The Allen Consulting Group

# The economic impacts of developing coal seam gas operations in Northwest NSW

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Report to Santos

The Allen Consulting Group

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# Acronyms and glossary

| | |
|---|---|
| ABARE | Australian Bureau of Agricultural and Resource Economics |
| ABARES | Australian Bureau of Agricultural and Resource Economics and Sciences |
| ABS | Australian Bureau of Statistics |
| BREE | Bureau of Resources and Energy Economics |
| CAPEX | Capital Expenditure |
| CGE | Computable General Equilibrium |
| Construction phase | 2011 - 2017 |
| CPM | Carbon Price Mechanism |
| CSG | Coal Seam Gas |
| GDP | Gross Domestic Product |
| GRP | Gross Regional Product |
| GSP | Gross State Product |
| LNG | Liquefied Natural Gas |
| ML | Megalitre |
| MMRF | Monash Multi-Regional Forecasting |
| NPV | Net Present Value |
| Operations phase | 2017 - 2035 |
| OPEX | Operating Expense |
| PEL | Petroleum Exploration License |
| PJ | Petajoule |
| SSD | Statistical Subdivisions |

# Executive summary

This study reports on the likely economic impacts of a potential coal seam gas (CSG) development in Northwest NSW. The region has the capacity to produce up to 210 PJs of CSG per annum. The nature and magnitude of these impacts have been assessed at a regional, state and national level.

Combined, it is estimated that the direct and indirect impacts of the development would:

- expand employment opportunities through increased economic activity throughout NSW increasing to around 2900 ongoing full time positions;
- create 200 direct permanent full time positions on the project, and additional direct employment during construction peaking at 1800 jobs in 2015;
- increase the level of NSW gross state product (GSP) by 0.20 per cent per annum, adding $15.2 billion to the state economy out to 2035;
- increase the gross regional product of Northwest NSW by some 3.2 per cent per annum — equating to an annual increase of around $470 million in today's dollars (retaining over half of the expected increase in NSW's GSP); and
- expand national incomes (gross domestic product) by an expected 0.04 per cent per annum; and
- by producing an extra 5GL per annum of water from deep coal seams, the potential development will benefit agricultural production in the region by an average of nearly one per cent per annum during the operations phase.

While NSW at large will accrue significant benefits from the development, these benefits are likely to be particularly concentrated in the Northwest region itself. More than two fifths of the benefits accrue directly back to the regional economy — including the communities of Boggabri, Coonabarabran, Gunnedah, Muswellbrook, Narrabri, Quirindi, Scone and Singleton. The North Central Plains, Northern Slopes and Central Macquarie regions are likely to experience the greatest growth.

The analysis has employed the Monash Multi-Regional Forecasting model — a Computable General Equilibrium model of the Australian economy. This model accounts for the interconnections and relationships that exist throughout the community and adopts the same framework as used by the Australian Treasury (Treasury 2011) and the Garnaut Climate Change Review (Garnaut 2008).

Inputs to the analysis include publically available data (such as Census data and other information about the economy) and information provided by Santos Limited ("Santos") regarding the scale and capacity of a potential development in the region. Santos estimates that a project of this scale would require an investment in the region between now and 2035 in excess of $16 billion and would create around 200 direct full time employment opportunities.

The initial economy wide analysis undertaken here indicates that the development of CSG operations in the Northwest NSW region would have a significant positive influence on the regional, State and national economies than if the proposed development did not proceed. The results of this evaluation have been summarised in the following table.

Table ES 1.1

**SUMMARY OF IMPACTS, LONG RUN INCREASE IN OUTPUT RELATIVE TO BASELINE**

| Region | Construction phase | Operation phase | Cumulative impact to 2035 | NPV (@7% real) | NPV (@12% real) |
|---|---|---|---|---|---|
| | | | $2011 | | |
| **NSW** | $253 million per annum | $821 million per annum | $15.2 billion | $5.8 billion | $3.1 billion |
| **Regional** | $28 million per annum | $470 million per annum | $8.5 billion | $3.0 billion | $1.6 billion |
| **National** | $309 million per annum | $531 million per annum | $10.7 billion | $4.2 billion | $2.5 billion |
| | | | Per cent change | | |
| **NSW** | 0.06 | 0.20 | na | na | na |
| **Regional** | 0.80 | 3.20 | na | na | na |
| **National** | 0.02 | 0.04 | na | na | na |

Source: The Allen Consulting Group.

*Chapter 1*

# About this report

Between now and 2035, Santos and its joint venture partners have the potential to invest over 16 billion dollars in Northwest NSW in pursuit of the region's coal seam gas (CSG) opportunities. Santos and its joint venture partners are spending circa $1.0 billion over the next 3-5 years in pursuit of exploring and appraising CSG resources require to underpin a material development to produce approximately 25 per cent to 30 per cent of Australia East Coast current gas demand and have the ability to transform NSW into a gas exporting state.

The likely impacts of a development as large as this will be far reaching for the region, the State and the national economy. This study reports on the likely magnitude and nature of those impacts in the region, the state of NSW and for Australia at large.

## 1.1 Coal Seam Gas

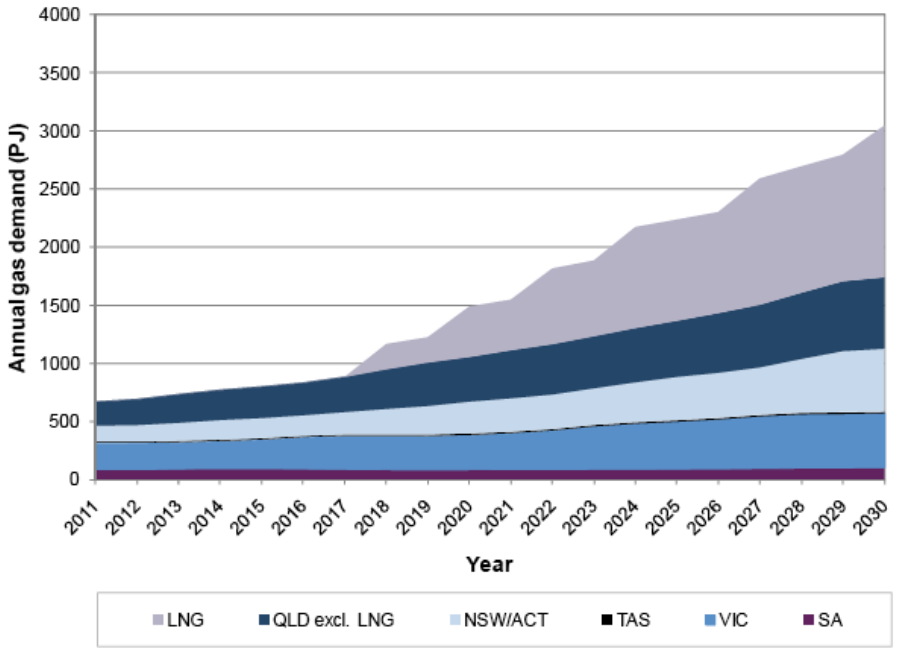
CSG is natural gas (methane) extracted at low pressure from coal and is already currently used by Australians today. It is formed as part of the same natural processes that produce coal over millions of years where the gas is absorbed within the coal by pressure. Recovery of CSG does not require coal extraction, rather through the releases of pressure by extracting water from the coal seams, the gas de-sorbs from the coal and is able to flow to the surface through the specially designed well-bores. In Australia, large coal resources lie in geological basins over a large area of eastern Australia extending approximately 2,000 kilometres from Townsville to Sydney. Queensland has Australia's largest known reserves of CSG in the Bowen and Surat Basins.

The applications of CSG are identical as conventional natural gas and include space heating, water heating, cooking and other domestic uses, as well as an input for industrial processes. The demand for gas in Australia has increased year on year for the past half century. Furthermore, demand is projected to continue increasing nearly every year for the next 30 years as Australia seeks ways to reduce its carbon footprint (see figure below).

The recent increase in demand for gas as a fuel source to transition to a low carbon economy both domestically (power generation) and internationally (via LNG) has led to a rise in development applications for CSG (ABARES 2011). Looking out to 2030, ExxonMobil (2010) expects gas to play an even larger role in the world's energy mix. By 2030 it is expected that gas will supply 26 per cent of the world's energy needs, up from 22 per cent in 2010.

Figure 1.1

**ANNUAL GAS DEMAND (INCLUDING LNG EXPORT)**




Source: AEMO 2010 (Decentralised world scenario).

## 1.2 The Northwest NSW regional economy

The Northwest NSW region is home to some 224,000 people. This is an important area for livestock production, particularly in the Hunter and Northern Slopes areas, where the bulk of agricultural gross value comes from livestock production.

The following figure identifies the regions assessed as part of this study.

Figure 1.2

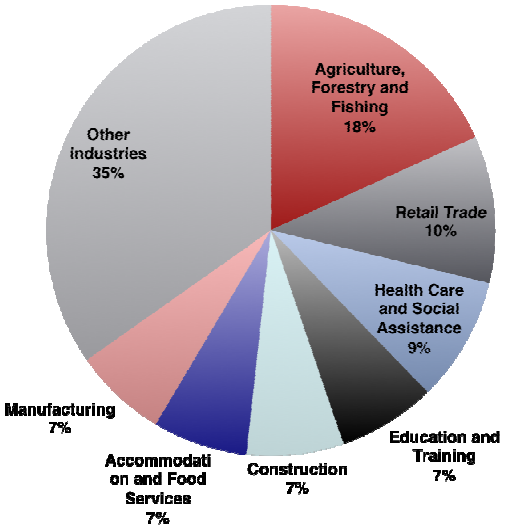
**REGIONS ASSESSED IN THIS STUDY**


Source: ABS 1216.0.

