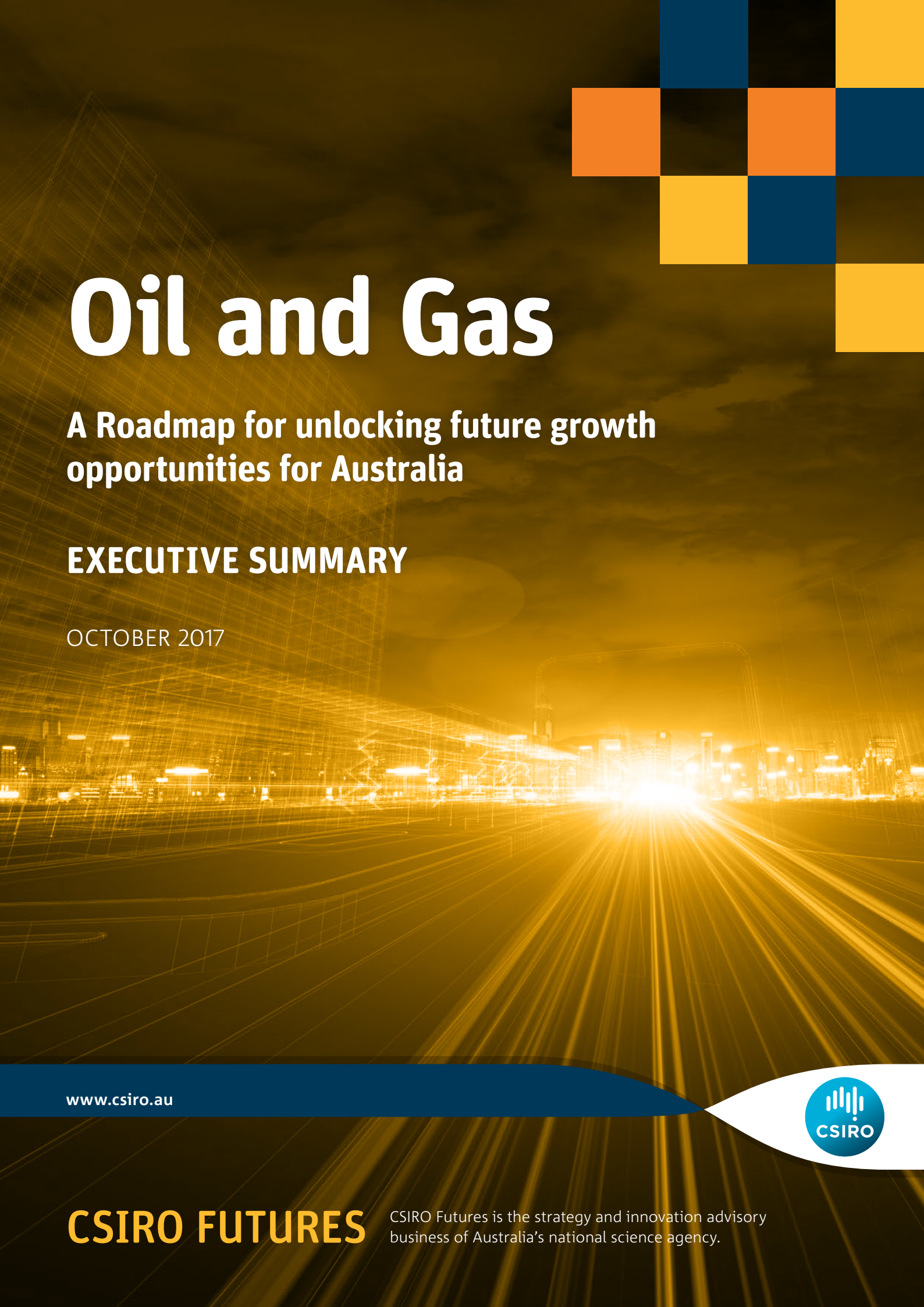
# Oil and Gas

## A Roadmap for unlocking future growth opportunities for Australia

## EXECUTIVE SUMMARY

OCTOBER 2017



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# Executive summary

**This report was informed by industry consultation and is based on the opinions of executives and managers from oil and gas operators, service firms and Government agencies. Dozens of interviews with technical experts from universities and CSIRO provide the report with a solid perspective on technology developments. In all, approximately 80 interviews were conducted to inform this report during the first half of 2017. Analysis of the content of these interviews, and additional desktop research helped to shape this report. It therefore represents a consensus view of the trajectory of the industry, developed by synthesising executive opinions, technical expertise and scientific research.**

## Introduction

Despite prior successes, the Australian oil and gas sector faces many challenges. Overcoming them will require innovation and new collaboration strategies. To help in this endeavour, the Oil and Gas Roadmap identifies four high-impact pathways to growth that are enabled by science and technology.

