Appendix A

Economic Evaluation

PACIFIC **ALUMINIUM**

Economic impacts of Katherine to Gove Gas Pipeline

Prepared for Pacific Aluminium

1 April 2013

ACIL Tasman

Economics Policy Strategy

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Glossary

Billion	$1x10^9$ (or 1,000 million) as per the US convention.
Bcf	Billion cubic feet.
boe	Barrel of oil equivalent.
CGE	Computable general equilibrium.
CO_2-e	Carbon dioxide equivalent. A unit of a greenhouse gas (such as methane or nitrous oxide, for example) converted to carbon dioxide equivalent units using the relative global warming potential (or GWP) of the gas relative to carbon dioxide. All conversions in this report use the 100-year GWP's that are to be used by countries for reporting their emissions to the UNFCC.
FTE	Full time equivalent.
GDP	Gross Domestic Product. Equivalent to economic output at the national level.
GJ	Gigajoule.
GRP	Gross Regional Product. Equivalent to economic output at the regional level.
GSP	Gross State Product. Equivalent to economic output at the state level.
I-O	Input Output.
KGGP	Katherine to Gove Gas Pipeline project. This project is considered to include the pipeline development and the associated gas conversion works required at Pacific Aluminium's alumina refinery.
NPV	Net present value. The value of a future stream of income (or expenses) converted into current terms by an assumed annual discount rate. [It should be noted that values converted into real 2012-13 terms already account for the impact of inflation.]
PJ	Petajoule. Equivalent to 1,000 TJ or 1,000,000 GJ.
RGNDI	Real Gross National Disposable Income. A measure of the total volume of goods and services available for consumption or investment (including investment to replace depreciated assets).

SSD	Statistical sub-division.
Tcf	Trillion cubic feet
TJ	Terrajoule. Equivalent to 1,000 GJ.
Trillion	$1x10^{12}$ (or 1,000 billion) as per the US convention.

Executive summary

This report analyses the potential economic impacts associated with Pacific Aluminium's proposed Katherine to Gove gas pipeline project and gas conversion (the KGGP Project) and the consequent impacts on the Gove alumina and bauxite operations in Nhulunbuy. The KGGP project will enable the Gove operations to convert to gas as its major energy source, which will achieve a significant cost saving compared to their current use of expensive fuel oil.

The report finds that if the KGGP Project does not proceed, alumina refining operations will cease but the bauxite operations will continue by increasing exports. The KGGP Project is therefore fundamentally about improving the economic viability of the operations thereby maintaining the jobs and economic activity within the East Arnhem region.

The report finds that the KGGP Project will deliver significant economic benefits to residents within the East Arnhem region.

Compared to the Reference Case, the KGGP Project would involve:

- Construction of a 603km 12-inch lined gas pipeline between Katherine and Gove
- Additional capital expenditure of approximately $1.1 billion (in 2012-13 dollars)
  - This will fund the construction of the pipeline, conversion of the Gove operations to use gas instead of fuel oil as well as additional ongoing capital expenditure to maintain the operations
    - … 34.2 per cent of the total capital expenditure is expected to be directly spent on goods and services purchased from Northern Territory with 9.2 per cent from the East Arnhem region.
- Direct employment of 819 full time equivalent employee years for the construction of the pipeline, most of which will occur in 2014 as the pipeline is laid
  - Northern Territory residents are expected to fill 340 FTE jobs, with 30 from the East Arnhem region, with the remaining positions filled from the rest of Australia
- An additional 19 ongoing jobs related to the pipeline operations and maintenance plus an additional 525 on-site jobs at the Gove Operations, the majority of which will be workers living in the East Arnhem region.

Gas availability

There are very large resources of conventional and unconventional oil and gas resources in the Northern Territory region. In the past, gas developments

have been hampered by the small local (Darwin) market. Supply of gas to Gove will effectively double the size of the domestic gas market in the Northern Territory, providing greater opportunities for onshore gas producers to monetise discoveries and so incentivising further exploration and development activity. Large offshore fields such as Greater Sunrise, Evans Shoal and Abadi will almost certainly require a foundation export project (LNG or gas-to-liquids) to justify development, with a side-stream of gas potentially available to the domestic market. However smaller fields such as Petrel and Tern are close to the existing Blacktip production facilities and infrastructure and may offer a domestic supply option in the future. Intense activity in exploration for unconventional oil and gas is likely to have a long lead time, but could provide additional supply options beyond the term of the initial ten-year supply arrangement for Blacktip gas.

Economic impacts

The regional economic impacts of the KGGP Project have been assessed using the *Tasman Global* computable general equilibrium (CGE) model of the Australian and world economies.

ACIL Tasman's analysis indicates that, over the period 2013 to 2036, the KGGP Project will increase the real economic output of:

- East Arnhem by a cumulative total of $5,687 million, relative to the reference case (with a net present value of $2,382 million, using a 7 per cent real discount rate)
- The Northern Territory economy (i.e. real GSP) by a cumulative total of $8,792 million, relative to the reference case (with a net present value of $3,629 million, using a 7 per cent real discount rate)
- Australia (i.e. real GDP) by a cumulative total of $8,920 million, relative to the reference case (with a net present value of $3,667 million, using a 7 per cent real discount rate).

This is a substantial amount of economic activity generated by a single project. To place these projected changes in perspective, the discounted present values (using a 7 per cent discount rate) is equivalent to 19.5 per cent of Northern Territory's current GSP with the average annual increase over the forecast period equivalent to 2.0 per cent of current GSP.

More importantly than the projected change in economic output, is the projected change in real income. Compared to changes in real economic output, real income is a better measure of the changes in the economic welfare of residents as it accounts for income transfers (including profit repatriation) and any changes in terms of trade. It is essentially the income that is available to the residents of a region to save or to spend.

Over the period 2013 to 2036, the KGGP Project is projected to increase the real income of:

- East Arnhem by a cumulative total of $1,488 million, relative to the Reference Case (with a net present value of $570 million, using a 7 per cent real discount rate)
- the Northern Territory by a cumulative total of $2,729 million, relative to the reference case (with a net present value of $1,098 million, using a 7 per cent real discount rate)
- Australia by a cumulative total of $6,188 million, relative to the reference case (with a net present value of $2,481 million, using a 7 per cent real discount rate).

To place these numbers in perspective, the discounted present values (using a 4 per cent discount rate) are equivalent to a one-off increase in the *average* real income of all current residents of the East Arnhem region and Northern Territory of approximately $3,500 and $5,200 per person, respectively.

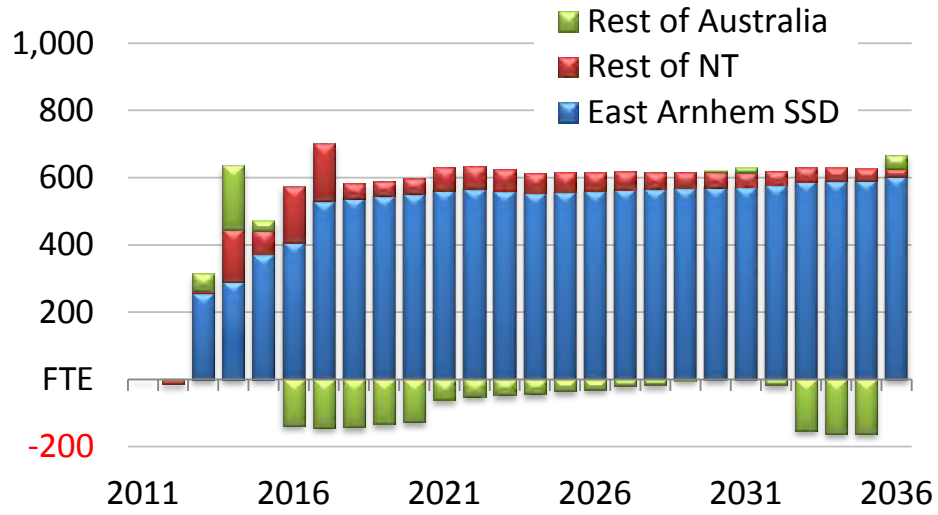
For the purposes of this analysis, the unemployment rate has been assumed to be unchanged relative to the reference case. The additional labour demand generated by the project has been assumed to be met by a combination of increased use of fly in fly-out/drive in drive out workers, increasing the amount of inward migration as well as the participation rate and average hours worked of the existing workforce.

The projected employment impacts are presented in Figure ES1. In summary, over the period 2013 to 2036, the KGGP Project is projected to increase employment in the:

- East Arnhem region by a total of 12,654 employee years[1] relative to the reference case (or an average of 506 FTE jobs a year)
- Northern Territory by a total of 14,149 employee years relative to the reference case (or an average of 566 FTE jobs a year)
- Australia by a total of 13,010 employee years relative to the reference case (or an average of 520 FTE jobs a year).

[1] An 'employee year' is defined to be equivalent to one full time job held for a year or, for example, 0.5 of a full time job held for two years.

Figure ES 1 **Projected change in employment by region due to the KGGP Project, relative to the Reference Case**



Note: FTE = full time equivalent.

Source: ACIL Tasman modelling

1 Introduction

This report has been prepared for Pacific Aluminium. It summarises the results of ACIL Tasman's assessment of the economic impacts arising from the construction of the proposed Katherine to Gove gas pipeline project and the consequent impacts on the Gove alumina and bauxite operations in Nhulunbuy (the KGGP Project).

The analysis evaluates the economic impacts of the KGGP Project in the context of a 'Reference Case' scenario which includes a carbon price in Australia from mid 2012 consistent with the Clean Energy Future legislation. The modelling has been undertaken to provide an estimate of the potential economic benefits to the locally affected region (the East Arnhem region), the Northern Territory and to Australia.

The impacts are assessed by means of economic modelling and should be considered in conjunction with any consequential social or environmental impacts of the KGGP Project.

In what follows:

- Chapter 2 provides a description of the framework used for undertaking this analysis
- Chapter 3 provides an overview of the key elements of the KGGP Project used for the economic modelling
- Chapter 4 provides an overview of the regional gas market and the availability of gas to support the KGGP Project
- Chapter 5 summarises the direct and indirect economic impacts of the KGGP Project.

2 Methodology

This economic impact assessment uses a multi-faceted methodology which includes an analysis of available statistics on the regions of interest, a review of relevant literature and reports pertaining to the regions of interest and economic modelling. The economic modelling uses *Tasman Global*, ACIL Tasman's computable general equilibrium (CGE) model.

2.1 Framework of analysis

The economic impacts of a policy, project or other activity can be estimated using a variety of economic analysis tools, with the most often utilised generally being input-output (I-O) multiplier analysis and computable general equilibrium (CGE) modelling. The selection of the right tool is critical to the accuracy of the estimated impacts and depends upon the characteristics of the project/industry. Sometimes a range of tools are required.

