Deloitte Access Economics

The economic impacts of a domestic gas reservation

Australian Petroleum Production & Exploration Association Limited

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Deloitte.

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Acronyms

AEMO	Australia Energy Market Operator
APPEA	Australian Petroleum Production & Exploration Association Limited
BREE	Bureau of Resources and Energy Economics
CSG	Coal seam gas
DAE-RGEM	Deloitte Access Economics computable general equilibrium model
LNG	Liquefied Natural Gas

Executive Summary

- At a time when questions are being raised regarding the long term outlook for the Australian economy and the sectors that will drive the nation's next phase of growth, the economic opportunity presented by Australia's vast gas reserves is a remarkable one.
- Indeed, the development and expansion of Australia's liquefied natural gas (LNG) industry presents an unprecedented opportunity for national income growth. With forecast investment in LNG production standing in excess of $190 billion, the development of Australia's gas export industry has been heralded as an opportunity which, by 2017, could generate $53 billion in export earnings. This would make Australia the world's largest gas exporter.[1]
- As Deloitte Access Economics has previously demonstrated, the resulting economic benefits will be widespread. Not only are the industry's economic linkages broader and deeper than commonly appreciated, but there are a variety of wider, welfare-enhancing economic spillovers that emanate from the industry's endeavours.
- However, reaping the economic benefits of this opportunity will mean higher charges for domestic gas consumers, as prices in the Australian market converge with global benchmarks.
- Concerns over the impact of such price rises on local industries that utilise gas in their production processes have led to calls for a quantity of production to be reserved for local use, at prices below those prevailing in the global market, or for other forms of market intervention.
- Indeed, such calls have seen the establishment of a domestic gas reservation (DGR) in Western Australia. And while the impact of the Western Australian scheme is still emerging, experience from overseas indicates that policies of this ilk have a variety of adverse, unintended economic consequences.
- The impact of a DGR is to – in effect – place a simultaneous tax on domestic gas production and subsidy on domestic gas consumption. Like all taxes and subsidies, the DGR distorts economic decisions and generates an unequivocal economic loss – one which compounds over time as future investment decisions are affected.
- Indeed, the analysis presented in this report demonstrates that the introduction of a DGR on the east coast of Australia would come at a significant cost to the nation's economic welfare.
- Against a scenario where production, investment and export decisions are not impeded, the introduction of a DGR on the east coast is projected to cost the Australian economy $6 billion in forgone GDP at 2025.
- This should not be surprising. Deferring resources from their highest and best use in the absence of market failure is seldom – if ever – welfare enhancing. A compelling economic case for providing support to Australia's manufacturing sector is difficult to mount under any circumstances; let alone when this support comes at the direct expense of export income in other sectors.

[1] Grattan Institute (2013)

- Analyses undertaken by DGR proponents fundamentally fail to account for the policy's full economic impacts. When the flow-ons are analysed comprehensively – in an economy-wide, general-equilibrium context – the economic losses are unequivocal. Every one per cent of future gas exports which is artificially re-directed towards the domestic market reduces GDP by an estimated $150 million at 2025.

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1 Introduction

Over coming decades, demand for gas around the world is expected to increase significantly, largely driven by the global transition towards a lower carbon economy and the rapid expansion and urbanisation of emerging Asian economies. Relative to coal, natural gas is increasingly being viewed as a more environmentally efficient energy resource and therefore an attractive fuel for electricity generation. The rapid expansion of liquefied natural gas (LNG)-based trade over recent years has worked to bridge the gap between locations with abundant gas reserves and resources and locations with rising demand. These forces have, thus far, facilitated an appropriate supply response to the increased demand across the globe.

Australia is well-placed to benefit from this global expansion, owing to our geographic proximity to emerging markets in Asia and our vast, largely untapped reserves and resources both onshore and offshore.

Although domestic consumption is also expected to increase – especially if some form of carbon pricing remains a feature of the economic landscape – the industry's growth will be underpinned by LNG exports, which are projected to increase from about 20 million tonnes to over 63 million tonnes annually by 2016-17 (BREE 2012). By 2015, Australia is expected to be the world's second largest exporter of LNG; shortly thereafter it may in fact be the largest.

Calls for a domestic gas reservation

The economic growth that could ensue from an expansion in domestic gas production is at risk of being curtailed as domestic gas consumers call for government intervention in the form of a domestic gas reservation (DGR) policy. These calls have been fuelled primarily by the difficult trading conditions that have beset Australia's manufacturing sector. The proposed policy would reserve a proportion of gas production for domestic use, to be sold at prices below those prevailing on the export market. According to proponents, the rising cost of gas in Australia is undermining the viability of domestic manufacturing, jeopardising jobs and economic growth.

However, any form of government intervention is costly and is only favourable if overall (and in the long run) the costs are outweighed by the benefits – that is, if it is economic welfare enhancing. This paper explores the issue of domestic gas reservation, as an example of an intervention in the gas market, and seeks to quantify the costs of such a policy in terms of forgone economic output and income.

1.1 Our task and approach

In light of the issues outlined above, the Australian Petroleum Production & Exploration Association (APPEA) engaged Deloitte Access Economics so analyse the potential economic impacts of a DGR policy.

Our approach to this analysis comprised of two broad components: (i) a critical examination of the theoretical underpinnings of gas reservation; and (ii) a quantitative analysis of its potential economy-wide impact.

The first component was primarily informed by a desktop review of the policy and academic literature related to reservation (and similar forms of industry protection), drawing heavily on microeconomic theory and anecdotal examples of its application relevant to this context.

To quantitatively assess the potential economic impact of a DGR policy, two scenarios were modelled using our in-house computable general equilibrium (CGE) model:

- Scenario 1 (baseline): No gas reservation policy – this scenario considers the growth path of the industry and economy if the sector continues to expand, produce and export gas as market drivers determine.
- Scenario 2 (policy shock): Gas reservation policy imposed – this scenario considers a growth path where a certain volume of Australia's gas output is reserved for domestic use and made available to users at a price below the world price. This scenario was informed using a variety of data sources and analytical techniques, described below.

Informing the modelling

In order to inform the economic modelling, primary information was sought directly from businesses operating in Australia's gas sector. A workshop was held with market participants to discuss the likely workings and impacts of such a policy. Following this, a series of one-on-one consultations were held with major gas producers and buyers. The primary objective of these conversations was to gather data on the sensitivity of investment in gas projects to the price and quantity of gas sold in the domestic market. This information could then be used to inform estimation of the likely impact a domestic gas reservation policy.

Following these consultations, a likely production and investment path under the DGR scenario was dimensioned based on: publicly available data on gas and LNG projects currently underway (across different stages) in Australia; the findings of previous analyses in this field; and the anecdotal information sourced through industry consultation. The methodology, underlying data, parameters and assumptions are described in latter sections of this report.

1.2 Report outline

The remainder of this report is organised as follows:

- Chapter 2 provides context to the analysis describing the global gas market and Australia's role and opportunity therein.
- Chapter 3 outlines the theoretical underpinnings of a DGR and the mechanisms through which it impacts the economy.
- Chapter 4 describes the modelling methodology, parameters and data sources and presents the results of economy-wide modelling to demonstrate the impacts of a DGR on the Australian economy.

2 Background

As a precursor to the analysis of the economic impacts of a DGR, this section describes Australia's gas industry – from both a production and consumption perspective – and places it in the wider context of the global gas market.

2.1 Australia's gas market in the global context

The precise size of Australia's gas reserves and resources are unknown. Proven and probable reserves of conventional and natural gas from coal seams are estimated at around 140,000 petajoules – having tripled since 2005, predominantly on the back of natural gas from coal seams. Nearly two-thirds of Australia's reserves are located in Western Australia (all of which are conventional), with the majority of the remainder being east coast natural gas from coal seams (EnergyQuest 2012). The potential in-ground resources of onshore gas (including natural gas from coal seams and from shales) could be four times as large as known reserves (BREE 2012). With production standing at around 2,000 petajoules in 2012, there is, by any measure, remarkable growth potential.

In recognition of this potential, nearly $62.5 billion has been committed to developing CSG-orientated LNG export facilities in Queensland (Table 2.1). At the same time, more than $120 billion is being spent on export capacity expansion in Western Australia and the Northern Territory (Table 2.2). Combined, this investment will underwrite the development of 13 new LNG trains currently under construction across the country. Beyond this, a further 19 trains are in the planning stage (Grattan Institute 2013).

Table 2.1: Major LNG projects under construction in Queensland at end-April 2013

Project	Company	Indicative capital cost estimate ($b)
Australia Pacific LNG	Origin / ConocoPhillips / Sinopec	24.7
Gladstone LNG	Santos / PETRONAS / Total / KOGAS	18.0
Queensland Curtis LNG project	QGC / CNOOC	19.8
Total		**62.5**

Source: BREE (2013)

Table 2.2: Major LNG projects under construction in Western Australia at end-April 2013

Project	Company	Indicative capital cost estimate ($b)
Icthys LNG	INPEX / Total	33.0
Gorgon LNG	Chevron / Shell / ExxonMobil / Osaka Gas / Tokyo Gas / Chubu Electric Power	52.0
Prelude Floating LNG	Shell / INPEX / KOGAS / CPC Corporation	12.6
Wheatstone LNG	Chevron / Apache / Kuwait Foreign Petroleum Exploration Company (KUFPEC) / Shell / Kyushu Electric Power Company / PE Wheatstone Pty Ltd	29.0
Total		**126.6**

Sources: BREE (2013), company websites.