Australia's oil and gas sector sits on the world stage, contributing strongly to the country's position as a leading energy exporter. The nation's world-class gas resources, geopolitical stability, proximity to lucrative markets and skilled workforce have long made it an attractive target for investment. Decades of investment, including that recently in LNG, have transformed the sector into the major global force it is today.

However, any assumption that this pattern will continue indefinitely fails to acknowledge a number of challenges facing the sector. Oil prices have plunged and are likely to remain low for the foreseeable future. This, coupled with the ongoing commoditisation of LNG, is damaging the economics of existing assets. In terms of attracting new investment, fierce competition from new low-cost producers, and 'sovereign risk' may mean that capital for future projects may not flow into Australia. On the demand side, rapid technological change makes the future energy mix difficult to predict. This difficulty is exacerbated by regulatory uncertainty and pressures on the energy sector to decarbonise. All of these forces challenge the future of the industry.

To remain globally competitive in such times, Australia's oil and gas sector cannot be complacent. A robust strategy is needed to deal with the challenges facing the industry and the uncertainties underlying them.

This oil and gas industry roadmap provides a high-level guide to addressing some of these challenges and uncertainties, to assist with ensuring the long-term viability of the sector.

Four major strategic opportunities are identified herein. Each represents a high-impact pathway to growth that is grounded in science and technology. If these opportunities are pursued collectively by companies and government entities, the Australian sector may become more competitive and innovative, thereby, unlocking its potential and solidifying its place as a major oil and gas player in the decades ahead.

In addition to these technology pathways, the sector will need to focus on a number of 'business ecosystem' improvements to unlock its full potential. These include engaging in new approaches to collaboration, focusing on energy security, streamlining the costs of doing business and reducing regulatory uncertainty. Critically important will be improving the sector's public image. This will be achieved, in part, by enhancing social performance by fostering trust between government, industry and other stakeholders to establish robust social licence to operate – particularly in unconventional oil and gas.

**FIGURE 1: REPORT STRUCTURE**

**CHAPTER 2: GLOBAL OIL AND GAS MEGATRENDS**

What global trends are shaping the sector?

**CHAPTER 3: AUSTRALIAN OIL AND GAS COMPETITIVE LANDSCAPE**

What are the Australian trends and issues facing the sector?

**CHAPTER 4: STRATEGIC OPPORTUNITIES**

What can the sector do to ensure its long-term viability?
What technologies can help unlock these opportunities?

What other changes are needed to help the industry capitalise on these strategic opportunities?

**CHAPTER 5: CREATING THE RIGHT BUSINESS ECOSYSTEM**

## Trends and competitive landscape

The sector faces a confluence of global trends and domestic challenges that require new ways of thinking about the exploration and production oil and gas, and the future of the energy sector more generally.

### CONSIDERABLE CHALLENGES FACE THE AUSTRALIAN OIL AND GAS SECTOR

To establish the state of play for the Australian oil and gas industry, CSIRO undertook *megatrends* and *competitive landscape* analyses. The former focused on global shifts, and the latter on the advantages and challenges facing the Australian oil and gas sector.

Findings point to five megatrends that will shape the global oil and gas industry over the next decade. Combined, they indicate that businesses and government must find economically-viable ways to produce increasingly challenging resource plays in a cost-constrained environment, in order to supply rapid demand growth (from the developing world especially), while at the same time excelling in the environmental and social aspects of doing business. These megatrends are shown in Figure 2.

**FIGURE 2: GLOBAL OIL AND GAS MEGATRENDS**

### ENERGY HUNGRY

Global primary energy demand is predicted to grow rapidly in the coming years, driven by a swelling population, increased urbanisation, and the rise of the middle class particularly in the developing world. However, uncertainties remain about the energy mix that will meet this demand.

### DIGITALLY ENABLED

Rapid improvements in digital technologies hold the promise to dramatically improve the way businesses operate. From embedded sensors to advanced analytics and AI, the industry is creating tools to improve how they create, deliver and capture value. The challenge for this sector is the integration of multiple technologies to capitalise on the next wave of the digital-enabled future.

