Owen Inquiry into Electricity Supply in NSW

Availability and Cost of Gas for NSW Baseload Generation

31st July 2007
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The information upon which this report is based has either been supplied to us by NSW Government or comes from our own experience, knowledge, and databases. The opinions expressed in this report are those of Wood Mackenzie. They have been arrived at following careful consideration and enquiry but, as of this date, are subject to change. We do not accept any liability for reliance on them by parties other than the NSW Government.
Executive Summary

- There is a reasonable expectation that there are sufficient gas supply resources to support the long term gas-fired generation capacity additions in NSW.
  - Gas reserves replacement ratio over the last 5 years in Eastern Australia has been a healthy 260%, with continued, strong CSG reserves additions expected in the medium term.
  - Potential exists for significant gas supply from within NSW (CSG) although at this stage material production is yet to be proven.
  - Higher gas prices will support further exploration and development of gas resources.

- Additional pipeline capacity will be required to meet the growing gas demand in NSW.

- New gas fired-generation is marginally competitive with coal fired generation as baseload in NSW but only with the support of NGAC's. This is due to the relatively high delivered cost (commodity plus capacity costs) of gas to potential generation locations in NSW.

- With possible implementation of a Carbon Trading scheme, gas fired-generation (at 75% load factor) would be competitive with coal fired generation for baseload in NSW with a carbon price of A$15-$30/tonne CO$_2$ equivalent.
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1. Introduction

1.1 Study Scope

As part of the NSW Government inquiry into the need for and timing of base load electricity generation in NSW, (the "Owen Inquiry"), the option for gas fired generation is being assessed. In evaluating the suitability of this technology, the key aspects of gas supply availability and the forecast cost of gas are of key concern. The Owen Inquiry has appointed Wood Mackenzie to investigate the ongoing availability and cost of gas supplies for base load generation in NSW.

In particular, the Owen Inquiry has requested that Wood Mackenzie assess the availability and cost of gas for the period out to 2030 under four specific scenarios. These scenarios represent the progressive substitution of the NEMMCO forecast (NEMMCO SOO 2006) coal fired generation by gas fired generation as new baseload generators over the period 2013 to 2016.

1.2 Methodology

The Eastern Australia gas and power markets have evolved from isolated state-based markets into a more integrated and dynamic semi-national energy market. As such, any evaluation of the gas supply availability and cost for NSW cannot be assessed in isolation but must be assessed as part of the integrated supply/demand system in Eastern Australia. This is especially so with NSW given its current reliance on gas supply from interstate sources, due to the very limited indigenous gas production.

To address the objectives, Wood Mackenzie has incorporated the following approach;

- Gas Demand – The generation scenarios being evaluated represent changes in gas demand in NSW. Wood Mackenzie utilised our generation modelling on Eastern Australia to determine the total gas demand for generation for NSW over the forecast period (out to 2030). This generation demand was added to our state-by-state and sector-by-sector gas demand model to provide an assessment of the outlook for total Eastern Australia gas demand.
- Gas Supply – Wood Mackenzie provides an overview of Eastern Australia’s gas reserves and gas production. In addition, given the growing importance of Coal Seam Gas (CSG) in Eastern Australia gas supply, we have provided an outlook for potential additional supply from CSG. The implication of the resulting gas demand and supply outlook in Eastern Australia is discussed.
- Gas Transmission System – Wood Mackenzie provides a review of the key pipelines delivering gas into NSW, current or future limitations of gas transmission, expansion capability and new pipeline infrastructure planned or required. The likely timing requirements for expansions or new pipelines together with estimates of the lead time for such augmentation are provided.
- Gas Supply Contracting for NSW Generation – Wood Mackenzie provides a review of recent contract terms for gas supply to gas-fired generation (annual and total volumes, supply source, term of contract and special conditions with respect to the supply source). We also outline key aspects affecting the future willingness of producers to supply together with lead times for contracting and developing supply.
- Delivered Gas Price Outlook – In assessing the implications for gas price, Wood Mackenzie assessed the key gas pricing driver, the relative cost of gas-fired and coal fired generation and the cost of long-distance gas supplies.
- Supply Security – Wood Mackenzie reviewed the development of the Eastern States gas market, key aspects of supply security (storage, pipeline flexibility, supply sources and delivery options). We reviewed some of the historical supply interruptions and consequences/timing of outage and the implications for future supply security.
Chapter 2 – Gas Demand

2. Gas Demand

Historically, the Eastern Australia gas markets were characterised by discrete demand regions connected to single supply sources by a single transmission pipeline. As such, these markets operated semi-independently. However, today’s market is much more interconnected, through additional gas delivery infrastructure as well as gas-fired generation into the NEM (National Electricity Market). Therefore, the availability of gas supply to meet the requirements of potential future gas-fired baseload generation in NSW, must be assessed in the context of the total Eastern Australia gas demand and supply picture.

In order to understand the gas demand requirements, Wood Mackenzie has modelled the generation capacity scenarios provided by the Owen Inquiry Secretariat. Wood Mackenzie’s power generation analysis utilises the same methodology which we used in our “Eastern Australia Gas & Power Outlook to 2025 – Fitting the pieces together” syndicated study. This methodology is summarised as follows:

- Establish the Macro drivers for electricity demand, by state
- Build up a Demand overview, based on macro economic drivers
- Construct the electricity Supply model, using known plant capacities, constraints and publicly announced projects
- Incorporate current and proposed generation plants, utilising new build costs as the basis of economic generation stack
- Develop outlook scenarios based on supply opportunities that meet market and legislative constraints.

It is important to note that the modelled gas demand requirements of this report are based on the generation capacity scenarios provided by the Owen Inquiry Secretariat and that these scenarios and their outcomes are different from the scenarios outlined in our “Eastern Australia Gas & Power Outlook to 2025 – Fitting the pieces together” syndicated study.

2.1 NSW Gas Demand Assumptions

As requested under our consultancy for the Owen Inquiry, the following analysis looks at the implications for demand as a result of the specified scenarios of gas-fired generation for NSW. The Owen Inquiry wished to assess the availability and cost of gas supply to potential baseload gas fired generation power stations (Combined Cycle Gas Turbine – CCGT) under a number of scenarios. In assessing the cost of gas, the Owen Inquiry Secretariat sought forecasts for the period out to 2030 to supply gas-fired generation at both 50% and 75% capacity.

The scenarios included:

1. Business as usual
2. 1,000MW of gas-fired baseload power generation in NSW;
3. 2,000MW of gas-fired baseload power generation in NSW; and
4. 2,500MW of gas-fired baseload power generation in the NEM.

The scenarios are based on the NEMMCO 2006 SOO with additional new gas fired generation progressively substituting for the new coal generation set out in the NEMMCO 2006 SOO table H8.

Scenario 1 – “Business as usual” represents a low gas demand case as all the baseload capacity installed for the period 2013 to 2016 in NSW and Victoria under this scenario are coal fired generators (consistent with the NEMMCO 2006 SOO table H8). We have referred to this resulting gas demand as our Base Gas Case Demand. The Base Gas Case Demand includes the existing gas-fired generation in NSW (including co-generation facilities and Coal Mine gas generators) plus committed gas-fired generation – Tallawarra CCGT (under construction).
Wood Mackenzie has also included the following publicly announced gas-fired generation projects in our modelling (Note: these are not firm commitments and ultimate development is not certain):

- Marulan and Bamarang CCGT – Proposed (sequenced based on Wood Mackenzie modelled timing)
- OCGT 2010 to 2012 – Advanced Proposals {Eraring (40MW), Munmorah (660MW), Uranquinty (640MW)}
- OCGT 2010 to 2012 – Proposed {Bega (120MW), Cobar (114MW), Tomago (500MW)}

OCGT (Open Cycle Gas Turbine) power stations are designed to provide peak period generation and their resulting generating hours in a year are generally low. They therefore have a limited impact on the overall gas demand volume requirements. However, their gas capacity requirements can be very significant but this has not been assessed as it is beyond the scope of this study.

### NSW Generation Capacity Expansion (MW) Scenarios

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**Note:** The timing of the capacities in the table above represent the first full year of operation of the installed generation capacity for modelling purposes only.

The annual gas demand for the 300 to 420MW Tallawarra, Marulan, and Bamarang CCGT’s at 75% load factor is approximately 10 to 13PJ/annum. For the 500MW CCGT’s, the gas demand at 75% load factor is approximately 15PJ/annum.

Scenario 4 – 2,500MW of gas-fired baseload power generation in the NEM represents the High Gas Case Demand as all the capacity installed for the period 2013 to 2016 in NSW and Victoria under this scenario are gas fired generators.

The total NSW gas demand forecast is represented in the following graph.

### NSW Gas Demand 2000-2030

**Source:** Wood Mackenzie
Scenarios 2 and 3 represent gas demand within the range of the Base and High Gas Case
Demands for NSW.

