

Queensland's petroleum and coal seam gas

2015–16

January 2017

Introduction

Queensland has sedimentary basins ranging in age from Precambrian to Tertiary with a variety of geological settings and histories (Figures 1 & 2).

In Queensland, the systematic exploration for conventional petroleum commenced in the early 1960s. Conventional petroleum exploration has resulted in the discovery of commercial accumulations in the Adavale Basin, the Bowen and Surat basins, and the Cooper and Eromanga basins.

Exploration for coal seam gas (CSG) commenced in the 1980s. Since the mid-1990s, CSG has grown to become the dominant source of gas in Queensland, comprising over 95% of the gas produced and over 99% of the remaining proved and probable (2P) gas reserves. Commercial production of CSG is sourced from the Bowen and Surat basins and is the gas supply for the state's export liquefied natural gas (LNG) industry based in Gladstone.

Outside of the producing CSG and key petroleum basins, many areas of the state remain largely under-explored.

More than 5000 kilometres of transmission pipelines connect producing gas fields to markets within Queensland, particularly southeast Queensland, Gladstone and Mount Isa.

Petroleum exploration 2015–16

Petroleum (including CSG) exploration expenditure in Queensland for 2015–16, reached A\$204.7 million compared with A\$751.6 million in 2014–15 (www.abs.gov.au). The level of exploration expenditure is a reflection of the current global markets and the move by companies from the exploration phase to one of development and production of their CSG reserves to service the export LNG industry. Exploration for other unconventional resources, including shale gas, basin-centred gas and tight gas, is expected to continue, particularly in the Cooper and Bowen basins.

Drilling rates have maintained high levels since the record of 1634 wells drilled in 2013–14 with 700 wells drilled in 2015–16. This was made up of 685 CSG wells and 15 petroleum wells (Figure 3). Of the 685 CSG wells, there were 3 exploration wells, 18 appraisal wells, 663 development wells and one injection well.

Quick facts (2015–16)

Coal seam gas production

1998–99	4 PJ
2005–06	63 PJ
2015–16	979 PJ

Coal seam gas reserves

As at 30 June 2016	41 229 PJ
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Conventional gas production

1998–99	131 PJ
2005–06	142 PJ
2015–16	45 PJ

Conventional gas reserves

As at 30 June 2016	370 PJ
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The initial high rate of drilling was required to ensure adequate gas could be produced to ramp up the three LNG plants. A slight drop in drilling occurred as activities focus towards production while ongoing drilling will be required as these reserves are depleted.

Petroleum (excluding CSG) exploration in Queensland decreased from the previous year. In 2015–16, 15 petroleum wells, made up of 8 exploration, 6 appraisal and 1 development wells were drilled. This compares with 37 wells drilled in 2014–15.

Coal seam gas

CSG is currently the dominant driver of drilling activities and gas production in Queensland. Exploration for other petroleum sources, such as shale gas and tight gas, is only just beginning in Queensland. The presence of gas in deeper parts of sedimentary basins indicates that formations have potential to contain significant tight gas resources.

Queensland has two basins currently producing CSG, the Bowen and Surat basins (Figures 4 & 5). A number of other basins have potential and are currently being explored.



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Figure 1: Queensland petroleum