### MORE COMPLEX AND COSTLY

Large conventional oil and gas resources are becoming harder to find and the sector is moving toward more complex resource plays. These have different cost profiles and many will require new technology to produce economically – particularly in a cost-constrained business environment.

### SOCIALLY CONCERNED

Global citizens are increasingly adept at shifting public sentiment around issues important to them. Using such tools as social media, groups of people can create strong opposition to business interests, shape public discourse, and influence government policy. A key challenge for the oil and gas sector in this regard is earning and retaining social licence for its resource projects.

### CARBON CONSTRAINED

Rising concentrations of CO2 and other greenhouse gases are believed to have increased average global temperatures and disrupted weather patterns. Government regulation, subsidies, and rapid cost reductions of renewables are all pointing to the fact that the decarbonisation of the energy sector has begun, which will impact the global oil and gas sector.

A more granular focus on the competitive landscape of Australia's oil and gas sector reveals a number of advantages that can be leveraged, in addition to a series of challenges that need to be addressed (see Figure 3). Importantly, the tremendous value of Australia's resource base risks being locked up for the foreseeable future due to a number of issues; including high development costs, lack of domestic innovation, adjusting to the new fiscal realities of remote and higher-risk unconventional resources, regulatory uncertainty and troubles with gaining social licence to operate. The potential solutions for many of these challenges are not technological, but will instead come from a concerted and proactive effort by the business community, government and stakeholders.

**FIGURE 3: AUSTRALIAN OIL AND GAS ADVANTAGES AND CHALLENGES**

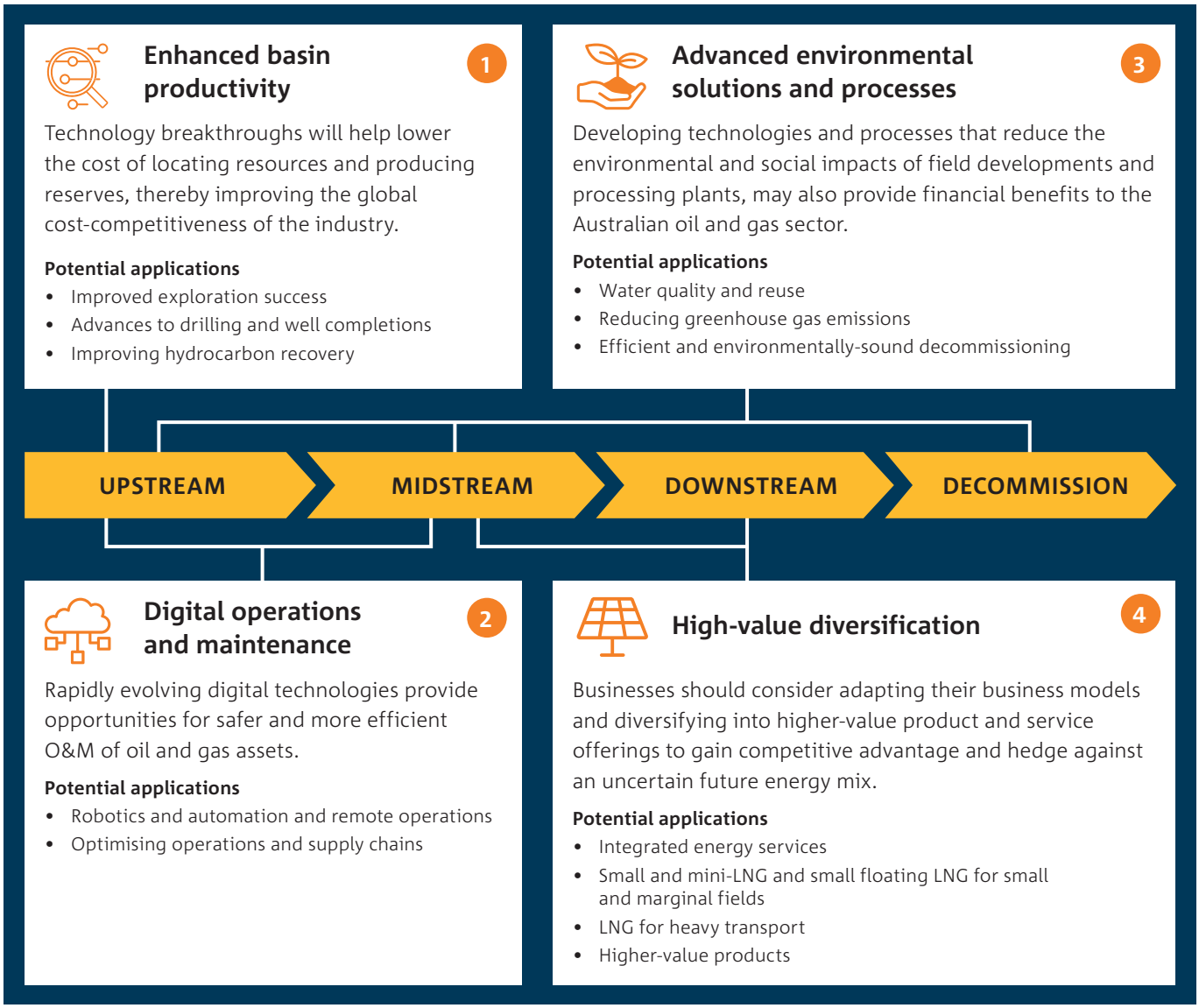
## Strategic opportunities to help address the sector's challenges and improve global competitiveness