Fundamentally, although various aspects of a policy or project – such as the number of jobs or the size of the investment expenditure – are of relevance to certain stakeholders, the key aggregate measure of the impact of a project is the extent to which the total wealth of the economy has changed as a result of the policy or project[2]. Typically this is measured at the national level by real gross national disposable income (RGNDI), although real gross domestic product (GDP) and consumer surplus (among others) can also be important aggregate measures depending on the nature of the policy or project being analysed.

The main factors that need to be considered when analysing the economic impacts of a project or policy include:

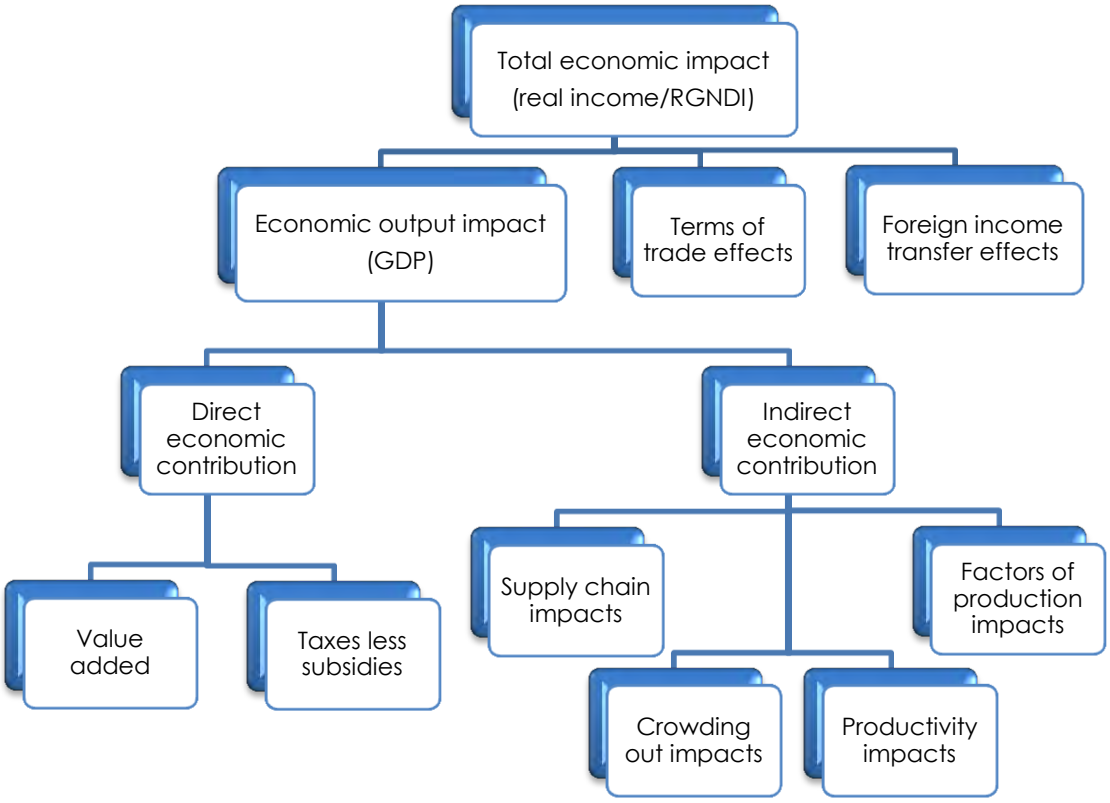
- the direct and indirect contribution to the economy as a result of the activities associated with the project
- any 'crowding out' implications, which is where the use of scarce resources in one project means that resources are diverted from other productive activities, potentially 'crowding out' those activities by delaying or preventing them from occurring
- any productivity effects generated as a direct result of the policy or project activities – particularly any enduring productivity changes or productivity spillovers to other activities not directly associated with the project or policy
- any changes to the factors of production in the economy

[2] Analysis of any non-market impacts (such as the loss of biodiversity, changes in air quality, social justice implications, etc.) may also be relevant in assessing the full implications of a project or policy. However, these are outside of the scope of this analysis.

- any welfare implications associated with changes in terms of trade or foreign income transfers
- whether there is a dynamic element to the size of any of the above effects (due to different phases of the project for example).

Figure 1 shows these components graphically. Some of these effects may have negligible impact while others may be very significant and an understanding of the relative size of these effects helps determine the most appropriate tool(s) for the analysis.

Figure 1 **Estimating the economic impact of a project or policy**



Source: ACIL Tasman

For many projects, static estimates of the direct economic contribution and supply chain implications can be obtained through the use of I-O multipliers. Estimating the size of other components using multiplier techniques is either not possible or very complex, as is estimating the economic impacts through time. In contrast, most CGE models are able to estimate all of the components shown in Figure 1 with dynamic CGE models able to estimate the impacts through time. The greater complexity of CGE models generally increases the cost of undertaking analysis compared to using I-O multipliers, but it enables a much broader range of economic impacts to be considered within a single framework.

2.2 The Tasman Global CGE Model

For this analysis, ACIL Tasman's CGE model, *Tasman Global*, has been used to estimate the impacts of the construction and operation activities associated with the development of the Katherine to Gove Gas Pipeline. *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. More detail of the *Tasman Global* model is provided in Appendix A.

CGE models mimic the workings of the economy through a system of interdependent behavioural and accounting equations which are linked to an input-output database. These models provide a representation of the whole economy, set in a national and international trading context, starting with individual markets, producers and consumers and building up the system via demands and production from each component. When an economic shock or change, such as the construction of the KGGP, is applied to a model, each of the markets adjusts according to the set of behavioural parameters which are underpinned by economic theory. The generalised nature of CGE models enables a much broader range of analysis to be undertaken (generally in a more robust manner) compared to I-O multiplier techniques, which are also often applied in economic impact assessments.

This theory and the use of the models are generally well understood and respected by decision makers from various Australian Governments. CGE can be a powerful tool for understanding the implications of a project to affected regions, the state and nationally as the models recognise not only the direct and second round impacts but the third and fourth round etc. impacts of a project.

2.2.1 Including the affected regions in the model database

The database which underpins the Tasman Global model contains a wealth of sectoral and regional detail. The foundation for this information is the input-output tables that underpin the database. Industries and regions in the model can be aggregated or disaggregated as required for a specific project. For this project the model's database has been aggregated to:

- East Arnhem statistical sub-division (SSD), Rest of Northern Territory and Rest of Australia.
- 39 industries/commodities (see Table 1).
- 97 occupations as those specified at the 3-digit level (or Minor Groups) under the Australian New Zealand Standard Classification of Occupations (ANZSCO) (see Table A2).

The aggregation was chosen to provide the maximum detail relevant for the key industries likely to be affected by the KGGP Project.

Table 1 **Industry/Commodity aggregation used in *Tasman Global* modelling**

	Industry/Commodity		Industry/Commodity
1	Crops	21	Textiles, clothing, footwear
2	Livestock	22	Wood, pulp and paper
3	Forestry	23	Metal products
4	Fishing	24	Transport equipment and parts
5	Processed food	25	Electronic equipment
6	Coal	26	Machinery and equipment nec
7	Oil	27	Other manufacturing
8	Gas	28	Water
9	Electricity	29	Construction
10	Petroleum & coal products	30	Trade services (includes all retail and wholesale trade, hotels and restaurants)
11	Iron & steel	31	Other transport
12	LNG	32	Water and air transport
13	Iron ore	33	Communications services
14	Bauxite	34	Financial services nec
15	Other mining	35	Insurance
16	Alumina	36	Other business services
17	Primary aluminium	37	Recreational and other services
18	Other nonferrous metals	38	Government services (including public administration and defence)
19	Nonmetallic minerals (including cement, plaster, lime, gravel)	39	Dwellings
20	Chemicals, rubber, plastics		

Notes: NEC = not elsewhere classified. Excludes micro-industries developed specifically for this analysis.

Data source: ACIL Tasman aggregation

The geographic boundaries of the East Arnhem SSD are presented in Figure 2. For the purposes of constructing the East Arnhem SSD economy within the CGE database, we relied on the data collected from ABS in conjunction with detailed information supplied by Pacific Aluminium about the Gove operations.

Figure 2 **East Arnhem statistical subdivision**

Data source: ABS and ACIL Tasman

2.2.2 Micro industry approach

To accurately assess the economic impacts or economic contribution of a major project, such as the KGGP Project, it must be accurately represented in the model's database. An accurate representation can be guaranteed by establishing the proposed project as a new 'micro' industry in the database.

The micro industry approach is so called because it involves the creation of one or more new, initially very small, industries in the *Tasman Global* database. The specifications of each of the micro industry's costs and sales structures are directly derived from the financial data for the project to be analysed. At the outset, the new industry is necessarily very small so that its existence in the *Tasman Global* database does not affect the database balance or the "business-as-usual" reference case outcomes.

Using the micro industry approach for project evaluations is the most accurate way to capture the detailed economic linkages between the project and the other industries in the economy. This approach has been developed by ACIL

Tasman because each project is quite unique relative to the more aggregated industries in the *Tasman Global* database.

Consequently, in addition to the 39 industries identified in Table 1, the construction and operation phases of the KGGP project have been identified as separate industries with their own input cost structure, sales, employment, tax revenues and emissions based on detailed information provided to ACIL Tasman from Pacific Aluminium.

Tasman Global includes a labour market module that allows for constrained movement between the regions of the Australian economy. For this project, due to its specialised nature, we have recognised that a significant proportion of the labour used in the construction and operation phases will be sourced from outside of the affected East Arnhem SSD.

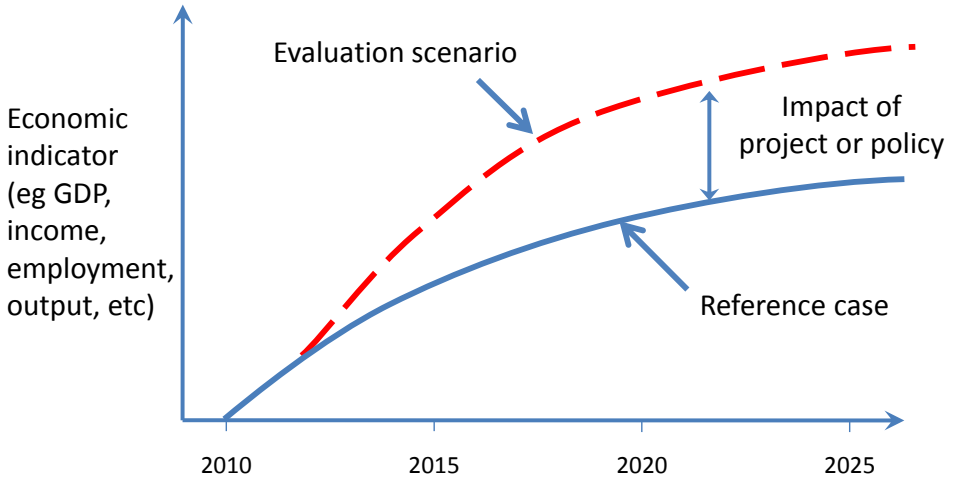
3 Project overview

The Gove facility is one of the world's leading bauxite mining and alumina processing operations. High grade bauxite is mined, refined into alumina and then shipped for smelting. The operation includes a mine, refinery, residue disposal area, steam power station, port and ship loading facilities. Power to the Gove refinery and mining operations is currently generated from imported fuel oil.

