Australian Government
Climate Change Authority

INDUSTRY ACTION ON CLIMATE CHANGE MITIGATION AND LOW-EMISSIONS TECHNOLOGIES

JULY 2019

Published by the Climate Change Authority

www.climatechangeauthority.gov.au

CONTENTS

FIGURES

TABLES

BOXES

1. INTRODUCTION

This paper provides an overview of how companies in Australia are positioning themselves for a carbon constrained future. The examples provided in this paper demonstrate some companies are actively considering climate change in their product development and operations, and are implementing changes to reduce greenhouse gas emissions where opportunities arise and it is in their long-term interests.

Climate action by companies is driven by a range of factors. These include the desire to reduce costs, brand and marketing considerations, stakeholder and investor expectations and anticipating future policies to reduce emissions. Requirements for companies to comply with current regulations and policies also affect their activities. This paper focuses on those activities that are not directly mandated or required by policy. However, as it is not always possible to distinguish the drivers of some activities, actions in response to key regulations and policies are discussed in some cases. The paper also considers the potential for companies to further reduce greenhouse gas emissions through low-emissions technologies currently available or under development.

This stocktake does not attempt to provide a complete list of actions that industry is undertaking. Many companies that are taking action do not appear as examples in this report. Conversely, the stocktake has not recorded examples of companies that are not mitigating emissions.

While every effort has been made to publish an accurate report, the Authority has drawn extensively on third party material. The Authority welcomes your input on the accuracy and reliability of the information contained in this report and any relevant additional information (see Chapter 13).

1.1. Informing future work

The stocktake does not analyse the effectiveness or scale of the action industry has taken so far or what policy approaches could be used to support emissions reductions in the future.

This document is one of a series of stocktakes the Climate Change Authority has released in early 2019. The others examine the:

- climate change policies that are currently in place at the Australian and state and territory government levels; and
- strategies other countries are using to achieve their emissions reduction goals.

All three stocktakes, along with other research and analysis, will assist the Authority to update its advice to the Australian Government on policies to meet Australia's emissions reduction commitments under the Paris Agreement.

The Authority will consult later in the year as it develops its approach to updating its advice.

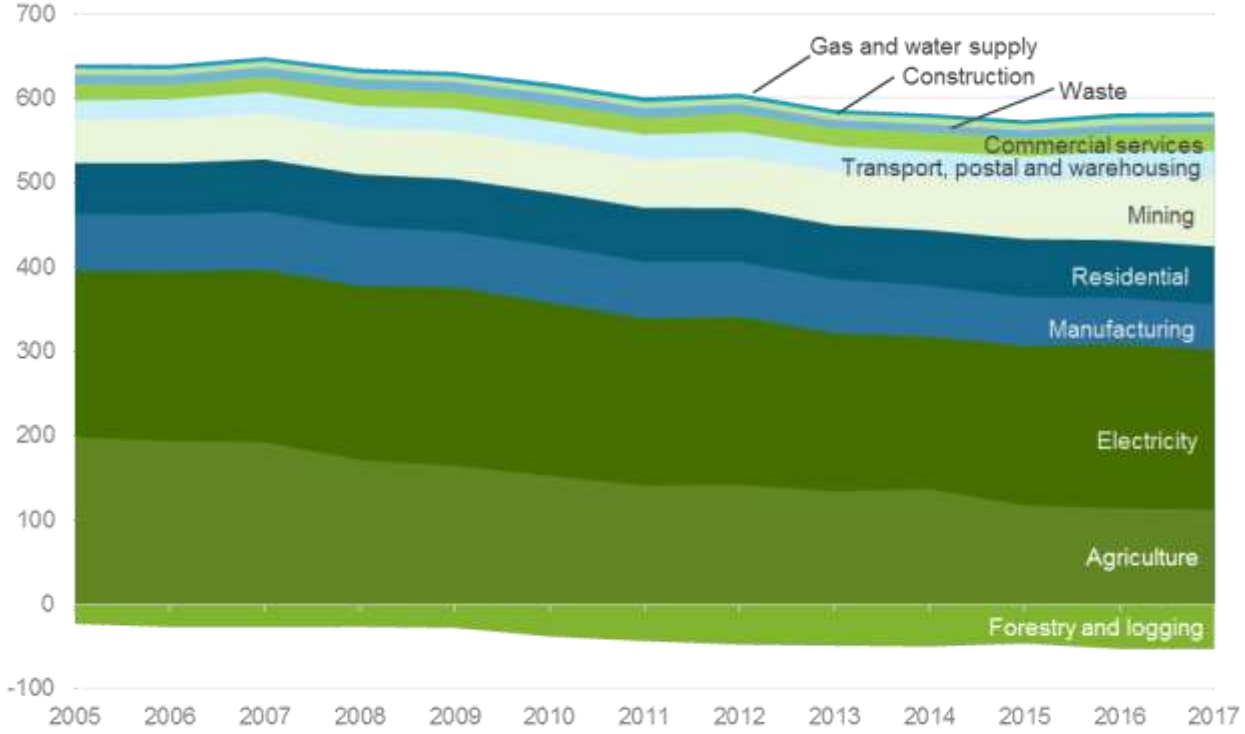
2. OVERVIEW OF AUSTRALIAN EMISSIONS BY ECONOMIC SECTOR

Figure 1 illustrates Australia's direct (scope 1) emissions by economic sector between 2005 and 2017.[1] Between 2007 and 2013, overall emissions went down, driven mainly by declines in deforestation activity in agriculture and increased removals in the forestry sector. Since 2013, overall emissions have slowly been rising and are on an upward trajectory to 2030 (Australian Government DoEE 2018a).

The emissions profile is not uniform across the economy. Emissions from the electricity, manufacturing, agriculture, forestry and waste sectors have mostly decreased since 2013 and were below 2005 levels in 2017. Commercial and construction sector emissions remained relatively stable between 2013 and 2017 but were still above 2005 levels in 2017. Emissions in the mining, transport and residential sectors have increased almost every year between 2005 and 2017.

The remainder of this paper provides examples of the actions taken by companies in Australia to reduce emissions and discusses the drivers of those actions. Many of these examples are relatively recent and the impacts on emissions may not yet be reflected in the national emissions data or be apparent for some time. As illustrated in Figure 1, national emissions have been rising in recent years. Reducing national emissions in line with the Paris Agreement goals will require further and sustained efforts right across the Australian economy.

FIGURE 1 DIRECT (SCOPE 1) EMISSIONS BY ECONOMIC SECTOR, 2005 – 2017



Source: Australian Government DoEE n.d.

[1] National emissions data in this report refer to emissions in the financial year preceding the date. For example, emissions for 2005 are those emitted in the 2004–05 financial year. This approach is consistent with national emissions accounting.

Table 1 summarises Australia's scope 1 (direct) and scope 2 (indirect) greenhouse gas emissions by economic sector, based on Australia New Zealand Standard Industry Classifications (ANZSIC).[2] Scope 2 emissions (shown in the last column of the table) are the emissions in each sector that are attributable to the use of electricity.

As well as looking at the economic sectors summarised in Table 1, this report also considers the actions being taken in the buildings sector, which is not separately identified as an economic sector. The emissions data by economic sector outlined in Table 1 allocates emissions associated with energy used in buildings to the sectors operating in the buildings.

TABLE 1 SCOPE 1 AND SCOPE 2 EMISSIONS BY ECONOMIC SECTOR, 2017

Economic Sector (ANZSIC)	Scope 1 emissions (Mt CO_2-e)	Scope 1 share of national emissions (%)	Scope 2 emissions (Mt CO_2-e)
Electricity	189.8	36	21.7
Mining	80.7	15	18.9
Manufacturing	53.7	10	48.9
Agriculture and forestry	59.6	11	1.6
Agriculture	*112.2*	*21*	-
Forestry and logging	*–52.6*	*–10*	-
Transport, postal and warehousing	32.4	6	3.5
Commercial services	23.1	4	47.1
Construction	8.4	2	0.1
Gas and water supply	5.4	1	2.1
Waste	8.9	2	-
Residential	68.8	13	45.9
Total	**530.8**	**100**	**189.8**

Note: Total Scope 1 and 2 emissions cannot be added together as scope 2 emissions are already accounted for in the scope 1 emissions for the electricity sector. Scope 2 emissions by sector do not account for company investments in sourcing low-emissions electricity, for example through purchase power agreements, so this may be an overstatement of scope 2 emissions in some sectors. Nonetheless, this provides an indication of the emissions associated with electricity use in the sector. Emissions reported based on economic sectors adhere to accounting processes consistent with the Kyoto Protocol. Australia submits an annual National Inventory Report under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. There is a difference in total reported emissions under the two approaches. Using the UNFCCC accounting methods, total emissions in 2017 were 534 Mt CO_2-e.
Source: Australian Government DoEE n.d.

[2] Scope 1 emissions are released as a direct result of an activity at a facility, for example by burning fossil fuels to produce energy or heat. Scope 2 emissions are indirect emissions resulting from the use of purchased electricity.

Box 1 Emissions based on economic sectors

For the purposes of this report, greenhouse gas emissions are considered on the basis of economic sector (using the ANZSIC categories). This is a useful way of looking at emissions data as it illustrates the relative significance of different sectors of the Australian economy. It also reveals the volume of emissions companies operating within a particular sector have the capacity to influence. The alternative approach, used in Australia's National Inventory Report and quarterly emissions inventory reports, is to classify emissions according to process-based (or activity) emissions categories as set out in guidelines prepared by the International Panel on Climate Change (IPCC).

The difference between the two classifications can be illustrated using the agriculture sector as an example.

- The **economic sector** of agriculture captures all emissions that can be attributed to agricultural businesses. These emissions include emissions arising from agricultural activities (such as livestock related emissions, or emissions from the use of fertilisers) as well as emissions from other activities by agricultural businesses (such as the use of farm vehicles or diesel generators).
- Under the **IPCC process-based emissions categories**, the agriculture category only captures emissions arising from agricultural activities. This includes emissions from livestock, fertiliser use, agricultural soils, rice cultivation and burning of agricultural residues.

3. DRIVERS OF INDUSTRY ACTION

There are a number of key drivers motivating industry to take action to reduce emissions beyond compliance with current regulation and policies. In one way or another, these drivers come back to what is in the best interest of the company and its profitability.

The nature and extent of action by a company depends on the influencing drivers and the company's capacity and capability to act. Where action can result in short-to-medium term cost reductions and increased profitability, the incentive to act is higher. Examples of these types of actions include installing more energy efficient equipment or rooftop solar PV to reduce costs and adopting voluntary public targets to increase the sustainability credentials of the brand and ability to market this to consumers.

This chapter explores some of the key drivers of industry action in more detail including cost reductions, brand and marketing, anticipated future government policies, disclosure and reporting, availability of finance and insurance and sustainable procurement practices.

3.1. Cost reductions

Cost reductions realised through improvements in energy efficiency and uptake of renewable energy are a clear driver of industry action to reduce emissions. Higher energy prices help to drive these investments. A 2018 report on energy affordability by the Australian Competition and Consumer Commission found that high electricity prices have increased operating costs and placed pressure on business viability (ACCC 2018).

3.1.1. Energy efficiency

According to the Energy Efficiency Council, improving energy efficiency could drive Australia's long-term economic growth, lower companies' energy costs and lift companies' productivity and resource efficiency. It is also one of the largest potential sources of reducing greenhouse gas emissions (EEC 2016).

Many companies are achieving reductions of greenhouse gas emissions through improvements in the energy efficiency of their operations that deliver immediate financial and other co-benefits. However, there is evidence businesses generally are underinvesting in energy efficiency even when there is a compelling business case to do so (EEC 2018). Lack of information on energy efficiency opportunities and data gaps on energy consumption patterns make it hard for business owners to justify capital expenditure on energy efficiency projects, with many businesses prioritising investment focused on revenue growth over avoided cost. Upfront capital costs can also be prohibitive, especially for cash flow constrained small and medium businesses (EEC 2018, Fresner et al. 2017).

The CEFC provided almost $1 billion in finance in 2017–18 for energy efficiency projects in property, infrastructure, manufacturing, agriculture and universities, helping these institutions address the barriers to accessing upfront capital investment (CEFC 2018a). Most of the states and territories also have energy efficiency schemes that provide financial support to businesses investing in energy efficiency projects (CCA 2019).

The Australian Alliance for Energy Productivity (A2EP), an independent coalition of business, government and environmental leaders, is actively promoting energy efficiency by focusing on optimising business operations and technology innovation (A2EP n.d.). New digital technologies, such as cloud based analytical tools, can help bridge the information and data gaps and identify areas for performance and process optimisation in business operations, including for mining, manufacturing, agricultural production and freight transport systems (A2EP 2018).

3.1.2. Renewable energy

Falling costs of wind and solar electricity generation, combined with increases in grid electricity prices and government incentives, are encouraging companies to invest in renewable energy. This is either through installing their own roof-top solar systems, or entering into Power Purchase Agreements (PPAs) (Box 2) (Climate Council 2018).[3]

In 2017, there were a total of 46,000 businesses with solar installations (Sunwiz n.d.). Modelling commissioned by the Clean Energy Regulator estimates that the number of commercial size (non-residential) photovoltaic system installations would almost double in the three years from 2017 to 2020 (Green Energy Markets 2018).

Companies are also increasingly entering into PPAs with renewable energy generators to supply electricity. PPAs create opportunities to reduce electricity bills and emissions, and also manage risks associated with electricity prices and market volatility. A PPA has the potential to provide savings of between 10 and 30 per cent of an electricity bill, compared with purchasing electricity from the grid (Energetics 2018).[4]

Since 2016 corporate PPAs have supported investment in new renewable energy projects with a combined capacity of 3100 MW. Companies that have implemented PPAs include the cement producer Adelaide Brighton, Sydney Airport, Bluescope Steel, Carlton and United Breweries, Telstra and the agri-business Nectar Farms (Energetics 2019).

[3] A PPA is a long-term agreement (typically 10 to15 years) for an energy buyer to purchase a quantity of electricity generated by an off-site renewable energy project, such as a solar or wind farm.

[4] Based on futures market contract prices, including the price of certificates under the renewable energy target.

Box 2 Use of Power Purchase Agreements

Orora Group

Orora Group is a global packaging producer operating 43 manufacturing plants and 91 distribution sites worldwide. Orora entered into two long-term PPAs with wind farms, securing the continued supply of renewable energy for volumes equivalent to 80 per cent of the company's total electricity demand in Australia (Orora 2018).

The PPAs provide Orora with increased commercial certainty by reducing the company's exposure to fluctuating wholesale energy prices (Macdonald-Smith 2018a).

Australian banks

Westpac, as a member of the RE100 global leadership initiative (Box 4), has committed to using 100 per cent renewable energy by 2025. The first phase of the commitment will be implemented through a power purchase agreement with the 120 MW capacity Bomen Solar Farm in New South Wales, which will be operational by mid-2020. Westpac has committed to purchase over a quarter of the solar farm's output under a ten year contract (Westpac Banking Corporation 2019a).

Bank Australia, also a member of RE100, became the first Australian bank to achieve 100 per cent renewable energy, one year ahead of its 2020 target. The bank achieved this through the installation of rooftop solar systems and a ten year agreement with renewable energy developer Pacific Hydro (Mazengarb 2019).

3.2. Brand and marketing

For many companies, perceived inaction on climate change comes with significant reputational risk. Companies producing fast moving consumer goods, such as food and beverages and household and personal care, are particularly sensitive to changing consumer preferences (CDP 2019, Scott 2019). Consequently, large consumer goods companies are accelerating product innovation to develop low-emissions products and are placing a larger emphasis on labelling and marketing the carbon footprint of products. For example, Unilever is phasing out petrochemicals in its products. These companies are also spending considerable amounts on mergers and acquisitions of smaller, sustainable brands to meet consumer demands for low-carbon sustainable products (CDP 2019, Edie newsroom 2019).

The significance of reputational risk on companies' profitability is illustrated by Coca Cola Amital's inclusion of 'loss of social licence to operate' as a key business risk in its latest annual report. The report states that a "failure to deliver on consumer, investor and community expectations in relation to… environmental impacts created by our activities could result in damage to our brand, reputation and consumer sentiment" (Coca-Cola Amital 2018).

There are a number of different ways Australian companies are demonstrating their commitment to reducing emissions to take advantage of the marketing benefits. These include joining international initiatives (Box 4), gaining carbon neutral certification, and promoting their own emissions reduction targets and activities.

In Australia, companies can use the National Carbon Offset Standard (NCOS) accredited by the Australian Government to independently demonstrate that they have achieved carbon neutrality through reducing and offsetting their emissions and report on this publicly (Box 3). In 2018, certified companies

offset 2.5 million tonnes of emissions (Australian Government DoEE pers.comm 2019). Since the program commenced in 2010 companies have offset around 14 million tonnes of emissions.

The popularity of certification against the Standard is growing. In June 2019, there were 95 active carbon neutral certifications under the Standard, implemented by 73 organisations.[5] This is compared with 53 certifications implemented by 45 organisations in December 2017 (Australian Government DoEE pers.comm 2019). Certified companies can be found in several industries including airlines (Qantas and Virgin), banks (ANZ, National Australia Bank, Westpac and Bank Australia), local Councils (including Cities of Melbourne, Sydney and Brisbane), products and services (wine, fish, paper and tourism), universities and not-for-profits (WWF, Uniting Communities). Several other non-government certification programs exist in Australia and some companies are choosing to implement their own approach.

A number of Australian companies also have voluntary company emissions reduction targets. In 2018, the Australian Council of Superannuation Investors (2018) reported that 21 per cent of ASX 200 companies (42 companies) had greenhouse gas emissions reduction targets.

