

# Unlocking Australia's resource potential

Innovation in the energy and mineral resources sector

A report by CSIRO Futures  
November 2015

**EXECUTIVE SUMMARY**

## CSIRO Futures

CSIRO Futures is the strategic advisory and foresight arm of Australia's national science agency. We build on CSIRO's deep research expertise to help clients create sustainable growth and competitive advantage by harnessing science, technology and innovation. We are a trusted advisor to some of Australia's largest companies and government, helping senior decision makers develop evidence-based strategies to address major opportunities and challenges.

## CSIRO Energy Flagship

CSIRO's Energy Flagship is delivering technology options and science that will enhance Australia's economic competitiveness and regional energy security while enabling the transition to a lower emissions energy future. By 2030, the flagship aims to unlock \$100 billion of in-situ value from our energy resources, and contribute 32 million tonnes per annum of greenhouse gas abatements.

## CSIRO Mineral Resources Flagship

CSIRO Mineral Resources Flagship works across the minerals value chain to grow Australia's resource base, increase the productivity of the minerals industry and reduce its environmental footprint, both in Australia and globally.

## Acknowledgements

CSIRO would like to thank the industry executives and thought leaders consulted throughout this project. We are very grateful for their time and their input.

## Copyright and disclaimer

© 2015 CSIRO. To the extent permitted by law, all rights are reserved and no part of this publication covered by copyright may be reproduced or copied in any form or by any means except with the written permission of CSIRO.

# Innovation is key to long-term competitiveness

Energy and mineral resources have long been a significant contributor to Australia's growth and prosperity. Innovation has played an important role in enabling this growth. For example, a recent study highlighted that innovation is the number one driver of productivity in the Australian oil and gas industry.<sup>(1)</sup> More generally, it has been shown that companies that innovate grow faster<sup>(2)</sup> and are more profitable<sup>(3)</sup> than those that don't.

However, future success is not guaranteed. Innovation will continue to play an important role in overcoming major challenges facing the industry today:

- ◆ The environment that resources firms operate in is changing rapidly, commodity prices have decreased significantly off their peak
- ◆ Firms are shifting focus from capital investment to improving productivity and controlling costs
- ◆ Ultimately, the sector's future success will depend on its ability to adapt and improve its innovation performance in the context of Australia's innovation efficiency challenges.



Despite only accounting for around **10% of GDP** ...