The NSW gas demand cases were added to the remaining gas demand for Eastern
Australia. Supply was then modelled to best meet the forecast demand.

Illustrated below is the aggregate Eastern Australia gas demand under the Base Gas Case
Demand for NSW. For comparison, we have included ABARE’s (Australian Energy National
and State Projections to 2029-30) gas demand. The difference in initial gas demand in 2006
between Wood Mackenzie and ABARE are a result of different gas demand methodologies:

- Wood Mackenzie’s gas demand represents the sales gas at the point of injection of
  each supply point (ie. Ex-plant, after fuel and production losses).
- ABARE’s gas demand represents the total gas production (ie well head production,
  before fuel and production losses) and including ethane.

The demand lines under the two approaches converge by the end of the forecast period.
Taking into account the different methodologies to gas demand, the Wood Mackenzie’s
Base Gas Case Demand for Eastern Australia therefore represents an overall higher growth
forecast than ABARE.

**Eastern Australia Base Gas Case Supply/Demand 2000-2030**

Source: Wood Mackenzie

The supply matching is addressed in the following section.
3. Gas Supply

The analysis in this section is based upon Wood Mackenzie’s extensive research databases together with the our recently completed “Eastern Australia Gas & Power Outlook to 2025 – Fitting the pieces together” syndicated study.

3.1 Gas Reserves

3.1.1 Proven and Probable (2P) Reserves

Proven and Probable gas reserves or 2P gas reserves, represent the industry’s expected volume of gas that can be produced and sold. It is general industry practice in Australia to contract based on 2P gas reserves volumes. Therefore the level of 2P reserves is a key indicator of the future potential of gas supply.

### Eastern Australia 2P Gas Reserves (1/1/07)

![Map of Eastern Australia 2P Gas Reserves](image)

**Source**: Wood Mackenzie
Chapter 3 – Gas Supply

The total 2P gas resource of Eastern Australia as of 1/1/07 is 13,980 PJ. This equates to approximately 23 years of production at current levels. The Gippsland Basin, with 6,859 PJ of reserves remains the most significant region in Eastern Australia in terms of gas reserves (and production) despite over 30 years of gas production. By contrast, the Cooper Basin has 1,213 PJ of 2P gas reserves and production is now in decline following 30 years of production.

CSG 2P reserves are approximately 4,000 PJ. The main area of CSG reserves is located in SE Queensland.

A comparison between the gas reserves (2P) in Eastern Australia over the last five year period (2002 to 2007) shows that despite approximately 2,800 PJ of sales gas being produced in this period, 2P gas reserves have actually increased by a net 4,710 PJ. This demonstrates a healthy reserves replacement ratio of 260% over this five year period.

![Eastern Australia 2P Gas Reserves Comparison 2002 vs 2007](image)

**Source:** Wood Mackenzie

The key areas that have contributed to this increase in 2P gas reserves are the Gippsland Basin and Coal Seam Gas (CSG) in Queensland. In the Gippsland Basin, significant reserves have been added through reserves upgrades from existing producing gas fields as well as appraisal of sub-economic discoveries (eg Longtom and Basker/Manter/Gummy). CSG reserves have increased from a small volume in 2002 to ~4,000PJ in 2007. This has occurred predominantly in Queensland where production has also increased significantly. CSG projects have established their economic viability through pilot projects and have begun to transform their gas resource (“Possible” component of 3P reserves) into contracted 2P reserves and production.

### 3.1.2 “Additional Potential” Reserves

A third category of gas reserves is 3P or Proven plus Probable plus Possible reserves. Generally, this reserves volume is only considered in assessing upside potential as it has greater uncertainty with a probability of only 10%. However, in CSG projects, the use of the 3P reserve figure reflects a different methodology used to calculate this resource compared to conventional gas fields – i.e. the believed extent of the gas-bearing coals, rather than the probabilistic approach used in conventional gas fields.

Strictly defining CSG 3P reserves as only having a 10% probability in areas surrounding existing production may be pessimistic. The areal extent and quality of the gas-bearing coals may be well understood but the reserves may only be classified as “Possible” because of the lack of closer spaced drilling. The process of conversion of the “Possible” component of 3P CSG resource to “Probable” may only require a more closely spaced drilling.
During the early stages of CSG development, the initial focus of activities is establishing the economic basis for future production. This involves pilot projects which test the production capabilities of the coal seams. The completion techniques of the wells may also be tested to optimise the production rates relative to the well costs. Additional drilling may also be undertaken to begin to establish a 2P reserves base to enable sales contracts to be executed once economic production has been established. Whilst the 3P resource may be high in this initial period, the 2P resource is generally low. Only though further drilling can the 2P reserves be increased.

With relative low production rates early on in a CSG projects development, drilling to establish 2P reserves can typically have a negative effect on cash flow. The conversion to 2P reserves therefore needs to be balanced against the expected rate of production growth (and commercialisation of the reserves through supporting contracts), particularly with smaller companies with limited financial resources.

As CSG projects begin commercial production, they can incrementally add capacity (pipelines, processing plant and compression) to increase production. The ultimate plateau rate for a project will depend on the available market, the costs of development, the production profile and ultimate recovery per well. As a result, CSG projects tend to expand capacity incrementally and 2P reserves growth increases over time until an economic plateau in production is reached and maintained.

This can be seen from a comparison of the Eastern Australia CSG reserves over time. In 2002, CSG 2P reserves were less than 500PJ but by 2007, CSG 2P reserves are ~4000PJ.

In order to capture an estimate of the likely evolving reserves and production growth of CSG in Eastern Australia, Wood Mackenzie’s has assessed a proportion of the “Possible” 3P CSG resource on the basis that it can be economically converted to 2P reserves and production within the timeframe of this study outlook. We have called this “Additional Potential”. This class of potential future supply utilises our estimate of supply, over and above current Contracted and Uncontracted reserves (Proven plus Probable - 2P). The “Additional Potential” resource and production forecast represents Wood Mackenzie’s estimated view of the medium term potential of the overall CSG gas resource. Further reserves additions and production above our forecast are possible.
The criteria Wood Mackenzie used for the Additional Potential resources was as follows:

- The ultimate “Additional Potential” reserves quantity used for a given project was limited to less than 80% of the “Possible” reserves for the project.

- A modelled production plateau of at least ten years was required to support the level of capacity expansion. This took into account the different production profiles of wells between projects. The number and timing of wells required (both production and work-overs) together with supporting infrastructure (pipelines, plant and compression) was analysed to determine the forecast production level.

- The production expansion of each CSG project was required to be economically viable at current gas prices.

The Additional Potential gas resource represents a significant volume (8,578PJ) of potential gas for future development and production. Note, this does not represent the ultimate 3P CSG resource potential of Eastern Australia, rather it is Wood Mackenzie’s view of the current 3P resource that we believe is capable of being economically developed in the period to 2030. Within the parameters set out above, we have forecast that 55% (4,935PJ) of this Additional Potential gas resource can be developed and produced in the period out to 2030.

The addition of further 3P reserves are likely over the forecast period as exploration continues and new projects are assessed.

### Eastern Australia 2P and Additional Potential Gas Reserves

- **Contracted**
- **Uncontracted**
- **2P Remaining**
- **Additional Potential**

*Source: Wood Mackenzie*

In the United States of America (US), CSG is a significant contributor to the gas production in that country. CSG production in the US will be approximately 2,000 PJ in 2007 (or over three times the total Eastern Australia annual gas demand).

The US CSG industry has been assisted by a number of factors including:

- Tax credits (until 1992)
- Readily available market for produced gas; and
- High gas price (post-2000)
Chapter 3 – Gas Supply

US CSG Production by Basin 1985 to 2015

 whilst Eastern Australia CSG development has not benefited from these factors available to the US CSG industry, there are some key characteristics of the nature of US CSG production that can be drawn on as an example of the potential for the developing Australian CSG industry. These are;

- Start-up timing – it generally takes ~2 to 5 years to establish commercial production.
- Production Ramp-up – once production has started, production capacity is expanded as more wells are drilled and brought on-line. This ramp-up period can be in the order of 5 to 10 years.
- Production Plateau – There is a natural plateau level which is established based on a number of technical factors including type of coals and resulting production and recovery rates per well. Production plateaus of 10+years are a common characteristic of CSG development.

The Australian CSG industry is very much in the early stages of development with many projects in the Start-up phase and only a handful in the Production Ramp-up phase. As a result, there is potentially an enormous production upside as the industry expands to a plateau level.

3.1.3 Yet-to-Find Gas Resource

It is highly likely that further discoveries of gas will be made in Eastern Australia in the period to 2030, however quantifying this potential is very difficult and Wood Mackenzie has therefore not included any estimate of Yet-to-Find resource in our analysis. In the period out to 2030, additional exploration for conventional gas reserves will be undertaken both onshore and offshore. In particular, further exploration is expected in the offshore Otway, Bass and Gippsland basins and each of these basins has illustrated successful discoveries of gas reserves in recent years.