**Four strategic opportunities that harness the power of science and technology have the potential to transform existing operations and create entirely new business prospects.**

This report asks '*What can the Australian oil and gas sector do, in the face of considerable obstacles, to remain viable into the coming decades?*' and '*What investments in science and technology are needed to prevail?*' Questions like these framed the industry consultation approach, with the aim of identifying the major strategic opportunities for the sector, specific enabling technologies, and research priorities over the next ten or more years.

The result of these efforts was the identification of four strategic opportunities as shown in Figure 4.

**FIGURE 4: OIL AND GAS OPPORTUNITIES ALONG THE VALUE CHAIN**



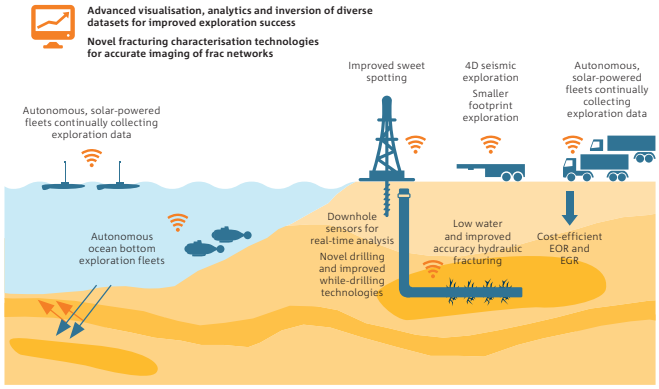
## Enhanced basin productivity

**Technology breakthroughs will help lower the cost of locating resources and producing reserves, thereby improving the global cost-competitiveness of the industry.**

With the recent downturn in oil prices, a gas market undergoing commoditisation, and stiff international competition for capital, reducing costs in the subsurface is a paramount activity for the continued health of the Australian sector. Locating and proving resources can be done more efficiently, drilling and completions can be done more economically, and recovery rates can be improved. These ideas are expanded below.

Firstly, exploration efficiency can be improved in a number of ways. Technologies that enable autonomous collection of seismic data might help to drive down costs, particularly in frontier basins. More detailed pre-competitive datasets, together with tools like cloud computing and Artificial Intelligence (AI), may help to locate and better characterise resources 'pre-drill'. Inversion of multiple existing imaging modes can provide higher resolution of the subsurface and enable improved outcomes. New technological paradigms, such as those based on quantum gravity sensors, may be used to locate oil and gas more readily in the future.

Secondly, drilling and well completions are important targets for cost reduction. With large numbers of onshore wells to be drilled in Australia over the next decade, focus should be on increasing drilling efficiencies and improving supply chains and infrastructure that support drilling and completions. If done correctly, the potential exists for businesses to apply some of the technological know-how about high-volume onshore drilling to other regions.