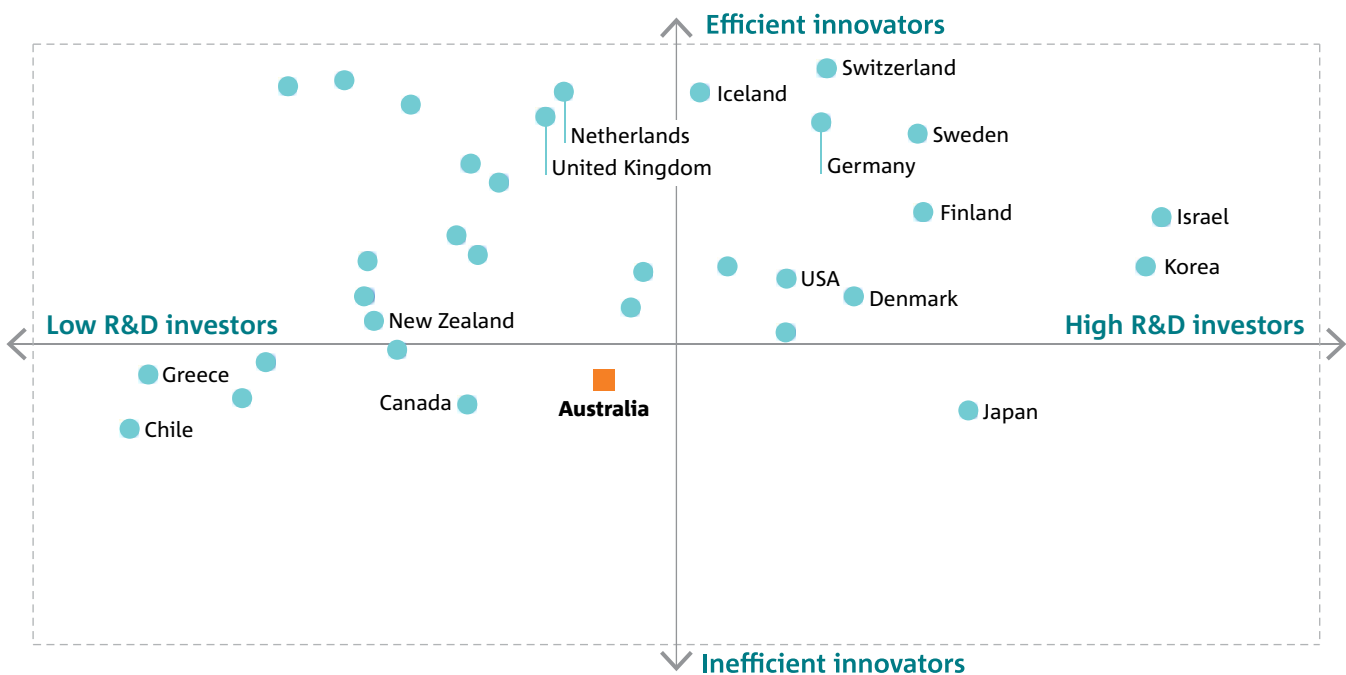


...the resources sector (including minerals, oil and gas) contributed **one-third** of Australia's income growth between 2005 and 2011<sup>(4)</sup> ...



...and is responsible for **more than half** of all Australian exports by value.<sup>(5)</sup>

## INNOVATION EFFICIENCY AND R&D INVESTMENT ACROSS THE OECD



Note: Contains 33 OECD member nations. Innovation investment scale relates to gross domestic expenditure on research and development (GERD) as a percentage of GDP, using 2013 OECD average of 2.4%. Innovation efficiency relates to Global Innovation Index – Innovation Efficiency Ratio (Percentage Ranking).

Source: Cornell University, INSEAD, WIPO, 2014<sup>(6)</sup>; OECD, 2014<sup>(7)</sup>

# Resources and innovation combined can (literally) move mountains

The resources sector has a strong history of developing and applying scientific and technological innovations to address both short and long-term opportunities and challenges

## Regolith and geochemistry – discovering new resources

impact

Regolith mapping and geochemistry has led to a range of Australian discoveries, two of which were new gold deposits worth over

**\$12**  
BILLION<sup>(8)</sup>

### Mineral resource discoveries (1983-1994) aided by regolith mapping studies



#### Gold

13 deposits in WA, 1 in NT



#### Lead-zinc-silver

2 deposits in QLD

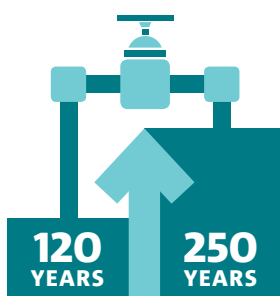


#### Copper-gold

2 deposits in QLD

## Shale gas – unlocking resources

impact



Years of production

The unlocking of Shale gas and other unconventional energy sources has doubled global estimates of the total remaining recoverable gas resources.<sup>(9)</sup>

### Shale gas as a percentage of total US domestic gas production has increased

FROM **1.6%** in 2000<sup>(10)</sup>



TO **40%** in 2012<sup>(11)</sup>



As a result, the US has created options for energy independence, altering global oil and gas markets, and spurring other countries such as Australia to consider further developing their own unconventional resources.

## Innovation Characteristics

Each case study provides a number of unique lessons on what was needed for success



**Strong collaboration**



**Non-linear journey**



**Perseverance**



**Visionary leadership**



**Measured risk taking**

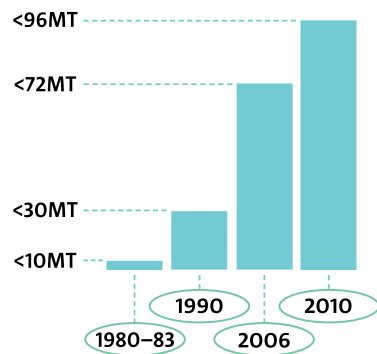


**Government participation**

## Longwall mining – optimising operations

impact

### Estimate of longwall production trends in Australia



Source: Cram, 2006;<sup>(15)</sup> International Coal News, 2007/2011<sup>(16,17)</sup>



Longwall mining techniques has an increased recovery rate (75% recovery rate) over conventional room-and-pillar techniques (60% recovery rate).<sup>(12)\*</sup>



By 1993, longwall mines had 19% higher labour productivity than room-and-pillar mines<sup>(13)</sup> and in 1994 longwall mining surpassed room-and-pillar extraction tonnage in the United States.<sup>(14)</sup>



Longwall mining has dramatically improved safety due to changes in mining practice, reduced labour requirements, and the removal of workers from dangerous areas.

