



Natural Gas Available Everywhere

Perspectives from Western Australia

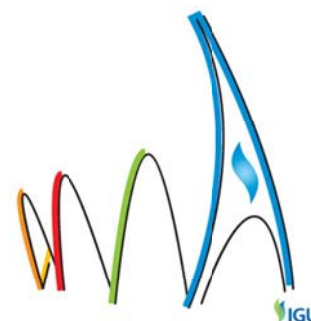


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Introduction

Western Australia is rising rapidly from being a mid-tier to a leading global energy supplier. By 2017, the State will be the world’s second-largest LNG producer, after Qatar. This is possible thanks to an extraordinary period of investment in the State’s infrastructure and capacity.

This paper describes the development of Western Australia as a major gas supplier, and some of the challenges the State had to overcome to develop its successful gas industry. It explains how the State Government has worked with the private sector to develop the State’s gas reserves.

About 90% of Australia’s known conventional natural gas reserves are in basins along the Western Australian coast. Development of these basins began in the 1960s, and proceeded in three distinct phases. The first phase focused on supplying gas to the domestic market. The second phase marked the State’s entry into the liquefied natural gas (LNG) export market and began in 1989, when the North West Shelf project exported 5 million tonnes of LNG to Japan. For many years, the North West Shelf was the State’s only LNG exporter. But the third phase of development, which is now under way, is seeing new projects entering the market. The Pluto project began exporting in 2012. There are currently three LNG projects under construction in Western Australia – Gorgon, Wheatstone and Prelude. These projects will cost \$98 billion to develop and will start producing within two years, adding 28 million tonnes a year to the State’s LNG export capacity. Other LNG projects are under consideration, including development of the Browse basin and smaller offshore reserves. The domestic market is also diversifying, with the number of domestic gas production



facilities in the state increasing from two to eight and domestic supply capacity rising from 637 to 1,465 terajoules a day in the past 30 years.

Western Australia is remote. It has a land area of 2.5 million square kilometres (more than three times the size of Texas) but a population of just 2.6 million. Most of its gas reserves are far from population centres and infrastructure. Each phase of development of the State's gas industry has faced the same fundamental challenge – to connect Western Australia's large gas reserves with customers. To borrow from the title of this conference session: we have long known that Western Australia has abundant gas in many parts of the State: "natural gas (almost) everywhere". The challenge has been making that "natural gas **available** everywhere", or at least everywhere there is domestic and export demand. This has required long-term, secure sources of energy and major investment in infrastructure. The third phase of gas development currently under way is seeing the emergence of new technologies such as floating LNG and geo-sequestration of carbon dioxide on an unprecedented scale. It will be marked by a focus on productivity and containing costs, for example through more efficient use of existing infrastructure and third party processing.

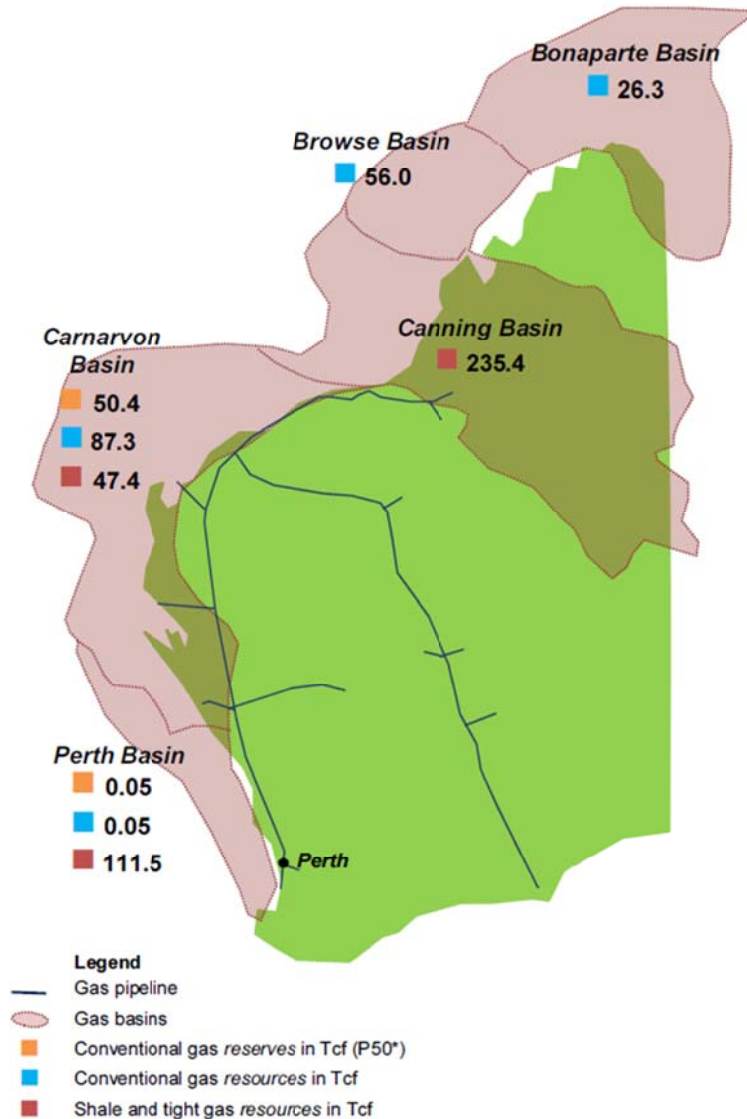
Western Australia's gas provinces

Western Australia is the largest state in Australia with a small population that lives mostly in the southwest corner of the State. The State has abundant resources including oil and gas, and minerals including iron ore, gold, alumina and nickel. Its population is less than one twentieth that of France but occupies four times the land area.

The State has six major sedimentary basins, five of which contain gas - the Bonaparte, Browse, Canning, Carnarvon and Perth basins.¹ Most of the productive fields are far from urban population centres. To connect the gas with large energy users it must be either piped or shipped long distances. A map with the reserve and resource estimates is shown in Figure 1 below.