Box 3 Carbon Neutral Austral Fisheries

Austral is one of Australia's largest commercial fishing companies specialising in environmental fishing practices that catch and source sustainable seafood. It owns and operates a number of refrigerated trawlers and longline vessels. In 2016, the company became the first certified carbon neutral seafood business in the world.

> *We identified a need to reduce and offset our carbon emissions to help ensure the health of our oceans, which is fundamental to our business* *David Carter, CEO (in Boothroyd 2016)*

In 2016, Austral's total greenhouse gas emissions were 32,619 t CO_2-e. This was independently audited by EY. The largest proportion of the company's emissions were from fuel use in vessels, which is equivalent to the emissions from diesel use by nearly 4500 cars per year.

The company aims to increase the efficiency of their operations and reduce carbon emissions where possible. It is certified as carbon neutral under the National Carbon Offset Standard. Carbon neutrality is achieved through purchasing carbon offsets, which support the planting of around 220,000 native trees annually, representing the revegetation of around 165 hectares of native Australian bush per year (Austral Fisheries 2016).

[5] Some organisations have more than one certification, for example the organisation and a product. Organisations include private companies, non-government organisations and government sector. A list of certified organisations can be found at http://www.environment.gov.au/climate-change/government/carbon-neutral/certified-businesses.

Box 4 International business initiatives

There are a number of multi-sector global initiatives seeking to encourage and support businesses to take action to address climate change. Companies join these groups to make a public commitment to contribute to the global emissions reduction task and promote their sustainability credentials.

Collectively, these types of commitments by companies can conceivably drive significant emissions reductions. Together, five of the business initiatives (RE100, EP100, Zero Deforestation, Science Based Targets, and the Low Carbon Technology Partnership initiative) have the potential to lead to emissions reductions of between 3.2 and 4.2 gigatonnes of carbon dioxide-equivalent by 2030, or 7 to 9 per cent of 2010 global emissions (New Climate Institute 2016). Some of these initiatives, such as RE100 and EP100, are commitments of a broader group of organisations — the We Mean Business Coalition.[6]

- **The United Nations Global Compact** is the world's largest corporate sustainability initiative through which businesses make a commitment to the sustainable development goals including climate action. There are 154 Australian participants (United Nations Global Compact 2019).
- **CDP** (formerly the Carbon Disclosure Project) runs a global disclosure system that enables companies, cities, states and regions to measure and manage their environmental impacts. It is the most comprehensive collection of self-reported environmental data in the world. The data is utilised by a network of investors with US$96 trillion in assets and supply chain purchasers with purchasing power of US$3.3 trillion (CDP n.d.).
- **RE100** is a group of influential companies committed to 100 per cent renewable energy. Australian companies participating in the initiative include Westpac, Commonwealth Bank, Bank Australia and Atlassian. RE100 is an initiative by the Climate Group (a network of business and government organisations accelerating climate action) and CDP (RE100 2019).
- **EP100** is an initiative of the Climate Group, in partnership with the Alliance to Save Energy, to bring together companies committed to using energy more productively. These companies are incorporating energy efficiency into business strategies. Australian companies participating include AMP Capital Wholesale Office Fund, Cbus Property, Frasers Property Australia, GPT Wholesale Office Fund, Nightingale Housing and Stockland (The Climate Group 2019).
- **The Zero Deforestation initiative** calls on businesses to remove commodity-driven deforestation from supply chains. Globally, 54 companies have committed to the initiative, including Bank Australia, Origin Energy and Westpac Banking Corporation (We Mean Business 2019).
- **Science Based Targets** is a partnership that promotes setting emissions reduction targets for companies using a best practice science-based approach. It is a collaboration between CDP, the United Nations Global Compact, World Resources Institute and the World Wide Fund for Nature (WWF). Australian companies who have adopted this approach include Edge Environment, Investa and Origin Energy (Science Based Targets 2019).
- **The Low Carbon Technology Partnership initiative** brings together companies to implement cross-sectoral projects to accelerate the deployment of low-carbon technologies in five focus areas. It is an initiative of the World Business Council for sustainable development. Since its launch in 2016, more than 235 companies have participated in the Partnership (WBCSD 2019).

3.3. Anticipated future policies

Anticipation of future changes in government climate change and energy policy is a factor in companies' decision making. The Carbon Market Institute's recent survey of 272 executives in Australian businesses found the majority of respondents thought Australia's emissions reduction commitments would increase over time (Carbon Market Institute 2018).[7] The survey results demonstrate a level of awareness of emissions reduction targets in the Australian business community, and an expectation of their increased importance in the future. This could lead to pre-emptive action to adjust to future policies.

The International Monetary Fund (2019) stated in its recent report on the Australian economy that clarifying greenhouse gas emissions policy would reduce policy uncertainty and catalyse investment. A survey conducted by the Australian Institute of Company Directors (2018) found that the top long-term priority that company directors thought the government should address was climate change. Climate change also rated as one of the top five issues government should address in the short term.

Firms are using internal carbon prices to help inform investment decisions and manage the risks of future climate policies. The Carbon Market Institute survey found 64 per cent of large greenhouse gas emitting companies surveyed are factoring in a carbon price in investment or operational decisions (Carbon Market Institute 2018). The use of an internal carbon price ensures investment decisions are made incorporating the potential future costs of emissions associated with the investment.

3.4. Emissions reporting and climate-related risk disclosure

Financial regulators, institutional investors and shareholders are placing increasing pressure on companies in Australia and around the world to align their operations with the Paris Agreement and the United Nations Sustainable Development Goals (SDGs). This extends to reporting on climate related risks, including greenhouse gas emissions, and how the risks are being managed. Growth in professional intermediary services is helping companies address this pressure (Box 5).

The increased pressure follows growing recognition that the physical impacts of climate change and the transition to a less carbon-intensive economy are likely to have first-order economic effects on many Australian businesses and the broader economy. The Reserve Bank of Australia, along with other central banks around the world, has recognised that monetary policy will need to consider the effects of climate change on output, prices, inflation and asset values and the implications for financial stability of the economy (Debelle 2019).

In June 2017, the Task Force on Climate-Related Financial Disclosures (TCFD), under the mandate of the G20 Financial Stability Board, released its final recommendations. The TCFD recommendations outline a comprehensive framework to promote better voluntary disclosure of climate-related financial risks. These risks include both risks associated with physical climate damages and transitional risks associated with moving to a lower-carbon economy (TCFD 2017).

[6] We Mean Business is a non-profit global coalition bringing together seven international non-profit organisations. The coalition works with some of the world's most influential businesses to take action on climate change including driving policy ambition to transition to a zero-carbon economy (We Mean Business n.d.).

[7] Survey respondents were executives working for, or with, companies or organisations with a large emissions profile, investors, carbon market experts and professional service providers.

While reporting in line with the TCFD framework is voluntary, a number of Australian financial institutions and regulators have supported the need for reporting on climate-related risks and recommended the use of the framework.

The 2019 ASX Corporate Governance Council recommends ASX listed companies identify climate change risks and consider making risk disclosures in line with the TCFD framework. If listed companies do not follow the recommendation, they need to set out reasons for not doing so in their annual corporate statements or on their websites (ASX Corporate Governance Council 2019).

The Australian Accounting Standards Board released advice in 2018 on what climate-risk matters should be included in company financial statements and complements the TCFD and ASX guidance, which is focused on disclosures outside the financial statements. Because financial statements need to be audited, this will now require auditors to ask questions of directors and others with regard to the materiality of climate risks (Australian Accounting Standards Board 2018).

There is growing consensus that climate change risks are a foreseeable risk to Australian companies, placing a legal duty of care on company directors to adequately consider, disclose and manage that risk (Hurtley SC and Hartford Davis 2019). The Australian Securities and Investments Commission (ASIC) has identified as key priorities the prudent and appropriate management of climate change led by company directors and senior management, and disclosure of climate risk in a way that is useful and relevant to the market (Price 2018).

Between its release in June 2017 and March 2018, 11 per cent of ASX 200 listed companies (22 companies) reported against the TCFD framework or committed to do so and a further 10 companies stated that they were reviewing the framework (Australian Council of Superannuation Investors 2018). Disclosure and reporting remains low, but the number of companies with a clear plan to reduce greenhouse gas emissions is growing as companies begin to see climate change as a material consideration in their business operations. A 2018 Market Forces (2019) study of the public disclosures of 72 ASX 100 companies found 57 per cent identified climate change as a material risk to their business and 24 per cent had a clear plan to reduce emissions.

While reporting under the TCFD framework does not directly equate to action to reduce emissions, it does create an incentive for companies to consider and reduce the risks posed to their businesses by climate change and policy responses. Reporting also informs investors and consumers.

Australian companies over certain thresholds are required by the National Greenhouse and Energy Reporting (NGER) legislation to measure and report their greenhouse gas emissions as well as their energy production and use to the Australian Government (CCA 2018a). The NGER scheme could inform climate change risk reporting under the TCFD framework. A 2018 review of the NGER legislation by the Climate Change Authority found the reporting scheme generates high quality data which helps companies better understand their energy and greenhouse gas emissions, meet other reporting requirements and informs investors and other analysts (CCA 2018a).

Providing useful and relevant information to the market can put companies at a competitive advantage in attracting investment and customers, who are increasingly demanding action on climate change. Investors are able to use the reported risks and mitigation strategies to analyse the climate risk exposure of the companies they invest in. They can assess which companies are making strategic

investments to diversify away from that risk into new opportunities and make more informed decisions about capital allocation (Summerhayes 2019).

Reporting on climate risks can lead to investor pressure to implement changes. There are a number of shareholder groups working to increase climate-related reporting and action. These groups take action by providing shareholders with information on company action, working directly with companies to implement change, and initiating shareholder resolutions.

For example the Climate Action 100+ Group comprises more than 320 investors with over US$33 trillion in assets collectively under management. AustralianSuper, the largest superannuation fund in Australia is part of the global steering committee (Climate Action 100+ 2019). Ten of Australia's ASX 100 companies are on the list of companies the Climate Action 100+ Group are focusing on. The Group has used its influence to drive emissions reporting and actions to reduce emissions in companies including global oil and gas company BP (BP 2019), Australia's largest coal producer Glencore (Glencore 2019) and mining company Rio Tinto (Rio Tinto 2018).

Follow This is an activist shareholder group that brings forward resolutions aimed at forcing companies to take action to reduce greenhouse gas emissions. For example, recent shareholder's resolutions at Rio Tinto (Rio Tinto 2019), Shell, and Exxon Mobil (Follow This 2019) were aimed at pressuring those companies to set targets to reduce greenhouse gas emissions including scope 3 emissions linked to the consumption and use of those companies' products.[8] The resolutions have had mixed results. In the case of Shell, the company agreed to introduce industry leading carbon emissions targets linked to executive pay including for scope 3 emissions, however in other instances resolutions have been blocked by company boards (Bousso 2018, Stevens 2019).

[8] Scope 3 emissions are all indirect emissions that are not included in scope 2 (indirect emissions from energy use) which occur in the value change of the reporting company. These include both upstream and downstream emissions (Greenhouse Gas Protocol n.d.), for example scope 3 emissions for a coal mine may include emissions associated with the transport of coal and from burning the coal.

Box 5 Professional intermediary services for managing climate change risks and emissions

There has been notable growth in professional intermediary services that provide planning and technical assistance to companies to help them manage climate-related risks. They operate across sectors and comprise NGOs, government agencies, philanthropic or private for profit organisations. In Australia, each of the big four consulting firms has dedicated climate change and sustainability teams. There are also a growing number of professional consulting service providers who specialise in climate change issues.

Growth in the provision of these services is an indicator of the growing awareness of climate related issues in the rest of the economy. It demonstrates that other companies are looking for ways to understand and improve their sustainability outcomes, including related to greenhouse gas emissions.

> *Sustainability is fast becoming the lens through which a business is judged by its customers, workforce, society, governments and even its investors.* *PwC (2017)*

Services offered include identifying ways to improve the sustainability of businesses, applying standards for assessing greenhouse gas emissions of goods and services, brokering services for the purchase of offset units, and auditing and assurance services associated with complying with policies such as the Emissions Reduction Fund and the Safeguard Mechanism (PwC 2017).

3.5. Availability of finance and insurance

Investor demand for sustainable investment opportunities has grown exponentially in the past decade, particularly since the Paris Agreement in 2015. There is now around US$1.45 trillion globally invested in climate-aligned bonds (Climate Bonds Initiative 2018).[9] In Australia, the green bond market grew from around $750 million in 2014, when the first green bond was issued, to around $13 billion in 2019 (Box 6) (Gilbert and Tobin 2019).[10]

On the money supply side, banks, investors and other financial institutions are increasingly including climate change risk considerations in decisions and rules regarding their investment and loan portfolios. They are considering their exposure to natural resource assets that may be affected by climate change and also activities that are exposed to current and potential climate change policies.

In early 2019, Norway's sovereign wealth fund, the largest in the world with over $1.4 trillion in investments, announced it would reduce its exposure to fossil fuel-based energy explorers and producers globally. The fund currently holds shares in a number of Australian companies totalling over $800 million including Woodside Petroleum, Santos Oil Search, Caltex Australia and Beach Energy (Wilmot 2019).

[9] Climate-aligned bonds are defined as those originating from issuers who generate at least 75 per cent of their revenues from low-carbon transport, clean energy, sustainable water and wastewater management, low-carbon buildings, sustainable forestry and agriculture and waste management and recycling.

[10] This includes green and sustainability bond issuances by Australian corporations and Australian state governments domestically and globally but does not include foreign bonds issued in the Australian market by non-Australian firms (so called 'kangaroo bonds').

Each of the big four Australian banks has set targets to fund low-carbon infrastructure and technology. For example, Westpac has a low-carbon investment target of $10 billion by 2020, which it exceeded in early 2019 (Westpac Banking Corporation 2019b).

Westpac has also analysed and quantified how limiting warming to 1.5°C will affect its loan portfolio in line with scenario analysis under the TCFD framework. The analysis focused on the transition risks associated with the policy, legal, technology and market changes that will be required to limit warming to 1.5°C (Westpac Banking Corporation 2019c). Macquarie Group plans to undertake a similar climate scenario analysis to support the assessment of physical and transition risks for its climate exposed sectors (Macquarie 2019).

Some of these institutions are also prohibiting or restricting finance to certain types of high-emissions projects. For example, ANZ has introduced a ban on financing new office buildings without high environmental ratings (ANZ 2018). At the Commonwealth Bank's annual general meeting, the Chairperson stated that it was unlikely the bank would finance any new greenfield fossil fuel developments (Market Forces 2018). As a result, companies seeking finance for carbon-intensive operations and projects may find finance is becoming harder to source.

Box 6 Retail green bonds

In April 2019, Woolworths Group became the first retailer in Australia, and the first supermarket globally, to issue a green bond certified by the Climate Bonds Initiative (CBI). The bond was five times oversubscribed, easily raising the targeted $400 million with orders of more than $2 billion before it closed (Shapiro 2019).

The bond is a certified climate bond under the CBI Low Carbon Buildings – Commercial Criteria, which defines property assets eligible for certification under the standard. Projects that could be supported by the bond include the implementation of energy efficiency initiatives, such as the installation of solar panels on the roofs of Woolworths Group stores and distribution centres or the development of low-carbon supermarkets (Woolworths Group 2019).

Australia is forecast to raise over $US10 billion in green bonds issued by retail companies over the next five years (Shapiro 2019).

Insurance companies are also increasingly concerned about the exposure of companies they insure to physical and regulatory climate risks. That means that companies that fail to recognise, plan and take action in response to climate risks may find it more challenging to source affordable insurance. QBE, for example has indicated it is reviewing its underwriting strategy on fossil fuels in line with detailed analysis of climate-related risks and opportunities. Other insurers such as Allianz and Zurich are already restricting their underwriting of coal companies (Insurance News 2018).

3.6. Procurement and supply chain sourcing

There is a growing global trend for sustainability credentials to be included in procurement and sourcing criteria for many companies, including in Australia. By sourcing inputs and products produced in sustainable ways (for example, with low greenhouse gas emissions) companies are able to further address their own operational, regulatory and reputational risks and consumer and investor demands. Suppliers are incentivised to implement emissions reduction activities and targets to ensure this part of the market is still open to them (CDP 2018).

CDP is an organisation that runs a global disclosure system enabling companies to report environmental data (on climate, water and forest related issues). They also facilitate transparency in global supply chains by enabling participating companies to request climate-related disclosures from potential suppliers. In 2019, 115 global companies representing US$3.3 trillion of procurement spend made disclosure requests to over 11,500 suppliers through CDP, including Telstra (CDP 2018).

A survey of the companies procuring through the CDP found that 47 per cent of the supply chain members had supply chain emissions reduction targets in place (CDP 2018).

As technology evolves, transparency and tractability of supply chains will continue to improve, including the potential use of global supplier databases and comprehensive supplier performance assessments. Buyers will be able to better assess climate related risks in their supply chains. This is likely to place increasing pressure on suppliers to have emissions reduction plans and climate-related risk disclosure reporting in place so they are not excluded by buyers on the grounds of environmental performance and risk (Ernst and Young 2016).

4. TECHNOLOGY DEVELOPMENTS

Technological development of new processes and products can help reduce greenhouse gas emissions without reducing economic activity. New technologies are expected to be pivotal in transitioning the economy to a low-emissions future.

Technological advances can enable current products to be produced in a low-emissions manner, either through improved or more efficient processes. For example, renewable energy generates electricity without the emissions associated with conventional fossil fuel electricity generation. Technology can also capture and store emissions arising from existing processes and products. Carbon capture and storage technologies, for instance, have the potential to significantly reduce the emissions associated with the production of liquefied natural gas (LNG), as well as other high-emissions processes. Finally, technological development can lead to new, alternative products that replace emissions-intensive products. For example, engineered wood products can replace emissions-intensive steel in building construction (Wood Solutions n.d.).