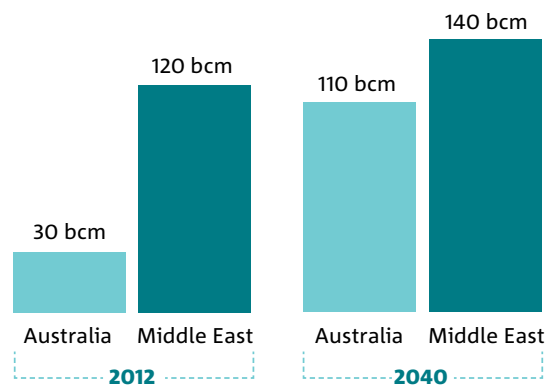
\*Actual recovery rates vary depending on the geological conditions and a number of other mining parameters.

## Liquefied natural gas – creating new markets

impact

LNG export revenues in Australia totalled \$14.6 billion in 2013-14,<sup>(18)</sup> with the North West Shelf gas project contributing over \$5 billion in taxation and royalties.<sup>(19)</sup>

### In a 2040 scenario, Australia could become one of the world's leading exporters of LNG



Source: IEA, 2014<sup>(20)</sup> – inter-regional LNG exports by source, New Policies Scenario.



It is estimated that natural gas accounts for one quarter of global energy consumption, with LNG the fastest growing gas supply accounting for 10% of global gas demand.<sup>(21)</sup>



International trade of LNG has rapidly increased with 29 importing countries and 17 exporting countries in 2013.<sup>(21)</sup>

# Innovation isn't easy

Despite this innovative history, many resource companies struggle to realise full value from their innovation investments. While R&D expenditure figures\* alone make it difficult to determine whether companies are spending 'enough' on innovation, there is evidence that suggests they are not gaining as much value from innovation as they could (and should) be, particularly in Australia:

A survey of 105 senior managers in industries related to the resources sector in Australia found that

**47%**

**of respondents** believed the sector was not investing enough in cutting-edge technology.<sup>(22)</sup>

A survey of senior leaders from over 100 mining and services companies found while majority (~60%) believed new technology introductions into the business were successful,

**33%**

**of mining companies** rated their new technology introductions as not very successful or a general failure.<sup>(23)</sup>

Globally, less than half of oil and gas executives say they have a well-defined innovation strategy, compared to 79% of the top innovators across industries.<sup>(2)</sup> Similarly,

**57%**

**of mining companies** implemented new innovations in a completely ad hoc or not very structured manner.<sup>(23)</sup>

None of the companies in BRW's list of Australia's

**50 most innovative companies**

are in the energy or minerals sectors, despite Australia being a global leader in both.<sup>(24)</sup>

**Despite nearly universal agreement amongst senior leaders on the importance of innovation, the reality falls short of the potential.**

These gaps in performance could be partially due to Australia's own innovation dilemma.

Australia is ranked at the 'bottom of the top' in global innovation, placing 17th in The Global Innovation Index 2014.<sup>(6)</sup> However, it ranks far worse in other dimensions.

**17th**

**Australia doesn't do a good job of converting research into tangible outcomes that generate business value**

Australia ranks 81st out of 143 countries in innovation efficiency – the ratio of innovation outputs to inputs.<sup>(6)</sup>

**81st**

**Australian companies are woefully short on skilled technical managers and labour**

Australia ranks 73rd out of 104 countries in the percentage of tertiary students graduating in fields of science and engineering.<sup>(6)</sup>

**73rd**

\*Definitions of innovation and R&D differ across companies, across countries and across different accounting standards, making the analysis of R&D expenditures difficult and often misleading.

# CSIRO analysis – innovation barriers

Synthesis of our interviews with 26 senior industry leaders revealed a number of significant innovation barriers, many of which will sound familiar.

## Who we interviewed:

### By position

- 5 Non-Executive Director
- 8 Chief Executive/Managing Director
- 7 SVP or GM of Innovation
- 6 Other Senior Managers

### By sector

- 10 Minerals
- 11 Energy
- 5 Services and suppliers

## IT IS DIFFICULT TO FOCUS ON INNOVATION DUE TO:

### Strategy

Short-term focus.  
Focus on maximising exiting assets.  
Regulatory considerations.

### Investment timing

Difficult to maintain investment across the business cycle.  
Challenge of trialling technology in the field.

### People & culture

Fear of failure.  
Lack of an innovation mindset.  
Difficulty attracting innovative thinkers.

### Collaboration

Industry needs and researcher priorities not aligned.  
Inefficient intellectual property arrangements.