It can be seen from the chart below that agriculture is the largest single employer, accounting for around one fifth of regional employment. Notably however, while agriculture plays an important role in the region, over 80 per cent of the regional economy is employed in other sectors. Other major industries include retail trade, health care, education and construction — all of which will have a direct positive impact as a result of such a large scale development.

Figure 1.3

**REGIONAL EMPLOYMENT BY INDUSTRY**




Source: ABS 2006 Census.

## 1.3 Assessing economy wide impacts

The impacts from large scale investments such as this, are likely to spread through many industries, and regions of the economy. There is broad acceptance of the idea that a change in one industry will flow through the economy when for example higher incomes raise demand for goods produced by others. As a diversified economy trading with the rest of the world the flow through impacts become quite complex. It is also possible that some changes are sufficiently large that they change relative prices in the economy including the price of goods and services, the price of labour (that is, wages), and may even change underlying factors such as the exchange rate.

Assessing these impacts and understanding their interconnections requires an economy wide model of the Australian economy. To the extent that economic activity is interlinked, a Computable General Equilibrium (CGE) model can capture most indirect effects that arise from changes in a single industry or products. Presented here are the initial CGE modelling results, which have been calculated using the Monash Multi Region Forecasting model (MMRF).

The MMRF model allows for an evaluation of the proposed development at a regional and industry level. Box 1.1 provides a brief overview of the model, and more detail can be found in Appendix B.

The use of a CGE model to assess broader economic impacts on the community is an accepted technique commonly used by policy makers, regulators and industry. This type of analysis has been used to assess:

- taxation reform;
- emissions trading;
- energy efficiency;
- regulation;
- the economic impacts of research and development;
- infrastructure investments (such as roads, rail and ports); and
- other policy matters of a national, state and regional context (Appendix B discusses the model and its applications in further detail).

The Commonwealth Treasury in its recent modelling of the Carbon Price Mechanism (CPM) made the following point (Treasury 2011, pg. 20).

> Economic models are useful for exploring the costs of climate change mitigation, as they ensure internally consistent long-term projections of economic activity and the resulting greenhouse gas emissions. While these models have their limitations, they integrate, in a comprehensive manner, economic and other data with economic theory about how the world responds to changing circumstances.

Box 1.1

**THE MONASH MULTI REGION FORECASTING MODEL**

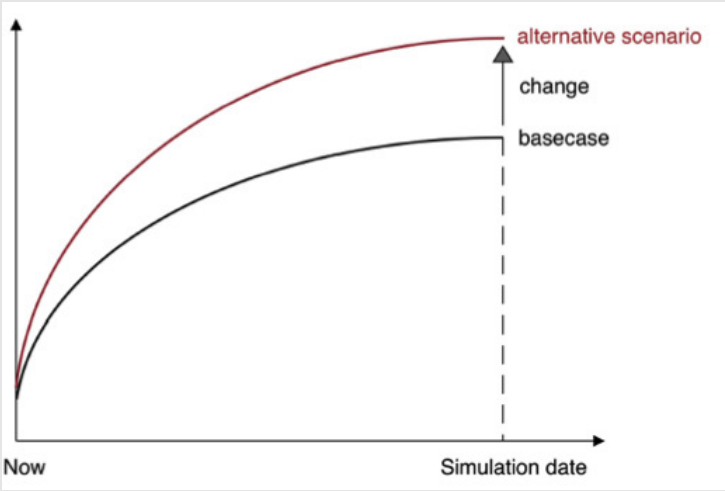
The Monash Multi-Regional Forecasting model is a Computable General Equilibrium model of Australia's regional economies developed by the Centre of Policy Studies (CoPS) at Monash University (CoPS, 2008). It is a model of the entire Australian economy and it captures the interactions between different regions and sectors. For a detailed description of the theoretical structure of the model see Peter et. al., 1996.

The MMRF model is used for a wide range of policy studies, including the analysis of state tax reforms and the potential benefits of the National Reform Agenda. More recently, the Department of the Treasury and the Garnaut Climate Change Review applied the MMRF model to the national climate change modelling to assess the impacts of the proposed CPRS on the Australian economy.

The results of the MMRF modelling simulations are estimated as deviations from the baseline. The baseline case represents a scenario that depicts the best estimate representation of the state of the world out to 2035. This includes expected demographic, economic and policy changes over time.

Reporting impacts in this way allows the discussion to focus on the 'change' that the investment can be expected to deliver (rather than on how the economy will develop over time). This is depicted in the following figure.

**APPROACH TO MODELLING**




Source: The Allen Consulting Group.

Regarding the oil and gas sectors, a number of previous studies have evaluated the impacts on expansions this sector will have on national and sub-national economies.

- Most recently, the Australian Petroleum Production and Exploration Association engaged ACIL Tasman (2011) to analyse and report on the economic impacts likely to arise from the growth of a major CSG industry in NSW. The study compared economic outcomes under a scenario in which NSW CSG production expands steadily to become the main source of gas supply in the State (base case) with an alternative scenario in which NSW CSG production does not expand beyond current levels (freeze scenario). In the base case scenario it was assumed that a CSG resource base of around 25,000 PJ is established in NSW, across various geological basins and a range of price points. It was further assumed that this resource base supports production capacity of up to 133 PJ/a (71 per cent of NSW gas demand) by 2020 and 222 PJ/a (77 per cent of NSW gas demand) by 2030. In the freeze scenario CSG production in NSW is maintained at a steady level of about 6 PJ/a throughout the modeling period. For the analysis, ACIL Tasman's CGE model, Tasman Global, was used to estimate the impacts of the construction and operation activities associated with the development of a NSW CSG industry. Tasman Global is a large scale, dynamic, computable general equilibrium model of the world economy that has been developed in-house by ACIL Tasman. Tasman Global is a powerful tool for undertaking economic analysis at the regional, state, national and global levels.

- KPMG Econtech (2010) conducted an economic impact assessment of the Australia Pacific LNG Project. The direct and indirect economic impacts of the construction and operation of the project were modelled at the national, state (Queensland) and regional levels. The direct impact of the baseline, construction and operation scenarios were fed into the MM600+ (operational phase) and Murphy Model Regional (MMR) (construction phase) models to determine the economic effects. For the construction scenario, the capital value of the project was $23 billion (nominal dollars). For the operation scenario, the total volume of Australian exports was input to increase by approximately 800 PJs per annum and domestic production of natural gas was set to increase by approximately 60 PJs per annum when the project was complete.

- In 2008 the Queensland Department of Infrastructure and Planning commissioned MMA Econtech to conduct a viability and economic impact study of the State's LNG industry. This study examined the costs and impacts of two generic industries exporting LNG from Gladstone: a 3 Mtpa industry commencing deliveries in 2014, with no expansion (2014 is estimated to be the earliest feasible delivery start date for a 3Mtpa industry); and an industry starting at 3Mtpa and expanding to 10 Mtpa from 2019. The economic impacts of LNG scenarios were quantified using macroeconomic models of the Australian economy, with inputs reflecting the key variables of each scenario. The direct and indirect economic impacts were estimated at the national, State and regional levels using Econtech's MM600+ model – a long-term CGE model of the Australian economy that models a long-run equilibrium. A dynamic analysis was undertaken using Econtech's Murphy Model 2 (MM2) – a fully integrated macro-CGE model.

- An earlier study by ABARE (1996) assessed the net economic benefits from the exploration, development and production of Australia's oil and gas resources for the period from 1980 to 2010. The economy-wide contribution of the industry was quantified using both the ORANI-E and MONASH models of the Australian economy. In the ORANI-E model oil, LPG and gas are specified as separate industries. The ORANI-E model was used to estimate the indirect net economic benefits of a 20 per cent increase in oil, LPG and gas production. Supplementary results for Australia's states and territories were obtained using the MONASH model. This model was used to estimate the impact of a 20 per cent increase in output from the oil, gas and brown coal sector.

## 1.4 Assessing the potential of CSG in Northwest NSW

This study has been informed by data provided by Santos about the nature of the potential development. Where possible the economic analysis has been supported by robust data from recognised, independent and publically accessible sources.

The dynamics of this investment are fundamental to the evaluation. The analysis has considered this investment in two phases.

Table 1.1

**DEVELOPMENT PERIODS**

| Period | Years | Detail |
|---|---|---|
| Construction phase | 2011-2017 | The main focus of activity in the phase is the development of the CSG wells and network. |
| Operations phase | 2017-2035 | In this phase, the focus is on gas production and the resources required to operate facilities. |

Source: The Allen Consulting Group and Santos.

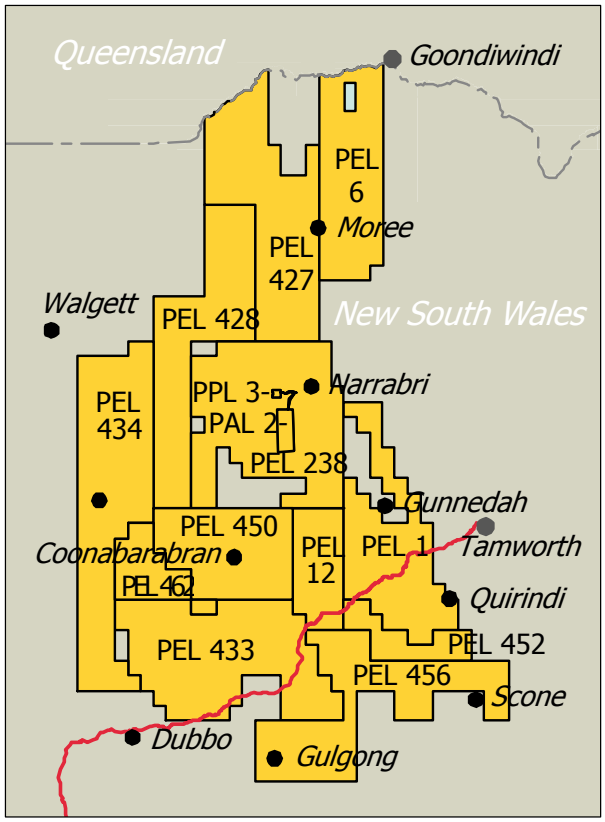
All costs and benefits in this report are expressed in real terms ($2011) unless otherwise indicated. Calculations of Net Present Values (NPV) have employed a real discount rate of 12 per cent. This is consistent with the real Weighted Average Cost of Capital used in previous studies.[1] A sensitivity analysis of alternative discount rates (ranging from 7 per cent to 15 per cent) is provided in Appendix A.