Conventional gas has the potential to have associated liquid hydrocarbons (oil and/or condensate) which can add significantly to the value of a gas resource. Together with the size and relative proximity to existing infrastructure, these factors could enhance the economic attractiveness in developing a new gas discovery over CSG developments (which contain no associated liquid hydrocarbons).
3.1.4 Alternative Gas Supply Options for Eastern Australia

Other alternative gas supply options may develop or have the potential to be developed as alternative supply sources to Eastern Australia in the period out to 2030. These include:

- **Tight gas** – tight gas resources exist in the onshore Cooper and Gippsland basins. These are known resources but with the higher development costs associated with extracting this resource, they are currently sub-economic. With higher gas prices, this tight gas resource could be developed and contribute to the gas supply in Eastern Australia. It is possible that this resource could begin to be developed within the next 15 years, subject to higher gas prices than present.

- **Long-distance pipeline gas** – Large volumes of undeveloped gas resources exist off the North West coast of Western Australia. A future pipeline linking these resources to Moomba (acting as a hub for Eastern Australia) has been considered in the past. Recent rises in the price of domestic gas in Western Australia have seen the gas price rise to over $5.00/GJ. At these prices, together with an indicative transportation cost from Western Australia (in the order of $1.50-2.00/GJ), the delivered price for Western Australia gas to Sydney would be in the order of $8.00/GJ. It is unlikely that there will be sufficient unmet demand to support the large capital investment of a trans-continental pipeline any earlier than 2020.

- **LNG Importation** – As an alternative to long-distance pipeline gas, LNG could be imported directly into NSW. This would require development of regasification infrastructure (jetty, re-gas plant and storage facilities). At current prices, the equivalent delivered cost of gas to NSW by LNG would be in the order of A$10 to $13/GJ. As with long distance pipeline gas, it is unlikely that the Eastern Australia gas market would require this type of supply before 2020.

3.2 Demand Supply Outlook

3.2.1 Methodology

Wood Mackenzie has built a gas supply forecast based on a project by project analysis of 2P (Proven plus Probable) gas reserves and supply capacity. In addition, we have evaluated a portion of the 3P (Possible) gas reserves of specific CSG projects that we believe is capable of development and production within the period to 2030. For this report, Wood Mackenzie has provided this analysis on a total supply basis for Eastern Australia, with future production divided into three categories, each with a different degree of certainty that the gas will be delivered to market. The three categories are: existing Contracted production, the Uncontracted remaining reserves, and the likely Additional Potential gas. The precise definition of each of these categories is outlined below.

3.2.2 Contracted production

The gas market in Eastern Australia has been characterised by long term gas sales agreements (GSAs) between gas sellers and buyers. We have modelled contracted volumes based on current 2P (Proven plus Probable) gas reserves.

For each gas field and CSG project, we have prepared production forecasts for known sales agreements. In most cases, the proven plus probable (2P) reserves of an individual field or project are sufficient to fulfil the GSA. However, there are several projects where the 2P reserves are insufficient to meet the contracted volumes. In these cases, we have only modelled the proven plus probable reserves. This methodology applies to both conventional gas fields and CSG projects. This contracted production provides the greatest certainty of delivery to market.

Gas that is sold within the portfolios of the energy retailers (eg. Origin Energy), is also included within the contracted production category.
3.2.3 Uncontracted production
Uncontracted production is the 2P reserves that are not assigned to a GSA, but which are likely to be produced following the fulfilment of the existing agreements.

There is a higher uncertainty as to whether this gas will be delivered to market according to our forecast. This uncertainty is primarily a market risk, rather than project risk.

3.2.4 Additional Potential production
As described in the previous section, this category relates to Wood Mackenzie’s analysis of how “Possible” reserves of CSG projects may be developed in the medium term. This has the highest degree of uncertainty of the production classifications but represent Wood Mackenzie’s view of the expected continued growth of the CSG industry in Eastern Australia.

3.2.5 Base Gas Case Supply/Demand
In the Base Gas Case Supply/Demand outlook, the gas volumes produced in the period 2007 to 2030 are as follows:

- Contracted: 6,467PJ
- Uncontracted: 6,972PJ
- Additional Potential: 4,857PJ

A supply shortfall against current 2P reserves (Contracted and Uncontracted) is forecast to develop around 2013. However when taking into account the Additional Potential, the supply gap begins from 2030 of 2,934PJ. Whilst onshore gas discoveries can be developed within a couple of years, a stand-alone offshore gas development can take in the order of 6 years to develop. However, there is a 13 year period for exploration and development to undertaken in order to try and fill this supply gap. This period provides a reasonable time period for potential yet-to-find resource and/or further development of the CSG resources in Eastern Australia to be undertaken. With a reserves replacement ratio over the last five years at a very healthy 260% and likelihood for continued reserves additions in the medium term, it can reasonably be expected that this supply gap can be met.
3.2.6 High Gas Case Supply/Demand

In the High Gas Case Supply/Demand outlook, the gas volumes produced in the period 2007 to 2030 are as follows:

- Contracted: 6,467PJ
- Uncontracted: 6,914PJ
- Additional Potential: 5,172PJ

In the High Gas Case Supply/Demand, the supply shortfall begins from 2018 (based on the Additional Potential forecast) and the volume shortfall to 2030 is 5,194PJ. This case creates a higher level of uncertainty than the Base Gas Demand Case for supply availability in the future. However, this higher demand is expected to drive gas prices higher over the forecast period and this should help encourage the search for future gas reserves. In addition, the higher gas prices may begin to make “tight gas” resources economically viable for development.

If insufficient gas reserves are discovered in the period to 2020, gas demand growth post 2020 is likely to be much lower than our forecast. A significant proportion of gas demand growth in the period out to 2030 is forecast to be driven by gas demand for generation. If gas availability and/or higher gas prices start to become an issue, new gas-fired generation capacity forecast to be installed in the period post-2020, is likely to switch to alternative technology, thereby reducing the gas demand growth rate post-2020.

### Eastern Australia High Gas Case Supply/Demand 2000-2030

![Graph showing gas supply and demand](image)

**Source:** Wood Mackenzie

3.2.7 CSG Gas Potential

CSG production to date has been located in two main areas NE Queensland (Moranbah project) and SE Queensland (multiple projects). NSW has had some small CSG production from the Camden gas project.

Additional areas in NSW are under evaluation including the Gunnedah-Surat, Clarence Morton, Sydney and Gloucester basins.
CSG production has grown significantly from ~5PJ/a in 2000 to >100PJ/a in 2007. In the same time period, CSG 2P reserves have grown from ~200PJ to 4,000PJ. There are currently sufficient Contracted and Uncontracted 2P CSG gas reserves to underpin a significant increase in production in the period from 2009 to 2015 (up to 300PJ/annum). Further growth of 2P reserves is likely but the rate at which reserves will be added will depend on the level of gas demand growth. There is limited incentive for CSG producers to build gas reserves if they are to remain in the ground un-produced for long periods of time.

The process of converting CSG 3P resource into 2P and into production is a continually evolving process. With the CSG industry in Eastern Australia in only the early stages of development there is significant potential for continued growth in both reserves and production. Queensland in particular has demonstrated the world-class quality of some of the existing CSG developments (Fairview, Spring Gully and Undulla Nose area).

Source: Wood Mackenzie
The potential for NSW CSG is enormous given the extent of gas bearing coals in the Gunnedah-Surat, Clarence-Morton and Sydney basins. However, these basins are only in the early stages of evaluation and yet to prove significant commercial production. As illustrated below, Wood Mackenzie’s NSW CSG outlook is relatively modest with ~30PJ/a forecast for NSW by 2019.

There are a number of projects in the early stages of production assessment in NSW. These include the Camden, Bohena, South Casino and Gloucester projects. Exploration around these projects is also continuing.

Santos recently announced their farm-in to CSG exploration acreage in the Gunnedah Basin. Santos bring considerable CSG expertise based on their Queensland CSG operations, together with their significant financial resources to fund exploration and possible future development in this region.
Future potential gas developments in NSW will have the benefit of the proximity to demand centre over interstate gas supplies. Therefore any future development will have a positive impact on both the delivered gas cost and supply availability for NSW.

3.2.8 Implications of Proposed LNG Export from Eastern Australia

Santos and Arrow Energy have recently announced proposals for LNG projects in Gladstone. A summary of the proposed projects is provided in Appendix I. It is important to note that these projects are in the early stages of assessment. Detailed studies are required to understand the viability of these proposed LNG projects. Both projects require the certification of sufficient gas reserves to underpin long-term LNG supply contracts. Whilst Wood Mackenzie has not assessed the specific economics of these projects, both companies have sufficient encouragement from initial scoping economics to proceed into the next phase of evaluation. However it should be noted, the large capital investment of LNG projects makes them particularly challenging under the current cost environment (labour and material).

