Western Australian Marine Science Blueprint

Online Appendix 7: Western Australian Offshore Oil and Gas Industry

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This Appendix provides an overview of offshore exploration, development and production activity in the oil and gas industry in Western Australia, as discussed in the Blueprint.

1. Overview of the Western Australian Offshore Oil and Gas Industry

A range of petroleum products are produced from the Western Australian offshore oil and gas industry including crude oil, condensate, Liquefied Petroleum Gas (LPG), Liquefied Natural Gas (LNG) for export markets and natural gas for the domestic market (sales gas). As illustrated in Figure 1 below, petroleum titles exist over large areas of the Western Australian marine environment. However, currently production revolves almost exclusively around a small portion of the Carnarvon Basin off the Pilbara coast. In addition, a small amount of crude is produced from the offshore Perth Basin and a small amount of sales gas that is marketed in the Northern Territory is produced from the Bonaparte Basin off the northern Kimberley coast. Exploration and development activity also primarily takes place in the wider Carnarvon Basin, with recent significantly escalated activity in the Browse Basin off the west coast of the Kimberley Region. (see area inset in Figure 1)
Figure 1 – Western Australian Petroleum Titles (June 2014)
Current gas reserves across the Carnarvon, Browse and Bonaparte Basins are estimated to be approximately 157 trillion cubic feet of gas. Figure 2 below summarises the distribution of these reserves across the three basins. A relatively small resource of 0.21 trillion cubic feet of gas also exists in the Perth Basin.

![Distribution of Western Australian Natural Gas Reserves](image)

**Figure 2 – Distribution of Western Australian Natural Gas Reserves**

In 2013, production assets offshore from Western Australia produced 40.6 million barrels of crude, 36.6 million barrels of condensate, 7.9 billion cubic feet of LPG, 887.9 billion cubic feet of LNG and 377.3 billion cubic feet of sales gas. With the exception of 2.2 percent of the State’s crude production (which was produced from a single asset in the Offshore Perth Basin) and 6.8 percent of sales gas (which was produced from a single asset in the Bonaparte Basin and marketed in the Northern Territory), all of this production was sourced from offshore assets in the Carnarvon Basin.

As discussed in the introduction to the Blueprint, a number of new petroleum projects in the Carnarvon and Browse Basins are currently being developed or under construction. These projects will substantially change the production profile from offshore Western Australia.

The following subsections discuss the various current and future projects that comprise the offshore Carnarvon, Browse and Bonaparte Basins.

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1 Department of State Development (2013), LNG in Western Australia: Fact Sheet, Western Australian Government Perth.
2. Carnarvon Basin

The oil and gas industry that produces hydrocarbon products from the offshore Carnarvon basin is a key industry for Western Australia in terms of contribution to Gross State Product (GSP), employment, export revenues, sustainability of regional communities and domestic energy security. It is also a significant industry for the Nation in terms of contribution to GNP, export revenues and Commonwealth taxation revenues.

In 2013, 39.7 million barrels of crude was produced from offshore Carnarvon Basin assets. This production is summarised in Figure 3 below.

![Figure 3 - 2013 Production of Crude from Offshore Carnarvon Basin Assets](image)

Approximately 90 percent of the 36.5 million barrels condensate that was produced from the Carnarvon Basin in 2013 was produced from the North West Shelf Joint Venture. 2013 production of condensate from the Carnarvon Basin is illustrated in Figure 4 below.

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2 Australian Petroleum Production and Exploration Association (2013), Production Statistics
3 Australian Petroleum Production and Exploration Association (2013), Production Statistics
As illustrated in Figure 5 below, the approximate 890 billion cubic feet of LNG that was produced in 2013, was produced exclusively from two Woodside operated assets, the North West Shelf Joint Venture and Pluto Project. Approximately 7.9 million barrels of LPG is also produced from the North West Shelf Joint Venture.

Finally, sales gas is produced for the domestic gas market from four offshore projects in the Carnarvon Basin. Domestic gas is produced for the domestic gas market by the North West
Shelf Joint Venture under the State’s domestic gas reservation policy, whereas gas production from the Varanus Island, Devil Creek and Macedon Projects is sold exclusively to the domestic gas market. Figure 6 below summarise the sources of domestic gas for 2013.