New technologies require investment in research, development and deployment. Both industry and government have a role in supporting this research. Investment by private companies is motivated by profit, driven by the factors outlined in Chapter 3. Among these drivers is minimising energy costs. Dechezleprêtre (2016) found a strong correlation between the number of patents for low-carbon technologies and the price of oil, which is strongly correlated to the price of other fossil fuels. Investment is also driven by a desire to gain a competitive advantage in the rapidly expanding low-emissions global economy.

Government also has a very important role in supporting the development of new technologies. Research and development is recognised as a public good, where private investors are unable to fully capture the returns from investment, leading to underinvestment. Government therefore has a role in filling the gap to realise optimal levels of investment in research and development. The Australian Government has a number of initiatives to support research, development and deployment of low-emissions technologies, including partnering with industry through the Australian Renewable Energy Agency (ARENA) and the Clean Energy Finance Corporation (CEFC). Australia is a participant in Mission Innovation, a group of governments of 23 countries and the European Commission working to accelerate clean energy innovation. The initiative was launched alongside the Paris Agreement in 2015 and the group has committed to double public investment in clean energy research, development and demonstration over five years and work to increase investment by the private sector (Mission Innovation 2019).

Investment in low-emissions energy technologies is increasing, both by governments and the private sector. The IEA estimates global government funding for research, development and demonstration (RD&D) for low-emissions energy technologies was US$21.6 billion in 2017, 13 per cent higher than in 2016. Publically reported investment by established private companies has steadily increased from US$43.9 billion in 2012 to an estimated US$58.0 billion in 2017. An additional US$2.5 billion was estimated to have been directed to venture capital funding for clean energy start-ups in 2017 (IEA 2018).

Research and development of new low-emissions technologies does not however, always result in emissions reductions. Other conditions are required to realise emissions reductions by commercialising

technologies. Pilot sites and overcoming information barriers are often needed to commercialise new technologies. Incentives for uptake are also critical (Nathan et al. 2019).

For example, carbon capture and storage (CCS) technologies have been the focus of research, development and deployment projects funded by both industry and government over a number of decades (World Coal Association 2019). CCS is a process where carbon dioxide produced through industrial processes or the generation of electricity using fossil fuels is prevented from entering the atmosphere. The emissions are captured and stored underground in geological rock formations or used for industrial processes (World Coal Association 2019). Globally, there are 18 large scale CCS demonstration projects (Global CCS Institute 2018). Widespread adoption in Australia is limited by a lack of incentives to reduce emissions rather than technology gaps (Minerals Council of Australia 2019, Greig et al. 2016). Industry also notes further work is required in characterising storage sites and aligning legal and regulatory frameworks (Minerals Council of Australia 2019).

Development of carbon dioxide capture technologies (capturing the gas directly from the atmosphere) is also progressing independently of emissions producing industries. Direct air capture systems use large fan arrays to pump air past chemical absorbents that selectively absorb CO_2 from the atmosphere (Geoengineering Monitor 2018). The absorbents are then removed and subjected to treatments that reverse the absorption reaction, releasing the CO_2. The released CO_2 is usually high concentration and high-purity and could be used for other industrial purposes, or stored underground. This technology faces challenges to deployment primarily due to high energy usage (Geoengineering Monitor 2018, National Academies of Sciences, Engineering and Medicine 2018).

As Australia often imports new technologies, global technology advances enables Australian businesses to lower their emissions profiles. Australian research and development also remains an important part of government and industry action to address climate change. Research helps to implement new technologies in Australian conditions, and also address challenges of particular relevance to Australia such as in the mining industry. Australia's black coal industry is investing in the development of low-emissions technologies for the coal-fired power generation sector and emissions reduction technologies for coal mines through COAL21. COAL21 was established in 2006 and most projects to date have focused on carbon capture and storage technologies (COAL21 2018). Australian research efforts also contribute to international developments. For example, the founder of Suntech, a leading solar manufacturer operating in China, was part of the UNSW solar research team. Suntech capitalises on the low labour costs in China to produce solar cells at scale and realised significant cost reductions as a result. Within two years of operation, Suntech had almost halved the cost of production from $5 per watt to $2.80 (Knight 2011). Australia is a key market for Suntech solar cells (Suntech n.d.).

As well as supporting current industries, new technologies have the potential to lead to the development of new or growing economic activities. Box 7 summarises two potential growth areas for Australia.

Box 7 New and growth industries in Australia for a low-emissions economy

Hydrogen

The global push to reduce emissions, coupled with recent advances in hydrogen generation and transport technologies, represent an opportunity for Australia to become a major exporter of low-emissions energy. Hydrogen can be produced using renewable energy or fossil fuels. Australia has a natural advantage in producing hydrogen energy with an abundance of both renewable energy and low-cost fossil fuel resources adjacent to carbon sequestration sites for carbon capture and storage (Finkel 2018).

Demand for imported hydrogen from Japan and other countries such as South Korea is expected to grow strongly in the future and Australia has begun positioning itself as a major supplier (Hydrogen Strategy Group 2018, HESC 2019). The Australian Government is supporting the development of a hydrogen industry through the National Hydrogen Strategy (COAG Energy Council 2018) and ARENA is providing funding support for demonstration projects (ARENA n.d.a.). Private industry is also providing in-kind support to a government funded demonstration trial to convert Victorian brown coal into liquid hydrogen for export using carbon capture and storage technology in the production process (Macdonald-Smith 2018b).

Battery-related industries

Batteries are expected to be a growth area as the economy becomes more electrified (through the use of electric vehicles for example) and there is a greater use of intermittent electricity generation that drives a need for energy storage. The production of batteries requires a range of metal and mineral inputs, which Australia is well placed to supply with a significant share of the world's known reserves of most of the key battery materials. Metals required for the production of batteries include lithium, graphite, nickel, cobalt and, manganese. One projection of global demand for lithium shows growth from around 250,000 tonnes lithium metal equivalent in 2018 to over 2,250,000 tonnes in 2025 (a nine-fold increase in 7 years). Most of this growth is projected to come from electric vehicles and batteries for electricity storage by utilities and end users. The cost of lithium-ion batteries has declined from around US$1000/kWh in 2010 to US$200/kWh in 2017 and cost declines are expected to continue. Australia supplied over 60 per cent of world lithium by value in 2017, worth $1.13 billion. This is projected to grow to $10.1 billion by 2025. Some have proposed further economic benefits could be realised with the development of more of the supply chain in Australia (Regional Development Australia 2018).

5. ELECTRICITY GENERATION

5.1. Sector overview

In 2016–17, a total of 929 petajoules of electricity was generated in Australia, 88 per cent of which was generated by the electricity sector and the remaining produced either by roof-top solar or off-grid generation (Australian Government DoEE 2018b). Black coal is the major fuel source for generation (46 per cent), followed by gas (20 per cent), brown coal (17 per cent), hydro (6 per cent), wind (5 per cent) and solar (3 per cent) (Australian Government DoEE 2018b). The primary uses of electricity are in the commercial services, manufacturing and mining sectors, as well as in the residential sector (Australian Government DoEE 2018b).

Electricity generation is the largest source of Australia's emissions, accounting for 36 per cent of emissions in 2017 (189.8 Mt CO_2-e) (Table 1). Australia's electricity sector emissions have declined by 10 per cent since their peak in 2009 (Australian Government DoEE n.d.). The decline is expected to continue. Australian Government projections indicate electricity sector emissions would decrease by 7 per cent between 2018 and 2020 and 11 per cent between 2018 and 2030 (Australian Government DoEE 2018a). These reductions are expected due to expanding renewable generation driven by federal and state renewable energy policies and declining costs.

Low-emissions electricity generation is likely to facilitate emissions reductions in other sectors of the economy, including through the electrification of processes that have previously been fuelled by other forms of energy. For example, a shift to electric vehicles combined with low-emissions electricity generation could significantly reduce emissions from the transport sector.

Australia's electricity generation and retail markets are concentrated primarily in three companies — AGL, Origin and EnergyAustralia. These companies account for 46 per cent of generation capacity and supply over 60 per cent of the retail market in the National Electricity Market (Australian Energy Regulator 2018).

5.2. Emissions reduction commitments

The three largest electricity generating companies in Australia have long-term emissions reduction commitments and participate in global reporting initiatives. For example:

- AGL has adopted a range of policies to gradually decarbonise by 2050 The company also adopted reporting and engagement commitments as part of the international We Mean Business initiative, initiated by CDP (Box 4) (AGL 2018).
- Origin has committed to halve scope 1 and 2 emissions and reduce scope 3 emissions by 25 per cent by 2032. Origin developed these targets and associated emissions reduction policies under the Science Based Targets initiative methodology (Box 4) and is also a member of the We Mean Business initiative (Origin 2018).
- EnergyAustralia's parent company, CLP Group, has a commitment to reduce the emissions intensity of its operations by 80 per cent by 2050, compared with 2007 levels. The Group reports in line with the Greenhouse Gas Protocol, a widely used international framework for measuring and managing greenhouse gas emissions, and CDP (Box 4) (CLP Group 2018a).

All three companies have also implemented reporting practices in response to the TCFD recommendations (EnergyAustralia is reporting through its parent company, CLP Group).

5.3. Current approaches to reducing emissions

As part of meeting emissions reduction commitments, and also in response to current and expected government policies, the three largest electricity companies are changing their electricity generation mix away from emission-intensive fossil fuels and making greater use of renewable energy sources. Origin has committed to removing coal-fired generation from its generation portfolio by 2032 (Origin 2018). AGL has made a commitment not to increase its current holdings of conventional coal-fired power stations and to close all existing coal-fired power stations by 2050 (AGL 2018). EnergyAustralia is also phasing out coal-based generation assets (CLP Group 2018b). The restriction of finance from major lenders for coal-fired power plants is expected to have influenced the general shift away from coal-fired generation (Yeates 2018).

The three companies also incorporate internal carbon pricing into their planning and investment decisions to help them manage risks associated with potential future climate policies (AGL 2018, Origin 2018, EnergyAustralia, pers. comm 2019).

Origin is also reducing emissions associated with its own energy use. In 2017–18, 100 per cent of the electricity purchased for its offices in Sydney, Brisbane and Adelaide was GreenPower. It also has a target to procure 100 per cent of energy from renewable sources for all of its offices and, where possible, all of its other operations by 2050 (Origin 2018).

Electricity retailers are also enabling emissions reductions through the provision of products and services to their customers. Many electricity companies offer green energy products or services as add-ons to customers' electricity contracts. For example, EnergyAustralia offers its customers the option to opt into a no-cost, certified carbon-neutral product where EnergyAustralia purchases carbon offsets on their customers' behalf to offset their electricity emissions (EnergyAustralia n.d.).[11] Electricity retailers offer feed-in tariffs for rooftop solar systems and advise customers on energy efficiency improvements. Some of these initiatives are motivated by government programs, such as the Retailer Energy Efficiency Scheme in South Australia (ESCOSA n.d.). Some retailers (such as Powershop, Origin and AGL) allow customers with smart meters to view detailed energy consumption data online or through mobile phone apps. This information assists customers to reduce or manage energy consumption (Potter n.d.).

Smaller generators are also taking actions in response to climate change risk to varying degrees. For example, Delta Electricity, an electricity generator with a coal-fired power plant, is investing in a range of renewable generation. It uses biomass fuels (forestry bi-products) for co-firing at its Vales Point facility, reducing greenhouse emissions by up to 20,000 tonnes each year (Delta Electricity n.d.a). The firm is also planning to invest in a large scale solar farm at Vales Point and a pumped-hydro project near Port Augusta (Delta Electricity n.d.b, c). Delta's Vales Point facility is the site of a pilot post-combustion carbon capture plant, which is used by research facilities to test carbon capture technologies under operational conditions (Delta Electricity n.d.d).

[11] The carbon neutral product is certified under the National Carbon Offset Standard.

A number of smaller electricity retailers are focused on renewable energy. Two examples are Powershop and Diamond Energy, retailers associated with renewable energy generators committed to providing customers with renewable electricity (The Green Electricity Guide n.d.). Powershop is certified as 100 per cent carbon neutral under NCOS by offsetting emissions associated with company and customer electricity use (Powershop n.d.).

5.4. Further opportunities for emissions reductions

5.4.1. Improvements in current electricity generation approaches

Current options to reduce emissions from electricity generation mostly centre on the use of renewable energy sources. Technologies with high uptake due to recent technological advancements are wind and solar photovoltaics. Solar photovoltaic efficiency has increased rapidly in recent years while costs have fallen dramatically. The efficiency of solar panels has increased from 6 per cent in 1954, to over 20 per cent in 2018 and tests in laboratories have achieved efficiencies of 45 per cent (Matasci 2019). At the same time, solar photovoltaic panel prices declined 60 per cent between 2009 and 2019 (Matasci 2019). This is due in part to the scale up of manufacturing, particularly in China, where 60 per cent of all solar cells were made in 2017 (Buckley et al. 2018). Solar photovoltaic technology is in a constant state of innovation and efficiencies and cost reductions are expected to continue as new materials are introduced and economies of scale are increased (CSIRO 2019). Some forecasts show that the costs of an average solar photovoltaic plant, based on levelised costs of electricity generation, is expected to fall 71 per cent between 2018 and 2050 (BloombergNEF 2018).

Wind technology has also advanced rapidly and hub height and rotor length increases have generated increased efficiencies and cost reductions. In Australia, General Electric will build the world's tallest offshore wind turbines at 260 metres for the proposed $8 billion, 2000 MW project, The Star of the South, off the coast of Victoria (Latimer 2018).

Bioenergy is another demonstrated low-emissions electricity generation technology. Although it currently contributes 1.4 per cent of Australia's electricity generation (Australian Government DoEE 2018b), there is potential for further investment in bioenergy production in Australia (CEFC 2015). The largest source of bioenergy in Australia is bagasse (sugar cane pulp). Bioenergy can also be produced using biogas from landfill and wastewater.

Continued technology development will play a major role in creating further opportunities to reduce emissions in the electricity generation sector. A low-emissions electricity sector will also enable emissions reductions in other sectors. Innovation and planning will also be important to support a changing electricity grid (Box 8).

Box 8 Managing the electricity system

Emissions reductions in the electricity sector are primarily resulting from the increased use of non-synchronous renewable electricity generation. The withdrawal of synchronous thermal generation and increased penetration of non-synchronous generation in Australia's electricity grids reduces the amount of inertia in the system. Lower levels of inertia in the grid generates new challenges for managing the security of the electricity system (AEMC 2017).

Inertia and frequency control can be provided by renewable energy systems such as hydroelectricity, and storage systems including pumped-hydro storage and fast response batteries. Investing in these technologies will help to maintain system security with increased renewable electricity generation (AEMC 2017).

Ensuring the security of the electricity system with increasing levels of renewable generation will enable emissions reductions in the rest of the economy through electrification.

5.4.2. Energy storage

Electricity storage technologies help address the intermittency of wind and solar generation by storing energy for use when electricity is demanded. This addresses a key concern with the extensive roll out of intermittent renewables.

A number of different technologies for energy storage are available and each work at different scales and locations and have different applications. The choice of energy storage technology is likely to be based on the nature of energy storage needs and also the efficiency, and capital and unit costs of operation.

Battery storage technology has improved rapidly in recent years and costs have fallen (Stock 2018). These developments are expected to continue and electric vehicles and home storage solutions are expected to be deployed widely in the next few decades. For example, over 70,000 Australian households are expected to install batteries in 2019 to support roof top solar installations (BloombergNEF 2019). Batteries are increasingly being used for grid storage in Australia as they have the capacity to respond very quickly to critical peak demand. The first utility-scale battery in Australia is a 100MW lithium-ion battery installed at Hornsdale in South Australia to provide network security services. The battery is owned by Neoen and received financial support from the South Australian Government (Neoen 2018). A utility-scale battery has also been installed at Ballarat, Victoria, which is located in an area of the network where the output of solar and wind was constrained by network capacity. The project is owned by Ausnet and supported by the Victorian Government and ARENA. The battery will help ease constraints on transmission lines in Western Victoria and improve the stability of the grid (ARENA 2018a). While current applications have been supported by governments, utility-scale batteries may see wider adoption as technical, commercial and regulatory risks are addressed (Australian Energy Storage Alliance 2018).

Pumped-hydro projects can act as large-scale batteries and add a firming capability to renewable generation, providing grid security. Pumped-hydro projects can also provide inertia and frequency control services (Box 8). Pumped-hydro is used widely overseas, but currently there are only three systems in operation in Australia (Blakers et al. 2017). Box 9 summarises some pumped-hydro projects currently under consideration in Australia.

Box 9 Development of pumped-hydro projects in Australia

There are more than 20 pumped-hydro projects currently being assessed in Australia (Australian National University 2019). These include projects in South Australia, New South Wales, Victoria and Tasmania. The characteristics and benefits of each project differ.

For example, a project under consideration in South Australia will look to use seawater. South Australia has a high level of renewables penetration, but limited freshwater resources for conventional pumped-hydro energy storage projects. The proposed 'Cultana' pumped-hydro facility has a capacity of 225 MW, sufficient to power 120,000 homes for eight hours. Pumped-hydro energy storage using sea water has been employed overseas but not in Australia. This project could demonstrate the feasibility of further seawater-pumped energy storage in Australia. The project has been proposed by EnergyAustralia and Arup, with financial support from ARENA (ARENA 2017a).

Hydro Tasmania, with support from ARENA, has identified three sites for pumped-hydro energy storage projects in Tasmania and is continuing to investigate further sites (Hydro Tasmania 2018). Hydro Tasmania is looking to develop 2500 MW of storage capacity, more than doubling the existing generation capacity of Tasmania. The additional storage capacity would be used to support the transition of the National Electricity Market to low-emissions sources. The feasibility of these projects is dependent on the development of an additional interconnector between Tasmania and the mainland (Hydro Tasmania 2018).