The east-west distinction

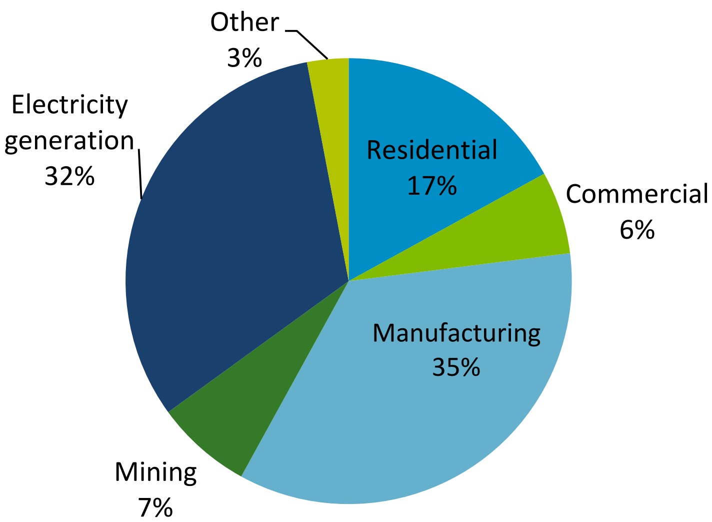
Australia's east and west coast gas markets are both physically separated and geologically distinct. Western Australia commenced exporting gas in 1989 from the North-West Shelf project in the Carnarvon Basin. This project alone produces about six per cent of all global gas exports (BREE 2012). Today, Western Australia's 90,000 petajoules of proven and probable reserves are largely conventional gas located in Commonwealth waters off the coast of northern Western Australia.

In contrast, the development of Australia's east coast gas market has been underwritten by its reserves of natural gas from coal seams, which account for 85% of proven and probable natural gas reserves on the east coast. With the development of LNG export infrastructure at Gladstone, the east coast's first LNG exports are expected to commence in late 2014. The economic opportunity presented by the development of an east coast LNG export industry is considerable. Modelling by KPMG Econtech (2009) finds that the creation of an LNG export industry in Queensland will increase the State's GSP by around $3.1 billion in 2007-08 terms.

Demand and consumption in the Australian market

Gas consumption on Australia's east coast takes a variety of forms. Residential use by households accounts for 17% of total consumption, while electricity generation represents a further 32% (Chart 2.1). The manufacturing sector is the single largest industrial user, accounting for 35% of domestic consumption, with mining the other major industrial user (7%) of consumption. Other commercial uses account for 6% and other uses a further 3%.

Chart 2.1: Gas consumption on Australia's east coast

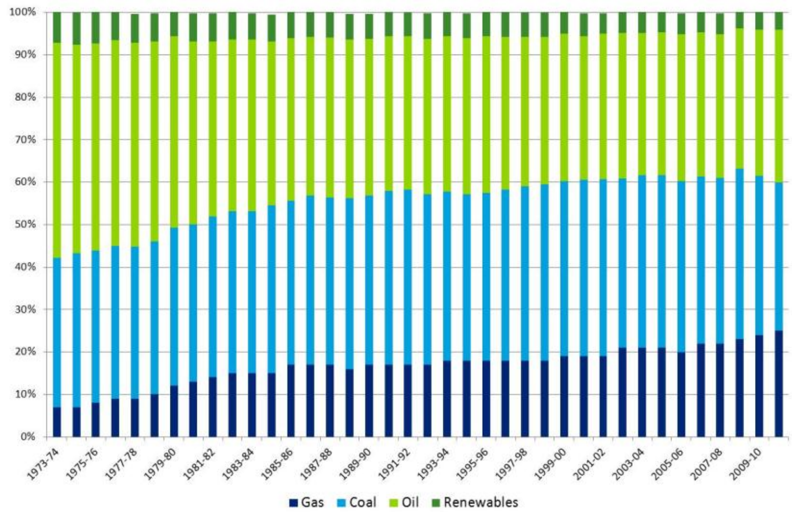


Source: BREE (2012)

Again, there are marked differences between the east and west. Gas consumption in the western market is dominated by mining (41% of total consumption); although manufacturing (30%) and electricity generation (24%) are still significant users. The northern market is dominated even more heavily by mining, which accounts for 62% of consumption; alongside electricity generation, which accounts for 37% of consumption.

Looking forward, domestic gas consumption is expected to increase steadily over the next two decades, especially if some form of carbon pricing is retained (see Chart 2.3 on the page below). The shift towards gas as an energy source has of course been underway for some time – its share of net energy consumption increasing from less than 7% in 1973-74 to 25% in 2010-11 (Chart 2.2).

Chart 2.2: Share of net energy consumption in Australia, 1973-4 to 2010-11

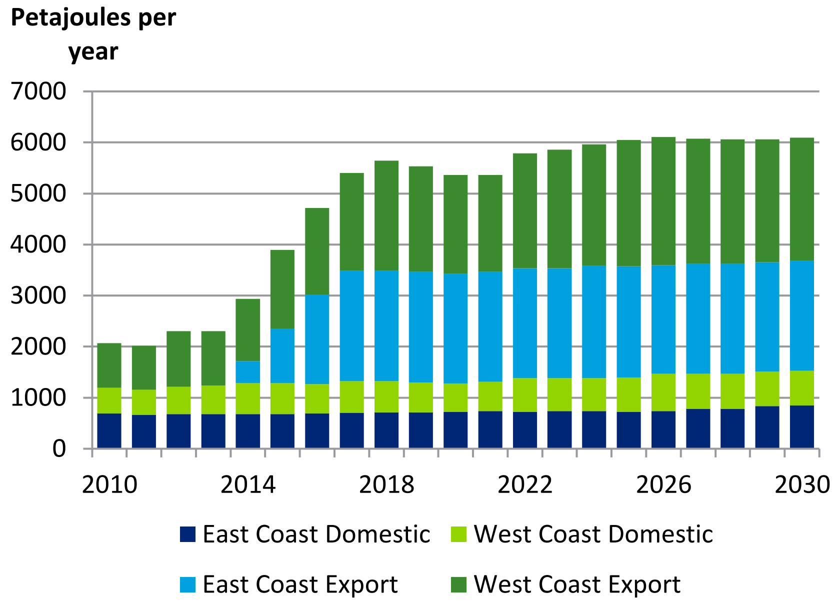


Source: BREE (2012b)

Globally, demand for gas is growing strongly, fuelled by a variety of factors, including: rapid economic development, particularly throughout emerging Asia; downward price pressure being exerted by supply expansions; and concerns over alternative fuel sources due to safety (in the case of nuclear) and carbon emissions (in the case of coal) (Grattan Institute 2013). Indeed, the International Energy Agency projects that, under current global policies, natural gas demand will increase by over 60% to 5.1 trillion cubic metres in 2035, with around 62% of this demand coming from non-OECD countries (BREE 2012).

The size of this opportunity, coupled with the development and expansion of Australia's LNG export industry, will see both strong growth in demand for Australian gas and a significant shift in the composition of the demand profile. As Chart 2.3 demonstrates, consumption of Australian gas is forecast to surge over the next five years, with export consumption rising from around half of total production to as much as 80% over a period where demand is projected to almost treble.

Chart 2.3: Forecast gas demand for eastern and Western Australia



Source: Grattan Institute (2013)

Prices in the Australian market

Gas prices are typically set on a contract basis, with contracts varying in duration from one or two years to decades. The physical disconnect between Australia's east and west coast gas markets has seen the two evolve quite differently. The inability of producers on the east coast to access export markets directly, or even indirectly via Western Australia, has seen contract prices driven largely by local factors. In contrast, Western Australia's LNG export capability has meant prices have been influenced by global market conditions as well as by local drives, with factors such as the State's booming mining sector (which has impacted both demand and production costs) recently bearing heavily on the prevailing contract prices.

