-tight transmission grid.

The upshot is that there are many plausible scenarios for the generating patterns which will emerge over the coming years, and each of these scenarios requires a different set of transmission grid developments. Powerlink can develop a transmission grid development program, and related capital expenditure forecast, for each plausible generating scenario (and did so for the recent ERU determination).

The challenge is – how should these be used in arriving at a **single value** for the forecast of capital expenditure in each year of the regulatory period? Is it appropriate for Powerlink (or the ACCC) to attempt to pick the “winning” scenario? Or is there a more rational approach?

2.2 Underlying principles

Powerlink’s grid development is driven by the need to meet the security, reliability and technical standards of the Code. In essence, it is driven by the growth in demand by loads. However, the ability of the network to provide adequate transmission capacity is affected by two factors: (i) changes in consumption (demand growth) and (ii) changes in production (the generation despatch pattern). Power flows on the network change as new generators connect to meet the growing demand (and the existing generation pattern impacted). Hence, *load-related capital expenditure* is influenced by movements in the generation market as well as demand growth.

Secondly, it needs to be made clear that the aim of estimating capital expenditure in the revenue setting process is NOT to give approval for new network projects. Such approvals have to come through a separate process (the *Regulatory Test*). Rather the aim is to set aside an appropriate allowance to best match network outcomes driven by National Electricity Code, Electricity Act and transmission licence obligations. Best practice regulation would seek to provide a capex allowance which closest matches the future network needs.

It is important for customers that the forecast capital expenditure used by the ACCC is as close as possible to the code-driven requirements. If the forecast is too high, the customers will experience higher than necessary TUOS charges until the next regulatory reset, when the over-estimation can be clawed back. However, if the forecast is too low, then there would be a "step increase" in TUOS charges at the next reset. Thus, whilst the objective is to forecast accurately, erring marginally on the upside is less impactful on customers than erring on the downside.

2.3 Conventional approach – the disadvantages

In its recent determination for the NSW transmission entity, Transgrid, and in earlier Powerlink determinations by the Queensland Interim Regulator, a "conventional" approach to the capital expenditure forecast was used. In the conventional approach, the transmission entity produced a single list of expected projects. The Regulator made an assessment of both the reasonableness of the quantum of capital for each project and the likelihood of occurrence of each project, effectively assigning each project a weighting of either 1 or 0.

This approach is arguably reasonable where the outlook for the power system is relatively stable (eg low demand growth, little or no new generation capacity).

However, the approach is not reasonable for the present Queensland system because, as mentioned above, there are many plausible scenarios for generating patterns, and hence transmission developments, ranging from plausible scenarios with limited need for grid development to plausible scenarios which would require significant grid development. It should be noted that the grid development in each scenario is driven by Powerlink's need to meet security, reliability and technical standards.

The "conventional" approach would require Powerlink (and the ACCC) to select a single scenario from the range of plausible scenarios and to produce a single list of projects as the basis of the capital forecast. This amounts to asking Powerlink (and the ACCC) to "pick a winner" from a range of quite different scenarios, when the drivers of the different scenarios is the future bidding behaviour of new Queensland and NSW generators, and incumbents striving to protect their positions against new entrants.

Powerlink believes that it is inappropriate for the ACCC to be making regulatory determinations in that manner, and that a sounder, more rational approach exists.

2.4 Proposed approach

Powerlink proposes an approach similar to that used in the recent ERU determination, of which ERU's independent consultants, Arthur Andersen, commented:

"… the main issue affecting the Capital Expenditure Forecasts is the uncertainty that has arisen due to the implementation of the deregulated generating industry and the ability of entrepreneurial projects to be developed, both with shorter lead times than previously. In the past it was recognised that transmission networks were expected to be able to effectively forecast the required capital development for the system up to 15 years in advance, as stated the confidence in this forecasting is no longer possible. ***To combat this Powerlink has developed a very detailed analysis and is to be commended for the level of effort that is being applied to the uncertainty problem."***

"… the overall capital plan is deemed to be in a good position to deal with complex and uncertain capital planning strategies for the network".

This paper presents a probabilistic approach to determine an appropriate allowance for capital expenditure instead of the traditional, single-scenario approach of outlining a single list of projects. A probabilistic approach is a logical and widely accepted way of addressing uncertainty where there are a range of plausible outcomes/scenarios.