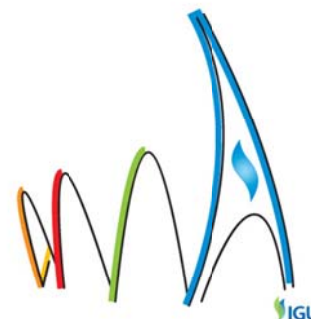


Figure 1: Western Australia's natural gas infrastructure, resources and reserves



Source: DMP.
*P90 refers to 50% probability of recovery.

The Perth Basin is closest to the urban populations and economic activity of the south west of Western Australia, and this proximity was a factor in the onshore exploration of the Perth Basin in the early 1950s and offshore in 1965.² It contains coal, oil and natural gas. Estimates of proved and probable gas reserves are 0.05 trillion cubic feet with potential resources of 0.77 trillion cubic feet, and around 10 trillion cubic feet of tight gas resources.³



Gas was discovered in the Perth Basin between 1964 and 1971, leading to the first phase of development of the State's natural gas industry (see below).⁴

The State's largest and most prospective offshore basin is the Carnarvon Basin, off the coast of Western Australia's remote Pilbara region. Oil was discovered in the northern Carnarvon Basin in 1953 with follow-up discoveries of oil at Barrow Island in 1964 and gas fields in 1971.⁵ The northern Carnarvon Basin has been intensively explored, with a large number of gas fields discovered, and is the location of the North West Shelf and Gorgon Gas Fields, LNG processing plants and domestic gas (pipeline gas) plants. The basin covers an area of 375,000 square kilometres with the gas fields mainly offshore with the fields typically in water of between 120 and 220 metres.⁶ In early 2015 proved and probable reserves were estimated to be 50.4 trillion cubic feet and potential resources of 87 trillion cubic feet.⁷

North of the Carnarvon Basin is the Canning basin, a large, mainly onshore basin in the remote northern Pilbara and southern Kimberley regions of Western Australia that is relatively unexplored but prospective for shale gas. The Canning basin may have the largest shale gas potential in Australia with shale and tight gas resources estimated at around 235 trillion cubic feet.⁸

The Browse and Bonaparte basins lie off Western Australia's north and north-west coasts, both mostly offshore and closer to Indonesia than to mainland Western Australia. The Browse Basin covers an area of 218,000 kilometres².⁹ Estimated conventional gas resources are 56 trillion cubic feet.¹⁰ Although exploration of these basins has been limited, the discovery rate is high but it is a difficult resource to develop due to the depth of the water and the limited infrastructure in the region.¹¹ The nearest gas processing facilities are south in the Carnarvon Basin or north east in the city of Darwin. The Ichthys project will draw gas from the Browse basin and pipe it 889 kilometres east to Darwin to produce 8.4 million tonnes of LNG and 1.6 million tonnes of liquefied petroleum gas a year.¹²

The Bonaparte Basin is located at the northern most tip of Western Australia with only the north-western portion within Western Australia's coastal waters.¹³ Proved and probable conventional gas reserves are estimated to be 0.93 trillion cubic feet with probable resources of 26.3 trillion cubic feet.¹⁴

Evolution of the Western Australian gas industry

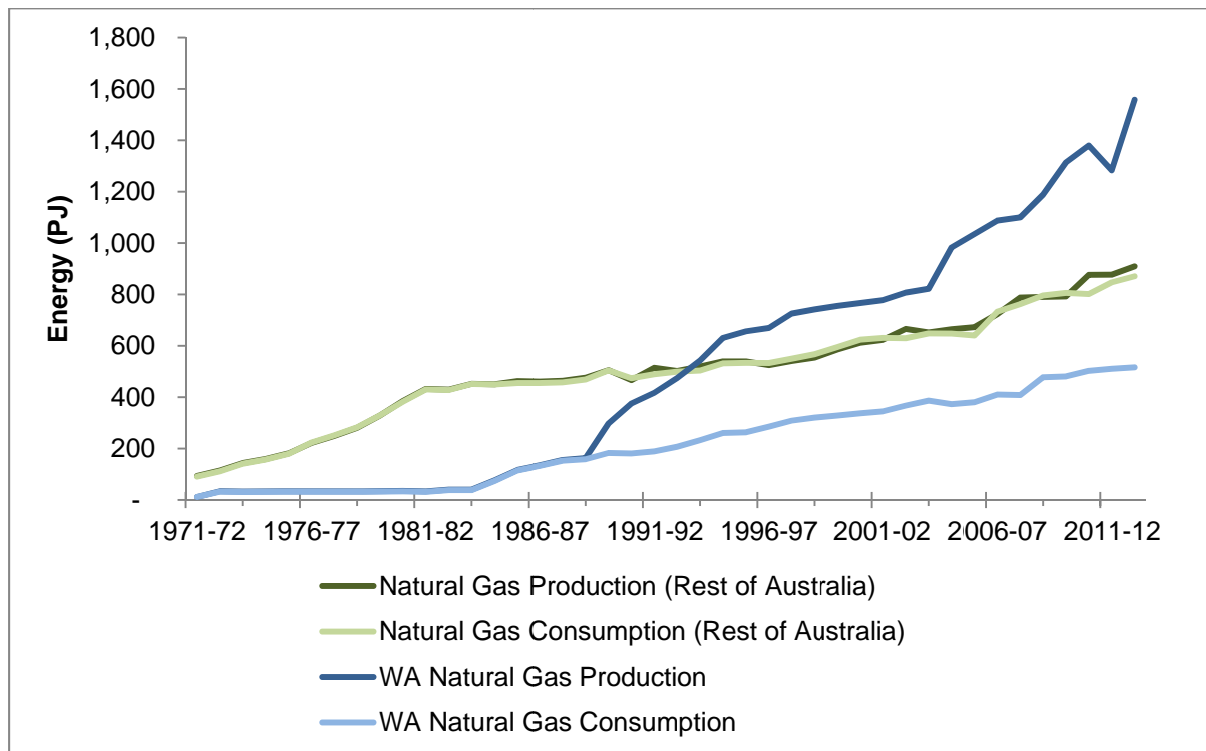
Gas production in Western Australia increased from 11.4 petajoules in 1971-72, when the Parmelia pipeline opened, to over 1,500 petajoules in 2012-13. Between 1980-81 and 2012-13 Western Australia's annual gas production growth rate was around 12%.¹⁵ Western Australia's population doubled from 1.3 million in 1981 to 2.6 million in 2014.¹⁶