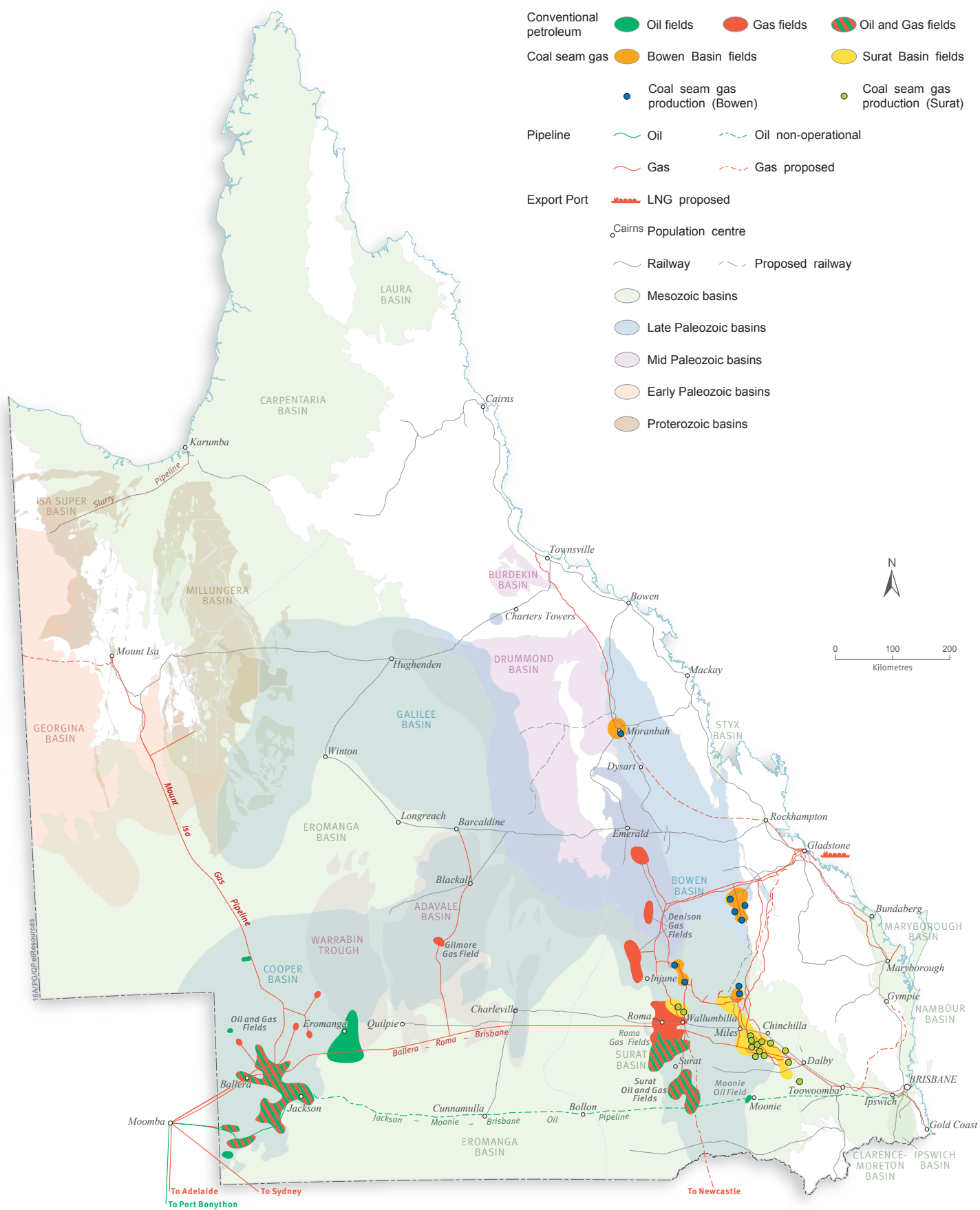
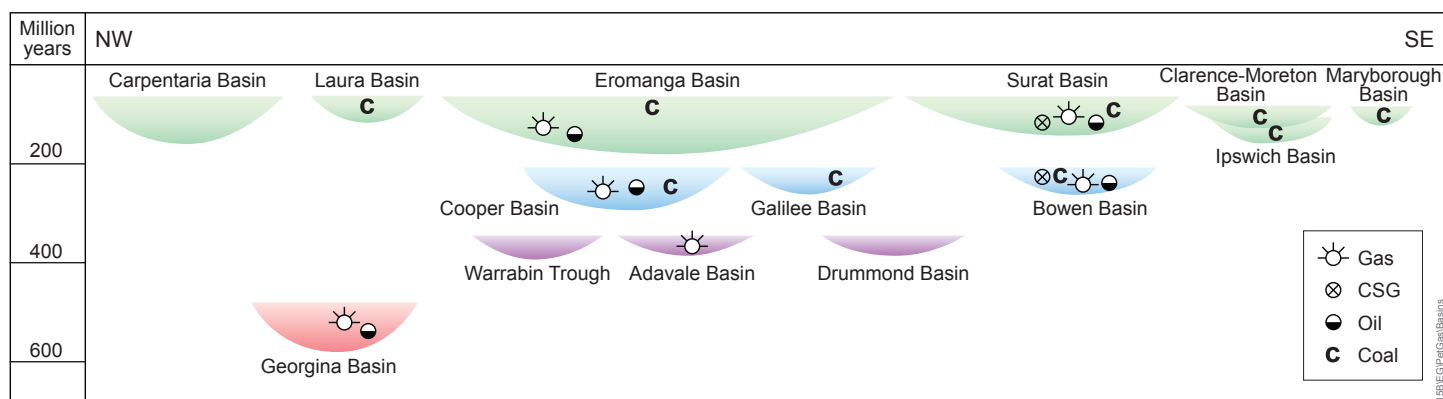


Figure 2: Time-space plot showing the relationship between the basins shown in Figure 1



Bowen Basin

The Permian to Triassic Bowen Basin is the birthplace of the CSG industry in Queensland. The first commercial production began in the Dawson River CSG area near Moura in 1996 and in the Fairview CSG area near Injune in 1998. Currently, commercial production occurs in the basin near Moranbah, Injune, Moura and Wandoan. The Permian coal measures are the main targets.

CSG produced at Moranbah is sourced from the Goonyella Middle (GM) and P seams of the Moranbah Coal Measures. Future production is likely from the Goonyella Middle Lower (GML) seam. The overlying Fort Cooper and Rangal Coal Measures also have potential.

Coal permeability in the Moranbah area is relatively low; CSG production is enhanced by in-seam drilling. Development has concentrated on seams from 200 to 500 metres (m) depth. As the Moranbah area is located in a geological hinge zone with its associated faulting, areas of increased permeability are expected.

At Moura, CSG is produced from the Permian Baralaba Coal Measures. Exploration and development is concentrated on seams around 200 to 500 m depth.

Permeabilities are less than 10 millidarcies (mD) in the Moura area. To cope with these low permeabilities, in-seam drilling has been utilised to enhance production.

East of Wandoan at Scotia and Peat, gas is sourced from the Baralaba Coal Measures. The Peat and Scotia areas are located on the Burunga Anticline and contain structurally trapped free gas. Gas is produced from around 700 to 800 m where permeability is enhanced by the anticlinal structure. Below 900 m, the seams are considered sub-economic because of lower permeability.

Production from Fairview and Spring Gully is sourced from the Permian Bandanna Formation. Three coal seams of the Bandanna Formation have been targeted at depths ranging from 500 to 880 m.

Permeability in the Fairview and Spring Gully areas (Comet Ridge fairway) is enhanced by their location within a large anticlinal structure. Due to lower stress and associated fracturing, tensional areas at the axes of anticlines and synclines are obvious targets for enhanced permeability and production. Permeabilities are generally higher than 50 mD. Up until 2014–15, the Bowen Basin had been the largest cumulative CSG producing basin. Certified proved and probable CSG reserves have remained steady.