The third approach is to use advanced technologies to improve hydrocarbon recovery and extend the life of oil and gas fields. For example, advanced characterisation of reservoirs can improve targeting of hydrocarbons, and enhanced oil recovery technologies can help improve ultimate recovery factors. One interesting potential technology applicable to Coal Seam Gas (CSG) is microbially-enhanced coal-bed methane,[1] also known as Reservoir Rejuvenation Technology (R2T).[2]

1 CSIRO Energy (2015). *Enhanced oil recovery,* [Online] Available from: http://research.csiro.au/oilandgas/wp-content/uploads/sites/49/2015/10/Enhanced-oil-recovery-2015.pdf Accessed 2/06/2017

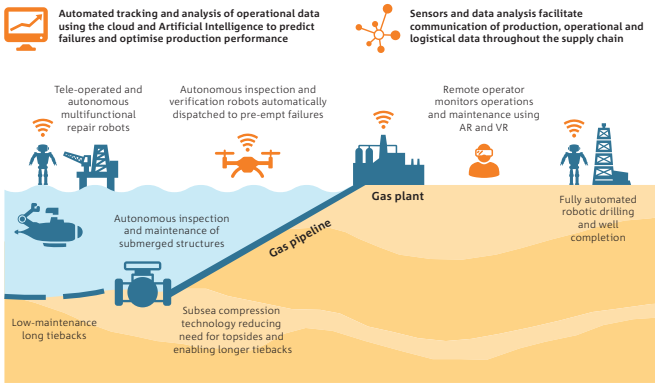
2 CSIRO (2017). Reservoir rejuvenation technology (R2T), [Online] Available from: https://www.csiro.au/en/Research/EF/Areas/Oil-gas-and-fuels/Onshore-gas/Microbes Accessed 17/07/2017

## Digital operations and maintenance

**Rapidly evolving digital technologies provide opportunities for safer and more efficient O&M of oil and gas assets.**

The fourth industrial revolution is well underway, and the convergence of sensors, nanotechnology, robotics and AI will change the way every company conducts business – regardless of sector. The oil and gas industry is in a prime position to use advanced robotics to reduce risks to personnel and decrease costs, and AI – such as machine learning – to drive faster and better decision making. Together, these applications will help to transform operations and maintenance of Australian oil and gas.

Robotics and automation will play an increasingly important role in driving cost efficiencies. Importantly, these technologies will play a critical role in Australia, given the remoteness of its resources. Such technologies will help to remove employees from the field, improve safety and reduce labour costs. For example, robotic drilling and completions will become increasingly common. Unmanned Aerial Vehicles (UAVs) and Autonomous Underwater Vehicles (AUVs) will enable remote inspection and will eventually undertake maintenance interventions. Virtual reality (VR) and augmented reality (AR) will allow experts in central locations to guide workers in remote areas. In the subsea environment, digital production technologies and other low-maintenance processing equipment will enable long tie-backs of remote and stranded assets, reducing the need for traditional infrastructure.




Improved utilisation of data represents another large opportunity for the sector. For example, low-cost sensors and AI can transform the way plants are operated and contribute to a step change in performance. These technologies can enable more precise predictive maintenance, increase uptime, and even help to coordinate supply chains. However, very few operators have fully embraced the decision making power that improved data collection and analysis can provide.

## Advanced environmental solutions and processes

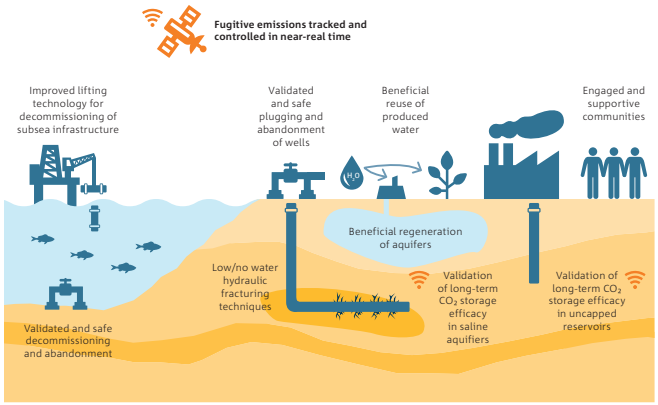
**Developing technologies and processes that reduce the environmental and social impacts of field developments and processing plants may also provide financial benefits to the Australian oil and gas sector.**

Facing several environmental and social challenges, Australia's oil and gas sector should continue to focus on coordinated, sector-wide investment in environmental technologies and processes to ensure best-practice management of oil and gas activities. Such investments could go some way towards addressing social concerns. For example, industry-wide activities, such as cost-effective baseline studies, or developing integrated approaches to spill preparation and response, will help build trust with stakeholders. (Such issues are also partly covered in Chapter 5 – *Improving the sector's public image*.) Moreover, pursuing the elimination of waste, addressing Greenhouse Gas (GHG) emissions, finding more sustainable uses for produced water, and addressing the sector's decommissioning liabilities may actually pay long-term dividends. For example, demonstrating leadership in areas like carbon capture and storage may position the industry for a new revenue stream: sequestration as a service for other industries.

