Preparing Australia's future oil and gas workforce

THREE SCENARIOS FOR WORKFORCE CHANGE
This report was commissioned by NERA (National Energy Resources Australia) and prepared by AlphaBeta. All information is derived from AlphaBeta analysis using both proprietary research and publicly available data and uses statistical techniques to provide insights on some of the drivers of defined scenarios, but is not intended to be statistically rigorous. Where information has been obtained from third-party sources, this is clearly referenced in the footnotes.

NERA is one of six Growth Centres established by the Australian Government under the Industry Growth Centres Initiative. It is an incorporated not-for-profit company governed by a board of industry experts to help drive projects to benefit the whole energy ecosystem in Australia. Through a national focus, NERA’s role is to grow collaboration and innovation to assist the energy resources industry manage cost structures and productivity, direct research to industry needs, deliver the future work skills required and promote fit for purpose regulation.
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Executive Summary

Australia has developed one of the strongest natural gas industries in the world and is on track to become the biggest exporter of liquefied natural gas (LNG) globally following an unparalleled investment boom. Between 2009 and 2017, resources companies invested an estimated A$320 billion into new oil and gas extraction projects across Australia, including developing a completely new coal seam gas (CSG) industry in Queensland. As a result, the country’s LNG processing capacity has tripled since 2012. Today, the oil and gas industry contributes $28 billion to the Australian economy, or roughly 1.6% of the total GDP.

The strong expansion of the LNG industry has caused Australia’s core oil and gas workforce to more than double from 9,000 workers in 2006 to 19,000 workers in 2016. More importantly, the indirect employment created by the oil and gas industry is substantial. Analysis used in this report shows that each oil and gas worker in Australia currently sustains another 10 jobs across the supply chain and wider economy — generating five times more indirect employment than an average worker in other industries. Oil and gas workers are also among the highest qualified in the country, with 44% employed in high-skill occupations, such as subsea engineers, geophysicists and production superintendents.

However, the future of the oil and gas workforce is uncertain. The industry’s ability to create new jobs has always been heavily dependent on a range of external factors that are difficult to predict, including the oil price, global supply and demand, and government policy. For example, the oil price has been highly volatile over the past five years and workforce growth has plateaued. An ongoing debate over CSG exploration and proposed resources taxes is affecting corporate investment decisions. As these sources of uncertainty are set to persist, it is challenging to reliably forecast the workforce needs of the oil and gas industry over the long, or even medium term.

This report, commissioned by NERA (National Energy Resources Australia), intends to offer guidance in uncertain times. Designed as a scenario-planning tool, it seeks to map the potential trajectory of the oil and gas workforce in Australia in the years ahead, so that companies, workers and policymakers can make informed decisions and prepare for a volatile future.

NERA, as an industry growth centre, has a mandate to foster collaboration and innovation, so that the oil and gas industry can deliver the future skills it requires. This includes informing the sector about expected workforce trends, liaising with education and training providers to ensure they are building and maintaining an adequate pipeline of skilled personnel, and helping the current workforce master periods of change driven by economic and technological trends.

This report uses scenario analysis to describe how Australia’s oil and gas workforce might look in 2030. It sets out three scenarios to estimate the potential direction of industry growth and employment. The three scenarios are by no means an attempt to predict the future. Rather, they should be seen as an exercise to test how the oil and gas workforce might react in a range of situations — from a sharp drop in oil prices to a reversal of current government policy.

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1 Australian Bureau of Statistics (ABS), 2010 to 2018, Private new capital exp. and expected exp., cat. no. 5625.0.
3 This report defines the direct (core) oil and gas workforce as people directly employed by oil and gas extraction or production companies, while the indirect workforce comprises of people in the supply chain and wider economy whose jobs indirectly rely on the oil and gas industry.
The upside and downside scenarios have been chosen to test the extremes and bracket the possible future at a time of ongoing uncertainty and global resource price volatility. In fact, the sharp swings in the oil price over the past decade suggest that not one, but all three scenarios may play out in some form in coming years through 2030. NERA has commissioned this report to help the industry prepare for this risk.

The scenarios, devised from over 30 interviews with industry experts across Australia, account for nine drivers of workforce change (including changes in oil prices and industry policy, as well as technological progress). Using historical workforce changes as a guideline, three scenarios were constructed.

**Operational efficiency scenario** *(business as usual)*

- Continuous investment in ‘operational efficiency’ is the most likely scenario and the one that most closely mirrors today’s situation. Assuming the oil price stays within the most recent range of US$60 to $80 per barrel, and Australian governments keep current policy settings steady (e.g. moratoria on CSG exploration remain in place), primary producers will likely remain focused on achieving greater production efficiency. Operators are expected to continue to upgrade and automate their operations using data analytics and predictive maintenance and technology such as advanced sensors.

- In this scenario, the size of the direct oil and gas workforce would not change greatly by 2030. A slight decline of 5%, or approximately 1,000 direct full-time jobs (primarily low- and medium-skilled corporate and production roles), would be offset by an estimated increase of around 3,000 jobs (+3%) in the supply chain, leaving the overall workforce supported by the oil and gas industry with a net gain of 2,000 jobs by 2030. This job growth would occur as the entire oil and gas industry becomes more competitive and increases demand for inputs from suppliers.

- Companies would require a healthy pipeline of workers with strong operational, maintenance and technology skills to achieve greater production efficiency.

**Industry growth scenario** *(upside)*

- The ‘industry growth’ scenario assumes that an increase in the oil price (to US$100 per barrel or higher) and favourable policy changes (such as lifting moratoria) provide a strong boost to the Australian oil and gas industry. It assumes that companies will continue to use automation technology to lower costs.

- The production upswing in this scenario has the potential to create around 29,000 new jobs (+14%) across the Australian economy by 2030. It is assumed that the majority of these new jobs (26,000) would emerge as indirect employment in the oil and gas supply chain and in the wider economy.

- However, the dramatic industry growth in this scenario could lead to talent shortages (in exploration, in construction and in operational roles) and create a strong need to improve the skills of the current workforce.

**Production decline scenario** *(downside)*

- A sharp and sustained fall in the oil price to between US$40 and US$60 per barrel is the basic assumption of the ‘production decline scenario’ (the downside case). This decline would be the result of strong competition from other gas producers, such as Qatar, Russia and East Africa. The scenario assumes that governments keep current policy settings steady and that companies continue to adopt new technology to lower costs and increase their operational productivity.

- In this worst-case scenario, the direct oil and gas workforce could decline by as much as 26%, or 5,000 jobs, (primarily corporate and production roles), accompanied by an even larger fall in employment across the supply chain and wider economy. In this extreme downside scenario, the total workforce supported by oil and gas in 2030 could be 34% smaller than in 2016.

- The assumed business downturn in this scenario might require intervention from government and industry to help transition a potentially large number of workers into new employment.

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Exhibit E1: Scenarios of Australia’s oil and gas workforce in 2030*

<table>
<thead>
<tr>
<th>Operational efficiency (BAU)</th>
<th>Industry growth (upside)</th>
<th>Production decline (downside)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Focus:</strong> using technology to lower costs, increase efficiency</td>
<td><strong>Focus:</strong> new exploration and construction</td>
<td><strong>Focus:</strong> managing production downturn caused by sharp decline in oil price</td>
</tr>
<tr>
<td><strong>Drivers</strong></td>
<td><strong>Drivers</strong></td>
<td><strong>Drivers</strong></td>
</tr>
<tr>
<td>• Oil price range US$60 to $80 for barrel (supply-demand trends unchanged)</td>
<td>• Oil price rises to US$100 per barrel (due to strong Asian demand for LNG)</td>
<td>• Oil prices falls to US$40 to $60 per barrel (due to strong supply from Qatar, USA, Africa)</td>
</tr>
<tr>
<td>• No policy change</td>
<td>• Positive policy change (moratoria lifted, tax changes)</td>
<td>• No policy change</td>
</tr>
<tr>
<td>• On-trend decline in exploration and construction spending</td>
<td>• Exploration, development and production spending rises</td>
<td>• Production decline; stronger focus on production efficiency</td>
</tr>
<tr>
<td>• Significant new investment in efficiency-enhancing technology</td>
<td>• New investment in exploration / development technologies</td>
<td>• Steep decline in exploration and construction spending</td>
</tr>
<tr>
<td><strong>Industry outcome</strong></td>
<td><strong>Industry outcome</strong></td>
<td><strong>Industry outcome</strong></td>
</tr>
<tr>
<td>• Production increases -13% for CSG and -50% for conventional gas to 2022; flat for rest of period</td>
<td>• Production increases -30% for oil, -50% for CSG and -96% for conventional gas</td>
<td>• Production declines -45% for oil, -50% for CSG and -17% for conventional gas</td>
</tr>
<tr>
<td>• Total capital expenditure -$120B</td>
<td>• Total capital expenditure -$200B</td>
<td>• Total capital expenditure -$80B</td>
</tr>
<tr>
<td>• 30% decrease in time spent on automatable tasks</td>
<td>• 15% decrease in time spent on automatable tasks</td>
<td>• 20% decrease in time spent on automatable tasks</td>
</tr>
<tr>
<td><strong>Workforce outcome</strong></td>
<td><strong>Workforce outcome</strong></td>
<td><strong>Workforce outcome</strong></td>
</tr>
<tr>
<td>• Direct workforce declines 5% (-1,000 jobs)</td>
<td>• Direct workforce grows 16% (+3,000)</td>
<td>• Direct workforce declines 26% (-5,000)</td>
</tr>
<tr>
<td>• Total workforce in 2030: 212,000</td>
<td>• Total workforce in 2030: 239,000</td>
<td>• Total workforce in 2030: 138,000</td>
</tr>
<tr>
<td>• Companies would require more workers with strong operational, maintenance and technology skills</td>
<td>• Dramatic expansion could lead to talent shortages and require stronger skills training and retraining</td>
<td>• Downturn would require policy intervention to help large number of workers transition into new roles</td>
</tr>
</tbody>
</table>

* See Appendix for further details on assumptions made in each scenario
The scenarios have been developed with significant industry input, based on what is possible and most relevant. The upside and downside case represent theoretical extremes that are meant to bracket a range of future outcomes. In fact, it is likely that the oil and gas industry will need to brace for all three scenarios to play out to some extent in coming years. Heavy swings in the oil price over the past decade (from around US$61 per barrel in 2009 to more than US$111 per barrel in 2011 and back to around US$43 in 2016) show just how unpredictable some of the drivers of the Australian oil and gas workforce are.

Regardless of the scenario, this report expects that a number of new occupations will emerge in the oil and gas industry, for example in specialist roles related to technology (Artificial Intelligence (AI)/machine learning specialists). The decommissioning of plants is seen as a growing business, which will create new jobs. Further job growth is likely if the industry decides to embrace opportunities around renewables and carbon capture, as well as other forms of unconventional energy to complement existing oil and gas extraction methods.

**How NERA will use these scenarios**

These scenarios have been devised to be used as an educational and planning tool for the industry, government, current and future workers and general public.

**Inform industry and public.** This report will be disseminated widely and launched on the NERA website with a simple and interactive occupation-level tool that will allow workers to plan their own futures and firms to prepare for workforce change.

**Prepare for workforce transitions.** The scenarios will also help firms in the industry plan to build a strong pipeline of skilled workers, inform the upskilling decisions that may be needed and the workforce transitions that may occur.

**Enable further collaboration.** The scenarios in this report will allow further industry-wide collaboration to improve training initiatives, competency frameworks, infrastructure planning and engagement of the supply chain.
Australia’s oil and gas workforce has doubled over the last decade
The direct oil and gas industry employs 19,000 people

The core oil and gas workforce in Australia consists of about 19,000 people who are directly employed by oil and gas exploration and production companies. Their qualifications are comparably high: nearly every second worker in the Australian oil and gas industry is employed in highly skilled positions, such as geophysicists, engineers, and accountants (Exhibit 1). Almost half (48%) are employed in production and 30% work in corporate services.

Exhibit 1: Workforce composition of Australia’s oil and gas extraction industry

2016 employment, Number of workers (% of workforce in parentheses)

<table>
<thead>
<tr>
<th>Skill Level</th>
<th>Exploration</th>
<th>Construction</th>
<th>Production</th>
<th>Corporate</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Higher skill</strong></td>
<td>1,225 (6%)</td>
<td>2,711 (14%)</td>
<td>3,355 (18%)</td>
<td>8,308 (44%)</td>
<td></td>
</tr>
<tr>
<td>Examples:</td>
<td>Geophysicist (exploration)</td>
<td>Production manager</td>
<td>Accountant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Examples:</td>
<td>Petroleum engineer</td>
<td>Engineer</td>
<td>HR professional</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Examples:</td>
<td>Construction manager</td>
<td></td>
<td>ICT manager</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Medium skill</strong></td>
<td>97 (1%)</td>
<td>5,281 (28%)</td>
<td>1,106 (6%)</td>
<td>6,653 (35%)</td>
<td></td>
</tr>
<tr>
<td>Examples:</td>
<td>Exploration driller</td>
<td>Plant operator</td>
<td>Personal assistant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Examples:</td>
<td>Inspector</td>
<td>Engineering technician</td>
<td>ICT support technicians</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lower skill</strong></td>
<td>196 (1%)</td>
<td>1,098 (6%)</td>
<td>1,122 (6%)</td>
<td>3,935 (21%)</td>
<td></td>
</tr>
<tr>
<td>Examples:</td>
<td>Field assistant</td>
<td>Labourer</td>
<td>General clerk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Examples:</td>
<td>Structural steel construction worker</td>
<td>General hands</td>
<td>Accounting clerk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Examples:</td>
<td>Development driller</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,518 (8%)</td>
<td>2,705 (14%)</td>
<td>9,090 (48%)</td>
<td>5,583 (30%)</td>
<td>18,896 (100%)</td>
</tr>
</tbody>
</table>

Source: ABS Census (2016), industry interviews, Talent Neuron, AlphaBeta analysis

1 Skill level categorised based on each occupation’s ANZSCO qualification level assessment. Value chain categorised based on interviews with industry experts and job ad data. Where an occupation is common to multiple stages of the value chain, it has been distributed based on assumptions informed by expert interviews. Components may not sum to totals due to rounding.