The MMRF model is principally informed by ABS Census data and the ABS' Standard Geographical Classifications (ABS 1216.0). In NSW, Santos has direct interests in 14 petroleum licenses, of which all but one are in the exploration phase. Santos' CSG exploration activities in the region encompasses an area of over 44 000 square kilometres. This area includes the communities of Boggabri, Coonabarabran, Gunnedah, Narrabri, Quirindi and Scone. The extent of Santos' interests in the regions is depicted in Figure 1.4.

[1] See MMA Econtech 2008, *Queensland LNG Industry Viability and Economic Impact Study*, Report to the Queensland Department of Infrastructure and Planning, February. ACIL Tasman (2011) used a seven per cent discount rate.

Figure 1.4

**SANTOS GUNNEDAH BASIN ACREAGE**




Source: Provided by Santos.

The assessed region is contained within four ABS Statistical Subdivisions (SSD). The table below shows how the ABS SSDs align with key communities in the region.

Table 1.2

**ABS REGIONAL DEFINITIONS**

| ABS SSD | Key communities in region |
|---|---|
| Hunter SD Balance | Muswellbrook, Singleton, Scone |
| Northern Slopes | Quirindi |
| North Central Plains | Gunnedah, Narrabri, Boggabri |
| Central Macquarie | Coonabarabran |

Source: ABS 1216.0 and the Allen Consulting Group.

## 1.5 Using this report

This report provides an assessment of the wider economic consequences of a hypothetical CSG development in Northwest NSW. No investment should be made either in the region, or the broader economy, that relies on the information contained in this report.

Importantly this report does not provide an assessment of the financial viability of a proposed project or a component of a project. The report is also not an assessment of Santos' operations and/or its related businesses.

The purpose of this report is to specifically isolate the impacts of the proposed CSG development, and abstract away from other economic developments, such as:

- tax and policy changes — current taxes apply into the future but new taxes and charges, are not included (including effect the CPM, Mineral Resource Rent Tax (MMRT) and the extended Petroleum Resource Rent Tax (PRRT));
- structural change in energy markets — the switch to renewables, the relative prices of oil reflect projections made by ABARE and other economic projections which incorporate a long term trend increase in the price of oil but not a 'peak oil' price shock which is feared by some analysts;
- the structure of gas and electricity transmission markets — the introduction of additional transmission facilities can have a transformative impact on many factors such as where gas can be consumed by whom and many other factors but these rely on the decisions made by many others; and
- investment decisions made by competitors — these may lead to many second and third round effects, but the many permutations rely on decisions made by many others outside of consideration of the development proposed by Santos.

This approach allows the assessment to articulate and isolate the impacts of the development holding all else constant. Accommodating the impacts of the proposed CSG development *and* a major policy change such as the CPM or the MMRT would blur the analysis. It would be difficult to attribute the impacts to the CSG development for example, as distinct from changes made by the CPM.[2]

Essentially, the approach undertaken here is a 'with and without' comparative static. This is a common technique used for evaluations of this nature and is consistent with other studies on this issue — ACIL Tasman (2011) and MMA Econtech (2008) — as well as by the Commonwealth Government. The Commonwealth Treasury for example, makes this point explicitly (Treasury 2011, pg. 24).

> Scenario modelling does not predict what *will* happen in the future. Rather it is an assessment of what *could* happen, given the structure of the models and input assumptions.
>
> Scenarios are an analytical lens through which to view a problem; they do not factor in all elements of the 'real world'… Scenarios guide understanding of policy impacts, relativities of different policy options and the extent that parts of the economy (technology, preferences and so on) need to shift from current trends to achieve particular outcomes, given the model's assumptions.

Furthermore, given the uncertainties that still remain about some policy and market issues, this analysis can be considered as reporting the impacts of the proposed CSG development *independent* of what occurs on those fronts.

[2] Furthermore, there are also distinct difficulties will modeling the CPM — despite recent legislation passing through both houses of Parliament. Many details of the CPM are still to come to light — with particular relevance to the CSG, LNG and broader energy markets. How shielding and assistance will apply to the LNG sector, for example, is yet to be fully articulated in supporting regulations. Confidence in the supply of international carbon units is also a concern and an issue still under negotiation.

## 1.6 Report structure

The remainder of this report is structured as follows. Chapter 2 describes the key inputs and assumptions used to model the potential development. This includes a profile of the capital and labour required to construct and operate a CSG operation in the region and the expected levels of production. Chapter 3 reports on the expected State and regional impacts of the development as estimated by the MMRF model. Chapter 4 reports on the national impacts of the development and Chapter 5 summarises the findings of the study.

*Chapter 2*

# Developing CSG in Northwest NSW

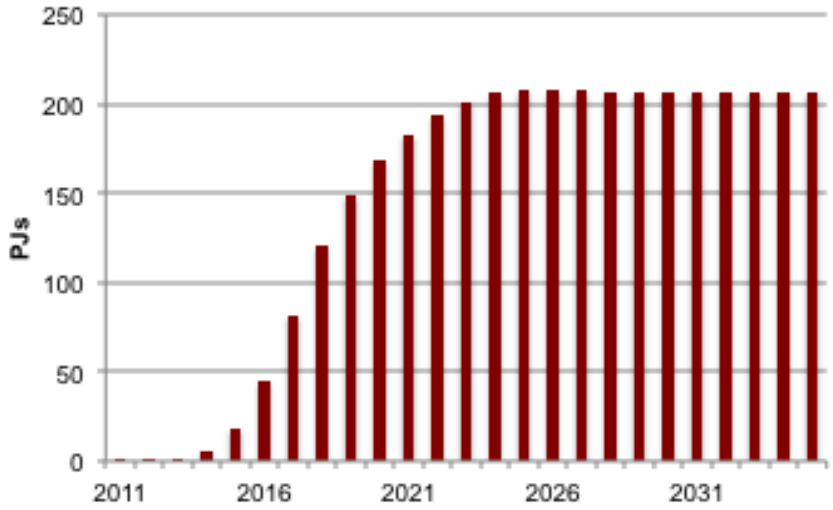
Data has been provided by Santos about the nature of a potential large scale CSG project. This chapter outlines that data; detailing the possible scale of the operation and the resources required for its construction and operation. This project relates to the development of a CSG field only, it does not include the investment or employment associated with gas transportation or end-use facilities, such as power generation, industrial uses and LNG.

## 2.1 Production potential

When fully operational, the scenario assumes that the CSG project will produce around 210 PJs of CSG per annum. The figure below illustrates the expected production profile from the region.

Figure 2.1

**EXPECTED ANNUAL NORTHWEST NSW CSG PRODUCTION**




Source: Provided by Santos.

The end market for this gas will be affected by local and international prices, future policy decisions and other factors.

For the economy to consume the gas domestically, there needs to be a combination of an increase in demand and/or a reduction in supply from other gas producing sources. Ordinarily, this type of expansion would generate a net gain to gas intensive industries that are able to expand and consume gas at a lower relative cost to what would have otherwise been the case.

However, with the advent of the CPM, it is less likely that, for example, a gas-intensive aluminium sector will emerge in NSW. Taking this into account, careful consideration must be given to which sectors in the domestic economy would accommodate an increase in gas supply[3] — at whatever price it comes onto the market.

The extent to which the CPM will impact on the market for CSG is unclear.

- On the one hand, CSG is a lower carbon intensive emission source of energy than certain other fossil fuels (primarily coal) and consequently the CPM may bolster the CSG market.
- On the other hand however, there still remains a significant price differential between current established coal plants and new gas fuelled electricity generation, and coupled with as yet unspecified rate shielding, it is not clear how or when the CPM will bridge this gap.
- Furthermore, the CPM is designed to bring about change in the economy. How this change will filter through and affect other consumers of gas in the domestic market is unclear. These changes will include increased competition from the renewable energy sector and changes to the international sector following on from developments made at the recent United Nations Climate Change Conference in Durban.

Moreover, significant details about the CPM are yet to be unveiled. Particularly relevant for this analysis are details about how shielding will apply to the LNG sector.[4]

Because of this uncertainty, it has been assumed that 50 per cent of gas production will be consumed domestically.

## 2.2 Required investment

Developing a network of CSG wells throughout the region will require a significant commitment of economic resources. This includes considerable capital and operating outlays, investment in local infrastructure and regional employment opportunities.

Santos' capital and operating expenditures will vary during different stages of the project, with the largest investment occurring during the initial construction phase. Cumulatively, Santos has indicated that the project will require an investment exceeding $16 billion to 2035. Specifically, the expected investment will require:

- around $4.3 billion in the construction phase; and
- a further $12.3 billion during operations.

