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A Strategic View: Electricity Supply, Carbon Emissions Reduction and the Generation Mix

THE PURPOSE OF THIS DOCUMENT: Brief description outlining purpose.

To provide an overview of an interpretation of the electricity generation coal and gas plant mix in the medium term based upon meeting the proposed electricity generation emission reduction and renewable energy targets and to highlight issues needing further consideration.

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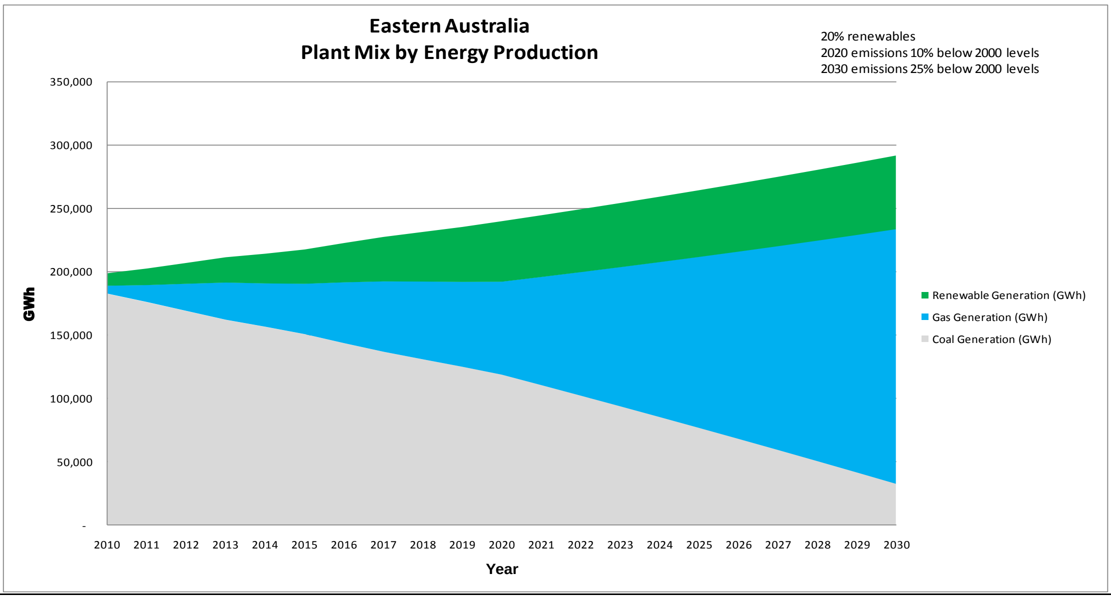

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TITLE

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EXECUTIVE SUMMARY

A generation business is characterised by large capital costs and relatively low operating costs, with investments lasting up to 40 years. In such circumstances, the selection of the generation technology to be utilised and the location of the plant to be constructed is critical. In this context, investment decisions must recognise technology changes and societal trends if a generation investment is to achieve the forecast economic and technical life.

Open access to the national electricity market, "pool", is the prime driver of generator on generator competition and should barriers to such access be raised, by structural positioning of competitors with respect to fuel or customers or by regulatory or market intervention to change the natural economic merit order, then the competitive nature of the generation sector will be diminished.

The influence of externalities do create investment uncertainty with respect to the level of potential returns however the external landscape of the CPRS is certain enough in its direction for generation investors to be able to make an informed technology and location choice for planned investments.

It is clear that new coal plants will be difficult to establish unless the carbon footprint is reduced significantly and most likely to below the carbon footprint of gas fired generation. This makes the immediate generation technology choice for base load plant very simple and in fact it is simpler now than it was several years ago when the external direction was not as clear. Current choices are gas, gas and gas. Combined cycle gas generation plants do however require a subsidy to compete as base load generators against coal. The CPRS "subsidy" is in the form of carbon costs to both technologies so that the cost of gas rises less than the cost of coal so that it becomes the cheapest technology to use. The economic merit order of generation which favours coal generation must be changed by the CPRS to favour gas generation otherwise a carbon reduction will not be achieved.

Vertically integrated generation, retail and gas supply companies have the option to construct open cycle gas turbines to mange retail risk and later convert them to closed cycle as energy requirements increase. They can do this as the incremental investment for combined cycle is low and can quickly capture generation market share to support an increasing customer base.

Renewable generation will need to continue to be at regulated levels of generation as current costs are well above that of combined cycle gas plant. As a result, they will have very limited or no place in an open access electricity market and renewable generation will continue to need regulatory support to be economic.

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The outcomes in the generation sector of an immediate reduction in carbon emissions are relatively straight forward to analyse after a basic assumption, that carbon emission reduction targets will be met, is made and the realisation is made that in the short to medium term that coal and gas generation must share the majority of the generation requirements after the generation from renewable is deducted.

The quantities of gas needed to meet forecast emission reduction targets are an order of magnitude greater than the current consumption of gas in the generation industry and in Queensland, with the proposed LNG plants, the rate of expansion of the gas production facilities will be unprecedented. With LNG initially taking up to 4 times the gas fired generation requirements, there is a significant risk that sufficient reasonably priced gas for electricity generation may not be available when required without regulatory intervention. The gas market dominance by internationally focused companies' means that the structure of the gas industry will be a significant factor in local gas pricing. This is reinforced by the linkage to export LNG gas pricing that has been made.

Being vertically integrated into fuel supply is the best long term strategic positioning for generation businesses. The implementation of a vertically integrated fuel strategy by government owned generators kept electricity pricing low for many decades prior to the splitting of the industry for a "reform and privatisation" agenda to be followed. Australian electricity customers have never faced a situation where fuel for base load generation (its greatest operating cost) has to be purchased at export parity pricing and not local production cost. They will face this situation as gas generation is the preferred fuel in a carbon constrained environment.

The dominance of gas fired generation for base load electricity generation will not change until new technology can compete on price, carbon intensity and is available at utility scale. This "technology hiatus" period may last 10-15 years.

The analysis calculates high valuations of carbon permits needed to change investment behaviour to favour gas and questions the ability of generation plant manufacturers to meet the growing global demand for gas plant. Low carbon permit prices will not change the economic merit order of generation from coal to gas and it must be changed to reduce carbon emissions.

Over this same term, the coal industry will have a technology response to the carbon emissions challenge and there will be other renewable or low emission technologies that become commercially viable. The R&D and commercialisation costs to achieve scale at a competitive price should not be underestimated if a short timeframe is required to bring forward alternative technologies to meet a sharply declining carbon emissions limit. The carbon target in 2020 is a critical element in the speed at which

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new gas fired needs to be constructed and coal plant needs to be retired and the magnitude of capital required.

Equally importantly, the role of nuclear generation needs to be considered where the carbon footprint is to be reduced quickly and at reasonable cost. Australia is the only country in the top 25 economies that does not have a nuclear generation build program and the only top 25 country that will be introducing a wide ranging carbon market. The effect on Australian global competitiveness and infrastructure costs is critical to understand prior to committing to short term emission reductions when zero emission technologies of a large scale and reasonably priced are not available.

The critical assumption in any analysis is the target carbon intensity in 2020. If the reduction target is greater than 10% below year 2000 emission levels, then the immediate issues and impacts on the generation market and electricity customers will be much higher. The volumes of base load gas plant to be constructed across the period to year 2020 to meet a decrease in year 2000 emission levels in 2020 are 1000MW per annum if a 10% reduction below year 2000 levels is chosen and 1800MW per annum if a 25% reduction below year 2000 levels is chosen. At the same time, the reduction in coal fired generation must be 850MW per annum and 1500MW per annum respectively.

This is a significant sensitivity and highlights the need to be clear on the reduction targets to be achieved, the actions needed to meet those proposed targets and the likely timeline for the introduction of new large scale low emissions technologies.

The introduction of reasonably priced zero emission technology from 2020 makes a significant difference to the demands on gas fired generation infrastructure development and makes it much easier technically and financially to meet carbon reduction targets. Deep emission cuts can be achieved once new zero emission technology emerges or nuclear generation is installed. As a result, the demands on the gas sector reduce as does the effects on coal fired generators. Gas construction requirements decrease from 2000MW per annum to 500MW per annum once large scale near zero emission technology is introduced. The phase to 2020 should be an R&D and planning phase for the introduction of new large scale low emission technologies as immediate reductions to 2020 are expensive, have little effect on the achievements at 2050 and long term carbon emission reductions rely upon the introduction of these new technologies.

With the CRPS imposing costs on gas fired generators, the technology that it is favoured in the short term, then the underlying electricity price must be increased above what would be required to change the economic merit order by regulation. The future cost of gas is a major determinant of the price of carbon permits needed to change the economic merit order and at \$6/GJ price for gas, the carbon permit

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price to change the economic merit order of generation is $63/t. A sensitivity of $15/t results from a change of $1/GJ of gas supply cost.

Beyond the mandated renewable, combined cycle gas plant is the only immediate term alternative to reduce carbon emissions from generation at a large scale to meet the short term carbon emissions reduction timetable. Capping of a carbon permit price below $63/t will not change the economic merit order of coal and gas generators and hence carbon reductions from electricity generation will not be achieved.

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INTRODUCTION

This report considers the implications for the electricity generation sector in meeting proposed carbon reduction targets when it contributes proportionally with all other sectors to the economies carbon footprint reduction. As the generation sector is the largest contributor to greenhouse emissions, it must proportionally meet or exceed its carbon reduction targets if the overall economy is achieve its targets. This assumption also removes from the calculations, interactions between sectors from a one size fits all carbon market and allows the concentration on a generation sector specific outcome where the burden of reductions must be equivalent or better than the target reductions set for the overall economy.

> the principle assumption is that the electricity generation sector will meet the same percentage carbon reduction target as the economy as a whole ("emission reduction targets will be met").

Econometric modelling that crosses business sectors at a high level is often too course for sector specific modelling and hence a different sector specific approach is needed. Once the stationary energy sector (electricity generation) is modelled by the methods in this report, then more detailed modelling methods may be used to refine the outcomes but within the boundaries set by this report.

STRATEGIC THINKING

Part of a strategic analysis must consider the target to be achieved, how to meet those targets with available technologies, review the competitive position of the major supplies that are needed to meet the targets and then derive conclusions of likely outcomes. An analysis at this fundamental level is a "strategic way" to estimate the likely bounds around future outcomes. The sensitivity of outcomes to important drivers, for example gas supply and electricity demand, can also be made.

The basic assumption underlying this analysis is that carbon emissions reduction targets will be met. If this is the objective of energy policy and the CPRS, then it must be assumed that those outcomes will be achieved.

The methodology utilised in this report works from the emissions reduction targets to determine the plant mixes needed to meet those targets and then considers the drivers to achieve those outcomes at reasonable prices to electricity customers.

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This approach is considered equally valid in setting new plant investment requirements as attempting to estimate electricity investment, generation technologies and electricity pricing by utilising models not dissimilar in concept to the NEM 5 minute dispatch and pool pricing algorithm. This reports methodology is a top down approach and not the bottom up approach which relies upon specific plant and bidding behaviour assumptions to be estimated across the forecast period. Determining micro assumptions for medium and long terms can be problematic.

Proponents of bottom up methods have a variety of ways to improve model outcomes through feedback loops that determine if the outcomes are economic and then adjusting the model inputs (bids) until the outcomes are economic. Bidding behaviour drives pricing which in turn drives investment decision as to size and type. These types of models can be used to improve the detail behind this analysis by providing a further dissection of the logic in specific and small timeframes and also to ensure that demand and reliability standards are met but it is considered that they have limited use as long term strategic models.

The report utilises the basic assumption that emission reduction targets will be met by a combination of renewable generation, gas fired generation and coal fired generation for the period to 2020 (renewable generation is fixed by legislation and coal and gas generation supply the remaining energy). This is a valid assumption and method as there are no alternative energy generation sources at a scale large enough to significantly alter the calculated generation from gas plants across the immediate term.

Renewable generation, built at a uniform rate across the modelling period, and reaching 20% of all energy generated at 2020 is assumed. This assumption avoids the debate about which renewable technology will be used to meet the renewable energy targets and when each of these renewable technologies will reach commerciality across time. It is a requirement of the methodology to determine the generation technology to be used as it is the renewable generation volume mandated by regulation that is used in the calculations. More detailed assumptions are not required as an input into a strategic view.

These assumptions for the base case are “constrained” as they do not allow for the introduction of new large scale generation technologies across time. As it is unclear when the new technologies can be deployed at a large scale, introduction of new technologies are considered a sensitivity to base case results. By default, the introduction of new technologies should improve (reduce costs) for customers across time otherwise they will not be able to enter the market without financial assistance.