The ANZSIC ‘Oil and Gas Extraction’ Code has been used to measure the ‘direct’ oil and gas workforce. It captures workers in the production of crude oil, natural gas or condensate through extraction of oil and gas deposits (upstream and downstream processing of oil and gas). It does not include employees in petroleum refining. ABS Census 2016 data.
Every job in the oil and gas industry supports another 10 jobs elsewhere in the economy

Compared to its relatively small core workforce of about 19,000 people, the indirect employment generated by the oil and gas industry is one of the largest in the Australian economy (Exhibit 2). Comprising an estimated 103,000 workers in 2016, the supply chain that fuels Australia’s oil and gas industry employs around five times as many people as the primary producers. In other words, every direct job in the oil and gas industry supports on average 5.4 other jobs in the oil and gas supply chain (see Exhibit 2). This multiplier is far higher than the average of 0.8 workers across all industries in Australia because the capital-intensive oil and gas industry requires a large amount of machinery, construction material and other intermediate inputs from specialist suppliers.

However, the size of the indirect oil and gas workforce can fluctuate. For example, primary oil and gas producers rely heavily on suppliers and contractors when they plan and build new plants. During the recent construction boom, many companies hired thousands of contract workers – steelworkers, drillers, construction labourers, building technicians and others – from specialist service providers, while employing only a small number of project management staff directly. Supply chain workers also contribute to generic supply chain activities such as providing IT services, financing and facilities management.

All these workers create further jobs through their consumer spending. Analysis of government input-output data indicates that household spending from income earned through direct or indirect oil and gas employment sustained 88,000 jobs in the wider Australian economy in 2016.

The combined employment effect is substantial: each job in the oil and gas industry indirectly support 10 other jobs in the Australian economy in 2016 – significantly more than the 1.9 jobs that the average industry supports.

Exhibit 2: Australian oil and gas workforce multiplier

<table>
<thead>
<tr>
<th>Direct industry employment</th>
<th>Supply chain</th>
<th>Wider economy</th>
<th>Employment multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oil and gas</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19k (19,000)</td>
<td>5.4x (103,000)</td>
<td>4.6x (88,000)</td>
<td>10x (210,000)</td>
</tr>
<tr>
<td><strong>Average industry</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>0.8x</td>
<td>1.1x</td>
<td>1.9x</td>
</tr>
</tbody>
</table>

Direct employment in oil and gas is 19,000 which is the total employees of firms listed with oil and gas ANZSIC codes.

The direct oil and gas workforce supports 5.4 times as many workers in the supply chain - more than other industries - because the oil and gas industry has very large capital and intermediate inputs from its supply chain.

The direct oil and gas workforce supports 4.6 times as many workers in the broader economy because the supply chain impact is so large. These firms and their workers create more activity across the economy.

Every worker in oil and gas supports a further 10 employees across the economy. As a result of the large supply chain and wider economy impact, oil and gas has a larger multiplier than most other Australian industries.

Source: ABS Input-Output tables, AlphaBeta analysis

Note: 2006 oil and gas employment ratios: supply chain = 5x; wider economy = 3.7x; total employment multiplier = 8.7x

6 The number of jobs in the oil and gas supply chain and the employment multiplicant were derived from AlphaBeta analysis of various pieces of data from the Australian Bureau of Statistics, including Input-Output tables.
The oil and gas workforce has doubled since 2006

The direct oil and gas workforce has changed dramatically over the last decade as a result of unprecedented investment. Between 2009 and 2017 alone, companies spent more than A$320 billion to build new LNG facilities across Australia. This has increased demand for workers, causing the direct oil and gas workforce to more than double from about 9,000 to 19,000 workers in the decade through 2016 (Exhibit 3). The biggest job growth was for medium-skilled production workers such as operators and maintenance technicians. High-skilled production workers (such as optimisation engineers) and corporate staff (such as accountants) were in strong demand between 2006 and 2016.

The investment boom created thousands of new jobs across the supply chain, causing Australia’s indirect oil and gas workforce to more than double from around 50,000 to 103,000 over the decade.8

Exhibit 3: Skills demand in Australian oil and gas extraction, 2006 to 2016
Increase in number of workers by value chain segment and skill level

Source: ABS Census (2006, 2011 and 2016), AlphaBeta analysis

7 ABS (2018), Private new capital expenditure and expected expenditure, cat.no. 5625.0.
8 See Appendix for further detail.
The mix of roles in the oil and gas industry has changed

The workforce changes over the last decade have largely been driven by a massive expansion of the industry. Oil and gas companies increased their spending on exploration, construction and production (Exhibit 4), as the oil price soared from around US$65 per barrel in 2006 to a peak of US$111 per barrel in 2011.9

Between 2006 and 2011, the direct oil and gas workforce grew significantly across the value chain (exploration, project development and construction, production and corporate roles). Employment in exploration increased particularly strongly by 100% in medium skilled roles and 120% in high skilled roles. Project and development employment increased even more over the same period by 140% in high skilled roles and 220% in medium skilled roles (Exhibit 5).

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10 The project and development workforce in this analysis refers to staff directly employed by primary producers to oversee the planning, development and construction of oil and gas projects. It does not include the substantial number of construction workers hired as contractors through the supply chain during peak construction periods.
As the industry moved from the exploration and construction phase to production, the workforce profile began to change. Following strong growth between 2006 and 2011, the direct workforce needed for project development, management and construction barely grew in the five years between 2011 and 2016 (Exhibit 6).

Meanwhile, jobs in exploration declined by about 20%-30%, particularly for petroleum engineers and geophysicists.

Exhibit 5: Past changes in the oil and gas workforce
Each bubble represents the size of each workforce segment in 2016

- Production
- Projects and Development
- Corporate
- Exploration

H = High skill
M = Medium skill
L = Low skill

Corporate and exploration roles have declined the most since 2011
Demand for project and development workers has slowed following the construction boom from 2006-2011
Production roles continue to grow as production ramps up

Source: ABS Census (2006, 2011 and 2016), AlphaBeta analysis
1 Based on ANZSCO occupations at the 4-digit level
Exhibit 6: Top occupation changes in the oil and gas industry

Absolute change in the number of direct oil and gas workers between 2011 and 2016 compared to the change between 2006 and 2011

<table>
<thead>
<tr>
<th>Top 10 occupation increases from 2011 to 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Production-related roles have increased most rapidly</td>
</tr>
<tr>
<td>• Increase has been sustained since 2006</td>
</tr>
<tr>
<td>• Most likely driver is the industry’s shift to production</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Occupation</th>
<th>2011 to 2016</th>
<th>2006 to 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant operators</td>
<td>+426</td>
<td>+316</td>
</tr>
<tr>
<td>Electricians</td>
<td>+327</td>
<td>+130</td>
</tr>
<tr>
<td>Structural steel workers</td>
<td>+204</td>
<td>+133</td>
</tr>
<tr>
<td>Building &amp; engineering technicians</td>
<td>+190</td>
<td>+163</td>
</tr>
<tr>
<td>Mechanical engineers</td>
<td>+149</td>
<td>+223</td>
</tr>
<tr>
<td>Production managers</td>
<td>+103</td>
<td>+176</td>
</tr>
<tr>
<td>Structural steel trades workers</td>
<td>+102</td>
<td>+73</td>
</tr>
<tr>
<td>Construction managers</td>
<td>+96</td>
<td>+56</td>
</tr>
<tr>
<td>Chemical engineers</td>
<td>+89</td>
<td>+26</td>
</tr>
<tr>
<td>Miscellaneous engineers</td>
<td>-30</td>
<td>+88</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Top 10 occupation decreases from 2011 to 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Exploration-related and corporate roles decreased most</td>
</tr>
<tr>
<td>• These roles had grown from 2006 to 2011, but the trend has since reversed</td>
</tr>
<tr>
<td>• Drivers include the shift away from exploration and focus on cost efficiency (potentially linked to oil price decline)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Occupation</th>
<th>2011 to 2016</th>
<th>2006 to 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petroleum engineers</td>
<td>-464</td>
<td>+964</td>
</tr>
<tr>
<td>Geologists and geophysicists</td>
<td>-249</td>
<td>+275</td>
</tr>
<tr>
<td>General clerks</td>
<td>-166</td>
<td>+282</td>
</tr>
<tr>
<td>Purchasing/supply logistics clerks</td>
<td>-101</td>
<td>+170</td>
</tr>
<tr>
<td>Accounting clerks</td>
<td>-89</td>
<td>+142</td>
</tr>
<tr>
<td>Accountants</td>
<td>-83</td>
<td>+252</td>
</tr>
<tr>
<td>Project administrators</td>
<td>-73</td>
<td>+443</td>
</tr>
<tr>
<td>Other construction labourers</td>
<td>-64</td>
<td>+135</td>
</tr>
<tr>
<td>Secretaries</td>
<td>-61</td>
<td>-23</td>
</tr>
<tr>
<td>Drillers</td>
<td>-56</td>
<td>+236</td>
</tr>
</tbody>
</table>

Source: ABS Census (2006, 2011 and 2016), AlphaBeta analysis
1 Based on ANZSCO occupations at the 4-digit level
A collapse in the oil price to around US$43 per barrel between 2014 and 2016 forced companies to cut operating costs. Between 2011 and 2016, the industry shed on average around 15% of corporate roles, such as general clerks and accountants. On the other hand, production roles continued to grow between 2011 and 2016 as new plants came online and bolstered production volumes. In production, plant operators, electricians, and structural steel workers were most needed between 2011 and 2016 (Exhibit 6).

The breakdown of the direct oil and gas production workforce across hydrocarbons has also shifted markedly over the past decade (Exhibit 7). Oil and gas production covers four types of hydrocarbon extraction:

- **Conventional gas production**: involves the extraction of natural gas, which typically occurs in underground rock deposits from which it flows to a production well under high pressure. It is mostly found offshore in Australia.
- **Coal seam gas (CSG) production**: involves the extraction of gas that is found in coal seams, trapped underground by water pressure. The water needs to be pumped out to release CSG. Australia’s coal seam gas industry is located onshore.
- **Oil extraction and processing**: involves the extraction and processing of crude oil and condensate (but not the refining into retail petroleum products). Many of Australia’s oil fields are offshore.
- **Liquified Natural Gas (LNG) production**: involves the cooling and compressing of gas (both conventional gas and CSG) for transportation.

### Exhibit 7: Employment trends in the oil and gas extraction production workforce

Change in the number of production workers 2006 to 2016 by hydrocarbon

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2011</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil production workforce</td>
<td>3,839</td>
<td>7,019</td>
<td>9,090</td>
</tr>
<tr>
<td>CSG production workforce</td>
<td>2,220</td>
<td>3,176</td>
<td>3,839</td>
</tr>
<tr>
<td>LNG production part of workforce</td>
<td>1,850</td>
<td>1,928</td>
<td>1,813</td>
</tr>
</tbody>
</table>

Source: Census 2006, 2011, 2016, AlphaBeta analysis

1 Breakdown estimated based on publicly available company data. LNG processing includes employees associated with domestic gas plants.

11 Calculation based on average employment decline across low-, medium and high skilled corporate roles.

12 CSG is a type of natural gas chemically similar to conventional gas. It is found in underground coal seams trapped by water at depths of 300 to 1,000 metres. LNG is natural gas that has been converted to liquid to make it easier and safer to transport.
The CSG production workforce grew particularly rapidly between 2006 and 2016, increasing from 5% to nearly 40% of all oil and gas workers in Australia as three new plants on Curtis Island in Queensland came online. Compared to offshore oil and gas, the onshore upstream CSG industry is comparatively labour-intensive, requiring considerable numbers of workers to drill, service and operate thousands of onshore wells and gas facilities that are often spread over large distances.\(^{13}\)

While the LNG production workforce continued to grow in absolute terms over the past decade, it reduced as a percentage of the total oil and gas production workforce in Australia. This is partly due to the emerging dominance of the CSG industry but also a result of the growing number of modern, high-tech LNG plants such as Pluto, Wheatstone and Gorgon, which require comparatively smaller workforces. The oil workforce has decreased from around 23% of Australia’s total oil and gas production workforce to nearly 10%, due to more efficient technology and declining production levels.