The development of Western Australia's gas industry has been different to the rest of Australia. Western Australia has been exporting LNG since 1989, and exports most of its gas production. In the rest of Australia most gas production has until recently been for the domestic market, though that is about to change, as three new LNG projects are under construction (Figure 2). In 2012-13 Western Australia produced around 70% more gas than the rest of Australia.¹⁷ Because Australia's eastern states have their own gas reserves, it has



not been economic to build a pipeline connecting Western Australia's gas reserves to the east coast, and the two markets evolved separately.

Figure 2: Natural gas production and consumption 1971-72 to 2012-13

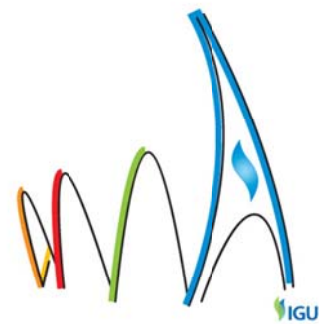


Source: Bureau of Agriculture and Resource Economics¹⁸

Phase 1: Establishing the domestic market

The first phase of the development of Western Australia's natural gas industry entailed exploration and early investment in gas extraction and supply infrastructure.

Oil processing drove the initial development of the petroleum and gas industry in Western Australia. Oil projects with gas volumes too small to justify constructing a pipeline to potential markets flared gas.¹⁹ Domestic gas was produced from coal until economic gas discoveries in the Perth Basin. Western Australia's first gas pipeline was built in 1971 in response to the discovery of economic gas fields approximately 320 kilometres from Perth.²⁰ It connected gas from Dongara fields with its foundations customers: alumina refineries at Pinjarra and Kwinana, some 416 kilometres away.²¹ Other major customers were the government owned energy utility, the State Energy Commission of Western Australia (SECWA) and industrial loads including Western Mining, Midland Brick Company, Swan Cement and the Fremantle Gas and Coke Company.²²



The pipeline was commissioned in 1971 with a capacity of 68 terajoules per day,²³ and the first gas was delivered in October 1971.²⁴ Capacity was expanded with the development of the Woodada field to 120 terajoules per day in the early 1980s to meet SECWA's demand.²⁵ This was a period of minimal consumption change.

Phase 2: Establishing the LNG industry and Domestic Market Reform

The second phase of the development of Western Australia's gas industry began with the development of the State's LNG export industry. This was also a period of market reforms that established the commercial and economic conditions for domestic market expansion. Gas was discovered on the North West Shelf in the Carnarvon Basin in the early 1970s.²⁶ The gas had considerable technical risk, and was located in 130 metre water depth in a cyclone-prone environment.²⁷ The risks and cost of developing this resource, and its large size relative to the domestic market, meant that it needed both export sales to support the volume of gas needed to make the project viable, and a domestic market to provide early cash flow and a secure source of revenue to underpin investment in the LNG trains and ships.²⁸

Political uncertainty added to the difficulty of making the project viable, as the Australian Government for a time favoured a transcontinental pipeline to serve eastern Australia over exports.²⁹ In 1975 Commonwealth policy changed with a change of government and the State Government intervened to help the North West Shelf resources to be developed. The Western Australia Government carried much of the commercial risk for the domestic component of the project.³⁰ In 1980 SECWA entered into a take-or-pay contract for 414 terajoules a day for 20 years to commence from 1985.³¹ The Government also agreed to construct a pipeline to make gas available to consumers in the south of the State.³² Oil price shocks in the 1970s encouraged alumina refineries to look for alternative energy sources.³³ Alcoa was also a foundation North West Shelf gas customer and underwrote half of the capital cost of the pipeline.³⁴

In return for secure domestic markets, the North West Shelf partners were required to sell 5,064 petajoules of gas in the domestic gas market.³⁵ This obligation was exhausted in 2014.

SECWA's take-or-pay contract and the terms of the *North West Gas Development Agreement Act* considerably reduced investment risks for the North West Shelf partners, and provided a secure and predictable source of revenue. This allowed the project to proceed. The joint venture partners announced the final investment decision in September 1980.³⁶ At the time, it was Australia's largest resource development project.³⁷

The first stage of the North West Shelf project consisted of two domestic gas trains at the Karratha Gas Plant. The Plant was opened on 4 September 1985. The first stage of the pipeline – covering a distance of 1,399 kilometres between Dampier and Kwinana - was commissioned in 1984 with an original throughput of 240 terajoules a day. It was extended to

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Bunbury the following year and has been progressively expanded since to today's capacity of 845 terajoules a day.³⁸

Iron ore exports to Japan developed through the 1960s and 1970s after an Australian iron ore export embargo was lifted at the end of the 1950s.³⁹ Oil price increases in the 1970s prompted Japanese interest in LNG to diversify its energy sector, which relied mainly on imported oil.⁴⁰ The Western Australian Government and the North West Shelf Partners sought to build on the mature trading relationship with Japan to develop the State's LNG export potential.⁴¹

Mitsubishi Corporation and Mitsui and Company were appointed in 1979 to facilitate negotiations with potential Japanese buyers to develop an LNG export market.⁴² Eight Japanese energy companies signed memoranda of intent to purchase 6 million tonnes of LNG annually from the North West Shelf.⁴³ The Japanese foundation customers signed twenty-year contracts for the supply of LNG to Japan in May 1985.⁴⁴ Mitsubishi Corporation and Mitsui and Company took a one sixth interest in the North West Shelf through a joint venture, Japan Australia LNG (MIMI) Pty Ltd, in 1985.⁴⁵

From the final investment decision in 1980, the North West Shelf Joint Venture built LNG trains and port facilities. Phase two of the North West Shelf project comprised LNG trains one and two with a combined production capacity of 5 million tonnes a year. The project made its first shipment to customers in Japan in July 1989.⁴⁶ The North West Shelf added additional LNG trains in 1992, 2004 and 2008.