In recent years, the Gove operations have faced challenging global market conditions particularly related to high fuel oil prices and a low alumina price. The purpose of the KGGP Project is to enable the delivery of competitively priced gas which will provide a significant reduction in the operating costs thereby improving the economic sustainability of the operations.

Estimating the likely economic impacts of the KGGP Project requires a good understanding of what is likely to happen in the absence of the KGGP Project proceeding. This is called the Reference Case or Baseline. Once the economic baseline has been determined, a policy scenario which includes the KGGP Project is then constructed. Comparing the forecasts against the baseline provides an assessment of the economic contribution of the proposed development (see Figure 3).

Figure 3 **Illustrative scenario description**



Data source: ACIL Tasman

As a result of Pacific Aluminium's recently completed Strategic Review, in the absence of the KGGP Project it is planned that the alumina refinery operations would be mothballed in 2013 while the bauxite mining operations will continue with the material exported rather than being predominantly used for onsite

alumina production. This has been taken to be the Reference Case for the analysis in this report. For the purposes of this analysis, it has been assumed that a gas conversion scenario is not possible and therefore the alumina plant moves to closure from 2016.

In terms of understanding the economic impacts of the KGGP Project, it is useful to consider that it is fundamentally about maintaining the jobs and economic activity within the East Arnhem region. The project will achieve this be returning the alumina refining operations to being financially viable by substantially reducing the cost of energy. By maintaining the operations, the KGGP Project will therefore prevent people losing their jobs in the local economy and will prevent current workers and their families leaving the region to seek work elsewhere in Australia. There will be a further impact on the Australian economy through the increased use of domestic gas resources in place of the imported fuel oil currently used for the Gove operations.

3.1 Capital expenditure

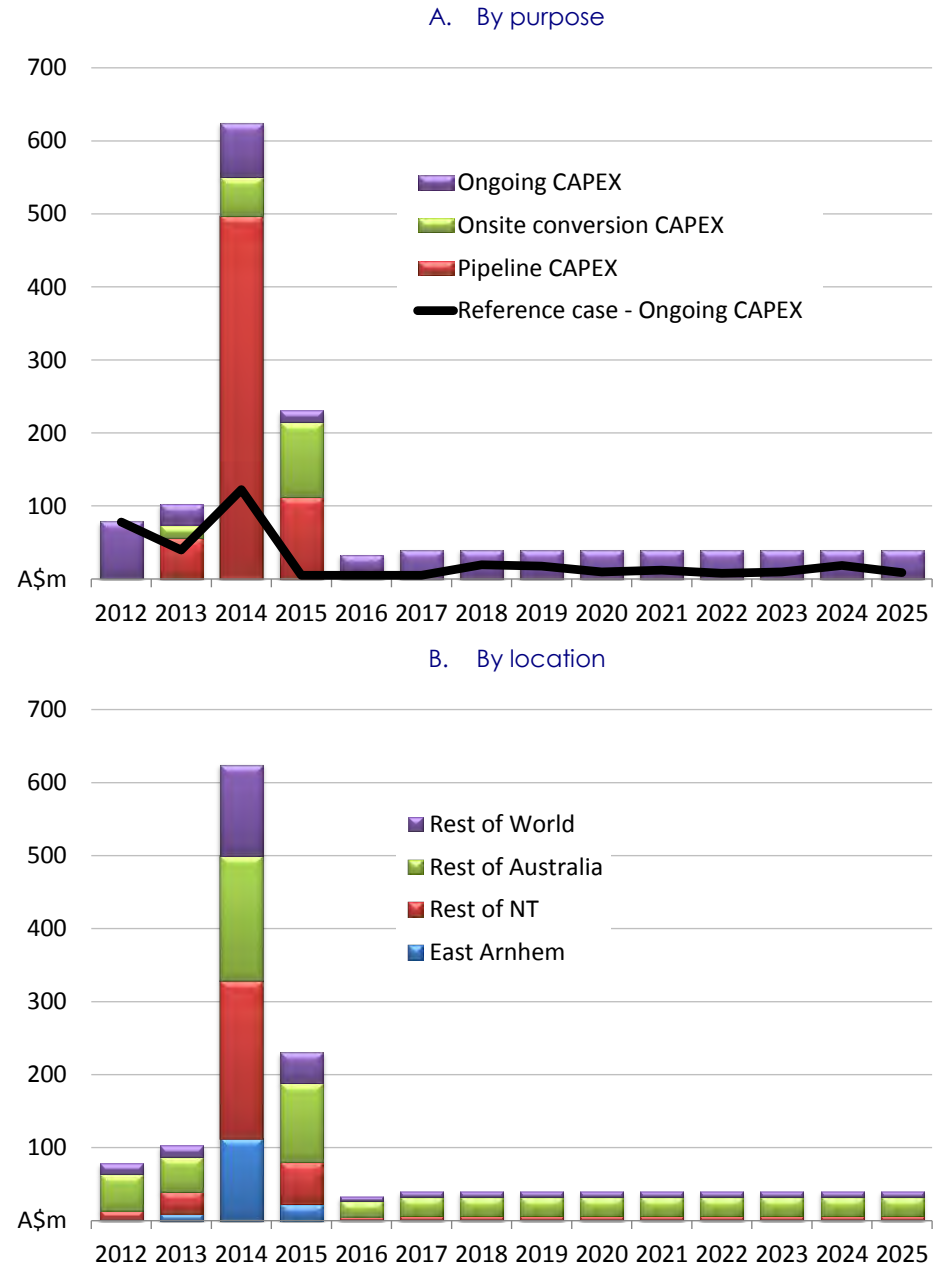
Figure 4 summarises the expected annual capital expenditure as a result of the KGGP Project by purpose as well as by location. The expected annual capital expenditure in the Reference Case is shown in Figure 4A.

As part of the operations, ongoing capital expenditure over the next twenty years is expected to total approximately $350 million under the Reference Case. With the KGGP Project, total capital expenditure over the next twenty years is expected to be $1.63 billion, comprising:

- $786 million ongoing capital expenditure
- $667 million for the Katherine to Gove pipeline
- $179 million to convert the Gove operations from operating on fuel oil to gas.

Approximately 34 per cent of total capital expenditure with the KGGP Project is expected to be spent on Northern Territory supplied labour, goods and services, with 9.2 per cent to be spent in the East Arnhem region.

Figure 4 **Capital expenditure under the Reference Case and with the KGGP Project by purpose and by location**



Data source: ACIL Tasman based on data supplied by Pacific Aluminium.

The majority of the employment related to the pipeline will occur in 2014, with an estimated 762 of the total 819 FTE jobs occurring in that year (see Table 2). In terms of the labour force requirements, pipeline construction requires skilled teams using specialist equipment. The on-site workforce for the construction is highly mobile and is moving through a remote region and therefore they will be housed in purposed built, mobile construction camps. The nature of the project therefore tends to have little scope for direct employment opportunities by local residents. Consequently, Pacific

Aluminium and the pipeline contractor are expecting only 30 FTE jobs of the total are likely to be filled using East Arnhem labour. These positions are principally labourers and drivers with appropriate heavy vehicle licences. Given the experience with other pipeline projects available in the rest of Northern Territory (as well as within the owner's team), Northern Territory residents are expected to fill 310 FTE jobs. These positions will be in a broad range of skill areas including labourers, licenced machinery operators, camp support (e.g. cleaning, catering, managing), supervisors, engineers, welders, wrappers, quality control, fauna handlers and cultural heritage controllers. The remaining workers are expected to be sourced from within Australia with no overseas workers expected to be required.

Table 2 **Pipeline construction employment by year and region**

	2013	2014	2015
	FTE Jobs	FTE Jobs	FTE Jobs
East Arnhem SSD	–	30	–
Rest of Northern Territory	16	281	14
Rest of Australia	12	451	6
Australia	**28**	**762**	**30**

Note: FTE = Full time equivalent
Data source: Pacific Aluminium

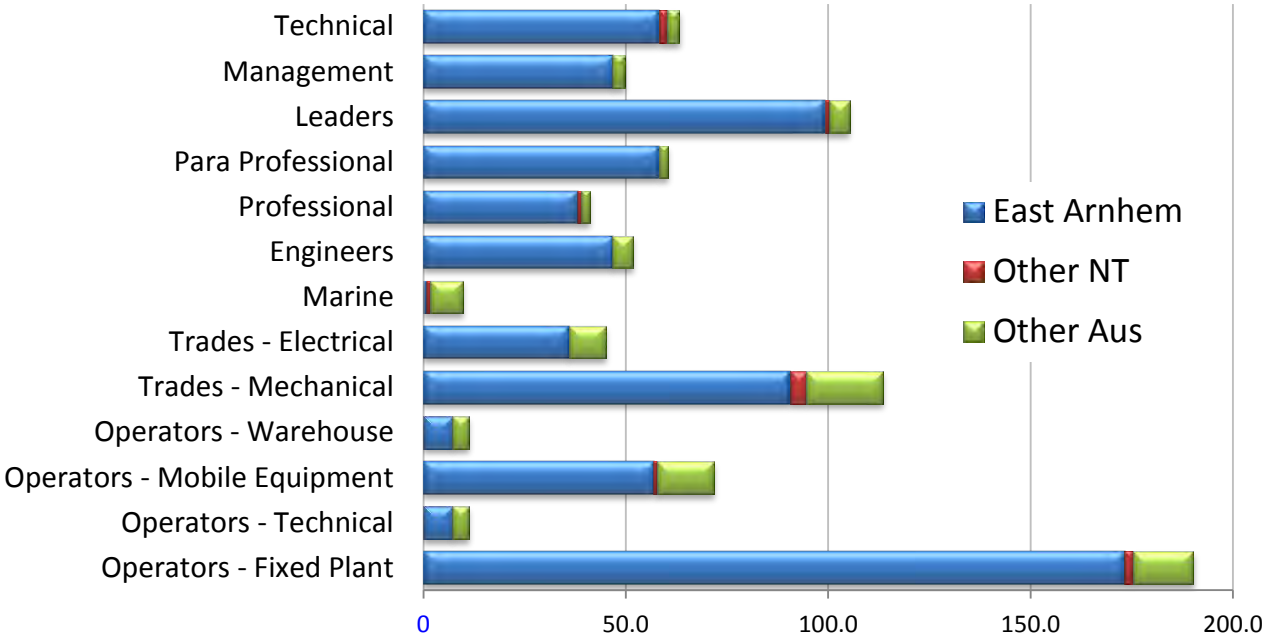
In the Reference Case scenario, cessation of alumina production and a decision to close the operation has been assumed to be taken in 2016. This is expected to require expenditure of $544 million through to 2020 associated with decommissioning and rehabilitation of the site back to its original condition. This expenditure will mean that a significant number of people will still be working at the site but the nature of the work will require significantly more expertise to be sourced from outside of the local and Northern Territory economies.