As the supply cost curve of generation has large steps between technologies types, refer to table 2, there is wide cost gaps into which new large scale technologies can

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target to create commercial advantage over competitors. Significant cost reductions are needed by new technologies that must compete in the open market against gas generation before they can enter the market at a scale to make a significant difference to the volume of gas fired generation calculated to meet carbon reduction targets. The period until the introduction of new technologies of significant scale and volume is a "technology hiatus period" and the effects of it must be considered in a strategic analysis or sensitivity.

METHODOLOGY

The methodology to calculate generation plant mixes utilises the annual energy forecast and carbon emission reduction target to calculate annually the generation from each technology group that in total equals the energy forecast whilst at the same time meets the emissions limits.

Annual energy forecasts are from the AEMO 2009 statement of opportunities up to 2019 and then escalated at the rate nominated by AEMO until 2030. They are escalated at the same rate from 2030 to 2050.

Emissions are based around the 2000 and 2007 generation emissions published by NEMMCO with assumptions on the emission levels, relative to 2000 emission levels, to be achieved in 2020, 2030 and 2050. The 20007 levels are allowed to rise slightly until 2009, remain relatively stable in 2010 and then decline at a uniform rate to meet the assumed target levels in 2020, 2030 and 2050.

Generation technology groups to meet energy forecasts are derived from renewable, gas and coal fired generation. A renewable percentage is applied from now until 2020 and ramping uniformly each year from 2% in 2008 to the assumed percentage of 20% in 2020. Similarly a uniform ramping in the percentage of renewable generation is applied over the years between the milestone dates of 2020, 2030 and 2050.

Annually, the energy from renewable generation is deducted from the total energy forecast and the remaining energy is generated by gas and coal fired generation in a proportion so that the emissions from each generation technology group when added, equals the total emission limit for that year. The final step is to calculate the required installed capacity of the renewable and gas generation by converting the energy of each generation type by the assumed capacity factor to determine the required installed capacity. This capacity does not allow for a reserve plant margin or guarantee that system reliability will be met as it is based upon the energy forecast alone. Calculated plant mixes have been assumed to meet the demand

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requirements whilst meeting energy and emission targets. Further analysis is required to calculate the additional plant for reserve and system reliability purposes.

With coal plant operating to meet the remaining energy requirements after renewables and gas and with declining generation from coal plant, no new coal plant is to be constructed. The spare capacity in the coal plant will also provide a “hangover” of plant capacity that will provide additional energy and reserve capacity to assist in the meeting of system reliability targets.

New gas plant requirements will be under stress in the early years of the projections as gas field development may not be able to meet the short term generation requirements and new generation plant other than gas may be required to meet system reserve plant margins. The rate of growth of renewable plant in the initial years will also be critical to new alternative plant build decisions. Further calculation will be required to understand this short term relationship however, it has little bearing on the strategic outcomes of the methods used in this report.

Gas plant has been assumed to operate in all years across the modelling term at high capacity factors. This may not be achievable in the early years of the model due to potential gas supply and gas plant supply constraints. Gas plant must however operate at high capacity factors for the economic merit order to change from coal to gas.

The calculated capacity for the renewable, gas and coal is the base data from which conclusions can be drawn including the estimation of the year on year gas and renewable plant commissioning requirements. The outcomes are driven by the chosen capacity factor for each technology and the required MW’s to be constructed have a simple linear inverse relationship with the capacity factor chosen.

Basic data on the cost of solar, wind, gas and coal fired generation and their representative emission levels are used to calculate the carbon price at each economic cost cross over point between technology types.

A graphical representation of the methodology is shown below.

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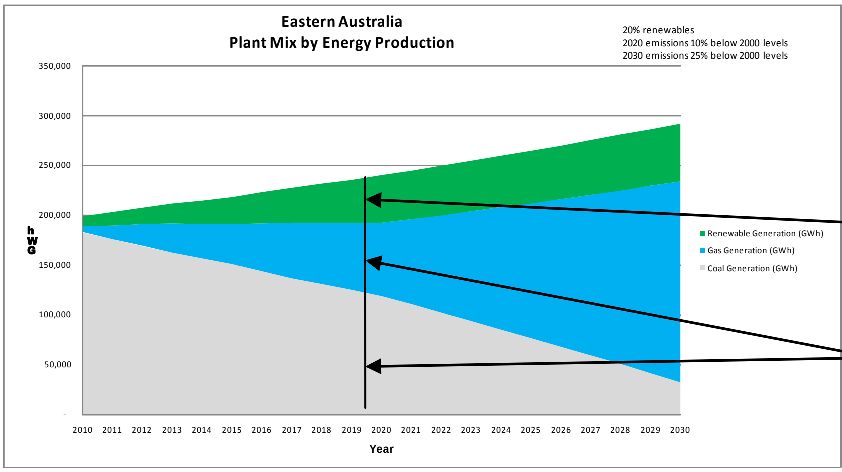
Graph 1: Methodology



Step 1 – determine annually permissible emissions, total energy requirements and renewable energy generation percentage

Step 2- take renewable energy from the total energy to determine the energy to be generated by coal and gas

Step 3- proportion the non renewable energy between coal and gas so that the emission limits are achieved

ASSUMPTIONS

Overall Emissions Targets

The underlying assumption for this analysis is that the overall emissions reduction targets will be met and that the generation sector will contribute an equal share to those reductions compared to the wider economy. Starting from this premise, allows for the simplification of the analysis and for electricity generation industry specific implications to be better understood.

> The underlying assumption is that "emissions reduction targets will be met".

This means that the energy forecast and the emission from each generation technology will drive the generation mix to meet the energy requirements and not the demand forecast. It also means that the analysis can be completed independent of pool price; a complicating factor as the bids assumed to forecast pool price are also used to determine the generation mix. The methodology does not calculate the pool prices from this generation mix to satisfy the revenue requirements for each technology type at the assumed capacity factors. However this pool price forecast can be added to the analysis.

The two important assumptions that drive the results from any analysis are:

- the percentage of renewable generation that will be mandated; and

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- the target carbon emissions levels, below 2000 levels, that are required to be met in 2020 and 2030.

Both have a significant influence on the changes to the generation mix that are needed to meet the carbon reduction targets in 2020 and a lesser effect in 2030 as new low emission technologies should have come forward. More aggressive targets in 2020 significantly change the generation mix and increase the cost of meeting short term targets. Large scale of the new zero emissions technologies available from 2020 mean that the generally accepted targets in 2030 and 2050 should be able to meet without any influence from the targets set in 2020. Any additional expenditure in the period to 2020 has little effect on the achievement of the longer term targets.

Renewable Energy and Carbon Emission Reduction Targets

To understand the impacts of the carbon emission targets on the mix of generation plant, it is necessary to estimate emissions reduction targets across a 20 year timeframe and then to determine the plant mixes within that envelope. The carbon emission reduction targets have not been confirmed but a base case can be built around information in the public domain.

The base case assumptions are:

renewable generation in 2020 – 20% of energy;

renewable generation in 2030 – 20% of energy;

2020 generation carbon emissions 10% below 2000 levels; and

2030 generation carbon emissions 25% below 2000 levels.

renewable generation in 2020 – 20% of energy;
renewable generation in 2030 – 20% of energy;
generation emissions in 2020 to be 10% below 2000 levels; and
generation emissions in 2030 to be 25% below 2000 levels.

A sensitivity to reduce the emissions in 2030 to 40% below 2000 levels has been calculated. The results highlight a different and significant issue for consideration.

These assumptions define the emission reduction targets bounds and the generation plant mix to meet those bounds can be calculated. With the annual renewable energy target being met, the remaining annual energy requirement is met by coal and

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gas plant generating in a proportion that their combined emissions meets the carbon emission limit.

These are good overall assumptions for the immediate term as the renewables are managed through the renewable energy target and the larger scale new and near zero emission technologies that will later compete with gas are not included. At some point in time they will become commercially viable and will enter the market but must do so at a scale that displaces existing large scale coal and gas generation to make a difference to the results. The initial short term effect of meeting emission reduction targets is however starkly shown. Differing timeframes for the introduction of the new low emissions technologies can be assumed and the changes in the generation mix calculated as a sensitivity analysis. This identifies the changes to annual gas and coal plant capacities from the introduction of these technologies and hence provides an indication of potential additional commercial pressures on coal and gas plant owners.

An additional benefit of this analytical method is that the demand profiles do not have to be considered. The plant mix outcomes are based upon energy consumption alone (it is the energy that produces the carbon footprint and not the demand) and the outcome for gas plant is the main result to consider. This means that as long as conservative capacity factor assumptions are utilised in the transposition from electrical energy to plant installed capacity requirements, the calculated gas generation capacities annual changes will be representative of the necessary actions to be taken.

These results meet strategic analysis goals as the coal and gas plant are calculated to be operating at acceptable capacity factor profiles and it is the annual installed capacity changes that are of strategic interest. The calculated mix of generation plant can be input into other energy models that utilise energy and demand to better define the coal or alternative technology generation capacities that will be required to reliably meet the demand and to understand the resultant energy pricing when transmission and other in-temporal constraints are considered. This analysis should not change the annual installed capacity changes which is what this analysis utilises to draw conclusions.

The critical outcome for customer supply reliability will be the drivers put in place by energy policy that keeps coal plant available to operate when the electricity demand is high until new gas or renewable plant is constructed and then allowing that coal plant to retire at the appropriate time. This will reduce the capital requirements of generation and keep customer cost as low as possible whilst maintaining energy and demand reliability. Coal plant should be able to provide the reserve capacity to meet the reliability limits of the electricity supply as with the change in economic merit

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order it will be changing its operating regime from base load to intermediate duty and it will have spare installed capacity. However if the coal plant shuts early due to running uneconomically at low capacity factors or is forced to close early by energy policy, the proposed gas plant to be constructed capacities may have to be increased annually by 10% to 20% to compensate.

Forecast coal plant capacities have been determined from an assumed capacity factor however they are of minor relevance as coal plant is fulfilling a role to supply the energy not supplied by gas and renewable. As the coal plant generation is in decline, no new coal plant should be required to be constructed however the controlled decommissioning of existing plant is expected to be required as a fall-back position. The timing of the retirement of coal plant could form a fall back strategy for customer energy and demand reliability should the gas generation not be presented to the market as required. This is a regulatory matter that requires consideration to ensure that customer supply reliability is not compromised but it may be at the expense of meeting the carbon reduction targets.

> In the absence of sufficient new gas plant, the timing of coal plant retirements is a regulatory matter that requires consideration to ensure that customer supply reliability is achieved.

Model Initialisation Point

The starting point of the mathematical model is based upon data published by NEMMCO on the total CO_2 equivalent from generation in year 2000 and 2007. The 2000 data is used to calculate the required carbon emission targets and the 2007 data is required to calculate the emission reductions year on year to meet the 2020, 2030 and 2050 carbon emissions targets.

> The year 2000 CO_2 equivalent generation emission is assumed at 161.9 million tonnes and the 2007 equivalent generation emission is assumed at 161.3 million tonnes.

Energy Forecast

The energy forecast in the model is the 50% probability of exceedance forecast published by AEMO in its 2009 Statement of Opportunities. Refer to section Appendix A - Extract from 2009 ESOO for details.

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The energy forecast has not been changed for price elasticity of carbon or for any other reasons. The reason for not changing the forecast energy is that there is no better public information upon which to sustain an alternative view.

The energy forecast is the 2009 AEMO 50% probability of exceedance energy forecast.

From the end of the AEMO forecast in 2019, the energy has been increased at the growth rates identified by AEMO for each state and for the Australian total.

The use of the energy forecast in this manner includes indirectly an additional simplifying assumption that energy consumption is unaffected by energy price increases as a result of the changes in the plant mix and the introduction of the carbon emission reduction targets or a broad ranging carbon trading scheme. This is a suitable assumption as the energy forecast by the AEMO already has a view on the energy consumption changes due to changing energy prices which have been calculated by the network service providers, the energy retailers and other industry professionals. It remains debatable the extent of the impacts of the emission reduction targets or a broad ranging carbon trading scheme on the energy forecast but if the view is used, that the Australian economy will not suffer and may in fact benefit, then the energy consumption should remain unchanged or increased. It has been left unchanged.