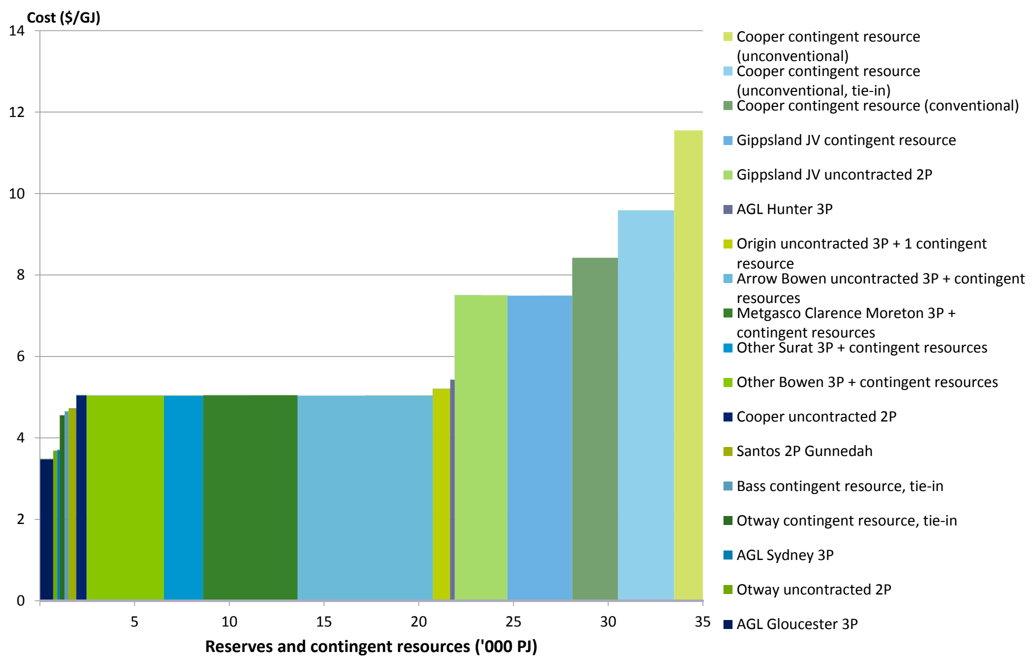
As a consequence of these varying market forces, domestic wholesale contract prices on the east coast are currently around $3-$4 per gigajoule, notably below prices in Western Australia, which average around $5.40 per gigajoule (AER 2012; values in AUD).

However, notwithstanding the State's greater levels of global market orientation, prices in Western Australia have remained relatively low compared with world prices (current prices in Japan, for example, are in the order of $15 per gigajoule).

A major factor behind this was the Western Australian Government's deal to purchase large volumes of gas from the North-West Shelf project – volumes which, over time, were sufficient to put downward pressure on domestic prices (see further discussion in relation to gas reservation in Western Australia below). Of course, there are other reasons why Western Australian prices are not converging to international levels, with the costs of LNG conversion, transportation and conversion back to gas estimated to account for $5-$6 per gigajoule (Grattan Institute 2013).

Looking forward, gas prices in Australia are forecast to rise sharply over coming years, with average analyst forecasts suggesting an increase of around 80% between now and 2020 (to $7.30 per gigajoule on the east coast and $9.10 on the west coast), before a moderation of growth thereafter. While expansion of Australia's LNG export industry is a contributor to the expected price increases, there are also other factors at play. Most significantly, production costs are rising. As low costs deposits becoming increasingly depleted, production is shifting to higher costs reserves. As EnergyQuest (2013) has recently demonstrated, the vast majority of Australia's uncontracted east coast reserves are subject to production costs of $5 per gigajoule or above, with a significant proportion above $7 (Chart 2.4). As production costs rise, so too must prices.

Chart 2.4: East coast uncontracted domestic gas production costs ($/GJ) 2013



Source: EnergyQuest (2013)

2.2 The origins of a DGR

The expectation of future rises in the price of gas coupled with difficult trading conditions facing Australia's manufacturing sector have fuelled calls for the Australian Government to introduce a policy of domestic gas reservation, or other forms of industry protection. A DGR would reserve a proportion of domestically-produced gas for domestic use to be sold at prices below those applying to exported gas Chapters 3 and 4 of this report analyse the economic impacts of a DGR both conceptually and empirically.

Reservation in Western Australia

A DGR policy has been in place in Western Australia – at least in principle – for some time. The Government struck a deal with the State Electricity Corporation of Western Australia (SECWA) in 1979 to purchase a large volume of gas (some 3,000 petajoules), with a further 2,000 petajoules reserved for domestic use, subject to a commerciality test (SKM, 2011). It also imposed a requirement on the Gorgon project to supply 2,000 petajoules of gas to the domestic market over the life of the project.

While these policies were effective in supressing domestic gas prices in the short term, as others – including, most recently, the Grattan Institute (2013) – have pointed out, their longer term impacts were perverse. Low prices reduced incentives for investment in gas processing capacity and, as the demand growth accelerated, supply was unable to keep pace and, over the latter part of the 2000s, contract prices rose sharply. In 2011, a Western Australian parliamentary inquiry into higher gas prices found that a lack of gas processing capacity had been a major factor.[2]

In 2006, the Government formalised a policy to reserve gas for domestic use. Under the policy, the Government negotiates for 15% of output from new LNG projects to be reserved for sale in the domestic market. However, it has not been a requirement that gas actually be sold on the domestic market. Rather, developers have been required to demonstrate their willingness and ability to meet the DGR policy and ensure gas is available from the date that exports commence.

In 2012, as part of its Strategic Energy Initiative (SEI), the Western Australian Government reaffirmed its commitment to a DGR policy, reinforcing the perceived need and clarifying arrangements for the policy's application. The policy statement stipulates that gas producers will be required to demonstrate their ability to meet the Domestic Gas Reservation Policy as a condition of project approval. *"The State will apply the policy flexibly and in accordance with the following requirements:*

- *LNG Producers will commit to make available domestic gas equivalent to 15% of LNG production from each LNG export project by:*
    - *reserving domestic gas equivalent to 15% of LNG production from each LNG export project;*

[2] Economics and Industry Standing Committee (2011). Higher prices did, in turn, lead to additional investment in processing capacity and recent analysis by the Independent Market Operator has found that there is expected to be adequate gas supply to meet forecast demand in the domestic market, that the gas processing capacity in the domestic market is anticipated to be double the forecast level of domestic gas demand by the end of 2022 and that existing gas reserves are forecast to be sufficient to continue to meet 2022 domestic and LNG demand levels for a very considerable period beyond 2022 (see http://www.imowa.com.au/GSOO).

- *developing, or obtaining access to, the necessary infrastructure (including a domgas plant, associated facilities and offshore pipelines) to meet their domestic gas commitments as part of the approvals process; and*
- *showing diligence and good faith in marketing gas into the domestic market".*[3]

The Government has not stipulated the commercial conditions that will govern the policy's operation; rather, it has indicated that they will be market-determined (including prices – thereby leaving open the prospect of another excess supply-fuelled cycle). The policy contains provision for offsets such that producers' domestic gas commitments arising from a new development can be met by supplying gas (or other energy) from an alternative source.

The government has committed to reviewing the policy in 2014-15.

Determinants of the policy impact

As well as the extent to which it is binding in practice, the economic impacts of a DGR hinge on a number of factors relating to the scheme's design and administration, and the dynamics of the associated markets. Critical among these are:

- **Scheme retrospectivity.** Applying a DGR retrospectively – i.e. to existing investments – would have the effect of considerably reducing investor confidence, potentially curtailing future investment in the sector (and indeed the economy more broadly). At the same time, applying the scheme prospectively – i.e. only to future investments – would potentially reduce its effectiveness (in terms of the cost and availability of domestic gas).
- **Production and extraction costs.** The projects most likely to be adversely affected by a DGR are those at the more marginal end of the spectrum. That is, those reserves where the cost of extraction is high as a result, for example, of location or the geology of the deposit. In these cases, any reduction in return on investment is more likely to compromise the project's commercial feasibility.
- **Conditions in downstream markets.** Conditions in downstream markets will dictate the ability of gas users to pass on higher gas prices to their customers. For example, in the case of manufacturers, the elasticity of demand for manufactured goods and prevailing levels of competition will determine how readily the industry can maintain margins in the face of rising input costs.
- **Input substitutability.** The impact of rising gas prices and/or gas reservation also hinge on the degree to which gas can be substituted for other inputs in the production process. The greater the ability to shift to alternative energy sources, the less the impact of rising gas prices.
- **Input intensity.** The degree to which industries are reliant on gas as a production input will impact the extent to which they are affected by gas price changes. The greater the share of gas in the overall cost of production, the greater the impact of price changes on production costs and, therefore, output decisions and/or downstream prices.

The parameters and assumptions that have been employed with respect to these variables are described in Chapter 4.

[3] Department of Finance (W.A.), 2012, Strategic Energy Initiative *Energy 2031 – Building the pathways for Western Australia's Energy Future,* August.

3 The economics of a domestic gas reservation

This chapter analyses—at a theoretical level—the economics of a DGR, examining its impacts on the affected markets and the economic inefficiencies that it generates. The framework developed in this chapter provides the underpinning for the economic modelling and empirical analysis presented in Chapter 5. The discussion also considers the analytical approach employed by DGR proponents and its limitations.

3.1 Technical analysis – a production tax with a consumption subsidy

The principle underlying free trade is that a country benefits when producers export goods and services at higher prices than they would otherwise receive in the domestic market. Not everyone gains from free trade—domestic consumers are worse off when they are required to purchase products at the higher world price—but overall there is a net gain to the economy, since exporters gain more than domestic consumers lose. The gain to exporters in turn flows well beyond those directly affected. Workers benefit through higher wages and increased employment opportunities; related industries benefit from the growth and income that is generated; and governments – and hence the broader society – benefit from higher tax receipts.