Figure 3: Annual Queensland conventional petroleum and CSG wells drilled, to 30 June 2016

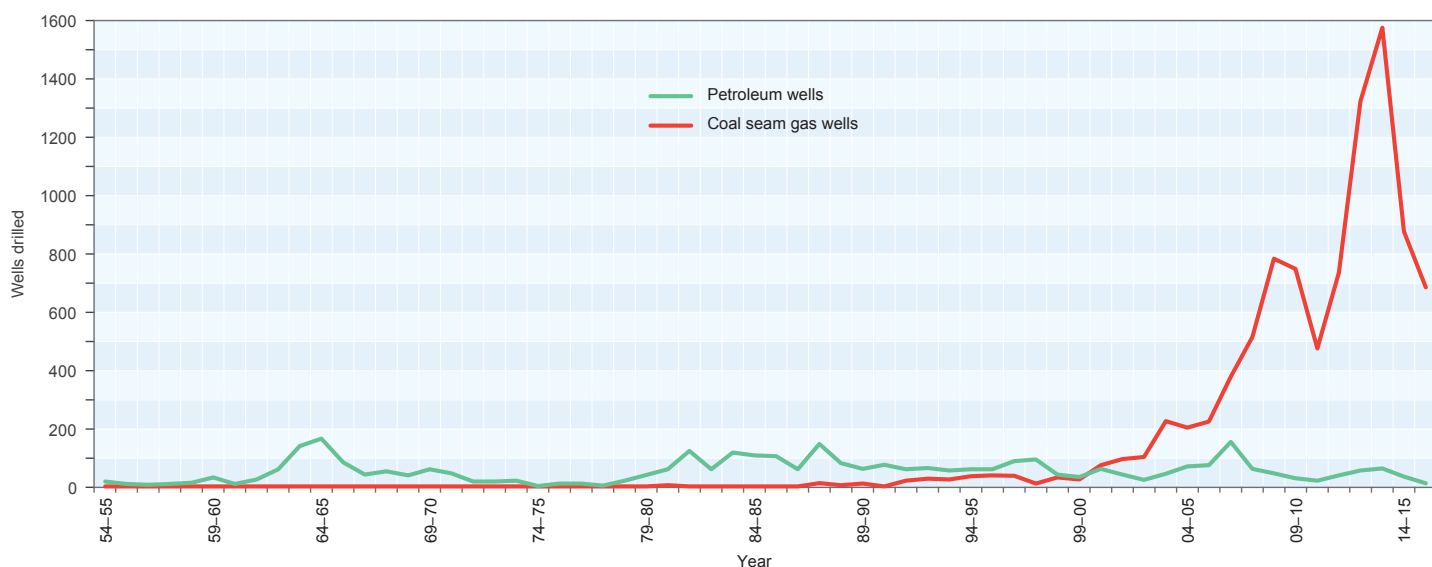


Figure 4: CSG well location

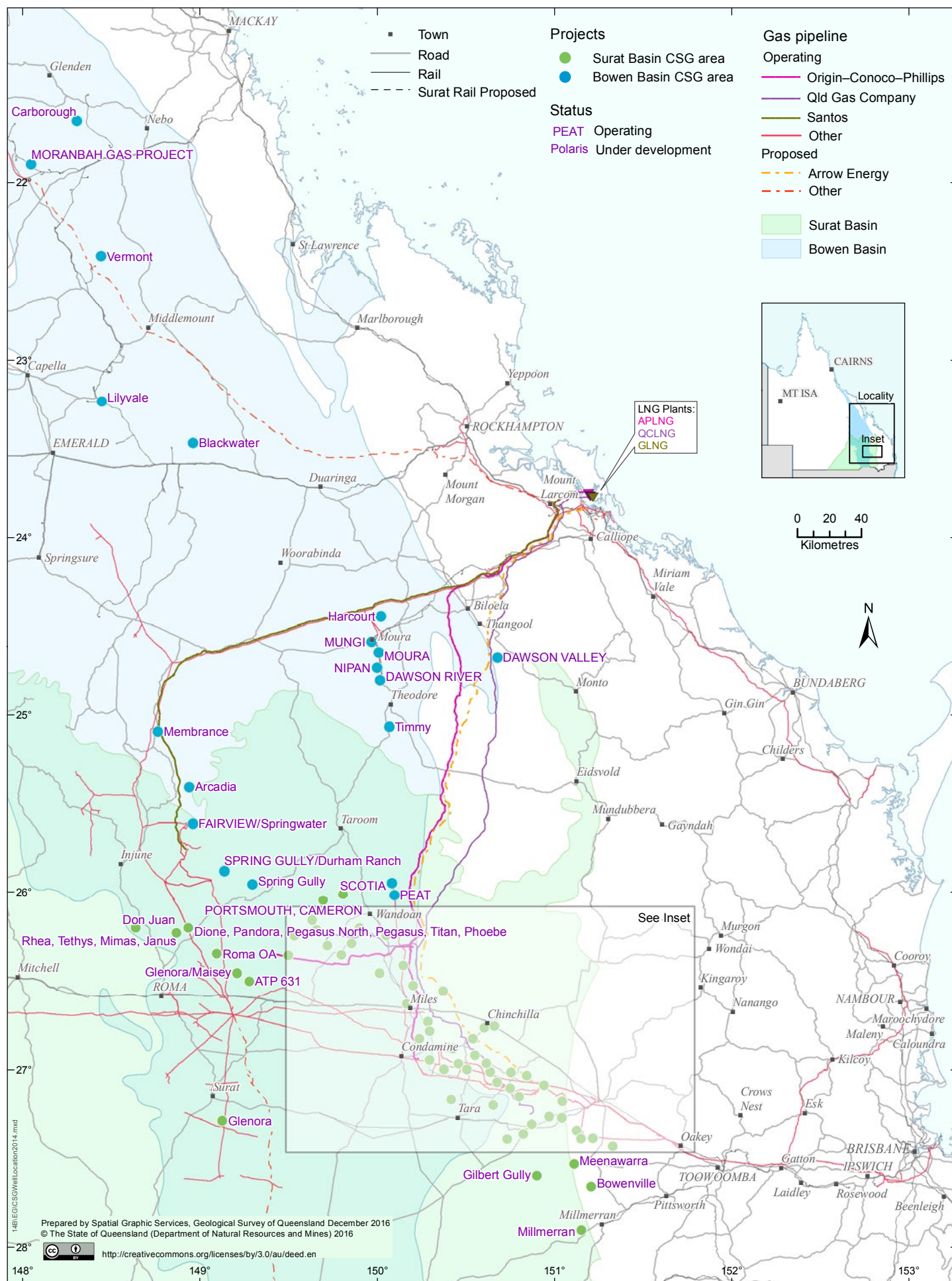
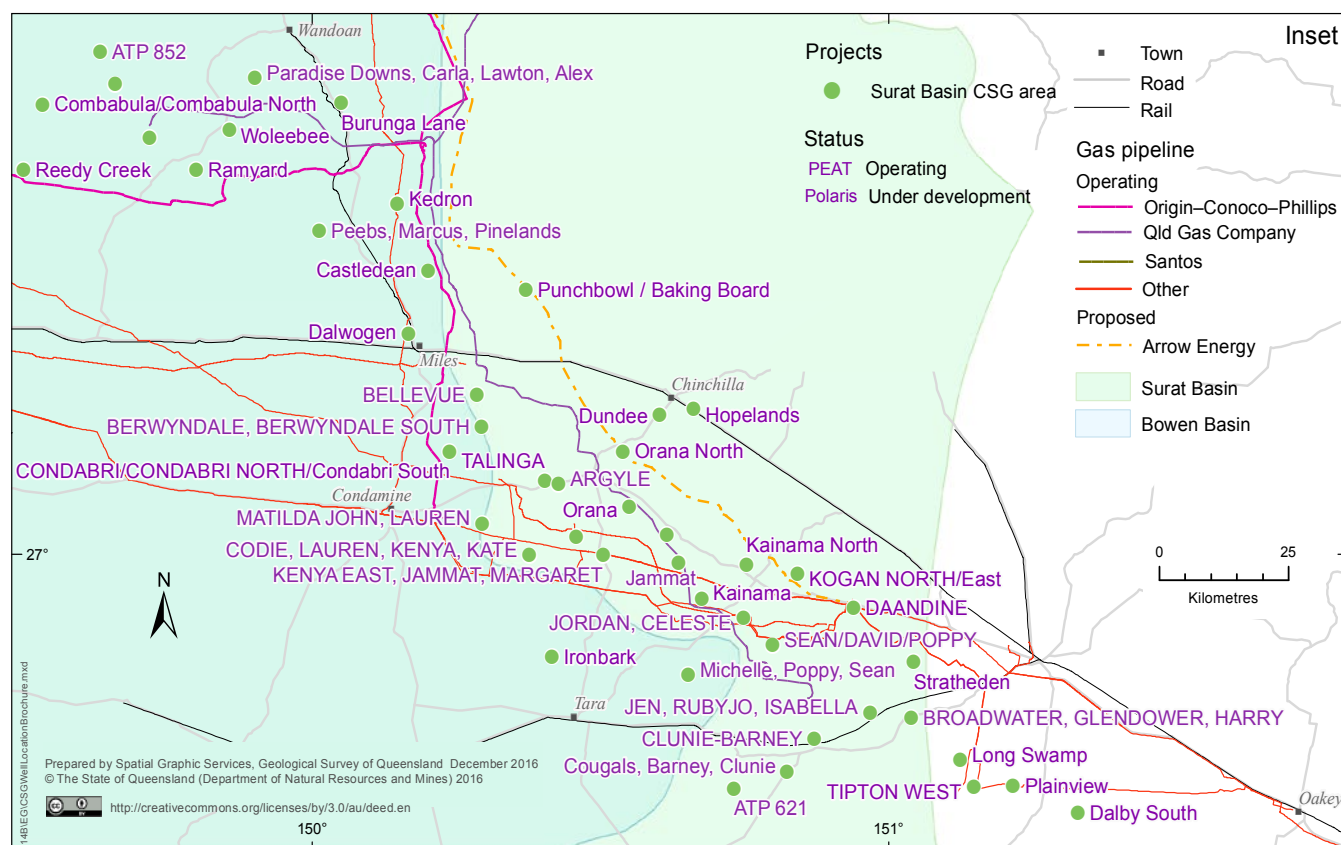


Figure 5: CSG well location 2016 (inset from Figure 4)



Surat Basin

The Surat Basin became the focus for emerging CSG companies from the early 2000s onwards, when it became clear that an analogue existed with the lower-ranked coals in the Powder River Basin in the United States of America, which were producing commercial quantities of gas.

The success of the QGC Argyle 1 well in 2000 demonstrated that the Surat Basin could become a significant CSG producer.