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**Case study 1: Legacy assets and the oil and gas workforce**

A substantial number of workers in Australian oil and gas production are currently employed in mature facilities. Automation technology could change this.

Despite the recent construction boom, around 50% of the LNG plants are more than a decade old.\(^ {14}\) Such older LNG plants make up approximately 30% of all LNG plants in Australia and include Woodside’s Karratha and ConocoPhillip’s Darwin plant. The situation is similar in the CSG industry where around 30% of extraction workers perform tasks at legacy wells and gas facilities, even though these assets make up only 15% of all wells and facilities.\(^ {15}\)

There are several reasons for the relatively large workforce in older assets. Older assets typically require more frequent maintenance and hence more workers to repair and replace ageing parts. Older assets also tend to be less automated, which means they still rely predominantly on humans, rather than sensors and robots, to operate them. Companies will perform a cost-benefit analysis at each plant on a case-by-case basis to decide whether to retrofit ageing plants with updated automation technology.\(^ {16}\)

By contrast, newer assets are more easily automated because they are more likely to have been designed with new technology in mind.

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**How automation technology is changing the oil and gas workforce**

Automation is changing the oil and gas workforce. New technologies, such as sensor technology and machine learning, are beginning to transform the way the industry operates and also changing the way workers do their jobs. For example, maintenance technicians are now likely to use data to determine which pieces of equipment require attention instead of working to pre-set schedules. In future, the ability to use and interpret data will only become more important for oil and gas occupations.

This report considers about 15 different technologies that have the potential to significantly increase the productivity and efficiency of oil and gas operations (see table below).

---

\(^{13}\) Upstream CSG production is defined as CSG field facilities including drilling, plant and pipeline components of the project.

\(^{14}\) Estimates based on expert interviews and publicly available information.

\(^{15}\) Estimates based on expert interviews.

\(^{16}\) Such analysis has not been carried out in this report due to a lack of data.
### Oil and gas technologies considered in this project

<table>
<thead>
<tr>
<th>Phase</th>
<th>Technology</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AI and connected ecosystem</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exploration</td>
<td>Machine learning applied to seismic data</td>
<td>Faster processing of seismic data using machine-learning algorithms.</td>
</tr>
<tr>
<td>Development</td>
<td>Intelligent design software (including digital twinning)</td>
<td>Use of algorithms to optimise processing plant design (e.g. to reduce total piping required) and to re-design rigs following reduction of human workers.</td>
</tr>
<tr>
<td>Production</td>
<td>Predictive maintenance</td>
<td>Use of real-time and historical data to anticipate issues with offshore, onshore and subsea assets.</td>
</tr>
<tr>
<td>Production</td>
<td>Machine learning / data analytics</td>
<td>Application of historical and real-time data to optimise the resource-to-market chain.</td>
</tr>
<tr>
<td><strong>Operational hardware</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development</td>
<td>Unmanned, intelligent drilling</td>
<td>Automation of already highly automated drilling process, supplemented by data analysis for more efficient drilling.</td>
</tr>
<tr>
<td>Production</td>
<td>4D seismic imaging</td>
<td>Acquisition, processing and interpretation of repeated seismic surveys of a producing field to analyse the seismic impact of production.</td>
</tr>
<tr>
<td>Exploration</td>
<td>Autonomous vehicles</td>
<td>Autonomous vehicles (aerial and subsea) powered by renewable energy and currents collecting data on exploration targets.</td>
</tr>
<tr>
<td>Production</td>
<td>Subsea processing and subsea tie-backs</td>
<td>Processing oil and gas on the seafloor rather than on a fixed or floating platform, where fields are located in harsh / deepwater conditions.</td>
</tr>
<tr>
<td>Production</td>
<td>3D printing</td>
<td>Additive manufacturing (3D printing) to construct spare and bespoke parts for platforms and plants.</td>
</tr>
<tr>
<td>Production</td>
<td>Inspection and caretaker robots</td>
<td>Autonomous robots (land, subsea, aerial and amphibious) for dangerous / remote maintenance work and data gathering.</td>
</tr>
<tr>
<td>Production</td>
<td>Autonomised, digitised sensor networks</td>
<td>Wireless sensor networks that collect physical, chemical and other data, converting it into a digital format for decision-making.</td>
</tr>
<tr>
<td><strong>Connected worker</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td>Use of wearables</td>
<td>Technologies that enable workers to interact with the sensors, robots and systems around them, or otherwise augment the worker.</td>
</tr>
<tr>
<td>Production</td>
<td>Remote operations centres</td>
<td>Monitoring / operation of equipment from a remote operations centre or other safe location, using advanced IT systems and virtual-reality technologies.</td>
</tr>
</tbody>
</table>
There are likely to be three stages of automation development to 2030 (Exhibit 8).

<table>
<thead>
<tr>
<th>Exhibit 8: Three stages of development in automation technology to 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRESENT</strong></td>
</tr>
<tr>
<td><strong>1. Automated equipment</strong></td>
</tr>
<tr>
<td><strong>Example technology</strong></td>
</tr>
<tr>
<td><strong>Level of interoperability</strong></td>
</tr>
<tr>
<td><strong>Drivers</strong></td>
</tr>
<tr>
<td><strong>Level of automation</strong></td>
</tr>
<tr>
<td><strong>Data maturity</strong></td>
</tr>
</tbody>
</table>
Phase 1 (today): Individual equipment automation

Most of today’s oil and gas assets are being transformed by the digitisation of individual pieces of equipment. For example, sensors can monitor equipment by constantly collecting activity data and alerting staff of irregularities in running an operation. They can capture information about the effectiveness of a drill rig by measuring the drill hole or detect corrosion on an underwater pipe. However, operation of the individual pieces of equipment cannot always be integrated, as much of the advanced equipment is still sourced from a handful of original equipment manufacturers (OEMs) and technology from different manufacturers still does not easily interact. In this phase, automation is partial and not complete. For example, underwater vehicles are often tele-operated, but still require substantial involvement from humans. A lack of IT capability and incomplete data also means that the full potential of real-time data analytics is not achieved.

Phase 2: Connecting equipment

By about 2025, oil and gas companies will have likely entered a new phase in their efforts to create the fully integrated and automated mine or plant. While the technology uptake in the first phase was primarily characterised by digitisation of individual pieces of equipment, the second phase will be marked by the growing interoperability of that equipment and adoption of automation technology. By 2025, most oil and gas plants will be fitted with an array of wireless smart sensors that monitor and control the movement of machines and operation of plants.

Technology manufacturers will spur this development by increasing the standardisation of their products, pressured by large producers who need their equipment to be interoperable. This is expected to open up the market for new competitors and lead to growing use of unbranded automation technology. It should also bring about new opportunities for companies in the supply chain. As the market for automation technology expands and technological progress becomes more entrenched, the data quality will improve along with the ability to analyse data using machine learning and artificial intelligence.

Phase 3: Connecting whole value chain

In a final phase, potentially starting in and around 2030, companies will continue to automate their production as they seek to realise very large benefits from technology integration. At this stage, many technologies will be highly interoperable across the entire value chain, from drilling through to shipping. Different pieces of equipment are now able to work in concert to perform highly complex tasks with unprecedented efficiency. Most equipment is expected to be fully autonomous by 2030, and most companies will be capable of using advanced data analytics and self-learning software to continuously improve product quality and operational efficiency. The increasing digitisation and integration of mining and oil and gas operations will substantially improve productivity.
Preparing Australia’s oil and gas workforce for the future
Scenario-planning as a tool to manage uncertainty

Forecasting the future of the oil and gas workforce over the medium and long term is challenging because the industry is subject to considerable volatility and uncertainty. Employment often ebbs and flows as the industry moves through cycles of expansion or contraction. For instance, jobs in oil and gas exploration increased by 107% between 2006 and 2011 and then decreased by 30% between 2011 and 2016.

Such abrupt changes are typically caused by external factors that are difficult to predict and that influence a company’s exploration spending, construction spending and production levels (Exhibit 9). For example, the oil price – the key driver of profitability in the gas industry – has been highly volatile in recent years (falling by 60% between 2014 and 2016) and influenced by geopolitics and global supply and demand. Domestic policy settings can also have a significant impact on growth in the oil and gas industry. Key areas of uncertainty include moratoria, exploration regulation and taxes.

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Level of uncertainty</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External drivers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil price (incl. supply/demand)</td>
<td>High</td>
<td>Significant volatility historically; impacted by geopolitics, supply, demand, government policy</td>
</tr>
<tr>
<td>Policy settings</td>
<td>Medium</td>
<td>Key areas of uncertainty include the policy around moratoria, exploration regulations, accelerated depreciation rules, remote lands taxation, ringfencing</td>
</tr>
<tr>
<td><strong>Industry drivers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exploration spend</td>
<td>High</td>
<td>Downward trend over last 5 years, but significant divergence of views on forward outlook and highly dependent on government policy</td>
</tr>
<tr>
<td>Construction spend</td>
<td>Medium</td>
<td>Trending downwards following construction boom, with uncertainty regarding commercial viability of future developments (e.g. Browse) to and beyond 2022</td>
</tr>
<tr>
<td>Oil production</td>
<td>Medium</td>
<td>Downward trend over last 3 years, with some projected future growth from condensates; production expansion prospects highly influenced by oil price</td>
</tr>
<tr>
<td>CSG production</td>
<td>High</td>
<td>Significant uncertainty regarding policy position on exploration and production in NSW, NT, Vic, as well as commercial viability in a low gas price environment</td>
</tr>
<tr>
<td>Conventional gas production</td>
<td>Medium</td>
<td>As noted above in construction, uncertainty regarding commercial viability of future projects beyond backfilling existing plants</td>
</tr>
<tr>
<td><strong>Technology drivers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td>Medium</td>
<td>Key areas of uncertainty include rate of tech development and industry adoption (highly conservative industry, possible complacency in high oil price)</td>
</tr>
<tr>
<td>Safety and environment</td>
<td>Low</td>
<td>Continued focus on safety and environment</td>
</tr>
</tbody>
</table>

The high degree of uncertainty around key drivers of the oil and gas industry means it is impossible to make a reliable forecast of the industry’s future workforce needs. Recognising this challenge, this report uses scenario-planning to help stakeholders understand the potential trajectory of Australia’s oil and gas workforce over the next 12 years. The next section sets out three different scenarios (‘operational efficiency’, an ‘upside’ and ‘downside’ case) for the potential direction of the industry and its workforce.
Constructing scenarios based on past workforce changes

To understand how the oil and gas workforce in Australia could develop in the future, it is important to identify what has caused it to change in the past (see Exhibit 10). This report uses a four-step approach to understand the various drivers of change and their historical impact on the workforce. The historical analysis, covering the decade between 2006 and 2016, is the key building block that allows us to create three plausible scenarios for Australia’s future oil and gas workforce.

Exhibit 10: Scenario methodology

1. Assign occupations to the value chain
   - Step 1 – Assign occupations: Occupations were assigned to different sections of the value chain such as exploration, construction and production, based on interviews with industry experts and job ad data.17 Occupations covering multiple stages of the value chain were distributed based on assumptions, informed by expert interviews. Skill levels were assigned based on the qualification level assessment in the Australian and New Zealand Standard Classification of Occupations (ANZSCO).

2. Identify historic drivers of change
   - Step 2 – Identify key drivers: A comprehensive list of drivers of workforce change was created, based on information from interviews, data analysis and literature review (see Exhibit 11, which also outlines the changes in the drivers between 2006 and 2016 and associated workforce impacts).18 These drivers were divided into three main groups. The first group comprises external drivers, such as the price of oil and domestic policy. The second group comprises industry-related drivers, such as exploration spending, construction spending, and the production of oil, coal seam gas and conventional gas.19 The third group comprises technological drivers, such as technologies that improve worker efficiency (predictive maintenance, 3D printing, smart glasses and others), as well as safety and environmental factors.

