Technology Investment Roadmap Discussion Paper

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INTRODUCTION

The Australian Petroleum Production & Exploration Association (APPEA) is the peak national body representing Australia's oil and gas exploration and production industry. It has about 60 full member companies. These are oil and gas explorers and producers active in Australia. APPEA members account for an estimated 98 per cent of the nation's petroleum production. APPEA also represents about 140 associate member companies that provide a wide range of goods and services to the upstream oil and gas industry.

APPEA works with Australian governments to help promote the development of the nation's oil and gas resources in a manner that maximises the return to the Australian industry and community. APPEA aims to secure regulatory and commercial conditions that enable member companies to operate safely, sustainably, and profitably.

The Association also seeks to increase community and government understanding of the upstream petroleum industry by publishing information about the sector's activities and economic importance to the nation. APPEA also hosts conferences each year to exchange ideas and contribute to the development of the industry's policy positions.

Further information about APPEA can be found on our website, at www.appea.com.au.

APPEA welcomes the opportunity to provide comment on the *Technology Investment Roadmap Discussion Paper* (the Discussion Paper).

APPEA is also a member of the Australian Industry Greenhouse Network (AIGN), a network of industry associations and individual businesses that contribute to the climate change policy debate and see value in joint industry action on climate change policy issues in order to promote sustainable industry development[1]. APPEA has also contributed to the AIGN submission on the Discussion Paper.

In addition to this APPEA submission, a number of APPEA members have made individual submissions on the Discussion Paper. This response should be read in conjunction submissions from individual APPEA members.

APPEA's submission addresses specific aspects of the Discussion Paper, focussing on those areas that are particularly important for the upstream oil and gas industry.

THE AUSTRALIAN UPSTREAM OIL AND GAS INDUSTRY

It is important to place our views on the issues raised by the Discussion Paper within the context of the current state and potential future contribution of the upstream oil and gas industry to the Australian economy and to the welfare of all Australians.

Reliable, secure and competitively priced energy is crucial to our everyday lives in Australia. Within this framework, oil and gas plays a key role in meeting many of our energy needs.

Our abundant natural gas resources in particular, place Australia in an enviable position to maintain long-term, cleaner energy security domestically and internationally. Natural gas makes

[1] See www.aign.net.au for further information.

it possible for Australia to meet the world's growing energy needs over the coming decades while incorporating a strategy to curb emissions and address the risks posed by climate change.

In particular, the further development of Australia's oil and gas resources is compatible with the overarching goals of the Government's technology investments, set out on page 13 of the Discussion Paper as:

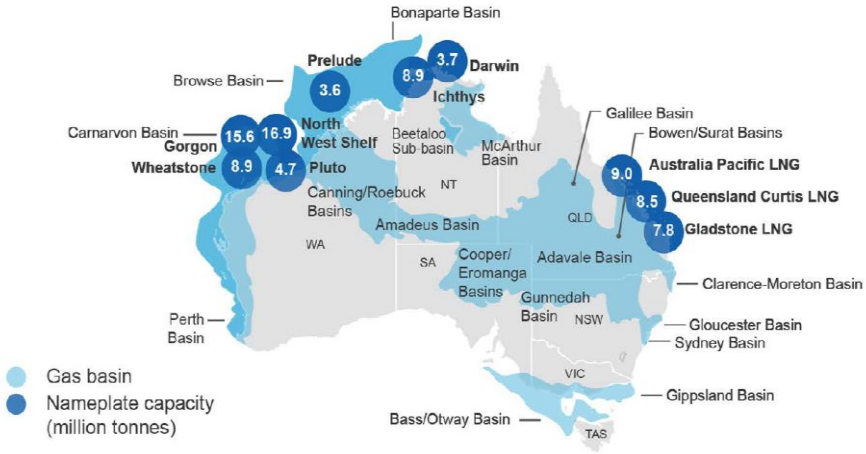
- *Improving **affordability** of energy for Australian households and businesses.*
- *Maintaining **security** and **reliability of** energy supply.*
- *Meeting, and where possible beating, **Australia's emissions reduction commitments** and **helping other countries** to lower their emissions through the export of low emissions technologies, products and services.*
- ***Seeking employment** and **growth** opportunities, particularly in regional areas, arising from increasing global demand for low emissions energy and products.*

Australia's oil and gas industry:

- Has invested more than $350 billion in the economy over the last decade. This investment will deliver returns for Australia for decades to come, through increased gas supply for Australian customers, export revenue, jobs, royalties and taxes.
- Supports 80,000 jobs directly and indirectly in Australia and hundreds of thousands more in the manufacturing sector rely upon natural gas.
- Paid more than $5.3 billion in wages to direct employees in 2016-17. The industry's average wages are more than double the national average.
- Supports a vast supply chain of businesses in manufacturing, services and construction. This is in addition to the hundreds of thousands of jobs in electricity generation, manufacturing, transport and other industries which rely on our outputs. Businesses ranging from national firms to local cafés all share in the economic benefits generated by the oil and gas industry.
- Contributes around 2.5 per cent to Australia's GDP and around 11 per cent of our total exports (goods and services) – and which is expected to grow in the coming years.

Liquefied natural gas (LNG) is now Australia's second largest export commodity after iron ore, with export revenue of around $51 billion in 2018-19 and $49 billion in 2019-20, and has more than doubled over the last two years (from $22.3 billion in 2016-17).