The proposed Snowy 2.0 pumped-hydro project recently received government funding and planning approval for exploratory works. Once completed, Snowy 2.0 will provide 2,000 MW of dispatchable generation capacity and 350,000 MW hours of storage (Snowy Hydro n.d.). Further pumped-hydro projects could be developed in the Snowy scheme in the future. The central location of the Snowy scheme allows it to supply both the Victorian and New South Wales electricity markets and it also has the benefit of being located with existing water infrastructure and can build on the existing knowledge and expertise of the Snowy scheme (Snowy2.0 2017).

5.4.3. Emerging electricity generation technologies

Emerging or potential technologies to reduce the emissions associated with electricity include hydrogen and concentrating solar thermal.

Concentrating solar thermal uses lenses and reflectors to concentrate solar energy and uses it to heat water or oil that then produces steam to drive a turbine. The technologies have not realised the same cost reductions as solar photovoltaic in recent years. However, a key advantage of concentrating solar technologies is they have integrated storage and can produce dispatchable electricity. Advances in solar thermal technologies will likely focus on new materials that can store solar energy at higher temperatures and generate electricity for longer periods of time. Australia currently has two large scale solar thermal plants, in Kogan Creek in Queensland and one co-located with the Liddell coal-fired power plant in NSW (Clean Energy Council n.d.). Further use of the technology is currently limited by its higher costs compared with other renewable energy technologies.

As noted in the previous chapter, hydrogen is emerging as a low-emissions technology that can generate electricity in turbines or in fuel cells, which can produce electricity for the grid and for use in vehicles (Hydrogen Strategy Group 2018). The Australian Government is supporting further

development of a hydrogen industry in Australia (Box 7). Hydrogen technology can also provide storage through the production of hydrogen when electricity supply is high and demand is low. The hydrogen can then be used to generate electricity when electricity supply is low and demand is high. Alternatively hydrogen produced from surplus renewable electricity can be used in place of natural gas or as a transport fuel or chemical feedstock. A hydrogen demonstration project in South Australia includes facilities to supply electricity back to the grid (Plouffe 2019).

6. MINING, OIL AND GAS

6.1. Sector overview

The mining sector (incorporating coal mining, oil and gas extraction, and metal ore and non-metallic mineral mining and quarrying) is Australia's biggest export sector, accounting for 54 per cent of Australia's merchandise exports in 2016–17, and employing around 215,000 people (ABS 2018a, 2019a). The sector accounted for 7 per cent of Australia's GDP in 2016–17 and 36 per cent of the growth in GDP between 2015–16 and 2016–17 (ABS 2018b, 2019b).

In 2017, Australia's mining sector generated 80.7 Mt CO_2-e, or 15.2 per cent of Australia's total economic sector emissions. The sector also generated 18.9 Mt CO_2-e of indirect (scope 2) emissions from purchased electricity (Table 1). Most direct emissions arose from coal mining (33.8 Mt CO_2 e), and oil and gas extraction (38.6 Mt CO_2-e) (Australian Government DoEE n.d.).[12] Emissions are made up of fugitive emissions and emissions from the combustion of fuel. Fugitive emissions are gases that leak, are vented or flared during the extraction, production, processing, storage and distribution of fossil fuels. Combustion emissions are created from the on-site generation of energy and the use of vehicles.

Natural gas production in Australia has grown strongly since 2004–05, primarily driven by a rapid expansion of the liquefied natural gas (LNG) industry (Geoscience Australia 2019). The growing LNG industry is one of the primary drivers of recent increases in Australia's national greenhouse gas emissions (Australian Government DoEE 2019a).

6.2. Sector emissions reduction commitments

Many of Australia's large mining companies have set emissions reduction targets. For example, Rio Tinto has committed to substantially decarbonise its business by 2050 and reduce its global greenhouse gas emissions intensity by 24 per cent between 2008 and 2020 (Rio Tinto 2019). BHP has set a long-term goal of achieving net-zero emissions from global operations in the second half of the century, and this is supported by shorter, five-year emissions reduction goals (BHP 2019).

Oil and gas producers have also set targets for improvements in energy efficiency or emissions. ConocoPhillips has a target to reduce the emissions intensity of its operations by 5 to 15 per cent between 2017 and 2030 (ConocoPhillips 2017); Woodside has a target to improve energy efficiency by 5 per cent between 2016 and 2020 (Woodside 2019); and Santos has a target to reduce emissions by more than 5 per cent across existing operations in the Cooper Basin and Queensland by 2025 (Santos 2019). Shell has a global ambition to reduce the net carbon footprint of their energy products to half of 2016 levels by 2050 and by 20 per cent by 2035 (Shell 2019).

On 20 February 2019, Glencore announced it would prioritise capital investment towards commodities essential to the transition required under the Paris Agreement and limit its coal production capacity to current levels (Glencore 2019). Glencore is Australia's largest coal producer and made the announcement after engagement with signatories to the Climate Action 100+ initiative (Chapter 3).

[12] For coal, oil and gas, emissions also arise from the burning of the fuels. Theses emissions are attributed to the sector burning the fuel, not the resource industry.

A number of large mining companies with operations in Australia have made public statements in support of implementing climate change policy in Australia. For example, Rio Tinto, Woodside and BHP have all called for the introduction of a carbon price in Australia (Morgan 2018).

Some companies in this sector are already subject to Government policies, such as the safeguard mechanism, which requires facilities to keep net emissions at or below baseline emissions levels. The Emissions Reduction Fund also provides opportunities to generate Australian Carbon Credit Units by managing coal mine waste gas, and improving electricity and fuel efficiency of operations. An Emissions Reduction Fund method is available to oil and gas producers for reducing fugitive emissions, but it has not been used (CER 2019a).

Some large facilities are also subject to requirements to reduce, or offset, emissions as part of their project approval processes at the state government level. For example, to meet licensing requirements for its Darwin liquid natural gas plant, ConocoPhillips supports the West Arnhem Land Fire Abatement Project. This project provides funding for Indigenous land owners to manage the landscape in Western Arnhem Land in ways that reduce emissions from savanna fires (ConocoPhillips n.d.). As part of its operating conditions for Gorgon, Chevron is required to capture and store 80 per cent of the carbon dioxide emissions from gas processing from Gorgon from the commencement of operations in 2017. Technical issues have delayed the storage project and to date no carbon dioxide has been stored (Mercer and Milne 2018).

6.3. Current approaches to reducing emissions

6.3.1. Reducing emissions from oil and gas production

Natural gas producers are seeking efficiencies to drive down costs, and investing in renewable energy and energy efficiency improvements that help reduce operational emissions (Santos 2019). Woodside emitted 10 Mt CO_2-e in Australia in 2017–18 and its operations include the North West Shelf and Pluto gas fields (Clean Energy Regulator 2019b, Woodside 2019). Woodside reported a 3.4 per cent improvement in energy efficiency between 2016 and 2018 and a 16.3 per cent reduction in flaring between 2017 and 2018, which helped reduce emissions (Woodside 2019). Chevron's Australian operations emitted 12 Mt CO_2-e in 2017–18 (Clean Energy Regulator 2019b). Chevron has implemented efficiencies at its Gorgon and Wheatstone operations by reducing flaring, recovering gas and reducing leakage. It has set a target to reduce flaring per unit of production by 25 to 30 per cent between 2016 and 2023. It also has a target to reduce methane emissions by 20 to 25 per cent over the same period (Chevron 2019).

6.3.2. Reducing fugitive emissions from coal mines

Fugitive methane released from underground coal mines can be converted to carbon dioxide through flaring or flameless oxidation, or captured for use in electricity production. Most methane, however, is emitted with ventilation air (Yonggang and Shi 2018). Mine operations that convert the methane to carbon dioxide are eligible to generate Australian Carbon Credit Units under the Emissions Reduction Fund. As of February 2019, 16 projects of this type were registered under the Fund (CER 2019a).

6.3.3. Reducing emissions from energy use

To help meet emissions reduction targets, companies in this sector are looking to improve energy efficiency of their operations and increasing their use of renewable energy and energy storage technologies (Box 10).

Box 10 Renewable energy in mining, oil and gas operations

Mines using renewable energy

South32 installed a 3 MW solar farm to power its accommodation, airport and silver and lead production operations in Cannington, Queensland and is expected to reduce emissions by between 4 and 6 kilotonnes a year (South32 2017). GMA Garnet signed a long-term power purchase agreement for wind and solar generated electricity for its garnet mine in Western Australia (GMA Garnet 2017).

Renewable energy for oil well pumps

Santos is reducing emissions from its oil well operations in the Cooper Basin by converting 56 crude oil well pumps to solar and battery power. Using renewable energy instead of oil allows the oil to be available for sale. The $16 million trial project includes a $4.2 million grant from ARENA as the next step to commercialising the technology (Santos 2018, ARENA n.d.b.).

Other initiatives helping to reduce emissions in the sector include the use of electric vehicles and batteries. BHP are trialling the use of electric light vehicles at their Olympic Dam operations in South Australia to reduce diesel use (BHP 2018). The initiative is expected to lower operating costs and reduce employee exposure to diesel particular matter in addition to reducing emissions. Woodside has established a micro-grid, including a 1 MWh battery, at its Goodwyn A facility off the coast of Western Australia to optimise its gas-powered electricity generation and use. The system enables Woodside to use fewer gas generators and operate at lower costs, as well as reducing emissions (Woodside 2018).

6.3.4. Reducing scope 3 emissions

Some companies in the sector are also working towards reducing scope 3 emissions associated with their operations. For example, BHP is working with customers, suppliers and other members of the value change to reduce emissions from the use and transport of its products. Several resource companies have come together to invest in the development of a low-carbon bulk shipping route from Australia to China (Box 11).

Box 11 Fuelling a green corridor of shipping between the Pilbara and China with LNG

Australia's mining industry is investing in the development of LNG powered bulk carriers for transporting iron ore and coal. These ships could reduce costs and also emissions of carbon dioxide, sulphur and particulate matter.

The "Green Corridor" project is a joint industry partnership including mining companies BHP Billiton, Fortescue Metals Group and Rio Tinto, ship owners MOL and U-Ming, ship designer SDARI, and LNG suppliers Shell and Woodside Petroleum. The project is investigating the potential to use LNG to fuel iron ore bulk carriers between the Pilbara in Western Australia and China (DNV GL 2018). This project is partly in response to an International Maritime Organisation requirement to reduce sulphur emissions by 2020. To highlight its improved environmental outcomes, the plan includes the aim to label future LNG-fuelled carriers operating on this route as the Green Corridor.

The technology being developed could be applied to ships carrying a range of cargo, including iron ore and coal. If the project is successful, it could open up a new market for LNG as a bunker fuel, potentially providing a boost to Australia's LNG industry. It has the potential to significantly reduce emissions from bunker fuels as LNG can reduce greenhouse gas emissions by up to 25 per cent when compared to diesel. It could also improve environmental outcomes as LNG-powered ships emit very low levels of particulates and sulphur (MacDonald-Smith 2017).

6.4. Further opportunities to reduce emissions

The coal industry is investing in a range of projects to increase opportunities for the reduction of fugitive methane from coal mines. For example, the COAL21 initiative is investing in the development of low-emissions technologies for coal-fired power stations and coal mines. COAL21 is supported by a voluntary levy on coal production and includes 26 investors from Australia's black coal industry. It has received $374 million of commitments to June 2018 (Coal21 n.d.a.). Among its investments, COAL21 has funded the Centennial Coal methane reduction demonstration project that aims to enable the safe connection of Ventilation Air Methane abatement technology at an operating underground coal mine (Coal21 2018). The project will undertake intermediary studies before considering options for a full-scale demonstration which ultimately aims to oxidise the methane to achieve up to a 98 per cent reduction in the methane released from the mining operation (Coal21 n.d.b).

The Oil and Gas Climate Initiative, which includes some companies operating in Australia, provides for international industry collaboration on actions to reduce emissions and includes a $1 billion climate investment fund for low-carbon technologies (Oil and Gas Climate Initiative 2018). There is also a World Bank initiative to eliminate routine flaring by 2030. Australian emissions from venting and flaring from oil and gas production were 16.3 Mt CO_2-e per year in 2017 (Australian Government DoEE n.d.).

7. MANUFACTURING AND INDUSTRIAL PROCESSING

7.1. Sectoral overview

In 2016–17, manufacturing contributed nearly 6 per cent of Australia's GDP and over $100 billion to merchandise exports (ABS 2018a, b, 2019b). It employed around 894,000 people in May 2017 (ABS 2019a).

In 2017, the manufacturing sector, which includes industrial processing, was responsible for 53.7 Mt CO_2 e, or 10 per cent of Australia's emissions (Table 1). Electricity use by the sector indirectly accounted for a further 48.9 Mt CO_2-e, or 26 per cent of Australia's electricity use emissions.

Emissions from manufacturing and industrial processes arise from energy use and processing of metals, minerals and chemicals.[13] A large component of emissions is the use of industrial heat. This was responsible for 8 per cent of Australia's total emissions according to research by Beyond Zero Emissions (2018). Most of this was through use of natural gas (Australian Government DoEE 2018b).[14] By industry, key sources of emissions are the production of cement, iron and steel and aluminium, and the use of halocarbons (Australian Government DoEE 2019b).

Across the sector as a whole, total direct (scope 1) and indirect (scope 2) emissions in 2017 were 16.8 per cent lower than in 2005 (Australian Government DoEE n.d.). Australia's economy is moving away from energy-intensive manufacturing to more specialised, advanced manufacturing (Australian Government DoEE 2017). This has been cited by ClimateWorks as one reason for the reduction in manufacturing emissions (ClimateWorks Australia 2018).

7.2. Sector-wide action

The peak bodies and industry groups representing metals and minerals processing companies in Australia advocate for global action on climate change and economy-wide technology neutral measures that minimise adverse impacts on trade-exposed industries.[15] The Australian Industry Greenhouse Network outlines principles that include government policies to support first-of-a-kind technologies and equitably share the burden of reducing emissions (AIGN n.d.).

A number of companies in the manufacturing sector have committed to reporting under the Task Force on Climate-related Financial Disclosures (TCFD) framework. Of these, several ASX 100 companies operating in the industrial processing sector (Rio Tinto, Alumina Ltd, Bluescope, Boral) have emissions targets, although they are intensity targets rather than targets for absolute reductions in emissions (Market Forces 2019).

[13] A range of production processes generate emissions including the use of carbonates (e.g. limestone, dolomite, magnesite); carbon when used as a chemical reductant (e.g. iron and steel or aluminium production); chemical industry processes (e.g. ammonia and nitric acid production) and the use of synthetic gases such as halocarbons (Australian Government DoEE 2019b).

[14] Manufacturing used 390 PJ of natural gas in 2016–17, excluding natural gas used to produce electricity on-site (Australian Government DoEE 2018b).

[15] Australian Industry Greenhouse Network, Minerals Council of Australia, Cement Industry Federation, Australian Aluminium Council, Australian Steel Institute submissions to the Climate Change Authority's review of the National Greenhouse and Energy Reporting legislation.

Some manufacturing and processing companies are also subject to the safeguard mechanism, which requires facilities to keep net emissions at or below baseline emissions levels.

7.3. Current approaches to reducing emissions

Emissions reductions in the manufacturing and industrial processes sector can be achieved through:

- improved energy efficiency of assets, such as plant and equipment
- electrification of industrial equipment and processes
- switching to lower-emissions fuels
- implementation of best practice to reduce emissions from industrial process

Some initiatives in key parts of the manufacturing sector are outlined below.

7.3.1. Aluminium production

Emissions from alumina and aluminium production arise from energy use as well as the chemical reaction in the production process, which produces perfluorocarbons — greenhouse gases with very high global warming potential.

The Australian Aluminium Council states that since 1990, emissions intensity has been reduced by 23 per cent for alumina production; 62 per cent for direct (scope 1) emissions from aluminium smelting; and 12 per cent for indirect (scope 2) emissions from aluminium smelting (Australian Aluminium Council n.d.). The 62 per cent reduction in emissions intensity from smelting is mainly due to improvements in the smelting process greatly reducing emissions of perfluorocarbons. This trend has occurred globally (World Aluminium 2016). In the period from 2005 to 2017 there has been a 39 per cent reduction in emissions per tonne of aluminium produced in Australia (Australian Government DoEE 2019b).

Box 12 Reducing emissions and lowering emissions intensity in aluminium production

The Kwinana alumina refinery in Australia, operated by Alcoa, has a production capacity of 2.2 million tonnes of alumina per year and is actively improving efficiency and reducing emissions. The refinery captures carbon dioxide that would normally be released to the atmosphere and locks it up by using it to neutralise bauxite residue from the refining process. The project is estimated to be reducing emissions by 70,000 tonnes of CO_2 a year (Alumina Limited n.d.).

Low-carbon aluminium

Rio Tinto has created a low-emissions brand of aluminium which is produced using special anode technology and renewable energy. Rio Tinto states that RenewAl is available from its Tasmanian smelter and is third-party certified to have been produced with 4 t CO_2 per tonne aluminium (scope 1 and scope 2 emissions) compared with an industry average of 11.5 t CO_2 (Rio Tinto 2016).

Alcoa is also continuing to develop smelting cell control technologies to further reduce perfluorocarbon emissions from its aluminium smelting operations globally (Alumina Limited n.d.).

7.3.2. Iron and steel production

Most steel produced in Australia uses blast furnaces with emissions arising from energy use and from the reaction between coal, coke and iron ore. There are currently two blast furnaces operating in Australia, BlueScope's Port Kembla steel works and Liberty's Whyalla steel works. Liberty's parent company, GFG Alliance, have stated they have plans to investigate the feasibility of a new steelworks in Whyalla (Australian Steel Stewardship Forum n.d., S. Vorrath 2018, Liberty 2018).