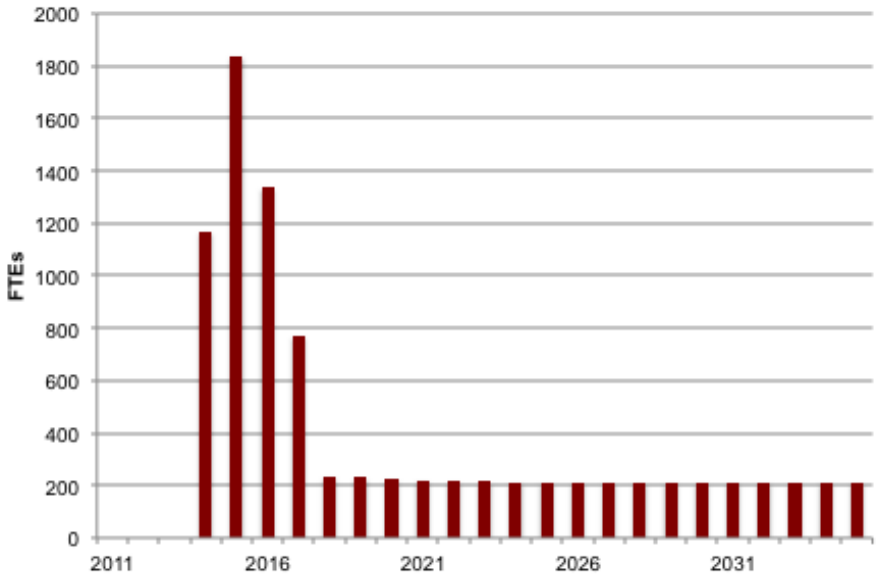
[3] The model assumes the current supply of gas will continue into the future.

[4] Presently, it is likely that the LNG sector will qualify for the lower shielding threshold and receive an administrative allocation of carbon units worth 66 per cent of liabilities (declining at a rate of 1.3 per cent per annum thereafter). Provisions for a supplementary allocation of permits to the LNG supply chain will be also be available and will provide an effective rate of 50 per cent assistance (Australian Government 2011). Details of how this mechanism will work in practice are not contained in the legislation or currently available policy documents.

## 2.3 Direct employment opportunities

The project will provide a significant direct employment opportunity for the region as well. Santos estimates that the company will require a workforce of up to around 1800 positions during the construction phase and more than 200 positions during operations. A profile of the expected labour required for this project is reported below. Importantly, this profile does not include the project's indirect impact on regional employment. These indirect impacts are considered in further detail below.

Figure 2.2
**DIRECT EMPLOYMENT OPPORTUNITIES**




Source: Data provided by Santos.

Importantly, the numbers above do not reflect the labour required to construct a gas transmission pipeline nor for end-use facilities, such as power generation, industrial and LNG.

## 2.4 Increasing regional water resources

The CSG process requires extraction, treatment and release of large quantitates of water. CSG water is contained within underground coal seams quite distinct from those used by current farming water bores and aquifers. This water is pumped from the coal seams as part of the gas extraction process.

The quality of CSG water is brackish, limiting its use without treatment. It is only after treatment, which costs up to $2,500/ML, that it can be beneficially reused. In this way, the CSG industry is turning a waste product into a water resource for the community. Treated CSG water represents an opportunity for irrigation, stock watering, boosting local supplies and recharging surface aquifers.

Santos expects to make available an average of nearly 5 GL of additional water to the region each year of the operations phase. This water would otherwise be untapped for irrigation and/or other agricultural purposes, and therefore represents an increase water resources for the local community.

*Chapter 3*

# Broader economic gains for NSW

This chapter reports on the broader economic impacts of a CSG development in Northwest NSW.

The economic impacts do not consider the immediate financial return to a prospective CSG operator, rather concentrating on the regional, state and national benefits. The key economic drivers of change for the larger economy are threefold.

- First, the potential development will lead to a net increase in economic activity. This occurs because the amount of accessible resources in the economy has expanded and is able to be put to a productive use
- Secondly, there is a second round income effect where increased output is sold in the market, especially as exports, leading to a flow on impact to households and capital owners throughout the economy. This in turn is spent by firms and households increasing expenditure on some goods and services, raising output, investment and employment in some sectors and regions.
- Third, the potential development promotes a reallocation of the economy's resources throughout the community. This churn is felt as an expansion in activity in sectors and some regions, and reduced activity in others.

The key headlines are as follows.

- Cumulatively to 2035, the project is estimated to add $15.2 billion to GSP in NSW, of which around $8.5 billion will contribute to an increase in Northwest NSW's GRP.
- The results show an increase in NSW employment of 2,900 full time positions in the medium to longer term, of which 200 will occur in the Northwest NSW region itself.

## 3.1 An opportunity for NSW

The development of a CSG industry and operation in Northwest NSW is expected to have a significant impact on the NSW economy. The indirect impacts will be felt across the State across a wide range of industries.

### *The construction phase*

The focus of attention when assessing large scale projects is often upon the economic stimulus in the construction phase. The model results indicate that during the years of the construction phase NSW Gross State Product (GSP) will increase by 0.06 per cent. This is the equivalent of an increase of approximately $253 million per annum in terms of the NSW economy from 2011-12.

In the short term, the economy is unable to rapidly adjust to large structural changes. As a consequence, the short-term impact on the economy is disproportionately favourable to more flexible resources in the economy — particularly labour. The economic growth in the construction phase is estimated to increase NSW employment opportunities by around 850 positions. These jobs represent the net increase in employment, having accounted for any reallocation that occurs in the economy.

### *The operations phase*

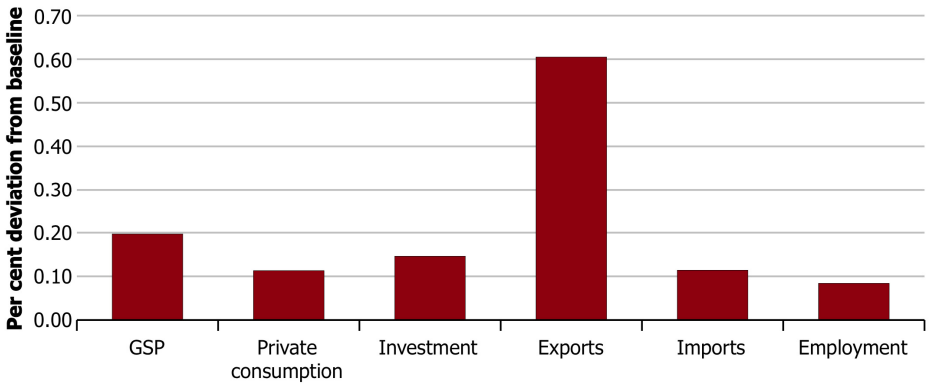
The substantive economic change from the development of new facilities does not arise from their construction but from their use. This is examined in operations phase simulation using the MMRF model.

The estimated impacts on key macro variables in the operations phase are depicted in Figure 3.1. These are the changes that are apparent in the medium to longer term after the direct changes and flow on impacts have worked their way through the economy. The indicators relate to the change in a typical year in the future.

From the results, NSW GSP is expected to rise by 0.20 percentage points — this has a value of over $800 million per annum.

Figure 3.1

**IMPACTS ON KEY MACRO VARIABLES, NSW OPERATIONS PHASE**




Source: Allen Consulting Group.

Cumulatively to 2035, the project is estimated to add $15.2 billion to GSP in NSW. This increase has value today of $3.1 billion when evaluated using a 12 per cent real discount rate (or $5.8 billion when evaluated using a 7 per cent real discount rate).

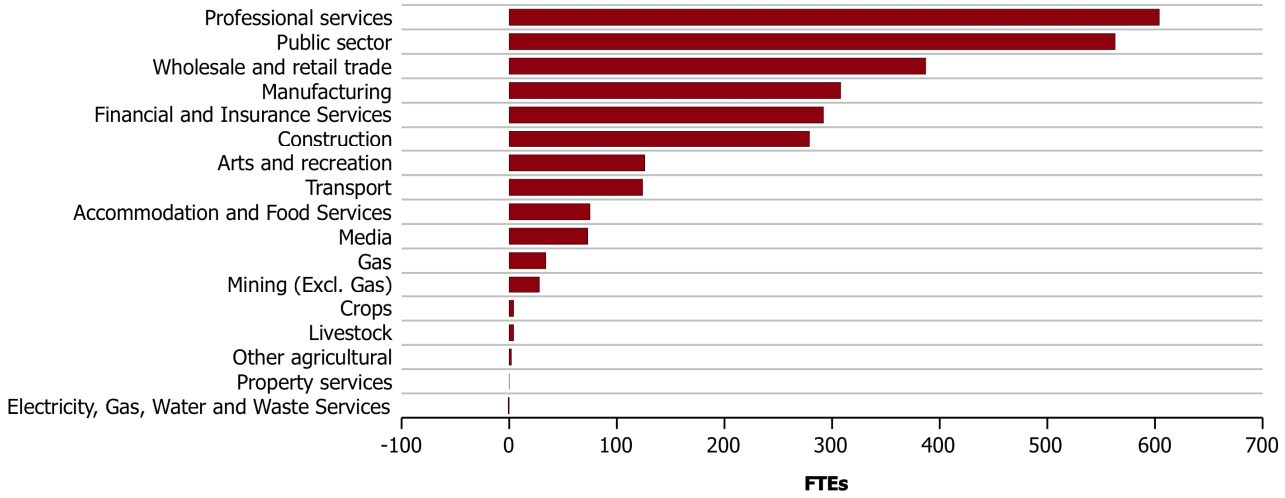
Some of the additional economic activity in the State will necessarily flow to labour — in the form of increased incomes and increased employment opportunities. The results show an increase in NSW employment of 0.2 per cent in the medium to longer term. This is equivalent to an increase of 2,900 full time positions.