Implications for gas availability in Eastern Australia – The announcements of the proposed developments for Eastern Australia LNG exports represent a significant vote of confidence by the proponents in the potential of the CSG resource. Of particular interest is:

- The gas reserves required to underpin these developments is significant. For the Santos proposal, between 4,000 and 5,500PJ will be required. For the Arrow Energy proposal at least 1,000PJ will be required, although with the option to expand, the volume could be in the order of 2,000PJ to 3,000PJ.
- The gas certification process will run in parallel with detailed studies. As a result the exploration and appraisal work will be undertaken over the next two years.
- The development of CSG processing capacity is significant, approximately three times the current level of CSG production.
- There is a risk that any development of an LNG export project could reduce the availability of gas to the domestic gas market in Eastern Australia. This could occur through the preferential allocation of uncontracted reserves to support the possible long-term LNG contracts entered into as part of any LNG development. However, it should also be recognised the significant investment (exploration and appraisal work) in reserves certification required from both Arrow Energy and Santos over next two years. Both companies have confidence in the potential of their CSG resources. In addition to these CSG producers, there are other CSG explorers and producers that will also be undertaking exploration and appraisal at this time. The significant increase in activity associated with this reserves and production expansion could be impacted by the availability of material, equipment and labour. A shortfall in gas availability in Eastern Australia is therefore more likely to be a result of constraints on the speed to develop the resource into production rather than limitations on the overall resource base available.
4. Gas Infrastructure

4.1 Existing Gas Infrastructure

The New South Wales current gas demand of 132 PJ per annum is supplied by two key transmission pipelines;

- Moomba to Sydney Pipeline (MSP); and
- Eastern Gas Pipeline (EGP)

(The Victoria / New South Wales Interconnect gas pipeline is a distribution pipeline linking between the two states with only a small volume throughput).

Current Pipeline Capacity (Assuming 85% Load Factor)

![Map showing pipeline capacities and regions](Map.png)

Source: Wood Mackenzie
In assessing the gas infrastructure requirements for NSW, Wood Mackenzie has focussed our analysis on pipeline annual throughput rather than total delivery capacity of the transmission pipelines. We have therefore made an adjustment to the nominal maximum capacities of the pipelines to recognise the need of these pipelines to meet the overall market demand in NSW. This adjustment limits the maximum annual throughput for the pipelines based on a maximum load factor (LF) of 85% of the pipeline capacity over a year.

The Moomba to Sydney pipeline allows gas to flow from the Cooper Basin to New South Wales. The 1,300 kilometre pipeline to Wilton, some 50 kilometres southwest of Sydney, is owned and operated by Australian Pipeline Trust (APT). Laterals from this pipeline distribute gas to other markets in New South Wales (e.g. Newcastle, Wollongong, Bathurst and Wagga Wagga) and the Australian Capital Territory (Canberra). The pipeline currently has a maximum capacity of 155 PJ per annum (throughput of 132PJ/a at 85% LF) but could be increased significantly with further compression if required.

**Existing and New Pipeline Details**

<table>
<thead>
<tr>
<th>Pipeline</th>
<th>Owner</th>
<th>Distance (KM)</th>
<th>Timing</th>
<th>Capacity (PJ/a)</th>
<th>Throughput @ 85% LF (PJ/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing/Committed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>South West Queensland Pipeline</td>
<td>EPIC Energy</td>
<td>756</td>
<td>Existing</td>
<td>53</td>
<td>45</td>
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<tr>
<td>Moomba to Sydney Pipeline</td>
<td>APT</td>
<td>1300</td>
<td>Existing</td>
<td>155</td>
<td>132</td>
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<tr>
<td>Eastern Gas Pipeline</td>
<td>Alinta</td>
<td>795</td>
<td>Existing</td>
<td>93</td>
<td>79</td>
</tr>
<tr>
<td>New/Expansion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hunter Valley Pipeline (New)</td>
<td>Hardie Holding</td>
<td>850</td>
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<td>60</td>
<td>51</td>
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<tr>
<td>Bulla Park (New)</td>
<td>APT</td>
<td>763</td>
<td>2014</td>
<td>60</td>
<td>51</td>
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<tr>
<td>Eastern Gas Pipeline (Compression)</td>
<td>Alinta</td>
<td>795</td>
<td>2013</td>
<td>132</td>
<td>112</td>
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<tr>
<td>QNS Link (New)</td>
<td>EPIC + APA</td>
<td>180</td>
<td>2009</td>
<td>73</td>
<td>69</td>
</tr>
<tr>
<td>South West Queensland Pipeline</td>
<td>EPIC Energy</td>
<td>756</td>
<td>2009</td>
<td>108</td>
<td>92</td>
</tr>
</tbody>
</table>

Source: Wood Mackenzie

In the Cooper Basin, the Ballera Processing Centre in Queensland is connected to the Moomba Gas Plant in South Australia by a 180 kilometre, dual phase line, which transports oil and gas from Queensland to South Australia. The capacity of this gas pipeline is around 50 PJ per annum. This pipeline is the only physical link between the gas suppliers in Queensland and the southern gas markets.

Historically, the majority of gas delivered to markets in Queensland was from Ballera. To meet contracts with gas buyers in southeast Queensland, gas is transported via a 756 kilometre pipeline (the South West Queensland Pipeline – SWQP), which links the Ballera Gas Centre to the ML1A station near Wallumbilla (ie flowing west to east). However in recent years, this pipeline has begun to deliver gas to the west (reverse flow) and from later this year is expected to do so permanently. This is a result of the declining Cooper Basin production, the growing production of CSG in Southeast Queensland and the continued requirement to supply gas to markets in NSW and South Australia. The SWQP is believed to have a maximum capacity of 53 PJ per annum (when configured to flow westward).

In August 2000, Duke Energy commissioned the Eastern Gas Pipeline (EGP). The 795 kilometre pipeline delivers gas from the Longford Gas Plant in Victoria to the New South Wales market. The pipeline is expected to have a maximum capacity of up to 93 PJ per annum (throughput of 79PJ/a at 85%LF) by end-2008 with the addition of mid-line compression.

### 4.2 Gas Swap Arrangements

Origin Energy signed an agreement with South West Queensland Gas Producers (“the SWQ Producers”) for the swapping of between 90 and 200PJ of gas between Queensland and Moomba until the end of 2011. The arrangement effectively enables Origin to deliver gas to NSW from their Queensland CSG projects. This is achieved by delivering an equivalent quantity to meet the contractual commitments of the SWQ Producers at Wallumbilla in Queensland. The SWQ Producers deliver raw gas from Ballera for processing at Moomba. There is a limit to the volumes that can be swapped in this arrangement and eventually, physical connection to the sales gas pipelines will be required (proposed QSN Link).
4.3 Potential Future Pipeline Capacity

In order to meet the forecast gas demand requirements of NSW, additional pipeline capacity will be required. This can be achieved through a combination of pipeline expansions together with new pipeline infrastructure. The investment decision for any new pipeline or expansion to the current pipeline, depends on the incremental demand for gas and the availability of future gas supply. Wood Mackenzie has taken a conservative approach to matching our gas supply outlook with the required proposed new pipelines and possible expansions.

The pipeline throughput was calculated based on a utilisation factor of 85% for all pipelines (both new and existing). The economics of the new capacity options (expansions and new infrastructure), demand requirements, required capacity, timing and supply opportunities were all taken into consideration in forming our view on the likely future pipeline developments. It is important to note that many valid alternative configurations of the gas transmission system could be developed in order to meet the future gas transportation requirements for NSW and therefore our analysis of future pipeline requirements should be treated as indicative only. Ultimately the infrastructure developments will be determined by the committed firm capacity.

The level to which indigenous gas supply within NSW can develop within the next few years will also have a bearing on the level and location of pipeline infrastructure augmentation. We have taken a conservative view on this indigenous gas in our analysis but as it has the potential for lower cost of delivery it could significantly change the supply landscape for NSW.

4.3.1 Expansions of Existing Pipelines

Existing pipeline infrastructure can be incrementally expanded through the addition of compression and looping. Initially, a pipeline will generally only have compression at the inlet of the pipe. However, as the pipeline increases throughput, the capacity of the pipeline can be increased by first adding midline compression. Depending on the length of the pipeline, additional compression can progressively added. The limiting factors on this additional compression are the operating limits under which the pipeline can run and the economic cost of the additional capacity gained (ie each additional compressor added will contribute a smaller incremental increase in capacity). After a pipeline has achieved its fully compressed capacity, the next option for additional capacity is “looping”. Looping involves the duplication of sections of the pipeline (between compression stations).

We have analysed the cost of incremental capacity to existing pipelines based on the addition of compression only. In general, compression is relatively easy and more cost effective for capacity expansion of a pipeline than looping. Addition of a compressor can be achieved within 12 months.