3. Isolate relationship between drivers and workforce change
   - Strength Direction Scenario 1 Workforce impact
   - Driver 1
     - D1
     - H
     - ++
   - Driver 2
     - D2
     - M
     - -
   - Driver 3
     - D3
     - L
     - +

4. Flex drivers to develop scenarios
   - Increase/decrease drivers to develop new scenarios based on interviews with stakeholders

---

17 Based on ANZSCO occupations at the 4-digit level.
18 Drivers have been separated as far as possible into mutually exclusive forces that impact the oil and gas industry, but there are inevitable overlaps.
19 Production values have been expressed in million barrels of oil equivalent (MMBOE) throughout in order to normalise production figures across hydrocarbons.
### Exhibit 11: Changes in drivers between 2006 and 2016

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Units</th>
<th>∆ 2006 to 2011</th>
<th>∆ 2011 to 2016</th>
<th>Workforce Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External drivers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil price (incl. supply/demand)</td>
<td>US$ per barrel</td>
<td>+71%</td>
<td>-61%</td>
<td>Accompanied workforce expansion to 2014, and exacerbated subsequent contraction</td>
</tr>
<tr>
<td>Policy settings</td>
<td>Investment barriers compared to the rest of the world</td>
<td>Moderate&lt;sup&gt;1&lt;/sup&gt;</td>
<td>High&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Foregone workforce growth due to additional regulations e.g. moratoria, resource tax, depreciation rules</td>
</tr>
<tr>
<td><strong>Industry drivers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exploration spend</td>
<td>A$ million</td>
<td>+95%</td>
<td>-57%</td>
<td>Increase in exploration workforce to 2011 and then reduction</td>
</tr>
<tr>
<td>Construction spend</td>
<td>A$ million</td>
<td>+414%</td>
<td>-4%</td>
<td>Increase in construction workforce to 2011 and then a subsequent slowdown</td>
</tr>
<tr>
<td>Oil production</td>
<td>MMBOE&lt;sup&gt;2&lt;/sup&gt;</td>
<td>-15%</td>
<td>-24%</td>
<td>Declining influence on production workforce</td>
</tr>
<tr>
<td>CSG production</td>
<td>MMBOE</td>
<td>+278%</td>
<td>+378%</td>
<td>Growing influence on production workforce</td>
</tr>
<tr>
<td>Conventional gas production</td>
<td>MMBOE</td>
<td>+9%</td>
<td>+48%</td>
<td>Growth in production workforce</td>
</tr>
<tr>
<td><strong>Technology drivers</strong></td>
<td></td>
<td>-9%</td>
<td>-9%</td>
<td>Less workers required for a given level of production</td>
</tr>
<tr>
<td>Safety and environment</td>
<td>LTIF rates</td>
<td>-29%</td>
<td>+67%</td>
<td>Small reduction in dangerous tasks</td>
</tr>
</tbody>
</table>

Source: Brent crude oil, Fraser Institute Global Petroleum Survey; ABS exploration expenditure, Accenture estimate; ABS Capex Survey; BIS Oxford Economics, Dept of Industry; AlphaBeta Automation Advantage model, AlphaBeta Oil and Gas Automation model; IOGP Safety Performance Indicators

<sup>1</sup> As evaluated by oil and gas companies in the Fraser Global Petroleum Survey.

<sup>2</sup> MMBOE (Million Barrels of Oil Equivalents)

<sup>3</sup> Based on ANZSCO occupations at the 4-digit level, 2006 to 2014.

**Step 3 – Isolate relationship between drivers and workforce:** To understand the impact each driver has on the workforce, the relationship was looked at in isolation by assigning a portion of the historical workforce change (by skill level and value chain step) to the relevant drivers, based on stakeholder interviews and data correlation. Matching the result with the actually observed historical change yielded a ‘historical workforce coefficient’, which signifies the strength and direction of the relationship between the driver and workforce change.

**Step 4 – Develop scenarios:** To establish three different scenarios for the future oil and gas workforce in Australia, drivers of workforce change were modified (modelling an increase or decrease in strength), using industry interviews and expected levels of investment. Applying the historical coefficient for each driver to the expected outcomes in each scenario allowed the report to estimate the size, skills composition and occupational changes in the future oil and gas workforce (by value chain segment).
Three scenarios were derived from the model: an ‘operational efficiency’ (business as usual) case, an ‘industry growth’ case, and a ‘production decline’ case (see Exhibit 12 and Technical Appendix for details). These scenarios are not exhaustive, nor do they represent an attempt to predict the future. Rather, they seek to help stakeholders understand what the future oil and gas workforce in Australia may look like for various levels of the oil price and for various industry policies.

**Exhibit 12: Scenarios of Australia’s oil and gas workforce in 2030**

<table>
<thead>
<tr>
<th><strong>Operational efficiency</strong> (BAU)</th>
<th><strong>Industry growth</strong> (upside)</th>
<th><strong>Production decline</strong> (downside)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Focus:</strong> using technology to lower costs, increase efficiency</td>
<td><strong>Focus:</strong> new exploration and construction</td>
<td><strong>Focus:</strong> managing production downturn caused by sharp decline in oil price</td>
</tr>
<tr>
<td><strong>Drivers</strong></td>
<td><strong>Drivers</strong></td>
<td><strong>Drivers</strong></td>
</tr>
<tr>
<td>• Oil price range US$60 to $80 per barrel (supply-demand trends unchanged)</td>
<td>• Oil price rises to US$100 per barrel (due to strong Asian demand for LNG)</td>
<td>• Oil prices falls to US$40 to $60 per barrel (due to strong supply from Qatar, USA, Africa)</td>
</tr>
<tr>
<td>• No policy change</td>
<td>• Positive policy change (moratoria lifted, tax changes)</td>
<td>• No policy change</td>
</tr>
<tr>
<td>• On-trend decline in exploration and construction spending</td>
<td>• Exploration, development and production spending rises</td>
<td>• Production decline; stronger focus on production efficiency</td>
</tr>
<tr>
<td>• Significant new investment in efficiency-enhancing technology</td>
<td>• New investment in exploration / development technologies</td>
<td>• Steep decline in exploration and construction spending</td>
</tr>
<tr>
<td><strong>Industry outcome</strong></td>
<td><strong>Industry outcome</strong></td>
<td><strong>Industry outcome</strong></td>
</tr>
<tr>
<td>• Production increases -13% for CSG and -50% for conventional gas to 2022; flat for rest of period</td>
<td>• Production increases -30% for oil, -50% for CSG and -96% for conventional gas</td>
<td>• Production declines -45% for oil, -50% for CSG and -17% for conventional gas</td>
</tr>
<tr>
<td>• Total capital expenditure -$120B</td>
<td>• Total capital expenditure -$200B</td>
<td>• Total capital expenditure -$80B</td>
</tr>
<tr>
<td>• 30% decrease in time spent on automatable tasks</td>
<td>• 15% decrease in time spent on automatable tasks</td>
<td>• 20% decrease in time spent on automatable tasks</td>
</tr>
<tr>
<td><strong>Workforce outcome</strong></td>
<td><strong>Workforce outcome</strong></td>
<td><strong>Workforce outcome</strong></td>
</tr>
<tr>
<td>• Direct workforce declines 5% (-1,000 jobs)</td>
<td>• Direct workforce grows 16% (+3,000)</td>
<td>• Direct workforce declines 26% (-5,000)</td>
</tr>
<tr>
<td>• Total workforce in 2030: 212,000</td>
<td>• Total workforce in 2030: 239,000</td>
<td>• Total workforce in 2030: 138,000</td>
</tr>
<tr>
<td>• Companies would require more workers with strong operational, maintenance and technology skills</td>
<td>• Dramatic expansion could lead to talent shortages and require stronger skills training and retraining</td>
<td>• Downturn would require policy intervention to help large number of workers transition into new roles</td>
</tr>
</tbody>
</table>

*See Appendix for further details on assumptions made in each scenario.

Note: The three scenarios above were created to illustrate potential industry growth trajectories under different assumptions. They should not be understood as comprehensive predictions, but as an analytical exercise to help understand possible future workforce needs. High oil price volatility and ongoing external uncertainty mean all three scenarios may play out to some degree over the next decade.
The scenarios have been developed with significant industry input, based on what is possible and most relevant. The upside and downside scenarios represent theoretical extremes that are meant to bracket a range of future outcomes. In fact, it is likely that the oil and gas industry will need to brace for all three scenarios to play out to some extent in coming years. Heavy swings in the oil price over the past decade (from around US$61 per barrel in 2009 to more than US$111 per barrel in 2011 and back to around US$43 in 2016) show just how unpredictable some of the drivers of the Australian oil and gas workforce are. This report does not consider any scenario that would reflect a large structural change in the use of energy by 2030. Industry stakeholders deemed such a structural change less likely (over the modelled time frame) and uncertain in consequences. For simplicity reasons, the report assumes that differences between the oil workforce and the gas workforce are limited.

Each scenario implies different challenges for Australia’s oil and gas workforce (see Exhibit 13 and Exhibit 14).

- In the ‘operational efficiency scenario’ (business as usual), which assumes the oil price remains within a range of US$60 to $80 per barrel and companies continue to use latest technology to make operations more cost-effective, the direct oil and gas workforce would shrink by 1,000 workers, or 5%. However, this slight decline would be offset by growing employment across the supply chain, resulting in a potential net gain of +2,000 new jobs and an increase in the total workforce supported by the oil and gas industry to 212,000 by 2030.

- The ‘growth scenario’ assumes that an increase in the oil price to US$100 per barrel or higher and positive policy changes, such as lifting of moratoria, will spur strong production growth. In this case, the total number of jobs supported by the oil and gas industry (including in the supply chain and the wider economy) is expected to increase by 29,000 people, or 14%, to 239,000 in the years to 2030.

- However, a sharp decline in the oil price to as low as US$40 to $60 per barrel could lead to a negative employment outcome, as seen in the ‘decline scenario’, which illustrates the risk that the core oil and gas workforce could shrink by 5,000 (26%) in the years to 2030 – with an even more substantial employment decline across the oil and gas supply chain and wider economy.
Exhibit 13: Estimated workforce trends in the direct oil and gas industry and its supply chain
Change in the number of workers by scenario

- Oil and gas workforce - historical
- Operational efficiency scenario
- Supply chain workforce - historical
- Declining production scenario
- Industry growth scenario

Employment supported by oil and gas producers across the supply chain

Direct employment in oil and gas industries

Source: ABS; AlphaBeta analysis

Note: This chart does not specify the estimated impact of the various oil and gas industry scenarios on the indirect employment across the wider economy (driven by changes in household incomes and spending). Generally, changes in the indirect oil and gas workforce across the wider economy follow the supply chain employment trend, but at a lower level (15,000 to 30,000 workers less).
### Exhibit 14: Estimated employment trends under various oil and gas industry scenarios

Number of workers, 2016 and 2030

<table>
<thead>
<tr>
<th></th>
<th>Operational Efficiency 2030</th>
<th>Industry Growth 2030</th>
<th>Declining Production 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2016</td>
<td>2030</td>
<td></td>
</tr>
<tr>
<td>Employment generated by O&amp;G in the wider economy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employment generated by O&amp;G in supply chain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct O&amp;G workforce</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>210,000</td>
<td>212,000</td>
<td>239,000</td>
</tr>
<tr>
<td>2030</td>
<td>+29,000</td>
<td>98,000</td>
<td>138,000</td>
</tr>
<tr>
<td></td>
<td>88,000</td>
<td>106,000</td>
<td>55,000</td>
</tr>
<tr>
<td></td>
<td>103,000</td>
<td>119,000</td>
<td>70,000</td>
</tr>
<tr>
<td></td>
<td>19,000</td>
<td>22,000</td>
<td>14,000</td>
</tr>
</tbody>
</table>

Source: ABS; AlphaBeta analysis

Note: Supply chain consists of all industries which supply oil and gas extraction sector or supply those firms which supply oil and gas. Future supply chain and wider economy employment modelled by using historical employment relationships between oil and gas, its supply chain and the wider economy, adjusted for future O&G construction spending and production.
Three scenarios for the future oil and gas workforce
Operational efficiency: companies will need more workers with operational, maintenance and technology skills

SUMMARY

- Under this scenario oil and gas companies will continue the deployment of emerging technology to maximise production efficiency. The oil price is assumed to remain at a moderate level of US$60 to $80 per barrel.
- The size of the future oil and gas workforce would be similar to today. Primary producers would require around 1,000 workers less in 2030 compared to 2016, mostly shedding low to medium skilled corporate and production roles such as drillers, project development workers and clerks.
- The direct workforce decline would be offset by growing employment in the supply chain as primary firms would become more competitive and demand more inputs. The result would be a net gain of 2,000 jobs supported by the oil and gas industry in 2030.
- The trend towards a higher production efficiency would require oil and gas workers to become more technologically adept and improve their operations management skills.

Drivers

The key driver in the operational efficiency scenario is a relatively steady oil price in the years to 2030 (see Exhibit 15). The scenario assumes that federal and state governments keep their current policy settings (moratoria, taxes etc.) unchanged, meaning the incentives for companies to increase exploration spending are low. As a result, companies are expected to focus on maximising production returns from existing assets, rather than expanding further. To achieve this, primary companies are expected to continue to invest heavily in automation technology (such as advanced sensors).

Workforce changes

In the operational efficiency scenario, the impact of change on the size and composition of the workforce would be muted (Exhibit 16). As primary companies continue to automate and refrain from further investments in exploration and construction, their direct workforce demand could fall by almost 1,000 workers by 2030, mostly driven by a lower need for low-skilled workers (see Exhibit 16).

However, the growing competitiveness and operational efficiency of primary producers would benefit suppliers, which – in this scenario – are expected to employ around 3,000 additional workers in 2030 to service the higher need for inputs from primary producers. This would result in a total net gain of 2,000 jobs supported by the oil and gas industry by 2030.