Japan is still the State's largest export market for gas and the world's largest importer of natural gas.⁴⁷ Figure 3 shows the quantity and value of LNG exports from Western Australia by destination.

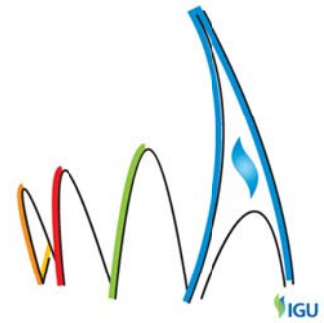
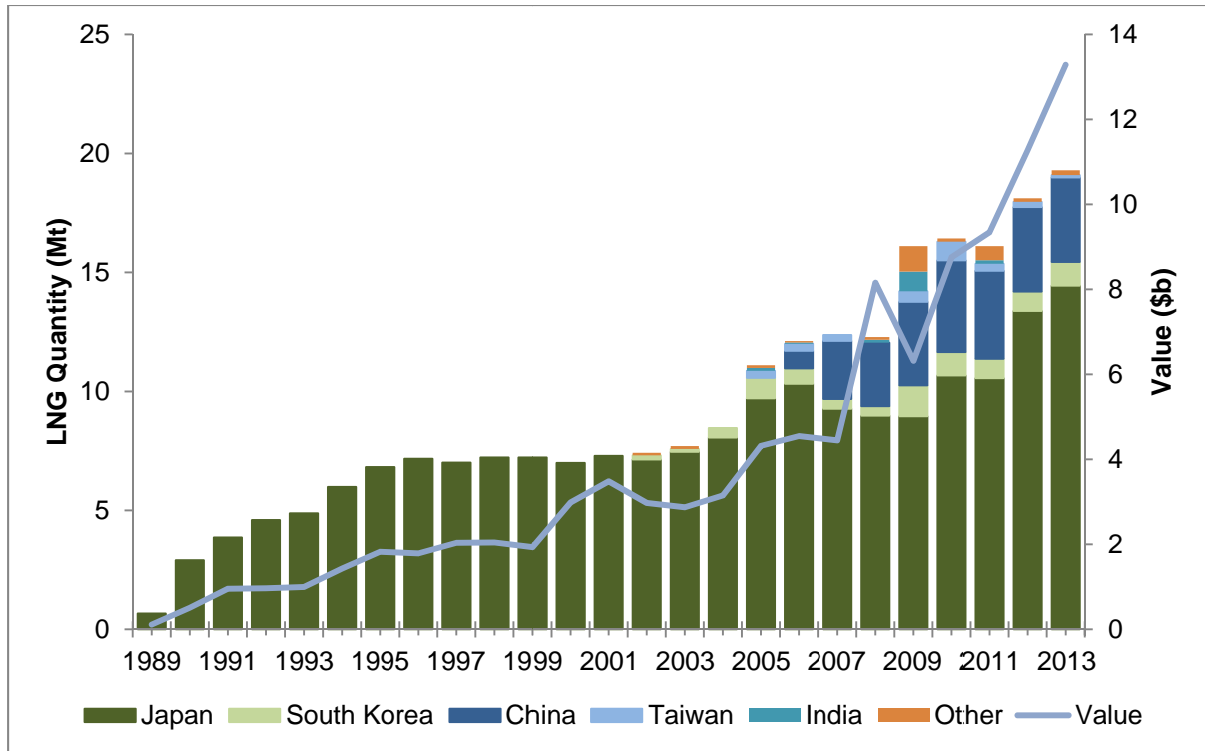


Figure 3: Quantity and value WA LNG exports



Source: Department of Mines and Petroleum (Western Australia), Ministry of Finance (Japan), Korean Customs Service, CEIC China Premium Database⁴⁸

In the domestic market, the Dampier to Bunbury pipeline delivered a large increase in gas availability in the south west of Western Australia. However, industry gas use lagged availability. Figure 4 shows domestic (onshore) gas consumption by industry from 1973-74 to 2012-13. The manufacturing sector (dominated by downstream processing) increased gas use from around 30 petajoules in 1982-83 to 56 petajoules in 1984-85. Gas use in the mining sector contributed little to overall demand. Over the five years after domestic gas availability increased, mining use increased from around 0.5 petajoules to 5.5 petajoules.⁴⁹