These estimates are *not* simply employment opportunities associated directly with the CSG gas field development. Rather, the vast majority of these positions will be a result of an increase in the general level of NSW activity that the project creates. This may be further compounded if you take into account the gas transmission and downstream uses of such gas, which has not been modelled for this report.

The employment opportunities created largely mirror NSW's current employment profile — growth in employment is expected to extend well beyond the proposed CSG sector. Figure 3.2 shows that, in fact, the majority of opportunities created are in the professional services sector, followed by public services (including health and education services) and trade.

Figure 3.2

**EMPLOYMENT IMPACTS BY INDUSTRY, NSW OPERATIONS PHASE**




Source: Allen Consulting Group.

In the long run, the increase in the NSW labour force will necessarily need to draw from labour outside the State. The increased economic activity in NSW will increase the State's wages in relative terms — making NSW a more attractive destination for Australian workers. Figure 3.3 illustrates the expected impacts on labour in other jurisdictions. Notably, the development of a CSG operation in Northwest NSW has the potential to reverse recent trends in labour flow — currently moving from NSW to other resource rich states.

Figure 3.3

**ATTRACTING LABOUR FROM OTHER JURISDICTIONS, OPERATIONS PHASE**


Source: Allen Consulting Group.

## 3.2 Regional gains

While NSW can expect to benefit from the development, the benefits are likely to be particularly concentrated in the Northwest region itself. In fact, more than two fifths of the benefits accrue directly back to the regional economy.

Cumulatively, the region can expect to benefit by around $8.5 billion — an NPV of $1.6 billion evaluated using a 12 per cent real discount rate (or $3.0 billion using a 7 per cent real discount rate).

In the construction phase of the development, Gross Regional Product (GRP) is estimated to be 0.8 per cent higher than it otherwise would be, equating to a $28 million dollar difference year on year.

Gains to the regional economy are most felt during the operations phase. GRP in the operations phase is estimated to be some 3.2 per cent more than it otherwise would be, equating to an annual increase of around $470 million in today's dollars. The impact of the proposed development is likely to be greatest in the Hunter and Central Macquarie regions[5].

It is estimated that the region will benefit from the creation of around 200 full time *additional* positions. This increase takes into account both those positions created as a direct result of the CSG project and indirectly through increased economic activity.[6]

A summary of the employment and GRP impacts for the region is provided in Table 3.1. These estimates report the expected deviation from the baseline case — where the regional economies would be in the absence of the CSG development.

[5] Although the majority of construction activity occurs in the Northern Slopes and North Central Plains regions, the model reports that the Hunter and Central Macquarie regions will reap the greatest increase in GRP. This is largely due to the existing economic structure in those regions, and their ability to provide services to Northwest NSW generally. Further, the existing industry and skill base of the Hunter and Central Macquarie are highly susceptible to growth following the CSG development.

[6] Some of the positions created by the development may see a worker move from one position to another. The additional 200 positions created refer to growth in the total number of jobs in the region.

Table 3.1

**REGIONAL IMPACTS, ESTIMATED DEVIATION FROM BASE LINE**

| Region | Employment (FTEs) | GRP ($million) |
|---|---|---|
| Hunter | 97 | 401.2 |
| Northern Slopes | 22 | 16.7 |
| North Central Plains | 16 | 0.4 |
| Central Macquarie | 32 | 51.3 |
| **Total** | **168** | **469.7** |

Source: The Allen Consulting Group.

Of note, the value of agricultural production is expected to increase during the operations phase. The CSG development will make available a considerable quantum of currently untapped water to be used as an input to agricultural production. This, combined with an increase in the region's labour force, raises the region's agricultural productive capacity. It is estimated that the value of the region's agricultural production will increase by nearly a full percentage point during the operations phase.

*Chapter 4*

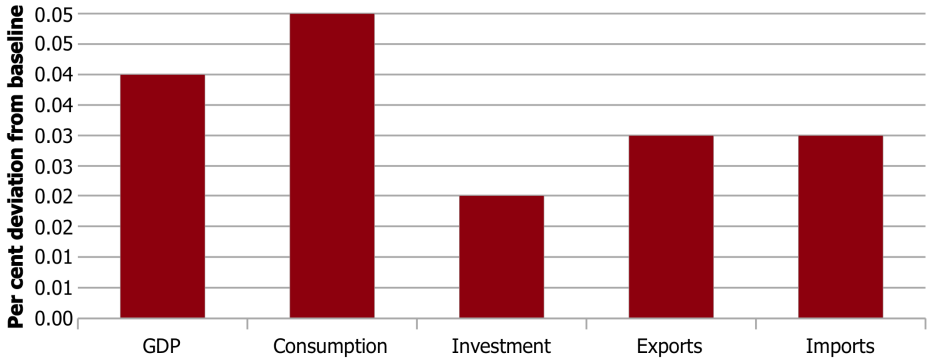
# Benefits to the Australian economy

The expected impacts of the project are not limited to NSW alone. On the whole, Australian incomes are expected to increase as a result of the development. As with NSW, the impacts on the Australian economy have been assessed for the construction and operation phases of the project.

During the construction phase Australia's GDP is estimated to increase by 0.02 per cent, approximately $309 million in today's dollars. During the operations phase, Australia's GDP is estimated to increase by 0.04 per cent, approximately $531 million in today's dollars. Cumulatively, the project's impact is expected to generate $10.7 billion over the period to 2035. In present value terms this equates to $2.5 billion when evaluated using a 12 per cent real discount rate (or $4.2 billion using a 7 per cent real discount rate). The project's impacts on key macro variables are illustrated in Figure 4.1. As is the case in NSW, consumption and investment both increase. The balance of trade (exports minus imports) is on the one hand influenced by the changes in the real exchange rate and on the other by increases in GDP. The net impact is an expected increased in overall trade — exports and imports both increasing.

Figure 4.1

**IMPACTS ON KEY MACRO VARIABLES, AUSTRALIA OPERATIONS PHASE**




Source: The Allen Consulting Group.

These results are in line with other major studies that have attempted to estimate the impacts of similar projects. In particular, a recent study by MMA Econtech (2008) estimated that the long-term impact of a 3Mtpa LNG (around 180 PJs) export industry in Queensland would increase long run GDP by 0.01 per cent. A much smaller project, 60 PJs of LNG per annum, has since been estimated by KPMG Econtech (2010) to increase GDP by 0.1 per cent. Some of these studies are summarised in Box 4.1.

Box 4.1

**BENCHMARKING RESULTS**

The following studies provide a reasonable benchmark against the proposed CSG development outlined here.

- ABARE's 1996 study estimated that, in the short run, as simulated using ORANI-E, a 20 per cent increase in oil and gas production results in a rise of 0.5 per cent in real GDP, 0.4 per cent in employment and exports by 2.5 per cent. In the long run, GDP increases by 0.4 per cent. In all of the MONASH results, real GDP also increases by 0.4 per cent. In the long run, all states and territories gain from increased activity in the oil and gas sector.
- MMA Econtech (2008) estimated that a 3Mtpa LNG export industry would increase real GDP in the longterm (over the life of the industry) by 0.01 per cent. The figures for the 10Mtpa industry were 0.06 per cent. It was estimated that a 3Mtpa LNG industry would contribute 0.22 per cent of real GSP over the life of the industry. A 10tpa LNG industry was estimated to contribute 0.68 per cent of real GSP over the life of the industry. Overall, it was estimated that a 3Mtpa industry would boost employment in Queensland by 0.2 per cent, and that a 10Mtpa industry would increase employment by 0.6 per cent.
- KPMG Econtech (2010) estimated that $23 million capital expenditure and an increase in production capacity of 60 PJs per annum of the Australia Pacific LNG Project would contribute 0.6 per cent to GDP and 3.2 per cent to GSP during the construction phase. It was estimated that, compared to the baseline case of the project not proceeding, the fully operational project would lead to 0.1 per cent higher GDP. At the State level, the total impact of the Australia Pacific LNG project was estimated to contribute to an annual average of 9 900 jobs in Queensland (or a boost of 0.1 per cent), and 0.9 per cent higher GSP.
- ACIL Tasman (2011) estimated that maintaining a 6PJ/annum CSG industry in NSW, as opposed to developing a 222PJ/annum industry results in a reduction of around $4.3bn (real 2011 dollars) in direct capital investment and loss of around $2.7bn of associated recurrent operating expenditure foregone in NSW over the period to 2035. This leads to in a reduction in real NSW GSP of $7.15bn in total over the period 2034-35 (with a net present value of $2.4bn, using a 7 per cent real discount rate). This loss in real GSP is equivalent to approximately a 0.9 per cent decrease of the level of NSW's 2010-11 GSP). Total employment in NSW is 1,361 lower per year on average (FTE basis).

The results of the studies are summarised below.

| Study | Production increase (PJ) | Impact on GDP (per cent) | Impact on GSP (per cent) | Impact on state employment (persons) |
|---|---|---|---|---|
| ABARE (1996) | 240 PJ | 0.14 | na | na |
| MMA Econtech (2008) | 189 PJ | 0.01 | 0.19 (Qld) | na |
| KPMG Econtech (2010 | 60 PJ | 0.10 | 0.90 (Qld) | 9 900 (Qld) |
| AcilTasman (2011) | 222 PJ | na | 0.90 (NSW) | 1 361 (NSW) |
| **ACG (2011)** | **210 PJ** | **0.04** | **0.20 (NSW)** | **2 900 (NSW)** |

Source: ABARE 1996, MMA ECONTECH 2008, KPMG Econtech 2010, ACIL Tasman 2011.