South West Queensland Pipeline (SWQP)

With the forecast continued decline in Cooper Basin production, both NSW and South Australia will require alternative gas supplies to meet future demand requirements. With the growth of CSG production in SE Queensland, the opportunity exists to deliver some of this gas to the southern states. In addition to the need to build the connection around Ballera to Moomba (QSN Link), the SWQP from Wallumbilla to Ballera will require additional compression in order to deliver the required quantities to Ballera and Mt Isa. With compression, this pipeline could run at a maximum capacity of 108 PJ per annum by 2009 in the westerly direction.

Eastern Gas Pipeline (EGP)

The EGP has recently committed to adding mid-line compression that will take its capacity up to 93 PJ per annum by end-2008. This pipeline can be expanded further with additional compressors up to a maximum capacity of 132 PJ per annum by 2014.
Moomba to Sydney Pipeline (MSP)

We have not assumed any future expansion of the MSP. This is due to limitations of supply into the MSP going forward. With the decline of Cooper Basin production, the MSP is currently running below its full capacity. Supplementing this decline in Cooper Basin production requires augmentation of the SWQP, as well as the building of the QSN Link (see below). However, even with this augmentation, the SWQP and QSN Link will not provide sufficient supply capacity to meet the maximum capacity of the MSP. To help support a higher level of throughput for the MSP in the future, APT have proposed the development of a new pipeline to bring gas from Wallumbilla to Bulla Park (WBP), mid-way along the MSP (see below).

4.3.2 Potential New Gas Infrastructure

A number of potential pipelines are currently being evaluated to deliver gas from Queensland into NSW. We have provided an assessment of the possible capacity and timing for these possible pipelines. It should be noted that the ultimate capacity and decision to proceed will be based on the level of firm commitment to the capacity on these proposed pipelines.

Queensland to South Australia/New South Wales Link (QSN Link)

On the 13th July 2007, Epic Energy announced they had entered into a long term contract with AGL to transport gas from SE Queensland for delivery into the Moomba to Adelaide Pipeline (MAPS) and the Moomba to Sydney Pipeline (MSP). In order to achieve this delivery, Epic has committed to build a pipeline connecting the SWQP to the MSP and MAPS (ie around Ballera and Moomba) – to be called the QSN Link (Queensland to South Australia/New South Wales Link). The QSN Link was formerly known as the Ballera to Moomba Interconnect. This 180 kilometre pipeline is expected to have a capacity of around 70 PJ per annum. When completed, this development will provide a seamless gas transport service from the CSG fields in SE Queensland to customers in the southern states. The pipeline is expected to commence its first delivery in January 2009.

Wallumbilla to Newcastle (Queensland Hunter Valley pipeline - QHVP)

Hardie Holdings has proposed to connect the Wallumbilla Gas Hub in SE Queensland to Newcastle via the Hunter Valley. This pipeline would provide a key link in the Eastern Australian gas supply system, creating additional gas supply security to Newcastle and Sydney. Hardie Holdings is evaluating this project with its joint venture partners, Weston Aluminium, Hunter Land and ANZ Infrastructure Services. The proposed pipeline will have an approximate total length of 850 kilometres. We have assumed a capacity of 60 PJ per annum and development by 2013. In November 2006, the NSW Government declared this pipeline to be Critical Infrastructure under Part 3A of the Environmental Planning & Assessment Act. In February 2007, the Queensland Government granted Environmental Approval for issuance of a pipeline permit.

Wallumbilla to Bulla Park pipeline (WBP)

APT are evaluating a 753 kilometre new pipeline that would connect Wallumbilla in SE Queensland to Bulla Park on the MSP (approximately mid-way between Moomba and Sydney) in NSW. This pipeline would support continued supply into Sydney via the MSP as the Cooper Basin production declines. We have assumed a capacity of 60 PJ per annum and development by 2014. The rationale for this pipeline would be to utilise spare capacity in the MSP as the Cooper Basin production continues to decline and the QSN Link reaches its capacity.
Possible Pipeline Capacity by 2013-14 (Assuming 85% Load Factor)

<table>
<thead>
<tr>
<th>Region</th>
<th>Capacity (PJ/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWQP (Compression)</td>
<td>~ 92</td>
</tr>
<tr>
<td>QSN Link</td>
<td>~69</td>
</tr>
<tr>
<td>MSP (under-utilized)</td>
<td>Moomba ~ 69 PJ/a and ~120 PJ/a from Bulla Park</td>
</tr>
<tr>
<td>EGP (Compression)</td>
<td>~ 112</td>
</tr>
</tbody>
</table>

Source: Wood Mackenzie

4.4 Forecast Gas Pipeline Throughput

The following graph illustrates the forecast throughput capacity of the pipelines to meet the High Gas Case Demand requirements. This is based on Wood Mackenzie’s assessment of the likely sequencing of capacity expansions and new build pipelines.

The building of the QSN Link and the reversal and compression of the SWQ Pipeline is required by 2009 to begin delivering gas supplies from Wallumbilla (the SE Queensland CSG projects) to NSW. A key driver for this investment is to help counter the forecast declining production from Cooper Basin.
However, even with the QSN Link, further expansion of capacity into NSW would be required to meet growing demand. Therefore further expansion of EGP is expected to be required by 2013, up to a total throughput of 112 PJ/annum. However in the period 2013 to 2019, growing NSW demand could result in the requirement for an additional 100 PJ/annum of new transmission capacity. This demand growth would drive the need for a direct connection from Wallumbilla, south into NSW. At present two options from Wallumbilla have been proposed, to Newcastle via the Hunter region (QHGP) and to Bulla Park (WBP), midway on the MSP.

Both pipelines have logical reason to be built. The WBP pipeline supporting the MSP which would be under-utilised at this time and the QHGP providing gas to a developing gas region in the Hunter/Newcastle area. Both would also contribute to security of supply and system support. We have modelled both pipelines with ~50PJ/annum each starting between 2013 and 2014.

With continued growth in gas-fired generation demand post 2020, additional pipeline capacity would be required from 2024, and this could be met by further pipeline expansions (including looping) but could also be met if indigenous NSW gas supply is larger than our forecast.

Based on these pipeline developments and the future gas supply locations, we have illustrated the locations of potential CCGT developments in NSW, represented as follows;

- Green Dot – Tallawarra (under construction)
- Light Blue Dots – Assumed development of the possible Marulan and Bamarang gas-fired generation pre-2013
- Yellow Dots – 4 x 500MW gas-fired generators 2013 to 2016

Each CCGT would be based proximal to the main gas transmission line due to the relatively large load requirements. There would be additional cost for transporting gas on the distribution system.
Our analysis shows that 6 new CCGT baseload developments (in addition to the Tallawarra power station) could be supported, with two each on the EGP, MSP and QHGP pipelines in the period from 2010 to 2016 (ranging 400 to 500MW CCGT's).
5. Gas Supply Contracting for NSW Generation

5.1 Gas contract terms

The price for gas sold under contract in Eastern Australia is usually a confidential agreement between the gas suppliers and the gas buyer. The gas price negotiated may be fixed for the term but is more likely to have some annual escalation (generally linked to CPI) and/or a price review at pre-determined intervals over the life of the contract.

Despite the confidentiality of gas contracts in Australia, Wood Mackenzie has a broad insight into the likely gas price of contracts in Eastern Australia based on our in-depth market knowledge, and generalised feedback from the key players within the market (both upstream operators and participants alike).

The current upstream price of gas in Eastern Australia falls between A$2.00 per GJ and A$3.50 per GJ. This broad range is a result of number of factors including:

- The time of the contract signing (contracts have been signed in different years across a variety of market conditions);
- Different contract terms such as contract volumes, firmness of supply, take-or-pay conditions, flexibility in daily quantity;
- Location of the supply source relative to the available market and competing supplies (transportation differentials); and
- Supply risk (the level of certainty on reserves and production for a supply source).

5.2 Recent contracts for generation

Some of the key contracts supporting base load gas generation projects in Eastern Australia in recent years include:

- International Power with BHP Billiton for gas supply to the Pelican Point 490MW CCGT in Adelaide. This gas agreement is believed to have a term of at least 10 years with a total supply volume of 279PJ. The gas is supplied from the Minerva Gas Project in Victoria.

- Enertrade with CH4 (now Arrow Energy and AGL) for gas supply to Townsville. Enertrade supplies gas to three major users including Transfield, the operator of the Yabulu gas-fired power station. The gas contract is for 15 years and has a maximum contract volume of 290PJ.

- TRUenergy – TRUenergy uses a portfolio of long term gas contracts to supply their gas-fired generation needs which included the Torrens Island Power station in Adelaide (recently sold to AGL). TRUenergy are currently building the Tallawarra 420MW CCGT in NSW and this will also be supplied from their portfolio of supply.