20 See technical Appendix for further details on the assumptions underpinning these drivers.
Exhibit 15: Drivers – Operational efficiency scenario

<table>
<thead>
<tr>
<th>External drivers</th>
<th>Policy settings</th>
<th>Oil price (incl. supply/demand)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rises to $70 per barrel from average Brent crude price of around $44 per barrel in 2016, and remains steady</td>
<td></td>
</tr>
<tr>
<td>Industry drivers</td>
<td>Exploration spend</td>
<td>Continues at 2016 rates (~$350m according to ABS data)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Construction spend&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Capex of -$7 to $10B p.a. (compared to $29B in 2016) Backfill projects to ensure that production continues at current rates</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil production</td>
<td>Increases to 140 MMBOE by 2022 then declines back to 2016 levels (127 MMBOE)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSG production</td>
<td>CSG production grows to 228 MMBOE by 2022 then flatlines</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conventional gas production</td>
<td>Conventional gas production grows to 620 MMBOE by 2022 then flatlines</td>
<td></td>
</tr>
<tr>
<td>Technology drivers</td>
<td>Technology</td>
<td>30% decrease in tasks that are automatable in oil and gas resulting in new investment in efficiency enhancing technology</td>
<td></td>
</tr>
<tr>
<td>Safety and environment</td>
<td>No change</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: All numbers in MMBOE (for consistency)

<sup>1</sup> Includes replacement capex (i.e. construction to backfill existing projects) and non-routine maintenance spend but excludes routine maintenance spend

---

Exhibit 16: Employment trends in the oil and gas workforce under the operational efficiency scenario (2016 vs 2030)

Projected change in the number of workers from 2016 to 2030 (absolute and %)

<table>
<thead>
<tr>
<th></th>
<th>Exploration</th>
<th>Projects and Development</th>
<th>Production</th>
<th>Corporate</th>
<th>Total</th>
<th>Broader Workforce&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher skill</td>
<td>-21 (-2%)</td>
<td>-266 (-26%)</td>
<td>120 (4%)</td>
<td>-316 (-9%)</td>
<td>-482 (-6%)</td>
<td>+2000 (+1%)</td>
</tr>
<tr>
<td>Medium skill</td>
<td>-2 (-2%)</td>
<td>-38 (-23%)</td>
<td>245 (5%)</td>
<td>-103 (-9%)</td>
<td>102 (2%)</td>
<td></td>
</tr>
<tr>
<td>Lower skill</td>
<td>-12 (-6%)</td>
<td>-290 (-19%)</td>
<td>-8 (-1%)</td>
<td>-257 (-23%)</td>
<td>-567 (-14%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>-34 (-2%)</td>
<td>-594 (-22%)</td>
<td>358 (4%)</td>
<td>-676 (-12%)</td>
<td>-946 (-5%)</td>
<td></td>
</tr>
</tbody>
</table>

Australia could require 9% more medium and high skill production workers (such as plant operators) to manage facilities developed during last decade’s construction boom

Australia could require almost 1,000 direct oil and gas workers less in 2030. Lower skilled oil and gas workers would be least needed due to an increase in automation

Oil and gas could support around 2,000 more workers as primary firms automate and produce more (due to higher productivity), sourcing more inputs from supply chain

Source: ABS 2016; AlphaBeta analysis

<sup>1</sup> Includes employment supported by oil and gas in the supply chain and wider economy. Supply chain consists of all industries which supply oil and gas extraction sector or supply those firms which supply oil and gas. Future supply chain and wider economy employment modelled by using historical employment relationships between oil and gas, its supply chain and the wider economy, adjusted for future oil and gas construction spending and production.
### Case study 2: How maintenance roles may change in an operational efficiency scenario

Maintenance technicians are a crucial part of the oil and gas workforce. They ensure that a plant is running at maximum capacity and that all of its electrical and mechanical equipment are in good condition. A steady rise in new electronic equipment has led to significant growth in electrical and instrumental technician roles, and this trend is expected to continue. However, new technology could significantly shift the day-to-day activities of technicians over the next decade.

Maintenance technicians are typically split into two categories: electrical and instrumental technicians, who maintain monitoring, control and electrical equipment such as metering, power supply and generators and account for about 70% of maintenance roles, and mechanical technicians, who perform maintenance and repairs on equipment such as rotating equipment. Both tend to carry out similar activities: maintenance and testing, fault finding in systems and equipment, modifying, repairing and replacing parts, and preparing reports on the work done.

Historically, maintenance technicians have done a large amount of scheduled routine inspections to ensure equipment is working. In the future, much of that routine maintenance could be supported by robotics and supplemented with predictive maintenance technology. With the rise of advanced sensors and growing amounts of real-time data, workers could be required to only maintain equipment on a case-by-case basis when they receive a data alert. Advances in technology mean maintenance work will likely shift from scheduled routine maintenance to more diagnostic tasks and ad-hoc repairs. However, these changes are likely to have only a small impact on maintenance workers numbers as workers will shift towards more diagnostic activities (Exhibit 17).

---

### Exhibit 17: Potential evolution of maintenance roles, now to 2016 (Production efficiency scenario)

<table>
<thead>
<tr>
<th>2016</th>
<th>2030</th>
<th>2016</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical</td>
<td>35%</td>
<td>20%</td>
<td>12%</td>
</tr>
<tr>
<td>Electrical &amp; Instrumental</td>
<td>65%</td>
<td>80%</td>
<td>24%</td>
</tr>
<tr>
<td>Logs</td>
<td>20%</td>
<td>10%</td>
<td>24%</td>
</tr>
<tr>
<td>Permitry</td>
<td>10%</td>
<td>30%</td>
<td>20%</td>
</tr>
</tbody>
</table>

**Shift away from field mechanical roles**

**Maintenance roles will require much less routine maintenance**

---

National Energy Resources Australia – Preparing Australia’s Future Oil and Gas Workforce
Occupation changes

Changes in the composition of the oil and gas workforce would be relatively mild in the operational efficiency scenario (Exhibit 18). A small number of additional production workers (particularly plant operators, metal fitters and electrical and instrumentation technicians) would likely be required to operate facilities that were built during last decade’s construction boom. On the flipside, demand for project construction workers (such as project managers and construction managers) and low-skilled corporate staff (such as clerks) is expected to fall, as construction activity tails off and routine tasks are automated.

Exhibit 18: Top occupation changes from 2016 to 2030 under the operational efficiency scenario

Absolute and % change in the number of workers from 2016 to 2030

<table>
<thead>
<tr>
<th>Top 10 increases</th>
<th>A small number of additional workers will be required in production roles, to operate and maintain to operate facilities developed during the last decade’s construction boom</th>
<th>change</th>
<th>% workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Operators</td>
<td>+73</td>
<td>-4%</td>
<td></td>
</tr>
<tr>
<td>Metal Fitters / Machinists</td>
<td>+31</td>
<td>-5%</td>
<td></td>
</tr>
<tr>
<td>Electricians</td>
<td>+28</td>
<td>-5%</td>
<td></td>
</tr>
<tr>
<td>Building / Engineering Technicians</td>
<td>+24</td>
<td>-5%</td>
<td></td>
</tr>
<tr>
<td>Production Managers</td>
<td>+20</td>
<td>-4%</td>
<td></td>
</tr>
<tr>
<td>Electrical Engineering Technicians</td>
<td>+11</td>
<td>-5%</td>
<td></td>
</tr>
<tr>
<td>Structural Steel Trades Workers</td>
<td>+10</td>
<td>-5%</td>
<td></td>
</tr>
<tr>
<td>Technicians and Trades Workers</td>
<td>+8</td>
<td>-5%</td>
<td></td>
</tr>
<tr>
<td>Plumbers</td>
<td>+7</td>
<td>-5%</td>
<td></td>
</tr>
<tr>
<td>Marine Transport Professionals</td>
<td>+5</td>
<td>-4%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Top 10 decreases</th>
<th>Demand for construction workers and corporate staff is expected to fall as construction activity tails off and routine corporate tasks are automated</th>
<th>change</th>
<th>% workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drillers</td>
<td>-108</td>
<td>-16%</td>
<td></td>
</tr>
<tr>
<td>Structural Steel Construction Workers</td>
<td>-72</td>
<td>-19%</td>
<td></td>
</tr>
<tr>
<td>General Clerks</td>
<td>-69</td>
<td>-23%</td>
<td></td>
</tr>
<tr>
<td>Petroleum Engineers</td>
<td>-62</td>
<td>-6%</td>
<td></td>
</tr>
<tr>
<td>Contract, Program / Project Administrators</td>
<td>-54</td>
<td>-9%</td>
<td></td>
</tr>
<tr>
<td>Accountants</td>
<td>-50</td>
<td>-9%</td>
<td></td>
</tr>
<tr>
<td>Construction / Mining Labourers</td>
<td>-48</td>
<td>-19%</td>
<td></td>
</tr>
<tr>
<td>Construction Managers</td>
<td>-44</td>
<td>-26%</td>
<td></td>
</tr>
<tr>
<td>Accounting Clerks</td>
<td>-35</td>
<td>-23%</td>
<td></td>
</tr>
<tr>
<td>Management / Organisation Analysts</td>
<td>-27</td>
<td>-9%</td>
<td></td>
</tr>
</tbody>
</table>

Source: AlphaBeta analysis

1 Based on ANZSCO occupations at the 4-digit level
2 Note drillers are employed in both the exploration and construction phases. The decline shown here is primarily driven by the decline in construction activity.
Case study 3: How field operator roles may change in an operational efficiency scenario

Field operators form a major part of the current oil and gas workforce. They look after the day-to-day running of oil and gas plants by streamlining production and keeping operations safe. Over the coming decade, new technologies could see the occupation mix within field operations shift as well as their day-to-day functions.

At present, field operators such as plant operators, undertake key activities such as monitoring plant processes, observing instruments and meters, starting and stopping equipment and inspecting the plant. To do these tasks, they need a range of skills and abilities. For example, plant operators need to be comfortable working with machines given their frequent interaction with machinery and equipment. Their jobs also demand good problem-solving skills and physical fitness as they patrol oil and gas plants and troubleshoot issues with plant equipment.

New technology will change the nature of field operations in the oil and gas industry. In 2016, field operators encompassed the majority of operations roles in oil and gas, comprising about 55% of these roles (Exhibit 19). Over the next decade, new technologies such as advanced sensors and automated testing will be able to perform field operations functions such as monitoring and controlling equipment e.g. doing gas tests. As a consequence, the number of field operators will likely decline. By 2030, field operators could only represent 30% of oil and gas operations roles.

Of the field operator roles that remain in 2030, their day-to-day activities will be quite different. Their work is already being influenced by technology. For example, tablets are now used to receive and send real-time data from their inspections, whereas previously they recorded observations manually. This is part of a broader movement toward reducing the volume of manual inspection activities and making plant operations more data driven. Eventually, advanced robotics could see an end to many of the taxing and risky physical tasks performed in oil and gas plants.

Exhibit 19: Potential evolution of operator roles, now to 2030 (Production efficiency scenario)

Flow of low/medium-skill workers from and within oil and gas between 2011 to 2016

<table>
<thead>
<tr>
<th>Control room operators</th>
<th>Permitry</th>
<th>Field operators</th>
<th>Multi-skilled field operators</th>
</tr>
</thead>
<tbody>
<tr>
<td>15%</td>
<td>15%</td>
<td>55%</td>
<td>15%</td>
</tr>
<tr>
<td>15%</td>
<td>15%</td>
<td>30%</td>
<td>35%</td>
</tr>
<tr>
<td>20%</td>
<td>15%</td>
<td>30%</td>
<td>35%</td>
</tr>
<tr>
<td>20%</td>
<td>35%</td>
<td>40%</td>
<td>35%</td>
</tr>
<tr>
<td></td>
<td>35%</td>
<td>70%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Shift away from field operator roles

Field operator roles would involve significantly less inspection

Source: Expert interviews
In the operational efficiency scenario, core production roles such as plant operator and production manager would remain vital to primary companies, albeit with a shift in skills requirements.

The heavy use of automation technology would require production workers to develop stronger multi-disciplinary skills (to use technology and to manage and maintain increasingly automated production plants). Almost 1,000 workers, predominantly lower skilled employees in primary exploration, project and development and corporate roles, would be affected by the automation trend (see Exhibit 16). These workers would need support transitioning into new roles – ideally in the direct oil and gas industry or its supply chain. Workers in the supply chain would also need stronger technology skills to service rapidly automating primary firms.

Over the next 10 years, most workers will be able to gradually acquire the new skills required in the oil and gas plants of the future. Inevitably, there will be some job losses due to growing use of automation technology in remote, hazardous operations and for repetitive, routine work. However, case studies (see Case study 2, 3 and 4 on how specific roles might change) indicate that automation technology is first and foremost changing the tasks within an occupation, not the occupation itself. Moreover, it is expected that technological progress will cause new jobs to emerge in roles focusing on technology supervision, maintenance, data evaluation and training. This would increase the need for re-training and teaching new skills, particularly technology skills, to workers.
Industry growth: rapid expansion may lead to a worker shortage and the need to lift workforce skills

SUMMARY

- Key assumption of this scenario is a sustained period of expansion in the Australian oil and gas industry, sparked by a strong increase in the oil price to US$100 per barrel or higher and favourable government policies (such as lifting of moratoria).
- Oil and gas companies will substantially increase their exploration activities and start new projects in the North West Shelf and East Coast, lifting overall production levels.
- The strong industry expansion could create around 29,000 new jobs in the core oil and gas workforce as well as indirectly across the supply chain and wider economy (see Exhibit 13).
- The expected dramatic workforce increase could lead to a skills shortage, particularly in exploration and production. To increase the supply in specialist workers and to keep pace with the technological change in the industry, education and training opportunities would need to improve.