In 2018, BlueScope announced a Power Purchase Agreement (PPA) to offtake energy from a solar farm to help power the Port Kembla steelworks. This is equivalent to 20 per cent of BlueScope's total Australian electricity purchases (Bluescope 2018). At the Whyalla Steelworks in South Australia, there are plans to invest in renewable energy through the Cultana Solar Farm (SIMEC Energy Australia 2018).

Steel is produced at three electric arc furnaces in Australia operated by Liberty and ComSteel (Australian Steel Stewardship Forum n.d., Liberty 2018, Kirkwood 2018). This type of furnace can be operated when cheaper power is available and is mainly used for recycled steel. Producing steel from scrap iron prevents 0.44 t CO_2-e for every tonne recycled (NSW Government DECCW 2010). Using renewable energy can further reduce emissions from this type of furnace.

7.3.3. Cement production

Cement is made from a mixture of clinker, which acts as a binder, and other minerals. Over half of the emissions from cement production arise from the chemical process used to produce clinker. This involves heating ground limestone with other materials at very high temperatures releasing carbon dioxide. The remaining emissions are from heating the kilns and electricity use (Mineral Products Association Cement n.d., Cement Industry Federation 2017).

The Australian cement industry states that it has reduced the emissions intensity of its products by over 20 per cent since 1991 (Cement Industry Federation n.d.) Improvements in industry practices, such as

the recycling of cement kiln dust, have resulted in this improved emissions intensity (Australian Government DoEE 2019b).

In 2016–17 over 10 per cent of all fuels used in the Australian cement industry were alternative fuels derived from waste products with lower emissions intensities compared with conventional fossil fuels (Cement Industry Federation 2017). Alternative fuels include used oil, demolition timber and solvent-based fuels. There is scope to increase use of alternative fuels and renewable electricity in cement production in Australia (Mineral Products Association Cement 2013, Cement Industry Federation n.d.b.).

The international Cement Sustainability Initiative identifies a reduction of the clinker to cement ratio as a key way to reduce emissions from cement production (IEA & CSI 2018). This can be achieved through the use of alternative materials such as fly ash and slag in place of clinker. In Australia, Boral is investing in lower-carbon concrete, such as ENVISIA, with higher levels of alternative materials (Boral n.d.). There is opportunity for higher substitution of clinker with fly ash in Australia (Millington 2019), although there are regulated limits on the amount of fly ash that can be used for some cement applications, such as for road surfacing (Roads and Maritime Services (NSW) 2018).

7.3.4. Other manufacturing

Other manufacturing operations are investing in renewable energy to lower costs and emissions (Box 13). For example, Sun Metals zinc refinery commissioned a 116 MW solar farm in north Queensland. The solar farm will provide one third of the business electricity needs (Climate Council 2018b). An example of a smaller manufacturing enterprise switching to renewables is Dobinson's Spring and Suspension that invested in a 517 kW solar system in response to electricity costs increasing over 250 per cent in the past ten years (Climate Council 2018b).

Box 13 Improving energy efficiency in manufacturing

The Australian chemical manufacturing company, Tri-Tech Chemical Co, won the Energy Efficiency Council's 2015 award for industrial energy efficiency for its combined energy efficiency and renewable energy project (EEC 2015). The company makes around fifty different chemical products for mining, agriculture, lubricants and other industries. It is focusing on using renewable alternatives to petrochemicals in lubricants (TriTech n.d.a).

After discovering inefficiencies in the processing plant through an audit of the company's energy use, energy consultants Genesis Now led a project to improve the company's energy efficiency and install a 60 kW solar array.

The project included installing variable speed drives on an air compressor, fan motors and cooling tower. A faulty steam trap that was found to be costing the company nearly $10,000 in wasted natural gas each year was repaired. The project also included improvements to lighting and insulation of boilers and pipes (TriTech n.d.b).

Tri-Tech Chemical Co was able to identify far greater improvements to energy use than expected. While maintaining production, total electricity use declined by 34 per cent and electricity from the grid declined by 54 per cent with the use of on-site solar. Natural gas use declined by just over 15 per cent (Genesis Now 2015). Tri-Tech Chemical Co estimated it has saved around $30,000 per year and 200 t CO_2-e (Hume City Council n.d.).

7.4. Further opportunities to reduce emissions

There are emerging industrial processing technologies for metals, minerals and chemicals that could be adopted by Australian companies in the future to reduce emissions. These technologies tend to focus on modifying processes so that they can occur at lower temperatures or using a lower emissions feedstock. Creating more efficient industrial processes can reduce energy costs and emissions. Some examples of these technologies are presented below (IEA 2018).

There are opportunities to reduce emissions from industrial heat in manufacturing by switching from using natural gas to electricity or direct heat from renewables or burning waste such as biomass. The temperature at which industries require heat is an important variable determining which new technologies can be used — the higher the heat the harder it is to produce with low-emissions. Heat requirements below 500°C can be met with steam. This makes up half of global heat requirements and is open to a range of low-emissions technology options, including solar thermal and use of heat pumps (ARENA 2015). There is also promising new technology for generation of temperatures greater than 500°C using renewable energy (Box 14).

Box 14 Renewable high temperature industrial heat

A new Australian technology, resulting from research at the University of South Australia, combines renewable energy with a novel approach to energy storage — using rocks and phase change materials to provide heat up to 700°C. The system could also be used to pre-heat very high temperature processes, such as cement production. According to the researchers, the process is economically competitive and simple to run (University of South Australia 2019).

Lower emissions steel could be produced by swapping coal for a low-carbon reducing agent. For example, technologies based on using hydrogen gas instead of coal as a reducing agent are due to be piloted in Sweden between 2021 and 2024 (IEA 2018). Bio-coke from wood is another prospective reducing agent (Nathan et al. 2019).

Technologies are being developed to improve the efficiency of cells that convert alumina to aluminium, or to build cells using a material other than bauxite leading to reduced emissions (IEA 2018). For example, Alcoa and Rio Tinto have been developing a process for making aluminium that removes all direct greenhouse gas emissions from the aluminium smelting process and emits oxygen as its by-product (Alcoa 2017). This is considered a break-through for the industry. Research to commercialise the technology is happening in Canada.

Researchers at RMIT have developed a nano-enhanced material with the potential to significantly reduce the energy used for industrial heat for chemical manufacturing by directly using light energy to drive chemical reactions more efficiently (RMIT 2019).

There is also analysis that suggests there are opportunities for Australian manufacturing and industrial processing industries to do more in terms of improving the energy efficiency of operations. A report by the International Energy Agency shows that Australia's economy-wide energy efficiency has not improved since 2008 (IEA 2017). Climate Analytics, an international policy research organisation, states that in recent years Australia has not made gains in energy efficiency when compared internationally and that Australia ranks poorly when compared to the world's top 25 energy-consuming countries (Climate Analytics 2018).

8. BUILDINGS

8.1. Sector overview

The buildings sector includes the design, construction and management of commercial and residential buildings and collectively accounts for around 20 per cent of Australia's gross value added in 2016–17 (Australian Trade and Investment Commission 2019).[16] Australia's population is growing at just under 2 per cent per year and is contributing to increasing demand for new buildings in both the residential and commercial space (ABS 2019c).

In 2015–16, direct (3.2 per cent) and indirect (18 per cent) emissions from buildings represented around 21 per cent of Australia's total emissions (ClimateWorks Australia 2018) and accounted for around 20 per cent of Australia's energy use (Council of Australian Governments (COAG) Energy Council 2019). Indirect emissions are from grid-supplied electricity consumption, and direct emissions from direct fuel combustion of gas or wood for heating, hot water systems and cooking (ASBEC 2016).

There have been reductions in the emissions intensity of the sector, driven mainly by the uptake of renewable electricity and energy efficiency improvements of new buildings, lighting and appliances. However, reductions in emissions have been outpaced by emissions from new activity (ClimateWorks Australia 2018).

Emissions from direct combustion in buildings is projected to remain unchanged to 2030, but improvements to energy efficiency and adoption of renewable energy sources, means overall the sector is currently projected to achieve an 11 per cent emissions reduction by 2030 (Australian Government DoEE 2018a). Increased standards in new buildings, refurbishment of existing buildings and switching appliances that use gas and other fuels with electric alternatives are expected to drive this improvement (ClimateWorks Australia 2018).

8.2. Current approaches to reducing emissions

Multiple stakeholders in the sector influence action on emissions reductions relating to design, construction, operation and maintenance of buildings. These stakeholders are driven by cost concerns, compliance with regulation and growing investor demand for green infrastructure investment (ASBEC 2016).

Electricity consumption in buildings can be reduced by installing energy-efficient appliances and equipment and improving the design and insulation of buildings. Building management companies can switch the energy source of buildings from fossil-fuel to renewable electricity either by installing renewable generation such as solar PV on site or entering into power purchase agreements for electricity from off-site renewable generators.

Consumer demand for increased affordability of operating new and existing buildings is driving energy efficiency and environmental improvements to buildings. A survey of commercial tenants by Abacus Property Group, an ASX 200 listed real estate investment trust, found 91 per cent of tenants rated

[16] The construction sector accounted for 8 per cent, rental, hiring and real estate services accounted for 3 per cent and ownership of dwellings accounted for 9 per cent of gross value added.

environmental considerations as important to them. The property group identified improving environmental standards as key to tenant attraction and retention (Abacus Property 2018).

Government policy and regulatory frameworks have increased consumer awareness and underpinned emissions intensity reductions in Australian building construction and management. Consumer awareness programs include:

- Australian Government's National Australian Built Environment Rating System (NABERS), which is mandatory for large commercial office spaces[17]
- Commercial Building Disclosure (CBD) program that requires energy efficiency information to be provided in most cases when commercial office space of 1000 square metres or more is offered for sale or lease
- Nationwide House Energy Rating Scheme (NatHERS), which rates thermal performance of a home's construction
- YourHome, a residential building guide that includes information on utilising renewable energy systems and energy efficiency.

The Green Building Council of Australia (GBCA) operates Green Star, a voluntary, internationally recognised environmental rating system. There are four Green Star rating tools that cover design and construction of buildings, interior fitouts, operational performance of buildings and precinct-scale developments. Green Star rating tools award points across nine categories: energy, water, materials, indoor environment quality, transport, land use and ecology, management, emissions and innovation. Around 37 per cent of Australia's office space is Green Star certified, accommodating 5 per cent of Australia's workforce. Green Star have also rated 70 communities, which house around 420,000 residents (GBCA 2019).

The GBCA has identified a roadmap for commercial, institutional and government buildings and fitouts to reduce greenhouse gas emissions. The roadmap establishes a target that new buildings and fitouts must have no greenhouse gas emissions from their operation by 2030 and existing buildings and fitouts must have no greenhouse gas emissions from their operation by 2050 (Green Building Council Australia 2017).

The National Construction Code (NCC) sets out all performance requirements for on-site construction of buildings including equipment, heating and plumbing systems. The NCC 2019, includes a package of measures focusing on reducing energy consumption in new buildings by as much as 35 per cent and the inclusion of new verification methods to demonstrate compliance with the NABERS and Green Star rating systems (ABCB 2018).

The Australian Sustainable Built Environment Council (ASBEC), a peak body for organisations from the building sector, has advocated for changes to the NCC to enable a transition to a net zero economy by 2050 (ASBEC and ClimateWorks Australia 2018). The ASBEC co-authored a report on an industry led pathway to a zero carbon ready building code, which formed the basis of the recent findings of the COAG Energy Council's Trajectory for Low Energy Buildings (COAG Energy Council 2019). The Trajectory aims to inform the NCC 2022 updates and focuses on new buildings.

[17] Properties that achieve a 5 star (Excellent) out of maximum 6 star NABERS energy rating can deliver up to 9 per cent premium in property value (Ecovantage 2017).

Around 60 per cent of ASX 200 listed real estate companies provided detailed reporting on sustainability and climate risks (Australian Council of Superannuation Investors 2018) and many of them have emissions reductions targets (Box 15). These companies are driven in part by increased investor demand for green infrastructure investment opportunities in the burgeoning green bond market (Chapter 3) (Climate Bonds Initiative 2018). International benchmarks such as the Global Real Estate Sustainability Benchmark (GRESB), which assesses and benchmarks the environmental, social and governance performance of real assets, helps provide validated data to capital markets and enables real estate companies to attract green infrastructure investment (GRESB n.d.).

Actions taken by real estate companies to achieve their emissions reduction targets include electrifying appliances; installing LED lighting; procuring off-site renewable energy and storage; installing solar energy and batteries on-site; and reducing emissions from waste and waste water, and refrigerants from air conditioning equipment (ASBEC 2016).

One property group, Frasers Property Australia, has launched its own electricity retailer to deliver carbon neutral energy to its tenants (Real Utilities n.d.). Companies in the sector track their performance against targets under a number of voluntary initiatives including the Global Reporting Initiative and to the CDP (Box 4).

Large commercial tenants are also taking actions to reduce emissions from their operations. With a large number of stores across Australia, Coles and Woolworths have significant footprints in terms of their area occupied and associated emissions. Box 15 provides an overview of the actions they are taking to reduce emissions, along with Stockland Property Group.

Many premium commercial buildings have undertaken energy efficient upgrades and either have, or are moving towards, Green Star certification and high NABERS energy ratings. However, many mid-tier commercial buildings have not undertaken energy retrofits and have low or no NABERS rating. Mid-tier buildings generally have a diverse ownership profile, higher vacancy rates and shorter term leases. The business case for energy efficiency upgrades and retrofits is highly dependent on the circumstances of the building owners and the tenants, who are often small and medium sized companies (GBCA and EY 2015).

Box 15 Actions in the building sector to reduce emissions and disclose climate change risk

Coles and Woolworths

In 2018, Coles scope 1 and 2 greenhouse gas emissions were 1.7 Mt CO_2-e. Coles set a target to reduce its emissions by 30 per cent by 2020 compared with 2009 levels. It met this target four years early in 2016 (Wesfarmers 2018).

Woolworths' emissions in 2018 were 0.6 Mt CO_2-e scope 1 and 2.3 Mt CO_2-e scope 2 (Woolworths Group 2018, Clean Energy Regulator 2019b). It reports its emissions under the Global Reporting Initiative and CDP and aims to align its disclosure of climate related risks with the TCFD framework by 2020. Woolworths set a target to reduce its emissions by 10 per cent below 2015 levels by 2020. It has overachieved on its target — in 2018, its emissions were 13 per cent below 2015 levels. To reduce emissions, both Coles and Woolworths reduced energy use in lighting, heating, ventilation and air-conditioning, and installed solar panels (Woolworths Group 2018, Wesfarmers 2018).

Stockland Property Group

Stockland Property Group is an ASX 100 listed real estate company that owns, develops and manages a large portfolio of retail town centres, workplaces and residential communities (Stockland n.d.). In 2006, Stockland set out a Climate Action Plan primarily concerned with monitoring and reducing emissions across its portfolio but also looking at innovation and adaptation strategies. Since 2006, the company has reduced its greenhouse gas emission-intensity across its retail business by 44 per cent and its business park portfolio by 56 per cent. This initiative has saved $91 million through energy efficiency measures (Shopping Centre News 2019). Stockland has also invested $30 million in solar systems and delivered 67 electric vehicle chargers and charge point stations across 23 of their retail town centre locations (Stockland 2018).

8.3. Further opportunities to reduce emissions

There are emerging opportunities to reduce emissions in the building sector. Heat pumps are a known technology that can replace conventional space and water heating technology. Similar to how fridges function, they transfer heat from outside to inside a building or vice versa. They can significantly reduce energy use and emissions compared with standard heating and cooling. The same principle can be used to generate hot water, reducing energy use by around 60 per cent. In the ACT, the government has banned new installations of electric resistance water heaters and restricted the type of installable water heaters for new dwellings to certain solar, heat pump (including electric boosted), gas storage and gas instantaneous water heaters (ACT Environment, planning and sustainable development directorate n.d.). Widespread uptake is still currently constrained by high upfront costs, split incentives between building owners and tenants, and a lack of consumer awareness (ClimateWorks Australia n.d.).

The CSIRO has recently developed a solar-powered air conditioning system for heating and cooling using concentrated solar thermal technology for commercial buildings. The system is expected to reduce heating, ventilation and air conditioning electricity usage (CSIRO 2018a).

Electrochromic windows are another technology that can be employed to reduce energy use. These windows are coated in a film that reduces light and heat penetration. They are currently installed in

some aircraft and could also be used in buildings. However, their uptake is currently constrained by their upfront costs (ClimateWorks Australia n.d.).

Some property owners are already using 'total building optimisation[18]' in commercial buildings to minimise energy use through information technologies. These technologies could become more widespread and emerging information technology developments, such as automation and data analytics, may increase their effectiveness (ClimateWorks Australia n.d.).

[18] Total building optimisation is a technology-enabled system that can be utilised in commercial buildings. It leverages computing technologies to optimise building equipment and appliances (ClimateWorks Australia n.d).

9. TRANSPORT

9.1. Sector overview

The commercial transport and storage sector accounted for around 4 per cent of Australia's GDP in 2016–17 (ABS 2018b, 2019b). Transport is integral to the operations of most other sectors of the economy by moving products to markets.

In 2017, the commercial transport sector accounted for around 6.1 per cent of Australia's total emissions (Table 1).[19] Domestic aviation contributed 27 per cent of Australia's transport emissions, railways 12 per cent and domestic shipping 6 per cent (Australian Government DoEE n.d.). The main fuels used for transport are petrol, diesel oil, liquefied petroleum gas (LPG), bunker fuel for shipping and aviation turbine fuel.