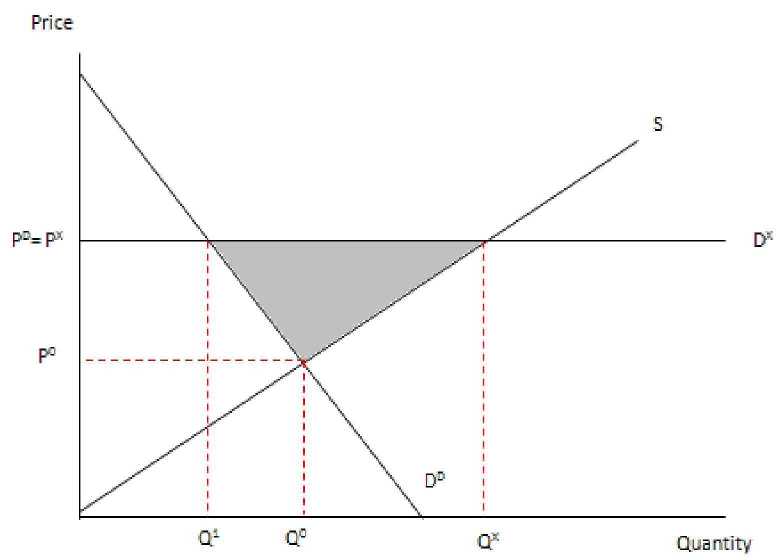
A free, open market for gas

In a free, open market, facing an export parity price (P^X) above the domestic non-trade price (P^0), gas producers will sell to domestic users if they are willing to pay a price at least as high as the export parity price (i.e. $P^D=P^X$).[4] Domestic users respond to this price by reducing the amount they purchase (from Q^0 to Q^1 in Figure 3.1 below).

Note that domestic users are not limited in the gas they can consume—they are simply required to pay the world price for what they purchase—and voluntarily reduce consumption in the face of higher prices. Producers are better off as they are able to sell their output at the higher price—they react by increasing supply (from Q^0 to Q^X).

[4] The price received by the exporter minus the costs of exporting.

Figure 3.1: A free, open natural gas market



Overall, the process is not a zero-sum game—the gain to the economy from being able to sell at a higher international price is unequivocally positive (shown as the grey shaded area in Figure 3.1). Intuitively, in the absence of trade, the domestic price of gas represents the value of a unit to the economy. When facing a higher export price, the country realises more value by exporting that unit to where it is more highly valued than using it domestically. In this sense, prices guide resources to their most valuable use and the economic value realised is maximised. This value flows not merely to directly affected industries, but is diffused across the economy via wages to workers, profits to shareholders, income to interlinked sectors and tax revenues to government.

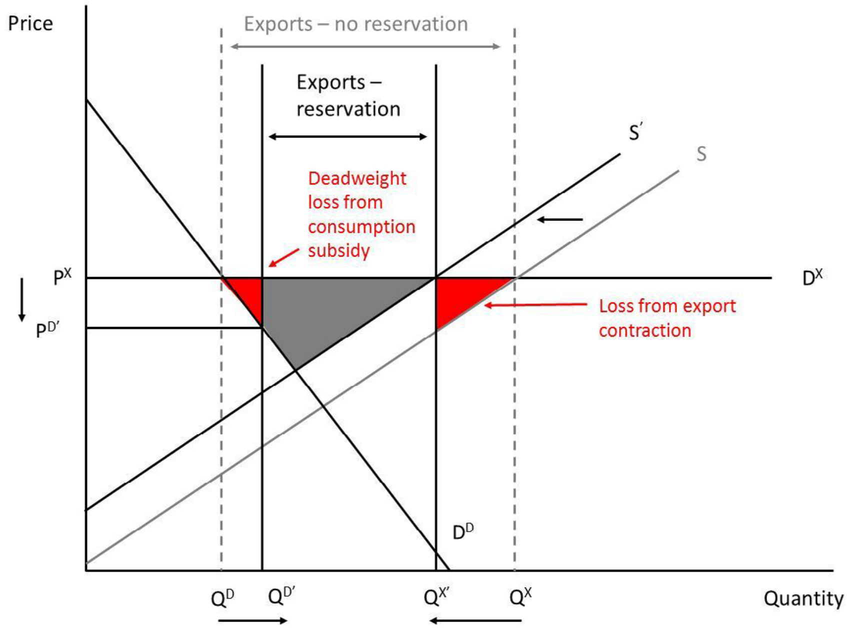
A gas reservation policy imposed

A reservation policy entails setting aside for domestic users an amount of gas greater than they would have consumed under free trade. This would result in excess supply of gas at the initial export parity price, causing the domestic price to fall.

Typically the amount of gas to be reserved is in direct proportion to the quantity of gas produced (for example, in Western Australia, it is 15% of LNG production). Since gas producers receive a lower price for this quantity (that is, they receive the artificially depressed domestic price rather than the international price), it is essentially a tax on production from their perspective.

In the short run, gas producers respond to this 'tax' by reducing total supply, illustrated by the shift in the supply curve from S to S' in Figure 3.2 below. This results in a contraction in the total supply of gas, including that reserved for domestic consumption, since one is proportional to the other. Gas exports are also reduced (from Q^X-Q^D to $Q^{X'}$-$Q^{D'}$ in Figure 3.2 below).

Figure 3.2: Gas market with a reservation policy imposed



The reduction in total gas output generates a loss of producers' surplus, shown in the diagram above as the right-hand red-shaded triangle. However, this is not the only loss. Unlike the usual case of a production tax, the proceeds from this 'tax' do not go to the government. Rather, they fund the domestic subsidy to gas consumers, resulting in additional distortions.

Although domestic gas users benefit from the lower 'subsidised' price, the value these users place on the gas is less than the value that could have been realised by exporting it, and this represents a net loss to the economy. The marginal benefit of the gas to the domestic user is below its opportunity cost to the producer (that is, the producer could sell the same quantity of gas at a higher price on the export market and be better off). This welfare loss is shown in the diagram as the left-hand red-shaded triangle.

What happens in the long run?

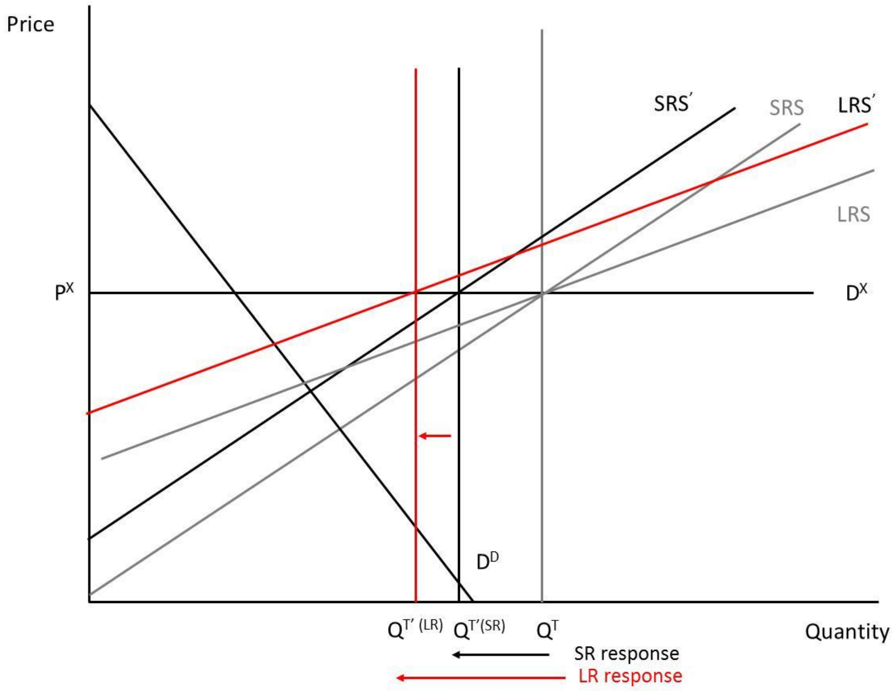
The above analysis is short run. In the short run, producers are limited in their ability to respond to the tax by contracting supply. Their supply response would largely result from a reduction in hours of production.

In the long run, however, domestic producers will respond to the lower return on gas production though their investment decisions. Less profitable gas production will lead to a reduction in investment in the industry and, as a result, total supply will fall even further. The recent experience in Western Australia stands as testament to this (refer to Section 2.2, above). Essentially, this means that the long-run supply is more elastic than short-run supply. The output responses in the short run and long run are illustrated in Figure 3.3. The actual size of the responses is uncertain and depends upon elasticities, which ultimately depend on factors such as competing investment opportunities and the overall level of uncertainty created by the reservation policy.

Irrespective of the precise orders of magnitude, what these mechanisms demonstrate is the potential for artificially low prices – and the reduced investment incentives that accompany them – to have long term consequences on the productive capacity of the sector. Over time, as the experience in Western Australia demonstrates, this raises the risk that long term domestic supply is in fact compromised by the DGR rather than assured by it.

It also raises the prospect of longer term inefficiencies on the demand side (that is, among gas consuming industries). The short-term demand side inefficiencies described above are amplified over the longer term if artificially depressed input prices lead to investment in downstream capacity that would not otherwise be productive.