- Origin Energy – Origin recently announced the go-ahead for their Darling Downs CCGT in Queensland. Gas will be supplied directly from Origin’s CSG upstream gas portfolio although they may also buy some gas from joint venture partners.
In Eastern Australia, large gas contracts still tend to be for terms of 10 to 20 years. Origin Energy recently announced a new gas contract with Rio Tinto Aluminium for a 20PJ per annum contract over 20 years (from Origin’s CSG projects). These long term contracts help underpin the producers investments in developing the gas production (as well provide the security of supply for the buyers projects). Therefore it is likely that producers would be willing to sign long term contracts to support a CCGT power station development in NSW in the future.

With a load factor of 75%, the variability in annual and daily swing in volumes for a CCGT could be managed with a standard 80% load factor and 80% take-or-pay gas contract. However with a lower load factor of 50%, this type of gas contract would be much more difficult to manage and would incur additional cost such as storage, pipeline flexibility and/or offloading of excess gas supply.

The gas-on-gas competition in recent years has ensured that gas is competitive with coal for intermediate and baseload generation in most states. However, the higher transportation cost of gas to NSW does create a disadvantage for gas versus coal in this state. NGAC’s have assisted gas become more competitive with coal in NSW. Longer term, gas will need the support of a carbon price to remain competitive with coal.
6. Delivered Gas Price Outlook

Wood Mackenzie’s gas price outlook is based on an assumption that rational economic investment decisions would be made based on cost and price. To the extent that market impediments or distortions exist, this will impact investment decisions and distort the gas price outcomes. Some of the market distortions include;

- The level of Government ownership of the retail sector in NSW;
- The level of participation of Government owned generators in new-build capacity in NSW;
- The Government mandated outcome for the technology for new-build generation in NSW.

6.1 Delivered Gas Price Forecast Assumptions

The increase in competing sources of gas supply, together with the interconnection of the states through gas transmission, has lead to the convergence of regional gas pricing in recent years. Gas-on-gas supply competition now occurs on an interstate basis. Gas market prices in Eastern Australia reflect the differences in transportation distances from the competing supply hubs to the city-gate markets. As a result, gas prices in NSW and South Australia are higher than the gas prices in Melbourne and Brisbane.

The delivered gas price to NSW is based on both the commodity price and transportation cost. For the forecast period, Wood Mackenzie has analysed the factors that will drive changes to these price components. In regard to the transportation cost, the following assumptions were used;

- The transmission tariff is based on full firm supply tariff adjusted for load factor (at 75% and 50%)
- Pipeline expansions and new build tariffs estimated based on current cost estimates and industry accepted economic returns
- Sequencing of pipeline expansions and builds based on Wood Mackenzie analysis (recognising that valid alternatives are possible)
- Gas load for new gas-fired generation will provide the incremental demand to support development of the required new pipeline infrastructure.

It is important to recognise that other factors will determine the price at which gas transportation agreements will be written and therefore a negotiated tariff could be less than our return based calculated tariff.

The commodity price of gas at the key supply hubs is based on an average price for the producing projects around that hub. We have assumed that contracted supply would have 80% take-or-pay and 80% load factor terms to enable sufficient flexibility to manage the 75% load factor gas-fired generation requirement. Addition costs to the commodity price would be incurred in order to manage a gas-fired generator with 50% load factor. These costs would include such services as storage and/or pipeline park-and-loan. We have not included an assessment of these costs in our analysis.

In providing the forecast delivered gas price under each scenario, we have taken into consideration the factors influencing the availability and cost of gas supply, the forecast investments required to deliver gas to the required generation locations and the relative competitiveness of gas versus coal for generation in NSW. We have assumed that a Carbon Trading scheme will be implemented in Eastern Australia by 2010.
6.2 Generation Economics

Gas and coal fired generation are the most economically viable technologies that can achieve the scale and timing for development required under the scenarios being assessed for NSW. Therefore, in order to compare the relative competitiveness of new gas-fired generation versus coal-fired generation, it is important to compare the respective Long Run Marginal Costs (LRMC).

We have compared the LRMC of baseload gas-fired generation with black coal generation under a fixed 75% load factor. The capital cost of a new coal-fired generation is large compared to a CCGT. With the recent escalation in the cost of labour and materials, there is a large uncertainty as to the current cost of a new coal-fired generator. We have therefore assessed two cases (Lower and Upper) for coal fired-generation to illustrate this uncertainty.

- Coal_Lower represents the lower-end cost estimate for new coal-fired generation ($1,400/kW Capital cost and variable cost $10.20/MW based on a coal price of $0.90/GJ)
- Coal_Upper represents the high-end cost estimate for new coal-fired generation ($1,950/kW Capital cost, variable cost $14.60/MW based on a coal price of $1.10/GJ).

The resulting LRMC for coal represents a range of approximately $15/MWh.

As the capital cost is significantly lower for a new CCGT than it is for a new coal-fired plant, there is greater uncertainty with the variable component of the LRMC of a CCGT. We have therefore analysed the LRMC for CCGT under three delivered gas costs;

- $4.50/GJ;
- $5.50/GJ; and
- $6.50/GJ

The impact of a possible Carbon Trading Scheme is also an important consideration in this LRMC analysis. Gas-fired generation is a lower emitter of Carbon Dioxide than Coal-fired generation. As such, the price of carbon under a Carbon Trading Scheme will impact the relative economics of these two fuels. We have provided our LRMC comparison under a range of Carbon prices from $0/tCO\textsubscript{2} equivalent up to $35/tCO\textsubscript{2} equivalent.

LRMC of Black Coal versus CCGT (75 % LF) under different carbon signals and different delivered gas prices

![Graph showing LRMC comparison between Black Coal and CCGT](image)
Summarising this broad comparison of coal versus gas-fire generation LRMC:

- New gas-fired generation under current delivered gas cost (~$4.50/GJ) would not be competitive against new coal-fired generation in NSW without some form of additional support (e.g. NGAC’s).

- With NGAC’s or a carbon price of approximately $15 to $20/tCO₂ equivalent, a delivered gas cost up to $5.50/GJ could compete with new-coal-fired generation.

- With a carbon price >$25/tCO₂ equivalent, new coal-fired generation is not competitive against new gas-fired generation, unless the delivered gas cost is >$5.50/GJ.

This broad comparison on similar terms provides some insight to the relative economics of gas and coal for new baseload generation in NSW. However, it is the future cost of delivered gas to NSW that is key to understanding the suitability of gas for baseload generation in NSW.

6.3 Delivered Gas Price Forecast

In 2006, gas contributed to approximately 6% of the total electricity output in Eastern Australia. This relatively small share of the electricity fuel mix is a result of the traditional reliance on low cost coal for baseload generation in Eastern Australia and the use of gas mostly in peaking to intermediate generation. However, in the future, gas is forecast to increase its contribution to the electricity fuel mix. This is a result of a number of factors including:

- Environmental and Social Issues – Gas is a lower emitter of greenhouse gases and therefore is perceived to be more environmentally friendly than coal fired generation. With the possible implementation of a Carbon Trading Scheme, gas should benefit more than coal in the development of future generation.

- Flexibility – Gas-fired generation is generally more flexible and suited to intermediate generation than coal fired generation.

- Availability – The increase in number of sources of gas supply and supporting infrastructure provide a greater opportunity to develop generation projects than has been the case in the past. In addition, with a lesser footprint than a coal-fired plant, a gas-fired plant may be seen as less intrusive in more populated locations.

Wood Mackenzie forecasts strong gas demand growth in Eastern Australia over the next two decades, driven by the increased use of gas in generation. However, this gas demand growth is strongly dependent on the competitiveness of gas relative to coal in generation (even with implementation of a Carbon Trading Scheme).

We have derived a range of delivered gas price forecasts (commodity plus transportation cost) for the New South Wales market, with the following demand cases (for gas-fired generation at 75% and 50% load factors):

- Business as usual;

- 1,000MW of gas-fired baseload power generation in NSW;

- 2,000MW of gas-fired baseload power generation in NSW; and

- 2,500MW of gas-fired baseload power generation in the NEM.
The derived gas price forecasts took into consideration the cost of gas supply (commodity and transportation), the relative competitiveness of gas versus coal for new generation (LRMC), proposed carbon pricing and the level of gas-on gas competition between gas suppliers. Initially, we expect a continuation of strong gas-on-gas competition between gas producers for new incremental demand. However, as gas demand increases through gas taking a larger role in the fuel supply for electricity, the gas-on-gas competition is reduced (as producers have committed their supply). Gas producers are expected to be able to achieve higher prices for the next incremental supply volumes. With a price for carbon likely to be imposed on generation in the future, the competitiveness of gas versus coal will be benefited. It is expected that producers will be able to increase the price which they sell gas up to the point where the alternative (new coal-fired generation) starts to become attractive.