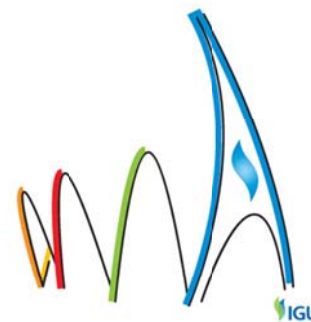
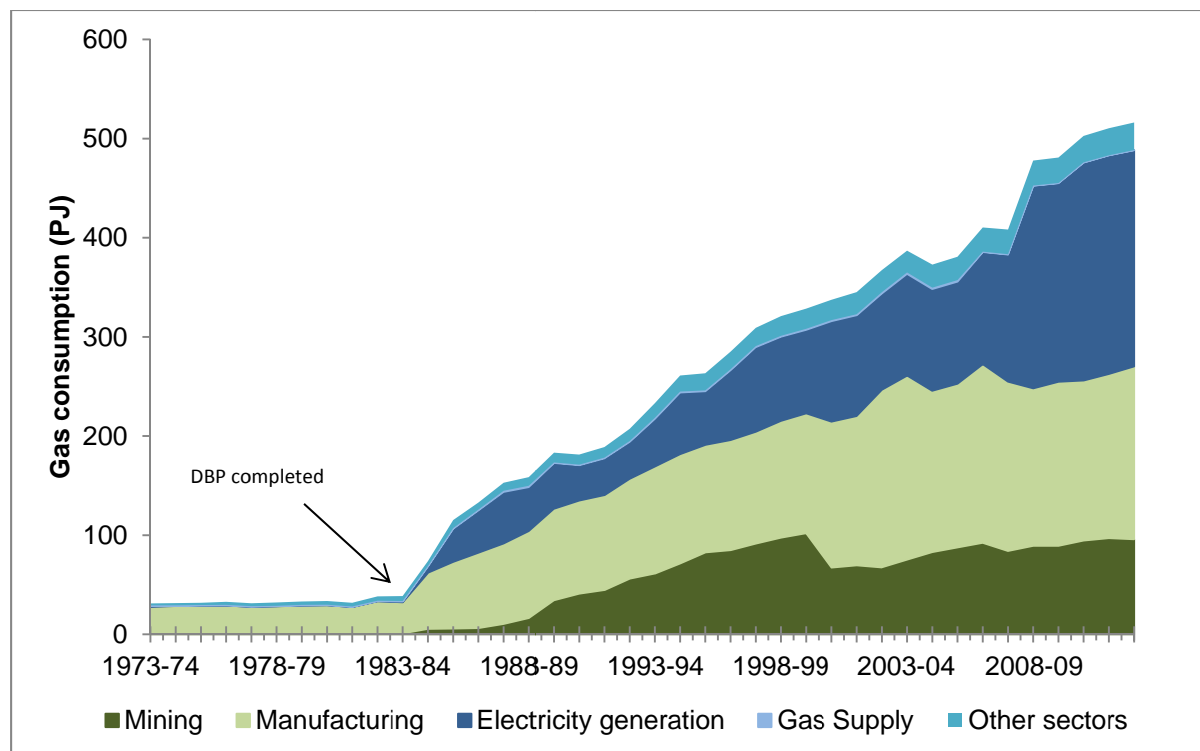


Figure 4: Domestic gas consumption by sector⁵⁰



Owning the state's monopoly utility allowed government to carry some of the risk of the domestic component of the project. However, SECWA's contracted gas volumes exceeded the market size for many years. SECWA retained its excess gas in inventory pending transport and sale.⁵¹ Further, due to its interests and structure some of its efforts to reduce its unused gas inventory hampered domestic market development by pricing gas marginally below alternative fuels such as coal or oil and constraining competition.⁵²

Successive energy market reforms enabled industry customers to use gas more widely. Pipeline ownership and sale reforms in 1988 and subsequent pipeline access reform in the 1990s reduced the barriers to new market entrants by enabling access to existing infrastructure.⁵³ A change to the North West Shelf Joint Venture Partners' supply contract allowed them to market gas in the Pilbara, at a time when the mining industry was growing rapidly in the region.⁵⁴

Energy reform continued through the early 1990s leading to the structural separation of gas and electricity elements of the SECWA and a stronger focus on corporate performance. Privatisation of the Dampier to Bunbury pipeline followed in 1998 and the gas retail utility Alinta was privatised in 2000.⁵⁵

Following these reforms, private sector projects extended domestic gas availability in Western Australia through the Goldfields Gas Pipeline and the Pilbara Pipeline System. The



Pilbara Pipeline System connected gas to iron ore mines for electricity generation through 325 kilometres of primary and lateral pipelines constructed between 1995 and 2009. The Goldfields Gas Pipeline, built in 1996, is 1,378 kilometres long and runs from Yaraloola to Kalgoorlie servicing iron ore, nickel and gold mines.⁵⁶

By the end of the second phase of development, natural gas exports had risen to 12 million tonnes a year to Japan, South Korea and China, and the domestic market had increased tenfold from around 30 petajoules to around 315 petajoules from four sources in the Perth and Carnarvon basins. The value of Western Australia's natural gas exports increased from \$330 million in 1989 to over \$14 billion in 2013-14.⁵⁷