Between 2005 and 2017, emissions from Australia's transport sector increased more than any other sector except for mining. The greatest percentage increase in emissions occurred in rail transport, followed by domestic aviation. Increased freight activity, supported by steady economic and population growth, is one driver of emissions growth in the transport sector (Australian Government DoEE 2019a).

Although transport is currently a growing source of Australia's emissions, there are opportunities in the sector to reverse the trend including adopting emissions standards for vehicles and fuels and new technological advances.

As the focus of this paper is on industry action to reduce emissions, options to reduce transport emissions by households, such as in the use of private cars, are not considered.

9.2. Current approaches to reducing emissions

Road transport companies are taking actions to improve the efficiency of their operations and reduce their emissions intensity including by upgrading their fleet and facilities, changing driver behaviour and improving logistics planning. Toll, for example is researching and trialling a range of options to replace its energy mix for road, sea and air based operations including moving to biodiesel, hydrogen, electric and solar (Toll 2019). In 2017, Linfox achieved its target of reducing greenhouse gas emissions across its business by 50 per cent compared with 2006–07 levels. Linfox is continuing to improve environmental outcomes through investments in renewable energy, fuel efficient and aerodynamic vehicle designs, supply chain optimisation and efficient driving practices (Linfox 2019).

Actions taken by aviation companies to reduce emissions include improving the fuel efficiency of their fleets, refining their operational procedures, and trialling new technologies such as biofuels.[20] A number of airlines have also certified their voluntary carbon offsetting schemes against the National Carbon Offset Standard including Qantas, Virgin Australia, Jetstar and Tigerair Australia (Australian Government DoEE n.d.).

Some rail companies, such as Aurizon, are implementing energy efficiency initiatives such as regenerative breaking and automatic stop start engines (Aurizon 2014). Some domestic shipping

[19] Transport emissions measured using the IPCC process-based emissions categories, which include residential light vehicle use, accounted for around 18 per cent of Australia's total emissions (Australian Government DoEE n.d.).

[20] Some of these activities are also incentivised through the Australian Government's Emissions Reduction Fund.

companies are converting their vessels to use new liquefied natural gas fuels resulting in significant reductions in emissions (Australian Government DoIRD 2016).

9.3. Further opportunities to reduce emissions

9.3.1. Road transport

Replacing conventional vehicles with electric vehicles powered by renewable energy could substantially reduce fuel lifecycle emissions. In 2017, there were 386,000 electric public buses in operation globally (Chediak 2018). Some Australian cities, such as Canberra and Perth, are trialling individual electric bus models and comparing their performance to existing fleets (Cranenburgh 2018). While the upfront cost of electric buses is still more than gas or diesel, the expected reductions in battery prices could make them competitive within the coming decade. In Australia, the first Australian-built electric public bus was commissioned by South Australian company Precision Buses in 2017 (Yoo 2017).

Efforts to expand the commercialisation of electric medium and heavy-duty vehicles are increasing. SEA Electric, an Australian company specialising in the assembly and electrification of commercial vehicles has the capacity to convert a complete range of commercial vehicles to electric vehicles from 4 tonne delivery vans to 26 tonne loading trucks. Box 16 provides an example of the uptake of this technology (SEA Electric 2019).

9.3.2. Aviation

Advances in aeroplane design and operation, including use of improved weather forecasts, have improved fuel efficiency and reduced emissions over time. Fuel use per kilometre in 2014 was almost half that of 1970 (National Geographic 2017). Further advances in aircraft design, including improving engines, enhancing aerodynamics and using lighter materials are expected to lead to planes burning even less fuel, and therefore reduce emissions further. Airbus and Boeing are investing in lightweight material and aerodynamic design technologies to reduce weight, improve lift-to-drag ratios and burn less fuel (Hemmerdinger 2019, AIRBUS n.d.).

Aviation biofuels, a low-emissions aircraft fuel option, are currently more expensive than conventional jet fuel. However, new biofuel sources and generation methods could make biofuels more financially viable and lead to greater uptake. ARENA funded Southern Oil Refining to develop Australia's first advanced biofuel laboratory. The project aimed to produce renewable diesel and jet fuels from biocrudes, which can be made from organic materials including wood waste, wastewater and agricultural waste, for use in aviation, shipping and defence industries (ARENA 2017b).

In 2018, Qantas operated its first dedicated biofuel flight between the US and Australia. The flight was fuelled by biofuel made from an industrial type of mustard seed developed by a Canadian agricultural technology company. Qantas is working with Australian farmers to produce the country's first commercial aviation biofuel seed crop by 2020 (Qantas n.d.).

Electric (battery) powered small passenger aircrafts are also being developed by several companies internationally. An aviation tech company MagniX, based on the Gold Coast, is aiming to transform commercial passenger planes by developing an electric propulsion system. The company is aiming to have an all-electric motor ready to install in a commercial plane by 2022 (ARENA 2019).

9.3.3. Railways

New developments in hydrogen fuel cells and batteries could transform the way that trains are powered. In 2018, two hydrogen fuel cell powered trains started operating along a 100 km route in Germany, which is normally serviced by diesel powered engines. This is a major technology advancement for trains to reduce emissions on non-electrified railways. Some old diesel powered trains can also be retrofitted with hydrogen fuel cells and tanks. The UK government is currently seeking to convert its existing rolling stock and remove all diesel trains from the network by 2040 (ARENA 2019).

Box 16 Commercial uptake of electric vehicles

IKEA

The Australian branch of the home furnishings multinational IKEA has committed to phase-out internal combustion engines for all its delivery and assembly vehicles nationally by 2025. The shift to electric commercial light vehicles will start immediately with a target of 5 per cent in the 2019 financial year, 10 per cent in the 2020 financial year and 100 per cent in 2025.

IKEA's Australian home-delivery transport operation is outsourced to partner transport and logistics companies. A fleet of around 100 trucks is used to deliver large furniture and another 250 vehicles are used for deliveries of smaller goods. The transport companies have been switching to electric vehicles in partnership with electric conversion specialist SEA Electric. Seven of the vehicles are already electric (Paulka 2019, Vorrath 2019).

10.WASTE

10.1. Sectoral overview

Waste is generated across economic sectors at all stages of production, from the extraction or harvest of materials through to transformation, use, reprocessing and disposal.

The waste sector includes waste collection, treatment and disposal services. Emissions are generated when organic matter decays under anaerobic conditions and are predominantly methane emissions (Australian Government DoEE 2019a).[21] The emissions intensity of waste differs according to the waste source and the method of disposal.

In 2017, emissions from the waste sector accounted for 1.7 per cent of Australia's emissions and has remained fairly stable as a percentage of total emissions since 2005 (Table 1, Australian Government DoEE n.d.). The decline in emissions from the waste sector since 1990 is mainly due to the uptake of technology that captures methane gas (Australian Government DoEE 2019c).[22]

10.2. Current approaches to reducing emissions

Waste emissions can be reduced by capturing methane at landfills, reducing the volume of waste generated, recycling and diverting materials from landfills.

There are more than 600 operating landfills in Australia that vary significantly in size, design and operational conditions. The widespread uptake of landfill methane capture is driven by state and territory regulations, reputational and social factors and financial returns. Australian Government policies that also encourage this practice include the Renewable Energy Target and the Emissions Reduction Fund. In the waste sector, 108 projects are currently registered under the Emissions Reduction Fund for landfill gas capture and combustion projects (CER 2019a).

On the waste generation side, the Australian Packaging Covenant Organisation (APCO) is a co-regulatory organisation that partners with government and industry to reduce packaging waste. All three major grocery retailers in Australia: ALDI, Woolworths; and Coles are members of APCO and have all made significant pledges to reduce plastic packaging, increase recycled material in their products and eliminate food waste to reduce waste going to landfill (APCO n.d.). APCO member Qantas recently operated the world's first zero waste flight from Sydney to Adelaide. This follows the announcement that Qantas would divert 75 per cent of its waste (13,000 tonnes) from landfill by 2021 including all food waste which will be composted or donated (Qantas 2019).

Recycling can play an important role in reducing greenhouse gas emissions. A study by the US Environment Protection Agency shows that recycling plastic waste results in net greenhouse gas savings when compared to landfilling and combustion of plastics (US Environment Protection Agency 2015).

In 2015–16, 55 per cent of all paper and paperboard products made in Australia were made from recycled paper (ABARES 2018). This lowers the carbon footprint by diverting paper from landfill and less energy is required to manufacture recycled paper compared with paper from wood pulp (Australian

[21] Methane is around 25 times more potent as a heat-trapping gas than carbon dioxide.

[22] Captured landfill gas can then be burned for heat or electricity.

Paper n.d., Business Recycling n.d.). Visy, a paper, packaging and resource recovery company, produced 1.4 million tonnes of paper, including 809,000 tonnes of recycled products in 2017–18 (Visy n.d.). This was partly made possible by CEFC financing used for new investments in energy efficient, renewable and low-emissions technologies and infrastructure. Visy's pipeline of projects includes better processing and sorting technologies to increase the amount of materials that can be recycled, as well as increased renewable energy generation internally to help offset grid energy needs (CEFC 2018b).

Coca-Cola announced 70 per cent of its plastic bottles manufactured for the Australian market will be made from 100 per cent recycled plastics by the end of 2019, replacing 16,000 tonnes of virgin plastic from being produced (Hughson 2019).

Metals, such as aluminium and steel, can be recycled with significantly lower emissions than the production of new metal. Recycled aluminium avoids the direct greenhouse gas emissions associated with aluminium production and reduces energy emissions by 95 per cent compared with producing new metal (The International Aluminium Institute 2018).

Recycled aluminium and steel retains the same qualities as the virgin product. In Australia, the recycling rate for aluminium and steel cans is around 66 per cent and 41 per cent respectively (Industry Edge and Equilibrium 2015). Approximately 75 per cent of all aluminium ever produced globally is still in use today (Suez n.d.), primarily because recycling stacks up on an economic and environmental basis (Australian Aluminium Council Ltd n.d.).

As electric vehicles and other battery uses become more common, the need to recycle lithium-ion batteries will increase. Up to 95 per cent of lithium-ion batteries can be recycled and used for new batteries (CSIRO 2018b). Recycling lithium-ion battery materials potentially reduces material production energy use by as much as 50 per cent (Gaines et al. 2011). Currently only 2 per cent of lithium-ion battery waste in Australia is recycled (CSIRO 2018b) and waste is growing by around 20 per cent per year. Most battery recycling is done offshore. In 2017, Envirostream became the first company in Australia to recycle lithium-ion batteries onshore. It recycled 7 per cent of the lithium-ion battery waste collected in Australia. The remaining waste was recycled offshore (Sustainability Vitoria 2018, CSIRO 2018b).

Council and community led initiatives to divert organic waste from landfill have gained momentum. The Compost Revolution started as a three-council regional environment program sponsored by the New South Wales Environment Trust. The organisation now works with over 31 councils across four states to provide residents with subsidised composting facilities. A number of councils across Australia are also running community composting hubs to turn food waste into compost for community gardens.

10.3. Further opportunities for emissions reduction

Advances in sorting and processing of waste are being made. For example, a new advanced waste treatment facility in Shoalhaven, New South Wales is the third of its kind built globally. The facility is able to sterilise, dry and separate out various groups of recyclable materials including plastic, glass, metals and organics from household mixed waste and is capable of diverting over 90 per cent of mixed waste from landfill.

A number of methods exist to convert waste to energy and divert waste from landfill. Burning waste and biomass (grate combustion), flue gas treatment and material recovery technologies are some of the

ways waste can be converted to electricity and fed into the grid. Waste to energy technologies are starting to gain traction in Australia driven in part by research and funding support from the Australian Renewable Energy Agency. Box 17 provides an example of the uptake of this technology (Compost Revolution n.d.).

New advances in landfill waste management also continue to be developed including polymeric membrane technology that converts methane from landfill into natural gas, and bio-covers to reduce the amount of methane landfills emit into the air (Rosengren 2016). For example, the City of Sydney plans to develop advanced waste treatment plants to eliminate non-recyclable waste going to landfill by producing natural gas from the treated landfill waste and delivering it to local areas using the existing gas grid infrastructure (City of Sydney n.d.).

Peak waste management associations see new investments in technology that divert organic waste from landfill as key to reducing greenhouse gas emissions (Australian Government DoEE 2016). New resource recovery technology able to extract organic content from waste streams (SACYR 2018) and produce compost for on-site mine rehabilitation has recently been deployed in New South Wales by Veolia in collaboration with a number of councils of Sydney (Veolia 2017).

Box 17 Reducing landfill and emissions through waste to energy

Rockingham-Kwinana waste to energy facility

A new $668 million waste-to-energy project in Kwinana, Western Australia co-developed by Dutch Infrastructure Fund, Macquarie Capital and Phoenix Energy is due to open in 2021. The plant will process 400,000 tonnes of waste diverted from landfill per year and use it for electricity generation. The project will utilise household, commercial and industrial waste.

By diverting waste from landfill, the new energy plant will lead to lower landfill emissions and also generate electricity.

The Clean Energy Finance Corporation committed up to $90 million in debt finance, and the Australian Renewable Energy Agency provided $23 million in grant funding, towards the project (Government of Western Australia 2019).

11.AGRICULTURE

11.1. Sectoral overview

Agriculture provides 6 per cent of the nation's merchandise export earnings (ABS 2018a). The sector supports a number of other industries and provides much of Australia's food and agricultural commodities.[23]

In 2017, the direct (scope 1) emissions of the agriculture sector were 112.2 Mt CO_2-e representing 21 per cent of Australia's emissions (Table 1).[24] This represents the net emissions from agriculture and the agriculture-related land-use change. In the agriculture sector, emissions are mostly methane from enteric fermentation in livestock (51.5 Mt CO_2 e in 2017). Fluctuations in livestock numbers have a big impact on the emissions in this sector. Nitrous oxide emissions from soils, especially from fertiliser use, contribute 14.2 Mt CO_2-e and emissions from manure and other sources contribute 7.3 Mt CO_2-e (Australian Government DoEE 2019b). The industry also generates emissions from energy use and transport (Heath et al. 2018).

Farmers and other landholders manage nearly 50 per cent of the Australian landmass (ABS 2017). Management of agricultural lands generates emissions or stores carbon in vegetation and soils. Land clearing for grazing and cropping is still a large contributor to Australia's emissions, although clearing has declined dramatically since 1990. Regrowth of vegetation on lands that were previously cleared also stores carbon emissions (Australian Government DoEE 2019c).

11.2. Sector-wide action

Agricultural industry peak-bodies are responding to the Paris Agreement by putting in place goals to reduce emissions by 2030 and beyond (Box 18). The National Farmers' Federation 2030 Roadmap envisages Australian agriculture trending towards carbon neutrality by 2030 and 50 per cent of farm energy sources being renewable by 2030 (NFF 2018). Actions planned to meet this goal include substantial abatement in livestock methane production and analysing all major commodities and individual farms for emissions reduction solutions. The industry also envisages the development of regional renewable energy precincts, which will provide renewable energy to farms. The Roadmap envisages that the carbon offset market could provide income of $40 billion to the land sector by 2050.

Peak bodies for individual commodities such as red meat, pork and dairy also have industry emissions reduction goals:

- The red meat industry has a goal to be carbon neutral by 2030 (MLA 2017, NFF 2018).
- The dairy industry target is to reduce emissions intensity by 30 per cent by 2020 compared with 2010–11 levels (Dairy Australia 2018).

[23] The impacts of climate change will have implications for agricultural productivity, however, climate impacts are not covered in this paper.

[24] The 112.2 Mt CO_2-e emissions allocated to the ANZSIC Agriculture sector includes all emissions directly associated with the economic activity of this industry. This includes all emissions from the process-based category for agriculture and emissions and removals of vegetation on agricultural land, and emissions associated with the use of combustible fuels by agricultural entities. It does not include environmental plantings on agricultural land (Australian Government DoEE pers. comm 2019).

- The pork industry goal is to reduce emissions on farm to 1 kg CO_2-e per kg pork produced (Australian Pork n.d.). In 2015, on-farm emissions intensities were found to average 3.9 kg CO_2-e per kilogram of pork produced (Box 19) (Australian Pork 2015).

Box 18 Climate Proofing Australia

The Red Meat Advisory Council, Farmers for Climate Action, the Australian Forest Products Association and Greening Australia have created an industry-led alliance focusing on carbon neutrality called Climate Proofing Australia. The alliance brings together industry, government and non-government organisations to work towards carbon neutrality in the agricultural landscape and through agribusiness supply chains. This includes better integrating farming and forestry with land conservation. The goals of Climate Proofing Australia include restoring 300,000 hectares of native habitat and establishing 100,000 hectares of farm forestry (Climate Proofing Australia n.d.).

11.3. Current approaches to reducing emissions

Many opportunities exist to reduce greenhouse gas emissions, sequester carbon and improve agricultural productivity using current and emerging technologies and on-farm management practices.

Areas where the technology currently exists to reduce emissions from agricultural industries include:

- improving energy efficiency and fuel switching
- improving production efficiency of livestock, such as through improving feed quality, breeding and management practices
- improving production efficiency of crops, such as through improving fertiliser use efficiency and changing crop rotations
- reducing land clearing and increasing revegetation
- improving soil management to increase plant biomass in the soil and reduce soil disturbance
- some options for reducing livestock methane emissions, such as through feed supplements.

Some companies and farms are already taking up these practices, including with support from industry bodies to do so. For example, Dairy Australia's Australian Dairy Carbon Calculator allows dairy farmers to identify any on-farm sources of emissions that are higher than the industry average and identify where efficiency improvements might both improve productivity and reduce emissions (Dairy Australia n.d.).

Consumers are increasingly demanding sustainable products. Company branding can maintain market share, open new markets or attract higher prices for those companies making sustainable products (Nielson 2015, NMI 2017). New sustainable products are also being developed in response to consumer trends, such as plant-based protein products (meat alternatives) with lower emissions (Rocky Mountain Institute 2017). One study has projected 6.6 per cent per year growth in plant-based protein products over the next decade (Research and Markets 2018).