Drivers

The key drivers in the industry growth scenario are a rising oil price due to strong global demand for LNG, as well as changes to federal and state government policies (such as lifting of CSG moratoria and changes to depreciation rules). Together, these two drivers are expected to encourage primary oil and gas companies to increase their spending on exploration, project development and construction. As a result, Australia’s hydrocarbon production, particularly production of CSG and conventional gas, is expected to soar (see Exhibit 20). This scenario assumes companies will invest in automation technology, particularly to lower exploration and construction costs. Technological progress is expected to reduce the number of automatable tasks performed by workers by 15%.

Workforce changes

The expected changes that underpin the industry growth scenario would have a strong and positive impact on employment, increasing the total workforce supported by oil and gas to 29,000 in 2030 (see Exhibit 21). In this scenario, the direct oil and gas workforce could grow by around 3,000 workers by 2030, with the largest growth in medium and high skill production workers such as plant operators and petroleum engineers (increase of 27%, or more than 700 workers, as seen in Exhibit 21). Demand for highly skilled exploration workers, such as geologists and geophysicists, could increase by nearly 300, or 24%, as companies invest more heavily in exploration (Exhibit 21).

A substantial expansion of primary oil and gas production would have a large economic knock-on effect. This growth scenario assumes that the indirect oil and gas workforce – people sustained by the oil and gas industry in the supply chain and wider economy – could increase by 26,000 in the years to 2030, resulting in a total 29,000 additional jobs supported by the oil and gas industry. The strong indirect employment growth would be fuelled by the primary producer’s growing demand of production inputs, which would likely cause suppliers to hire additional workers. The expected increase in household spending power would stimulate further growth and jobs in the wider economy. At the peak of construction activity, potentially around 2024, the oil and gas industry in this scenario would be expected to employ a large temporary workforce of around 10,000 construction and support workers.

---

21 The decrease is not as pronounced as the operational efficiency scenario. In that scenario, it is assumed that companies will be even more focused on improving production efficiencies because of the flat oil price and unchanged government policies and thus invest more heavily in automation technologies.
### Exhibit 20: Drivers – Industry growth scenario

<table>
<thead>
<tr>
<th>Driver Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External drivers</strong></td>
<td></td>
</tr>
<tr>
<td>Oil price (incl. supply/demand)</td>
<td>Steady increase to 2021 Peaks at $100 per barrel, starts to decrease in 2024</td>
</tr>
<tr>
<td>Policy settings</td>
<td>Positive policy changes including lifting moratoria, improving accelerated depreciation rules, ringfencing etc</td>
</tr>
<tr>
<td><strong>Industry drivers</strong></td>
<td></td>
</tr>
<tr>
<td>Exploration spend</td>
<td>Increases from $350m to $1.1B in 2021 then decreases to $550m in 2030</td>
</tr>
<tr>
<td>Construction spend¹</td>
<td>Strong forecast spend (~$15B a year) $120B ($90B conventional, $30B unconventional) spend from 2018 to 2024 (albeit a decline compared to $29B in 2016) Further $60B to 2030</td>
</tr>
<tr>
<td>Oil production</td>
<td>30% increase over 2016 levels by 2030</td>
</tr>
<tr>
<td>CSG production</td>
<td>50% increase over 2016 levels by 2030</td>
</tr>
<tr>
<td>Conventional gas production</td>
<td>Conventional gas production increases -90% from 417 MMBOE in 2016 to 816 MMBOE in 2030</td>
</tr>
<tr>
<td><strong>Technology drivers</strong></td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td>15% decrease in tasks that are automatable resulting in new investment in efficiency enhancing technology</td>
</tr>
<tr>
<td>Safety and environment</td>
<td>No change</td>
</tr>
</tbody>
</table>

Note: All numbers in MMBOE (for consistency)

¹ Includes replacement capex (i.e. construction to backfill existing projects) and non-routine maintenance spend but excludes routine maintenance spend

### Exhibit 21: Employment trends in Australia’s oil and gas workforce under the industry growth scenario (2016 vs 2030)

Projected change in the number of workers from 2016 to 2030 (absolute and %)

<table>
<thead>
<tr>
<th>Work-force composition</th>
<th>Exploration</th>
<th>Projects and Development</th>
<th>Production</th>
<th>Corporate</th>
<th>Total</th>
<th>Broader Workforce¹</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Higher skill</strong></td>
<td>294 (24%)</td>
<td>-196 (-19%)</td>
<td>721 (27%)</td>
<td>404 (12%)</td>
<td>1,223 (15%)</td>
<td>+29,000 (+14%)</td>
</tr>
<tr>
<td><strong>Medium skill</strong></td>
<td>16 (16%)</td>
<td>-28 (-16%)</td>
<td>1,393 (26%)</td>
<td>164 (15%)</td>
<td>1,545 (23%)</td>
<td></td>
</tr>
<tr>
<td><strong>Lower skill</strong></td>
<td>52 (26%)</td>
<td>-207 (-14%)</td>
<td>291 (27%)</td>
<td>6 (1%)</td>
<td>143 (4%)</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>361 (24%)</td>
<td>-431 (-16%)</td>
<td>2,406 (26%)</td>
<td>574 (10%)</td>
<td>2,910 (15%)</td>
<td></td>
</tr>
</tbody>
</table>

Australia could require 24% more high-skill exploration workers (e.g. geologists) to capitalise on new exploration technologies and investment

Australia could require around 2,100 more medium and high skill production workers (e.g. plant operators, petroleum engineers) to operate newly developed facilities

Oil and gas industries will support around 29,000 more workers as primary firms produce more, sourcing more inputs from supply chain and as additional workers in primary firms stimulate jobs growth in the wider economy

Source: ABS 2016, AlphaBeta analysis

¹ Includes employment supported by oil and gas in the supply chain and wider economy. Supply chain consists of all industries which supply oil and gas extraction sector or supply those firms which supply oil and gas. Future supply chain and wider economy employment modelled by using historical employment relationships between oil and gas, its supply chain and the wider economy, adjusted for future O&G construction spending and production.
Occupation changes

In the industry growth scenario, the dramatic increase in production and exploration would require companies to hire more workers in occupations related to production and exploration (see Exhibit 22). For instance, oil and gas producers could require around one-quarter (26%) more plant operators, fitters and electricians to operate and maintain new or expanded facilities in 2030. Drillers and geologists are also expected to be in greater demand as companies are set to increase their exploration activity. On the flipside, there could be a small reduction in construction roles (particularly structural steel workers, labourers and managers) by 2030 in the direct workforce, as the industry continues to move from the construction into the production phase.

Exhibit 22: Top occupation changes from 2016 to 2030 under the industry growth scenario

<table>
<thead>
<tr>
<th>Top 10 increases</th>
<th>change</th>
<th>% workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Operators</td>
<td>+428</td>
<td>26%</td>
</tr>
<tr>
<td>Metal Fitters / Machinists</td>
<td>+174</td>
<td>26%</td>
</tr>
<tr>
<td>Electricians</td>
<td>+158</td>
<td>26%</td>
</tr>
<tr>
<td>Petroleum Engineers</td>
<td>+137</td>
<td>14%</td>
</tr>
<tr>
<td>Building / Engineering Technicians</td>
<td>+134</td>
<td>26%</td>
</tr>
<tr>
<td>Production Managers</td>
<td>+125</td>
<td>27%</td>
</tr>
<tr>
<td>Drillers</td>
<td>+121</td>
<td>18%</td>
</tr>
<tr>
<td>Geologists / Geophysicists</td>
<td>+93</td>
<td>20%</td>
</tr>
<tr>
<td>Industrial, Mechanical / Production Engineers</td>
<td>+89</td>
<td>17%</td>
</tr>
<tr>
<td>Contract, Program / Project Administrators</td>
<td>+87</td>
<td>15%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Top 8 decreases</th>
<th>change</th>
<th>% workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Steel Construction Workers</td>
<td>-48</td>
<td>-13%</td>
</tr>
<tr>
<td>Construction and Mining Labourers</td>
<td>-33</td>
<td>-13%</td>
</tr>
<tr>
<td>Construction Managers</td>
<td>-32</td>
<td>-18%</td>
</tr>
<tr>
<td>Building / Surveying Technicians²</td>
<td>-10</td>
<td>-7%</td>
</tr>
<tr>
<td>Carpenters</td>
<td>-8</td>
<td>-16%</td>
</tr>
<tr>
<td>Earthmoving Plant Operators</td>
<td>-5</td>
<td>-13%</td>
</tr>
<tr>
<td>Logistics Clerks</td>
<td>-4</td>
<td>-11%</td>
</tr>
<tr>
<td>Machine Operators</td>
<td>-2</td>
<td>-9%</td>
</tr>
</tbody>
</table>

Source: AlphaBeta analysis
1 Based on ANZSCO occupations at the 4-digit level

The dramatic industry growth that is expected to occur in this scenario would require Australia’s oil and gas industry to build a strong pipeline of workers in key production, exploration and corporate roles to avoid facing a skills shortage. New and existing workers would need to be upskilled to ensure they have the required technology competency to thrive in a high-tech environment. Australia would also need to develop a flexible, innovative and skilled workforce in the supply chain to support an increasingly automated and digitised oil and gas industry.
Case study 4: How workers would operate in a highly automated LNG plant

By 2030, an onshore LNG plant will likely be highly automated and remotely operated. A combination of wireless sensors and robots might be used to operate the plant. Wireless sensors would monitor an array of additional variables, which engineers could then remotely analyse with the help of machine-learning algorithms to find potential deficiencies in the plant’s production rates. Specialist repair teams, often a combination of robots and humans, will be tasked to resolve any issues. Operations management teams in metropolitan areas, often hundreds of kilometres away, will monitor the overall situation and ensure that the automated LNG plant runs smoothly.

**Automation is a key driver of workforce change.** Automation technology helps companies increase their production efficiency and makes workplaces safer by reducing human exposure to extreme heat and noise and other hazards. Automation will reduce the need for onsite workers. In a highly automated LNG plant, the workforce could shrink by 20% compared to today. This would be driven by more than halving onsite worker numbers from approximately 30 workers to around 10 maintenance technicians as sensors, robotics and remote operations centres replace most human plant inspectors. Workers whose services are no longer required onsite (operators and some maintenance technicians) can be transitioned to other higher-value roles, for instance, using data analytics to suggest and implement process improvements to make the plant run more efficiently – a role which can be carried out from a high-tech remote operations centre.

**Some roles will change.** Operators will no longer need to conduct as many inspections in person and can instead operate a plant remotely using advanced advisory systems. Maintenance technicians can use predictive maintenance analytics to do plant maintenance work on a case by case basis. They will be able to use tablets and smart glasses in the field to easily access information about the assets they maintain. Production engineers will increasingly apply machine-learning algorithms to analyse large amounts of data and detect opportunities to improve a plant’s efficiency.

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22 Based on a modern LNG plant with one train, with 90 workers onsite and offsite. Figures compiled from expert interviews.
Production decline: downturn could require a large number of workers to leave the industry

SUMMARY

- This scenario assumes a challenging future for Australia’s oil and gas industry, marked by a potential oil price decline to as low as US$40 to 60 per barrel and a continuation of current industry policy settings (such as exploration moratoria), which would discourage further exploration and construction spending.

- The direct oil and gas workforce is assumed to decline by as much as 5,000 jobs, or 26%, as companies shed corporate and production roles. The assumed downturn in the oil and gas industry would cause further job losses in the supply chain and wider economy.

- The assumed production decline would require industry and governments to increase their support for a large number of workers who would need to find employment outside the oil and gas industry.

Drivers

The key assumption and driver of change in the production decline scenario is a sustained, dramatic decline in the oil price to as low as US$40 to $60 per barrel. Such a fall could occur if major rivalling oil and gas producers Qatar, USA, and East Africa were to significantly increase their output (Exhibit 23). The scenario also assumes that federal and state governments leave their current industry policies unchanged (for example, keeping CSG moratoria, depreciation, ring-fencing and other constraints in place), which would dampen incentives for oil and gas companies to increase their exploration and construction spending. As a result, the industry may enter a period of contraction. Companies could halve their capital expenditure and decide to merely invest in maintaining existing assets (around A$3 to $5 billion per annum). Industry-wide exploration spending is estimated to steadily decline in this scenario, likely falling to A$250 million by 2030, from around A$350 million in 2016. It is assumed that companies continue to invest in efficiency-increasing automation technology, which in this scenario could take over 20% of repetitive, routine tasks from human workers by 2030 (see Exhibit 23).23

The falling oil price would hurt all hydrocarbon producers in Australia. The CSG industry could be particularly affected by the potential decline in profitability due to the high ongoing cost required to sustain falling production; CSG production may halve from 200 to 100 MMBOE over this period. Conventional gas producers, which typically face longer production cycles and lower ongoing production costs compared to CSG producers, would be least affected with an annual expected output decline of only 2%.