Figure 1. Australia's LNG projects and gas basins

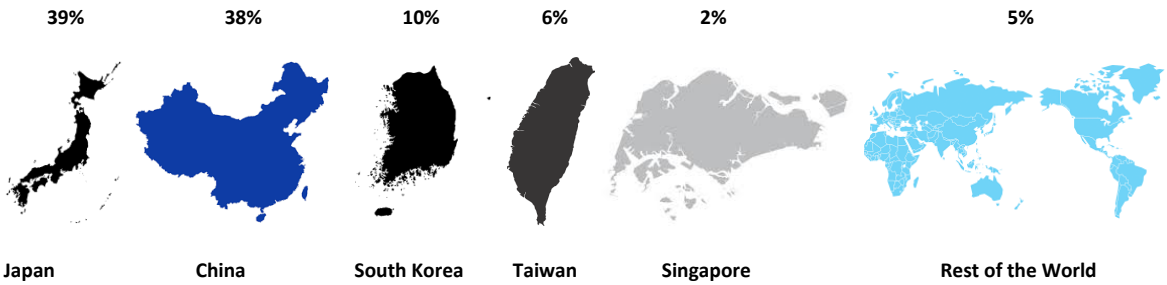


Source: Department of Industry, Science, Resources and Energy (2020).

Figure 2. Australia's LNG, 2019

Source: Department of Industry, Science, Resources and Energy (2020).

Figure 3. Australia's LNG exports, by destination, 2019[2]



Source: BP Statistical Review of World Energy (2020).

The continued expansion of Australia's oil and gas industry provides incredible opportunities to all Australians. The economic advancement in our region is overwhelmingly positive for the nation, playing to our comparative advantages as a secure and reliable energy exporter.

Going after a vigorous reform agenda, ensuring open and competitive markets and a tax system that helps us maintain our international competitiveness can see industry and governments work together to support the positive role the Australian oil and gas industry can play in contributing to Australia's economic recovery following the COVID-19 global pandemic.

This means that the stakes are high in realising the industry's potential benefits. The Technology Investment Roadmap has an important role to play in supporting these outcomes.

AUSTRALIA'S CLIMATE CHANGE POLICY FRAMEWORK AND LINKAGES TO THE TECHNOLOGY INVESTMENT ROADMAP

APPEA is committed to working with policymakers as they develop policy responses to climate change. With that in mind, APPEA released a second edition of its *Climate Change Policy Principles* – a copy of which is at Attachment 1[3] – setting out the principles that APPEA considers should underpin Australia's response to climate change.

APPEA supports a national climate change policy that delivers greenhouse gas emissions reductions, consistent with Australia's Paris Agreement commitments, at least cost and facilitates broad-based investment decisions consistent with an international price on carbon.

[2] In 2019, Australian LNG was exported to ten different destinations (United Arab Emirates, China, India, Japan, Malaysia, Singapore, South Korea, Taiwan, Thailand and Other Asia-Pacific).
[3] A copy of APPEA's *Climate Change Policy Principles* can also be found at www.appea.com.au/2016/02/appea-updates-climate-change-policy-principles. A third edition of the *Principles* is under development and is expected to be released later in 2020.

It is important, therefore, that the work of the Technology Investment Roadmap, and the associated annual Low Emissions Technology Statements, are an integrated element of the Government's overall climate change policy response.

This includes Australia's Long Term Emissions Reduction Strategy, to be delivered ahead of the 2021 UN Climate Change Conference (UNFCCC COP 26), to be held in Glasgow in November 2021.

It will also be important that the way in which the Roadmap is developed and implemented is cognisant of the Australia's policy framework for reducing emissions. To facilitate the further development and deployment of the technologies (those identified in the Roadmap and the associated annual Low Emissions Technology Statements), it will be vital to consider the extent to which Australia's policy framework for reducing emissions can help meet any targets set for individual technologies and consider as part of the annual Technology Statement process to consdier amendments to the policy framework to ensure they are mutally reinforcing.

THE ROLE OF AUSTRALIAN NATURAL GAS IN A CLEANER ENERGY FUTURE

Greater use of Australian natural gas – in the domestic market, and in Asia as LNG exports – can significantly reduce greenhouse gas emissions.

NATURAL GAS: INTEGRAL TO A LOWER CARBON AUSTRALIAN ECONOMY

Australia could generate significant additional national economic, environmental and social benefits through greater utilisation of its substantial natural gas resources.

As the Discussion Paper notes on page 28-29, natural gas has an essential role to play in reducing emissions. In the home, natural gas is a cleaner fuel and can see the emissions intensity of electricity generation in the National Electricity Market (NEM) fall.

Gas-fired generators can be rapidly started making them complementary with intermittent renewable energy. Exporting gas as LNG will allow our Asian trading partners to reduce the emissions from their economies[4].