To illustrate the relative competitiveness of each of our delivered gas price forecasts with coal-fired generation, we have highlighted the range (blue shaded region of the following graph) in which delivered gas prices equal the LRMC of new coal-fired generation (with Carbon Cost ranging $15 to $30/tCO$_2$ equivalent). For example (post-2009)

- At a $5.00/GJ delivered gas price (and $15/tCO$_2$ equivalent cost of carbon), the LRMC for a new CCGT would be equal to the LRMC of a new coal-fired plant
- At a $6.50/GJ delivered gas price (and $30/tCO$_2$ equivalent cost of carbon), the LRMC for a new CCGT would be equal to the LRMC of a new coal-fired plant

Note: our LRMC of new coal plant utilised the mid-range capital cost estimate for new coal-fired generation capacity ($1,680/kW capital cost). The LRMC analysis was also undertaken with the coal-fired generation at 85% capacity, a more realistic level for a coal-fired plant.

**NSW Delivered Gas Price Forecast at 75% Load Factor**

Under the Business as Usual Scenario, we expect a limited increase in delivered gas price into NSW for the forecast period. With gas supplies required from Wallumbilla to replace declining Cooper Basin production, pipeline augmentation is required by 2009 including, compression on the SWQP and building of the QSN Link. This is expected to have an added cost impact in that year. Upstream producers will have limited scope to increase gas prices as gas would start to become uncompetitive with coal generation when competing for the first increment of generation in NSW in 2013. We would expect an initial price of carbon in the order of $15/tCO$_2$ equivalent if a Carbon Trading Scheme was introduced. This would limit the delivered gas price to $5.00/GJ if gas was to be competitive with new coal-fired generation on a LRMC basis.
In the 1,000MW gas fired scenario, a new-build pipeline is required from Wallumbilla to NSW. In addition, with two gas-fired plants in NSW, gas prices are likely to increase as supply starts to tighten around 2014. Further prices rises are possible with the increase in the price of carbon above $15/tCO$_2$ equivalent.

Under the 2,000MW and 2,500MW gas fired generation Scenarios gas demand will increase both the tightness of gas supply as well as incur the cost of the required transmission augmentation to deliver this gas to NSW. These scenarios are likely to cause a step-change in delivered gas price to NSW, pushing the boundaries of the competitiveness of gas versus coal for generation in future years. The level of carbon price will be a key driver for the level at which the delivered gas cost will rise to but at $30/tCO$_2$ equivalent, the delivered gas price could rise to $6.50/GJ and still remain competitive with coal on a LRMC basis.

Other key aspects that need to be considered based on these results include:

- The inferred electricity price differential between NSW and other states such as Queensland, where the delivered cost of gas is much lower
- The trade-off between gas transmission versus electricity transmission and the security of electricity supply based on interstate electricity importation and indigenous generation
- The possible growth of indigenous gas production in NSW that could reduce the need and cost for gas importation
- Possible competitive premium to encourage gas sales into NSW

Under the 50% Load Factor, gas is significantly higher as a result of the cost of reserving firm gas transportation rights but utilising less throughput. However, it is important to recognise that this coal fired generation at 50% load factor is a very inefficient operation (we have not adjusted out LRMC comparison to account for this). Gas fired generation does have the flexibility to operate at this lower level of load factor and would be more ideally suited in regard to operational reliability than coal, if required.
6.3.1 Implications of proposed LNG projects for future gas price in Eastern Australia

Santos and Arrow Energy have recently announced proposals for LNG projects in Gladstone. A summary of the proposed projects is provided in Appendix I. The key drivers for both Santos and Arrow Energy in proceeding with their proposals for LNG projects in Gladstone are the potential for earlier monetisation of their significant CSG resources and the possibility for a higher net-back price for their produced gas. In particular, it is possible that by creating the opportunity to sell gas for a higher netback price from an LNG development, that there will ultimately be a linkage of the Eastern Australia gas price to an equivalent LNG net-back price.

If either of these projects were to proceed, there is no doubt the local gas price would come under upward pricing pressure. However, there are a number of other factors that will come into play that could reduce the degree of future linkage to LNG netback pricing including:

- The future growth in the domestic gas demand is strongly dependent on the level of growth in gas-fired generation development. If gas prices rise too high, gas will be less competitive with coal for generation and future gas demand growth could be limited.
- The ability to bring on incremental CSG production at relatively low cost has created the strong environment for current growth in CSG supply. With increased gas prices, CSG should become a more attractive investment, ensuring strong gas-on-gas competition remains.
- With strong gas-on-gas and coal-on-gas competition, the linkage to an LNG netback price is weakened.

The recent announcements of Arrow Energy and Santos for proposed developments of an LNG export facility at Gladstone underline the growing confidence in the potential of CSG as a large volume, long-term gas supply source. Creation of a future LNG export link in Eastern Australia would likely place upward pressure on gas prices. However this would be tempered to a degree by the level of gas-on-gas competition and the relative competitiveness of gas as a fuel for electricity generation.

6.4 International Gas Price Comparison

Whilst the historical gas price is no indication for future gas prices, it is interesting to compare the gas price in Victoria (Eastern Australia’s only transparent gas marker) with Western Australia and the international markets of the United States (US) and United Kingdom (UK). Note, in this comparison the Western Australia gas price is based on yearly weighted average contracted prices except for the last 6 months where we have included some recent, small volume, contract prices.

Both the UK and US gas price show a higher level of volatility and absolute price compared the Victoria and Western Australia gas prices. This is due to the strong linkage of the gas price to the oil price in the US and to a lesser extent in the UK. The UK’s lesser link to the oil price is partially seasonal in nature, with the summer periods having strong gas-on-gas competition and lower demand contributing to a de-linkage with oil pricing. Whilst in winter gas is imported from Europe which has a strong linkage to oil price.
Victoria and Western Australia by contrast have no linkage to the oil price. With gas competing with coal in the electricity market the gas price has been relatively low compared to other regions of the world. Western Australia illustrates a significant upturn in gas price over the last six months. This is based on a few new small contracts that have achieved significant prices in a tight supply market. Possible future indirect linkage of the gas price to oil price in Western Australia could evolve due to the development of the LNG export industry.

In Victoria, recent increase in the spot price has been a result of significantly higher gas demand for generation as a result of the droughts effect on electricity prices. With increased gas production due to come online (Otway Gas Project) and the breaking of the drought, we expect the gas price to return to more normal levels reflective of the contracted gas market price.
7. Security of Gas Supply

The term security of supply is widely used to cover a range of issues spread over different time frames. It is important to define precisely what we mean by security of supply in order to enable us to compare different markets in a consistent manner. Our classification defines three distinct categories:

- **Operational** – This relates to the ability to maintain continuity of supply on a daily basis, for example in the face of exceptional demand. Operational security is primarily an “intra-State” requirement, and the demand profile is a very important variable in this regard (e.g. proportion of seasonal residential demand, volume of interruptible load, etc).

- **Strategic** – This is the ability to withstand a significant unexpected interruption of a major source (e.g. Longford or Moomba), and is therefore often the most sensitive issue and of greatest concern to governments. Those markets that are heavily dependent on one source or physical link need to seek strategic measures that can be introduced to mitigate the impact of such an event.

- **Longer-term** – In the future there is inevitably uncertainty about the precise availability of gas supplies, in terms of where it will come from and the cost of such supplies. For Eastern Australia, in the long term, the existence of gas reserves should not be a principal concern, rather it is the cost of delivering gas to market that is important.

The tragic events in Victoria during September 1998, when a serious explosion at the Longford gas processing and crude stabilisation plant suspended production, and led to curtailment of gas supplies to all consumers, highlighted the vital importance of strategic security of gas supply. The outage had forced shutdown of 95% of Victorian supply (with the NSW interconnect only able to supply 5% of peak demand) and demonstrated the level to which Victoria was dependent on Bass Strait gas output at the time. Whilst partial restoration of supply to the market took 9 days, it took more than 19 days for supply to be restored to households. However, the full plant restoration took longer than 6 months.

An equally serious fire on the 1st January 2004 led to the shut down of the Moomba gas plant in Southern Australia. Gas plant production was suspended, significantly impacting gas supplies to NSW and South Australia. However the impact on these markets was much reduced as alternative gas supplies were available from the Eastern Gas Pipeline and the SEAGas Pipeline. The SEAGas pipeline fortuitously had only recently been constructed and was under-going commissioning tests at the time of the Moomba fire. The Moomba facility was recommenced on 27th of January 2004. However, it took eight months to restore plant supply back to full capacity.

The Ministerial Council of Energy (MCE) has been working with industry in the development of arrangements for a national gas emergency response protocol for major supply disruptions. The MCE established a Memorandum of Understanding in relation to national gas emergency protocol (including use of emergency powers) in October 2005. The protocol seeks to minimise the impact on the economy and community of disruption to gas and electricity supplies by providing a more coordinated and efficient management of major gas supply shortages.