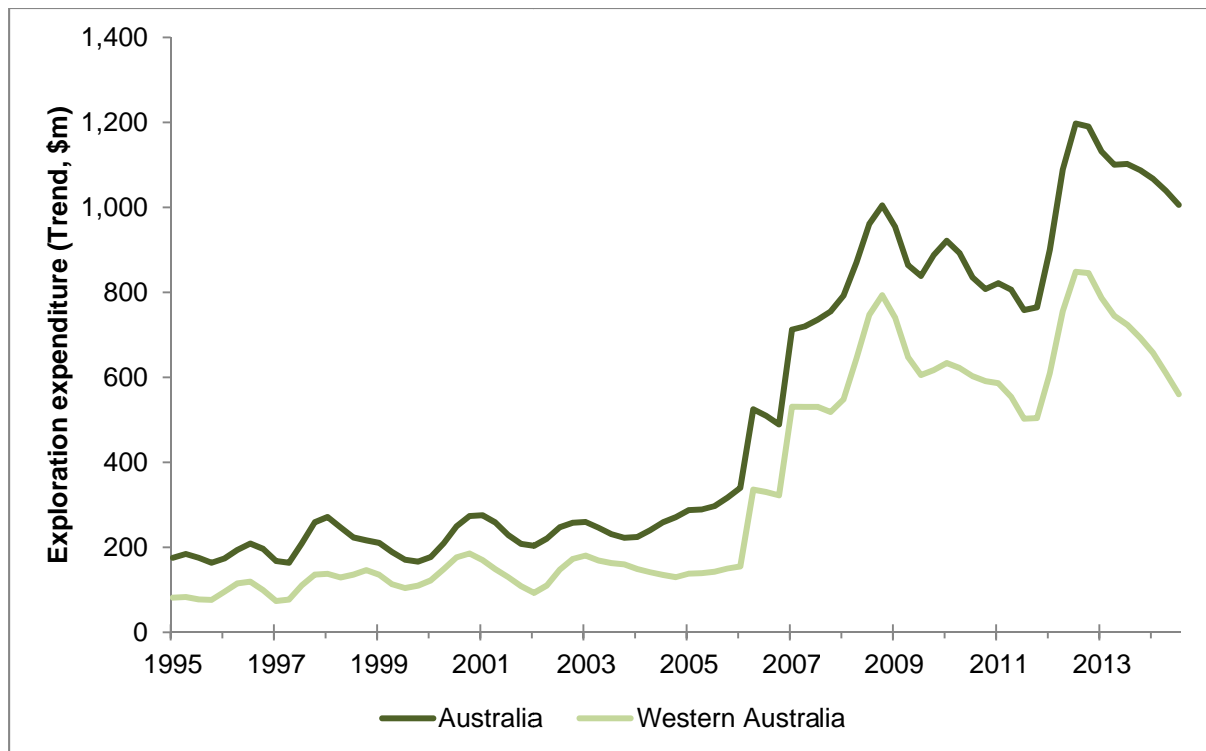
Phase 3 – diversification and consolidation

Just as the second phase of development of the State's gas industry built on the infrastructure and customer base established in the first, so the third phase builds on foundations of the first two phases. Large reserves had been identified in the State's known gas provinces, and increasing exploration had identified new gas fields, but many were in remote and deep water offshore. As ever, the main challenge was finding ways of getting it to market economically. Rising oil and gas prices in the 2000s made these challenging resources economic to produce.

The result was a wave of exploration activity and new investment in both the domestic and LNG markets. Western Australia started regular exports to South Korea in 2002 and to China in 2006.⁵⁸ **Error! Reference source not found.** shows an increase in exploration expenditure, mostly occurring in Western Australia, coinciding with growth in export markets in South Korea and China.



Figure 5: Australian and Western Australian petroleum exploration

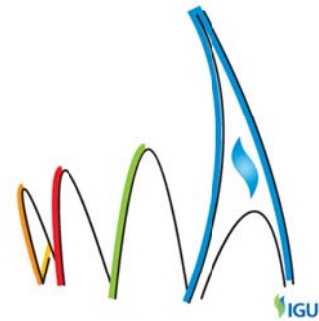


Source: Australian Bureau of Statistics⁵⁹

Western Australia's first LNG project after the North-West shelf was Woodside Petroleum's Pluto project, which reached final investment decision in 2007 and started production in April 2012 with a capacity of 4.3 million tonnes a year. This increased the State's LNG production capacity to 20.6 million tonnes a year.⁶⁰ The Gorgon project reached final investment decision in 2009 and is currently nearing completion, with production expected to start in 2015. It will have a production capacity of 15.6 million tonnes per year and cost \$55 billion, making it the largest project of its type ever undertaken in Australia.

Wheatstone reached final investment decision in 2011 and will have a production capacity of 8.9 million tonnes a year. One of the world's first floating liquefied natural gas projects, Prelude, is under construction with a capacity of 3.6 million tonnes a year. Other new gas developments are considering using this technology to reduce the cost of developing LNG processing facilities.⁶¹

Collectively these committed projects will add 28 million tonnes per year to the State's LNG production capacity, raising it to 48.7 million tonnes, mostly from fields located within the Carnarvon Basin. When the current suite of committed projects across Australia is completed in 2017, Western Australia will account for just over half of national LNG capacity. Western Australia will be the second largest LNG producing jurisdiction in the world,



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increasing its share of global LNG capacity from just under 7% in 2013 to around 12% by 2017.⁶²

Projects currently under consideration, including Browse, Scarborough, Equus and expansions to existing fields at Gorgon and Pluto, could boost capacity and production further.