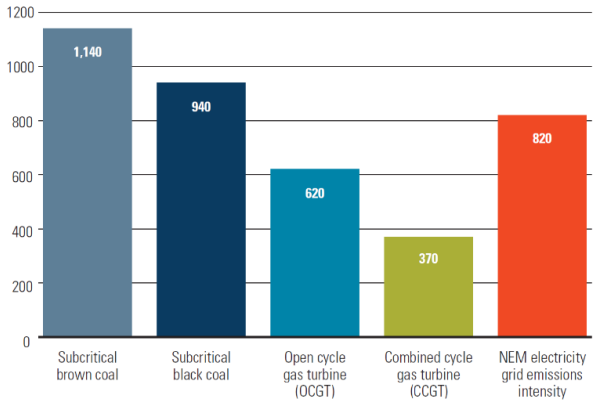
Using more natural gas in Australia's power generation and resource processing could significantly enhance the nation's ability to meet increasing energy needs and reduce emissions.

These outcomes are possible because, as data on page 203 of the *Independent Review into the Future Security of the National Electricity Market – Blueprint for the Future* (the Final Report) shows[5], available natural gas power generation technologies can reduce greenhouse gas emissions by 68 per cent compared to current brown coal generation technologies and 61 per cent compared to current black coal generation technologies. This is illustrated in Figure 4, which shows, using data from page 203 of the Final Report, the significantly lower greenhouse gas emission associated with the use of gas-fired power generation compared to the use of other conventional fuels.

[4] See *Gas Vision 2050* for more information. *Gas Vision 2050* was developed by Australia's peak gas industry bodies and demonstrates how gas can continue to provide Australians with reliable and affordable energy in a low-carbon energy future. See www.appea.com.au/media_release/gas-vision-2050 and www.appea.com.au/wp-content/uploads/2017/03/GasVision2050_March2017.pdf for more information. A second edition of *Gas Vision 2050* is under development and is expected to be released later in 2020.

[5] See www.energy.gov.au/publications/independent-review-future-security-national-electricity-market-blueprint-future for more information.

Figure 4. Estimated Operating Emissions for New Power Stations (kg CO_2-e/MWh)



Source: Data from Independent Review into the Future Security of the National Electricity Market – Blueprint for the Future (2017).

Intermittent renewable energy requires "on call" electricity generation to manage falls in renewable output or peaks in demand. Gas-fired generation is a key technology capable of delivering that flexible response. As more renewable energy is integrated into the grid, this balancing role becomes more critical.

As the Discussion Paper illustrates on pages 13 and 55, the use of gas with renewables is a commercial technology option, one that can achieve significant emission reductions across the short-, but particularly across the medium- and long-term compared to the existing emissions intensity of electricity generation in Australia.

Further technology-related developments in gas-fired power generation are under consideration globally. These could be further considered through the Roadmap. In the United States, for example, a 50 MW demonstration project in La Porte, Texas is using a gas-fired power station utilising Allam-Fetvedt Cycle-based technology to demonstrate gas-fired power generation that can be cost effective with zero emissions.

Allam-Fetvedt Cycle-based gas-fired power generation burns natural gas with pure oxygen, and the resulting CO_2 is sent through the combustor, turbine, heat exchanger, and compressor. For this project, extra CO_2 that is produced is pipeline ready and sold to other industries[6].

Experience in the United States demonstrates how quickly emissions from the generation sector can be cut by fuel switching. Data from the US Government's Energy Information Administration (EIA)[7] shows energy-related emissions in the US in the first six months of 2016 were at their lowest level since 1991, having fallen about 13 per cent from their peak in 2007. This was possible in substantial part because the US is developing its abundant natural gas resources. The

[6] Further information on Allam-Fetvedt Cycle-based technology and the Texas-based project are available at 8rivers.com/portfolio/allam-cycle and netpower.com. A similar project is planned in Canada. See canadacleanenergy.com/technology for more information.
[7] See www.eia.gov/todayinenergy/detail.php?id=28312 and www.eia.gov/todayinenergy/detail.php?id=30712 for more information.

EIA also found[8] emissions from power generation are expected to fall by over 2 per cent in 2019[9]. The EIA noted:

> *Although the electric power sector is using more natural gas, EIA does not expect the increase in natural gas emissions in 2019 to offset the decrease in coal emissions because natural gas-fired electricity generation is less carbon-intensive than coal-fired electricity generation.*

We have a similar opportunity in Australia. If the industry is able to develop them, there are sufficient natural gas resources to underpin a historic shift to a lower emissions generation sector, across Australia.

The increased use of natural gas also has several additional environmental benefits, such as:

- Reduced emissions of fine particulates.
- Reduced emissions of sulphur dioxide (an important contributor to smog and acid rain) and nitrogen oxides.
- Significantly lower demand for water for power station cooling.

Much greater use of Australia's extensive gas resources will be crucial in meeting the challenge of significantly reducing global greenhouse gas emissions at least cost whilst enhancing Australia's economic and export performance.

NATURAL GAS: INTEGRAL TO LOWER CARBON ECONOMIES IN ASIA

Australia's resources of natural gas and proximity to growing markets make us well-placed to meet the global climate change challenge while substantially contributing to Australia's economic growth.

While the demand for energy as part of the industrialisation of Asian economies is a key driver, the properties of natural gas as a lower emitting and cleaner burning fuel is also driving much of the international demand for LNG.

As the International Energy Agency (IEA) found in its *2019 World Energy Outlook* (2019 WEO)[10], the use of natural gas is expected to grow consistently over the Outlook period (to 2040) under all scenarios.