Commercial production of CSG from the Jurassic Walloon Coal Measures of the Surat Basin began in January 2006 from the Kogan North CSG area west of Dalby. This was followed in May 2006 by production from the Berwyndale South CSG area, southwest of Chinchilla. CSG is also currently produced from several areas between Dalby and Chinchilla.

Surat Basin CSG was first used to supply the Swanbank E gas-fired power station near Ipswich in southeast Queensland.

Commercially produced CSG from the Walloon Coal Measures is typically obtained from seams between 200 and 600 m. The term Walloon Coal Measures is used for the combined thicknesses of the Taroom Coal Measures (lower), Tangalooma Sandstone and Juandah Coal Measures (upper).

Coals in the Surat Basin were not as deeply buried as those in the Bowen Basin and therefore are less thermally mature, with generally lower gas contents. Vitrinite reflectance values for coals in the Walloon Coal Measures in Queensland range from 0.35% to 0.6% Rv. Seams in the Walloon Coal Measures are generally not as thick or laterally continuous as those in the Bowen Basin, but typically have a higher permeability. This has allowed the Surat Basin CSG to be commercialised using a range of well-completion techniques. The Surat Basin is now the major source of CSG in Queensland.

Certified proved and probable reserves in the Surat Basin have increased significantly since 2006. By 2008 more certified 2P CSG reserves had been reported for the Surat Basin than the Bowen Basin. From 2011–12 on, CSG production from the Surat Basin has been higher than that from the Bowen Basin. In 2015–16, production from the Surat Basin was more than four times that of the Bowen Basin.

Other basins

Other basins have attracted CSG exploration interest including the Galilee Basin, Clarence–Moreton Basin, Styx Basin, Cooper Basin, Eromanga Basin, Ipswich Basin, Laura Basin, Maryborough Basin and Tertiary basins (Duaringa, Herbert Creek, Hillsborough, Yaamba basins and the Nagoorin Graben).

Production and reserves 2015–16

Coal seam gas

CSG is currently only produced from the Bowen and Surat basins (Table 1, Figure 6). Production for 2015–16 was 26 145.35 million cubic metres (Mm³) (923.3 billion cubic feet (bcf), 979.1 petajoules (PJ)) and is comprised of 4957.94 Mm³ (175.1 bcf, 185.7 PJ) from the Bowen Basin and 21 187.41 Mm³ (748.2 bcf, 793.4 PJ) from the Surat Basin. The proportion of CSG production from the Surat Basin has increased relative to the Bowen Basin. (Figures 6 & 8).

Cumulative CSG production to June 2016 was approximately 86 841 Mm³, (3067 bcf, 3252 PJ) with about 60% of production coming from the Surat Basin. As at 30 June 2016, the remaining 2P CSG reserves were 1 100 829 Mm³ (38 874 bcf, 41 229 PJ) (Figure 7).

During the six months ending on 30 June 2016, 5127 wells were reported as producing CSG. In 2015–16, approximately 60 498.95 megalitres (ML) of associated water was produced as part of the state's CSG production.

Table 1: Queensland petroleum — production summary 2015–16

	Gas Mm ³ (PJ)	Coal seam gas Mm ³ (PJ)	Oil (ML)	Condensate (ML)	LPG (ML)
Production 2015–16					
Adavale (conventional)	–	–	–	–	–
Bowen–Surat (conventional)	27.89 (1.0)	–	4,0118	3,0768	1,7928
Cooper–Eromanga (conventional)	1096.91 (41.1)	–	441,0021	63,1100	90,8404
Denison (conventional)	64.88 (2.4)	–	–	0.6211	–
Bowen Basin (coal seam gas)	–	4957.94 (185.7)	–	–	–
Surat Basin (coal seam gas)	–	21 187.41 (793.4)	–	–	–
TOTAL PRODUCTION	1189.68 (44.5)	26 145.35 (979.1)	445,0139	66,8079	92,6332

Note: Tenure holders are required to report to the department their gas production and reserve figures in millions of cubic metres (Mm³) and other petroleum products in megalitres (ML)
One Petajoule (PJ) is the equivalent to 26.7 Mm³

Table 2: Queensland petroleum — 2P reserves as at 30 June 2016

	Gas Mm ³ (PJ)	Coal seam gas Mm ³ (PJ)	Oil (ML)	Condensate (ML)	LPG (ML)
2P reserves as at 30 June 2016					
Adavale (conventional)	575.07 (21.5)	–	–	–	–
Bowen–Surat (conventional)	4600.65 (172.3)	–	1038,36	263,02	273,90
Cooper–Eromanga (conventional)	4714,53 (176.6)	–	2417,21	328,32	277,12
Denison (conventional)	–	–	–	–	–
Bowen Basin (coal seam gas)	–	267 523.01 (10 019)	–	–	–
Surat Basin (coal seam gas)	–	833 306.62 (31 210)	–	–	–
TOTAL PETROLEUM 2P RESERVES	9890.25 (370.4)	1 100 829.63 (41 229)	3455,57	591,34	551,02

Note: Tenure holders are required to report to the department their gas production and reserve figures in millions of cubic metres (Mm³) and other petroleum products in megalitres (ML)
One Petajoule (PJ) is the equivalent to 26.7 Mm³

Liquefied petroleum gas

Liquefied petroleum gas (LPG) is sourced from the Cooper and Eromanga basins and historically from the Bowen and Surat basins. Total production for 2015–16 was 92.63 ML (49 265 tonnes (t)). Production from the Cooper and Eromanga basins was 90.84 ML (48 312 t) and production from the Bowen and Surat basins was 1.79 ML (953 t) (see Table 1). As at 30 June 2016, the remaining 2P LPG reserves were 551.02 ML (293 051 t) (Table 2). Cumulative LPG production to June 2016 was about 4800 ML (2.55 million tonnes (Mt)), with over half coming from the Cooper and Eromanga basins.