Generation Plant Capacity Factor Assumptions:

To back calculate the installed capacities of gas and renewable plant from the energy requirements, the capacity factors of plant in table 1 below have been used. The capacity factor for gas plant is skewed towards base load as gas plant must generate an increasing proportion of the energy and for commercial, technical and carbon efficiencies; new gas plant should be closed cycle plant and not open cycle plant. A 75% capacity factor represents a reasonable capacity factor for CCGT's. As a result, the plant installed capacities calculated will be slightly less than is required to meet energy reliability requirements unless coal plant is assumed to remain available to meet reliability limits. In this case, the capacity factor of coal plant does not have an impact on the new plant requirements but the capacity factor assumed allows for an estimate of the coal plant capacity that has to be annually retired. As coal plant is the "swing" generator, it runs simply to meet the outstanding energy and demand requirements. This is a good assumption as coal plant is declining in its market share and the only risk is that it retreats too quickly and the gas plant cannot be constructed in time to make the replacement.

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Table 1: Assumed Plant Capacity Factors

Plant type	Capacity factor
Renewable	50%
Gas	75%
Coal	Run to meet the outstanding energy and reliability requirements. 75% assumed to calculate the changes in coal plant installed capacity equivalents

This method will underestimate the required plant investments in gas as it does not reference the demand duration curve but simply allocates energy under the energy curve at a predetermined capacity factor. It does provide guidance on capacity requirements for new plant and will closely estimate the future gas fuel requirements as the calculation is energy based. A bias towards open cycle gas fired generation will significantly increase the required new gas plant capacities, gas consumptions and put at risk the ability to meet the carbon emission reduction targets. If all new gas plant is run as open cycle, then both the new gas plant capacities and gas consumption must increase by approximately 50%. This is considered an unlikely outcome.

A different analysis is required to confirm coal plant and peaking plant capacity requirements to meet the demand projections and reliability requirements. As the coal plant is being retired, capacity should be available to meet the demand requirements as long as the electricity market pool prices are sufficiently high at the capacity factor at which the coal plant runs. This additional analysis will make the investigation more complete but is expected not to make differences to gas plant construction or gas supply requirements as this the calculations are energy based and not demand based.

Due to the significant volumes of gas plant to be constructed, it is essential to understand the scale of gas generation and supply requirements as it is the most “stressed” generation source in terms of fuel development and plant delivery requirements.

A sensitivity analysis calculates the annual gas plant capacities if they operate at 65% capacity factor to better represent the intermediate load duty that gas plant may operate at in the initial period of the study. The results show that an annual

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additional 150 MW of gas plant (making a total of 1150 MW) is required to be constructed annually in the years to 2020.

NEW GENERATION TECHNOLOGIES TO REDUCE CARBON

A review of the commercially available technologies to meet the carbon reduction targets suggests that there is a limited number currently available that can meet high proportions of the energy requirements from low carbon technologies in a reliable manner and that are capably of construction in a short timeframe.

There are technologies that can produce large volumes of energy but they are not cost competitive with the main stream technologies of coal and gas. The best of the renewable technologies being wind and solar are not cost competitive in an open and free access market like the Australian energy market and hence rely upon financial subsidies through regulation to create for them a market position. Others, like geothermal, are at the demonstration stage of development and show good potential.

A review of the technologies to reduce the carbon intensity of generation would not be complete without mentioning the timeframes within which each technology can be implemented. This provides the best medium term strategic view of likely directions of the industry. What is obvious is that gas generation is the only technology that can be implemented on a large scale and in a short time frame to make an immediate impact on generation carbon emissions. There are a significant number of projects involving numerous technologies that are striving to be the first to find a solution but to prove commerciality, to produce the manufacturing plant for the supply of the equipment, and to implement a pipeline of suitable projects with willing clients will take an extended period of time.

> What is obvious is that gas generation is the only technology that can be implemented on a large scale and in a short time frame to make an immediate impact on generation carbon emissions

There is a growing list of emerging technologies that may be able to fill a base load generation role at reduced emission limits but these are yet to become commercially available on a scale that will alter the calculated generation mix across the short to intermediate term. What this says is that the competitive market position of current generation technologies and generation fuel suppliers will essentially dominate the landscape across the next 10 years. The competitiveness of suppliers will drive the market pricing outcomes for customers and this is particularly so for gas suppliers

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who will drive gas generation investments and their relative competitive positions. The gas industry structure will be the main determinant of electricity pricing across the immediate period

With step changes between the costs of generation from competing technologies, sufficient pricing gaps exist for non competitive behaviour where one technology can increase the market price to shadow price the next cheapest technology. Competitive structures within gas suppliers and within the generators utilising gas technology will be the prime determinant of electricity customer pricing.

A number of analyses of the likelihood and timing of emergent technologies can be made but the commercialisation of them will be research and demonstration project dependant to prove the technology limitations and the real costs at utility scale. Potential generators must prove their technology capability prior to being given a policy leg up by regulation into the market if they ultimately prove not to be competitive with the mainstream technologies at market price and the carbon emission targets are not being met. Increasing carbon pricing to bring them forward may not be the best solution for customers as cheaper technologies simply make a pricing windfall.

This means that there will be at least a 10 year hiatus and possibly a 15 year technology hiatus period prior to the bringing forward of new technologies in sufficient volumes to create any real competition to gas generation. Sensitivities to new plant requirements are therefore best carried out beyond 2020 when additional low emission technologies become available. The sensitivity can be calculated by simply increasing the renewable percentage in the model and then considering the changes to the gas plant construction requirements and the coal plant retirements.

Technology on technology competition for base load generation has not existed in the generation industry in the past (as coal has been financially superior) as there is and continues to be a step change in production costs as technology changes. Coal generation has always held the status of low cost producer and with gas fired generation significantly more expensive.

> There will be at least a 10 year and possibly a 15 year technology hiatus period prior to the bringing forward of new technologies in sufficient volumes to create any real competition to gas generation

There appears to be no short term relief to this principle. The implication is that the structure of a particular market segment is what actually drives competition in generation supply and the management of energy costs to customers. The gas

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industry structure is therefore of vital importance if we are to rely on competition to contain generation prices close to production costs and not at the level of the next more expensive technology. Shadow pricing is a well known economic principle.

As the cost of gas fired generation is an international problem, there will be significant pressures on the availability and cost of large scale gas generator manufacture as well as the availability and pricing of local gas supplies. It is an international problem as the vertically integrated state government owned electricity industry took the strategic position to disconnect the local fuel cost for generation from the international price of fuel and this led to reduced prices for electricity consumers for decades. With the disaggregation of the industry, this strategic positioning has been "lost" with the result that the local cost of gas is now benchmarked to international LNG pricing which may not be reflective of the incremental production cost. It is significantly lower.

In addition, the international problem includes the ability of global gas plant manufacturers to produce plant in sufficient quantities and at reasonable pricing when there is a "dash for gas" across the planet. If they cannot produce the plant at reasonable cost, then carbon pricing will increase and if they cannot produce the plant in sufficient quantities, then carbon emission targets in economies without low emission alternatives (for example nuclear) may not meet their reduction targets.

Each technology that can be used in the near term has a step differential in production cost and carbon intensity. This is illustrated in the following table:

Table 2: Approximate Costs and Carbon Intensities

Technology	Total Cost ($/MWh)	Carbon Intensity (t/MWh)
Coal	40 - 50	0.8-1.2
Gas	70 - 80	0.4-0.6
Nuclear	60 - 150	~0
Wind	140 - 180	~0
Solar	250 - 350	~0

Note: emissions in procuring the fuel or plant manufacture have been ignored. The direct generation carbon footprint is only included.

What can be recognised is that there is a significant opportunity for the coal industry to reduce its carbon footprint and to fit within the carbon cost windows that exist between its production cost and that of gas fired generation and other emergent technologies.

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NEW TECHNOLOGIES AND THE TECHNOLOGY HIATUS PERIOD

The pricing gaps between technology types indicates that there is wide gaps in the energy supply curve for new technology types as they become commercially viable. The gaps are sufficiently wide and the demand for new low emissions plant sufficiently high that as new technology improves its economics and becomes more competitive, it will have an opportunity to quickly move from the demonstration stage to high utilization.

It also indicates that there is a need for new technologies in the interim period as to allow the gas sector to meet the carbon emission target reductions alone over an extended period is not desirable and can be classified an energy security risky. Secure electricity supplies require large known fuel resources and diversity of location of fuel and preferably of fuel types. The gas sector needs to be competitively challenged in the electricity generation space so that external pricing is not "forced" onto the generation sector and so that it does not become a dominate high cost supplier as opposed to current position of coal as a dominate low cost supplier of electricity.

Numerous technologies are progressing in a quest for a position in the generation pricing supply curve but none are as yet in a position to have progressed past demonstration projects to commerciality and into large scale production where they can take up a sizeable proportion of the generation supply curve at a price cheaper than gas in the near term. To ramp up these technologies on a world scale (technology is transportable across international borders) and at a scale that meets world demand will take a period that may stretch to 10 or 15 years beyond the commercialisation of the technologies. This leaves a sizable time gap within which gas will remain the dominate technology.

Again, the international demand for a solution will dictate that an adequate supply of new technologies at a scale to make a large difference to the world carbon footprint will create an enormous surge in new production line capacity. The wealthier nations will also have a greater economic leverage to get the technologies implemented earlier and to support the expanding production lines. Whether Australia has this economic muscle on a world scale is unknown.

With the lack of scale of new low carbon emission technologies in the near term, the competitive position of gas plant manufacturers, gas suppliers and energy companies across this technology hiatus period is critical to understand and for governments to consider in the energy policy mix and for the regulators to manage on behalf of the customers.

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CARBON COST IMPACTS ON DIFFERENT GENERATION TECHNOLOGIES

Any comparison of generation competitiveness in the National Electricity Market must compare the incremental as well as the total costs of generation as incremental costs are important in the determination of the economic merit order and total costs in the determination of the returns to investors.

With the renewable energy target met, any further reductions in the carbon footprint from the remaining generation must change the merit order of coal and gas to achieve the targeted reductions in the carbon footprint. This change must occur on an incremental as well as a total cost basis for gas investments to come forward.

It is the cost of base load technologies that drive the merit order and the base load new entrant price which is considered as the average electricity price and the average electricity price received by the base load generators. Base load plant must be first in the merit order; that is it must run in preference to other plant, and it must have incremental or fuel costs that allow this to occur. The remaining technology types must fit below the demand duration curve and their respective capacity factor will determine their revenue from the price duration curve. They must be technically capable of generating at that capacity factor as well as surviving economically at the corresponding price for them to survive economically in the prevailing energy market.

An example is that if the base load price is $80/MWh (say gas plant) and the next cheapest technology is $160/MWh at 50% capacity factor (say wind), then the market pricing must be:

50% of the time	$0/MWh; and
50% of the time	$160/MWh

for both of the technologies to survive in the market and receive their required average pricing of $80/MWh and $160/MWh respectively. To conduct a detailed analysis of differing technologies under revised energy policy will require some specifics of that policy to be known and the management of the regulation beneath it to be published. Once the strategic position is understood as per this report, such detailed work can be undertaken within the parameters set by this strategic

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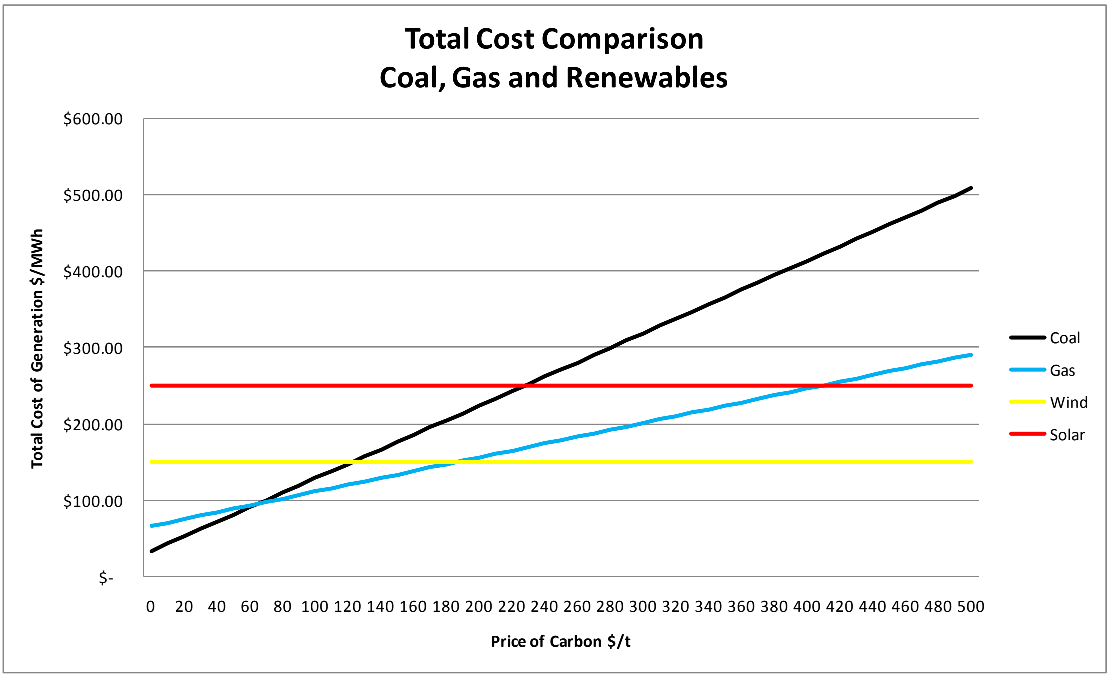
methodology to determine the likely pricing of market segments occupied by differing technologies.