Three examples of the application of new environmental technologies and processes are highlighted below.

Firstly, ensuring water quality and dealing with produced water more sustainably are factors vitally important for the Australian sector. Technologies that treat and recycle water and minimise salt by-products, particularly in relation to CSG, are needed to reduce the environmental impact of operations. In future shale gas developments, well stimulation techniques that require water will be a problem in Australia's dry areas. This will require well-fracturing techniques that use low-quality water, lower volumes of water, or no water at all.

Secondly, improved management of GHG emissions is an important element of demonstrating environmental stewardship. Fugitive GHG emissions such as methane pose a risk, especially in unconventional gas infrastructure, due to the high number of wells and long-distance pipelines. Techniques to measure and mitigate this risk are needed. Likewise, Carbon Capture, Utilisation and Storage (CCUS) technologies offer solutions for preventing $CO_2$ being released into the atmosphere. New techniques for




separating carbon from gas streams are needed to drive down the costs of capture. Proving the efficacy of novel geological formations for storage is another opportunity. For example, moving beyond the traditional 'capped' reservoir paradigm would open up Australia's geography to many more potential sequestration sites. Oil and gas businesses could provide geological and engineering sequestration services both here and abroad, allowing coal-fired power plants to cost-effectively meet obligations for future emissions regulations. However the economics of these opportunities will depend upon governments placing cost on carbon emissions.

The third potential application of advanced environmental solutions is in the efficient and environmentally-responsible decommissioning of infrastructure.
New technologies and processes are required to enable flexible approaches to decommissioning, while ensuring optimal social, economic and environmental outcomes are achieved. Technologies which allow for more efficient well plugging and abandonment, infrastructure disassembly, transport and waste disposal will be important.
More research is also needed to assess the environmental and social impacts of various decommissioning alternatives, from the complete removal of infrastructure to leaving it in place.

## High-value diversification

**Businesses should consider adapting their business models and diversifying into higher-value product and service offerings to gain competitive advantage and hedge against an uncertain future energy mix.**

Although this report assumes continued robust demand for oil and gas, the energy mix of the future is not predictable. Technological and regulatory uncertainty looms large in this equation. Rapidly falling costs of grid-scale solar photovoltaics (PV), energy storage technology (including batteries) and electric vehicles are likely to influence the future energy market. Future regulations in the area of GHG management could stimulate this shift. While such matters are not the explicit focus of this report, they have the potential to decrease demand for oil and gas. For example, a rapid decarbonisation of the energy sector could completely undermine the ostensible role of gas as the bridge to a zero-carbon future – a potentially large risk for the Australian gas export industry. In the face of such uncertainty, the sector would be remiss to take a 'business as usual' approach. Instead, it must proactively pursue new products and services and devise new business models that diversify revenue streams. Four potential diversification approaches are highlighted.

Firstly, Australia's remoteness provides an opportunity to investigate off-grid/distributed energy systems, since Australia's remote resource developments and regional communities need clean and reliable energy. There are also opportunities to export these systems to energy-impoverished developing nations that lack grid infrastructure. A foray into this area is simply the integration of renewables into existing oil and gas operations. This takes advantage of the rapidly falling costs of renewables, especially solar PV, but includes wind and tidal, leveraging them to produce power for operations instead of burning valuable product.

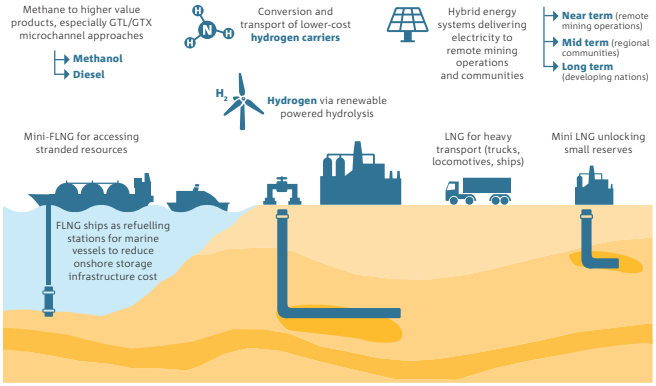
This activity would enable companies to build new capability in the area, and provide the opportunity to forge new partnerships. The more strategic second step is to develop fully-integrated hybrid energy systems. Such systems combine, for instance, a petroleum fuel source and renewable energy (typically solar) to provide consistent base and peak load for off-grid or micro-grid applications. Remote mines and regional communities could serve as domestic test beds for such technologies, (many of which, such as micro-grids, are already under development), with the ultimate goal of creating of large export market in developing nations.