As a final step in this capital forecasting process, there is a “reasonableness test” to compare the probabilistically-derived estimates with the inherent long term trendline for capex in a network of this size.

3 The Capital Forecasting Process for Powerlink

3.1 The capability of the existing network

Powerlink’s network is one of the longest in the world – extending more than 1700km through diverse and demanding natural environments. It is largely made up of a double circuit 275kV backbone stretching from Cairns in far North Queensland to the border with New South Wales with the new interconnector.

The system has been developed using a minimalist approach, keeping transmission supply just ahead of the power demand. The result is a long, thin system that is **heavily utilised and is being operated very close to its limits**. As such, it cannot respond to increasing demand and significant changes to the pattern of generation despatch without significant additional capital investment.

Most of the existing base-load generating capacity in Queensland is found in the Central Queensland region, with the highest forecast demand growth occurring in the Far North and South-Eastern areas of the state – that is, at the extremities of the grid. Some 60% of the demand arises in the South East corner, remote from the major existing and committed new generation. The growth superimposed on this topology gives rise to a need for significant network investment for many years. In addition, the situation is exacerbated by the significant changes in future generation patterns that are evident in Queensland.

3.2 Powerlink’s obligations for network development

As a transmission network service provider (TNSP), Powerlink is obliged to meet the requirements of Schedule 5.1 of the National Electricity Code (NEC) and in particular, clause S5.1.2.1:

“Network Service Providers must plan, design, maintain and operate their transmission network … to allow the transfer of power from generating units to Customers with all facilities or equipment associated with the power system in service and may be required by a Code Participant under a connection

agreement to continue to allow the transfer of power with certain facilities or plant associated with the power system out of service, whether or not accompanied by the occurrence of certain faults (called "credible contingency events").

The following credible contingency events and practices must be used by Network Service Providers for planning and operation of transmission networks…

The credible contingency events must include the disconnection of any single generating unit or transmission line, with or without the application of a single circuit two-phase-to-ground solid fault on lines operating at or above 220 kV."

Powerlink's transmission authority also includes a responsibility

"… to ensure as far as technically and economically practicable, that the transmission grid is operated (and if necessary, augmented or extended to provide enough capacity) to provide network services to persons authorised to connect to the grid or take electricity from the grid …" (Electricity Act 1994, S34)

3.3 The ACCC's Regulatory Test

The ACCC has an obligation under clause 5.6.5(q) of the Code to promulgate a *regulatory test*. The aim of the regulatory test is to protect customers against over-development and ensure that only prudent network augmentations are allowed to enter the asset base. On 15 December 1999, the ACCC published a document named *Regulatory Test for New Interconnectors and Network Augmentations* which sets out this regulatory test.

The Regulatory Test identifies 2 types of network augmentations:

(a) those required to meet technical standards, and

(b) those which may deliver a net market benefit (eg removal of a constraint)

Almost all of Powerlink's anticipated network augmentations are type (a) – to meet security and reliability standards for network loads.

The regulatory test states that the test must not be applied to a proposed augmentation more than 12 months prior to the start of construction date. This means that most of the network augmentations which are included in the forecast capex estimate for determination of Powerlink's revenue cap will still have to pass the Regulatory test in the future.

3.4 Identifying potential network augmentations

To forecast future capital expenditure, a transmission network service provider (TNSP) estimates the cost of what is predicted to be the required future transmission augmentations (new works) and refurbishment/replacements of aged/obsolete plant and equipment, particularly plant whose service rating is exceeded. The process involves determining:

- a load (particularly demand) forecast;
- a future generation program;
- future operation of the energy market, in sufficient detail to estimate network flows;
- required augmentations to maintain network security and reliability standards in accordance with the National Electricity Code (NEC) and its transmission licence;
- any augmentations which may result in net market benefits (as defined by the regulatory test), eg by removing constraints;
- required plant replacements to maintain safety and security standards;
- estimated yearly capital expenditure based on network augmentations/replacements for the required forecast period.

The main drivers to augmentations of the transmission network are:

- To ensure that the system complies with the security and reliability standards of the NEC and other instruments (eg transmission licence); (almost all of Powerlink's augmentations)
- To alleviate constraints in the network if this will result in a net market benefit.