---

23 The decrease is not as pronounced as the operational efficiency scenario, as declining profitability in the industry decline scenario is likely to limit the ability and inclination of primary companies to invest as heavily in automation technologies.
### Exhibit 23: Drivers – Production decline scenario

<table>
<thead>
<tr>
<th>Description</th>
<th>External drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil price (incl. supply/demand)</td>
<td>$40 per barrel decrease from 2016 to 2021, increases from 2024 to $60 per barrel</td>
</tr>
<tr>
<td>Policy settings</td>
<td>No change to current policies</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Industry drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration spend</td>
<td>Exploration spend of $350m in 2016, reducing by ~20%, bottoms out at $250m</td>
</tr>
<tr>
<td>Construction spend&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Capex halved from 2018 levels, used primarily for non-routine maintenance ($3-5 billion p.a.)</td>
</tr>
<tr>
<td>Oil production</td>
<td>Oil declines from 127 MMBOE to 70 MMBOE</td>
</tr>
<tr>
<td>CSG production</td>
<td>CSG rides out decline curves – production halves from 200 to 100 MMBOE in 2030</td>
</tr>
<tr>
<td>Conventional gas production</td>
<td>Declines at -2% p.a.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Technology drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>20% decrease in tasks that are automatable resulting in new investment in efficiency enhancing technology</td>
</tr>
<tr>
<td>Safety and environment</td>
<td>No change</td>
</tr>
</tbody>
</table>

Note: All numbers in MMBOE (for consistency)

<sup>1</sup> Includes replacement capex (i.e. construction to backfill existing projects) and non-routine maintenance spend but excludes routine maintenance spend

### Workforce changes

The production decline scenario would pose the greatest challenge for Australia’s oil and gas workforce. A production downturn, as assumed in this scenario, would lower the labour demand of oil and gas companies across the value chain. Production and project and development workers are expected to be most affected (Exhibit 24). This model suggests that the direct oil and gas workforce could shrink by up to 26%, or 5,000 positions, by 2030.

The assumed decline in the direct workforce would include a loss of more than 680 project and development roles (due to slowing construction activity) and a loss of about 4,000 production and corporate roles (due to cost pressure), as seen in Exhibit 24. Demand for low-skill, medium-skill, and high-skill workers across the value chain could decline by around one-quarter each by 2030.

More jobs may be lost in the supply chain and the wider economy as the oil and gas industry would likely need fewer inputs from suppliers to fuel a slowing production. The shrinking employment in the oil and gas industry and supply chain would ripple across the economy and likely threaten other jobs in supported industries as affected workers are expected to curb their consumption spending. The total number of jobs in the Australian economy that are supported by the oil and gas industry could fall by 34% in this downside scenario (see Exhibit 24).
Exhibit 24: Employment trends in Australia's oil and gas workforce under the production decline scenario (2016 vs 2030)

Projected change in the number of workers from 2016 to 2030 (absolute and %)

<table>
<thead>
<tr>
<th>Workforce Composition</th>
<th>Exploration</th>
<th>Projects and Development</th>
<th>Production</th>
<th>Corporate</th>
<th>Total</th>
<th>Broader Workforce&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher skill</td>
<td>-161 (-13%)</td>
<td>-310 (-30%)</td>
<td>-713 (-26%)</td>
<td>-948 (-28%)</td>
<td>-2,132 (-26%)</td>
<td>-72,000 (-34%)</td>
</tr>
<tr>
<td>Medium skill</td>
<td>-9 (-9%)</td>
<td>-44 (-26%)</td>
<td>-1,242 (-24%)</td>
<td>-322 (-29%)</td>
<td>-1,618 (-24%)</td>
<td></td>
</tr>
<tr>
<td>Lower skill</td>
<td>-36 (-18%)</td>
<td>-329 (-22%)</td>
<td>-334 (-30%)</td>
<td>-451 (-40%)</td>
<td>-1,150 (-29%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>-206 (-14%)</td>
<td>-683 (-25%)</td>
<td>-2,289 (-25%)</td>
<td>-1,722 (-31%)</td>
<td>-4,900 (-26%)</td>
<td></td>
</tr>
</tbody>
</table>

Australia would require around 700 less workers in project and development roles, as construction activity slows and backfill projects are deferred.

Australia would require around 4,000 less production and corporate workers due to combined pressures of low oil price, declining curves and automation.

Oil and gas will support around 72,000 fewer workers, as primary firms source less inputs from supply chain.

Source: ABS, AlphaBeta analysis

1 Includes employment supported by oil and gas in the supply chain and wider economy. Supply chain consists of all industries which supply oil and gas extraction sector or supply those firms which supply oil and gas. Future supply chain and wider economy employment modelled by using historical employment relationships between oil and gas, its supply chain and the wider economy, adjusted for future O&G construction spending and production.

Occupation changes

The production decline assumed in this scenario would change the role mix in the oil and gas workforce. Production and corporate workers such as plant operators, petroleum engineers and contract administrators could experience the sharpest fall in demand (see Exhibit 25).

Exhibit 25: Top 10 occupation changes from 2016 to 2030 under the production decline scenario<sup>1</sup>

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Change</th>
<th>% Workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Operators</td>
<td>-379</td>
<td>-23%</td>
</tr>
<tr>
<td>Petroleum Engineers</td>
<td>-205</td>
<td>-21%</td>
</tr>
<tr>
<td>Contract Administrators</td>
<td>-170</td>
<td>-29%</td>
</tr>
<tr>
<td>Metal Fitters / Machinists</td>
<td>-155</td>
<td>-24%</td>
</tr>
<tr>
<td>Accountants</td>
<td>-149</td>
<td>-28%</td>
</tr>
<tr>
<td>Electricians</td>
<td>-140</td>
<td>-24%</td>
</tr>
<tr>
<td>Industrial / Mechanical / Production Engineers</td>
<td>-138</td>
<td>-27%</td>
</tr>
<tr>
<td>Drillers</td>
<td>-137</td>
<td>-21%</td>
</tr>
<tr>
<td>General Clerks</td>
<td>-122</td>
<td>-40%</td>
</tr>
<tr>
<td>Production Managers</td>
<td>-122</td>
<td>-26%</td>
</tr>
</tbody>
</table>

Source: AlphaBeta analysis

1 Based on ANZSCO occupations at the 4-digit level.
Case study 5: Transitioning workers in the oil and gas industry

The cyclical oil and gas industry has experienced several upswings and downturns over the past few decades. A closer look at where the industry managed to transition these workers in the past can provide valuable insights and help to prepare for potential future downturns.

During the most recent contraction, between 2011 and 2016, more than 3,000 low and medium skilled oil and gas workers in Australia were made redundant in their existing roles, including trades workers, building technicians, plant operators, and labourers (see Exhibit 26). Around 29% of these workers simply changed roles within the oil and gas industry, the majority remaining in low and medium skilled roles. It is estimated, however, that up to 13% of the affected workers successfully re-trained to perform higher skilled occupations in the industry. Around half (51%) of the affected workers were able to find new employment in other industries, while 20% exited the labour force entirely – either moving into retirement or unemployment.

Exhibit 26: Movement of low/medium-skill oil and gas workers between 2011 and 2016

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Redundant</th>
<th>Retained in oil and gas</th>
<th>Moved to other industries</th>
<th>Exited the labour force</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trades Workers (e.g. Power Generation Plant Operators, Metal Fitters)</td>
<td>38%</td>
<td>29%</td>
<td>51%</td>
<td>20%</td>
</tr>
<tr>
<td>Building Technicians (e.g. Safety Inspectors)</td>
<td>18%</td>
<td>26%</td>
<td>18%</td>
<td>20%</td>
</tr>
<tr>
<td>Stationary Plant Operators (e.g. Crane Operators)</td>
<td>26%</td>
<td>26%</td>
<td>26%</td>
<td>20%</td>
</tr>
<tr>
<td>Construction/Mining Labourers</td>
<td>13%</td>
<td>13%</td>
<td>13%</td>
<td>13%</td>
</tr>
<tr>
<td>Electricians</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Source: ABS Census Longitudinal Data 2016; AlphaBeta analysis
Note: Those lost from labour force either retired or became unemployed
Roles in the oil and gas workforce will continue to change due to greater use of new energy, automation and decommissioning of plants

Regardless of which scenario eventuates, the oil and gas workforce will inevitably change in coming years because of three major industry trends: an increase in automation technology, an increase in decommissioning of plants and wells, and a shift to new energy sources.

Automation and digitisation

Primary firms will increasingly adopt automation technologies such as wireless sensor networks, advanced robotics and data analytics at each stage of the value chain to identify new reserves and improve production efficiency. New work opportunities are expected to emerge in four main areas:

- Software development – such as coding machine-learning algorithms for seismic interpretation;
- Analytics – such as undertaking predictive maintenance analytics for an onshore LNG plant;
- Hardware development – such as designing, manufacturing and maintaining robots and sensors; and
- IT infrastructure – such as constructing and maintaining offshore wireless networks.

It is estimated that approximately 5% of the direct workforce could be employed in jobs related to automation and digitisation by 2030 (between 700 and 1,100 workers depending on the scenario).\(^\text{24}\) These jobs could be filled by existing workers who would need to acquire new technology skills or new candidates from outside the industry.

Decommissioning

Decommissioning involves the planned shutdown and removal of fixed assets. The cost of decommissioning ageing oil and gas infrastructure in Australia has been estimated at more than A$21 billion over the next 50 years.\(^\text{25}\)

In the production decline scenario, older LNG plants could be decommissioned by 2030, and in all scenarios, numerous CSG wells (which have a short lifespan of around five years) would need to be decommissioned.

The expected increase in decommissioning work would create demand for new specialist professionals who could oversee the dismantling and decommissioning of ageing assets. New opportunities could also emerge related to the procurement and management of key decommissioning activities, including the plugging and abandonment of wells and the removal of offshore platforms.

Regardless of the scenario, it is estimated that 400 to 500 specialists could be required for decommissioning work in Australia’s oil and gas industry by 2030.\(^\text{26}\) A large project (such as decommissioning a large LNG plant) alone may require between 100 and 200 people, while smaller projects (such as a single offshore asset) may require between 20 and 30 full-time staff. As a large number of decommissioning activities are expected to be outsourced, considerable employment opportunities would emerge across the supply chain.

New energy

Against the backdrop of Australia’s Paris Agreement targets and growing economic interest in renewable energy, primary oil and gas producers might explore new business opportunities around renewables and carbon capture to reduce/offset greenhouse gas emissions and renewables and unconventional energy to complement existing oil and gas extraction methods.\(^\text{27}\)

Due to uncertainty regarding the size of the opportunity to 2030, this report does not quantify the workforce impact of a shift towards new energy business models. However, it is expected that a number of new roles will emerge, both within the direct workforce and supply chain, related to:

- developing in-house expertise to enable plant electrification, carbon capture, shale exploitation etc.;
- business models involving consulting and infrastructure sharing with renewables companies, such as sharing pipelines and offshore wind platforms; and
- buying and selling electricity.

\(^\text{24}\) This figure and the decommissioning figure have been estimated separately to the scenario figures, due to the novel forward-looking nature of the workforce opportunity (which might not be captured in a historical-based approach).

\(^\text{25}\) Wood Mackenzie (2016).

\(^\text{26}\) Assessment based on interviews with experts.

\(^\text{27}\) The Paris Agreement is a global climate agreement agreed at the United Nations Framework Convention on Climate Change (UNFCCC) at the 21st Conference of the Parties (COP21) in Paris (November / December 2015). The Australian Government has set a target of reducing greenhouse gas emissions by 26-28% below 2005 levels by 2030.
How NERA will use these scenarios
NERA, as an Industry Growth Centre, has a mandate to grow collaboration and innovation across the energy resources sector to build a strong workforce with relevant skills for changing times. As part of its role, NERA informs the sector on future workforce trends and expected skill needs. It liaises with education and training providers to support them in building relevant curricula and increasing the number of job-ready graduates. NERA also gives strategic advice and supports initiatives aimed at transitioning workers through periods of volatility and economic and technological disruption.

This report is a further step towards developing a common expectation about the potential trajectory of the workforce in the oil and gas industry. It provides a starting point for a collaborative discussion, as stakeholders prepare their business and workforce strategies for an uncertain future.

Informing the sector of potential workforce change

Since the end of the investment boom, there has been limited thinking at a sectoral level about how the oil and gas workforce could evolve over the next decade and what this might mean for future skills and transition requirements. This report aims to help bridge this gap by outlining the range of plausible workforce scenarios. It estimates, based on historical trends, how the occupational composition of the oil and gas workforce in Australia might change by 2030, and why.

An online occupation tool is available to use on the NERA website which will provide all workers in the industry with an opportunity to see how different occupations have changed over time and how they could evolve in future. This will help workers in the industry to better manage their own careers and allow industry stakeholders to manage their workforces. This free tool is available on NERA’s website www.nera.org.au.

Preparing the sector for a variety of outcomes

Designed as a scenario-planning tool, this report seeks to help the oil and gas industry in Australia prepare for the future. It offers a helpful guide, as companies assess how to recruit workers in coming years, which skills these workers should bring and where workers may need support to transition into new roles.

NERA will use the three scenarios outlined in this report to engage with industry and education providers on three skills-related questions:

**How can education and training providers ensure they are developing an appropriate pipeline of skills for the future?**

As this report shows, more workers may be needed with technology and decommissioning skills, and education and training providers would need to respond to these trends.