![Diagram](image)

**Figure 6 – 2013 Sales Gas Production from the Carnarvon Basin**

The following subsections summarise some of the key projects that comprise the Carnarvon Basin offshore oil and gas industry.

**Operating Carnarvon Basin Projects**

**Barrow and Thervenard Islands**

Barrow Island is in fact an onshore oil field located on an island in the offshore Carnarvon Basin. Barrow Island is a Class A Nature Reserve on which Chevron has operated since 1964. It is the largest onshore oil field in Australia, having produced more than 320 million barrels of oil. It is also the base for the Gorgon Project (see subsequent section).

**Devil Creek**

The Apache Energy operated Devil Creek domestic gas plant sources gas from its Reindeer gas field, located approximately 45 kilometres off the coast of Dampier. Gas production from the unmanned wellhead platform at the Reindeer field is piped to the Devil Creek plant via a 105 kilometre long subsea trunkline. The Devil Creek plant is comprised of two gas trains designed to process 200mcf gas per day, as well as 1,000bbls of condensate per day. The project currently has a lifespan of between 20 and 30 years and it is intended that it will supply gas the Citic Pacific’s Sino Iron project when operational.

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Northwest Shelf Project
The North West Shelf Project is the single largest resources project in Australia and one of the largest Liquefied Natural Gas (LNG) projects in the world. Each year it contributes approximately A$5.0 billion to State and Commonwealth Government revenues in the form of taxes and royalties.

It accounts for approximately 30 percent of Australia’s oil and gas production and has provided the majority of Western Australia’s domestic gas supply for the past 30 years. Since 1989 the project has delivered approximately 4,000 LNG cargoes to customers around the world.

Production from the Angel, Goodwyn A and North Rankin A platforms is piped to Woodside’s Karratha Gas Plant where five LNG trains produce LNG for export and a domestic gas plant delivers gas to the Dampier-Bunbury pipeline. In recent times, there has been additional investment in the re-development of the North Rankin and Pereus gas fields and fields associated with the Goodwyn A platform.

Enfield
The Enfield project is operated by Woodside and is located approximately 50 kilometres northwest of Exmouth. Oil is produced via five subsea wells which are connected to the FPSO, Nganhurra, which has a maximum production rating of 10,000 barrels per day, with storage capacity of approximately 900,000 barrels of oil.

Macedon Gas Project
The BHP Billiton Petroleum operated Macedon Gas project sources gas from the Macedon Gas Field via four offshore production wells approximately 100 kilometres off the coast of Onslow. Production gas is piped to a domestic gas plant located at Ashburton North near Onslow.

Mutineer – Exeter
The Santos operated Mutineer-Exeter project is located approximately 150 kilometres north of Dampier. Subsea production systems deliver oil to the FPSO, MODEC Venture II, which has a maximum production rate of 100,000 barrels per day and storage of 930,000 barrels, but is currently producing at a rate of approximately 5,000 barrels per day.

Pluto LNG
The Pluto LNG project is operated by Woodside. The Pluto and Xena gas fields are located approximately 190 kilometres north of Karratha where gas is sourced via a normally unmanned platform connected to five subsea wells. Gas is piped from this facility via a 180 kilometre long trunkline to the onshore LNG plant near Karratha, where a single LNG train produces 4.3mtpa.

Pyrenees
The Pyrenees Project is located approximately 45 kilometres off the coast of Exmouth and approximately 20 kilometres from BHP Billiton Petroleum’s Stybarrow Project (see below). The Pyrenees Project is operated by BHP Billiton Petroleum and produces oil from a network of 13 subsea wells connected through a subsea gathering system delivering oil to the Pyrenees.

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FPSO. The Pyrenees FPSO has production capacity of approximately 96,000 barrels of oil and has a gas reinjection capacity of 60 million cubic feet of gas per day.\(^7\)

**Stag**
The Stag oil field is located approximately 60 kilometres off the coast of Dampier and is operated by Apache. Eleven production wells and three water injection wells produce to a fixed production facility, the Stag Platform. Crude oil produced from the platform is piped 1.9 kilometers to the bony moors for the FPSO Dampier Spirit, which has a storage capacity of 700,000 barrels of oil.\(^8\)

**Stybarrow**
Stybarrow is operated by BHP Billiton Petroleum and is located 65 kilometres north west of Exmouth. The project produces oil from a subsea development where it is transferred to the Stybarrow FPSO, which is capable of processing 100,000 barrels of liquid per day and has a storage capacity of approximately 900,000 barrels.