Figure 1 below illustrates the variables that influence the decision-making process:

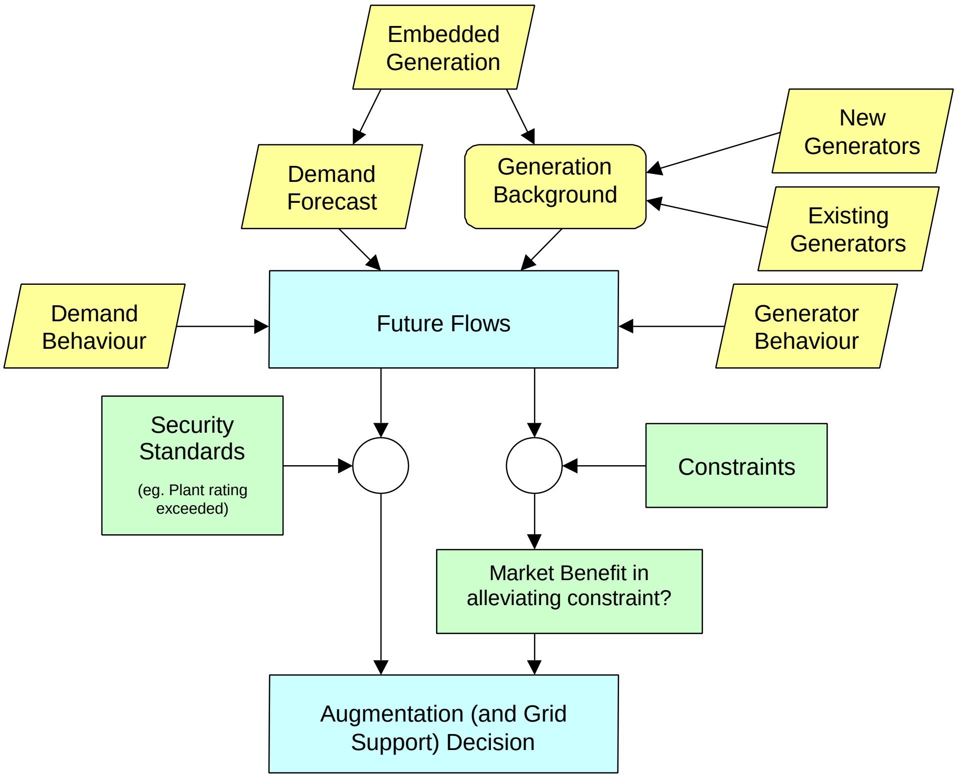


Figure 1. Principal Factors which drive Network Augmentations

In the above diagram:

- yellow blocks represent external factors to the process;
- blue blocks are process blocks, and
- green blocks are known or agreed triggering factors.

For a single assumed demand forecast and a single pattern of generation despatch, the future flows on the transmission system can be estimated using a combination of market modelling and transmission network analysis techniques.

These network power flows are then analysed for compliance with NEC security and reliability standards. Identified problems in meeting these standards trigger the need for augmentations to ensure compliance with NEC and other requirements. These augmentations can include Grid Support options.

In Queensland, where there are multiple plausible scenarios for the future patterns of generation despatch, this step can be undertaken for each plausible scenario, thereby delivering multiple scenarios for network augmentation.

Augmentations to alleviate network constraints may also be identified if this is seen to provide net benefits, as defined in the regulatory test.

3.5 Identifying the multiple generation scenarios

At any point in time, there is an existing set of generators, and a generation despatch pattern which arises from the bidding behaviour of those generators.

If that present situation was going to remain more or less stable over the 5-year regulatory period for Powerlink, then that single generation pattern could be used as the basis for forecasting the capex needed for network augmentations.

However, that is not the case. There are many committed new entrants progressively over the 5-year period which will change the generation despatch pattern. There are multiple plausible patterns based on the future bidding behaviour of both the new entrants and the incumbent capacity (including NSW generators).

By using modelling techniques for the wholesale market and various scenarios of bidding behaviours, a range of plausible generation scenarios can be identified.

For its recent ERU determinations, Powerlink used this approach to identify plausible generation patterns, which led to a range of corresponding network capital forecasts. No attempt was made to determine the relative probability of occurrence of each plausible scenario – thus, each was weighted equally, and the final capex forecast was simply the average of the plausible scenarios.