Notably, the cumulative impact on the Australian economy is less than the cumulative impact on NSW. This is because the Australian results reflect the churn of resources (labour and capital) moving *to* NSW, *from* other jurisdictions (see Figure 3.3 above). When resources relocate across the nation, this ultimately means that the productive capacity of other jurisdictions is necessarily reduced. Individuals remaining in those jurisdictions however, will still enjoy a dividend from the proposed development.

Not reported in the figure above is an estimate of the impact on employment. Australia wide, the investment in CSG is not expected to increase or decrease Australia's total labour supply. Total long-run labour supply is considered invariant — that is it is determined by factors not related to the development of gas resources such as natural population growth and the level of immigration. As a consequence, the impacts of the project are instead likely to manifest mainly as changes to the composition of the labour force and its employment in the mix of Australian industries.

Indeed, different sectors of the economy will be impacted in different ways. By reallocating towards higher yielding activities, both labour and capital will profit from the new opportunities presented to them. The impacts on output by industry are depicted in the table below. Australia wide, the increase in economic activity is concentrated in the construction sector (additional growth of 0.16 per cent), followed by mining (additional growth of 0.11 per cent) and services (additional growth of between 0.05 and 0.11 per cent).

Table 4.1

**CHANGES IN INDUSTRY OUTPUT**

| Sector | Per cent deviation from baseline |
|---|---|
| Agriculture | -0.07 |
| Business services | 0.05 |
| Communication | 0.07 |
| Construction | 0.16 |
| Financial services | 0.09 |
| Hotels and restaurants | 0.08 |
| Manufacturing | -0.06 |
| Mining | 0.11 |
| Other services | 0.11 |
| Public services | 0.09 |
| Trade services | 0.03 |
| Transport | -0.03 |
| Utilities | 0.00 |

Source: The Allen Consulting Group.

In the baseline scenario,[7] all sectors of the Australian economy will experience growth. The impacts depicted in the table only report the expected baseline deviation. A positive number for example, suggests that the CSG development will provide *additional* growth to that which would have occurred regardless. (This is the case for nearly all sectors of the economy.) Similarly, a negative number indicates slower growth for that particular sector. This is the case for the transport, manufacturing and agriculture sectors. These sectors still experience growth, albeit potentially less than in the project's absence.[8]

Importantly, changes in each industry's production do not illustrate *just* the direct impact of the proposed CSG activities. Rather, these impacts (and indeed other impacts reported elsewhere in the report) are a combination of the development and relationships throughout the economy. This includes:

- changes in the real exchange rate;
- the relative mobility of workers in these sectors; and
- competing opportunities in other industries (and in NSW more broadly).

Moreover, the structural base of the economy is such that many of the changes identified in Table 4.1 would be observed following any significant investment in the energy or resources sector. That is, impacts are not particular to a CSG development per se, but rather are typical of investments of this scale.

[7] That is, a scenario without the proposed CSG development.

[8] Refer to Box 1.1 for more on how the impact analysis has been conducted.

*Chapter 5*

# Conclusions and summary

The economy wide analysis undertaken here indicates that the development of CSG operations in the Northwest NSW region would have a significant positive influence on the regional, State and national economies than if the potential development did not proceed. This has been estimated using an economy wide CGE model that takes into account the direct and flow-on impacts of the investment.

While the Australian economy enjoys a considerable boost, the NSW and the Northwest regional economy perform particularly well. This is because, in addition to the direct gains of the project, these economies become highly prospective relative to other jurisdictions. Households migrate to NSW, which is now able to offer higher wages.

As a result of the potential CSG development in Northwest NSW, the NSW economy can expect gains from increased economic activity that will add $15.2 billion in today's dollars to 2035. Associated with this expansion is an increase in NSW employment opportunities of around 3000 jobs.

The results of this evaluation have been summarised in the following table.

Table 5.1

**SUMMARY OF IMPACTS, LONG RUN INCREASE IN OUTPUT RELATIVE TO BASELINE**

| Region | Construction phase | Operation phase | Cumulative impact to 2035 | NPV (@7% real) | NPV (@12% real) |
|---|---|---|---|---|---|
| | $2011 | | | | |
| **NSW** | $253 million per annum | $821 million per annum | $15.2 billion | $5.8 billion | $3.1 billion |
| **Regional** | $28 million per annum | $470 million per annum | $8.5 billion | $3.0 billion | $1.6 billion |
| **National** | $309 million per annum | $531 million per annum | $10.7 billion | $4.2 billion | $2.5 billion |
| | Per cent change | | | | |
| **NSW** | 0.06 | 0.20 | na | na | na |
| **Regional** | 0.80 | 3.20 | na | na | na |
| **National** | 0.02 | 0.04 | na | na | na |

Source: The Allen Consulting Group.

*Appendix A*

# Sensitivity analysis — alternative discount rates

The assumed discount rate in any cost benefit analysis involving future impacts is always one of the most sensitive parameters of the study.

The discount rate provides a comparator for what could be earned by investing in an alternative project, with similar risk, elsewhere in the economy. It is the minimum return that would be required for a project to be considered economic.

In this analysis, a real discount rate of 12 per cent is employed for consistency with other recent studies (such as MMA Econtech 2008).

Notably, a 12 per cent real discount rate is towards the upper limit for most benefit cost analyses. For example, the Office of Best Practice Regulation requires a Regulation Impact Statement assess policy using a central case assumption of 7 per cent, with sensitivity at 3 and 11 per cent. (These rates reflect a different level of risk then what is inherent for this project.)

While the central case assumption here is high, it is also conservative. A high discount rate penalises earnings that occur far off in the future. A lower discount rate places a greater significance on distant earnings in the assessment of benefits and costs.

Table A.1 illustrates how the estimated NPV of the change in output or GDP over the forecast period is affected by the choice of discount rate. Reported in the table are the development's NPV for NSW and Australia evaluated at 7, 12 and 15 per cent.

Table A.1

**DISCOUNT RATE SENSITIVITY TESTING, CHANGE IN OUTPUT: NPV**

| Discount rate | Regional | NSW | Australia |
|---|---|---|---|
| 7 per cent | $3.0 billion | $5.8 billion | $4.2 billion |
| 12 per cent | $1.6 billion | $3.1 billion | $2.5 billion |
| 15 per cent | $1.1 billion | $2.4 billion | $1.8 billion |

Source: The Allen Consulting Group.

*Appendix B*

# The MMRF Model

The Monash Multi-Regional Forecasting (MMRF) model is a Computable General Equilibrium (CGE) model of Australia's regional economies developed by the Centre of Policy Studies (CoPS) at Monash University (CoPS, 2008). It is a model of the entire Australian economy and it captures the interactions between different regions and sectors. For a detailed description of the theoretical structure of the model see Peter et. al., 1996.

The MMRF model is used for a wide range of policy studies, including the analysis of state tax reforms and the potential benefits of the National Reform Agenda. More recently, the Department of the Treasury and the *Garnaut Climate Change Review* applied the MMRF model to the national climate change modelling to assess the impacts of the proposed CPRS on the Australian economy.

## B.1 Introduction to the MMRF model

The MMRF is a dynamic model of the Australian economy that models the behaviour of economic agents within each of Australia's eight states and territories. Each region is modelled as an economy in its own right, with region-specific commodities, prices and industries. The model contains explicit representations of intra-regional, inter-regional and international trade flows.

Each sector produces capital that is specific to the region in which it is located. In each region, there is a single representative household and a regional government. At the national level, the Commonwealth Government is also represented. Finally, the rest of the world is represented as a single agent, whose behaviour is driven by regional international exports and imports. The regions are linked through inter-regional trade, labour and capital mobility, and the taxing and spending of the federal government.

## B.2 The database

There are many versions of the MMRF model. The version of MMRF used for this project provides a representation of the Australian economy as it was in 2005-06.

The model allows for joint production — where one industry can produce a number of different commodities. Specifically, the model contains 58 industrial sectors, which produce 63 commodities. The industries and their related commodities are detailed in Table B.1 and Table B.2 respectively.

Table B.1

**MMRF: INDUSTRIES**

| Industry | |
|---|---|
| **Agriculture, Forestry and fishing** | 30. Motor vehicles and parts |
| 1. Sheep and beef cattle (high emissions) | 31. Other manufacturing |
| 2. Dairy cattle | **Utilities** |
| 3. Other livestock (low emissions) | 32. Electricity generation: Coal |
| 4. Broadacre agriculture except for animal | 33. Electricity generation: Gas |
| 5. Other agriculture | 34. Electricity generation: Oil products |
| 6. Agricultural services and fishing | 35. Electricity generation: Nuclear |
| 7. Forestry | 36. Electricity generation: Hydro |
| **Mining** | 37. Electricity generation: Other |
| 8. Coal mining | 38. Electricity supply |
| 9. Oil mining | 39. Gas supply |
| 10. Gas mining | 40. Water supply |
| 11. Iron ore mining | **Services** |
| 12. Non-ferrous ore mining | 41. Construction services |
| 13. Other mining | 42. Trade services |
| **Manufacturing** | 51. Financial services |
| 14. Meat and meat products | 52. Business services |
| 15. Other food, beverages and tobacco | 53. Dwelling services |
| 16. Textiles, clothing and footwear | 54. Public services |
| 17. Wood products | 50. Communication services |
| 18. Paper products | 43. Accommodation, hotels and cafes |
| 19. Printing and publishing | 55. Other services |
| 20. Petroleum and coal products | 56. Private transport services |
| 21. Chemicals | 57. Private electricity equipment services |
| 22. Rubber and plastic products | 58. Private heating services |
| 23. Non-metal construction products | **Transport** |
| 24. Cement | 44. Road passenger transport |
| 25. Iron and steel | 45. Road freight transport |
| 26. Alumina | 46. Rail passenger transport |
| 27. Aluminium | 47. Rail freight transport |
| 28. Other non-ferrous metals | 48. Water, pipeline and transport services |
| 29. Metal products | 49. Air transport |

Source: CoPS, MMRF database.