For example, in its 'Stated Policies Scenario'[11] (the central scenario in the 2019 WEO), the IEA forecasts global natural gas demand to grow by around 36 per cent over the Outlook period. Average annual growth of 1.4 per cent means natural gas increases its share in global primary

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[8] See www.eia.gov/todayinenergy/detail.php?id=40094 for more information.
[9] The EIA has since noted (see www.eia.gov/todayinenergy/detail.php?id=43715 for more information) significant falls in power generation and associated emissions (of over 11 per cent) are expected in 2020 as a result of estimates of the travel restrictions and general economic slowdown associated with the efforts to mitigate the spread of COVID-19. However, the EIA also notes that *"… even before the effects of COVID-19 became apparent in mid-March, EIA had expected a decline in 2020 energy-related emissions, generally consistent with the trend of lower U.S. CO_2 emissions since their peak in 2007."*
[10] See www.iea.org/weo for more information.
[11] See www.iea.org/weo/weomodel/steps for an overview of the 'Stated Policies Scenario'.

energy demand from 22 per cent today to 25 per cent in 2040. In the 'Sustainable Development Scenario'[12], gas use plateaus from the 2030s, but the IEA notes, as a clean and flexible fuel, gas still sees its share increasing. Most of the growing demand for natural gas will come from China (as part of a long-term and deliberate coal-to-gas switching program[13]), India and other countries in Asia which are turning more and more to natural gas to help improve urban air quality.

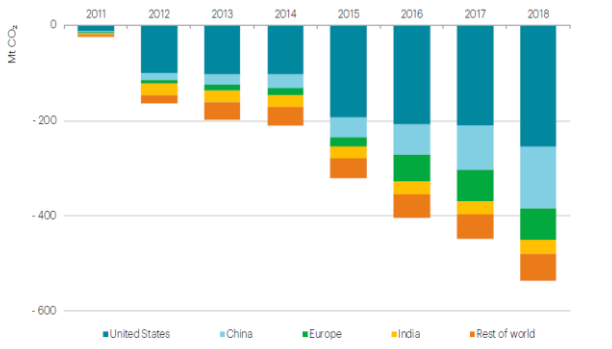
More recently, and as the Discussion Paper notes on page 28, the IEA's July 2019 report *The Role of Gas in Today's Energy Transitions*, examined the role of fuel switching, from coal to natural gas, to reduce greenhouse gas emissions and air pollutants globally[14]. The report found that since 2010, coal-to-gas switching has saved around 500 million tonnes of CO_2 (see Figure 5 below) – the equivalent of putting an extra 200 million electric vehicles on the road running on zero-carbon electricity over the same period. The report also highlighted a significant opportunity in the global electricity generation sector to reduce emissions by switching from coal-fired power plants to gas-fired power plants, which presented *"a potential quick win for emissions reductions"*.

The report found:

> *There is potential in today's power sector to reduce up to 1.2 gigatonnes of CO_2 emissions by switching from coal to existing gas-fired plants, if relative prices and regulation support this potential.*

To put this opportunity in perspective, the potential for emission reductions across the global economy of 1.2 gigatonnes is more than double Australia's total annual emissions over the year to the December quarter 2019[15].

Figure 5. CO_2 savings from coal-to-gas switching by region compared with 2010



Note: Mt CO_2 = million tonnes carbon dioxide. Coal-to-gas switching includes emissions reductions in sectors where the market share of coal decreased, and the market share of gas increased within each region. The baseline increase in emissions assumes no improvement in the carbon intensity of energy or the energy intensity of gross domestic product (GDP) since 2010. Savings are calculated as those which occur compared to 2010.

Source: International Energy Agency (2019).

A 2008 (updated in 2011) study by WorleyParsons[16]compares lifecycle greenhouse gas emissions of Australian LNG exports from the North West Shelf Project with Australian east coast black coal

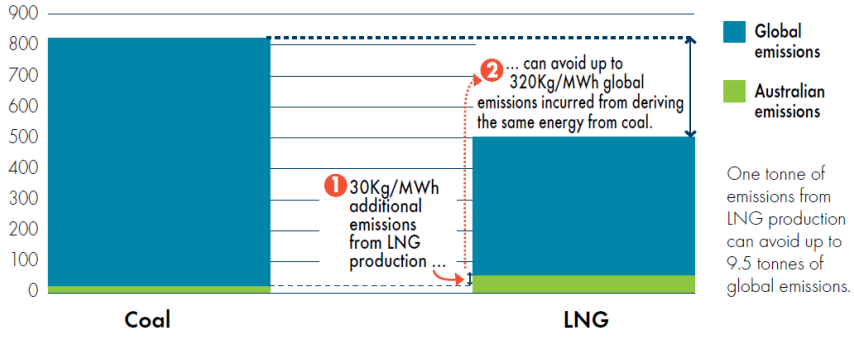
[12] See www.iea.org/weo/weomodel/sds for an overview of the 'Sustainable Development Scenario'.
[13] For an overview of the role natural gas, including Australian LNG, plays in China's coal-to-gas switching program, see Oxford Institute for Energy Studies (2018), *The Outlook for Natural Gas and LNG in China in the War against Air Pollution*, December (available at www.oxfordenergy.org/publications/outlook-natural-gas-lng-china-war-air-pollution).
[14] See www.iea.org/publications/roleofgas for more information.
[15] The *Quarterly Update of Australia's National Greenhouse Gas Inventory for December 2019* estimates Australia's total emissions over the year to the December quarter 2019 at 532.5 Mt CO_2-e (see www.industry.gov.au/data-and-publications/national-greenhouse-gas-inventory-december-2019).
[16] WorleyParsons (2008; 2011), *Greenhouse Gas Emissions Study of Australian LNG*, originally prepared August 2008; updated for public release, March 2011.

exports in terms of lifecycle greenhouse gas emissions – from extraction and processing in Australia through to an end use of combustion (using different power generation technologies) in China for power generation.