Oil

Total Queensland oil production for 2015–16 was 445,0139 ML (2.8 million barrels (MbbL)); 441.00 ML (2.80 MbbL) was produced from the Cooper and Eromanga basins, and 4.01 ML (25 236 barrels (bbL)) from the Bowen and Surat basins (Table 1). Cumulative oil production to June 2016 was about 29 451 ML (185 MbbL). As at 30 June 2016, the remaining proved and probable oil reserves were 3455.57 ML (21.74 MbbL) (Table 2).

Condensate

Condensate is produced from the same basins as oil and gas, with minor production from the Denison Trough in the Bowen Basin. Production for 2015–16 was 66.81 ML (420 252 bbl) and is comprised of 63.11 ML (396 991 bbl) from the Cooper and Eromanga basins, 3.08 ML (19 354 bbl) from the Bowen and Surat basins and 0.62 ML (3907 bbl) from the Denison Trough (Table 1). Cumulative condensate

production to 2015–16 was about 5451 ML (34 million barrels (MbbL)). As at 30 June 2016, the remaining proved and probable reserves were about 591 ML (3.7 MbbL) (Table 2).

Conventional gas

Conventional gas has been produced from the Cooper and Eromanga basins, Bowen and Surat basins, Adavale Basin and the Denison Trough in the Bowen Basin. Production for 2015–16 was 1189.68 Mm³ (42.0 bcf, 44.5 PJ), and comprised 1096.91 Mm³ (38.7 bcf, 41.1 PJ) from the Cooper and Eromanga basins, 27.89 Mm³ (1.0 bcf, 1.0 PJ) from the Bowen and Surat basins and 64.88 Mm³ (2.3 bcf, 2.4 PJ) from the Denison Trough (Table 1, Figure 8).

Cumulative conventional gas production from 1964 to June 2016 has been about 77 781 Mm³ (2747 bcf, 2913 PJ). As at 30 June 2016, the remaining proved and probable conventional gas reserves were 9890.25 Mm³ (349.3 bcf, 370.4 PJ) (Table 2).

Total gas production

Total gas production (conventional gas + CSG, excluding LPG) for 2015–16 was 27 335.03 Mm³ (965.29 bcf, 1023.78 PJ) with over 95% attributed to CSG.

Total gas reserves

Total remaining proved and probable gas reserves (conventional gas + CSG, excluding LPG) as at 30 June 2016 were 1 110 719.88 Mm³ (39 223 bcf, 41 599 PJ) with over 99% being CSG.