The MCE has sought to accelerate the development of a more reliable, secure and competitive national gas market. The continued move towards a liberalised and deregulated gas market will be enhanced by promoting such an environment. For example, the construction of the Eastern Gas Pipeline and the SEAGas pipeline provides New South Wales and South Australia, respectively, with alternative sources of supply, leading to greater diversity and enhanced security of supply, even though this was not the explicit intention of either project. The establishment of competition in downstream gas markets has encouraged the development of new sources of supply.

We have summarised below three potential types of incidents related to gas supply security that could impact gas supplies to NSW, the level of market impact and the likely timing to restore supply.
• Offshore Platform
  o A major platform incident could result in a long-term supply disruption
  o Catastrophic event could disrupt supply for 2 - 5 years (if platform or pipelines need to be replaced)
  o Impact could be up to 70PJ/a if one field was affected
  o Market supply impact is relatively small but potentially with long term effect

There has not been a major platform incident in Australia of the kind described here. Internationally these events are also rare. The Piper Alpha platform explosion/fire in the North Sea (UK) is one example of this type of catastrophic event and fire that resulted in the complete destruction of the production facility and the tragic loss of many lives. The lessons learnt from this incident have been applied world-wide to improve the level of safety on offshore production facilities and reduce the risk of this event occurring again.

In Eastern Australia, the development of new gas supply sources in recent years has reduced the significance of any one particular offshore gas field for supply. The increased development of onshore CSG projects will also help diversify supply risk to this type of event.

• Processing Plant
  o Processing plant incident could result in short to medium term supply disruption
  o Up to 1000 mmcfd of capacity could be lost out of the system (although in the future, only Longford will have this scale with most other gas plants in Eastern Australia having supply deliverability less than 300 mmcfd)
  o Impact could last weeks to months (e.g. 1998 Longford gas outage – Partial supply restoration took 9 days, while full plant restoration took greater than 6 months)
  o Market supply impact is large but potentially short term effect (of major disruption)
  o Over the last 30 years, there have been two events of this type and scale in Eastern Australia
  o With more plants and infrastructure, future impact is reduced

The risk of major gas supply disruption from a potential processing plant incident in the future has been reduced in recent years with the development of new gas supply sources and infrastructure. The reducing dominance of supply from Longford and the Cooper Basin plants (Moomba and Ballera) is illustrated by their reducing market share of gas supply. In the year 2000, the Longford, Moomba and Ballera gas plants supplied 92% of the total Eastern Australia gas market. By this year (2007), these three plants will supply approximately 60% of the total market and this is forecast to fall to just under 40% by 2013.

• Pipeline
  o Pipeline failure could cause short to medium term supply disruption
  o Could take up to 400 mmcfd out of the system
  o Impact could last days to weeks
  o Market supply impact is large in the short term
In 1982, the Moomba to Sydney pipeline suffered an explosive rupture as a result of corrosive fatigue in the pipeline. Pipelines today are now routinely examined with sophisticated technology to monitor corrosion and fatigue. Preventative action such as replacement of sections of the pipeline may be required. However with routine monitoring, testing and maintenance, the risks of this type of event are significantly reduced.

Whilst each of these types of incidents can clearly have a significant impact on the security of gas supply, the risk and impact on the market today is significantly less than it was a decade ago. With continued market development, investment in infrastructure and supply, this supply security risk and impact will be reduced further still. The added benefit is a more dynamic and competitive gas market.
8. Conclusions

Concerns for the future gas supply for Eastern Australia have been raised in recent years based on the forecast decline in the Cooper Basin and the decision by the PNG Gas Project partners not to proceed with developing gas supply from Papua New Guinea to Queensland. However, rather than a bleak outlook for future gas supply in Eastern Australia, Wood Mackenzie’s analysis shows a gas industry that has demonstrated a very healthy growth in gas reserves and supply in recent years. The upstream industry in Eastern Australia has delivered a reserves replacement ratio of 260% over the last five years – a level indicating significant supply growth potential.

In particular, CSG reserves have grown from less than 500PJ to around 4,000PJ in the corresponding period. CSG is now generally accepted in the industry as a reliable source of gas supply (typified recently by Rio Tinto Aluminium’s contract with Origin Energy for 20PJ/ a over 20 years to supply the expansion of their Gladstone Alumina refinery). Wood Mackenzie forecasts that CSG production potential is such that by the end of next decade, CSG could account for more than 50% of the total gas supply in Eastern Australia.

Under the generation Scenarios provided by the Owen Inquiry Secretariat, the potential to increase the level of baseload gas fired generation in the state in the period to 2016, is substantial. The required gas supply to meet this forecast gas demand would be predominantly from Victoria and Queensland and would require expansion of existing gas transmission, as well as new pipeline investment. In particular, there is a need to develop a gas pipeline directly from Wallumbilla to supply gas into NSW. This pipeline could connect to Newcastle and/or Bulla Park in central NSW. This new pipeline would complete an important loop in the gas transmission system that would improve overall security of gas supply as well as support exploration and development of potential new gas supplies within NSW along the pipeline route.

Wood Mackenzie’s analysis indicates that there is likely to be sufficient gas supply available to meet this demand out to at least 2020. Whilst beyond 2020 there is greater uncertainty, the CSG industry continues to increase gas reserves at an impressive rate and the ultimate potential of this industry in Eastern Australia could be enormous (with potentially decades of supply). There is scope for additional gas to be discovered and developed in the intervening period from conventional sources. Ultimately the option exists for importation of gas from Western Australia by new pipeline or as LNG. There is also scope for demand growth in this period to be reduced as new gas fired generation options switch to alternative fuels/technologies, delaying the requirement for long distance supply.

Environmental and social benefits exist with the choice of gas over coal generation. These include reduced greenhouse gas emissions, lower development footprint and lower water use. With the development of gas fired generation, gas supply security will be enhanced as additional gas transmission is developed and indigenous gas supply encouraged. Whilst still to be proven commercially, the indigenous gas supply of NSW has the potential to grow dramatically and reduce the need for interstate gas importation in the future.

Gas is currently not competitive with coal for baseload generation in NSW without NGAC’s. This is a result of the additional cost of transporting the gas from inter-state. However if a Carbon Trading Scheme were to be introduced, gas could be competitive for baseload generation in NSW at a cost of carbon in the range $15 to $30/t CO_2 equivalent. Under the High Gas Demand Case, delivered gas prices will rise, with the price of carbon ultimately determining the level at which gas prices compete with coal for future baseload generation.
Appendix I - Proposed Eastern Australia LNG Projects

Santos’ LNG Proposal.  On the 18th of July 2007, Santos announced a proposal to construct a 3-4 million tonnes per annum (mmtpa) liquefied natural gas (LNG) facility at Gladstone.  Santos will now embark on detailed engineering and environmental studies as well as preliminary marketing of the LNG.  A Final Investment Decision is planned by the end of 2009 and would enable construction to proceed with first gas cargoes by early 2014.

Santos estimate the capital cost in the range of A$5-A$7 billion (including upstream development, liquefaction plant and associated infrastructure).  The annual gas supply volumes required would be in the range of 170-220 PJ per annum. The total volume of gas required to support an LNG scheme of this scale (assuming 20 to 25 years supply) is estimated to be between 4,000 and 5,500PJ.

It is important to note that Santos have only proposed to enter into detailed evaluation at this stage.  In addition to the studies, they will also need to establish sufficient gas reserves to allow them to sign long-term LNG contracts.  This reserves certification will run in parallel to the studies.  Santos have indicated that they will be using CSG gas from their Bowen and Surat Basin fields.  With the scale of reserves required in the order of 5,000PJ, this would require a significant increase to Santos’ current CSG gas reserves.

Santos are currently assessing the Gladstone LNG project on their own.  Santos does have some experience with LNG through their equity in the Darwin LNG Project, although they have not operated or developed an LNG project in their own right.  Santos could potentially bring in other partners as plans progress, including a partner with LNG development and operating experience.

Arrow Energy’s LNG Proposal.  On the 30th of May 2007, Arrow Energy announced it had signed a HOA with LNG International Pty Ltd (“LNGI”), to supply gas to a proposed LNG facility to be located within the Gladstone Port area and designed to produce approximately 1 mmtpa of LNG (with an option to expand to 2 mmtpa).  The annual gas supply volume required for a 1 mmtpa LNG Train is approximately 55 PJ per annum.  Arrow Energy have stated that the initial supply to the LNG terminal under the HOA is for a period of 12 years, commencing in late 2010.  An option to supply a further 55 PJ per annum, starting as early as mid 2011, subject to the second LNG train being developed. Arrow Energy are targeting a gross reserves volume of 1,100PJ to support the initial LNG Train development of this project.

In addition to the smaller scale of this LNG project, the ownership structure is also different to the Santos’ proposal.  Arrow Energy currently only intends to sell the gas to the LNG project that would be developed by LNGI.  Arrow Energy has indicated it could act as aggregator of gas supply from other sources including its joint venture partners.
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