3.2 Operations

The KGGP Project will enable the alumina operations to access a significantly lower cost source of energy which will make the continuation of refinery operations viable. The on-site workforce with the KGGP Project is expected to total 824 from 2016 onwards compared to just 229 if the alumina operations are ceased under the Reference Case.

The expected positions within the operational workforce with the KGGP Project are presented in Figure 5. These are largely the same as current operations and are expected to remain constant from 2014 onwards.

Figure 5 **Positions required for Project Operations – with KGGP Project (2014 onwards)**



Data source: Pacific Aluminium

87 per cent of workers live in the East Arnhem region (principally in Nhulunbuy) with 1.5 per cent commuting to the site from the rest of Northern Territory (principally Darwin), with the remainder commuting from the rest of Australia (principally Queensland). As most workers live in permanent residences in Nhulunbuy and there is a lack of alternative local employment, closure of the refinery under the Reference Case will result in a substantial reduction in the local population as most employees (and their families) are highly likely to leave the region.

3.3 Northern Territory taxes and other payments

The Gove Operations currently pay royalties on their mining activities. The payments are a bespoke arrangement with bauxite exports attracting a higher royalty than alumina exports, thereby incentivising the conversion of bauxite to alumina. Under the present arrangements therefore, in the absence of the KGGP Project total mining royalty payments will increase as more bauxite is exported rather than refined locally. In contrast, with the KGGP Project, total royalties will increase initially as additional bauxite is exported but return to current levels as the bauxite is used for local alumina production.

Payroll taxes payable to the Northern Territory Government will decrease under the Reference Case as the future employment and payroll decline.

Pacific Aluminium makes a contribution to the local Yolngu traditional owners under a confidential agreement.

Depending on the source of any new gas fields that are brought on line in the future as a result of the KGGP Project (see Section 4), the Northern Territory Government may also obtain additional petroleum royalties.

3.4 Closure

At the end of the life of the Gove Operations, all infrastructure on the site will need to be decommissioned and dismantled with the affected sites rehabilitated back to their original condition. Based on the known bauxite reserves and the lease conditions, this is not expected to occur until at least 2035. As mentioned in Section 3.1, however, closure of the alumina refinery under the Reference Case will bring forward the decommissioning and rehabilitation of the refinery site to 2016. With the KGGP Project, the closure may also require decommissioning and rehabilitation of the pipeline and pipeline route[3]. The pipeline itself will have a designed operational life of 50 years.

The closure workforce needs will be identified as part of closure planning. The exact requirements will depend on circumstances at the time, especially the possibility of alternative demands for the pipeline infrastructure. Although the expected closure expenditure under the Reference Case scenario has been modelled in this analysis, the closure costs under the KGGP Project scenario have not been considered.

3.5 Financial viability of the KGGP Project

Due to confidentiality constraints, detailed information surrounding the financing and commercial arrangements has not been provided to ACIL Tasman. However, there is evidence that in the absence of a large reduction in the future price of fuel oil, there will be a significant reduction in the costs of operating the alumina refinery as a result of the KGGP Project.

Based on our analysis of the KGGP Project, the increased financial viability of the Gove operations as a result of the proposed pipeline and gas conversion should ensure the alumina operations continue throughout the forecast period. Consequently, it seems to be a reasonable expectation that the pipeline owners will receive a fair and reasonable return on their investment. The long term financial viability of the Gove operations as a result of the KGGP Project is further underpinned by the extensive low cost, high quality bauxite resource.

[3] It is likely the pipeline will remain buried as this is generally preferable to the environmental impact from the disturbance associated with excavating and removing the pipeline.

As discussed in Section 4, the availability of gas in the near term has been arranged. Similarly, the very large resources of conventional and unconventional gas in the Northern Territory implies that the availability of gas through to the end of the life of the project should not be an issue but will require new sources of supply to be connected to the existing gas network.

3.6 Profit repatriation and wealth transfers

An important issue in estimating the regional impacts of a project is determining how much of the returns to capital (i.e. profits) will remain within the region and how much will be transferred to other regions. This is an important issue as the more profits that stay within the local region, the greater the indirect benefits to that region. Conversely, the more profits that are transferred out of the region, the less the project will result in local economic benefits beyond the direct impacts.

The simplest estimate of the profits that will be retained in the region can be made based on the percentage of foreign ownership of the capital. General intervention by Australian governments, however, will also act to increase or decrease the amount retained in the region through various wealth transfers. For example, a fast growing region whose returns on capital are being distributed elsewhere may attract additional government spending (compared to average) to address various infrastructure and/or social service issues. Conversely, governments may reduce spending in a relatively wealthy region to aid development of a relatively poorer region (as per the principle underlying the progressive taxation or fiscal equalisation system, for example).

The precise future ownership of the KGGP Project (and of Pacific Aluminium) is, of course, impossible to predict over the life of the KGGP Project. At a national level, repatriation of profits and/or government induced wealth transfers from the project region to other regions within Australia, will generally only have a minor effect on the aggregate Australian economic indicator (such as GDP, GNP, employment etc.). The impacts at the regional level, however, will be significantly affected by the assumed level of profit and/or wealth transfers. Due to the complexity of forecasting or modelling such transfers, many economic impact assessments (particularly those using I-O multipliers) tend to simply assume that there are no profit or wealth transfers. Consequently, the regional impacts are typically grossly overstated compared to what is likely to happen.

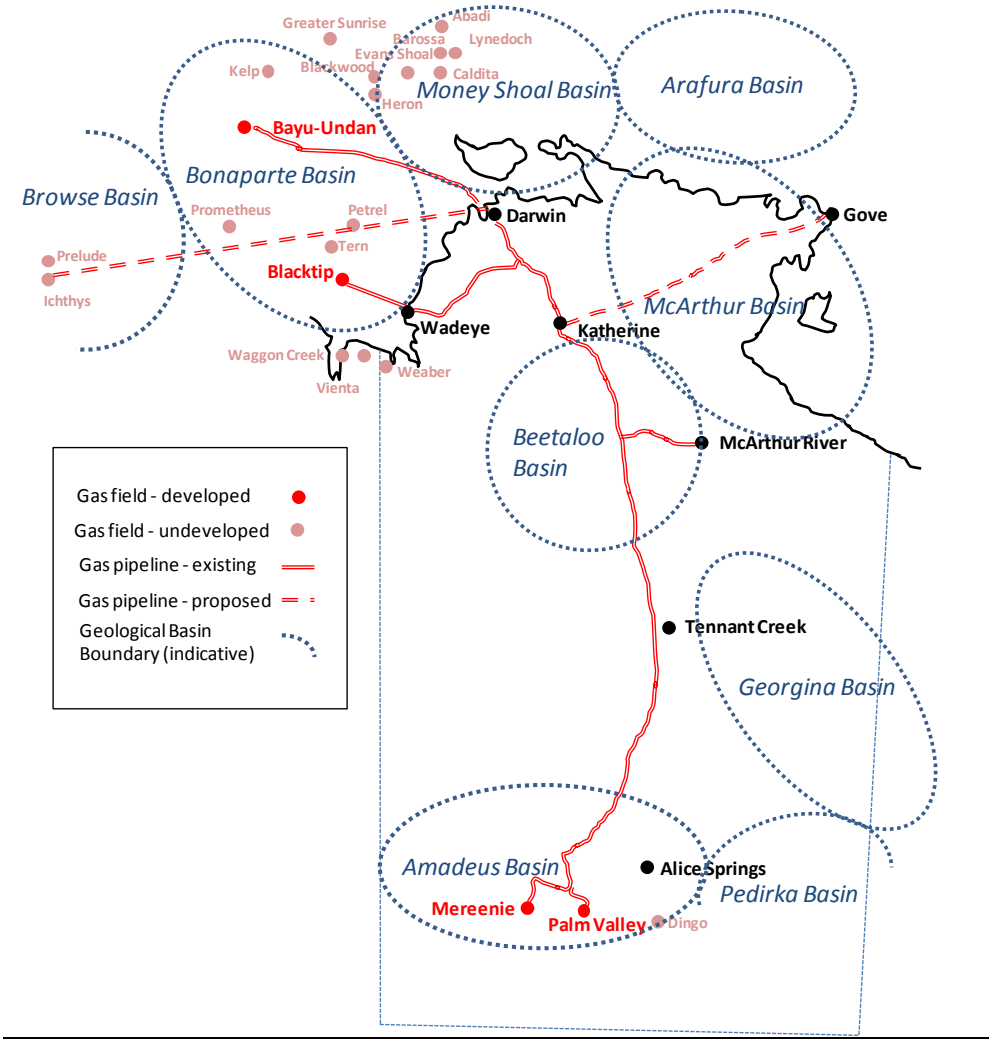
In the case of the KGGP Project analysed in this report, it has been assumed to be 40 per cent foreign owned, while ownership of the net profits generated by the KGGP Project to people living in each Australian region has been

assumed to be proportional to the population in each region. This is deemed to be a neutral assumption.

4 Availability of gas for existing and potential customers

This section examines the sources of gas that are, or are likely to be, available to service the Gove Alumina Plant and other potential customers using the Katherine to Gove Gas Pipeline. Relevant gas fields (developed and undeveloped) as well as prospective hydrocarbon basins are shown in Figure 6.

Figure 6 **Northern Territory gas fields and prospective basins.**



Source: ACIL Tasman compiled from various public sources

4.1 Initial Gas Supply to Gove

In February 2013, the Northern Territory Government agreed to provide sufficient gas to supply the Gove alumina refinery for a period of ten years drawing on PWC's supply entitlements under the Blacktip contract. It is anticipated that gas supply under this arrangement will commence in 2016.

In a media release dated 20 March 2013, the Minister for Resources and Energy and the Federal Member for Lingiari announced that Commonwealth's Export Finance and Insurance Corporation is conducting due diligence on a loan guarantee to support financing of the construction of the gas pipeline from Katherine to Gove.

The question which then arises is whether there is likely to be gas available after the initial ten-year supply arrangement with the Northern Territory Government so that the Katherine to Gove Pipeline can continue to deliver gas to Gove. The potential supply options are discussed in the following sections.

4.2 Current gas supply sources

The current sources of gas supply available for delivery into the Katherine – Gove Gas Pipeline are:

- Offshore Bonaparte Basin — Blacktip field
- Amadeus Basin — Mereenie and Palm Valley fields.