A comparison of the cross over points between technologies at differing costs of carbon is graphed below based upon the following assumptions:

Table 3: Plant Performance Assumptions

	Coal	Gas
Heat rate	9.00	7.50
Fuel cost ($/GJ)	1.50	6.00
Carbon intensity (kg/MWh)	950	450

Graph 2: Total Cost of Generation at Increasing Carbon Prices



notes: coal price $1.50/GJ and gas price $6.00/GJ landed at the plant; and carbon intensities as per table 3 above.

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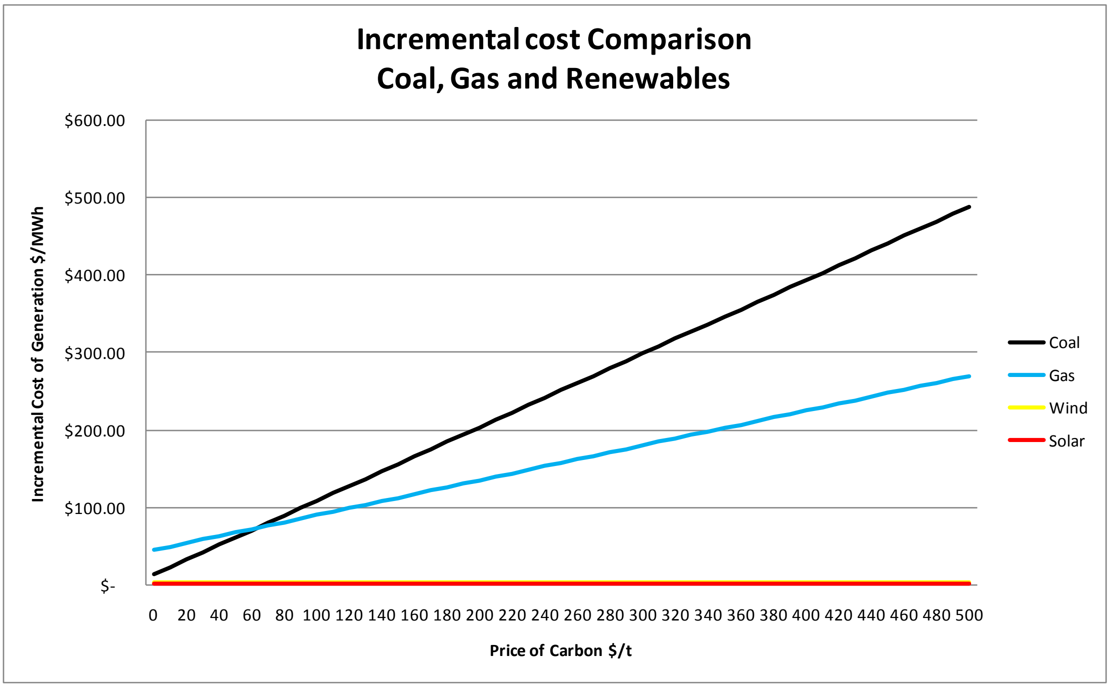
Graph 3: Incremental Cost of Generation at Increasing Carbon Prices



What these graphs show is that the incremental cost (in economic terms fuel cost) of wind and solar is nearly zero so they can economically generate without reference to pool pricing and hence generate at times most suitable to them. Broad pool pricing indicates that these low emission technologies will not have sufficient revenue from the pool to be economic and must continue to have subsidies for them to operate in a market that has gas fired generation as the base load source of electricity.

An important message from the graphs is that the change over carbon price from coal to gas in incremental and total cost terms is almost the same at $65/tonne of carbon equivalent. This means that the change over point at $65/tonne of carbon equivalent is reasonably robust and is the minimum carbon price to have gas fired generation built in presence to coal plant and also to ensure that existing coal plant reduces its market share to allow the additional gas generation into the market. This additional generation is required so that the carbon targets will be met by constructing gas plant in excess of the load growth and the normal retirement of coal plant.

The carbon price will have to be "held up" to this level to ensure gas plant investments. At any carbon price below this, the carbon market would not function to change the generation merit order from coal to a gas preference and hence only

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limited carbon emission reductions from electricity generation will occur. Under these circumstances, the carbon market would simply function as a limited base tax with a wealth redistribution scheme and it would be ineffectual in reducing carbon emissions.

In addition, every time that compensation is provided to generators to limit the effects of the carbon pricing, then the carbon price must increase to offset that compensation so that the economic merit order remains in favour of gas over coal otherwise no carbon emission reductions can occur through market based mechanisms.

> Every time that a compensation is provided to generators to limit the effects of the carbon pricing, then the carbon price must increase to offset that compensation so that the economic merit order remains in favour of gas over coal otherwise no carbon emission reductions can occur through market based mechanisms.

The effects of compensation payments to coal generation on the price of carbon so that the compensation paid does not affect the economic merit order needed to reduce carbon emissions, is easily calculated. The sensitivity is that for every $1/MWh of compensation given to coal plant, the carbon price must rise by approximately $2/t so that the uncompensated competitive position between coal and gas is not affected and the economic merit remains in favour of gas over coal.

> For every $1/MWh of compensation given to coal plant, the carbon price must rise by approximately $2/t so that the uncompensated competitive position between coal and gas is not affected so that the economic merit remains in favour of gas over coal.

The large step change in costs between technology changeover carbon prices is again a feature of the outcome. To limit cost rises to customers, competition within the gas sector and a structure of the carbon market that does not require technologies that are not competitive with gas to compete directly with it (allows gas to shadow price to the next most expensive technology of wind) will remain important to manage. The need for regulation outside of the market will remain important to bring forward more expensive technologies that cannot compete in a carbon market but can contribute to the immediate reduction in carbon intensity of generation. Wind and solar are in this category.

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With the assumption of $1.50/GJ coal cost at a generation plant heat rate of 9.00 and a carbon intensity of 950kg/MWh for coal plant and $6.00/GJ gas cost (landed at the plant) at a generation plant heat rate of 7.50 and a carbon intensity of 450kg/MWh for gas plant, the carbon price needs to be greater than $65/t before gas plant is more economical than coal plant to run. At this carbon price, the incremental fuel cost is approximately $75/MWh. The total cost of generation under this regime is approximately $95/MWh, approximately treble the current market new entrant base-load coal generation costs.

For the total cost of coal and gas fired generation to be similar to the total generation costs of renewable energy generation costs of $150/MWh for wind generation and $250/MWh for solar generation, the carbon costs are very high indicating that a carbon market cannot be used without severe customer pain if renewables are to compete in the same open access electricity market as coal and gas plant. The carbon prices for wind and solar plant to be competitive with coal plant are $120/t and $230/t and for gas plant are $180/t and $400/t. Without a substantial reduction in the cost base, regulation outside of a carbon market will be required to be maintained to facilitate the entry of renewable energy technologies of wind and solar.

The most important competitive point however is that different technologies do have a significant cost differential therefore the ability of one technology to shadow price ("price optimise") against the next competitive technology is significant. For example, in the absence of a competitive wind market, wind can increase its price to $249/MWh before solar generation takes its market share. It is a similar situation between gas and wind. This dynamic must always be understood and considered by industry regulators when considering the real underlying competitive position of the generation market under carbon emissions limitations.

The need to ensure high levels of price competition in gas generation is again highlighted as an important market structural issue to manage prior to having a hands-off approach to the carbon market design as has been stated by some corporations.

The impact of the costs of carbon capture and storage are not linear to the underlying generation costs and hence a separate analysis is required to compare the expected change over carbon prices for when carbon capture and storage is commercially available. In general terms, as coal has a higher carbon intensity than gas, the introduction of carbon capture and storage has the potential to decrease the change over carbon price between coal and gas by approximately$10-$15/t. It must however be economic at these prices and that remains a significant challenge. Further technology developments and commercialisation is needed to improve the confidence in these numbers.

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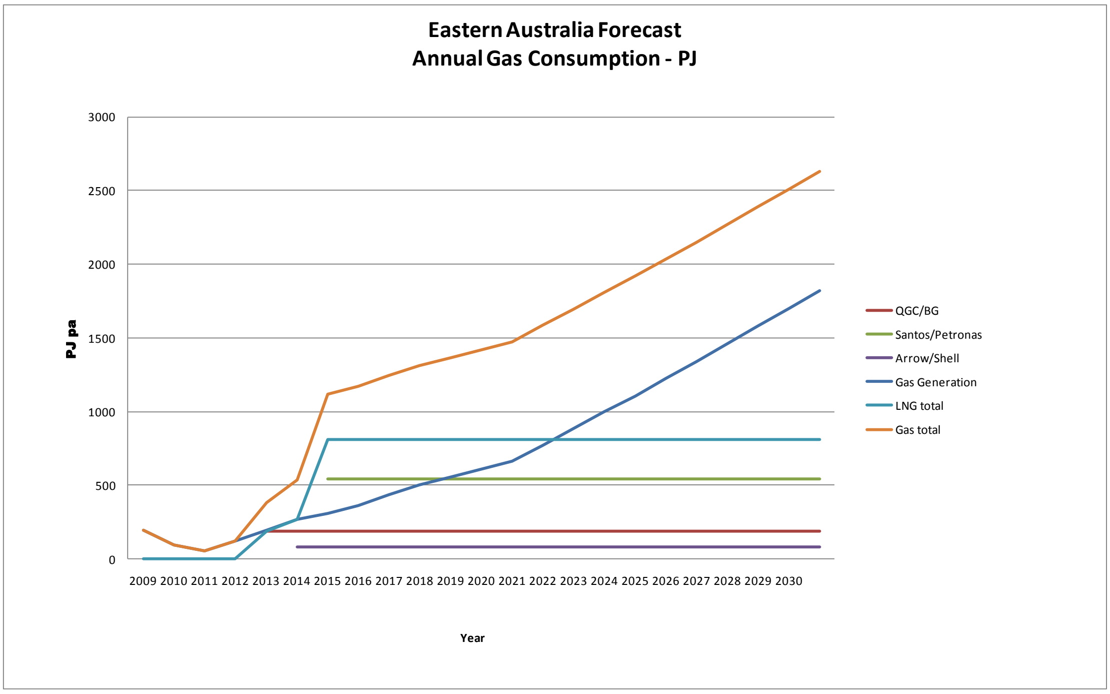
Gas Production Requirements and Pricing

The analysis shows that the Australian gas fired generation requirements are increasing at approximately 60 PJ annually reaching 665 PJ annually by 2020. This is a significant annual increase and should export LNG be part of the mix, then an additional 810 PJ of annual gas consumption will be added to the gas demand from 2014.

These forecasts of gas production and consumption are below.

Graph 4: Total Gas Consumption for Generation and LNG



The effects of a single successful development for LNG will remain significant for the meeting of the gas fired generation targets in the short term. Whilst the additional funds to explore for and produce the additional gas have not been estimated, they can be assumed to be significant should both the gas fired generation requirements and LNG build timetable be met. The critical near term issue is whether exploration and development activity will be directed to both projects streams and if so at what increase cost to the current development costs.

The expected local gas prices based upon LNG export prices are forecast to be in excess of $5.00/GJ. Future gas pricing is uncertain but the growth in the LNG market would indicate that pricing will be stable and high enough to continue with the

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LNG developments that are being established across Australia and across the world. This report has used $6.00/GJ gas pricing landed to the generation plants ($5.00 gas purchase and $1.00 average transportation as gas plants will be located close to the gas fields); a price which is clearly under pressure. It is anticipated that gas fired generation will be constructed close to the gas fields and the electricity transported rather than transporting the gas to distant gas fired generation plants as it is cheaper to transport electricity than to transport gas. Any regulatory changes in electricity transmission that increase the generators costs so that it is cheaper to transport gas than electricity will create a need for further gas pipelines construction and the stranding of electricity transmission infrastructure.