Table B.2

**MMRF: COMMODITIES**

| Commodities | |
|---|---|
| 1. Sheep and beef cattle (high emissions) | 33. Other non-ferrous metals |
| 2. Dairy cattle | 34. Metal products |
| 3. Other livestock (low emissions) | 35. Motor vehicles and parts |
| 4. Broadacre agriculture except for animal | 36. Other manufacturing |
| 5. Bio fuel | 37. Electricity generation: Coal |
| 6. Other agriculture | 38. Electricity generation: Gas |
| 7. Agricultural services and fishing | 39. Electricity generation: Oil products |
| 8. Forestry | 40. Electricity generation: Nuclear |
| 9. Coal mining | 41. Electricity generation: Hydro |
| 10. Oil mining | 42. Electricity generation: Other |
| 11. Gas mining | 43. Electricity supply |
| 12. Iron ore mining | 44. Gas supply |
| 13. Non-ferrous ore mining | 45. Water supply |
| 14. Other mining | 46. Construction services |
| 15. Meat and meat products | 47. Trade services |
| 16. Other food, beverages and tobacco | 48. Accommodation, hotels and cafes |
| 17. Textiles, clothing and footwear | 49. Road passenger transport |
| 18. Wood products | 50. Road freight transport |
| 19. Paper products | 51. Rail passenger transport |
| 20. Printing and publishing | 52. Rail freight transport |
| 21. Petrol | 53. Water, pipeline and transport services |
| 22. Diesel | 54. Air transport |
| 23. LPG | 55. Communication services |
| 24. Aviation fuel | 56. Financial services |
| 25. Petroleum and coal products nec | 57. Business services |
| 26. Chemicals | 58. Dwelling services |
| 27. Rubber and plastic products | 59. Public services |
| 28. Non-metal construction products | 60. Other services |
| 29. Cement | 61. Private transport services |
| 30. Iron and steel | 62. Private electricity equipment services |
| 31. Alumina | 63. Private heating services |
| 32. Aluminium | — |

Source: CoPS, MMRF database.

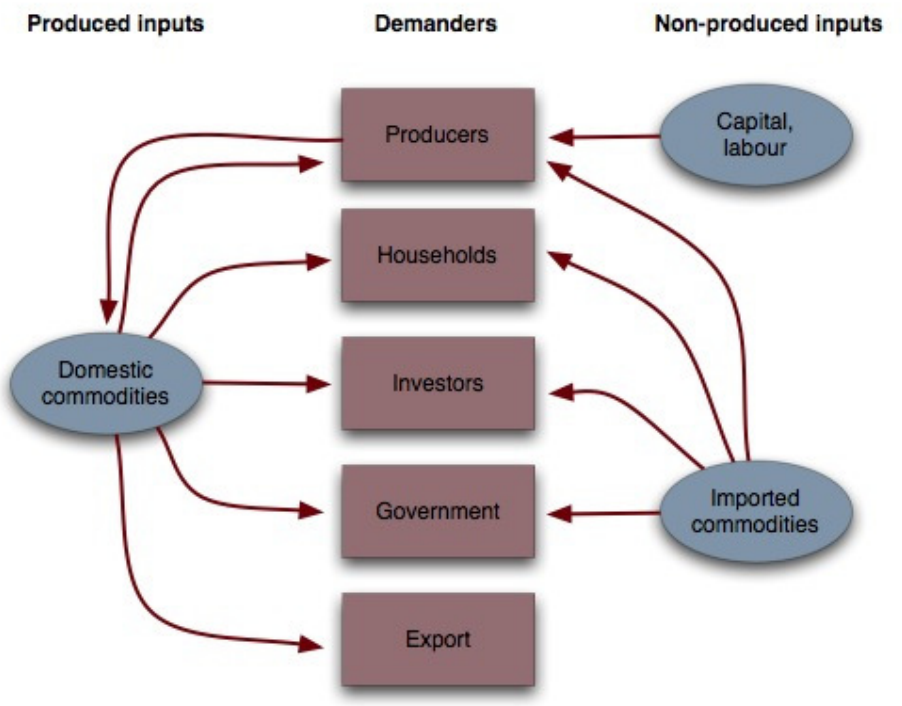
The MMRF database is comprised of detailed input-output tables for each state and territory as well as a set of government fiscal accounts. Each of the eight input-output tables details the core cost structure of each region specific industry and how each industry in each state economy is linked to other industries within that state and other states. Further, they show the flow of goods through the economy and the final demands of the principal economic agents.

## B.3 Structure of the model

The core structure of the MMRF model is illustrated in Figure B.1. Producers use primary factors (labour, land and capital), region specific intermediate goods, and imports to produce domestic commodities. Domestic commodities and imported commodities flow to households, investors, and governments. In addition a proportion of domestic commodities flow to foreigners as exports. As well as demand schedules, the MMRF model has a detailed government budget and a set of regional labour markets.

Figure B.1

**STRUCTURE OF THE MMRF MODEL**




Source: Allen Consulting Group analysis, 2010, adapted from Monash.

The MMRF model is built on the core assumptions of neoclassical economics. Consumers aim to maximise utility within a fixed budget constraint, while firms select the mix of inputs that minimises costs for their level of output. This optimising behaviour determines the regional supplies and demands of commodities and the demand for primary factors within the model. Labour supply at the national level is governed by demographic factors and national capital supply is determined by rates of return. Both labour and capital can cross regional borders such that each region's stock of productive resources reflects relative employment opportunities and relative rates of return.

Assumptions regarding the economic behaviour of agents together with detailed input-output tables for each of the eight regions are linked by mathematical equations. This allows for second round impacts or feedback responses to be accounted for in the modelling framework. For instance, it allows for price response adjustments across all industries and factors. In this way, the results detail the actual effect of a change on the entire economy, not just within the region or industry that is directly affected. This allows a more sophisticated insight into policy analysis than is possible from partial equilibrium analysis or input-output analysis.

The model is driven by the assumption of competitive markets. That is, all markets clear and there exists equality between the producer's price and marginal cost for each sector in each region (all markets clear with the exception of the labour market). The purchaser's price and producer's price differs by the size of any government taxes and associated margins. All government taxes are levied as ad valorem sales taxes on commodities. Margins are additional costs associated with transport or retail trade required for market transactions.

### *Aggregate demand*

Demand for goods from households, investors, governments and foreigners together comprise aggregate demand as represented in the equation below.

$$Y = C + I + G + (X - M)$$

Where:

- $Y$ is aggregate demand;
- $C$ is household consumption;
- $I$ is investment;
- $G$ is government spending;
- $X$ is exports; and
- $M$ is imports.

The components of aggregated demand and how they are represented within the model are discussed below.

### *Household demand*

There exists a utility maximising representative household in each of the eight regions. Households consume bundles of goods from either domestically produced or imported commodities. Domestically consumed goods are a combination of goods from the eight regions. Total household demand is disaggregated into essential goods and luxury goods, as represented in the equation below.

$$X_i = X_i^{Sub} + X_i^{Lux}$$

Where:

- $X_i$ is total household demand;
- $X_i^{Sub}$ is essential consumption; and
- $X_i^{Lux}$ is luxury consumption.

In MMRF it is assumed that a household will first purchase all essential goods before purchasing any luxury goods such that disposable income for luxury goods is a function of total income and the summed value of essential consumption.

$$Y^{Lux} = Y - \sum{}' P_i X_i^{Sub}$$

Where:

- $Y^{Lux}$ is income for luxury goods;
- $Y$ is total disposable income
- $P_i$ is price of good i; and
- $X_i^{Sub}$ is quantity of essential good X.

MMRF assumes a non-homothetic utility function (MMRF applies a Klein-Rubin utility function), which allows both income and relative prices to affect consumption.

### *Capital creation*

Investors in each regional sector combine inputs to generate capital. Investors are limited to the technology set that is available for production in that regional sector. Rates of return are used as a signal for capital investment or disinvestment.

### *Government demands*

There are nine governments represented in MMRF — the eight regional governments and a federal government — each demanding commodities. Government demands are either imposed on the model or determined endogenously by setting government expenditure rules. For example, government expenditure could be linked to aggregate consumption.

### *Foreign demand*

Most exports can be categorised as either traditional exports, non-traditional exports or tourism exports. Demand for traditional exports is characterised by a downward sloping demand curve and associated assumptions regarding foreigners' preferences for Australian goods. Each regional sector has an associated export market, which faces a downward sloping foreign demand curve. It is assumed that the foreign demand schedules are specific to the regional sector; as such movement in world prices can differ across different regions.

The demand for non-traditional export goods is driven by the average price of the collective non-traditional export bundle. In the MMRF database, non-traditional exports account for two per cent of total national exports and include: electricity generation, gas and water, construction, trade services, rail transport and dwellings.

Within MMRF, it is assumed that the tourism sectors — hotels and cafes, road transport, air transport and other services — do not face their own individual demand schedules. Rather, foreigners purchase a holiday bundle, the quantity of which is determined by the average price of the tourism goods.

#### *Demands for inputs used in production*

Producers in each region utilise primary factors — land, labour and capital — intermediate goods and imported goods to produce domestic commodities. Producers are assumed to choose the mix of inputs that minimises costs for a given level of production. The MMRF model assumes a multi-stage nested structure of production. At the first stage the optimal combination of region specific intermediate goods and the optimal combination of occupational specific labour is selected. At the second stage, producers make decisions regarding the optimal combination of the three primary factors and the combination of imported and domestically sourced goods. Finally, producers combine primary inputs and intermediate goods to produce a level of output at minimum cost.