4.2.1 Blacktip field

The Blacktip field is located in shallow water 110km off the northern coast of Australia in the Timor Sea's Bonaparte Basin. The field is 100% owned and operated by Eni. The gas produced at Blacktip is transported through a 108km long, 18in diameter subsea pipeline to an onshore gas processing facility at Wadeye. It is then transported via the 286 km Bonaparte Gas Pipeline which connects to the Amadeus Gas Pipeline at Ban Ban Springs.

Blacktip commenced production in 2009, delivering gas to the Northern Territory's Power and Water Corporation (PWC) under a 25 year supply contract with supply rising to 18,000 boe/day (about 38 PJ/a) over the life of the contract. According to a notification by PWC to the Australian Competition & Consumer Commission in 2006[4], the supply of gas under the Blacktip Gas Supply Agreement (GSA) represented all of PWC's forecast

[4] http://transition.accc.gov.au/content/index.phtml/itemId/750462/fromItemId/729985/display/notification

demand for gas from 2012 until 2032. The same notification pointed out that the total contract quantity under the GSA exceeded Eni's then-current proved (P1) gas reserves in the Blacktip field, but also noted that there was potential for further recoverable gas to be found in prospects in Eni's tenements in and around Blacktip. The field has proven and probable (2P) reserves of around 900 bcf (960 PJ) of which about 625 PJ are committed under the PWC 25-year contract.

The Blacktip facilities and associated infrastructure are either readily expandable, or could already accommodate, very substantial supplies of gas to third parties.

4.2.2 Amadeus Basin

There are three identified gas fields in the Amadeus Basin, two of which (Mereenie, Palm Valley) are long established producers that supported development of the Amadeus Gas Pipeline to Darwin and underpinned Northern Territory gas supply for more than 20 years. The two fields provided the Northern Territory's total gas demand from 1983 to 2009, when the Blacktip field commenced operation. The other (Dingo) has not yet been brought into production.

The Mereenie and Palm Valley fields commenced production in the early 1980s and are still in production with significant remaining reserves and contingent resources. Remaining Proved plus Probable (2P) Reserves for the Mereenie and Palm Valley gas fields are approximately 150 PJ of gas.

The Mereenie field is located about 270 km west of Alice Springs and is one of Australia's largest onshore oil fields. A total of 62 wells have been drilled at Mereenie, and gas is gathered in the field through approximately 80 kilometres of pipelines and flowlines. According to field owners Santos and Magellan Petroleum[5], gas sales to 2011 totalled 216 PJ. The field had also at that time produced 16.5 million barrels of oil. The Mereenie field is not currently producing gas for sale but is capable of producing around 35 TJ per day (around 12.5 PJ per annum). The processing plant has a capacity of 55 TJ per day. Additional drilling would be required to meet this full capacity.

The nearby Palm Valley gas field is approximately 150 kilometres east of Mereenie and provides gas to Alice Springs via the 145 kilometre Palm Valley-

[5] Santos & Magellan Petroleum submission regarding proposed revisions to the access arrangement for the Amadeus Gas Pipeline (AGP), http://www.aer.gov.au/sites/default/files/Submission%20from%20Santos%20Limited%20%26%20Magellan%20Petroleum%20Australia%20Limited.pdf

Alice Springs gas pipeline which is connected to AGP at Palm Valley. The Palm Valley field is currently supplying gas at a rate of around 7- 9 TJ per day (around 2.0 PJ per annum). The gas was sold under a 25-year contract which ended in January 2012. Gas sales to date total approximately 174 PJ (152 Bcf).

The **Dingo** gas field is an undeveloped resource located approximately 60 kilometres south of Alice Springs. A total of four wells have been drilled on the field which has a contingent resource of approximately 20 PJ of gas. The field is currently capable of flowing at a rate of around 2.5 TJ of gas per day.

Santos and Magellan indicated in their submission to the AER that they are actively marketing gas into the Northern Territory gas market from the Mereenie and Palm Valley gas fields, and that, since the fields have significant remaining conventional and unconventional gas resources, both Santos and Magellan are considering marketing opportunities for supply to customers up to 2030.

4.3 Other existing or committed gas production facilities

4.3.1 Bonaparte Basin, Bayu-Undan field

The Bayu-Undan field in the Bonaparte Basin has been supplying gas into the ConocoPhillips Darwin LNG project since 2006. Recoverable gas reserves in the Bayu-Undan field are estimated at 3.4 Tcf (about 3,600 PJ) which is sufficient to supply the current Darwin LNG project for almost 20 years. The Bayu-Undan fields are not expected to supply any gas into the Northern Territory domestic market, with all reserves and production currently committed to LNG exports.

4.3.2 Browse Basin, Ichthys field

In January 2012 Inpex Browse Ltd (Inpex) and Total E&P Australia (Total) committed to the $34 billion Ichthys LNG and condensates project and chose Darwin as the site for construction of the project's 8.5 Mtpa LNG facilities. The Ichthys gas processing facility will include two LNG trains, with room to expand to 6 trains, a liquefied petroleum gas processing facility and a condensate separation plant. Gas from the Ichthys field in the Browse Basin west of Darwin will be transported through an 890 km long, 42-inch diameter gas pipeline. The plant is expected to be operational and shipping LNG by the end of 2016.

There is currently no expectation that the Ichthys project will provide gas to the Northern Territory domestic market. Recent statements by the project

proponents indicate that all currently proven reserves in the Ichthys project are committed to LNG exports.

4.4 Other potential supply sources

4.4.1 Offshore Timor Sea

As shown in Figure 6, there are numerous discovered gas fields in the Timor Sea region, many of which could potentially supply gas into the Northern Territory domestic market if a foundation offtake can be established with a large enough gas requirement to justify the costs of offshore field development, subsea pipeline infrastructure and gas processing. The following table provides an indication of the reserves available in several of the fields in this area.

Table 3 **Timor Sea undeveloped gas reserves**

Field	Reserves (tcf)	Reserves (PJ)
Sunrise[1]	5.13	5,490
Evans Shoal[1]	6.6	7,060
Petrel/Tern[1]	2.1	2,250
Abadi[1]	10	10,700
Caldita/Barossa[2]	3.5	3,750

Data source: 1: Northern Territory Government "Northern Territory oil and gas. Overview of developments", February 2011; 2: MEO Australia at http://www.meoaustralia.com.au/page/Projects/Timor_Sea_Exploration/

4.4.2 Onshore Bonaparte Basin

A number of small gas discoveries have been made in the onshore Bonaparte Basin in an area straddling the Northern Territory – Western Australia border, south west of Wadeye (Figure 6). Titleholder Advent Energy has announced an independently audited mean recoverable resource of 18.4 Bcf (about 20 PJ) in the Weaber Gas Field, with a 3C contingent resource of 45.8 Bcf (about 50 PJ).

During 2011 and 2012 Advent Energy also demonstrated gas flows from the Vienta and Waggon Creek wells, but no reserve estimates have yet been released.

4.4.3 Unconventional gas prospects

Unconventional gas prospects (shale gas, tight gas, basin-centred gas accumulations) are currently being pursued across several geological basins in the Northern Territory. A number of large international oil companies are involved as well as local and overseas junior explorers. Most of these projects are at an early stage of exploration and face high exploration risk. However,

they have very large resource potential that could translate into bankable reserves and production capability over the next decade.

- In the **Beetaloo Basin** Falcon Oil & Gas and Hess Corporation are investigating a thick Precambrian sedimentary sequence that was originally drilled by a subsidiary of Rio Tinto in the 1980s. Extensive core material gathered during that drilling campaign demonstrates the presence of thick organic rich source rocks that are oil and gas prone. Conventional source rocks may also exist. An independent resource report released in May 2010 estimated a potential resource in the Beetaloo Basin of 17 billion barrels of recoverable oil and 64 Tcf of natural gas.[6]
- The **McArthur River Basin** is of particular interest in the context of potential gas supply to Gove, given that the proposed Katherine – Gove Pipeline will traverse the basin. Amour Energy Limited has identified 314 PJ of risked, prospective resources in the Coxco Dolomite, a free-flowing conventional reservoir in the Batten Trough, McArthur Basin. Unconventional prospective resources in the area are much larger, with Armour Energy targeting unconventional naturally-fractured and shale gas accumulations with a current mean prospective resource estimate of 18.7 Tcf (about 20,000 PJ) in the Batten Trough[7]. Empire Energy Group (through subsidiary company Imperial Oil & Gas) is also exploring for unconventional hydrocarbons in the McArthur Basin, targeting thick organic rich shales and siltstones of the Barney Creek and Velkerri Formations. The hydrocarbon potential of these targets has been demonstrated by sustained high flow-rate, liquids-rich gas production from a mineral exploration core hole in the 1970s as well as common oil bleeds from drill core. The company has estimated a potential recoverable resource of around 24 Tcf in its acreage[8].
- The **Georgina Basin** which straddles the Queensland – Northern Territory border has long been recognised as having good hydrocarbon potential. Companies including Central Petroleum, PetroFrontier (Canada), Statoil (Norway) and Baraka Resources are currently exploring in the Georgina Basin. Central Petroleum operates permits and applications in the Southern Georgina and Amadeus Basins that have been assessed independently as having a total of 6 billion barrels of oil and 59 Tcf of gas in technically recoverable prospective resources at "mean" level[9]. A joint

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6 Paltar Petroleum Limited, http://www.paltar.com.au/beetaloo-basin_overview.php

7 Armour Energy Limited, http://www.armourenergy.com.au/assets/downloads/announcements/2013/feb/asx_20130212-armour-energy-updates-its-northern-territory-targets.pdf

8 Imperial Oil & Gas, *"McArthur Basin Shale Gas Play Northern Territory Onshore Australia"*, www.empireenergygroup.net/_literature_50838/McCarthur_Basin

9 Central Petroleum Limited, ASX Announcement dated 11 April 2011 *"Central's unconventional resources rival the Bakken"*,

venture including PetroFrontier, Statoil of Norway and Baraka Resources is targeting very large unconventional oil and gas prospects (27 Bboe best estimate un-risked prospective recoverable resource) in the southern Georgina Basin in Cambrian age sediments analogous to the Bakken Shale in North America[10].