Figure 6 below is derived from data within the study, and shows that:

- For every tonne of CO_2-e emitted in LNG production within Australia, between 5.5 and 9.5 tonnes of emissions from the coal alternative can be avoided globally.
- LNG has a substantially lower greenhouse footprint associated with it compared to coal – not just in combustion emissions, but throughout its lifecycle.
- The lifecycle greenhouse intensity for LNG is about 50 per cent lower than that of coal.

Figure 6. Displacement of Coal by LNG (kg/MWh CO_2-e by Fuel Source)



Source: Derived from data in WorleyParsons (2008; 2011).

More recently, a report[17] by Environmental Resources Management (ERM) in conjunction with Life Cycles (and peer reviewed by CSIRO), released in November 2019, analysed the full life-cycle impacts of LNG production and utilisation from two proposed gas reservoirs; Browse and Scarborough. The main market for LNG from these reservoirs is Asia, and in particular China, Japan, Southeast Asia (ASEAN) and India.

The study compares the environmental impact of electricity generated in the four target markets, from LNG originating from Browse and Scarborough, with the environmental impact of specific electricity grid mixes in the same markets. This analysis demonstrates how Browse and Scarborough-sourced gas would compare, either on a grid-average basis, directly against coal-fired generation, or against a portfolio of fossil fuel power sources.

- The report finds increasing natural gas use tends to contribute to lower greenhouse gas emissions, as it can replace the burning of coal and oil for power generation, as well as combustion for heat. Natural gas is also increasingly used as a substitute for petroleum fuels in petrochemicals.
- In Europe, the USA and China, increasing consumption of natural gas has contributed to lower emissions. Natural gas has played a varying role in these three markets, but in all of them it has substantially contributed to decarbonisation. Gas from the Browse and Scarborough projects is expected to play this role in the four markets under consideration.

[17] See Environmental Resources Management Australia (2019), *Comparative Life Cycle Assessment: Browse and Scarborough*, November (see www.erm.com/woodside-proposed-gas-fields-lca) for further details, including details of the scenarios considered in the analysis.

- The report finds, under scenarios that examine production of gas from Browse and Scarborough produced to 2040, with an assumed distribution into the target markets of China (33 per cent), Japan (25 per cent), ASEAN (26 per cent), India (16 per cent), where Browse and Scarborough gas is assumed to be displacing fossil-generated electricity:
    - using Browse and Scarborough gas to generate power in the target markets, results in avoided emissions of between 406 Mt CO_2-e and 415 Mt CO_2-e. The report also finds significant benefits for particulate matter ($PM_{2.5}$), photochemical ozone equivalents (NMVOC e), acidification (H^+e) for electricity produced from LNG sourced from Browse and Scarborough for all four regions, under three different policy scenarios, averaged over the timeframe 2025-2040. Electricity from LNG has significant benefits in photochemical ozone formation, acidifications, and particulate matter in all regions.

In eastern Australia, a recent landmark report by the CSIRO's Gas Industry Social and Environmental Research Alliance (GISERA) confirmed the greenhouse gas emissions benefits from increased use of natural gas in domestic and export markets. The report[18] *Whole of Life Greenhouse Gas Emissions Assessment of a Coal Seam Gas to Liquefied Natural Gas Project* analysed life-cycle emissions, including extraction, transportation and usage of coal seam gas (CSG) in Queensland's Surat Basin.

This is the first time estimates of life-cycle greenhouse gas emissions associated with an operating CSG-to-LNG project in Australia have been used – and provides data about the benefits of natural gas for electricity generation. The report presents a comparison of greenhouse gas emissions from electricity production in Australia from Queensland thermal coal or natural gas derived from CSG operations which finds – incorporating the full life cycle of greenhouse gas emissions from all parts of the supply chain – a reduction in emissions of up to 50 per cent. This is the first time estimates of life-cycle greenhouse gas emissions associated with an operating CSG-to-LNG project in Australia have been used – and provides data about the benefits of natural gas for electricity generation.

The report found:

> *… considerable climate benefits are possible where natural gas replaced coal for electricity generation; particularly in developing countries.*

According to recent Australian Government estimates, Australian LNG exports in the year to December 2019 have the potential to reduce greenhouse gas emissions by 164 million tonnes in customer nations[19]. This is equivalent to over 30 per cent of Australia's emissions during that same period.

In addition, and as noted above, burning gas instead of coal improves urban air quality. This is particularly important in many Asian countries that are importing Australian LNG or considering imports.

There are significant benefits to Australia and internationally from the greater use of gas as a lower greenhouse gas emitting energy source.

[18] See gisera.csiro.au/project/whole-of-life-cycle-greenhouse-gas-assessment for more information.
[19] See www.minister.industry.gov.au/ministers/taylor/media-releases/emissions-fall-2019 for more information.