### B.4 Government finances

MMRF contains a set of equations detailing government revenues and government expenditures for each government. Government revenues are comprised of income taxes, sales taxes, excise taxes, taxes on interregional trade and receipts from government assets. Government expenditures include — as detailed above — expenditure on commodities as well as transfer payments to households. In addition, for the Federal government there is a set of equations describing fiscal transfers to the states.

### B.5 MMRF dynamics

There are two main types of inter-temporal links incorporated into MMRF: physical capital accumulation and lagged adjustment processes.

#### *Physical capital accumulation*

It is assumed that investment undertaken in year t becomes operational at the start of year t+1. Thus, given a starting point value for capital in t=0, and with a mechanism for explaining investment through time, the model can be used to trace out the time paths of industry capital stocks.

Capital stock in industry *i* in state/territory *s* in year t+1 is determined by the equation below.

$$K_{i,s}(t+1) = (1 - DEP_{i,s}) * K_{i,s}(t) + INV_{i,s}(t)$$

Where:

- $K_{i,s}(t)$ is the quantity of capital available in industry *i* located in state/territory *s* at the start of year *t*;
- $INV_{i,s}(t)$ is the quantity of new capital created through investment for industry *i* in state/territory *s* during year *t*; and
- $DEP_{i,s}$ is the rate of capital depreciation in industry *i*, treated as a fixed parameter.

Investment in industry *i* in state/territory *s* in year *t* is explained via a mechanism that relates investment to expected rates of return. The expected rate of return in year *t* can be specified in a variety of ways. In MMRF two possibilities are allowed: static expectations and forward-looking model-consistent expectations. Under static expectations, it is assumed that investors take account only of current rentals and asset prices when forming current expectations about rates of return. Under rational expectations the expected rate of return is set equal to the present value in year *t* of investing $1 in industry *i* in state/territory *s*, taking account of both the rental earnings and depreciated asset value of this investment in year t+1 as calculated in the model.

#### *Lagged adjustment processes*

One lagged adjustment process is included in MMRF. This relates to the operation of the labour market in year-to-year simulations.

In comparative static analysis, one of the following two assumptions is made about the national real wage rate and national employment:

- the national real wage rate adjusts so that any policy shock has no effect on aggregate employment; or
- the national real wage rate is unaffected by the shock and employment adjusts.

MMRF's treatment of the labour market allows for a third, intermediate position, in which real wages can be sticky in the short-run but flexible in the long-run and employment can be flexible in the short-run but sticky in the long-run. For year-to-year simulations, it is assumed that the deviation in the national real wage rate increases through time in proportion to the deviation in aggregate employment from its baseline-forecast level. The coefficient of adjustment is chosen so that the employment effects of a shock are largely eliminated after about ten years. This is consistent with macroeconomic modelling in which the Non Accelerating Inflation Rate of Unemployment (NAIRU) is exogenous.

### B.6 Closure assumptions of MMRF

In MMRF, there are more endogenous variables than the number of equations. For the model to generate a solution, the number of endogenous variables must match the number of equations. Hence, some endogenous variables are set to be exogenous to ensure the number of endogenous variables matches the number of equations.

The desired economic environment/assumption for the policy scenario determines the choice of exogenous variables. These choices are also known as the closure assumptions. The most common closure assumptions are the long-run, short-run economic closure and fiscal closure.

#### *Short-run closure*

In the short-run, the economy is less able to respond to policy changes, as prices and wages are sticky (or fixed). Labour market (in terms of employment) is flexible and unemployment rate can be above or under its natural rate. Capital stock is fixed in the short-run, and investment responds to changes in rates of return.

### *Long-run closure*

The key elements of a typical long-run economic environment are:

- At the national level, long-run employment is determined by demographic factors (birth and death rates, the level of international migration, etc.). Additionally, the unemployment rate reverts to its natural rate or NAIRU in the long-run. Therefore, the national employment figure is fixed. However, labour is perfectly mobile across industry and states, thus there can be changes in industry and state employment.
- Labour market adjusts via changes in real wages.
- Capital stock in each industry adjusts to equilibrate its expected and actual rates of return on capital. The baseline expected rates of return are determined by values in the MMRF database. Industries' demands for investment goods are linked by an exogenous investment/capital ratio to changes in their capital stock.
- Nominal household consumption in each region is a constant share of post-tax household disposable income.

### *Fiscal closure*

The role of government also plays a part in determining the impacts of a simulation. A typical fiscal closure will have the following assumptions:

- real government consumption (Commonwealth and States) is fixed; and
- government budget balances (Commonwealth and States) are fixed, via changes in the fiscal item 'Government transfers to households'.

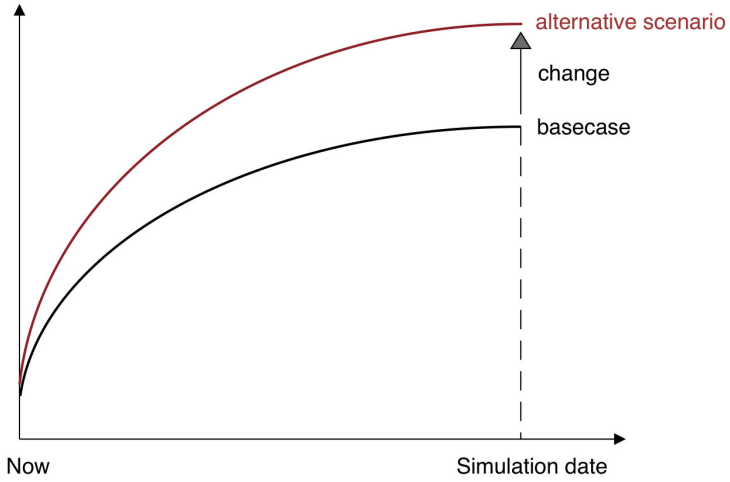
## B.7 Interpretation of MMRF simulations

The MMRF can be solved in comparative static or recursive dynamic modes. Comparative static modelling shows the effect of a policy shock only. That is, it answers 'what happens when this happens?' without stating the adjustment process.

A dynamic CGE model would provide answers on the forecast structure of the economy under the baseline and the alternative case. It provides an explicit baseline over time against which the impact of a policy change can be compared. The model could incorporate more up to date data and the timing and policy paths are clear.

Figure B.2

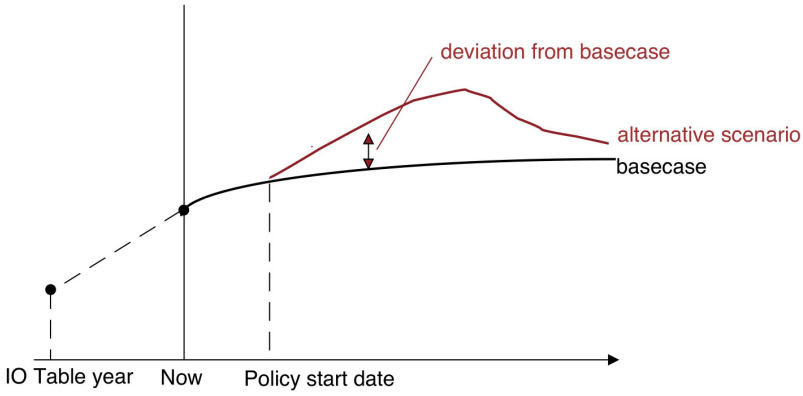
**COMPARATIVE STATIC INTERPRETATION OF RESULTS**




Source: Allen Consulting Group analysis, 2010.

Figure B.3

**DYNAMIC INTERPRETATION OF RESULTS**




Source: Allen Consulting Group analysis, 2010.

## B.8 Other applications of MMRF

Numerous applications of MMRF have been commissioned by commercial and government organizations. Some of these studies simulated:

- the regional effects of national policies;
- the effects of region-specific infrastructure projects;
- the effects of alternative regional forestry policies;
- the effects of different policies to reduce Australian emissions of CO2 in line with Kyoto commitments.

Recently, MMRF was used by the Australian Government to model the potential impacts of the Carbon Price Mechanism to capture interactions between different sectors of the economy and among producers and consumers. Treasury modelled a range of scenarios, which explored different environmental targets and design features in a carbon pricing scheme.

The modelling included two top-down, computable general equilibrium (CGE) models developed in Australia: the Global Trade and Environment Model (GTEM) and the Monash Multi-Regional Forecasting (MMRF) model. These CGE models are economy-wide models that capture the interactions between different sectors and among producers and consumers. GTEM models the global economy. MMRF models the Australian economy with state and territory level detail. A series of bottom-up sector-specific modelling for electricity generation, road transport, agriculture and forestry complement these CGE models.

The results from each of the models were drawn together into an integrated set of projections that were consistent at the macroeconomic level and sufficiently detailed in key sectors to provide insights into the likely transformation of the Australian economy under carbon pricing. The economic impacts of carbon pricing were examined at global, national, sectoral and household levels.

MMRF has also been widely used to assess economic impacts across a variety of industries.

- Chevron (2005) used MMRF to evaluate the impact of the Gorgon Development. Deloitte Insight Economics used MMRF to assess the potential effects of the Australian uranium industry of the economy.
- Verikios and Zhang (2011) used to MMRF to estimate the direct and indirect effects on household income of gas industry changes.
- The Centre for Policy Studies (2011) used MMRF to describe the economic impact of large increases in the price of oil on Tasmania.
- In 2010 the Allen Consulting Group has used MMRF to assess the contribution of scientific institutes to the Queensland and national economies.

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