Figure 6: Western Australian natural gas projects in the Carnarvon Basin



Source: Department of State Development

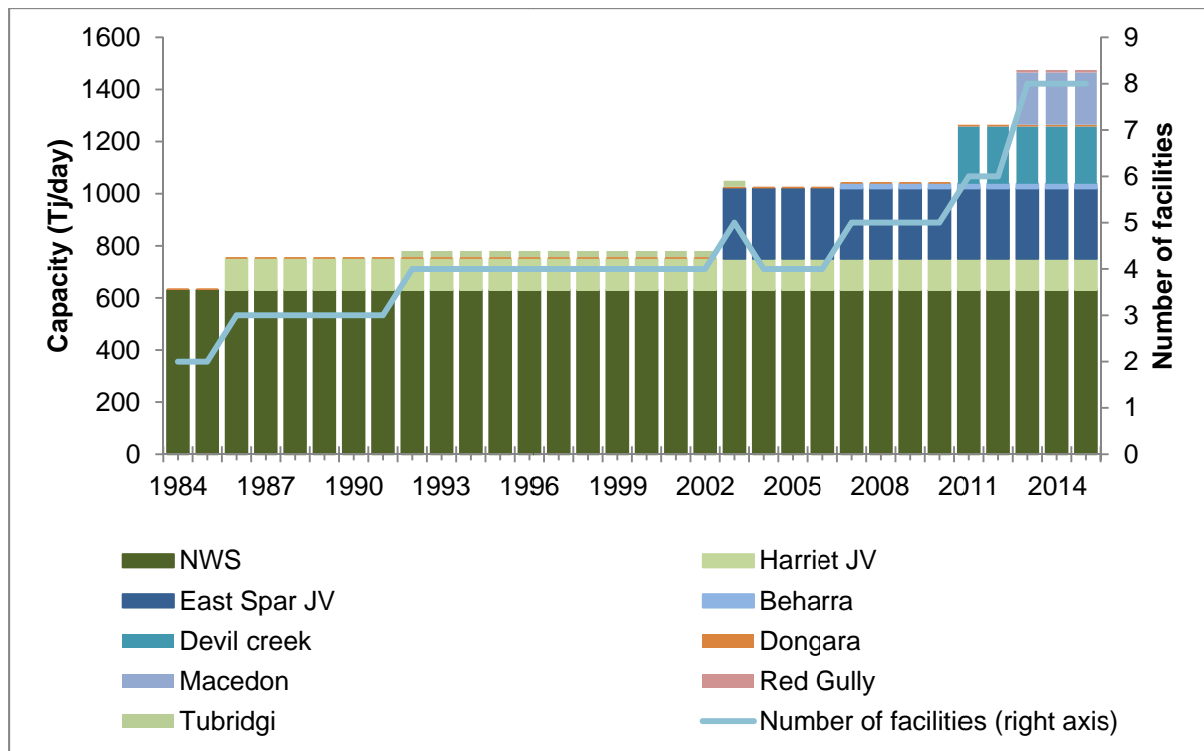
The domestic gas industry was for many years highly concentrated, but it has also diversified in this third development phase. The risks associated with market concentration became clear in 2008, when an explosion at the Varanus Island gas processing facility cut gas supplies to the State by around 30% for some months.⁶³

Figure 7 shows the State's installed domestic gas processing and supply capacity. Concentration reduced as more facilities entered the market including the Harriet Joint Venture in 1986 and the East Spar development in 2003 on Varanus Island. Since then, capacity has grown through new plant built at Devil Creek in 2011 (220 terajoules per day) and Macedon in 2013 (200 terajoules per day). An exhausted gas field at Mondara was also converted into a storage facility in 2013 with a storage capacity of 15 petajoules and a discharge capacity of 150 terajoules per day.⁶⁴



Consistent with the State's domestic gas policy (see below), Both Gorgon and Wheatstone are building domestic gas plants as part of their LNG projects.

Figure 7: Domestic gas facilities and capacity, 1984-2015



Source: Independent Market Operator and supplier information⁶⁵

Future prospects

Annual gas demand is forecast to grow by 1.6% with most of the increase in demand to occur in Asia, where Western Australia has established markets, with growth rates of 3.8%.⁶⁶ China will become increasingly important as a natural gas consumer, although pipelines are expected to meet some of this demand after Russia formalised a trade agreement with China.⁶⁷ The fields to be developed to supply the pipeline are not linked with the European market and represent a net addition to the world's gas trade.⁶⁸

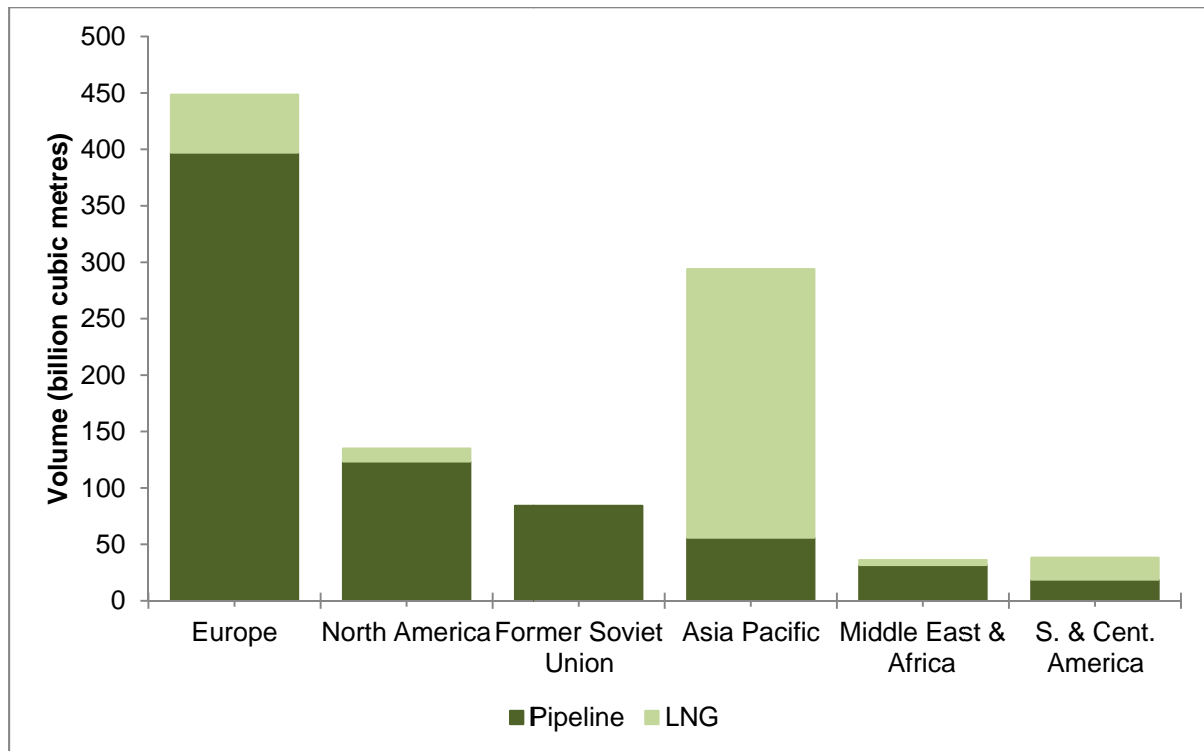
Third party processing and shared use of infrastructure has been rare in Western Australia's gas market, unlike many markets overseas. This may soon start to change, as more efficient use of infrastructure could help the sector improve productivity, and some projects – notably the North West Shelf – develop spare capacity. The Wheatstone Project is promoted as a natural gas hub that is open to processing third party gas. It plans for a fifth of the gas processed at the facility to come from neighbouring gas fields.⁶⁹ Hess has signed a non-binding letter of intent with the North West Shelf partners to process gas from its Equus gas



field. Hess and the North West Shelf have complementary capabilities; one party with capability in deep water drilling and the other in gas processing and liquefaction.⁷⁰