“ CEOs are not paid to think 10 years out...they are now being selected for their ability to do the quick fixes to get the share price where it needs to be

“ The industry does incremental innovation reasonably well but there are a range of technologies that need more than a 3 year timeframe

“ As market conditions go down, prices also go down and organisations focus on cost and may not have the spare cash for innovation

“ One of the biggest issues is the lack of acceptance of failure – the industry DNA is wired to focus on mitigating risk to prevent failure

“ It is important that researchers solve industry problems, not just science problems

# Opportunities for improvement using a tailored approach to innovation

There is no ‘one size fits all’ approach to innovation – the solution requires a tailored approach at a company level. Therefore, rather than presenting a set of generic recommendations or a rigid framework, the report concludes with a set of questions that may be helpful for organisations seeking to critically review their current approach to innovation. Based on what we heard from interviews and our analysis of historical case studies, we see four key factors to improving innovation outcomes in the industry:



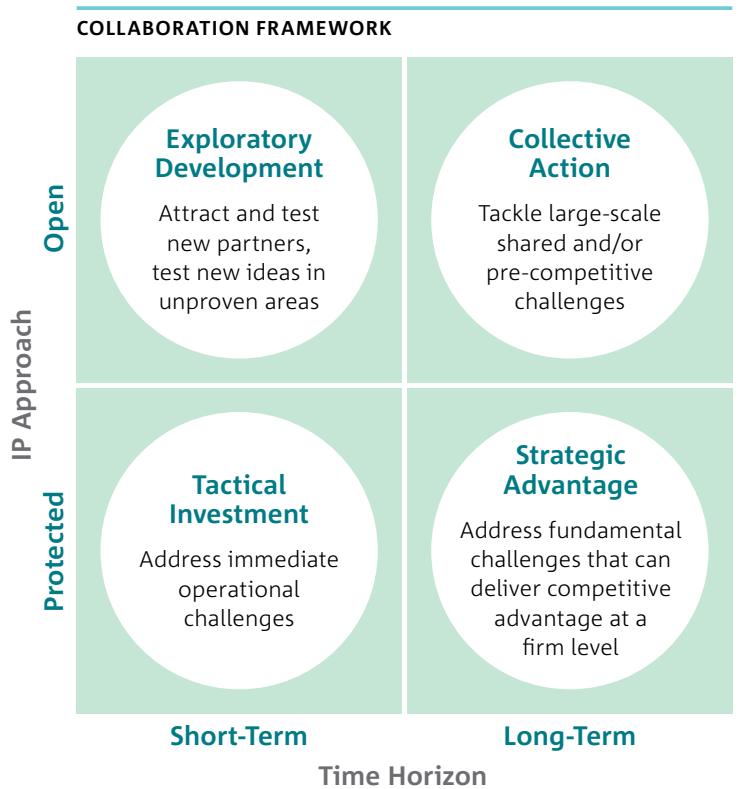


# Where do we go from here?

As market and operating conditions change, the sector will continue to look to innovation to create value and improve productivity. The reality is that innovation is a difficult process to master and there are a number of challenges and barriers which can prevent the sector from effectively harnessing the value of innovation.

This report does not attempt to provide all of the answers - there is no single solution. It does however aim to open up a broader dialogue around how innovation can be better leveraged to ensure that Australia's resources sector prospers into the future.

One particular area that requires further discussion relates to the identification and selection of appropriate collaborative models for specific innovation projects. Depending on the partners, objectives and timeframes, different collaboration modes can have their own advantages and disadvantages. To explore the different collaboration modes, the following framework has been adapted from work by Markus Perkmann and Ammon Salter published in the MIT Sloan Management Review.<sup>(25)</sup>



## Effective collaboration tactics

Similar to having a portfolio of innovation projects, collaboration efforts can be regularly evaluated as a portfolio using the above framework.



Are there regular reviews of tactical collaborations to determine if a more strategic model would deliver greater value?

Are there areas where there could be greater sharing of funding, resources and risk?

How well does the organisation maximise on-going investment in unproven research areas to stay ahead of technology change?