Figure 3.3: Short and long run responses to a production tax



In principle, a gas reservation represents a distortion in the market that prevents Australia from realising the full value of its gas reserves. There would be winners, as there are with any price change, but the gains to these winners would not offset the direct losses to producers and the broader losses that emanate from this. The net losses are likely to be large and can be estimated by investigating the magnitude of projects rendered uneconomic through the scheme and the lost profits to producers. This is the subject of Chapter 4.

The intuition behind the theory

The benefits of freer markets and freer trade have been accepted by successive Australian governments in recent decades and indeed by the developed economies of the world, as evidence by the principles of the World Trade Organization and their predecessor the General Agreement on Tariffs and Trade. The steady removal of market distortions has delivered significant economic benefits to the nation. A domestic gas reservation would only serve to reverse these gains. The implicit tax imposed on local gas producers by a reservation policy would discourage investment in otherwise profitable gas deposits and reduce supply for both domestic use and export.

The implicit subsidy to domestic gas users, on the other hand, would encourage inefficient use of gas where other energy sources would be more efficient. Overall, diverting profitable gas exports to domestic use will come at significant cost to the economy – a cost which is borne widely across the economy. Proponents of domestic gas reservation fail to point out the economic cost of such a policy. Regardless of the price domestic gas users actually pay for their gas, the Australian economy forgoes the export revenue from selling gas at the higher world price to foreign buyers. This acts like a tax on the export of gas, and domestic producers respond by reducing production and, over time, investment, raising the risk that future supply is compromised. The income forgone affects not only gas exporters, but associated industries, workers, shareholders and government revenues.

Meanwhile, the gas which is diverted to domestic use is employed in activities that, by definition, fail to generate economic value at least equal to the world gas price (otherwise the domestic users would have no difficulty paying the world price in the first place). The loss of economic value that occurs when gas is used in ways that generate less economic value than their opportunity cost (i.e., what foreigners would have paid for the same gas) is a net loss of economic welfare to all Australians. In fact, it is equivalent to "flaming off" an equivalent volume of gas into the atmosphere for no economic gain.

A similar argument is sometimes made about beef or fruit destined for Australia's export markets. Why is it always the best beef or the choicest apples that get exported, leaving the lower quality produce for Australians to consume? Shouldn't we have a beef or fruit reservation so that Australians can afford to eat better quality produce without paying export prices?

When put this way most people understand that reserving beef or fruit would lower our living standard compared with selling produce at international prices and then using the export income earned to buy whatever we want on world markets, including export-quality beef or fruit. Forcing Australian farmers to sell their export-quality produce to Australian consumers at lower domestic prices makes our farmers poorer and lets domestic consumers eat higher quality beef and fruit than they would otherwise have been willing to pay for. The farmers are taxed and domestic consumers are encouraged to consume produce which costs the economy more than they are willing to pay for it.

The same is true of gas reservation. The economic value forgone when gas is diverted from export to domestic use exceeds any value created in domestic use. It must do so otherwise domestic users would happily pay world prices, as Australians do who value our export-quality primary produce.

3.2 The 2012 Energy White Paper

The issue of a domestic gas reservation scheme was recently considered in the Australian Government's *Energy White Paper*. The White Paper strongly advised against the creation of a domestic reservation scheme, arguing in support of allowing markets to determine the most efficient distribution of resources through the economy. In advising against intervening in the price mechanism and thereby restricting export supply in the gas market, the White Paper argued:

> *"…the key to stimulating effective and timely market response is to maintain open trading arrangements that do not constrict the proven ability of the market to deliver. This must allow price to play its role as a balancing incentive that can drive the development of additional supply. It is also critical that current impediments to the safe and sustainable development of new gas resources are addressed as a matter of priority.*
>
> *For this reason, the Australian Government does not support calls for a national gas reservation policy or other forms of subsidy to effectively maintain separation between domestic and international gas markets or to quarantine gas for domestic supply."*[5]

In regard to issues of supply, the White Paper saw that a reservation would not support domestic supply as argued by some proponents of the scheme. Instead, the effective tax imposed on domestic gas producers would reduce incentives to develop otherwise profitable supply:

> *"…a national reservation policy would add to, rather than reduce, long-term market risk by eroding development and supply incentives. It would be likely to impede the development of efficient gas markets and reduce returns to the economy from the development of our natural gas resources."*[6]

And further:

> *"The government does not accept the proposition that export developments are compromising Australia's gas security. Transitional pressures notwithstanding, LNG exports provide a critical platform for the expansion of our domestic markets and gas supply infrastructure. LNG projects are expected to produce $30 billion in export earnings by 2016–17 (BREE 2012g). These projects provide enormous returns to the Australian economy that would not be possible from domestic development alone."*[7]

Hence, in all respects the analysis in the White Paper rejects the assertions by proponents of a DGR that the market cannot be relied on to deliver an efficient price or amount of gas to the domestic market. Not only this, but it argues such a scheme could carry additional costs, being *"damaging to the nation's investment reputation, and would be at odds with our longstanding national commitment to open and fair trade".*

In summary, the *White Paper* saw no justification for a domestic reservation scheme, or for government intervention to direct resources away from the market outcome. It recognised the significant benefits that gas production and exporting could provide to the Australian economy and argued that intervention in the form of a reservation could jeopardise, rather than support, domestic supply.

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[5] *Energy White Paper, 2012: Australia's energy transformation*. Department of Resources, Energy and Tourism, 2012. pages 143-144.

[6] Ibid, page 144.

[7] Ibid.

3.3 Arguments for a reservation scheme based on multipliers

In the debate regarding the economic merits of reservation, arguments have been put based on input-output multiplier analysis. These arguments assert that the value of a unit of gas when used domestically is greater than its market price. It is argued that, since gas is an input into other goods and that these goods will not be produced if that unit is not used domestically, the cost of exporting the unit is the whole of the loss of production that would otherwise have been produced domestically.

The approach taken is to track the use of gas in the economy and measure the amount of output a unit of gas, when combined with other inputs, contributes to production. The argument is then that the whole of this final output, with a market value some multiple of the gas used in its production, is lost to the economy if the gas is not used for that purpose.

That a unit of gas has less value than the final output it contributes to producing is self-evident. However, it does not follow that the value of this output would be lost if the gas is not directed towards its production. Such an assertion would only be true if the other inputs used in production of the final good sat idle were they not used in this way and this is unrealistic in an economy with near-full employment. Instead, these resources have an opportunity cost when used in the production of one good, in that they could have instead been used in production elsewhere in the economy.

For this reason, analyses based on input-output tables and multipliers are most appropriate when measuring the way in which a policy flows through an economy, allowing policy analysts to identify which industries will be affected. However, the question to be answered is not how production will change when a unit of gas is exported rather than sold domestically, but instead which approach generates more wealth for the economy. An approach based on multipliers is not suited to answer such a question and is typically not the appropriate approach to use in policy evaluation.

Indeed, this is recognised formally in the Australian Government's *Handbook of Cost-Benefit Analysis* which states[8]:

> *"Inclusion of a multiplier effect from income and spending generated by a project is justified only when (a) the affected resources would otherwise have been unemployed and (b) the activities displaced by the project would not also have made use of the idle resources."*

By failing to account for the productive use to which the remaining inputs into final production would have otherwise been put, a multiplier analysis fails to give an accurate representation of the value of directing gas for domestic use. If, as has been claimed (National Institute of Economic and Industry Research 2012), one dollar's worth of export could be used to generate 21 dollars' worth of output if used domestically, it begs the question why the supply chain was not willing to pay more for that unit of gas than it was.

[8] *Handbook of Cost Benefit Analysis*. Commonwealth of Australia, January 2006, page 118.

The answer is that it would be more efficient to use the remaining inputs elsewhere rather than pay the world price for the gas input.

The implication is that, in the absence of significant market failures or unemployed resources, the value of a good to the economy is simply the price at which it trades. Requiring gas producers to sell to domestic users at a price below the world market level on the grounds that its value is not fully reflected by the market price, is based on a false premise. Indeed, if we take the multiplier argument seriously, the government would be called on to estimate multipliers for each market in the economy and redirect resources to those markets with the largest multipliers, instead of relying on free market prices to achieve an efficient allocation. Such central planning is not supported by any economic principles and would come at a large cost to the Australian economy.

Summary of findings

The economic theory and principles governing the impact of a DGR are well established and, under the vast majority of circumstances, undisputed. A DGR acts as a simultaneous tax on the export of gas and subsidy to domestic gas users – both of which directly undermine the economy's efficiency. The result is an unequivocal economic loss, with the economy forgoing the export income only to inefficiently subsidise domestic consumption. The longer term consequences see reduced investment incentives leading to lower levels of capacity and production, which in turn raises the risk that domestic supply is in fact compromised by a DGR, rather than assured. At the same time, artificially depressed prices fuel inefficient investment in downstream productive capacity, adding to the inefficiency that the policy perpetuates.

In the absence of market failures, the price of a good represents its value to the economy, and when goods can be sold at a higher price internationally than domestic users are willing to pay, economic welfare is increased by doing so.

Arguments in favour of a domestic reservation scheme are based on inappropriate economic modelling which is partial in nature and does not account for the opportunity cost of the inputs used in domestic production. The framework which does appropriately capture the impacts of the policy is a computable general equilibrium (CGE) model, such as that used to inform the modelling in Chapter 4 of this report.