For its upcoming submission to the ACCC, Powerlink has engaged specialist consultants to conduct the pool modelling, and this has resulted in the identification of a significant number of plausible generation scenarios each with its respective network capex forecast. This time, the consultants have also identified the relative probability of occurrence of each plausible scenario.

3.6 Final capex forecast

The final capex forecast under this probabilistic approach is derived as the probability-weighted average of the network capex forecasts for the plausible generation pattern scenarios. That is, each forecast is weighted by the relative probability of occurrence of the underlying generation pattern.

In essence this delivers the "expected" capex in each year, with the standard deviation representing the relative uncertainty of that "expected" value.

The methodology is statistically sound and therefore a reasonable basis for determining the regulated revenue cap.

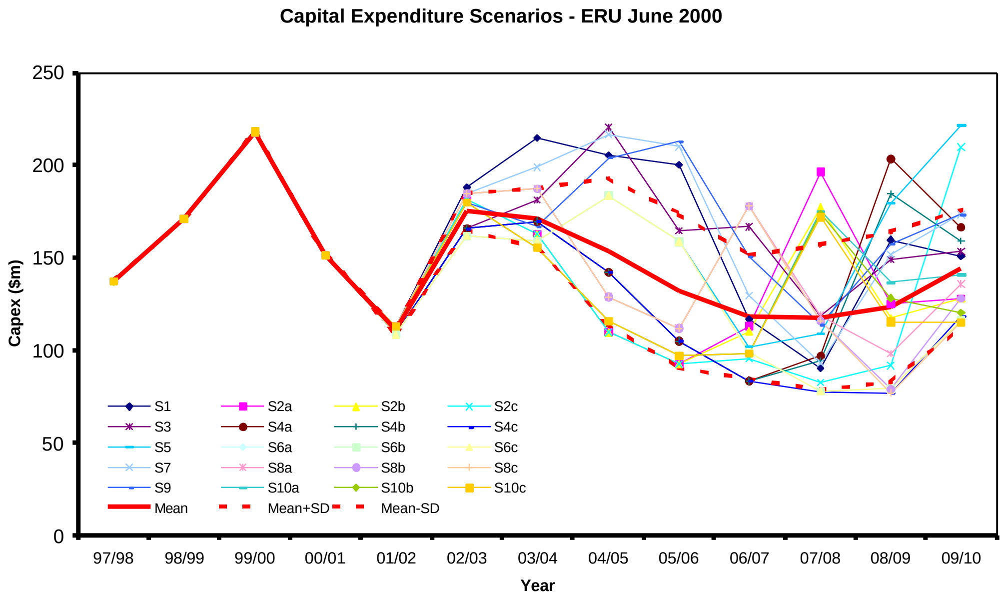
3.7 Reasonableness check

The reasonableness of the final forecast can be checked against the inherent long term trendline of capex for a network of this size.

The inherent long term trendline is the sum of the capex needed to replace aged assets (replacement capex) and the new capex needed to accommodate load growth (growth capex).

4 Review process

The different scenarios for network development do not vary much from each other in the first 3 years, as any network projects which are to be completed in those years are reasonably well known at the start of the regulatory period. The scenarios tend to diverge after year 3. By way of illustration, the following graph shows the forecast produced for the recent ERU determination.



The options open to the ACCC include a year 3 review of the capex for years 4 and 5, with adjustment of the revenue caps for those 2 years to reflect the then best estimate of capex. Another possibility – and one which would be more light-handed – would be for the ACCC in its initial determination to calculate an index for each of years 4 and 5 which would be used to automatically adjust the revenue cap for those years based on Powerlink's then best estimate of capex for those years. The index would be derived from sensitivity studies done at the time of the initial determination.

5 Conclusions

1. It is inappropriate to use the traditional single scenario/single list of projects approach to forecasting transmission capex in Queensland, due to the existence of many plausible scenarios for the pattern of generation despatch.

2. It is rational, and mathematically sound, to use a probabilistic approach to forecasting transmission capex in Queensland, coupled with a reasonableness check.

3. There are options for the ACCC to adjust the capex forecast (and hence Powerlink's regulated revenue cap) in the later years of the regulatory period.

4. It is important for the capex forecast to be as close as possible to the actual outcome to avoid later price shocks for customers and to enable Powerlink to meet its Code obligations for network reliability and security.