To meet the carbon emission reduction targets, combined cycle gas generation for eastern Australia is required to increase at 1000MW annually until 2020 and 1900MW annually beyond that should the renewable percentage remain at 20%. These are unprecedented gas fired generation and field development growth rates. With the majority of gas being produced from coal seams, vast quantities of gas must be produced from a yet unrealised potential in a relatively new industry. The long term ability to economically extract the gas at a steady price and quantity from yet unproven fields which are of variable quality is a major risk.

Gas Market Structures

Gas exploration companies in both Queensland and NSW will remain under pressure of consolidation and external purchase for a number of reasons. Both states have large gas exploration acreages held by relatively junior explorers who have limited cash flow for exploration activities and pilot programs to prove "economic gas". Most need cash injections and consolidation provides one way to use cash more efficiently in field explorations as well as providing a larger base of acreages upon which to expand business size. There are numerous smaller companies looking at the success of QGC and Arrow and wanting to duplicate it elsewhere and this has spread the available exploration capital thinly between the junior explorers. These companies however remain popular with investors and may be able to attract further investment funds as more people understand the importance of future gas supplies under a carbon emissions target.

In Queensland, British Gas and Shell have paid significant premiums to take stakes in QGC and AOE respectively and when both companies had limited reserves. They may have done so to manage the spiralling construction and operating costs in natural gas reservoirs like Western Australia by developing an alternative and cheaper gas supply and to manage the time frames of natural gas field depletions

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and increasing production costs. The alternative view is that they can protect the LNG market pricing by consolidation of emerging gas companies who may have been able to produce LNG at a cost lower than the current or forecast LNG prices. As the Queensland industry is the world leader in thin seam CSM production, by the securing of QGC and AOE, the multinationals can manage emerging local alternative LNG production that would have been capable of delivering LNG at world competitive pricing. It also places them in a position to hold alternative LNG feed stock and to investigate the economics of such alternatives on a world scale. This is a real strategic possibility.

As the demand for gas increases, a lot of the small gas explores will become gas producers but they will have to find markets for their gas. Generators will want field diversification to manage gas supply risk but may find it difficult to manage gas purchase and gas transport coordination. Gas supplier consolidation will allow generation projects to be more easily bought to financial close. Natural competition between numerous emerging gas producers will also drive them and other more senior players on a consolidation path as gas becomes valuable and as production pressures expose contractual commitments that may not be able to be met. In NSW there are no substantial gas producers and as they develop their businesses, consolidation will become a natural progression.

The nature of the CSM geology is that there will be good gas producing areas and ones that will not produce as well. At present, investors appear to have assumed that all fields are equally capable of turning 3P reserves into 1P reserves. Experience and time will be required to understand longer term gas extraction risks and field valuations.

Gas and Carbon pricing

With the structure of the gas industry dominated by multinational companies pricing gas reflective of LNG export prices, the price competition for local gas supplies will be driven by the market dominance of the international players.

The linking of the gas pricing to the LNG market has seen the gas price rise by a factor of 2 to 3 over the last couple of years without any real increase in gas production cost (except for CPI) other than the cost to purchase new acreage for exploration. This is driven by the netback of production cost from the LNG export pricing revaluing the price of gas in the ground. Large 3P reserves are unrealised gas supply potentials and the methods and costs to extract the gas long term are yet to be proven on the scale needed to sustain the LNG export industry and local gas fired generation. There will be gas fields that do not produce the volumes of gas that

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the initial fields do and hence some fields will have difficulty in converting the 3P reserves to long term gas sales contracts.

The critical structural element for vigorous competition across gas producing companies in the near and longer terms will be the ownership structure of the fields and the ability to access pipelines at reasonable costs without committing to underwriting all of the pipeline asset value. Without these elements it will be difficult for the smaller producers to expand and possibly supply the local gas generation industry but will expose them to takeover risk from the larger companies who can further consolidate and strengthen their pricing positions. LNG plant owners have the option of leaving the gas in the ground and extracting it when an additional LNG train is to be constructed or to simply extend the life of the existing trains. They do not have to interact with the local market by selling them gas for local generation facilities.

This is a critical concept for the electricity customers to understand as the pricing of electricity from a generation perspective had been held down for decades by the government generators through the ownership of upstream fuel resources. With the gas being the near term preferred fuel type and the gas in the ground ownership being dominated by a few major companies, the potential for increased gas costs reflective of the market price for LNG export gas remains very high.

This is not a good outcome for the local electricity customers who are proposed to be paying a carbon cost impost to run gas in preference to coal and who are not seeing a local gas supply market that accurately reflects gas incremental production costs.

Achieving gas price competition is about ensuring that the ownership of the underlying gas resources is competitive. This is a tough assignment for the regulators during a fast moving and consolidation period in the gas supply industry especially when governments recognise that the investments in the gas fields are providing an elevated level of economic stimulus.

There has been a significant increase in the cost of steel over the last few years which has significantly increased the capital cost of projects. This has increased the cost of both coal and gas plants. There however is a much bigger capital cost increase looming. Affecting gas plant capital cost will be the "Dash for Gas Generation" which is gaining momentum across the world.

Around the world as the push for a low carbon economy becomes wide spread and should the meeting of carbon reduction targets becomes mandatory, all manufacturing capacity of gas turbine plant may be quickly consumed. The more wealthy nations may purchase the gas plant at "stressed pricing" so that they can

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meet their emissions targets, but the increasing generation capital costs will, in the medium term, increase the energy pricing above the single affect of the carbon price.

> Limited gas turbine production capability will, in the medium term, increase the energy pricing above the single affect of the carbon price.

The ultimate cost of gas fired generation and gas pricing will be driven by the requirement to reduce the carbon emissions meaning that the gas fired plant must across time run as base load to displace coal. The carbon pricing must be high enough to ensure that the incremental cost of gas generation is less than the incremental cost of coal generation when adjusted for the cost of carbon and the price of compensation and that the total cost of gas generation is less than the total cost of coal generation when adjusted for the same factors.

Based upon the assumptions as per table 3, the relationship between the cost of gas and the carbon price to change the generation merit order on an incremental basis is:

Table 4: Carbon Price Sensitivity to Gas Price

Cost of gas ($/GJ)	4	6	8	10
Cost of carbon ($/t)	$33	$63	$93	$123

The landed costs of gas for generation is forecast to be in the range of $5-10/GJ by a variety of market observers. The sensitivity is that for every $1/GJ change in gas price, then the carbon price must rise by $15/t CO_2 equivalent to ensure that gas plant runs in preference to coal plant on an incremental cost basis.

> The sensitivity is that for every $1/GJ change in gas price, then the carbon price must rise by $15/t to ensure that gas plant runs in preference to coal plant on an incremental cost basis

What also has to be considered from a commercial and strategic perspective is that for any impost charged on the final product, (eg. a carbon price on electricity generation emissions), then there is a “rule of thumb” that says that potentially “25% of the value of the impost will flow to the upstream producers as they recover some of the increased value of their product”. The effect is that the value of gas increases relative to coal and the gas producers will look to capture 25% of that value.

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At $63/t carbon cost, the carbon cost differential between coal and gas is (.95-.45)*63 = $31.50 or $4.20/GJ of gas. If the gas suppliers capture 25% of this value, then an additional $1.05/GJ will be added to the gas cost and a further $15/t will need to be added to the carbon cost to ensure that gas plant remains incrementally cheaper than coal plant.

Role of Nuclear Generation or other Near Zero Emission Technologies

Clearly one of the technologies that can be utilised is nuclear generation and with near zero greenhouse emissions, it may stake a claim for a role in meeting carbon reduction targets around the world and it has commenced meeting carbon emission reduction targets in countries where nuclear generation is already established. Its role in Australia will be defined by a combination of the necessity to meet carbon emission reduction targets at a reasonable cost and the public acceptance of the technology.

It is noted that Australia is the only country in the top 25 economies yet to embrace nuclear technologies even though it exports the raw materials. It is also the only country in this top 25 economies to push for a common carbon market for all of the economy. These two positions are a delicate balance to mange when the carbon reduction targets are large and when carbon reduction targets must be met.

The graph below has 20% renewable in 2020 and 2030 and nuclear expanding from 0% in 2020 to 20% in 2030 and remaining at 20% to 2050. The renewable line on the graph includes for renewable and nuclear generation.

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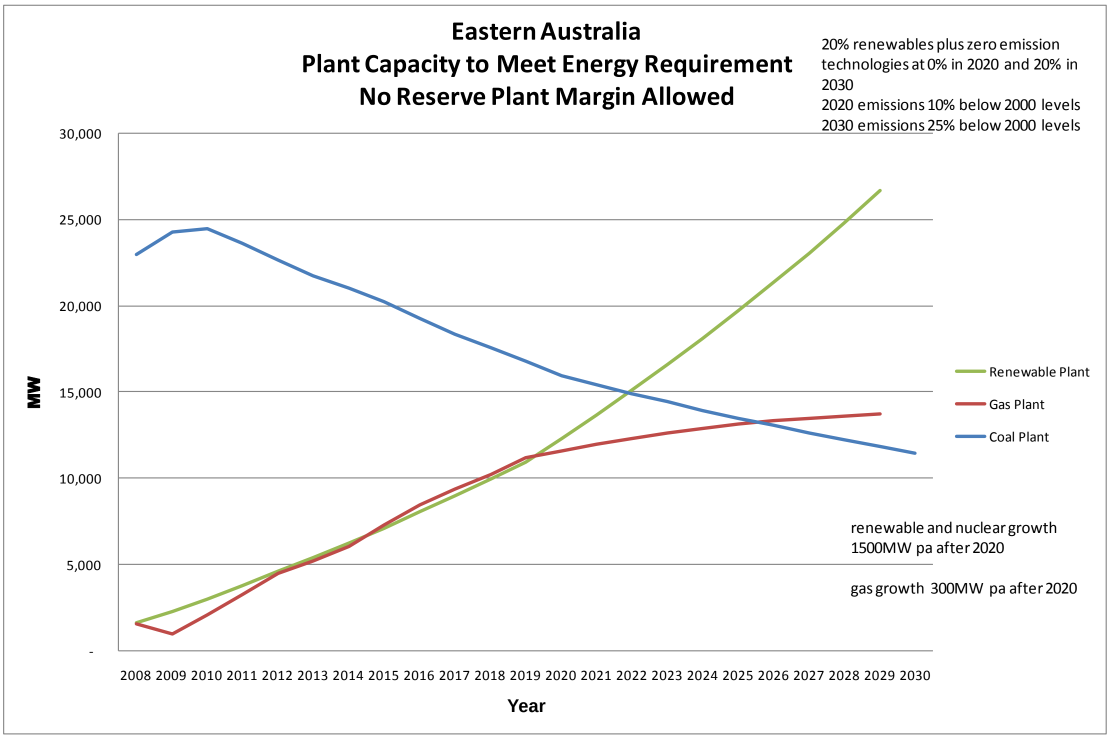
Graph 5: Inclusion of Nuclear Generation



What can be seen is that with the introduction of nuclear generation, the effect on the coal industry is less with approximately twice the volume of coal generation surviving in 2030. This will dramatically reduce any potential compensation to existing coal fired generation as a result of the introduction of a carbon market. This results from the method of calculating the mix between coal and gas to meet the carbon reduction target after the renewable have been taken from the energy forecast. Similarly, the volumes of gas plant to be constructed by 2030, is halved, dramatically reducing the pressures on gas turbine plant manufacturers and increasing gas on gas competition. It also reduces gas pricing and delivery pressure on the gas sales market and the gas generation market.

The important observations are three fold:

- the use of nuclear generation or any appropriately priced near zero emission technology does nothing to relieve the difficulty in meeting carbon reduction targets to 2020;

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- any near zero emission technology at a large scale that enters the market will create less disruption to the coal plant and will reduce the impact of changes in the gas sector; and
- near zero emissions technologies provide a greater chance for the longer term goals of carbon reduction to be met.

The use of nuclear generation or any other near zero emission technology at a large scale will have less disruptive effects on the coal and gas sectors and provide a greater chance for the long term goals of carbon reduction to be met.

IS A CARBON MARKET APPROPRIATE IN THE SHORT TERM FOR ELECTRICITY GENERATION?

The generation sector of the electricity industry is characterised by high capital investments and relatively low operating costs; the strategic management of costs focusing on capital and fuel. Manage these well to maintain asset values and competitive advantage. Competitive generation pricing requires a generation sector where all players can strategically manage costs and a forum where they can equally transact their products.