Figure 8 shows international gas trade by region. The Asia-Pacific region, the destination for Western Australia's LNG exports, accounted for nearly three quarters of global LNG imports in 2013.⁷¹

Figure 8: Gas imports by region and mechanism - 2013

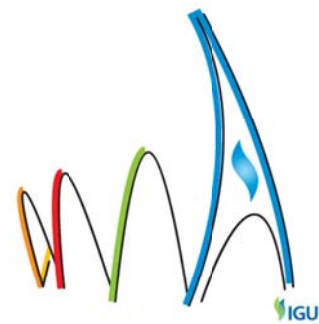


Source: BP⁷²

Government's role

The role of the State Government and its trading entities has changed since the early years of the State's gas industry. The industry has matured, and no longer needs direct government support to make export projects viable. The Government works with proponents to ensure that broader impacts arising from projects are identified and addressed – for example, the roads, schools, hospitals and transport infrastructure needed by projects and their workers in remote communities. Government may help to develop land and identify sites suitable for new development, and encourage projects to share infrastructure and land to promote productivity and minimise projects' environmental impacts.

The Western Australia Government operates a policy to support energy security by ensuring that LNG projects make gas available to the domestic market. The policy is not legislated,



but is applied by negotiation on a case-by-case basis with projects. Typically, projects must make available to the domestic market the equivalent of 15% of LNG production, ensure that the infrastructure and facilities are in place to deliver and process the gas, and diligently market the gas to consumers. The policy leaves the terms of domestic gas sales to commercial negotiation between seller and buyer – it does not set prices, or require gas to be delivered at a fixed rate.

Conclusions

Western Australia has large reserves of gas in basins along much of its coastline. Its enduring challenge has been to get those reserves to customers in domestic and overseas markets. The State's gas industry developed initially to meet local demand, and this first phase of development established the domestic infrastructure and customer base that became the foundation for the second phase, a move into export markets. The industry grew and matured, but development of the State's large, but deep and remote, untapped resources was not economic until oil and gas prices rose in the 2000s. This prompted a major expansion of capacity, with one new LNG project now in operation, and three more under construction. LNG production capacity has grown from 5 million tonnes a year in 1989 to 20 million tonnes today. In a few years it will have more than doubled, to almost 50 million tonnes, or around 12% of expected world LNG capacity. If some of the projects currently under consideration come to fruition, capacity will be higher still.

The way this current phase of expansion develops will be shaped by innovation and market dynamics. The industry's competitiveness will depend on its ability to contain costs and boost productivity: for example, by adopting new technologies such as floating LNG, and more efficient use of infrastructure. But however the future unfolds, the development and consolidation now under way will ensure that Western Australia will remain a global leader in LNG exports for decades to come.

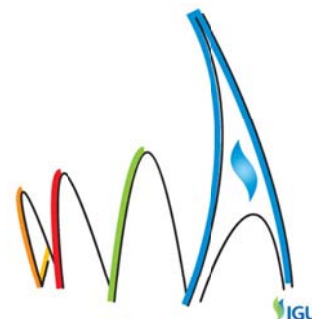
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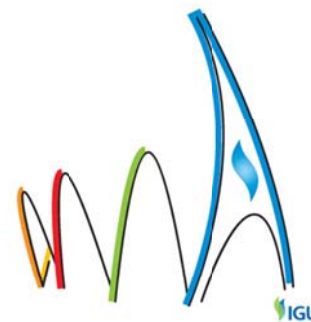
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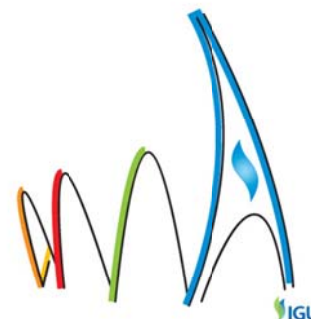
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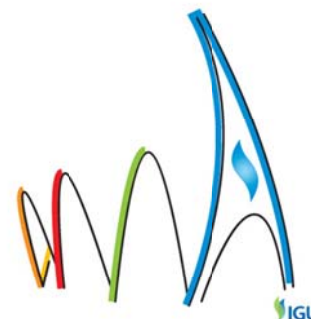
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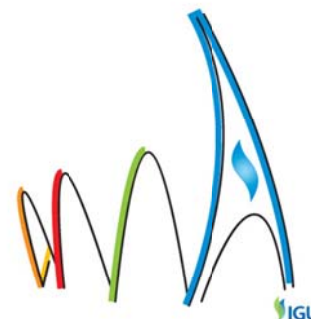
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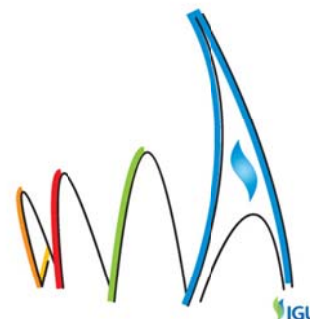
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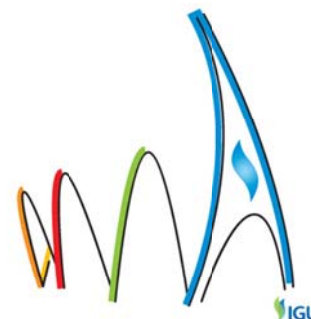
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