Some food and beverage companies are becoming carbon neutral certified. For example, Ross Hill Wine Group and Keith Tulloch Wine are certified under the Government's National Carbon Offset Standard (Australian Government DoEE n.d.) and Tahbilk winery is certified through an internationally

accredited greenhouse gas certification, carboNZero (Tahbilk n.d.).[25] Other companies are setting emissions targets, such as McDonald's who has committed globally to a 31 per cent reduction in emissions intensity (per tonne of food and packaging) across its supply chain by 2030 from 2015 levels (McDonald's n.d.).

There are also examples of farms investing in renewable energy, from pork and poultry producers to vegetable growers. Companies include Austchilli, Westpork and Nectar Farms (Parkinson 2017a, Parkinson 2017b, Austchilli n.d.). Actions are often on farm, such as the installation of solar, wind and battery systems, and lead to lower costs as well as lower emissions for the companies.

Renewable energy is also being produced from agricultural waste such as effluent. For example, intensive pig meat production produces methane emissions from the anaerobic decomposition of manure. Covered effluent ponds or engineered biodigesters can capture this methane and combust it and some systems can also generate energy.[26] A number of these systems are in place in larger Australian piggeries in conjunction with ERF projects (Box 19).

The requirements of export markets can drive emissions reductions in agriculture. For example, the European Union has regulations in place requiring canola imported for use in biofuels to be produced using low-emissions practices (GRDC 2018). This is an important market for Australia — it represents 91 per cent of exported canola and was worth around $1 billion in 2016–17 (CSIRO 2017).

The agriculture and land sector is also participating in the carbon market. Most abatement from the Government's Emissions Reduction Fund is from the land, including from revegetation, avoided deforestation, sequestration of organic matter in soils, savanna burning and manure management. The Emissions Reduction Fund is discussed in the Authority's 2017 review of the ERF and the Authority's 2018 research paper, Reaping the Rewards.

[25] The carboNZero program meets the ISO 14065 standard.

[26] Combusting methane coverts it to carbon dioxide, which is a much less potent greenhouse gas than methane.

Box 19 Emissions reductions in the pork industry

The Australian pork industry has a goal to reduce emissions on farm to 1 kg CO_2-e per kilogram of pork produced. In 2015, on-farm intensities averaged 3.9 kg CO_2-e per kilogram of pork produced (Australian Pork 2015).

Two-thirds of the emissions associated with pork production come from effluent ponds. Studies commissioned by Australian Pork Limited suggest capturing and combusting the methane component of biogas can reduce emissions from piggeries by between 62 per cent (when the methane is flared) and 80 per cent (when the methane is used for heat and power, offsetting energy emissions) (Australian Pork 2011, Wiedemann 2016).

Blantyre Farms and Rivalea are both companies that are managing their effluent ponds to reduce greenhouse gas emissions. Blantyre has an Emissions Reduction Fund project that has earned over 79,000 ACCUs and reduced energy costs by $20,000 a month (Locke 2017, CER 2019a). Rivalea operates two wastewater methane recovery plants (Rivalea n.d.).

There are 14 registered piggeries projects under the Emissions Reduction Fund that credit the management and reduction of effluent emissions (CER 2019a).[27] Eight of the registered projects were also accredited power stations under the Large-scale RET scheme (CER 2019c).

The cost effectiveness of implementing the technology is site specific and depends on, among other things, the size of the herd. Generation of electricity is a key element in offsetting the costs associated with covered effluent ponds. The pay-back period for projects may be less than five years and as short as one to two years (Pork CRC 2016a). One of the registered ERF projects paid back an almost $1 million capital investment in 2.5 years (Pork CRC 2016b).

There is also the potential to co-locate horticultural greenhouses with piggeries to use excess heat and also carbon dioxide generated from the piggeries to enhance horticultural growth. One project located in Stanhope, Victoria, seeks to demonstrate these benefits by generating electricity and producing high quality fertiliser at the site (Victorian Government 2016, Waranga Green Energy n.d.).

11.4. Further opportunities to reduce emissions

11.4.1. Livestock methane management

Further technologies under development globally for the reduction of greenhouse gases in the livestock industry include: genetic and genomic selection technologies to reduce methane production and intensity in sheep and cows; chemical inhibitors that reduce methane emissions in sheep and cattle; and vaccines to reduce ruminal methanogens. In Australia, CSIRO is working on a seaweed feed supplement that aims to substantially reduce methane emissions and simultaneously improve livestock production (CSIRO n.d.).

11.4.2. Fertiliser management

Enhanced-efficiency fertilisers are a combination of fertilisers and inhibitors that can reduce nitrous oxide emissions from soils by 14 to 98 per cent depending on the agricultural system (Australian

[27] Current as of 17 May 2019.

Government DoAWR 2015a). They can also improve nitrogen use efficiency in some cases, which can allow less fertiliser to be applied or can increase yields for the same level of application (Australian Government DoAWR 2015b).

The University of Queensland is currently working with the sugar industry to produce an enhanced-efficiency fertiliser that is designed to ensure good crop yields, reduce nitrous oxide emissions and reduce runoff of nutrients to the Great Barrier Reef (University of Queensland 2018).

In Australia, the use of enhanced efficiency fertilisers is not currently widespread. A scheme is being developed that could encourage greater market uptake of enhanced-efficiency fertilisers by providing financial incentives for reduced emissions and reduced run-off of nutrients in the Great Barrier Reef catchments (Box 20).

Box 20 Incentives for lower emissions and reduced nutrient run-off

Enhanced-efficiency fertilisers that reduce nitrous oxide emissions will also reduce nutrient run-off, which improves downstream water quality. In the Great Barrier Reef catchments, there is a focus on improving water quality as one way to improve the health of the Reef.

To reduce nutrient and sediment run-off into the Great Barrier Reef a crediting scheme is being developed called the Reef Credit Scheme, which issues credits for improvements in water quality (Greencollar n.d.). Reef Credit Scheme projects could dovetail with Emissions Reduction Fund projects allowing land holders to receive multiple incentives provided they meet the requirements of both schemes. The standard that establishes the rules and requirements for the Reef Credit Scheme was released in March 2019 and the methods for projects to use under the scheme will follow (Reef Credit 2019). Reef credits would be available for industry and government to purchase to support actions that benefit the health of the Great Barrier Reef.

11.4.3. Digital agricultural technologies

Digital agricultural technologies have the ability to accelerate the adoption and application of many agricultural technologies and management practices, which can reduce emissions. These include enhancing farmers' ability to optimise soil management and implement optimal application practices for crop irrigation, fertiliser and chemical use.

Digital technologies include integrated business information systems, data analytics and decision making tools, variable rate technology, remote sensing technologies, and geospatial tools and imagery from satellites and drones to map and monitor soil health, type, carbon content as well as irrigation use and crop health (CSIRO 2018c, Future Farming 2018). One barrier to the active management of soil organic carbon is the cost of the methods available to measure soil organic carbon levels. Current technology involves repetitive sample collection and off-site analysis. The emergence of new low cost technology developments to measure soil organic carbon, including remote sensing and satellite data, have the potential to help alleviate this barrier although significant further development of the technology is still required (Australian Government DoAWR 2016).

12.FORESTRY

12.1. Sectoral overview

Australia exports $3 billion in wood products and forestry and forest product manufacturing made up 0.5 per cent of Australia's GDP in 2016–17 (ABS 2018a, b, 2019b). An estimated 65,000 people were employed in the forestry and forest products manufacturing industries in 2016–17 (ABS 2019a).

Australian producers harvest wood from native forests and plantations. Over recent years, there has been a structural transition away from harvesting in the native forest sector to harvesting from commercial plantations (Australian Government DoEE 2017, Australian Government DoEE 2019c). Australia now has around 2 million hectares of commercial plantations (ABARES 2017).

Forestry is the only Australian industry sector that stores more greenhouse gases than it releases, as trees remove carbon dioxide from the air and store it as they grow. There are emissions associated with forestry operations (including energy and fuel use and post-harvest management) but they are less than the carbon stored in the trees and wood products (Australian Government DoAWR 2013). Forestry operations and wood products manufacturing contributed a net sink of 58.2 Mt CO_2-e in 2017 (Australian Government DoEE n.d.). On the manufacturing side, the production of wood products and paper generates emissions from energy use.

12.2. Sector-wide action

The Australian Forest Products Association has estimated that the forest and wood products sector could contribute 18 million tonnes of abatement (CO_2-e) in 2030. Around 13 Mt CO_2-e of this would be through 400,000 hectares of planned new plantations, and there is support for this in an Australian Government strategy for the timber industry (Australian Government DoAWR 2018, Australian Forest Products Association n.d.). The remaining 5 million tonnes of abatement would be from initiatives to improve forest management, use of wood instead of reinforced concrete in building construction, and use of bioenergy and biofuels (Australian Forest Products Association n.d.).

12.3. Current approaches to emissions reductions

12.3.1. Forest management certification schemes

Improved forest management allows forests to store more carbon in trees and soils and reduces losses, such as from soil erosion, while maintaining productivity.

Forests can be certified by independent accreditation schemes for adhering to sustainable forest management practices, including managing the forest carbon cycle. In Australia, there are two recognised schemes: the Forest Stewardship Council standard; and the Responsible Wood Certification Scheme, which is recognised under the international Programme for the Endorsement of Forest Certification and Australian Standards (Responsible Wood n.d., Australian Government DoAWR 2018). Over 26 million hectares of Australian forests are certified under the Responsible Wood Certification Scheme (Australian Government DoAWR 2018).

12.3.2. Products and manufacturing

There are opportunities to lower emissions in the processing and manufacturing of wood and paper products through improved efficiencies, re-use of waste and reduced fossil fuel use (Box 21). Overall, direct (scope 1) emissions from the pulp and paper industry have declined by 5 per cent between 2014–15 and 2016–17 (Australian Forest Products Association 2018).

Box 21 Opportunities in the wood and paper industry

Sawmills

Some sawmills reduce emissions by using wood waste to produce heat or energy instead of using fossil fuels. For example, Reid Brothers Sawmill in Victoria estimates a 1 MW wood-fired boiler saves them $269,000 annually compared with burning LPG. This wood waste would otherwise have gone to landfill (Victorian Government DELWP 2017). There is potential for further expansion of bioenergy in the industry (CEFC 2015).

Waste sawmill residue can be refined to produce bio-diesel and bitumen. The use of renewable liquid fuels in heavy vehicles provides emissions reductions of more than 80 per cent compared with fossil fuels (Rural Industries Research and Development Corporation 2013). Boral Timber will be undertaking a $1.2 million feasibility study, co-funded by the Australian Renewable Energy Agency, to determine the technical and financial viability of converting up to 50,000 tonnes of sawmill residues into renewable diesel and bitumen each year. Boral has stated that if the feasibility study is successful, the transport-grade diesel and bitumen produced could potentially supply up to 15 per cent of its needs (ARENA 2018b).

Paper mills

Australian Paper's Maryvale Mill, the largest integrated pulp and paper manufacturing site in Australia, produces carbon-neutral paper products. In 2017, carbon-neutrality was achieved through saving 21,000 t CO_2-e from reduced use of steam, gas and electricity and retiring around 300,000 t CO_2-e in offsets (Australian Paper 2017). In addition, Australian Paper is proposing to build an Energy from Waste plant to produce heat energy for paper manufacture at Maryvale to remove the use of coal-fired electricity, significantly reduce the use of gas and reduce energy costs (Australian Paper n.d.).

Recycling steam back into the manufacture of paper is reducing emissions at the Norske Skog Boyer paper mill in Tasmania. The process means less steam is needed from the coal-fired boiler. The project was registered in 2016 under the Emissions Reduction Fund and is estimated to be reducing emissions by 37,000 t CO_2-e every year (Australian Forest Products Association 2018, CER 2019a).

12.4. Further opportunities to reduce emissions

A priority area for research is the development of innovative wood-based products that can be used to replace emissions-intensive and oil-based products (National Institute for Forest Products Innovation n.d., Planet Ark n.d.). Wood contains many similar compounds to those in oil, and when it is processed, can be turned into bio-plastics (used in the bodywork of cars), bio-solvents (used in paints and glues) and it can be used as innovative building materials to replace steel (Box 22) (Lawton 2019).

Research is also focussing on improved tree genetics, and improved management practices through the value chain, such as through the use of remote sensing data and automated systems (National Institute for Forest Products Innovation n.d.).

Box 22 Timber in buildings

There are expanding markets for timber in the building industry with changes to the building code and building rating system over recent years, partly enabled by new timber technologies.

Sustainability rating systems for buildings are becoming increasingly important for those looking to reduce their environmental footprint including building developers. The Green Star rating system includes life-cycle assessments that compare the whole-of-life performance of building products. Forest products, which avoid emissions compared with concrete and steel, can contribute to a low-carbon footprint for a building (WoodSolutions n.d.).

In addition, changes to the National Construction Code have expanded the types of multi-story buildings that can use fire protected timber construction systems, to include for example schools and retail premises. These changes follow others in 2016 that allowed multi-residential and office buildings to use the product (ABCB 2018, Wood Solutions n.d.).

These changes to the building code are opening up opportunities for new wood-based products with low-carbon footprints, and the industry is responding. Cross-laminated timber, a strong product suitable for pre-fabrication, is being produced in a new plant in Wodonga (Logic 2019). A processing site in Queensland will be producing glue-laminated timber, which can be a low-carbon alternative to steel and concrete in large-scale commercial and infrastructure construction projects (Australian Forest Products Association 2018).

Lendlease has constructed a 10-storey apartment building in Melbourne using cross-laminated timber, which was estimated to have reduced emissions by 1400 t CO_2-e due to replacing steel and concrete with wood products (Lend Lease 2014). Other buildings, such as International House Sydney at Barangaroo, are also using engineered wood products (Lend Lease 2018).

13.NEXT STEPS

The Authority is updating its advice to the Australian Government on policies to meet Australia's commitments under the Paris Agreement.

This stocktake on industry drivers and actions to reduce greenhouse gas emissions, together with the stocktakes released by the Authority in March 2019 on Australian and international climate change policies, will be inputs to that work along with other research and analysis.

The Authority welcomes your input on the accuracy and reliability of the information contained in this stocktake and any relevant additional information. To provide comments, please contact the Climate Change Authority on freecall 1800 475 869 or via email at enquiries@climatechangeauthority.gov.au.

REFERENCES

Abacus Property 2018. "Sustainability report." Viewed 26 April 2019. https://www.abacusproperty.com.au/sustainability/sustainabilty-reports.

ABARES 2017. "Australia's forests at a glance." Viewed 29 April 2019. http://www.agriculture.gov.au/abares/forestsaustralia/australias-forests-at-a-glance.

ABARES 2018. "Australian forest and wood products statistics: March and June quarters 2018. Table 22." Viewed 6 June 2019. http://www.agriculture.gov.au/abares/research-topics/forests/forest-economics/forest-wood-products-statistics.

Australian Bureau of Statistics (ABS) 2017. "Agricultural Commodities, Australia, 2015-16, cat. no. 7121.0." Viewed 10 April 2019. http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/7121.0Main+Features12015-16?OpenDocument.

ABS 2018a. "International Trade in Goods and Services, Australia, April 2019, cat. No. 5368.0, Table 32a." Viewed 19 June 2019. https://www.abs.gov.au/Ausstats/abs@.nsf/mf/5204.0.

ABS 2018b. "Australian System of National Accounts, 2017–18, cat. no. 5204.0, Table 5." Viewed 19 June 2019. https://www.abs.gov.au/ausstats/abs@.nsf/mf/5368.0.

ABS 2019a. "Labour Force, Australia, Detailed, Quarterly, Feb 2019, cat. no. 6291.0.55.003, Table 06." Viewed 19 June 2019. https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/6291.0.55.003Main+Features1Feb%202019?OpenDocument.

ABS 2019b. "Australian Industry, 2017–18, cat. no. 8155.0." Viewed 19 June 2019. https://www.abs.gov.au/ausstats/abs@.nsf/mf/8155.0.

ABS 2019c. "Australian Demographic Statistics, Sep 2018, cat. no. 3101.0." Viewed 26 April 2019. http://www.abs.gov.au/ausstats/abs@.nsf/mf/3101.0.

ACT Environment, planning and sustainable development directorate n.d. "Hot water heater requirements." Viewed 30 May 2019. https://www.planning.act.gov.au/customer_information/community/hot_water_heater_requirements.

AEMC 2017. "System Security Market Frameworks Review." Viewed 26 April 2019. https://www.aemc.gov.au/sites/default/files/content/f510069a-791b-4e4d-8bc0-9e6a216be7a2/System-Security-Market-Frameworks-Review-Final-Report.pdf.

AGL 2015. "AGL adopts 'We Mean Business' commitments." 25 September. Viewed 26 April 2019. https://www.agl.com.au/about-agl/media-centre/asx-and-media-releases/2015/september/agl-adopts-we-mean-business-commitments.

AGL 2018. "2018 Sustainability report." Viewed 24 April 2019. https://www.2018sustainabilityreport.agl.com.au/.

AIGN. n.d. "AIGN policy principles." Viewed 26 April 2019. http://aign.net.au/policy_principles.html.

AIRBUS n.d. "Minimising environmental impact." Viewed 29 April 2019. https://www.airbus.com/company/responsibility-sustainability/minimising-environmental-impact.html.

Alcoa 2017. “2017 Alcoa Sustainability Report.” Viewed 26 April 2019. https://www.alcoa.com/sustainability/en/pdf/2017-Sustainability-Report.pdf.

Alumina Limited n.d. “Greenhouse gases.” Viewed 30 April 2019. https://www.aluminalimited.com/greenhouse-gases/.