Capital and fuel costs vary significantly across generation technologies and an optimum portfolio of plant to meet the total system load profile at minimum cost requires a mixture of high capital, low operating cost plant and low capital, high operating cost plant. There is a known step wise supply cost curve between generation technologies which leads to a natural order in the preferential running of the plant (economic merit order) and the resultant lowest cost to customers.

To achieve lower carbon intensity outcomes, the proposed carbon market when applied to the generation industry, must alter the underlying generation cost structures so that the natural merit order is changed in preference to lower carbon intensity plant. Unless a change in the natural merit order occurs, carbon market costs will have been incurred without a reduction in the generation sectors carbon emissions.

Unless a change in the natural merit order occurs, carbon market costs will have been incurred without a reduction in the generation sectors carbon emissions.

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Regulation can also change the natural merit order, which is the principle behind the Queensland gas scheme and the federal renewable energy scheme. Regulation of this type imposes the additional generation costs directly onto customers and does not require a widely applied central "collection and wealth redistribution" principle like the proposed CPRS.

The prime difference for customers and governments can be summarised as:

Table 5: Comparison of Regulation and Carbon Markets

	Regulation	Wide Ranging Carbon Market
Customers	incur only direct costs of the regulation costs imposed directly to customers and costs are generally reflective of production costs	increases the cost to all suppliers into the market costs imposed not reflective of production cost but of wider carbon market pricing
Government	low cost to implement little direct or indirect collect of "fees"	high cost to implement direct collection of "fees" from all market participants and some "fees" returned as compensation to suppliers and customers compensation distorts the underlying financial incentive for change that the carbon market is trying to achieve so increases costs to all customers

When a wide ranging carbon market is considered for customers in electricity and in markets other than electricity, the cost to those customers is complex to calculate as it is possible that the electricity market carbon pricing may be driving the carbon price impacts in industries other than electricity. This results from electricity emissions making up a large portion of the total carbon market.

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As initially, gas is the only generation technology that can come to the market in sufficient volumes to meet carbon reduction targets, from a generators perspective and from the perspective of customers in other markets that will have their carbon price set by generators, a “one size fits all” carbon market’s sole outcome must be to bring forward construction of gas fired generation.

A regulatory alternative can achieve the same result and would ideally specify the maximum emissions from new generation plant and also manage the exit of high carbon intensity generation plant in the proportions that are required by the analysis in this report. This will be able to be implemented as there are significant volumes of coal plant nearing the end of their economic life and new capacity must be built to replace them and to meet the increasing energy requirements. The government owns some 43% of the installed coal fired generators. Both government and private interests own the oldest coal fired power stations.

Clearly any carbon emission limits and carbon limit reductions across time (carbon emission reduction trajectories) of new plant can be established to ensure that alternatives to gas plant can be established and that carbon emission targets can be met. The carbon emission limits for new generation plant can be moved to below that of current gas plant technologies thereby ensuring that these technologies can be improved and that carbon capture technologies or alternative lower emission technologies are bought forward. A small “carbon tax” can be introduced to gather funds for R&D to, more quickly, bring forward new technologies. In this manner, the electricity customers directly pay the costs of new generators to reduce carbon, subsidise electricity only R&D without significant financial leakage and may achieve a cheaper solution to them. It does require however a direct government involvement as opposed to a hands off, limited government influence carbon market.

A summary of the high level matters for regulation and market options is:

Table 6: Matters Comparing Regulation and Carbon Markets

	Regulation Solution	Market Solution
Government	No revenue from electricity industry unless a small “carbon tax” or levy is introduced No revenue redistribution	High revenue from electricity industry (customers ultimately pay) Revenue redistributed by government in a manner that they determine

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	Direct influence and direct responsibility for the cost of meeting the carbon reduction target Low cost to implement	One step removed from the customer cost impacts and responsibility of energy policy as the market is deemed to have sets the pricing High cost to implement
Customers	Incur direct costs only	Cost depends on the extent of competition in a limited response market and the management efficiency of the central funds collection and redistribution system No guarantee that the carbon target will be met even though electricity pricing will increase

Whatever energy policy is adopted, carbon market or regulation, consideration should be given to establish which infrastructure is for the common good and hence what long term control that the government should retain over its establishment and cost to customers. For any policy outcome, private investors will have an opportunity to participate.

Whatever energy policy is adopted, carbon market or regulation, consideration should be given to establish which infrastructure is for the common good and hence what long term control that the government should retain over its establishment and cost to customers

Each time the electricity generation economic merit order is changed, there is a step increase in the underlying costs of generation. Typical steps in the cost of generation are broadly $35/MWh (coal), $80/MWh (gas), $150/MWh (wind) and $250/MWh (solar). A reduction on the carbon footprint at generation prices between these steps can only occur with the introduction of new technologies as the preferential running of generation plant will not change.

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The modelling and graphs clearly show, gas generation alone replacing coal will not deliver the proposed long term carbon reduction targets and new technologies must be in place. Currently wind and solar cannot produce sufficient volumes at reasonable prices to be considered as a long term replacement for coal or gas fired generation and regulation may continue to be the appropriate method to bring forward these technologies in a controlled manner to allow them to immediately contribute to carbon emission reductions. Suggestions by the suppliers of cheaper forms of energy to force these technologies to compete in the same market are self serving and will be costly to electricity customers.

Parallels between a market solution and a regulated solution on the customer effects can be drawn by considering the "Californian outboard example". In the trailer boating industry, trailer boats use outboard motors based upon 2 technologies, 4 stroke and 2 stroke. The 4 stroke industry had higher costs and lower sales but lower emissions than 2 strokes which had lower costs and high sales but higher emissions. With the environmental focus of the Californian government, a future emissions limit was imposed on outboard emissions. The government did not create a market for emissions but simply imposed a regulation for a low target on emissions from outboards. A target much lower than 2 strokes could currently achieve but also imposed a timetable over which the new emissions limits were to be introduced. The regulation was introduced in 1996 and required a 75% reduction in 1996 emissions by 2006 and with the first emission reduction step to be introduced in 1998.

The result was a technology response from the 2 stroke outboard manufacturers that delivered the target emissions at competitive pricing thereby not allowing the 4 stroke manufacturers market dominance. There remains healthy world-wide competition between the 2 technologies. Older outboards simply left the market at the end of their economic lives.

For electricity customers, this is akin to the position of coal and gas (low cost high emissions coal compared to high cost lower emissions gas). The question that must be reconsidered is whether a "glide path on emissions" will deliver a cheaper cost to customers compared to a wide ranging one size fits all carbon market especially when there is no available technology to make a response over the initial technology hiatus period of 10-15 years. An interesting fact is that governments across Australia own 43% of the installed coal plant capacity and can choose to withdraw it from the market to make way for gas plant or later new low emissions plant or can choose to retrofit new low emission technology to existing coal plant when it becomes available. Funding for additional research to reduce emissions of new plant more quickly can be gained by a "carbon tax" or levy on electricity at the point of consumption or production. By this method, it is direct and does not require any wide ranging central

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collection and wealth redistribution system which is in the form of a carbon market. In the short term, the proposed carbon market is distorted by scale, scope, redistributions of wealth and compensation that it does not function as a competitive market. Regulation may be "cleaner", clearer and more effective than a distorted carbon market.

It is worth recapping that as there is no change in the carbon intensity of electricity generation until the economic merit order is changed and in a "one size fits all" carbon market where the main carbon emitters, the stationary energy sector, sets the underlying carbon prices for all industries at the cost cross over points of the economic merit order, then economic inefficiencies may occur. As a result, for an economic balance to be struck between financial pain and carbon benefit, individual industry segments could argue to be separately regulated. In the near term, there appears to be a need to consider well directed regulation within the energy policy mix so that electricity and other customers do not suffer a step change in costs.

THE GRAPHS

Modelling Outcomes

Base case

Base case modelling outcomes show that electricity consumption is increasing at a steady rate and increasing by approximately 70% to 2020. Across this same period, the carbon emissions have to be reduced to below the levels of year 2000 from a base that has an increase of 10% above the 2000 levels. A 10% reduction below 2000 emission levels is actually a 20% reduction below existing levels. This is why, with limited technology responses in the short term, the meeting of targets to 2020 has increased difficulty and may be more difficult than the meeting of longer term targets.

Base case modelling indicates that approximately 1000MW of gas fired generation and 850MW of renewable generation will have to be annually introduced into the east coast interconnected electricity market between now and 2020. The annual build rate may have to increase towards the later part of the decade as the average build rate will not be able to be achieved immediately. A gas fired generation build rate of 1900MW per annum from 2020 applies if a 25% reduction below 2000 levels is to apply in 2030. All coal plant will have to be closed shortly afterwards.

It is anticipated that alternative large scale low emission technologies will be available later in the period to assist in the emission reductions thereby reducing gas fired generation build requirements.

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All carbon emission targets will be difficult to achieve without the introduction of alternative low emission technologies.

Sensitivity

To achieve a 20% reduction in 2000 emission levels in 2020, requires that the gas fired generation be constructed at a rate of 1500MW per annum and this rate will need to be increased to 2000MW to 2030 if a 40% reduction target applies at that year. In addition, approximately 2000MW of technologies with zero emissions will have to be introduced from 2027 as all coal plant will have been closed. This capital program and rate of construction of gas plant may not be achievable and new technologies with zero emissions may need to be introduced to achieve these higher carbon emission reduction targets. Should nuclear or other near zero emissions technologies become available from 2020, and they have a target of a 20% market share by 2030, then they will have to be constructed at the rate of 1500MW per annum and the gas fired generation build rate can be scaled back from 2000MW per annum to 500MW per annum to 2030.

Clearly the ability to supply near zero emission technologies at competitive cost has a significant effect on the requirements of gas plant and on the volume of generating capacity that has to be installed. Achievement of the commercialisation of these technologies will have a greater long term effect in the reduction of carbon emissions than trying to make more costly changes now in the pursuit of immediate reductions. This effect comes in the form of cheaper long term costs and an ability to reduce carbon more quickly. A lower emission target at 2020 is very costly and does not constrain the achievement of longer term targets in 2030 or 2050 as the carbon emissions can be reduced very quickly when near zero emission technologies are available at large scale.