Much greater use of Australia's extensive gas resources will therefore be crucial in meeting the challenge of significantly reducing global greenhouse gas emissions at lowest possible cost whilst enhancing Australia's economic and export performance.

The Technology Roadmap should confirm and reinforce the vital role Australian LNG exports can play in global greenhouse emissions reductions. As the Discussion Paper notes on page 28, LNG represents a continuing export opportunity for Australia, one that can provide cleaner energy to Asia for decades to come.

COMMENTS ON ISSUES RELEVANT TO THE DISCUSSION PAPER

The following sections set out APPEA comments on key areas of the Discussion Paper. As noted above, APPEA's submission addresses specific aspects of the Discussion Paper, focussing on those areas that are particularly important for the upstream oil and gas industry.

The sections set out views on a subset of the technologies set out on in Table 7 on pages 32-33 of the Discussion Paper, highlighting those technologies the industry recommends be considered as priority technologies for inclusion in the first Low Emission Technology Statement.

Two technologies are the focus of these sections:

- Industry—Feedstock/Industrial Processes: Greenhouse Gas Storage (including Carbon Capture and Storage (CCS)/Carbon Capture, Use and Storage (CCUS).
- Industry—Process Heating: Hydrogen.

Drawing on the APPEA *Industry Action on Emissions Reduction* report at Attachment 2, the following sections also set out a number of case studies of the way in which the Australian upstream oil and gas industry is implementing a range of low emissions technologies and taking action to reduce its emissions. The case studies include ways in which the industry is investigating or, in some cases, developing and deploying these technologies. Further detail on this report is provided in Box 1.

Box 1. *Industry Action on Emissions Reduction* report

The *Industry Action on Emissions Reduction* report examines the key role natural gas plays in reducing global greenhouse gas emissions and provides detail on Australian oil and gas industry activities and initiatives to reduce greenhouse gas emissions through an overview and case studies. These actions encompass the entire oil and gas exploration and production life cycle and include:

- Industry joint initiatives.

The Oil and Gas Climate Initiative, the World Bank Zero Routine Flaring by 2030 initiative and the Climate & Clean Air Coalition Oil and Gas Methane Partnership and Methane Guiding Principles.

- What we do when we design our facilities.

Providing case studies of actions taken by the industry in both the design and construction of its facilities to reduce emissions or to minimise the facility's emissions profile.

- What we are doing in our facilities (both in Australia and globally).

Providing case studies of activities and initiatives undertaken by APPEA member companies at facilities across the industry to reduce their greenhouse gas emissions.

- What we are doing around our facilities.

Providing case studies of activities and initiatives undertaken by APPEA member companies around their facilities to reduce greenhouse gas emissions.

- Low emissions research & development.

Highlighting the Australian oil and gas industry's strong supporter of research, development and demonstration (R,D&D) in Australia.

A range of other technologies (Electricity: gas generation to firm variable renewables, Fugitive emissions and waste, Mining and industry equipment: energy management technologies/control systems and Enabling technologies: digital technology enables) are also worthy of consideration. A number of these technologies and their development, deployment and application in the Australian upstream oil and gas industry are considered in submissions from APPEA member companies.

In addition, APPEA welcomes the use of a number of examples (such as the Boxes on page 16 and page 30) from the Australian upstream oil and gas industry in the Discussion Paper, highlighting the already widespread use of low emissions technology and the emissions reduction focus of the industry.

In recommending inclusion or consideration of these technologies for the first Low Emission Technology Statement, APPEA has utilised the filters for prioritising technology that have been outlined in various of the consultation sessions held following the release of the Discussion Paper, namely:

- Large scale abatement: in the applications proposed both Greenhouse Gas Storage (including Carbon Capture and Storage (CCS)/Carbon Capture, Use and Storage (CCUS) and hydrogen, have the potential for large scale abatement across the economy. This is demonstrated in the Discussion Paper itself through the 'bubble charts' set out in various parts of the document.
- Large scale economic opportunity: both Greenhouse Gas Storage (CCS/CCUS) and hydrogen can provide large scale opportunities – they have the potential for large scale abatement across the economy and this has been highlighted in the recent work of the Global Carbon Capture and Storage Institute[20] (GCCSI) and in the National Hydrogen Strategy[21].
- Australia has a comparative advantage: Australia's comparative advantage and experience in natural gas development and export provides significant opportunities, including the opportunity to leverage Australia's extensive natural gas resource base and the industry's capital, depth of experience, and world-leading technical and commercial expertise, all of which are vital to the further development of both technologies. This is considered further in the sections below.

[20] See, for example, GCCSI (2020), *The Value of Carbon Capture and Storage (CCS)*, 13 May (available at www.globalccsinstitute.com/resources/publications-reports-research/the-value-of-carbon-capture-ccs).
[21] Available at www.industry.gov.au/data-and-publications/australias-national-hydrogen-strategy.

- Technology readiness: as highlighted in the Discussion Paper and has been noted elsewhere, Greenhouse Gas Storage (including CCS/CCUS) is an available and utilised technology. This is also considered further in the sections that follow. Hydrogen is already produced from natural gas, particularly in the United States, but further technological improvements to various part of the production, supply, transportation are required and have been considered through, for example, the National Hydrogen Strategy. Improvements to enable large scale production and commercial application at competitive cost is required.