4 Modelling the economic impacts

The impact of a national DGR on the Australian economy is modelled in this study via a two-staged approach. The first stage is underpinned by a purpose-built partial-equilibrium model that analyses the direct impacts of the policy on production and investment in Australia's gas sector. As the discussion below describes, the model has been designed and constructed drawing on an array of industry data and based on information sourced through consultations with industry. The second stage utilises the outputs of this partial-equilibrium model as an input to Deloitte Access Economics' in-house regional general equilibrium model (known as DAE-RGEM) to simulate the economy-wide impacts of the policy.

Like other models of this form, DAE-RGEM is a large scale, dynamic, multi-region, multi-commodity computable general equilibrium model of the world economy. The model allows policy analysis in a single, robust, integrated economic framework, projecting changes in macroeconomic aggregates such as GDP, employment, investment and private consumption. At the sectoral level, detailed results such as output, exports, imports and employment are also produced.

The model is based on input-output or social accounting matrices, as a means of describing how the Australian economy is linked through production, consumption, trade and investment flows. For example, the model considers:

- direct linkages between industries and countries through purchases and sales of each other's goods and services; and
- indirect linkages through mechanisms such as the collective competition for available resources, e.g., labour, that operate in a global, economy-wide context.

Compared with alternative tools of analysis, such as Input-Output modelling, the superiority of the CGE model lies in its ability not only to capture the unconstrained effects of policy change – which are likely to be a crude approximation of its net impacts – but also to provide a comprehensive assessment of the full suite of flow-on impacts in a single, robust, integrated economic framework.

In the case of a policy as pervasive as a DGR, the sophistication of the CGE framework allows the myriad number of flow-ons that the policy generates to be captured and simultaneously analysed. For example, it allows the stimulus to economic activity in sectors that are downstream users of gas to be analysed alongside the reduction in output and investment in the gas sector, in an environment where wages, exchange rates and factor prices are changing in response to these forces. In this sense, it provides a comprehensive assessment of the *net overall economic impact* of the policy.

More information on the modelling framework can be found in Appendix A.

4.1 Methodological overview

This study adopts a bottom-up approach to determine the impact of a 15% DGR policy on gas production. This involved undertaking a comprehensive review of publicly available information on gas production, using key resources such as the Bureau of Energy Economics (BREE), the Australian Energy Market Operator (AEMO) and other independent research on the Queensland gas market. Commercial information was used to compile a registry of gas projects, their cost profiles and, therefore, the potential impacts of the adoption of a domestic gas reservation regime on gas projects over time.

Following this desktop review, a stylised partial gas market model was used to develop a dynamic gas supply curve for eastern Australia under a scenario with no DGR policy (Business as Usual profile) and a dynamic gas supply and demand response curve in a scenario with a DGR policy (Domestic Gas Reservation Policy profile).

Figure 4.1: Methodology overview

The following sections outline the assumptions used to develop Business as Usual and DGR policy profiles.

4.1.2 Business as Usual profile

The Business as Usual (reference case) gas supply profile outlines the most likely path for the evolution of eastern Australian gas output in the absence of a domestic gas reservation. This essentially forms a reference point, or counterfactual, against which the impacts of changes in the market or policy directions are compared.

Over the next few decades, the eastern Australian gas production profile will look very different from what it does today. Currently, eastern Australia's gas market operates in isolation from other gas markets in Australia and internationally. As a result of access to export markets for its substantial reserves of natural gas from coal seams, and underwritten by the significant levels of investment described in Chapter 2, the eastern Australian gas market will see significant growth in LNG exports over the coming decades.

Table 4.1 outlines Eastern Australia's current and potential gas production levels, by field, together with indicative production costs. The Business as Usual profile assumes that domestic gas and LNG prices will increase sufficiently to allow these gas projects to be operative. The results of our review of BREE and AEMO data suggest that by 2025, gas fields in Eastern Australia will be producing approximately 3,700 petajoules per annum.

In particular, major gas projects such as APLNG, GLNG, QCLNG and Arrow Energy are assumed to commence operating and contributing to the domestic gas market and LNG export market — leading to an average growth in output of 15% per year for the Eastern

Australia gas market by 2025. The analysis assumes the projects nominated face no hurdles of sufficient magnitude to prevent their coming on line.

AEMO has forecast that NSW will be a relatively large producer of onshore gas by 2025 and this expectation has resulted in strong production growth in the NSW gas output market over the period to 2025.

Table 4.1: Eastern Australia current and potential gas production

Field	Production (PJ pa)	Cost at 10% Return ($/GJ)	Cost at 0% Return ($/GJ)
Yolla	17	4.77	1.71
Kipper	30	7.37	5.36
Longtom	25	4.28	1.72
Gloucester (CSG)	15	3.40	3.07
Moranbah	17	4.62	4.11
Fairview / Spring Gully	81	3.17	2.04
Walloons East	74	3.53	1.53
QCLNG	471	3.53	1.53
APLING	499	3.53	1.53
GLING	432	3.53	1.53
Camden (CSG)	6	5.58	3.12
Arrow LNG	443	3.53	1.53
Cooper	182	1.54	0.64
Gunnedah (Tier 1)	150	2.61	1.66
Gunnedah (Tier 2)	32	4.31	2.93
Sydney Onshore	314	5.58	3.12
Clarence Morton	544	6.69	4.96
Hunter Area	9	5.38	3.32
Walloons Mid	100	4.80	2.39
Walloons West	151	5.04	4.11
Ironbark	48	4.80	2.39

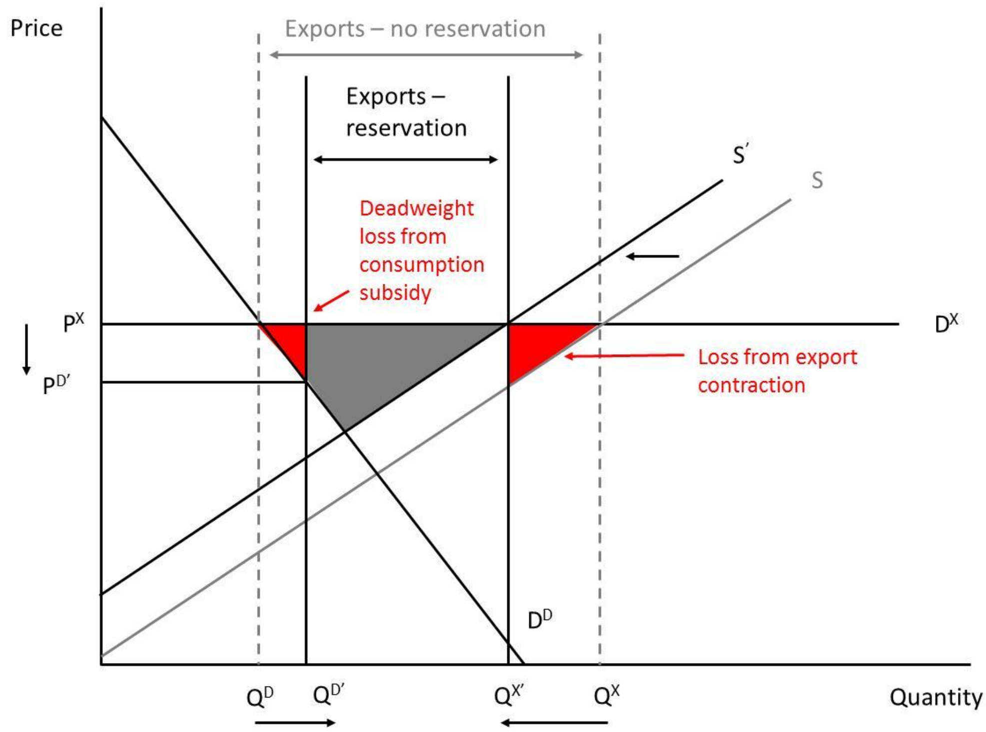
Source: AEMO Gas production Costs (2012), BREE Resource and Energy Major Products (2013)

4.1.3 Domestic Gas Reservation profile

Imposing domestic gas reservation on the Eastern Australian natural gas market will affect both the domestic gas demand and supply curves. To determine the impact, it is necessary to develop a partial stylised demand and supply model of the Eastern Australian gas market, as represented in Figure 3.2 (reproduced in Figure 4.2, below).

Consistent with the underlying economics, the DGR is expected to result in a reduction in total gas output and prices. For some production fields in Eastern Australia, the lower price would make the marginal returns from gas lower than the unit production costs, rendering them uneconomic and resulting in a reduction in aggregate gas output. The sizes of the changes in output and prices are dependent on the shape of the supply and demand curves.

Figure 4.2: Gas market with a reservation policy imposed



Note: Not drawn to scale.

To determine the shape of the supply side of the model (curve S, in Figure 4.2), it is necessary to estimate the per unit production cost for each project. While much of the detailed supply side information is commercially sensitive, unit costs for each gas field were estimated from information in the AEMO 2012 Gas Production Cost report (Table 4.1). The AEMO report developed per unit operating costs which included exploration costs, development, drilling and completion, gas processing, gas gathering systems, water handling, tax and royalties, and general administration.