**Varanus Island**
The Varanus Island Project is operated by Apache. The domestic gas plant at Varanus Island sources gas from Apache’s Halyard and Spar gas fields, located approximately 70 kilometres west of Varanus Island.\(^9\)

**Vincent**
The Vincent oil project is operated by Woodside and is located approximately 50 kilometres north-west of Exmouth. The project is comprised of 15 development wells, two water injection wells and one gas injection well. These subsea wells are connected to the Nguijima-Yin FPSO. The Nguijima-Yin FPSO has a product capacity of approximately 120,000 barrels per day and a storage capacity of 1.2 million barrels of oil.\(^10\)

**Wandoo**
Operated by Vermillion Energy, the Wandoo project produces oil from the fixed Wandoo B Platform, located 75 kilometres northwest of Dampier. The project produces approximately 6,500 barrels per day from 21 producing wells.\(^11\)

**Projects Currently Under Construction**

**Gorgon Project**
The Gorgon Project is operated by Chevron and is located on Barrow Island. Barrow Island is a Class A Nature Reserve with an associated State marine reserve located approximately 60 kilometres off the coast. The Gorgon project sources gas from a combination of production

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\(^7\) [http://www.bhpbilliton.com/home/investors/news/Pages/Articles/First%20Oil%20Production%20From%20Pyrenees%20Development%20Offshore%20Western%20Australia.aspx](http://www.bhpbilliton.com/home/investors/news/Pages/Articles/First%20Oil%20Production%20From%20Pyrenees%20Development%20Offshore%20Western%20Australia.aspx)


\(^11\) [http://www.vermillionenergy.com/operations/australia/australiabackground.cfm](http://www.vermillionenergy.com/operations/australia/australiabackground.cfm)
rigs and subsea production systems at the Jansz and Io fields located in the Greater Gorgon Area, 130 kilometres of the coast. Once commissioned, gas will be piped to processing facilities on Barrow Island via a subsea pipeline where it will be processed into LNG for export via three LNG trains with a combined capacity of 15mtpa, as well as a domestic gas plant which will supply the Dampier-Bunbury pipeline via a subsea pipeline from Barrow Island. LNG will be offloaded onto LNG tankers at Barrow Island via a 2.1 kilometre long LNG jetty.

The Gorgon Project will also have a CO\textsubscript{2} injection facility located on the central eastern coast of Barrow Island that will inject up to four times more CO\textsubscript{2} underground than any similar existing project in the world and over the life of the project, 120 million tonnes of CO\textsubscript{2}.

Wheatstone
The Chevron operated Wheatstone project will process gas produced from the Chevron operated Iago gas fields as well as the Apache Energy operated Julimar and Brunello fields. Gas sourced from these fields will be piped via a 225 kilometre trunkline to an onshore gas processing facility at Ashburton North, 12 kilometres north of the town of Onslow, where it will be processed into LNG for export via two LNG trains with a combined capacity of 8.9mtpa and to domestic gas via a domestic gas plant linked to the Dampier-Bunbury pipeline.

Scarborough
While the ExxonMobil operated Scarborough project is at a relatively early stage of pre-FID development, it is worth noting because if it proceeds it will likely be the first application of FLNG technology in the Carnarvon Basin. The Scarborough Gas Field is located approximately 220 kilometres northwest of Exmouth and is one of the most remote Carnarvon Basin gas fields.

3. Browse Basin

Located off the coast of the Kimberley Region of Western Australia, the Browse Basin is currently not in production. However, there are two projects currently under development, one project proceeding to Final Investment Decision and considerable exploration activity in the region. The Browse Basin will likely evolve into a major gas producing region for Western Australia.

The following subsections describe the projects currently under construction in the Browse Basin, as well as projects that are at a pre-final investment decision phase. These projects are being developed in the context of limited operating experience in the region.