Figure 6: Queensland coal seam gas production

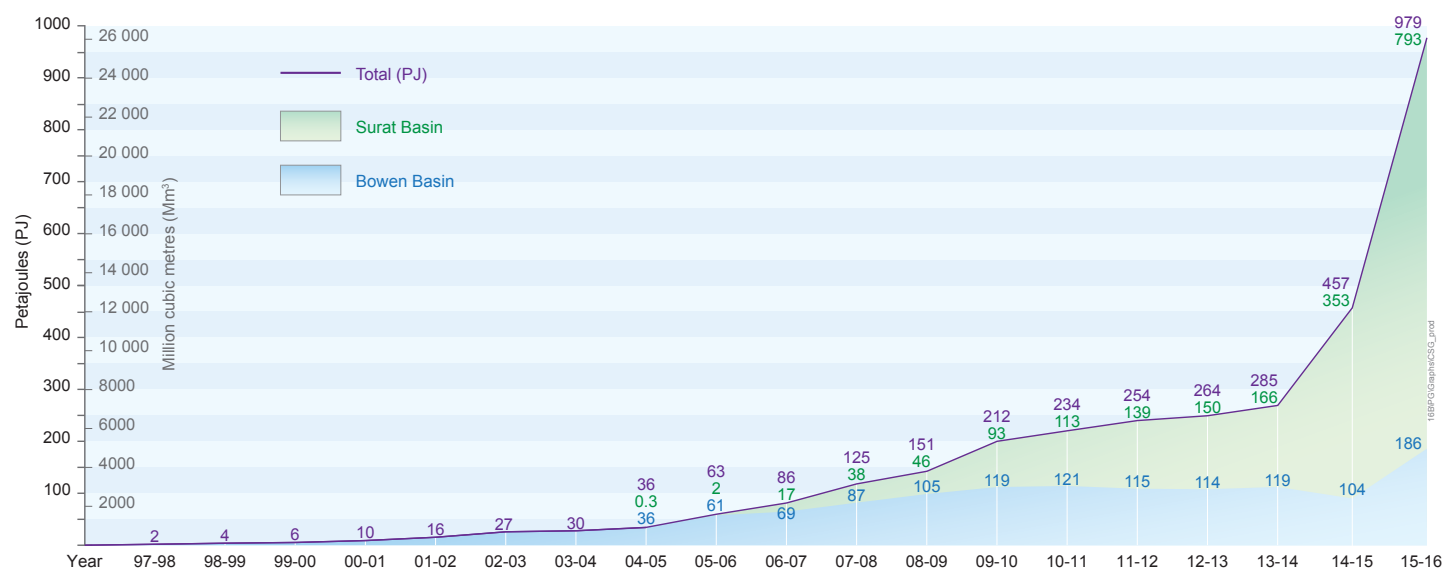


Figure 7: Queensland coal seam gas 2P reserves

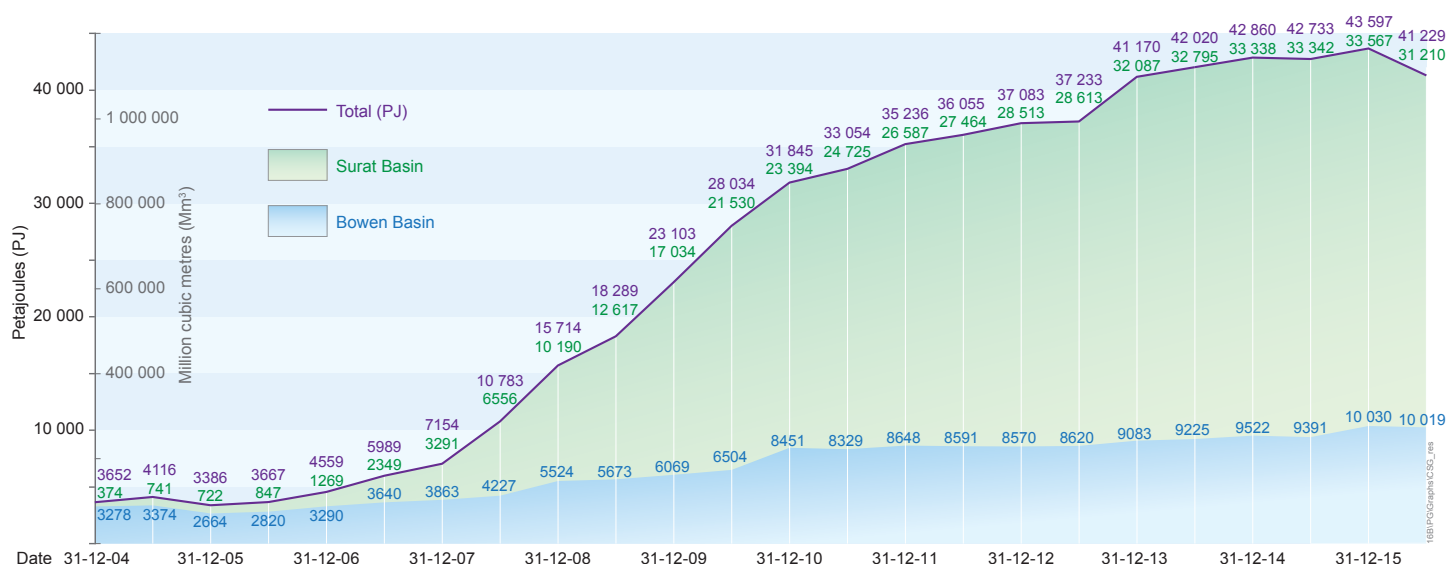


Figure 8: Queensland conventional gas and CSG annual production by basin to 30 June 2016