Deloitte Access Economics used the AEMO operating costs and gas production data as a base to develop a stylised gas supply curve for Eastern Australia. In developing the supply curve for the stylised model, DAE assumes supply curve a hurdle rate of 10% return on investment. The bottom up construction of an aggregate gas supply curve from available individual proponent data in this way results in a supply curve that displays non-constant elasticities. That is, it replicates the real world lumpiness that is naturally observed in industries such as the gas supply sector.

As the demand side of the gas market involves a much greater number of heterogeneous users, development of a stylised demand response curve relies on observation of historical price and quantity data, combined with a survey of econometric estimation of long and short run domestic demand elasticities. A review of literature on the demand for natural gas demonstrated that short term and long term demand price elasticities were relatively inelastic and could vary between -0.25 and -0.5. For this analysis, Deloitte Access Economics used the upper bound of -0.5 for the demand price elasticity in the stylised gas model. This -0.5 drives the slope of the demand curve (curve D^D in Figure 4.2).

The combination of the bottom-up supply curve and the econometrically driven demand curve allows the analysis to test, at each price point, the likely downward pressure on local gas field development and the local demand expansion resulting from the wealth transfer from domestic producers to domestic consumers.

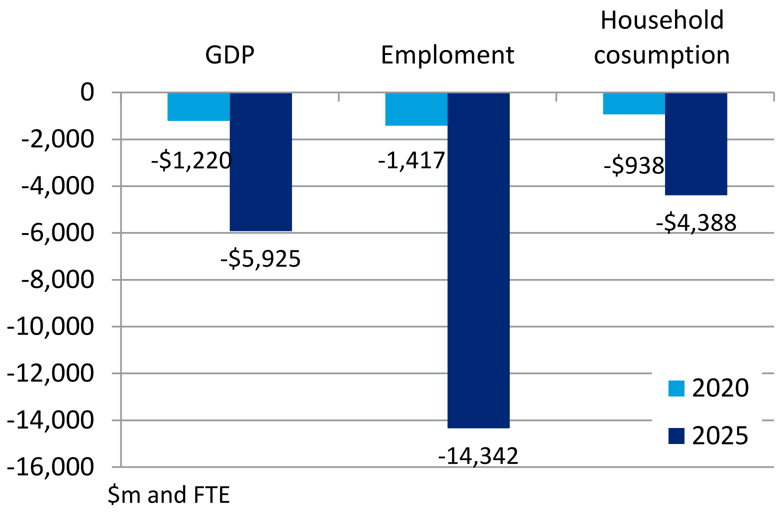
Calibration of the modelling framework also relies on assumptions regarding the netback prices that local projects might expect to face. Projections of long run netback LNG prices are highly sensitive to foreign demand, which over the long term is driven by a number of variables such as the rate of international recovery from the global financial crisis and future international climate change policy settings. The analysis presented in this report assumes a long run netback price of $9/gigajoule in 2025.

4.2 Economy-wide impacts

Simulating the impacts of a DGR using Deloitte Access Economics' CGE modelling framework shows that it has a significant and pervasive impact on the national economy. As the impacts of the policy become progressively more binding and production and investment decisions are increasingly affected, the economic impacts grow rapidly over time. The activity stimulated in sectors utilising gas as an intermediate input – by virtue of domestic gas prices being lower than under the reference case – is insufficient to offset the substantial export income that is forgone in the gas sector and its related industries.

Indeed, as Chart 4.1 shows, the cost to the Australian economy of a national gas reservation grows rapidly over time. In 2020, it is estimated that a DGR lowers Australian GDP by $1.2 billion compared to the reference case, with this figure increasing to $6 billion by 2025. Associated with this forgone economic output is an estimated 1,400 full time equivalent (FTE) jobs at 2020 – a figure which increases to 14,300 FTE jobs by 2025. Chart 4.1 also shows that, at 2025, real household consumption – a commonly used proxy for economic welfare – is reduced by an estimated $4.4 billion across the economy.

Chart 4.1: Aggregate economic impacts; 2020 and 2025



Source: Deloitte Access Economics

All dollar figures represent real $2011-12, deviations from reference case

At an industry level, Chart 4.2 shows that, as well as curtailing output in the gas sector, a DGR policy significantly lowers production in industries that are intensively used as an intermediate input to the sector (upstream industries). For example, output in the construction industry is expected to be $1.3 billion lower than in the reference case in 2025, due to the reduction to economy-wide investment, as the production in the gas industry declines. Other upstream industries such as Trade, and other service industries (Communications, Property and Business Services and, Finance and Insurance) are also adversely impacted by the policy. Output from these service industries are expected to be $1.8 million lower than the reference case in 2025.

At the same time DGR policy is projected to stimulate additional production in industries that utilise gas as an intermediate and/or are trade exposed, although as the macroeconomic results demonstrate, this additional benefit does not outweigh the costs imposed on other sectors.

The reduction in LNG exports places downward pressure on the value of the Australian dollar. The lower value of the dollar in turn reduces the price of other trade exposed goods to foreigners and increases the demand for other Australian exports – in part offsetting the first order downward pressure from reduced LNG exports, culminating in a long run depreciation in the local currency of approximately 1%.

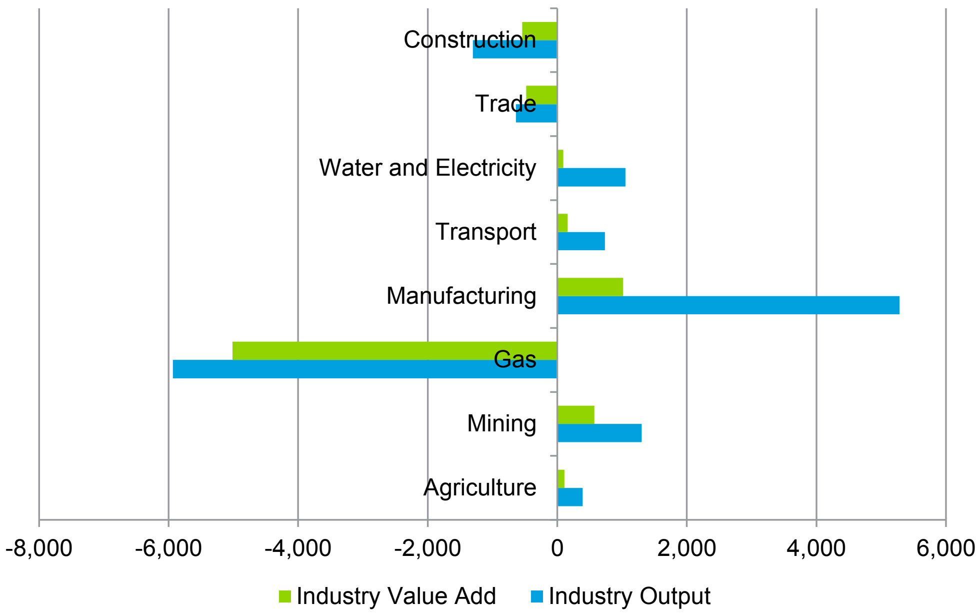
Chart 4.2 shows the output and the value added deviations in Manufacturing, Mining and Agriculture – all relatively trade exposed industries which are expected to benefit from the introduction of a DGR policy. The additional activity stimulated in these sectors reflects both the lower cost of gas as an intermediate input and the aforementioned impacts of a depreciation in the Australian currency – in particular for the Manufacturing sector which enjoys less competition through the exchange rate and a cost subsidy on the production side. Manufacturing production is estimated to be $5 billion higher than the reference case in 2025, while Agriculture and Mining production is estimated to be $390 million and $1.3 billion higher, respectively.

Chart 4.2 also shows the impact on production in the Electricity and Water, and Transport industries. These industries in particular experience a combination of both upside and downside as a result of the policy. For the most part they are not directly trade exposed, but are suppliers to the LNG sector, the domestic manufacturing sector, and the variety of upstream industries and final demanders that are exposed to the impacts of the policy.

Finally, Chart 4.2 demonstrates the differential impacts that would be expected on output and value add in selected industries. It is important to note the GDP is a measure of aggregate value added in an economy rather than output and hence it is changes in value added that best describe the policy's net economic impacts. The gas sector in particular has a high value added component, with the most recent ABS Input Output table suggesting a value add ratio of 0.80 for the oil and gas sector, compared to an average of 0.28 across the manufacturing sector as a whole (with the ratio in some parts of the sector as low as 0.13). Notably, 0.80 is the highest value added ratio observed in the Australian economy, and 0.13 is the lowest of the value added ratios.

The result of the wide range of value added to output ratios, and in particular the transfer of economic activity from a high to a low value added sector of the economy is that the sum of industry output is a particularly poor measure of economic outcomes.