# References

1. EY. Delivering a step change in organisational productivity: Findings from the Australian Oil & Gas Productivity and Innovation Survey. 2013.
2. PwC. Gateway to growth: innovation in the oil and gas industry. 2013.
3. Department of Industry. Australian Innovation System Report. Commonwealth of Australia, 2014.
4. Taylor C, Bradley C, Dobbs R, Thompson F, Clifton D. Beyond the boom: Australia's productivity imperative. McKinsey Global Institute, 2012.
5. ABS. 5368.0.55.006 – Characteristics of Australian Exporters, 2012-13: Australian Bureau of Statistics; 2014 [16 February 2015]. Available from: <http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/5368.0.55.006Main+Features12012-13?OpenDocument>.
6. Cornell University, INSEAD., WIPO. The Global Innovation Index 2014: The Human Factor In innovation. Fontainebleau, Ithaca, and Geneva: 2014.
7. Organisation for Economic Cooperation and Development (OECD). GERD as a percentage of GDP – Main Science and Technology Indicators: Mimas, University of Manchester.; 2014 [cited 2014 15 December].
8. CSIRO. Australian innovation for a global industry – Technology that is changing the minerals world. 2013.
9. Geoscience Australia, BREE, Department of Resources, Energy and Tourism. Australian Gas Resource Assessment 2012. Commonwealth of Australia, 2012.
10. Wang Z, Krupnick A. A Retrospective Review of Shale Gas Development in the United States: What Led to the Boom? Resources for the Future DP. 2013:13-2.
11. U.S. Energy Information Administration. Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States: U.S Department of Energy; 2013 [16 February 2015]. Available from: <http://www.eia.gov/analysis/studies/worldshalegas/>.
12. World Coal Association. Coal Mining: WCA; n.d. [16 February 2015]. Available from: <http://www.worldcoal.org/coal/coal-mining/>.
13. U.S. Energy Information Administration. Longwall Mining. DOE/EIA, 1995 DOE/EIA-TR-0588.
14. Kingshott M, Graham M, editors. Coal Age – A Longwall Look at Tomorrow. Coal 1998: Coal Operators' Conference; 1998: University of Wollongong & the Australasian Institute of Mining and Metallurgy.
15. Cram K. Australian black coal mining operations Proceedings 5th Longwall Conference, 30–31 October 2006. 2006.
16. International Coal News. Exclusive Survey: Australian longwall mine production 2006 2007. Available from: <http://www.internationalcoalnews.com/storyView.asp?storyID=95015&feature=Australian+Longwall+Statistics+2006&sectionsource=f125&aspdsc=yes>.
17. International Coal News. Production from Australian longwall mines Period January 2010 – December 2010 2011. Available from: [www.internationalcoalnews.com/web.../Australia\\_LW2010.pdf](http://www.internationalcoalnews.com/web.../Australia_LW2010.pdf).
18. Australian Petroleum Production & Exploration Association. Export revenue – LNG export markets n.d. [16 February 2015]. Available from: <http://www.appea.com.au/oil-gas-explained/benefits/benefits-of-lng/export-revenue/>.
19. Woodside Energy Ltd. North West Shelf Project – Overview Brochure n.d. [16 February 2015]. Available from: <http://www.woodside.com.au/Our-Business/North-West-Shelf/Documents/NWSV%20Corporate%20Brochure.PDF>.
20. International Energy Agency (IEA). World Energy Outlook 2014. OECD / IEA, 2014.
21. International Gas Union (IGU). World LNG Report – 2014 Edition. 2014.
22. Kitney D. Mining industry needs more automation, survey shows: The Australian; 2014 [cited 2015 16 February]. Available from: <http://www.theaustralian.com.au/business/powering-australia/mining-industry-needs-more-automation-survey-shows/story-fnnnpqpy-1227090428680>.
23. VCI. Innovation State of Play 2014 Report. Virtual Consulting International Limited (VCI), 2014.
24. BRW. 50 Most Innovative Companies 2014 2014 [cited 2015 16 February]. Available from: <http://www.brw.com.au/lists/50-most-innovative-companies/2014/>.
25. Perkmann M, Salter A. How to Create Productive Partnerships with Universities. Sloan Management Review. 2012;53(4).



#### CONTACT US

**t** 1300 363 400  
+61 3 9545 2176  
**e** [csiroenquiries@csiro.au](mailto:csiroenquiries@csiro.au)  
**w** [www.csiro.au](http://www.csiro.au)

#### AT CSIRO WE SHAPE THE FUTURE

We do this by using science and technology to solve real issues. Our research makes a difference to industry, people and the planet.

As Australia's national science agency we've been pushing the edge of what's possible for over 85 years. Today we have close to over 5,000 talented people working out of over 50 centres in Australia and internationally. Our people work closely with industry and communities to leave a lasting legacy. Collectively, our innovation and excellence places us in the top ten applied research agencies in the world.

WE ASK, WE SEEK AND WE SOLVE

#### FOR FURTHER INFORMATION

James Deverell  
**t** +61 2 9490 8456  
**e** [james.deverell@csiro.au](mailto:james.deverell@csiro.au)  
**w** [www.csiro.au/Futures](http://www.csiro.au/Futures)