The following sections consider Greenhouse Gas Storage (including CCS/CCUS) and hydrogen as technologies and their development and use by the upstream oil and gas industry. The sections do not consider policy frameworks to support their development, which have been considered through other processes during 2019 and 2020.

In addition, the sections do not offer views on the 'stretch goals' that have been outlined in the Discussion Paper and consultation sessions (for example, hydrogen (referred in the Discussion Paper as 'H2 under $2') or permanent carbon sequestration (outlined in the consultation sessions as 'cost < $X per tonne of CO_2 stored')). A number of submissions from APPEA members may offer views on these stretch goals.

INDUSTRY—FEEDSTOCK/INDUSTRIAL PROCESSES: GREENHOUSE GAS STORAGE (CARBON CAPTURE AND STORAGE (CCS)/CARBON CAPTURE, USE AND STORAGE (CCUS))

Greenhouse gas storage (or carbon capture and storage (CCS)/carbon capture, use and storage (CCS)) is the process whereby large volumes of captured carbon dioxide (CO_2) are safely injected and stored deep underground rather than being released to the atmosphere.

While the application of CCS to particular projects depends on a range of technical and commercial factors and CCS cannot be applied in a range of circumstances, it has growing application and use across the world.

CCS is already well established as a safe, large scale, permanent abatement solution. In 2019, the number of large-scale CCS facilities reached 51. Of these, 19 are operating (of which 10 are for oil and gas projects), four are under construction, 10 are in advanced development using a dedicated front end engineering design (FEED) approach and 18 are in early development. Those in operation and construction have the capacity to capture and permanently store around 40 million tonnes of CO_2 every year. This is expected to increase by about one million tonnes in the next 12-18 months. In addition, there are 39 pilot and demonstration scale CCS facilities (operating or about to be commissioned) and nine CCS technology test centres[22].

As the Discussion Paper notes on page 56:

[22] See Global Carbon Capture and Storage Institute (2020), *Global Status of CCS 2019*, March (available at www.globalccsinstitute.com/resources/global-status-report).

Carbon capture and storage (CCS) is a proven technology that can separate the emissions from existing combustion processes using gas and coal, as well as non-combusting industrial processes such as limestone calcination.

Since 1996 the global oil and gas industry has led the world in the practical deployment of this technology. For example, Equinor is operating large projects alongside their Sleipner and Snøhvit gas processing operations[23] and in Canada, Shell has developed the Quest CCS project[24].

In Australia, the oil and gas industry has been at the leading edge of researching and deploying greenhouse gas storage technologies. The industry instigated significant research efforts into greenhouse gas storage in the late 1990s through the Australian Petroleum Cooperative Research Centre which undertook the first assessments of possible storage sites across Australia.

Several years later that work was taken over by CO2CRC Limited. The CO2CRC is recognised as one of the world's leading collaborative research organisations focused on carbon capture and storage and continues to receive significant backing from the Australian oil and gas industry.

The Australian industry has privately spent several hundred million dollars undertaking detailed storage site and project scoping assessments in the Perth, Carnarvon, Browse, Bonaparte and Cooper Basins as well as assisting other organisations undertaking storage site assessments in the Gippsland and Perth Basins.

Case Study: Gorgon Carbon Dioxide Injection Project

As the Discussion Paper notes on page 16, the Gorgon Project on Barrow Island, operated by Chevron, includes the Gorgon Carbon Dioxide Injection Project, the safe underground injection and storage of between 3.4-4.0 million tonnes CO_2-e greenhouse gases per year, or around 100 million tonnes over the life of the project[25].

The Gorgon Carbon Dioxide Injection Project is the largest greenhouse gas mitigation project in Australia and the largest undertaken by industry globally.

In addition to assessing potential storage sites the Australian oil and gas industry has played a pivotal role in the development of legislative and regulatory regimes required to enable the technology to be deployed. The legislation enabling the Gorgon Carbon Dioxide Injection Project is believed to be the world's first storage specific legislation and the Project was the first large-scale project to have its environmental impact assessed under State and Federal environmental laws.

The experience at Gorgon was subsequently used to help develop the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* and continues to be a test case for regulatory developments in other areas such as the reporting of storage site emissions.

Case Study: Santos CO_2 capture

Santos has entered front end engineering design (FEED) for the Moomba CCS project.

[23] See www.equinor.com/en/what-we-do/carbon-capture-and-storage.html for more information.
[24] See www.shell.ca/en_ca/about-us/projects-and-sites/quest-carbon-capture-and-storage-project.html for more information.
[25] See australia.chevron.com/our-businesses/gorgon-project for more information. In addition to being the largest greenhouse gas mitigation project in Australia and the largest undertaken by industry globally, the Gorgon Project is itself one of the world's largest LNG projects and the largest single resource project in Australia's history.

The project proposes to capture the 1.7 million tonnes of CO_2 currently separated from natural gas at the Moomba gas processing plant each year and to reinject it into the same geological formations that have safely and permanently held oil and gas in place for tens of millions of years.

The CO_2 would be compressed, dehydrated (removing any water) and transported to a target field nearby for injection. Santos is collaborating with experts including Occidental Petroleum, which has world-leading operational expertise in CO_2 injection in the United States.