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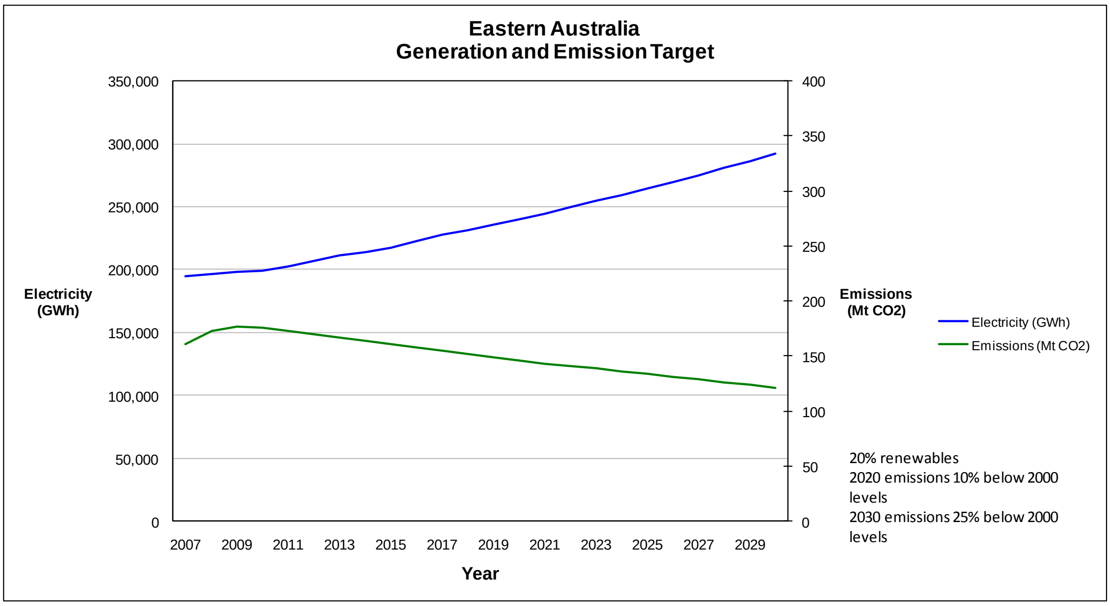
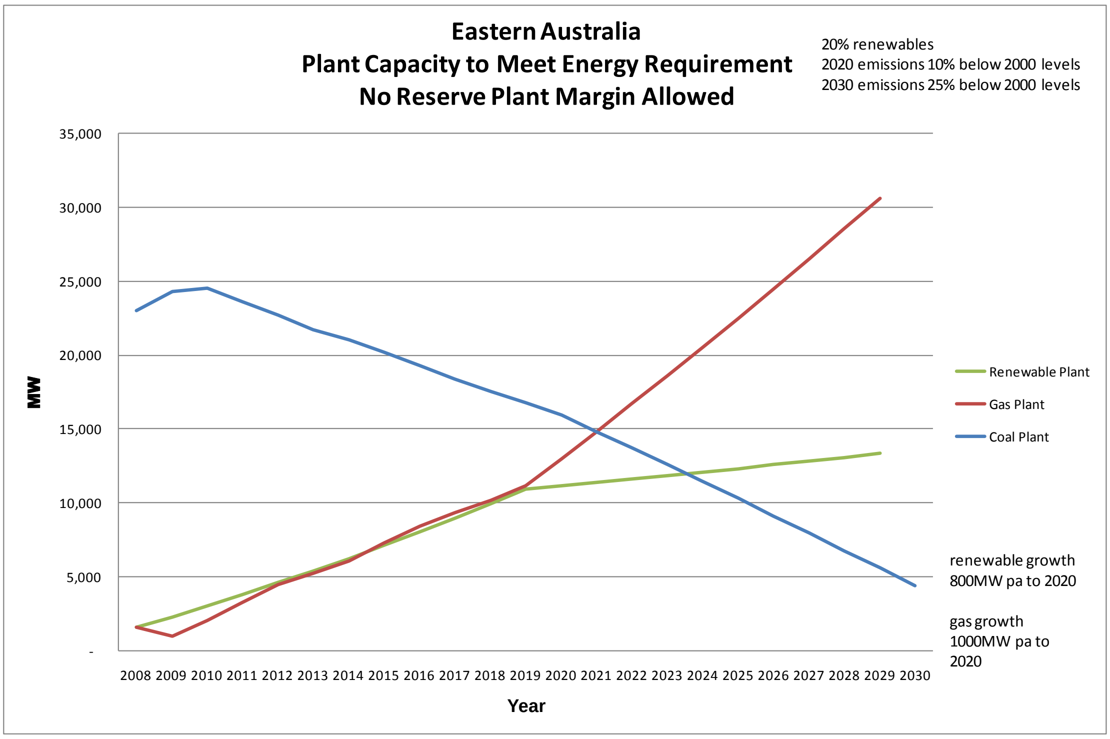
Graph 6: Electricity Consumption and Emission Targets



Graph 7: Generation Capacity to 2030



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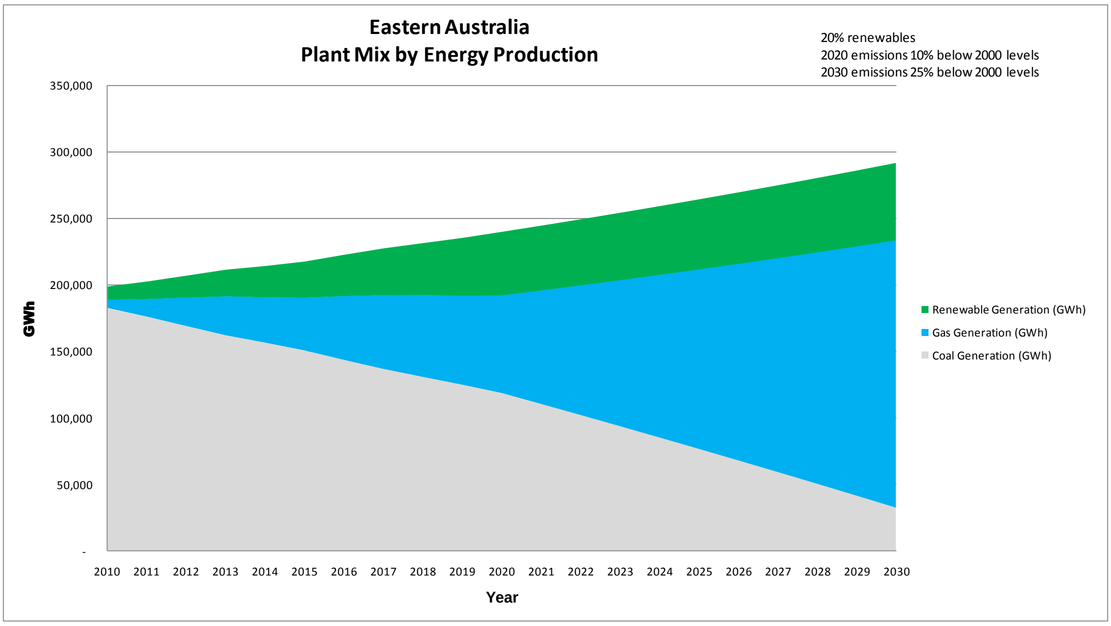
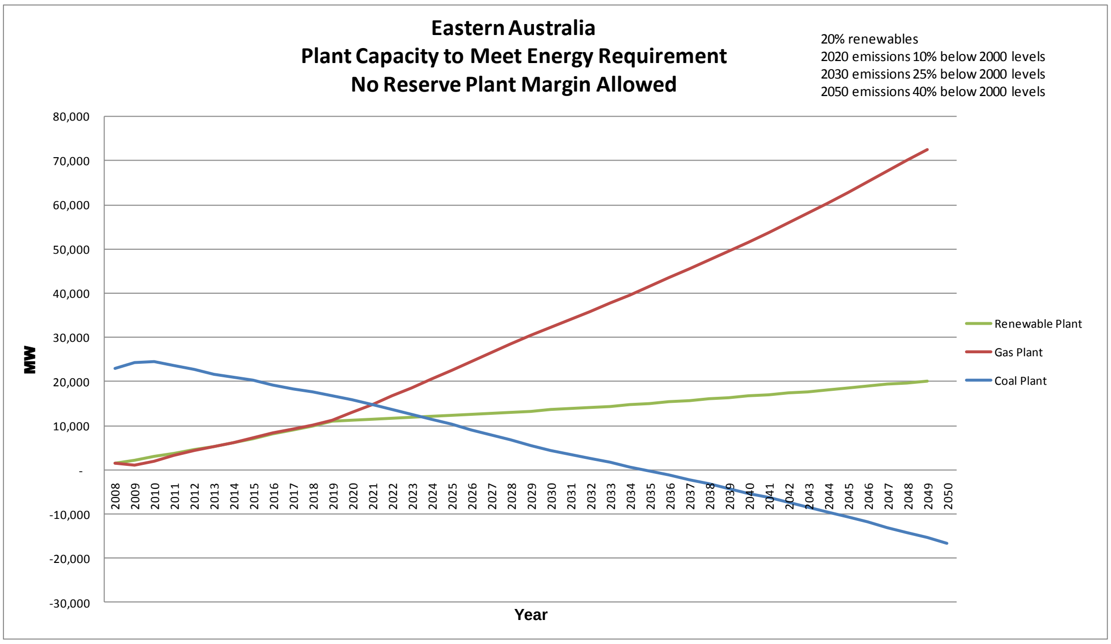
Graph 8: Generation by Energy Production



Graph 9: Generation Capacity to 2050



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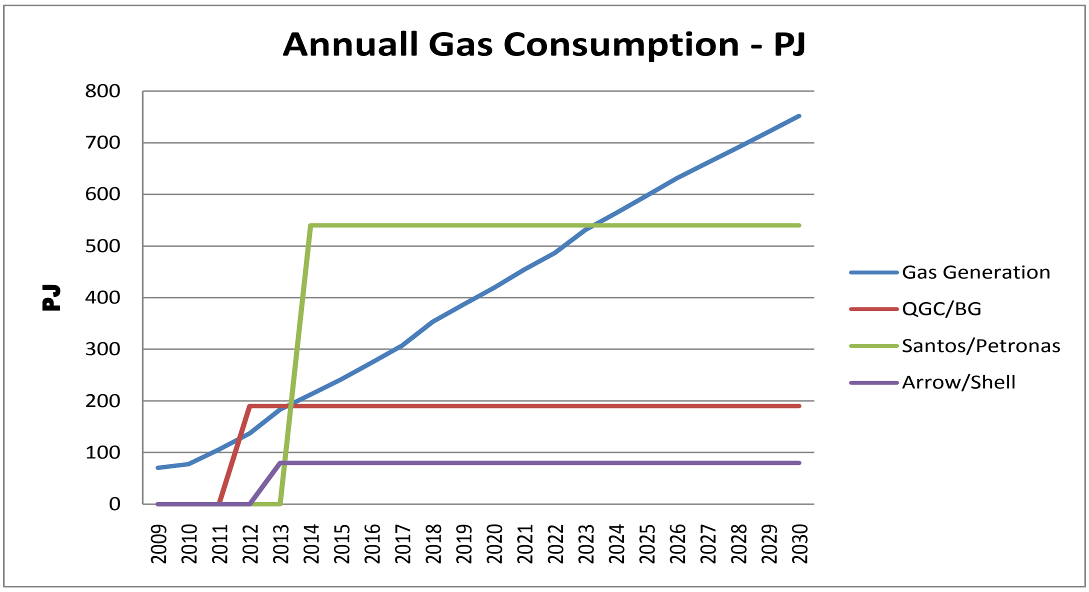
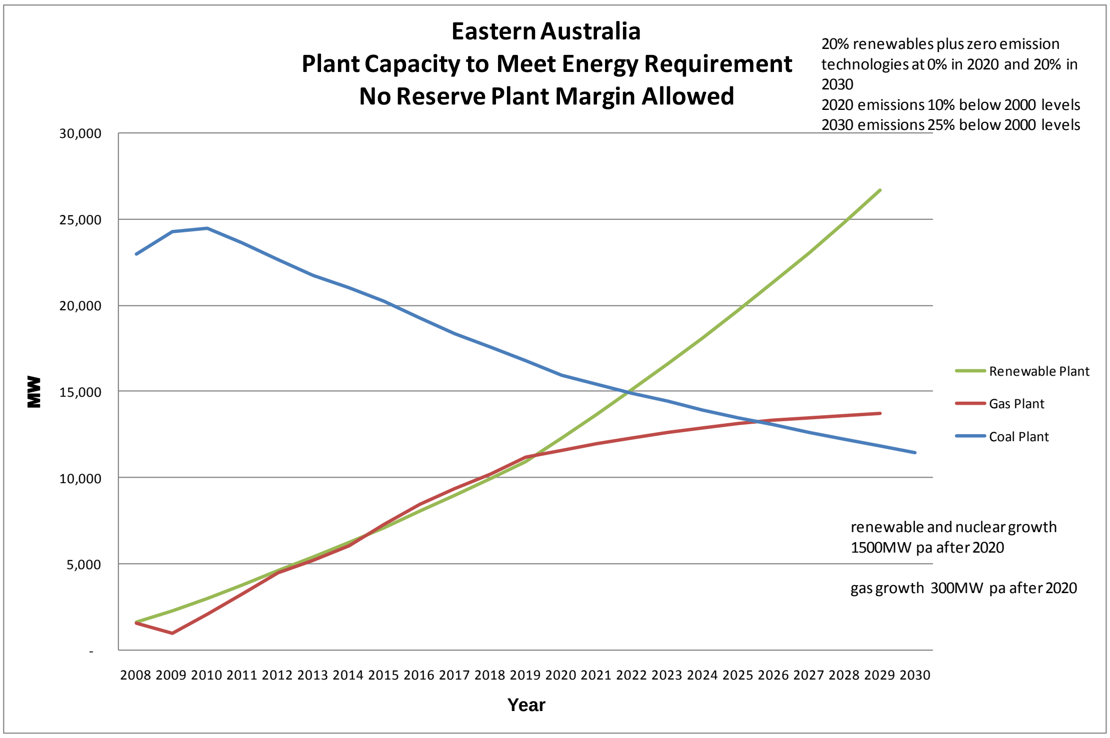
Graph 10: Base Case Annual Gas Requirements – Generation and LNG



Base Case Plant Mix with Additional Zero Emission Technology - 0% in 2020 and 20% in 2030