4.5 Conclusions regarding future gas supply

As the foregoing survey of existing and potential gas supply sources demonstrates, there are very large resources of conventional and unconventional oil and gas resources in the Northern Territory region. In the past, gas developments have been hampered by the small local (Darwin) market. Supply of gas to Gove will effectively double the size of the domestic gas market in the Northern Territory, providing greater opportunities for onshore gas producers to monetise discoveries and so incentivising further exploration and development activity. Large offshore fields such as Greater Sunrise, Evans Shoal and Abadi will almost certainly require a foundation export project (LNG or gas-to-liquids) to justify development, with a side-stream of gas potentially available to the domestic market. However smaller fields such as Petrel and Tern are close to the existing Blacktip production facilities and infrastructure and may offer a domestic supply option in the future. Intense activity in exploration for unconventional oil and gas is likely to have a long lead time, but could provide additional supply options beyond the term of the initial ten-year supply arrangement for Blacktip gas.

http://www.centralpetroleum.com.au/files/downloads/11.04.11_sthn._georgina_unconventional_resources_966139.pdf

[10] PetroFrontier *"Unlocking massive light oil resource in Australia's Georgina Basin"*, Corporate Presentation, January 2011

5 Projected economic impacts

5.1 Measures of macroeconomic impacts

One of the most commonly quoted macroeconomic variables at a national level is real Gross Domestic Product (GDP), which is a measure of the aggregate output generated by an economy over a given period of time (typically a year). From the expenditure side, GDP is calculated by adding together total private and government consumption, investment and net trade. From the income side, GDP can be calculated as the sum of returns to the primary factors (labour, capital and natural resources) employed in the national economy *plus* indirect tax revenue. The regional level equivalent to GDP is Gross Regional Product (GRP) – at the state level it is called GSP (Gross State Product). To reduce the potential confusion with the various acronyms, the term **economic output** has been used in the discussion of the results presented in this report.

These measures of the real economic output of an economy should be distinguished from measures of the economy's **real income,** which provide a better indication of the economic welfare of the residents of a region. It is quite possible for real economic output to increase (that is, for GDP to rise) while at the same time real income (economic welfare) declines. In such circumstances people and households would be worse off despite economic growth.

In *Tasman Global*, the relevant measure of real income at the national level is "real gross national disposable income" (RGNDI) as reported by the Australian Bureau of Statistics (ABS).

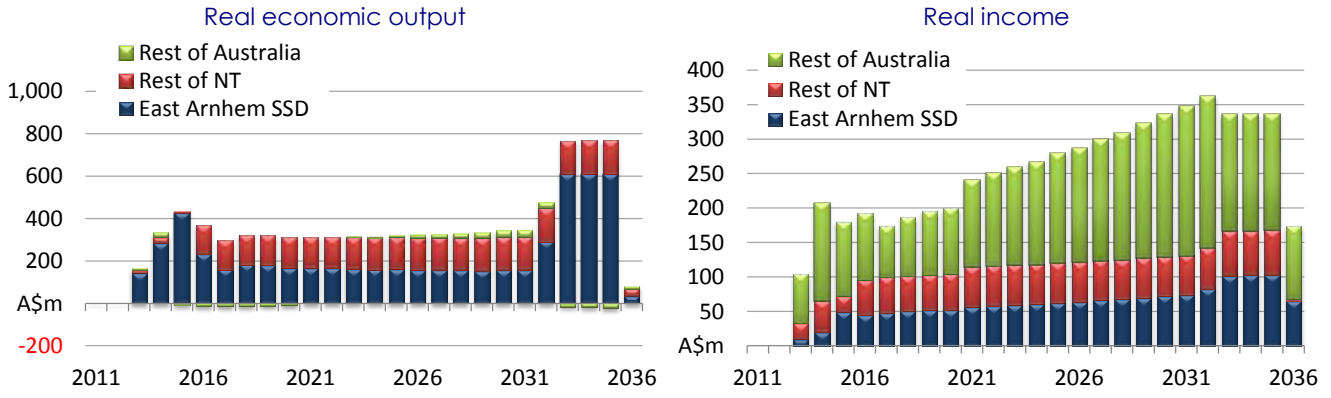
The change in a region's real income as a result of a policy change (often referred to by economists as a policy "shock") is the change in real economic output *plus* the change in net external income transfers *plus* the change in the region's terms of trade (which measure the change in the purchasing power of the region's exports relative to its imports). As Australians have experienced first-hand in recent years, changes in the terms of trade can have a substantial impact on residents' welfare independently of changes in real economic output.

5.2 Real economic output and real income

Figure 7 shows the change in real economic output and real income in each region for each year of the projection period (2013 to 2036) under the Policy Case (with the Katherine to Gove Gas Pipeline project) compared to the

Reference Case (bauxite operations only). A summary of the projected impacts for all regions are presented in Table 4.

Figure 7 **Change in economic output and real income as a result of the KGGP Project relative to the Reference Case (in 2012-13 terms)**



Source: ACIL Tasman

It can be seen that the largest changes in real economic output occur once the operations commence using the gas (2016 onwards). This is not surprising as the operations phase is where the key benefits of the conversion are realised – namely, through the improved profitability of the Gove Operations and through monetisation of an otherwise unutilised resource. In contrast, the pipeline construction phase is largely increasing demand for scarce factors of production and so has a much smaller effect on economic output compared to the size of the investment.

However, the additional construction activity associated with the pipeline has a noticeable effect on the real income of residents in the NT and the Rest of Australia as there is increased demand for labour and goods and services and this boosts local incomes relative to the reference case.

Table 4 **Cumulative change in real economic output and real income – Gas Conversion scenario, relative to the reference case (in 2012-13 terms)**

	A. Real economic output			B. Real income		
	Total (2013 to 2036)	NPV (4% discount rate)	NPV (7% discount rate)	Total (2013 to 2036)	NPV (4% discount rate)	NPV (7% discount rate)
	2012-13 A$m	2012-13 A$m	2012-13 A$m	2012-13 A$m	2012-13 A$m	2012-13 A$m
East Arnhem SSD	5,687	3,324	2,382	1,488	833	570
Rest of Northern Territory	3,105	1,794	1,247	1,241	739	528
Total Northern Territory	**8,792**	**5,118**	**3,629**	**2,729**	**1,572**	**1,098**
Rest of Australia	127	63	38	3,459	1,983	1,383
Total Australia	**8,920**	**5,181**	**3,667**	**6,188**	**3,555**	**2,481**

Notes: SSD = Statistical sub-division (as defined by the Australian Bureau of Statistics). NPV = Net Present Value. It should be noted that the NPV calculation only includes the impacts through to 2036 even though the project may continue producing benefits beyond this artificial time horizon. Increasing the time horizon by a further 10-15 years is likely to add around 10 per cent to the projected NPV totals.

Data source: ACIL Tasman

Table 5 provides a decomposition of the changes in the real economic output changes (top panel) and the real income changes (bottom panel) for each Australian region.

Table 5 **Decomposition of changes in real economic output and real income for each region as a result of the KGGP Project, relative to the Reference Case (Total 2013 to 2036)**

	East Arnhem SSD	Rest of Northern Territory	Rest of Australia	Australia
	2012-13 A$m	2012-13 A$m	2012-13 A$m	2012-13 A$m
Real economic output (expenditure side)				
Private consumption	606	950	2,092	**3,647**
Investment	645	214	–244	**615**
Government consumption	335	654	260	**1,249**
Net trade (to all domestic and foreign regions)	4,101	1,288	–1,981	**3,409**
- Exports	*23,668*	*3,581*	*–2,239*	***25,011***
- Contribution of imports	*–19,568*	*–2,293*	*258*	***–21,602***
Real economic output	**5,687**	**3,105**	**127**	**8,920**
Real Income				
Real economic output	5,687	3,105	127	8,920
Terms of trade	–662	215	692	**245**
Net foreign income transfers	–3,537	–2,079	2,640	**–2,977**
Real income	**1,488**	**1,241**	**3,459**	**6,188**

Data source: ACIL Tasman Modelling

Real economic output

Over the period 2013 to 2036, the KGGP Project is projected increase the real economic output of:

- *East Arnhem SSD* by a cumulative total of $5,687 million relative to the Reference Case (with a net present value of $2,382 million, using a 7 per cent real discount rate).
- *The Northern Territory* as a whole (i.e. real GSP) by a cumulative total of $8,792 million relative to the Reference Case (with a net present value of $3,629 million, using a 7 per cent real discount rate).
- *Australia* as a whole (i.e. real GDP) by a cumulative total of $8,920 million relative to the Reference Case (with a net present value of $3,667 million, using a 7 per cent real discount rate).

To place these projected changes in economic output estimates in perspective, the discounted present values (using a 7 per cent discount rate) are equivalent to:

- 19.5 per cent of Northern Territory's current GSP
- 0.25 per cent of Australia's current GDP.

The annual average increase in Northern Territory's real economic output over the forecast period is equivalent to 2.0 per cent of current GSP.

Real income

The extent to which the local residents will benefit from the additional economic output depends on the level of ownership of the capital (including the natural resources) utilised in the business as well as any wealth transfers undertaken by Australian governments as a result of the taxation revenues generated by the Gove Operations.

Given the importance of the refinery to local employment and the number of people living in the local area, a significant amount of the additional personal incomes that are generated as a result of the KGGP Project are likely to stay in the local region. However, as little of the Gove Operations are owned by local residents, a significant portion of the wealth generated by the business is transferred outside of the East Arnhem SSD (including to overseas shareholders). Further, although the Northern Territory Government will receive additional royalties based on the additional gas production, ownership of the capital associated with the gas production is likely to be predominantly owned by overseas and interstate shareholders. Consequently, most of the real income benefit associated with the Gas Conversion Project, in absolute terms rather than in per capita terms, is projected to accrue to residents in the Rest of Australia.

More specifically, over the period 2013 to 2036, the KGGP Project is projected to increase the real income of:

- *the East Arnhem SSD* by a cumulative total of $1,488 million, relative to the reference case (with a net present value of $570 million, using a 7 per cent real discount rate)
- *the Northern Territory* as a whole by a cumulative total of $2,729 million, relative to the reference case (with a net present value of $1,098 million, using a 7 per cent real discount rate)
- *Australia* as a whole by a cumulative total of $6,188 million, relative to the reference case (with a net present value of $2,481 million, using a 7 per cent real discount rate).

To place these income estimates in perspective, the discounted present values (using a 7 per cent discount rate) are equivalent to a one-off increase in the *average* real income of all current residents of:

- the East Arnhem SSD by approximately $3,500 per person
- the Northern Territory by approximately $5,200 per person
- Australia by approximately $150 per person.

This is a significant increase in the context of a single project.

5.2.2 Employment impacts

As well as creating additional short-term employment in the Northern Territory during the construction of the infrastructure the boost to real incomes will generate a substantial number of ongoing jobs across Australia (predominantly in sectors associated with final consumption). In addition to the direct jobs generated on-site, the construction phase will require significant quantities of goods and services sourced from the state and national economies. Production of these inputs will further increase the demand for labour.