In 2020 Santos will complete the design phase and be ready to make a final investment decision, subject to the required Government policy being in place. CO_2 injection could commence from as early as 2022.

With the right policy settings and incentives to accelerate CCS deployment[26], the Cooper Basin could become a large-scale, commercial CCS hub capturing emissions not only from oil and gas, but from other industries such as power generation, steel, cement and chemicals.

Case Study: Ichthys LNG facility CCS-ready

The Ichthys LNG facility has been designed as CCS-ready, meaning that provisions have been made in the design to be able to retrofit the facility with CCS capability in the future.

INPEX, the operator of the Project, has conducted investigations into capturing reservoir CO_2 from the acid gas removal unit (AGRU)[27] and re-injecting this CO_2 in a suitable reservoir. This included a detailed site selection and characterisation assessment, which indicated that suitable storage reservoirs may exist, but at a significant distance from the LNG facility.

To date, in excess of USD$10 million has been spent on evaluating CCS as an abatement option for the Ichthys LNG Project. These studies confirmed that, whilst there may be no technical barriers to implementation, implementation of CCS cannot be commercially justified for this project at this stage.

INDUSTRY—PROCESS HEATING: HYDROGEN

Introduction

Australia's upstream oil and gas industry is well-placed to assist in the development of a large-scale and innovative commercial hydrogen industry, both in using natural gas to produce hydrogen and using gas infrastructure to process and transport hydrogen.

Australia's LNG export success story means the Australian upstream oil and gas industry has the technology, expertise and commercial and trade relationships to make, in particular, hydrogen exports a reality. This means Australia is well placed to capitalise on our already abundant natural advantage. Hydrogen is already being produced from Australian LNG exports.

[26] These policy recommendations were outlined in detail in the APPEA submission to the *Expert panel examining additional sources of low cost abatement* (the King Review). A number of these submissions were supported by the King Review Report and the Australian Government's response. APPEA encourages the Government to maintain momentum to implement these recommendations.
[27] Acid gas removal is a process undertaken as part of the operation of an LNG facility that removes H_2S, CO_2 and organic sulphurs in the raw feed gas so as to make it comply with LNG liquefaction process or sales gas production standards. An AGRU is the equipment used at an LNG facility to undertake this process.

As the Discussion Paper notes on page 30, existing technology, known as steam methane reforming (SMR), allows for the economic conversion of natural gas into hydrogen. The process can be combined with CCS or otherwise carbon offset to produce a carbon neutral hydrogen product. The production of hydrogen combining natural gas as the feedstock and utilising SMR technology and its ongoing improvement and cost reduction and CCS technology and its ongoing improvement can provide a range of medium-term opportunities for hydrogen development, supported through Government process such as the National Hydrogen Strategy, and the recently announced Advancing Hydrogen Fund.

These developments can also support the development of other technologies, such electrolysis of water to separate hydrogen from oxygen, as they become more economically viable.

A technology neutral approach, which focusses on all possible pathways to hydrogen development (both domestically and for exports), is vitally important to Australia achieving the best outcomes from this technology and its focus in the Roadmap and associated Statements, and APPEA recommends the Roadmap and associated Statements maintain a technology neutral approach to hydrogen development.

Case Study: Woodside and hydrogen

A number of APPEA members are already exploring hydrogen opportunities. For example, Woodside Energy Ltd is the pioneer of the LNG industry in Australia and their experience in producing and exporting LNG, underpinned by strong customer relationships, positions them well for complementary opportunities in large-scale hydrogen.

In June 2018, Woodside signed a non-binding memorandum of understanding with Korea Gas Corporation to cooperate on hydrogen opportunities, and with Pusan National University in South Korea to jointly explore technology applications across the hydrogen value chain.

In March 2020, Woodside also signed an agreement with Japanese companies JERA Inc, Marubeni Corporation and IHI Corporation to undertake a joint study examining the large-scale export of hydrogen as ammonia for use in decarbonising coal-fired power generation in Japan.

CONCLUSIONS/NEXT STEPS

To conclude:

- The Australian upstream oil and industry's technology driven focus on the safe, sustainable, and commercial development of the nation's oil and gas resources in a manner that maximises the return to the Australian industry and community makes it possible for Australia to meet the world's growing energy needs over the coming decades while incorporating a strategy to curb emissions and address the risk of climate change.
- As the Discussion Paper notes, natural gas has an essential role to play in reducing emissions. In the home, natural gas is a cleaner fuel and can see the emissions intensity of electricity generation in the NEM fall. Gas-fired generators can be rapidly started making them complementary with intermittent renewable energy. Exporting gas as LNG will allow our Asian trading partners to reduce the emissions from their economies.
- It is important that the work of the Roadmap, and the associated annual Low Emissions Technology Statements, form an integrated element of the Government's overall climate change policy response.
- APPEA's submission focusses on two technologies – greenhouse gas storage and hydrogen – as technologies that can achieve large-scale abatement, provide a large scale economic

opportunity for Australia and where Australia's existing comparative advantage and experience in natural gas development and export provides significant opportunities for the further development of both technologies.

APPEA will continue to participate in the development of the Roadmap and looks forward to ongoing consultation ahead of the release of the first Low Emissions Technology Statement later in 2020.