The second example is the development of small stranded gas fields using small-scale Liquefied Natural Gas (LNG), and Floating LNG (FLNG). These approaches allow the monetisation of fields where typical infrastructure such as pipelines would be cost prohibitive. Stranded gas is a global challenge, and Australia has a number of small stranded fields. Offshore, cost-effective mini-FLNG (e.g. using repurposed ships) is particularly appealing since these systems can be used domestically, or be easily redeployed to new markets when needed.

Thirdly, there is significant potential for the use of LNG as a transport fuel (in domestic and international markets) for heavy road transport, locomotion and maritime shipping. Annual demand for such applications is estimated to exceed 100MTPA by 2030.[3] Increased regulatory scrutiny on ship emissions, in particular, opens up a potentially large market for LNG-powered vessels, and represents about one-third of the anticipated demand. To enter this market, advanced storage and bunkering technologies are needed.

3 MacDconald-Smith, A., (2016). *Shipping to become 'major new sector' for LNG: Shell, Australian Financial Review,* [Online] Available from: http://www.afr.com/business/energy/gas/shipping-to-become-major-new-sector-for-lng-shell-20161101-gsfw74 Accessed 2/06/2017

Fourthly, businesses must consider developing energy and chemical products that can command larger profit margins. The renewed interest in hydrogen in many parts of the world represents an appealing way to diversify and to help contribute to lowering the carbon intensity of the energy sector. Its appeal for end-users is that with few changes to equipment, clean burning hydrogen can be directly used in combustion applications including stationary power generation, as well as used directly in fuel cells for power and transport. While making hydrogen by reforming methane is one approach, economical methods of deriving it from less carbon-intensive routes are needed. For example, using solar PV to power water electrolysis can lessen the carbon footprint of hydrogen production. Furthermore, the logistics of hydrogen production need to be improved since hydrogen liquefaction is costly. Hydrogen carriers such as ammonia, that require less energy to transport, are needed. However, these alternatives will only be economically viable once affordable conversion technologies are commercialised to support the point-of-use hydrogen applications.




Value-added petroleum products, such as chemical intermediates and liquid fuels, represent another opportunity to diversify. Instead of traditional petrochemical refining routes, the sector chould leverage the next generation of gas-to-liquid (GTL) and gas-to-product (GTX) plants based on micro-channel technology. This technology is smaller and more nimble, and could be coupled with small gas field developments or appended to existing LNG plants. Due to their high efficiency, these technologies may provide more affordable routes than traditional refining to various liquid fuels and chemical intermediates, such as methanol and diesel. Their small scale and nimbleness means that the product mix could be quickly changed in response to market signals, thereby maximising profit margins at any given time.

## Creating the right business ecosystem

In order to unlock these strategic opportunities, several changes in the business ecosystem may be required. Figure 5 summarises two types of changes: opportunity-specific and cross-cutting.

Opportunity-specific changes focus on (a) processes, standards and regulations, as well as (b) people, skills and collaboration.

The cross-cutting changes deal with broad themes that affect the sector and that may be hindering innovation and collaboration. Importantly, the sector needs to act on these points soon, or risk being overtaken by international competition.