Graph 11: Inclusion of Zero Emission Technologies



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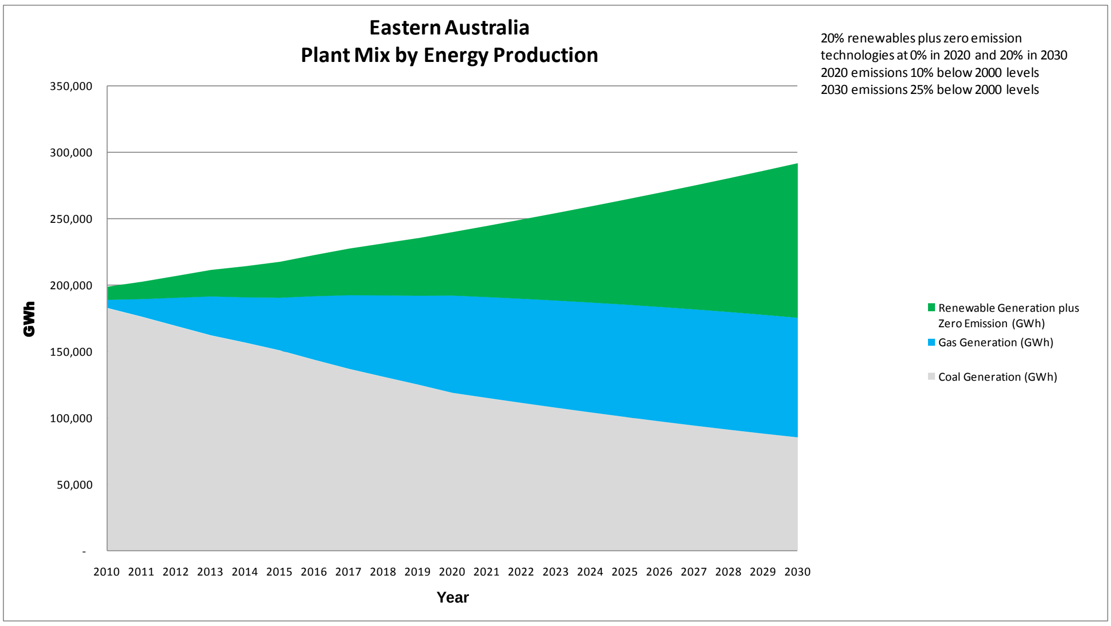
Note: near zero emission technologies have been included in renewable generation.

Graph 12: Generation by Energy Production including Near Zero Emission Technologies



BEYOND THE GRAPHS

During the last decade, there has been a political trend to implement market solutions and not regulatory solutions to manage policy matters. This has been driven by economists, accepted by governments and supported by vocalists with vested interests. Such solutions are of interest to governments as once a market is introduced, they are one step removed from pricing outcomes which relieves some direct political pressures. These solutions are also driven by the underlying wish to sell government assets and the need to sell these into initially competitive market structures for initial pricing control. The success of these solutions for monopoly infrastructure has not been researched or compared to the performances when the government owned these assets so no conclusions can be drawn in this report.

Markets are good at short term optimisation by directing resources to places where prices and margins are high but only in the absence of competitive barriers. Markets are not good at allocation of scarce or strategic resources over a long term, as long term holding costs decrease immediate shareholder returns (shareholders are not concerned with the actual price of a product but with the relative price to the next

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competing product). Governments are concerned with the long term pricing of essential infrastructure as that is at the heart of the countries international competitiveness and wealth.

A strategic resource is one that must be preserved for later generations or for the long term management of social or financial outcomes. In some cases this means that resources need to be carried over periods that are beyond private investor tolerances. The management of strategic resources is the domain of governments and government regulation.

From a customer's and tax payers perspective, the policy role of governments should be to minimise costs of infrastructure over the longer term so that the country is in a good position to compete on the international stage. This means that governments may need to take strategic roles in resources or take market positions to manage outcomes to maintain lower long term costs to customers as compared to raising infrastructure costs to change behaviour.

The imposition of artificial costs to all of a market to increase pricing to change investors or customers behaviour does not appear meet the fundamental role of reducing costs of infrastructure as it increases both short and long term pricing, uses resources that would not otherwise be used and increases the cost of commodities to achieve the result of changing behaviour. Regulation can achieve the same outcomes and it does not require the introduction of artificial costs to market segments and the redirection of those centrally collected monies to manage the finances of displaced businesses.

The Californian outboard example shows how well directed regulation in a suitable timeframe created a response from the market to achieve the required result. As we know, across the technology hiatus period, there will be limited technology on technology competition and potentially limited gas supply competition. Regulation of old and new generation plant emission limits and a levy on customers to fund additional research on low emission options may be a cheaper way for customers to fund the glide path to lower electricity generation emissions. It is certainly a simpler method and is directed only at a single market segment that uses the underlying commodity.

In the electricity market, the fallback position if no new low emission technologies come forward across the technology hiatus period is the construction of government subsidised low emission generation technologies. This can be achieved by direct ownership, by the use of PPA's or other means. If these assets are directly government owned, they can be later sold to reclaim some or all of the government cost. This would only need to be introduced where market failure is likely to occur or where market pricing needs to be managed to meet the carbon emission reduction

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targets. The government can also choose not to meet the targets depending on external drivers and Australian competitive positions thus providing it with flexibility to manage the Australian economy.

The setting of emission targets for new plant manages the introduction of competitive suppliers with appropriate emission standards without the favouring of one technology but it does not manage the exit, either forced or timely, of high emission generation technologies. This needs to be considered separately and with 43% of government ownership of coal fired generation installed capacity, there is a capability to manage the closures of this plant and at a cost under the direct control of governments.

As the electricity market cannot be allowed to fail, there appears to be a case for combination of markets (there is an open access generation market at present) and regulation to achieve the lowering of emissions, the control of pricing and the least impact on GDP, Australia's international competitive position and customers.

Long term low generation pricing requires fuel assets to be held for extended periods. The management of long term fuel reserves (coal, gas) can still be a government role. They can hold reserves for extended periods and then release or "sell" them in portions to develop future electricity generation projects. The management of solar, wind, nuclear and other low emissions technologies do not require a long term holding structure for fuel resources. Geothermal is more closely aligned with coal and gas fuel management and it may need to be continually managed by market releases of the underlying resources.

A view from certain sectors is that governments favour markets to regulation as the government is one step removed from the market outcomes as it is the market that has set price and not the government by regulation. To manage resources across the long term and with government's role to keep low infrastructure costs across the same term, they may have to remain in some markets either directly or indirectly to achieve this goal. Artificially increasing costs to all customers to change behaviours of markets may increase government revenues however simple technical regulation can achieve the same end. Regulation, cost imposts (CPRS) and compensation are market intervention mechanisms and distort natural market outcomes.

Regulation is responded to by technical changes and competition ensures that it is delivered at low cost. Cost imposts rely upon continuously changing customer behaviour in markets where customer price elasticity is not clearly known. The forcing of a price so high as to create price elasticity and to change customers and investors behaviour does not appear to meet the governments long term low price outcome objectives.

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This may mean that a mix of markets and well directed regulation will be required in the energy policy mix. Whilst a market solution distances politicians from the solution and the resultant outcome has an ideological following, it may not provide the best result for the economy and the customers as a whole across the technology hiatus period and beyond.

It has been shown that there are step changes in the electricity price supply curve and reductions in carbon emissions will not be made unless the carbon price causes the electricity price to cross one of those steps. Pricing between these steps will have limited effect on electricity generation emissions but may have a significant effect on other industries that are required to be part of the single "one size fits all" carbon market. Similarly it is unclear why a carbon price should be the sole arbiter of behaviour and outcomes across the wider community when a single carbon price will have a significant impact on the rearrangement of economic activity between industries, between countries and may impose costs to industries that have little ability to manage the imposed cost.

Additionally, apart from the introduction of gas generation, there is little that can be done immediately to significantly reduce the carbon emissions of the electricity sector at the required rate to 2020. The cheapest method to manage the introduction of additional gas fired generation to 2020 is what needs to be determined and the method of management of carbon emission reductions suited to electricity generation designed from that base. It may be better to distort the electricity market across the technology hiatus period by regulation than to introduce managed markets which are designed to make the same distortion to the economic merit order of the generation in favour of more expensive but less carbon intensive generation technologies. As costs are artificially increased through the purchase of emission permits for all electricity generators, the carbon price to make a change to the economic merit order similarly increases. Compensation and leakage by not returning 100% of the collected monies further increases the carbon cost required to reduce carbon emissions. When additional new technologies are cost competitive with gas, then reconsideration of a carbon market for generation would be timely.

In these contexts, the early introduction of a CPRS and the holding down of the carbon price to one that can be absorbed by the Australian economy and not a higher carbon price that will change the generation merit order can fail to reduce carbon emissions. Any proposed carbon costs must be able to be demonstrated to reduce carbon emission efficiently and immediately. Ultimately the generation mix should return to one based upon non subsidised generation technologies with the cheaper higher carbon intensive technologies held out by regulation eg through generation plant carbon emission limits within the environmental legislation. In any

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case, until new technologies enter the market, the putting in place of an unconstrained carbon market cannot provide the cheapest outcome for customers.

The calculations of investment capacity to meet the emissions targets from an energy perspective means that 10,000MW of new gas fired power stations will be required from now to 2020. This has an estimated capital expenditure of $10 billion for power stations and possibly a further $2 billion for gas pipeline infrastructure (annual total of $1.2 billion). In the corresponding period, the capacity of the coal generation declines by 60,000,000MWh per annum or approximately 8,000MW of installed capacity.

Determining whether the gas plant requirements needed to meet the Australian carbon emission reduction targets are achievable in a climate of the global economy trying to make similar adjustments across numerous countries needs consideration. Extrapolation of the results across the world would be unrealistic however it is clear that the level of gas plant investment is unprecedented and an analysis of whether the gas plant manufacturing capability can achieve such an increase in production capacity needs to be completed.

Any investment by the gas plant manufacturers must consider whether and when the response from the other industries will take place and hence what is the timeframe across which they must recover the costs of the establishment of the manufacturing facilities. If the electricity industry believes that gas is the near term solution and if they believe that gas plant manufacturing may be limited, a gas generators strategy of installing open cycle turbines immediately and later converting them to closed cycle limits the capex at risk, reduces gas turbine supply risk and for the vertical integrated generation and retail businesses, allows them to manage their retail risks across an extended period.

The modelling shows that to make the longer term carbon emission adjustment, progressive energy policy to establish new and emerging near zero carbon emission technologies will have the greatest long term effect on carbon emission reductions and implementation costs than any response to immediately reduce carbon emissions. The cost of immediate action needs detailed consideration and a conscious decision on the cost and emission reductions achievable.

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APPENDIX A - EXTRACT FROM 2009 ESOO

B.1 Regional Energy Projections

This section presents the annual regional and NEM-wide energy projections. These projections are:

- inclusive of scheduled, semi-scheduled, and significant non-scheduled generation;
- provided on a sent-out basis (see Chapter 3, Section 3.7.5, for more information);
- for medium, high and low economic-growth scenarios; and
- developed on the basis of energy policy considerations and economic forecasts provided by KPMG [2] (see Chapter 8 for more information).

The projections and supporting information for each region are provided by the region's jurisdictional planning body (JPB) and are consistent with the region's annual planning report (APR) [1-5]. See Chapter 3 for more information.

B.1.6 NEM-wide

Projections of annual energy

Table B.6 lists the NEM-wide historical energy and projections for each of the medium, high and low-growth scenarios.

NEM-wide energy is calculated as the sum of the energy for all the regions. Energy is projected to change over the next 10 years at an average annual rate of:

- 1.9% under the medium-growth scenario; and
- 3.4% and 1.1% under the high and low-growth scenarios, respectively.

Table B.6 NEM-wide Annual Energy Projections (GWh)

Financial Year	Medium	High	Low
2004/05 actual		186,387	
2005/06 actual		191,767	
2006/07 actual		194,635	
2007/08 actual		196,779	
2008/09 estimate		198,188	
2009/10	198,716	202,086	195,707
2010/11	202,467	208,609	197,938
2011/12	206,876	215,460	198,959
2012/13	211,379	222,852	201,771
2013/14	214,182	229,867	203,167
2014/15	217,533	237,490	205,175
2015/16	222,640	245,426	208,647
2016/17	227,483	252,704	211,167
2017/18	231,431	263,912	213,742
2018/19	235,377	272,105	216,191

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Energy projections beyond ESOO are escalated at 1.9% being the average rate over the 10 years projected by AEMO. There is no reason to change the average rate for this analysis however beyond 19 years, the projects and model conclusions are subject to the changes noted for new technologies. The results for gas and coal generation beyond 10 years are not reliable.

The energy projections used in the calculations are based upon the median scenario with 50% probability of exceedence.

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