Projects Currently Under Construction

Ichthys Gas Project
The Ichthys gas and condensate field is located in the Browse Basin, approximately 200 kilometres off the Kimberley coast. Gas from the Ichthys field will be sourced from up to 50 subsea wells and undergo preliminary processing to remove water and raw fluids (including most of the condensate) on what will be the world’s largest semi-submersible platform. The removed condensate will be pumped to a FPSO facility to be anchored nearby. The gas will be transported to a LNG processing facility in Darwin via a 890 kilometre long subsea trunkline.
The Ichthys LNG Project is expected to produce 8.4 million tonnes of LNG and 1.6 million tonne of LPG per annum, along with approximately 100,000 barrels of condensate per day at peak. The project is expected to have 40 year operational life.

Prelude

The Prelude and Concerto gas fields are located approximately 475 kilometres north-east of the Kimberley town of Broome. Gas will be produced from these fields via a series of subsea wells delivering raw hydrocarbon fluids to the Prelude Floating LNG production vessel, which is currently under construction. The Prelude FLNG vessel is 488 metres in length and 74 metres wide with a fully-loaded weight of approximately 600,000 tonnes. It has the capacity to process 3.6mtpa of LNG, as well as condensate and LPG. Production from the Prelude FLNG vessel will be loaded onto LNG carriers directly at sea. The vessel will be permanently moored at the location for 25 years and is rated to withstand a 1 in 10,000 year weather event. The application of this technology in the Browse Basin is likely to be a world-first.

Pre Final Investment Decision Projects

Browse

The Woodside operated Browse Project is comprised of the Torosa, Brecknock and Calliance fields located approximately 425 kilometres north of Broome. The original plan for the development of the Browse project was to source the gas via a series of subsea wells connected to a platform, with the gas piped to an onshore LNG and domestic gas plant to be located near James Price Point, approximately 60 kilometres north of Broome. For economic reasons, Woodside abandoned this development option and are currently exploring the application of FLNG technology to the project.

4. Bonaparte Basin Projects

Blacktip

The ENI operated Blacktip gas field is located approximately 110 kilometres off the north Kimberley coast. Two wells deliver gas to a platform, from which it is piped to an onshore gas processing plant at Wadeye in the Northern Territory via a 108 kilometre long pipeline. All of the gas produced from Blacktip is sold to the Northern Territory utility, Power Water Corporation.

Other Bonaparte Basin Projects

Other pre-production projects in the Bonaparte Basin include the Bonaparte Gas Project (Santos) and the Cash-Maple Project (PTTEP).

5. Aging Offshore Infrastructure

Because the horizon of the Blueprint is 2050, issues associated with decommissioning of offshore assets is relevant. Ecosystems naturally form around offshore infrastructure, which may have conservation, commercial or social (recreational) value. Removing infrastructure also affects
the decommissioning risk profile. Understanding the importance of these ecosystems and the decommissioning risk profile will be critical to supporting decommissioning decisions.

Estimating the life of offshore assets is difficult, because a range of factors affect the technical and economic aspects of decommissioning decisions including market conditions, new discoveries and technology development that extends the life of existing infrastructure. Table 1 below summarises the expected operating life of some key offshore assets in Western Australia that are currently in operation.