**Which key skills will the current workforce require?**

As this report shows, the need for technologically adept workers with operations and maintenance skills is set to grow. Companies, and education and training providers need to ensure the current workforce is acquiring these relevant skills, which would allow them to transition into new roles as the industry is changing.

**What support do current workers need to master periods of change driven by economic and technological trends?**

As this report shows, external factors that are beyond the control of the industry, may cause a slowdown or even decline in business. In this case, workers would need strong support to transition into new employment outside of the industry.

NERA is committed to ensure that Australia’s oil and gas workforce remains as agile and flexible as possible as potential scenarios of workforce and industry change eventuate. By working with key stakeholders in the oil and gas industry on the key issues outlined above, NERA is meeting its mandate and mission to help ensure ongoing industry growth.

Assisting firms in the industry to collaborate and plan for the future

One of the key learnings from the previous period of oil and gas investment has been the crucial need for collaboration on workforce planning issues to increase efficiency and industry productivity. NERA will use these scenarios as a starting point to discuss potential outcomes with industry and build a consensus on a potential path forward. Issues that should be discussed include:

- Co-operation on key operational standards to de-bottleneck industry (e.g. shutdowns)
- Arrangement with the supply chain to develop a more flexible and integrated contracting model
- Working with government, community and other stakeholders to maintain social license
- Common standards of training and competencies across disciplines (e.g. new LNG framework)
How changes in the workforce composition were calculated

As part of our four-step approach to construct three scenarios for Australia’s oil and gas workforce by 2030 (see Chapter 3), stakeholder interviews and data correlation were used to assign a certain portion of observed workforce change (by skill level and value chain stage) to drivers identified earlier. These portions, in per cent, are outlined in Exhibit 27 and Exhibit 28 (Exhibit 28 details the shares for various hydrocarbon segments of the production workforce). As noted in each exhibit, oil price and industry policy settings have a significant impact on other drivers (e.g. exploration spend, production and construction). However, on their own, their impact as drivers of workforce change is less significant.

Exhibit 27: Contribution to observed production workforce change by hydrocarbon and skill quadrant

More important: [ ] Less important: [ ]

<table>
<thead>
<tr>
<th></th>
<th>Exploration Spend</th>
<th>Construction</th>
<th>Production</th>
<th>Corporate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H</td>
<td>M</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>Oil price</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Policy settings and regulation</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Spend on exploration</td>
<td>70%</td>
<td>50%</td>
<td>45%</td>
<td></td>
</tr>
<tr>
<td>Spend on construction</td>
<td></td>
<td>70%</td>
<td>70%</td>
<td>60%</td>
</tr>
<tr>
<td>Oil production</td>
<td></td>
<td></td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td>CSG production</td>
<td></td>
<td>30%</td>
<td>30%</td>
<td>20%</td>
</tr>
<tr>
<td>Conventional gas production</td>
<td></td>
<td>20%</td>
<td>17.5%</td>
<td>12.5%</td>
</tr>
<tr>
<td>Technology</td>
<td></td>
<td>15%</td>
<td>20%</td>
<td>30%</td>
</tr>
<tr>
<td>Safety and environment approach</td>
<td></td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: AlphaBeta analysis, stakeholder interviews

Note: oil price and policy have a significant impact on other drivers (e.g. exploration spend, production and construction) but on their own are less significant drivers of workforce change

Exhibit 28: Contribution to observed production workforce change by hydrocarbon and skill quadrant

More important: [ ] Less important: [ ]

<table>
<thead>
<tr>
<th></th>
<th>Oil</th>
<th>CSG</th>
<th>Conventional Gas</th>
<th>LNG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H</td>
<td>M</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>Oil price</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Policy settings and regulation</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Spend on exploration</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spend on construction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil production</td>
<td>70%</td>
<td>50%</td>
<td>45%</td>
<td>70%</td>
</tr>
<tr>
<td>CSG production</td>
<td></td>
<td>70%</td>
<td>50%</td>
<td>45%</td>
</tr>
<tr>
<td>Conventional gas production</td>
<td></td>
<td>70%</td>
<td>50%</td>
<td>45%</td>
</tr>
<tr>
<td>Technology</td>
<td>15%</td>
<td>20%</td>
<td>40%</td>
<td>15%</td>
</tr>
<tr>
<td>Safety and environment approach</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Details on the assumptions underpinning each workforce scenario

Exhibit 29, Exhibit 30 and Exhibit 31 contain further detail on the assumptions about the drivers of oil and gas workforce change that underpin each scenario. They also provide details on the basis for these assumptions.

Exhibit 29: Assumptions – Operational efficiency scenario

<table>
<thead>
<tr>
<th>External drivers</th>
<th>Description</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong> Oil price (incl. supply/demand)</td>
<td>Rises to $70 per barrel and remains steady</td>
<td>No assumed change in oil price during whole scenario</td>
</tr>
<tr>
<td><strong>2</strong> Policy settings</td>
<td>No change to current policies</td>
<td>Assumes policies remain the same over time period</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Industry drivers</th>
<th>Description</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2</strong> Exploration spend</td>
<td>Continues at 2016 rates (~$350m according to ABS data)</td>
<td>No incentive to significantly increase exploration and development in current climate</td>
</tr>
<tr>
<td><strong>2</strong> Construction spend</td>
<td>Capex of ~$7 to 10B p.a. Backfill projects to ensure that production continues at current rates</td>
<td>Inline with RBA projections(^2) on replacement capex (~$10B p.a. for next 5 years) and Accenture capex forecasts to 2030(^3)</td>
</tr>
<tr>
<td><strong>2</strong> Oil production</td>
<td>Increases to 140 MMBOE by 2022 then declines back to 2016 levels (127 MMBOE)</td>
<td>Based on Department of Industry Innovation and Science forecast to 2022</td>
</tr>
<tr>
<td><strong>2</strong> CSG production</td>
<td>CSG production grows to 228 MMBOE by 2022 then flatlines</td>
<td>Based on Department of Industry Innovation and Science forecast to 2022</td>
</tr>
<tr>
<td><strong>2</strong> Conventional gas production</td>
<td>Conventional gas production grows to 620 MMBOE by 2022 then flatlines</td>
<td>Based on Department of Industry forecast to 2022</td>
</tr>
<tr>
<td><strong>3</strong> Technology</td>
<td>30% decrease in tasks that are automatable in oil and gas</td>
<td>Interviews suggest that technology could accelerate disruption in this scenario (e.g. drone tech in CSG)</td>
</tr>
<tr>
<td><strong>3</strong> Safety and environment</td>
<td>No change</td>
<td>No change</td>
</tr>
</tbody>
</table>

Note: All numbers in MMBOE (for consistency)

\(^1\) Includes replacement capex (i.e. construction to backfill existing projects) and non-routine maintenance spend but excludes routine maintenance spend
\(^2\) Reserve Bank of Australia ‘Mining Investment beyond the boom’ (2018)
\(^3\) Accenture ‘Ready or not?’ (2015)
### Exhibit 30: Assumptions – Growth scenario

<table>
<thead>
<tr>
<th>Description</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External drivers</strong></td>
<td></td>
</tr>
<tr>
<td>Oil price (incl. supply/demand)</td>
<td>Steady increase to 2021 Peaks at $100 per barrel starts to decrease in 2024</td>
</tr>
<tr>
<td>Policy settings</td>
<td>Positive policy changes including lifting moratoria, improving accelerated depreciation rules, ringfencing etc</td>
</tr>
<tr>
<td><strong>Industry drivers</strong></td>
<td></td>
</tr>
<tr>
<td>Exploration spend</td>
<td>Increases from $350m to $1.1B in 2021 then decreases to $550m in 2030</td>
</tr>
<tr>
<td>Construction spend</td>
<td>Double forecast spend (-$15B a year) $120B ($90B conv., $30B unconv.) spend from 2018 to 2024. Further $60B to 2030</td>
</tr>
<tr>
<td>Oil production</td>
<td>30% increase on top of 2016 levels by 2030</td>
</tr>
<tr>
<td>CSG production</td>
<td>50% increase on top of 2016 levels by 2030</td>
</tr>
<tr>
<td>Conventional gas production</td>
<td>Conventional gas production increases -90% from 417 MMBOE in 2016 to 816 MMBOE in 2030</td>
</tr>
<tr>
<td><strong>Technology drivers</strong></td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td>15% decrease in tasks that are automatable</td>
</tr>
<tr>
<td>Safety and environment</td>
<td>No change</td>
</tr>
</tbody>
</table>

Note: All numbers in MMBOE (for consistency)

¹ Includes replacement capex (i.e. construction to backfill existing projects) and non-routine maintenance spend but excludes routine maintenance spend
² Department of Industry, Innovation and Science ‘Resources and Energy Major Projects List’ December 2017
## Exhibit 31: Assumptions – Production decline scenario

<table>
<thead>
<tr>
<th>Description</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oil price (incl. supply /demand)</strong></td>
<td>Decrease from 2016 to 2021 to $40 per barrel. Increases from 2024 to $60 per barrel. Assumes oversupply of oil and gas and lack of competitiveness relative to rest of world.</td>
</tr>
<tr>
<td><strong>Policy settings</strong></td>
<td>No change to current policies. Assumes policies stay as currently set to industry.</td>
</tr>
<tr>
<td><strong>Exploration spend</strong></td>
<td>Explo spend of $350m in 2016 reduces by -20%, bottoms out at $250m. No incentive to increase exploration while production is declining.</td>
</tr>
<tr>
<td><strong>Construction spend</strong></td>
<td>Capex halved from current levels; used primarily for non-routine maintenance ($3-5 billion p.a.). No incentive to do further construction.</td>
</tr>
<tr>
<td><strong>Oil production</strong></td>
<td>Oil declines from 127 MMBOE to 70 MMBOE. No investment in oil over time horizon.</td>
</tr>
<tr>
<td><strong>CSG production</strong></td>
<td>CSG rides out decline curves – production halves from 200 to 100 MMBOE in 2030. Based on Dwyer analysis of CSG decline curves (APPEA presentation ‘Australian gas outlook’ 2017).</td>
</tr>
<tr>
<td><strong>Conventional gas production</strong></td>
<td>Declines at -2% p.a. Conventional gas would not decline as fast as CSG as sustaining capital costs are lower. Some operators may choose not to invest in costly backfill projects.</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>20% decrease in tasks that are automatable. Interviews suggest that technology could accelerate disruption in this scenario (e.g. drone tech in CSG).</td>
</tr>
<tr>
<td><strong>Safety and environment</strong></td>
<td>No change. No change.</td>
</tr>
</tbody>
</table>

Note: All numbers in MMBOE (for consistency).  
1. Includes replacement capex (i.e. construction to backfill existing projects) and non-routine maintenance spend but excludes routine maintenance spend.
Supply chain and wider economy employment

The indirect workforce in the supply chain – people whose jobs indirectly rely on the oil and gas industry – could be 4-6 times the size of the direct oil and gas workforce by 2030, depending on the scenario.

- In the **industry growth scenario**, jobs in the oil and gas supply chain could grow significantly, peaking at about 129,000 workers in 2026 and then declining by around 10,000 workers in the following years as temporary construction workers leave the industry.
- In the **operational efficiency scenario**, employment in the oil and gas supply chain would gradually return towards the 2013 peak of around 110,000 jobs and then flatten out in the following years.
- In the **production decline scenario**, employment in the oil and gas supply chain could decline substantially amid an assumed downturn in oil and gas production.

Employment generated in the wider economy generally mirrors the supply chain trends between 2016 and 2030, but at lower levels. The wider economy workforce could be 3-4.5 times the size of the direct oil and gas workforce by 2030, depending on the scenario.

The supply chain and wider economic employment analysis was done by:

- Examining the historical relationship between employment in the oil and gas industry, its supply chain, and the wider economy. Using ABS Input-Output tables for the period 2006 to 2015, the GVA generated per unit of output by the oil and gas industry, its supply chain and the wider economy was calculated.
- Applying the GVA multipliers to historical oil and gas output gave total GVA generated in the entire supply chain and the wider economy. Dividing supply chain and wider economy GVA by GVA per worker (A$110,000 for the supply chain, and A$145,000 for the wider economy) provided historical supply chain and wider economy employment generated by oil and gas. The employment ratios between the oil and gas industry, its supply chain and the wider economy were then calculated for each year.

For each scenario, a composite index was calculated consisting of the total output in the oil and gas industry and construction spending for each year between 2017 and 2030. The index was then applied to the historical employment ratios for each year between 2017 and 2030 to factor in the impact of these key drivers.

For the **operational efficiency scenario**, the index-adjusted median historical employment ratios were used to estimate the impact on employment in the supply chain and wider economy during the first part of the analysis period. This reflects the business-as-usual aspect of this scenario. However, due to eventual efficiency gains, the index-adjusted maximum historical employment ratios were then used in the latter part of the analysis period.

For the **industry growth scenario**, the same method was used. However, the employment ratios in the latter part of the analysis period were lowered according to the multiplier relationship found between the oil and gas industry and the construction industry. This accounts for the transient nature of many of the indirect construction roles at the 2026 employment peak. It is assumed that most of these workers would leave their roles as construction spending would dampen in this scenario through to 2030.

In the **production decline scenario**, the index-adjusted median historical employment ratios were used through to 2030.