**FIGURE 5: SUMMARY OF BUSINESS ECOSYSTEM CHANGES**

| | | STRATEGIC OPPORTUNITIES | | | |
|---|---|---|---|---|---|
| | | **ENHANCED BASIN PRODUCTIVITY** | **DIGITAL OPERATIONS AND MAINTENANCE** | **ADVANCED ENVIRONMENTAL SOLUTIONS AND PROCESSES** | **HIGH-VALUE DIVERSIFICATION** |
| **Opportunity-specific business ecosystem changes** | **Processes, standards and regulations** | Support collection, publication and smart analytics on geoscience data from underexplored Australian regions. | Address interoperability and integration issues though development of common standards for IoT sensors and associated technology.<br>Work to improve shared digital infrastructure to enable full use of the cloud, including cybersecurity. | Investigate and prepare for future decommissioning efforts and potential changes in carbon regulations.<br>Support development of standards for fugitive emissions measurement.<br>Development of CCS standards and protocols for novel formation types. | Assess need for incentives to develop appropriate market conditions to encourage technology development for value-adding technologies such as GTL or GTX.<br>Support development of standards for technologies that create new markets for LNG. |
| | **People, skills and collaboration** | Improve exploration efficiency through multidisciplinary collaboration and skills development. | Foster skills development and collaboration to drive digital transformation and integration.<br>Collaborate across value chain in terms of scheduling and work-loading to drive efficiencies in O&M | Strive to improve collaboration and planning of developments at the basin scale, including lifecycle planning for decommissioning activities, and sharing of common infrastructure. | Explore new business models, partnerships and technology investments.<br>Upskill staff on diversification technologies. |
| **Cross-cutting business ecosystem changes** | | **Pursuing diverse collaborations for innovation** – Companies must collaborate in new ways. Bold collaborations will be needed to build competencies new to the business and to crack new markets.<br>**Reducing the cost of doing business** – Australia has a growing reputation for high costs, which may deter industry investment. Investments in digital infrastructure and reducing the costs of physical infrastructure through shared models may help.<br>**Improving Australia's energy security** – Additional analysis of the supply side of the energy market from an energy security perspective is needed. This may develop support for opening up exploration and production of Australia's resource base, and decrease its reliance on imported liquid fuels.<br>**Reducing regulatory uncertainty** – Common standards, streamlined approval processes, and stable greenhouse gas emissions policy will help to provide investment stability in the upstream oil and gas sector.<br>**Improving the sector's public image** – Improving the sector's public image and social licence to operate – through strong and productive trust-based relationships with local communities, stakeholders and the Australian public – is critical to the future viability of the sector. Continued research around issues pertaining to social licence, improved integrated basin-wide planning, and strengthened science communication with the public may help. | | |

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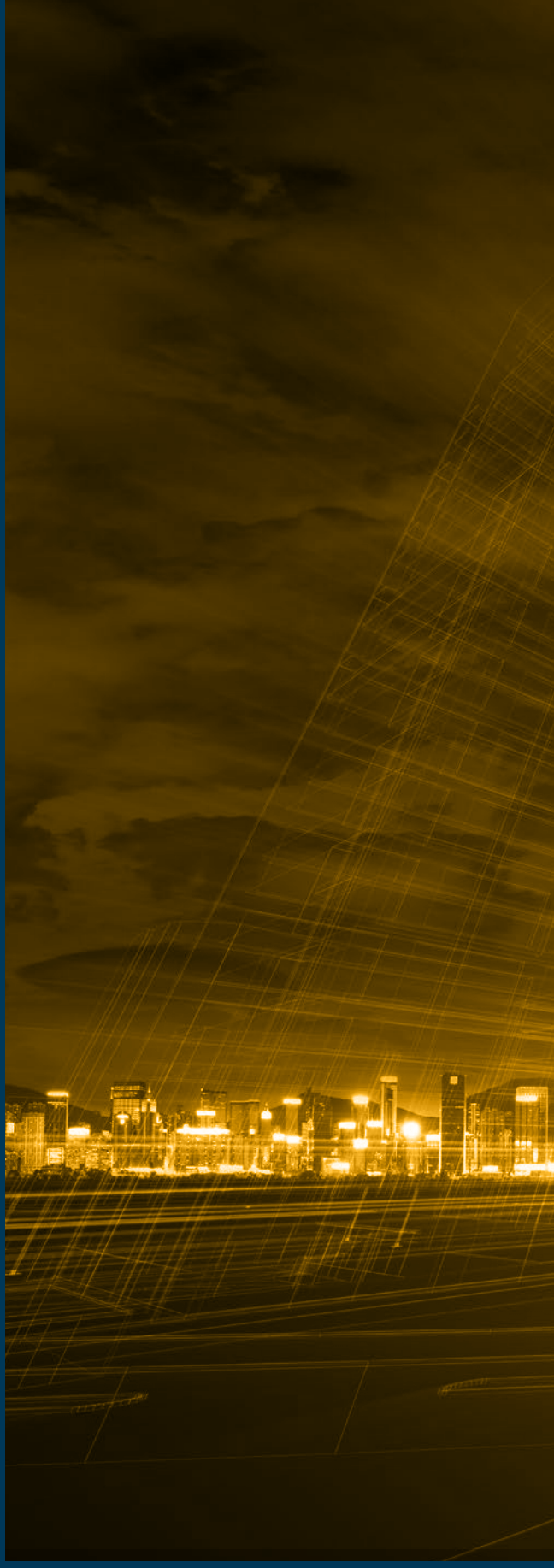

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