A key issue when estimating the impact of a project is determining how the labour market will provide the additional labour required for the KGGP Project.[11] For this analysis, increases in the demand for labour associated with the KGGP Project can be met by three mechanisms: increasing migration from the rest of Australia (for the purposes of this analysis, migration includes short-

[11] CGE models place explicit limits on the availability of factors and the nature of the constraints can greatly change the magnitude and nature of the results. In contrast, most other tools used to assess economic impacts, including I-O multiplier analysis, do not place constraints on the availability of factors. Consequently, these tools tend to overestimate the impacts of a project or policy.

term fly-in fly-out employment); increasing participation rates and/or average hours worked; and by reducing the unemployment rate. The first two mechanisms are driven by changes in the real wages paid to workers in the local region while the third is a function of the additional labour demand relative to the reference case. Given the already low unemployment rate in the local region (which is assumed to continue throughout the projection period), the unemployment rate has not been allowed to change in these projections. Consequently, changes in the real wage rate accounts for the additional labour supply in the policy scenarios relative to the reference case.

It should be noted that this analysis does not assume any change in net foreign migration as a result of the KGGP Project.

The projected changes in employment in each Australian region are summarised in Table 6 and Figure 8.

Table 6 **Cumulative and average annual change in employment by region – Gas Conversion scenario, relative to the reference case**

	Cumulative employee years (2013 to 2036)	Average FTE jobs per year (2013 to 2036)
	FTE jobs	FTE jobs
East Arnhem SSD	12,654	506
Rest of Northern Territory	1,495	60
Total Northern Territory	**14,149**	**566**
Rest of Australia	-1,138	-46
Total Australia	**13,010**	**520**

Notes: FTE = full time equivalent. An employee year is equivalent to one full time job held for a year or, for example, 0.5 of a full time job held for two years.

Source: ACIL Tasman modelling

Over the period 2013 to 2036, the KGGP Project is projected to increase employment in:

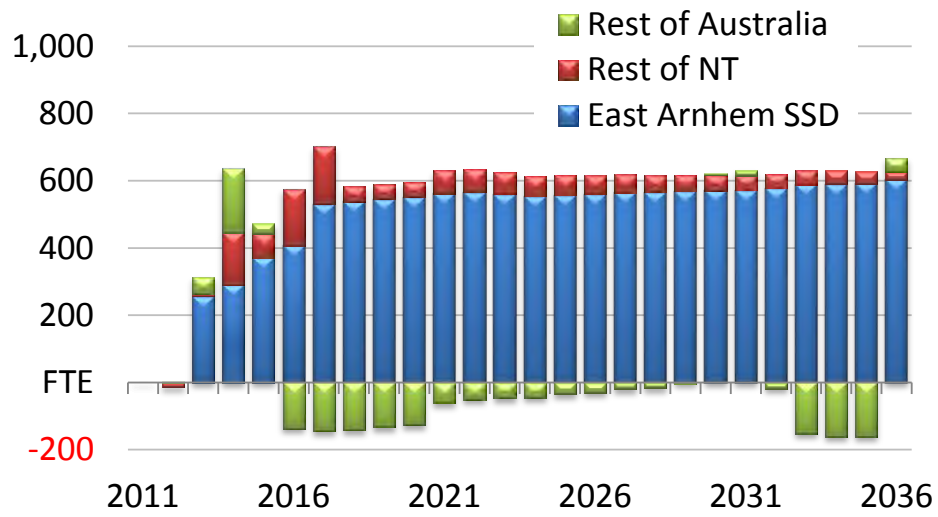
- *the East Arnhem SSD* by a total of 12,654 employee years[12] relative to the reference case (or an average of 506 FTE jobs a year)
- *the Northern Territory* by a total of 14,149 employee years relative to the reference case (or an average of 566 FTE jobs a year)
- *Australia* by a total of 13,010 employee years relative to the reference case (or an average of 520 FTE jobs a year).

The estimated changes in employment as a result of the operation phase of the KGGP Project are affected by the amount of direct employment generated by

[12] An 'employee year' is defined to be equivalent to one full time job held for a year or, for example, 0.5 of a full time job held for two years.

the production chain (i.e. particularly the gas industry) as well as the indirect employment induced by the changes in the real income of the residents. Consequently, the projected impact of the KGGP Project on regional employment is influenced by the income that stays in the region (and in Australia) via the assumed repatriation of profits (see Section 3.6).

Figure 8 **Projected change in employment by region as a result of the KGGP Project, relative to the reference case**



Notes: FTE = full time equivalent.

Source: ACIL Tasman modelling

Appendix A The *Tasman Global* model

ACIL Tasman's computable general equilibrium (CGE) model *Tasman Global* is a powerful tool for undertaking economic impact analysis at the regional, state, national and global level.

There are various types of economic models and modelling techniques. Many of these are based on partial equilibrium analysis that usually considers a single market. However, in economic analysis, linkages between markets and how these linkages develop and change over time can be critical. *Tasman Global* has been developed to meet this need.

Tasman Global is an analytical tool that can capture these linkages on a regional, state, national and global scale. *Tasman Global* is a large-scale computable general equilibrium model which is designed to account for all sectors within an economy and all economies across the world. ACIL Tasman uses this modelling platform to undertake industry, project, scenario and policy analyses. The model is able to analyse issues at the industry, global, national, state and regional levels and to determine the impacts of various economic changes on production, consumption and trade at the macroeconomic and industry levels.

A.1 A dynamic model

Tasman Global is a model that estimates relationships between variables at different points in time. This is in contrast to comparative static models, which compare two equilibriums (one before a policy change and one following). A dynamic model such as *Tasman Global* is beneficial when analysing issues where both the timing of and the adjustment path that economies follow are relevant in the analysis.

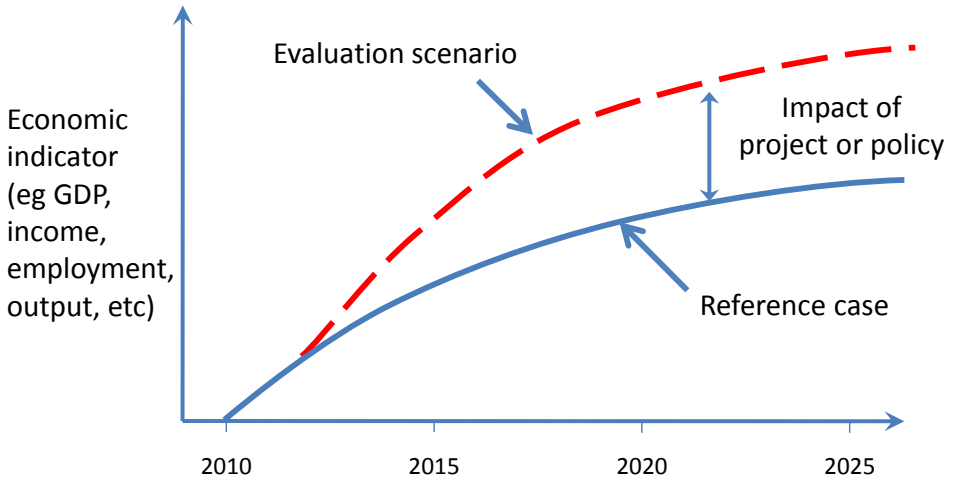
In applications of the *Tasman Global* model, a reference case simulation forms a 'business-as-usual' basis with which to compare the results of various simulations. The reference case provides projections of growth in the absence of the changes to be examined. The impact of the change to be examined is then simulated and the results interpreted as deviations from the reference case. (See Figure A1).

The database

A key advantage of *Tasman Global* is the level of detail in the database underpinning the model. The database is derived from the latest Global Trade Analysis Project (GTAP) database which was released in 2008. This database is a fully documented, publicly available global data base which contains

complete bilateral trade information, transport and protection linkages among regions for all GTAP commodities.

Figure A1 **Illustrative scenario analysis using Tasman Global**



Source: ACIL Tasman

The GTAP model was constructed at the Centre for Global Trade Analysis at Purdue University in the United States. It is the most up-to-date, detailed database of its type in the world.

Tasman Global builds on the GTAP model's equation structure and database by adding the following important features:

- dynamics (including detailed population and labour market dynamics)
- detailed technology representation within key industries (such as electricity generation and iron and steel production)
- disaggregation of a range of major commodities including iron ore, bauxite, alumina, primary aluminium, brown coal, black coal and LNG
- the ability to repatriate labour and capital income
- a detailed emissions accounting abatement framework
- explicit representation of the states and territories of Australia
- the capacity to explicitly represent multiple regions within states and territories of Australia.

Nominally the *Tasman Global* database divides the world economy into 122 regions (114 international regions plus the 8 states and territories of Australia) although in reality the international and Australian regions are frequently disaggregated further. ACIL Tasman regularly models projects or policies at the statistical division (SD) level, as defined by the ABS, but finer regional detail has been modelled when warranted.

The *Tasman Global* database also contains a wealth of sectoral detail currently identifying up to 70 industries (Table A1). The foundation of this information is the input-output tables that underpin the database. The input-output tables account for the distribution of industry production to satisfy industry and final demands. Industry demands, so-called intermediate usage, are the demands from each industry for inputs. For example, electricity is an input into the production of communications. In other words, the communications industry uses electricity as an intermediate input. Final demands are those made by households, governments, investors and foreigners (export demand). These final demands, as the name suggests, represent the demand for finished goods and services. To continue the example, electricity is used by households – their consumption of electricity is a final demand.

Each sector in the economy is typically assumed to produce one commodity, although in *Tasman Global*, the electricity, diesel and iron and steel sectors are modelled using a 'technology bundle' approach. With this approach, different known production methods are used to generate a homogeneous output for the 'technology bundle' industry. For example, electricity can be generated using brown coal, black coal, petroleum, base load gas, peak load gas, nuclear, hydro, geothermal, biomass, wind, solar or other renewable based technologies – each of which have their own cost structure.

The other key feature of the database is that the cost structure of each industry is also represented in detail. Each industry purchases intermediate inputs (from domestic and imported sources) primary factors (labour, capital, land and natural resources) as well as paying taxes or receiving subsidies.