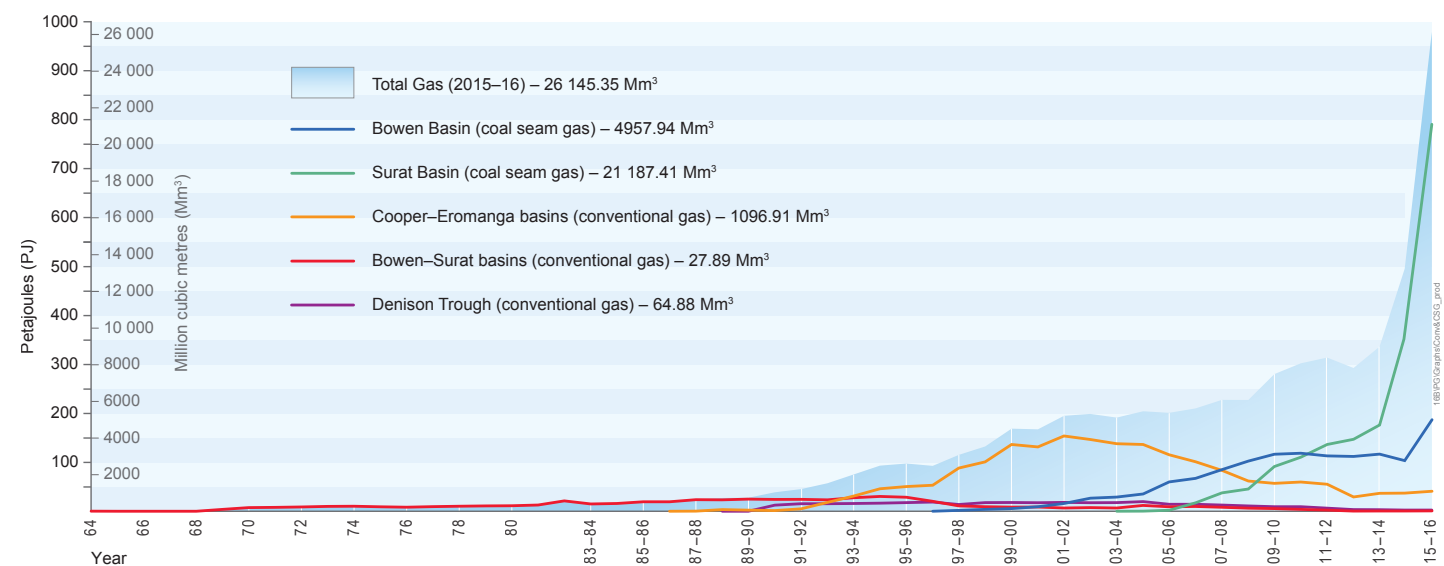


Figure 9: Drilling exploration success rates — Bowen–Surat basins

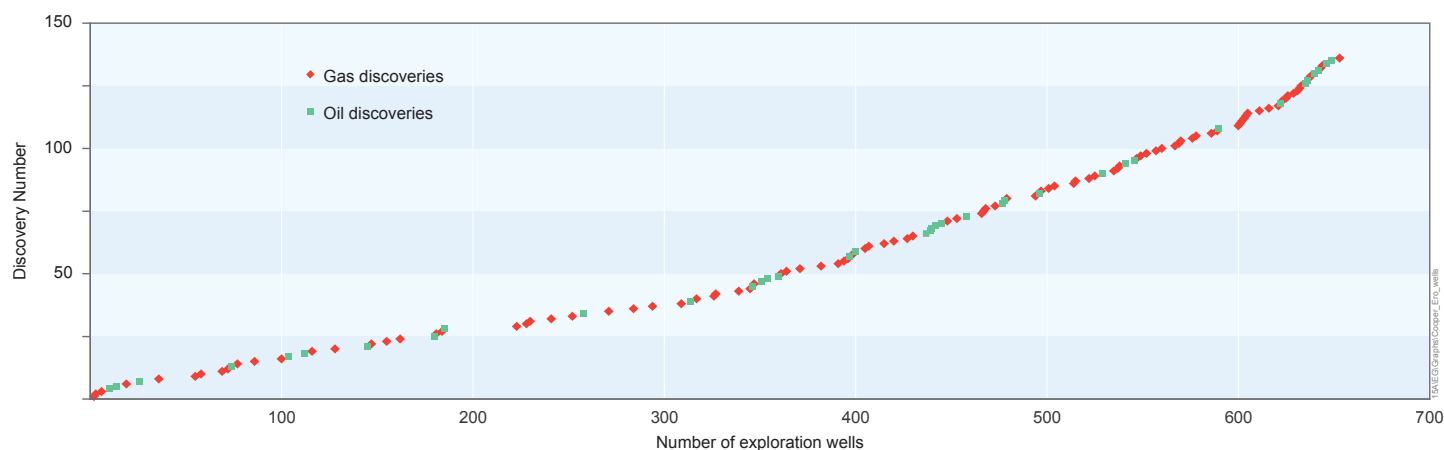
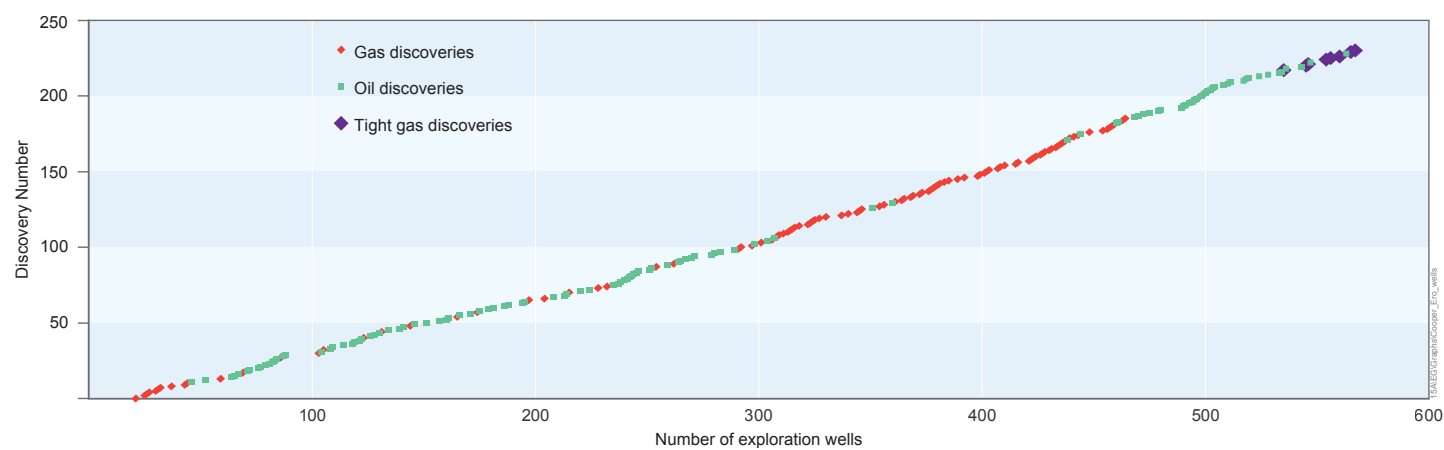


Figure 10: Drilling exploration success rates — Cooper–Eromanga basins



Drilling exploration success rates

The petroleum (excluding CSG) exploration success rates in Queensland's petroleum-producing basins are generally very good with approximately 20% of wells drilled in the Bowen/Surat basins and 40% of wells drilled in the Cooper/Eromanga basins reported as discoveries by exploration companies. (see Figures 9 & 10).

This history of drilling in the Bowen and Surat basins provides insight into key factors driving exploration. Exploration in the mid to late 1960s and 1970s followed on from the discoveries made in the early 1960s. The success rate increased slightly in the early 1980s through until the mid-1990s, as the result of the application of new technology, especially the digital recording of seismic data. The improvement in the latter part of the exploration history in these basins is due to the use of new drilling technology.

The exploration history of the Cooper and Eromanga basins differs from the other basins in that the overall success rate remains relatively consistent.

Further information:

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Note: Statistics quoted in this brochure were compiled by the Department of Natural Resources and Mines, 2015–16.