Chart 4.2: Impact on industry output – selected sectors; 2025



Source: Deloitte Access Economics

All dollar figures represent real $2011-12, deviation from reference case

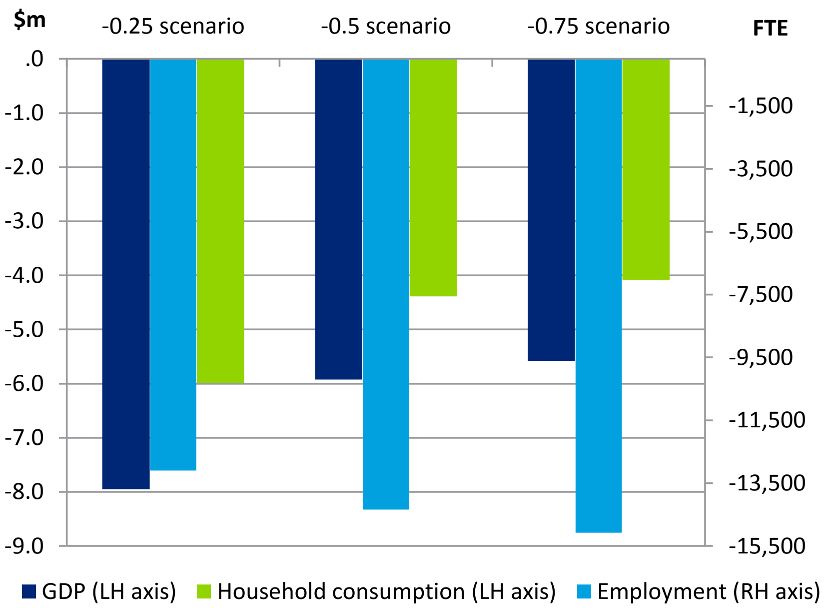
4.3 Sensitivity analysis

As one of the parameters most critical to the modelling results, sensitivity analysis has been undertaken on the demand elasticity assumption. Under the central case (presented above), the assumed elasticity is -0.5, reflecting a conservative estimate based on the available literature pertaining to the elasticity of demand for gas. In order to assess the sensitivity of the modelling results to variations in this assumption, a high and low scenario has been modelled, employing parameters of -0.75 and -0.25, respectively.

As the results presented in Chart 4.3 demonstrate, varying the assumption regarding demand elasticity varies the economic consequences of the policy. Increasingly the elasticity of demand parameter reduces the magnitude of the fall in domestic gas prices that the policy generates and, in turn, reduces the loss of economic welfare, since the value of export earnings forgone is reduced. That is, the differential between the international price and the domestic price is reduced. Conversely, the lower demand elasticity assumption increases the magnitude of the fall in domestic gas prices and increases the loss of economic welfare. The impacts are non-linear, with the low elasticity scenario seeing a ~25% increase in the GDP loss at 2025 (relative to the central case), while the high elasticity sees a ~5% fall in the GDP loss at 2025 (relative to the central case). The employment impacts move in the opposite direction, with the low elasticity scenario – and the lower domestic gas prices that it implies – stimulating employment (relative to the central case (that is, reducing the loss of jobs)).

In any case, the sensitivity analysis demonstrates that, across a range demand elasticity assumptions, a DGR imposes a significant, unambiguous cost on the Australian economy.

Chart 4.3: Demand elasticity sensitivity analysis; 2025



Summary of findings

Computable general equilibrium modelling is the only analytical method capable of comprehensively and robustly assessing the broad-ranging economic impacts of a domestic gas reservation policy. The CGE modelling conducted to inform this report demonstrates that, consistent with the theory, a DGR imposes sizeable economic inefficiencies and significantly undermines the nation's economic wellbeing.

Moderate short term impacts grow rapidly over time as production and investment in the gas sector is artificially curtailed. By 2025, an estimated 14,000 jobs and $6 billion in GDP (in that year alone) have been sacrificed as a result of the policy. Modest economic benefits to gas users are dwarfed by the losses emanating from forgone export earnings – losses which have are rooted in the gas sector, but flow not merely to related sectors like construction and trade, but to households via reduced wages and employment opportunities and to government via reduced tax receipts.

Taxing the exports of a sector that is not only one in which Australia has a comparative advantage but one that generates more value-added per unit of output than any other is unlikely to be economic welfare-enhancing. It is unequivocally not welfare-enhancing when those tax receipts are not collected by government, but rather are transferred in the form of a direct subsidy to another sector which produces lower value-added per unit of output than any other.

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Appendix A: General equilibrium model

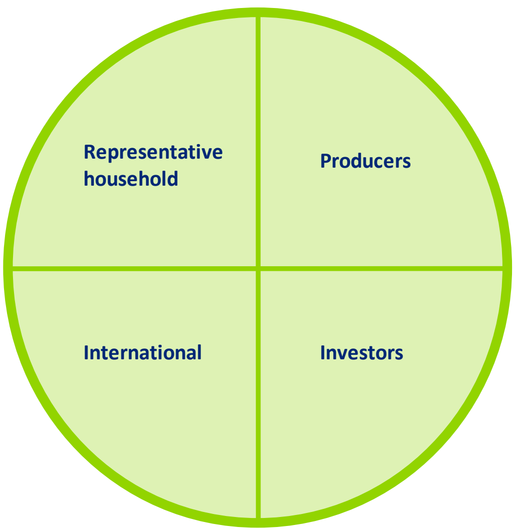
DAE-RGEM is a large scale, dynamic, multi-region, multi-commodity computable general equilibrium model of the world economy. The model allows policy analysis in a single, robust, integrated economic framework. It projects changes in macroeconomic aggregates such as for GDP, employment, export volumes, investment and private consumption. At a sectoral or industry level, detailed results such as output, trade flows and employment are also produced.

The model is based on a set of key underlying relationships between different groups of agents in the economy: households, producers, investors and international agents. Each of these groups is represented as a discrete *component* in the model. The relationships between components are solved simultaneously and, as such, there is no logical start or end point to conceptualise the model's operation.

Figure A.1 shows the key components of the model for an individual region. Regions can be specified for particular analyses and can be entire countries (or multi-country regions like the Euro Zone or East Asia) or specific areas of a country like Australian States and Territories.

The model's database and broad economic foundations are outlined below.

Figure A.1: Key components of DAE-RGEM



The database

DAE-RGEM is underpinned by a detailed global database. This is derived from the Global Trade Analysis Project (GTAP), which produces a global database for general equilibrium modelling that covers 113 regions or countries and 57 industry sectors (the base year is 2004).

The Australian component of the database is provided by the Productivity Commission and is based on Australian input-output tables developed by the Australian Bureau of Statistics. As noted, the model also splits Australian economic activity into States and Territories, thus allowing regional analysis to be undertaken.

The base data quantifies the economic flows between sectors, including bilateral trade, and also accounts for greenhouse gas emissions from fossil fuel combustion. The database is 'benchmarked' or calibrated so that an initial equilibrium solution exists that replicates actual sectoral production, consumption, trade and factor usage in the base year (2004).

Economic foundations of the model

Income, consumption and savings

- Each region contains a 'representative household' that receives all income from factor payments (labour, capital, land and natural resources), taxes and net foreign income from borrowing (lending).
- Under standard economic setting (otherwise known as the model's closure), savings are a function of the rate of return on capital which reflects the return on savings. Government consumption moves in line with national income. Household consumption, therefore, is determined as the residual of national income, savings and government consumption.
- At the detailed level, household consumption for composite goods is determined by minimising expenditure via a CDE (Constant Differences of Elasticities) expenditure function. For most regions, households can source consumption goods only from domestic and imported sources. In the Australian regions, households can also source goods from interstate. In all cases, the choice of commodities by source is determined by a CRESH (Constant Ratios of Elasticities Substitution, Homothetic) utility function.
- Government consumption for composite goods, and goods from different sources (domestic, imported and interstate), is determined by maximising utility via a C-D utility function.
- Producers supply goods by combining aggregate intermediate inputs and primary factors in fixed proportions (the Leontief assumption). Composite intermediate inputs are also combined in fixed proportions, whereas individual primary factors are combined using a CES (constant elasticity of substitution) production function.
- Producers are cost minimisers, and in doing so choose between domestic, imported and interstate intermediate inputs via a CRESH production function.
    - The model contains a more detailed treatment of the electricity sector that is based on the 'technology bundle' approach for general equilibrium modelling developed by ABARE (1996).
- The supply of labour is influenced by movements in the real wage rate and is governed by an elasticity of supply parameter. This implies that changes in the demand for labour, positively or negatively, will impact both the level of employment and the wage rate.

Investment

- Investment takes place in a global market and allows for regions to have different rates of return that reflect their individual risk profiles and policy impediments to investment. A global investor ranks countries as investment destinations based on two factors: the current level of global economic growth and comparative regional rates of return.
- Once aggregate investment is determined in each region, the regional investor constructs capital goods by combining composite investment goods in fixed proportions, and minimises costs by choosing between domestic, imported and interstate sources for these goods via a CRESH production function.

Market clearing

- Prices are determined via competitive market-clearing conditions that require sectoral output (supply) to equal the amount sold (demand) to final users (households and government), intermediate users (firms and investors), foreigners (international exports), and other Australian regions (interstate exports).
- Internationally traded goods (imports and exports) are differentiated by the country of origin and treated as imperfect substitutes (according to the so-called Armington assumption). But in relative terms, imported goods from different regions are treated as closer substitutes than domestically-produced goods and imported composites. Goods traded interstate within the Australian regions are assumed to be closer substitutes again.

Limitation of our work

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