Table A1 **Sectors in the *Tasman Global* database**

	Sector		Sector
1	Paddy rice	36	Paper products, publishing
2	Wheat	37	Diesel (incl. nonconventional diesel)
3	Cereal grains nec	38	Other petroleum, coal products
4	Vegetables, fruit, nuts	39	Chemical, rubber, plastic products
5	Oil seeds	40	Iron ore
6	Sugar cane, sugar beef	41	Bauxite
7	Plant- based fibres	42	Mineral products nec
8	Crops nec	43	Ferrous metals
9	Bovine cattle, sheep, goats, horses	44	Alumina
10	Animal products nec	45	Primary aluminium
11	Raw milk	46	Metals nec
12	Wool, silk worm cocoons	47	Metal products
13	Forestry	48	Motor vehicle and parts
14	Fishing	49	Transport equipment nec
15	Brown coal	50	Electronic equipment
16	Black coal	51	Machinery and equipment nec
17	Oil	52	Manufactures nec
18	Liquefied natural gas (LNG)	53	Electricity generation
19	Other natural gas	54	Electricity transmission and distribution
20	Minerals nec	55	Gas manufacture, distribution
21	Bovine meat products	56	Water
22	Meat products nec	57	Construction
23	Vegetables oils and fats	58	Trade
24	Dairy products	59	Road transport
25	Processed rice	60	Rail and pipeline transport
26	Sugar	61	Water transport
27	Food products nec	62	Air transport
28	Wine **a**	63	Transport nec
29	Beer **a**	64	Communication
30	Spirits and RTDs **a**	65	Financial services nec
31	Other beverages and tobacco products **a**	66	Insurance
32	Textiles	67	Business services nec
33	Wearing apparel	68	Recreational and other services
34	Leather products	69	Public Administration, Defence, Education, Health
35	Wood products	70	Dwellings

a A detailed beverage database and model structure covering 52+ alcoholic and non-alcoholic sub-categories and alternative sales channels is also available.
Note: nec = not elsewhere classified

Detailed energy sector and linkage to *PowerMark* and *GasMark*

Tasman Global contains a detailed representation of the energy sector, particularly in relation to the interstate (trade in electricity and gas) and international linkages across the regions represented. To allow for more detailed electricity sector analysis, and to aid in linkages to bottom-up models such as ACIL Tasman's *GasMark* and *PowerMark* models electricity generation is separated from transmission and distribution in the model. In addition, the electricity sector in the model employs a 'technology bundle' approach that separately identifies twelve different electricity generation technologies:

1. brown coal (with and without carbon capture and storage)
2. black coal (with and without carbon capture and storage)
3. petroleum
4. base load gas (with and without carbon capture and storage)
5. peak load gas
6. hydro
7. geothermal
8. nuclear
9. biomass
10. wind
11. solar
12. other renewables.

To enable more accurate linking to *PowerMark* the generation cost of each technology is assumed to be equal to their long run marginal cost (LRMC) while the sales price in each region is matched to the average annual dispatch weighted prices projected by *PowerMark* – with any difference being returned as an economic rent to electricity generators. This representation enables the highly detailed market based projections from *PowerMark* to be incorporated as accurately as possible into *Tasman Global*.

Factors of production

Capital, land, labour and natural resources are the four primary factors of production. The capital stock in each region (country or group of countries) accumulates through investment (less depreciation) in each period. Land is used only in agriculture industries and is fixed in each region. *Tasman Global* explicitly models natural resource inputs as a sector specific factor of production in resource based sectors (coal mining, oil and gas extraction, other mining, forestry and fishing).

Population growth and labour supply

Population growth is an important determinant of economic growth through the supply of labour and the demand for final goods and services. Population growth for the 112 international regions and for the 8 states and territories of Australia represented in the *Tasman Global* database is projected using ACIL Tasman's in-house demographic model. The demographic model projects how the population in each region grows and how age and gender composition changes over time and is an important tool for determining the changes in regional labour supply and total population over the projection period.

For each of the 120 regions in *Tasman Global*, the model projects the changes in age-specific birth, mortality and net migration rates by gender for 101 age cohorts (0-99 and 100+). The demographic model also projects changes in participation rates by gender by age for each region, and, when combined with the age and gender composition of the population, endogenously projects the future supply of labour in each region. Changes in life expectancy are a function of income per person as well as assumed technical progress on lowering mortality rates for a given income (for example, reducing malaria-related mortality through better medicines, education, governance etc.). Participation rates are a function of life expectancy as well as expected changes in higher education rates, fertility rates and changes in the work force as a share of the total population.

Labour supply is derived from the combination of the projected regional population by age by gender and the projected regional participation rates by age by gender. Over the projection period labour supply in most developed economies is projected to grow slower than total population as a result of ageing population effects.

For the Australian states and territories, the projected aggregate labour supply from ACIL Tasman's demographics module is used as the base level potential workforce for the detailed Australian labour market module, which is described in the next section.

The Australian labour market

Tasman Global has a detailed representation of the Australian labour market which has been designed to capture:

- different occupations
- changes to participation rates (or average hours worked) due to changes in real wages
- changes to unemployment rates due to changes in labour demand
- limited substitution between occupations by the firms demanding labour and by the individuals supplying labour; and

- limited labour mobility between states.

Tasman Global recognises 97 different occupations within Australia – although the exact number of occupations depends on the aggregation. The firms who hire labour are provided with some limited scope to change between these 97 labour types as the relative real wage between them changes. Similarly, the individuals supplying labour have a limited ability to change occupations in response to the changing relative real wage between occupations. Finally, as the real wage for a given occupation rises in one state rise relative to other states, workers are given some ability to respond by shifting their location. The model produces results at the 97 3-digit ANZSCO (Australian New Zealand Standard Classification of Occupations) level which are presented in Table A2.

The labour market structure of *Tasman Global* is thus designed to capture the reality of labour markets in Australia, where supply and demand at the occupational level do adjust, but within limits.

Labour supply in *Tasman Global* is presented as a three stage process:

1. labour makes itself available to the workforce based on movements in the real wage and the unemployment rate
2. labour chooses between occupations in a state based on relative real wages within the state; and
3. labour of a given occupation chooses in which state to locate based on movements in the relative real wage for that occupation between states.

By default, *Tasman Global*, like all CGE models, assumes that markets clear. Therefore, overall, supply and demand for different occupations will equate (as is the case in other markets in the model).

Table A2 **Occupations in the Tasman Global database, ANZSCO 3-digit level (Minor Groups)**

ANZSCO code, Description	ANZSCO code, Description	ANZSCO code, Description
1. MANAGERS	**3. TECHNICIANS & TRADES WORKERS**	**5. CLERICAL & ADMINISTRATIVE**
111 Chief Executives, General Managers and Legislators	311 Agricultural, Medical and Science Technicians	511 Contract, Program and Project Administrators
121 Farmers and Farm Managers	312 Building and Engineering Technicians	512 Office and Practice Managers
131 Advertising and Sales Managers	313 ICT and Telecommunications Technicians	521 Personal Assistants and Secretaries
132 Business Administration Managers	321 Automotive Electricians and Mechanics	531 General Clerks
133 Construction, Distribution and Production Managers	322 Fabrication Engineering Trades Workers	532 Keyboard Operators
134 Education, Health and Welfare Services Managers	323 Mechanical Engineering Trades Workers	541 Call or Contact Centre Information Clerks
135 ICT Managers	324 Panelbeaters, and Vehicle Body Builders, Trimmers and Painters	542 Receptionists
139 Miscellaneous Specialist Managers	331 Bricklayers, and Carpenters and Joiners	551 Accounting Clerks and Bookkeepers
141 Accommodation and Hospitality Managers	332 Floor Finishers and Painting Trades Workers	552 Financial and Insurance Clerks
142 Retail Managers	333 Glaziers, Plasterers and Tilers	561 Clerical and Office Support Workers
149 Miscellaneous Hospitality, Retail and Service Managers	334 Plumbers	591 Logistics Clerks
	341 Electricians	599 Miscellaneous Clerical and Administrative Workers
2. PROFESSIONALS	342 Electronics and Telecommunications Trades Workers	
211 Arts Professionals	351 Food Trades Workers	**6. SALES WORKERS**
212 Media Professionals	361 Animal Attendants and Trainers, and Shearers	611 Insurance Agents and Sales Representatives
221 Accountants, Auditors and Company Secretaries	362 Horticultural Trades Workers	612 Real Estate Sales Agents
222 Financial Brokers and Dealers, and Investment Advisers	391 Hairdressers	621 Sales Assistants and Salespersons
223 Human Resource and Training Professionals	392 Printing Trades Workers	631 Checkout Operators and Office Cashiers
224 Information and Organisation Professionals	393 Textile, Clothing and Footwear Trades Workers	639 Miscellaneous Sales Support Workers
225 Sales, Marketing and Public Relations Professionals	394 Wood Trades Workers	**7. MACHINERY OPERATORS & DRIVERS**
231 Air and Marine Transport Professionals	399 Miscellaneous Technicians and Trades Workers	711 Machine Operators
232 Architects, Designers, Planners and Surveyors		712 Stationary Plant Operators
233 Engineering Professionals	**4. COMMUNITY & PERSONAL SERVICE**	721 Mobile Plant Operators
234 Natural and Physical Science Professionals	411 Health and Welfare Support Workers	731 Automobile, Bus and Rail Drivers
241 School Teachers	421 Child Carers	732 Delivery Drivers
242 Tertiary Education Teachers	422 Education Aides	733 Truck Drivers
249 Miscellaneous Education Professionals	423 Personal Carers and Assistants	741 Storepersons
251 Health Diagnostic and Promotion Professionals	431 Hospitality Workers	**8. LABOURERS**
252 Health Therapy Professionals	441 Defence Force Members, Fire Fighters and Police	811 Cleaners and Laundry Workers
253 Medical Practitioners	442 Prison and Security Officers	821 Construction and Mining Labourers
254 Midwifery and Nursing Professionals	451 Personal Service and Travel Workers	831 Food Process Workers
261 Business and Systems Analysts, and Programmers	452 Sports and Fitness Workers	832 Packers and Product Assemblers
262 Database and Systems Administrators, and ICT Security Specialists		839 Miscellaneous Factory Process Workers
263 ICT Network and Support Professionals		841 Farm, Forestry and Garden Workers
271 Legal Professionals		851 Food Preparation Assistants
272 Social and Welfare Professionals		891 Freight Handlers and Shelf Fillers
		899 Miscellaneous Labourers

Source: ABS (2009), ANZSCO – Australian and New Zealand Standard Classifications of Occupations, First Edition, Revision 1, ABS Catalogue no. 1220.0.

Greenhouse gas emissions

The model has a detailed greenhouse gas emissions accounting, trading and abatement framework that tracks the status of six anthropogenic greenhouse gases (namely, carbon dioxide, methane, nitrous oxide, HFCs, PFCs and SF_6). Almost all sources and sectors are represented; emissions from agricultural residues and land-use change and forestry activities are not explicitly modelled but can be accounted for in policy analysis.

The greenhouse modelling framework not only allows accounting of changes in greenhouse gas emissions, but also allows various policy responses such as carbon taxes or emissions trading to be employed and assessed within a consistent framework. For example, the model can be used to measure the economic and emission impacts of a fixed emissions penalty in single or multiple regions whether trading is allowed or not. Or, it can used to model the emissions penalty required to achieve a desired cut in emissions based on various trading and taxation criteria.

Model results

Tasman Global solves equations covering industry sales and consumption, private consumption, government consumption, investment and trade. The model therefore produces detailed microeconomic results, such as:

- output by industry
- employment by industry; and
- industry imports and exports.

Tasman Global also produces a full range of macroeconomic results, for each Australian and international region including:

- total economic output – i.e. gross domestic product (GDP), gross state product (GSP) and gross regional product (GRP)
- total employment
- gross national product (GNP)
- private consumption
- public consumption
- investment and savings
- imports; and
- exports.

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