<table>
<thead>
<tr>
<th>Project</th>
<th>Main assets</th>
<th>Start</th>
<th>Forecast end</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Projects in the Carnarvon Basin</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Devil Creek | Unmanned wellhead platform  
105km subsea trunkline to gas plant | First production in December 2011 | 2032 to 2042 |
| Enfield | Five subsea production wells  
FPSO, Nganhurra | First production in July 2006 | n/a |
| Macedon | Four production wells  
90km subsea pipeline to gas plant | First production in August 2013 | 2023 |
| Mutineer-Exeter | Subsea oil production system consisting of 10 production wells and four manifolds (at Mutineer, Exeter, Fletcher and Finucane).  
FPSO, MODEC Venture II | First oil production in March 2005  
Three wells at Fletcher/Finucane first produced in May 2013 | n/a |
| Northwest Shelf | North Rankin A and B platforms (29 production wells)  
Goodwyn A platform (19 production wells, with capacity to expand to 30 wells)  
Angel platform (Three production wells)  
FPSO, Okha (12 production wells from the Wanaea, Cossack and Lambert, Hermes fields) | The years in which the platforms were commissioned are:  
North Rankin A - 1984  
Goodwyn A - 1995  
Angel - 2009  
Okha – 2011 (the connected wells have been in production since 1995)  
North Rankin B – 2013 | n/a |
<p>| Pluto | Five subsea wells connected to an unmanned platform | First gas production in May 2012 | 2027 |</p>
<table>
<thead>
<tr>
<th><strong>Project</strong></th>
<th><strong>Main assets</strong></th>
<th><strong>Start</strong></th>
<th><strong>Forecast end</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>180km subsea trunkline to gas plant</td>
<td></td>
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</tr>
<tr>
<td>Pyrenees</td>
<td>Subsea gas gathering system consisting of 13 wells and seven manifolds FPSO, Pyrenees</td>
<td>First gas production in March 2010</td>
<td>2035</td>
</tr>
<tr>
<td></td>
<td>Expansion work carried out in 2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stag</td>
<td>11 wells connected to a production platform 1.9km pipeline to a manifold and buoy moors FPSO, Dampier Spirit</td>
<td>First oil production commenced (from five wells) in May 1998 Additional wells producing oil in 2000</td>
<td>n/a</td>
</tr>
<tr>
<td>Stybarrow</td>
<td>Five subsea production wells FPSO, Stybarrow</td>
<td>First oil production in November 2007</td>
<td>2017</td>
</tr>
<tr>
<td>Varanus Island</td>
<td>John Brookes well Halyard well 55km subsea pipeline from John Brookes to gas plant 65 km pipeline (from pre-existing, depleted East Spar well) from Halyard to gas plant</td>
<td>First gas production from John Brookes in 2005 First gas production from Halyard in 2011 Current expansion planned with further wells in Spar field</td>
<td>n/a</td>
</tr>
<tr>
<td>Vincent</td>
<td>13 subsea production wells FPSO, Nguijima-Yin</td>
<td>First oil production in 2008 Expansion activity is underway.</td>
<td>n/a</td>
</tr>
<tr>
<td>Wandoo</td>
<td>Wandoo B platform 21 production wells</td>
<td>First oil production in March 1997</td>
<td>2018</td>
</tr>
</tbody>
</table>

**Projects in the Bonaparte Basin**
<table>
<thead>
<tr>
<th>Project</th>
<th>Main assets</th>
<th>Start</th>
<th>Forecast end</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blacktip</td>
<td>Two production wells</td>
<td>First gas production commenced in September 2009</td>
<td>2034</td>
</tr>
<tr>
<td></td>
<td>Unmanned wellhead platform</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>108km subsea pipeline to gas plant</td>
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</tbody>
</table>

**Table 1 – Life Expectancy of Offshore Assets Currently in Operation**

Table 2 below summarises the expected lifespan of assets associated with projects that are currently under construction.
### Projects under construction in the Carnarvon Basin

<table>
<thead>
<tr>
<th>Project</th>
<th>Main assets</th>
<th>Forecast start</th>
<th>Forecast end</th>
</tr>
</thead>
</table>
| Gorgon      | 18 production wells [Eight for the Gorgon field and 10 for the Jansz-Io field]  
A subsea gathering system with 5 manifolds [Three for Gorgon, two for Jansz-Io]  
Three subsea pipelines, 58km from Gorgon and 134km from Jansz-Io to the gas plant at Barrow Island, and one to carry domestic supply gas 70km from Barrow Island to the mainland.  
A 2.1 km long LNG jetty at Barrow Island to offload onto LNG tankers | mid 2015        | 2055-2075       |
| Wheatstone  | An offshore platform to be connected to a number of wells from the Wheatstone, Iago, Julimar and Brunello fields.  
A 225km subsea trunkline from the platform to the gas plant, west of Onslow. | late 2016       | 2046            |

### Projects under construction in the Browse Basin

<table>
<thead>
<tr>
<th>Project</th>
<th>Main assets</th>
<th>Forecast start</th>
<th>Forecast end</th>
</tr>
</thead>
</table>
| Ichthys | A central processing facility, a large semi-submersible platform connected to up to 50 subsea wells [currently drilling 20 development wells]  
FPSO to be permanently moored 3.5km from the central processing facility  
A 889km subsea pipeline to the gas plant [in Darwin] | late 2016       | 2056         |
| Prelude | Prelude FLNG platform, to be connected to a number of subsea wells in the Prelude and Concerto gas fields [currently drilling 7 development wells] | 2016           | 2036-2041    |

**Table 2 – Life Expectancy of Offshore Assets Currently Under Construction**