ANZ 2018. “2018 Sustainability review.” Viewed 30 April 2019. https://www.anz.com.au/content/dam/anzcomau/documents/pdf/aboutus/wcmmigration/2018-anz-sustainability-review.pdf.

ARENA 2015. “Renewable Energy Options for Australian Industrial Gas Users.” Viewed 26 April 2019. https://arena.gov.au/assets/2017/05/ITP-RE-options-for-industrial-gas-users-Summary.pdf.

ARENA 2017a. “Cultana Pumped Hydro Project.” Viewed 26 April 2019. https://arena.gov.au/assets/2017/09/Cultana-Pumped-Hydro-Project-_Public-FINAL-150917.pdf.

ARENA 2017b. “ARENA's war on waste: Five ways we're turning your unwanted trash to energy.” Viewed 26 April 2019. https://arena.gov.au/blog/arenas-war-on-waste-five-ways-were-turning-your-unwanted-trash-into-energy-treasure/.

ARENA 2018a. “Victoria's first of two large-scale, grid-connected batteries reaches completion in Ballarat.” 23 October. Viewed 26 April 2019. https://arena.gov.au/news/victorias-first-of-two-large-scale-grid-connected-batteries-reaches-completion-in-ballarat/.

ARENA 2018b. “Boral could turn sawmill residue into renewable diesel.” 24 August. Viewed 26 April 2019. https://arena.gov.au/news/boral-could-turn-sawmill-residue-into-renewable-diesel/.

ARENA 2019. “Renewables take to the skies rails and roads.” Viewed 26 April 2019. https://arena.gov.au/blog/renewables-take-to-the-skies-rails-and-roads/.

ARENA n.d.a. “Projects.” Viewed 6 June 2019. https://arena.gov.au/projects/

ARENA n.d.b. “Conversion of remote crude oil beam pumps to solar and battery project.” Viewed 10 May 2019. https://arena.gov.au/projects/conversion-of-remote-crude-oil-beam/.

ASX Corporate Governance Council 2019. “Corporate Governance Principles and Recommendations. 4th edition.” Viewed 24 April 2019. https://www.asx.com.au/documents/asx-compliance/cgc-principles-and-recommendations-fourth-edn.pdf.

Aurizon 2014. “Sustainability report.” Viewed 26 April 2019. https://www.aurizon.com.au/en/news/2014/Aurizon-2014-Sustainability-Report.

Austchilli n.d. “Sustainability.” Viewed 26 April 2019. https://www.austchilli.com.au/our-story/sustainability.

Austral Fisheries 2016. “How and why, Austral Fisheries has become Carbon Neutral from 1 January 2016.” Viewed 24 April 2019. https://www.australfisheries.com.au/getattachment/Sustainability/Austral-CN-Background-information-2016-calendar-year.pdf?lang=en-AU.

Australian Accounting Standards Board 2018. “Climate-related and other emerging risks disclosures: assessing financial statement materiality using AASB Practice Statement 2.” Viewed 24 April 2019. https://www.aasb.gov.au/admin/file/content102/c3/AASB_AUASB_Joint_Bulletin_13122018_final.pdf.

Australian Alliance for Energy Productivity (A2EP) n.d. “Creating an energy=productive nation.” Viewed 29 April 2019. https://a2se.org.au/about-us.

A2EP 2018. “Transforming Energy Productivity in Manufacturing.” Viewed 29 April 2019. https://www.2xep.org.au/files/pdf/A2EP%20Transforming%20EP%20in%20Manufacturing%20Final.pdf.

Australian Aluminium Council n.d. “AAC Position on Climate Change Policy.” Viewed 26 April 2019. https://aluminium.org.au/climate-change/aac-position-on-climate-change-policy/.

Australian Building Codes Board (ABCB) 2018. “What to expect from NCC 2019.” Viewed 26 April 2019. https://www.abcb.gov.au/News/2018/12/02/What-to-expect-from-NCC-2019.

Australian Competition and Consumer Commission (ACCC) 2018. “Restoring electricity affordability and Australia's competitive advantage.” Viewed 24 April 2019, https://www.accc.gov.au/publications/restoring-electricity-affordability-australias-competitive-advantage.

Australian Council of Superannuation Investors 2018. “Corporate Sustainability Reporting in Australia 2018.” Viewed 24 April 2019. https://www.acsi.org.au/images/stories/ACSIDocuments/generalresearchpublic/2018-Sustainability-Report-FINAL-June-2018.pdf.

Australian Energy Regulator 2018. “State of the energy market report 2018.” Viewed 26 April 2019. https://www.aer.gov.au/publications/state-of-the-energy-market-reports.

Australian Energy Storage Alliance 2018. “Opportunities for Utility Scale Battery Storage in NSW”. Prepared in partnership with AECOM for the NSW Department of Industry. Viewed 18 June 2019. https://energystoragealliance.com.au/site/wp-content/uploads/2018/06/AESA-AECOM_Report_June-2018.pdf.

Australian Forest Products Association 2018. “National Pulp and Paper Sustainability report.” Viewed 29 April 2019. http://ausfpa.com.au/publications/2018-national-pulp-and-paper-sustainability-report/.

Australian Forest Products Association n.d.”18 Megatonnes of CO2 equivalent by 2030.” Viewed 25 March 2019. https://d3n8a8pro7vhmx.cloudfront.net/afpa/pages/169/attachments/original/1529295400/AFPA_18_BY_2030-_test.pdf?1529295400.

Australian Government DoAWR 2013. “Australia's State of the Forests Report 2013.” Viewed 1 May 2019. http://www.agriculture.gov.au/abares/forestsaustralia/sofr/sofr-2013.

Australian Government DoAWR 2016. “Boosting farm productivity - improved soils and reduced greenhouse gas emissions.” Viewed 1 May 2019. www.agriculture.gov.au/SiteCollectionDocuments/climate-change/carbon-farming/boosting-farm-productivity.pdf.

Australian Government DoAWR 2018. “Growing a better Australia – a billion trees for jobs.” Viewed 29 April 2019. http://www.agriculture.gov.au/forestry/publications/growing-better-australia.

Australian Government DoAWR 2015a. “Nitrous oxide emissions.” Viewed 2 May 2019. www.agriculture.gov.au/ag-farm-food/climatechange/australias-farming-future/n2o-emissions.

Australian Government DoAWR 2015b. “Nitrous oxide research.” Viewed May 2, 2019. http://www.agriculture.gov.au/ag-farm-food/climatechange/australias-farming-future/climate-change-and-productivity-research/nitrous-oxide-research.

Australian Government DoEE 2016. “National Waste Report.” Viewed 26 April 2019. https://www.environment.gov.au/protection/waste-resource-recovery/national-waste-reports/national-waste-report-2016.

Australian Government DoEE 2017. “Australia's 7th National Communication on Climate Change.” Commonwealth of Australia, Canberra. Viewed 26 April 2019. https://unfccc.int/files/national_reports/national_communications_and_biennial_reports/application/pdf/024851_australia-nc7-br3-1-aus_natcom_7_br_3_final.pdf.

Australian Government DoEE 2018a. “Australia's emissions projections 2018.” Viewed 26 April 2019. https://www.environment.gov.au/climate-change/publications/emissions-projections-2018.

Australia Government DoEE 2018b. “Australian Energy Update 2018.” Commonwealth of Australia, Canberra. Viewed 26 April 2019. https://www.energy.gov.au/sites/default/files/australian_energy_update_2018.pdf.

Australian Government DoEE 2019a. “Quarterly Update of Australia's National Greenhouse Gas Inventory: December 2018.” Viewed 6 June 2019. http://www.environment.gov.au/system/files/resources/408fcc37-dcfd-4ab8-a4f9-facc6bd98ea6/files/nggi-quarterly-update-dec-2018.pdf.

Australian Government DoEE 2019b. “National Inventory Report 2017. Volume 1.” May 2019. Viewed 6 June 2019.

Australian Government DoEE 2019c. “National Inventory Report 2017 Volume 2.” May 2019. Viewed 6 June 2019.

Australian Government DoEE n.d. Australian Greenhouse Emissions Information System. Viewed 6 June 2019, http://ageis.climatechange.gov.au/Electricity.aspx, http://ageis.climatechange.gov.au/ANZSIC.aspx.

Australian Government DoEE pers.comm 2019.

Australian Government DoIRD 2016. “Trends: Transport and Australia's development to 2040 and beyond.” Viewed 26 April 2019. https://infrastructure.gov.au/infrastructure/publications/files/Trends_to_2040.pdf.

Australian Institute of Company Directors 2018. “Directors Sentiment Index: Research findings second half 2018.” Viewed 24 April 2019. https://aicd.companydirectors.com.au/advocacy/research/director-sentiment-index-second-half-2018.

Australian National University 2019. “Pumped Storage Hydropower a 'game changer'.”ANU research. 25 March. Viewed 26 April 2019. https://www.anu.edu.au/news/all-news/pumped-storage-hydropower-a-%E2%80%9Cgame-changer%E2%80%9D-anu-research.

Australian Packaging Covenant Organisation Ltd (APCO) n.d. “Our members.” Viewed 1 May 2019. https://www.packagingcovenant.org.au/our-members.

Australian Paper 2017. "Australian Government Carbon Neutral Program Public Disclosure Summary Jan-Dec 2017." Viewed 1 May 2019. http://www.environment.gov.au/system/files/pages/63b47577-06b2-49e9-9b2f-180f0f80e7af/files/australian-paper-pds-2017.pdf.

Australian Paper n.d. "Creating energy from waste. Viewed 29 April 2019. https://www.australianpaper.com.au/our-future/creating-energy-from-waste/.

Australian Pork 2011. "Fact sheet: Reducing greenhouse gas emissions from piggeries." Viewed 12 June 2019. http://australianpork.com.au/wp-content/uploads/2013/10/FACT-SHEET-Reducing-GHG-Emissions-from-Piggeries.pdf

Australian Pork 2015. "Summary of 55 PigGas reports: national PigGas extension project." Viewed 11 April 2019. http://australianpork.com.au/wp-content/uploads/2013/10/APL-Website-Summary-of-55-PigGas-Reports.pdf.

Australian Steel Stewardship Forum n.d. "Iron and Steelmaking." Viewed 30 April 2019. http://steelstewardship.com/lifecycle/iron-and-steelmaking/.

Australian Sustainable Built Environment Council (ASBEC) 2016. "Low Carbon, High Performance." Viewed 26 April 2019. https://www.asbec.asn.au/research-items/low-carbon-high-performance-report/.

Australian Trade and Investment Commission 2019. "Why Australia: benchmark report." Viewed 26 April 2019. https://www.austrade.gov.au/International/Invest/Resources/Benchmark-Report.

BHP 2019. "Climate Change Position." Viewed 26 April 2019. https://www.bhp.com/environment/climate-change.

Blakers Andrew, Lu, Bin, Stocks, Matthew 2017. "100% renewable electricity in Australia." Energy (Australian National University) 133: 471-483. Viewed 26 April 2019. http://re100.eng.anu.edu.au/resources/assets/1708BlakersREAust.pdf.

BloombergNEF 2019. "Australia to be largest residential storage market in 2019." January 22. Viewed 26 April 2019. https://about.bnef.com/blog/australia-largest-residential-storage-market-2019/.

BloombergNEF 2018. "New Energy Outlook 2018." Viewed 26 April 2019. https://about.bnef.com/new-energy-outlook/.

Bluescope 2018. "Bluescope underwrites investment in 500,000 panel solar farm." 20 July. Viewed 30 April 2019. https://s3-ap-southeast-2.amazonaws.com/bluescope-corporate-umbraco-media/media/2418/bluescope-media-release-ppa-final.pdf.

Boral n.d. "ENVISIA." Viewed 30 April 2019. www.boral.com.au/envisia/about.html.

Boothroyd, Aoife 2016. "Austral Fisheries becomes world's first carbon neutral seafood business." Hospitality Magazine. 11 March. Viewed 29 April 2019. https://www.hospitalitymagazine.com.au/austral-fisheries-becomes-worlds-first-carbon-neutral-seafood-business/.

Bousso, Ron 2018. "Shell to set sector-leading emissions targets after investor pressure." Reuters, 3 December. Viewed 24 April 2019. https://www.reuters.com/article/us-shell-carbon/shell-to-set-sector-leading-emissions-targets-after-investor-pressure-idUSKBN1O20NK.

BP 2019. “BP to support investor group’s call for greater reporting around Paris goals.” 1 February. Viewed 29 April 2019. https://www.bp.com/en/global/corporate/news-and-insights/press-releases/bp-to-support-investor-groups-call-for-greater-reporting-around-paris-goals.html.

Buckley et al, Tim 2018. “China 2017 Review.” Institute for Energy Economics and Financial Analysis. Viewed 26 April 2019. http://ieefa.org/wp-content/uploads/2018/01/China-Review-2017.pdf.

Business Recycling n.d. “Environmental benefits of commercial recycling for paper and cardboard.” Viewed 30 May 2019. https://businessrecycling.com.au/info/enviro-paper.cfm.

Carbon Market Institute 2018. “Australian Climate Policy Survey 2018.” Viewed 24 April 2019. http://carbonmarketinstitute.org/wp-content/uploads/2018/11/Australian-Climate-Policy-Survey_2018.pdf.

CDP 2018. “Cascading Commitments: driving ambitious action through supply chain engagement.” Viewed 26 April 2019. https://www.cdp.net/en/articles/supply-chain/cascading-change-through-the-supply-chain.

CDP 2019. “Fast Moving Consumers”. Viewed 24 April 2019. https://6fefcbb86e61af1b2fc4-c70d8ead6ced550b4d987d7c03fcdd1d.ssl.cf3.rackcdn.com/cms/reports/documents/000/004/150/original/CDP_Consumer_Goods_2019_Exec_summary.pdf?1551891654.

CDP n.d. “Our vision our missions.” Viewed 24 April 2019. https://www.cdp.net/en/info/about-us.

Clean Energy Finance Corporation (CEFC) 2018a. “CEFC annual report 2017-18 – Investing for impact and innovation.” Viewed 29 April 2019. https://annualreport2018.cefc.com.au/.

CEFC 2018b. “CEFC and Visy to substantially lift resource recovery from waste in bd to cut emissions and reduce landfill.” 3 October. Viewed 24 April 2019. https://www.cefc.com.au/media/files/cefc-and-visy-to-substantially-lift-resource-recovery-from-waste-in-bid-to-cut-emissions-and-reduce-landfill/.

Cement Industry Federation 2017. “Australian industry Statistics 2017.” Viewed 30 April 2019. http://www.cement.org.au/Portals/0/Documents/Fast%20Facts/CIF%20Fast%20Facts%202017.pdf.

Cement Industy Federation n.d. “Australian cement industry.” Viewed 30 April 2019. http://www.cement.org.au/.

Chevron 2019. “Update to climate resilience.” Viewed 26 April 2019. https://www.chevron.com/-/media/shared-media/documents/update-to-climate-change-resilience.pdf.

Clean Energy Council n.d. “Solar Thermal.” Viewed 26 April 2019. https://www.cleanenergycouncil.org.au/resources/technologies/solar-thermal.

CEFC 2015. “CEFC identifies potential to double Australian bioenergy sector in five years.” 12 November. Viewed 29 April 2019. https://www.cefc.com.au/media/files/cefc-identifies-potential-to-double-australian-bioenergy-sector-in-five-years/.

City of Sydney n.d. “Our starategy for managing Sydney’s waste resources to 2030,” Viewed 24 April 2019. https://www.cityofsydney.nsw.gov.au/vision/sustainable-sydney-2030/sustainability/waste-management.

Clean Energy Regulator (CER) 2019a. “Emissions Reduction Fund Project Register.” 18 April. Viewed 26 April 2019. http://www.cleanenergyregulator.gov.au/ERF/project-and-contracts-registers/project-register.

CER 2019b. "Corporate emissions and energy data 2017-18." Viewed 26 April 2019. http://www.cleanenergyregulator.gov.au/NGER/Pages/Published%20information/Reported%20greenhouse%20and%20energy%20information,%20by%20year/Corporate-emissions-and-energy-data-2017%E2%80%9318.aspx?SortField=Total_x0020_Scope_x0020_1_x0020_&SortDir=Desc&View.

CER 2018c. "REC Registry- Register of Accredited Power Stations." Viewed 29 April 2019. http://www.cleanenergyregulator.gov.au/OSR/ANREU/Data-and-information.

Climate Action 100+ 2019. Global Investors Driving Business Transition. Viewed 24 April 2019. http://www.climateaction100.org/.

Climate Analytics 2018. "Australia's Industry: Inefficient and standing still." Viewed 26 April 2019. https://climateanalytics.org/media/australiaclimatefactsheets2018-industry-climateanalytics.pdf.

Climate Bonds Initiative 2018. "Bonds and climate change: the state of the market." Viewed 24 April 2019. https://www.climatebonds.net/resources/reports/bonds-and-climate-change-state-market-2018.

Climate Change Authority (CCA) 2018a. "Review of the National Greenhouse and Energy Reporting Legislation." Commonwealth of Australia, Canberra. Viewed 29 April 2019. http://www.climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/files/2018%20NGER%20Review/CP/NGERCP.pdf.

CCA 2018b. "Reaping the rewards: improving farm profitability, reducing emissions and conserving natural capital." Commonwealth of Australia, Canberra. Viewed 29 April 2019. http://www.climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/files/2018%20Reaping%20the%20Rewards/Final%20Report%20-%20Reaping%20the%20Rewards.pdf.

CCA 2019. "Australia's climate change policies at the Australian and state and territory government levels: A stocktake." Commonwealth of Australia, Canberra. Viewed 29 April 2019. http://www.climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/Australian%20climate%20change%20policies%20-%20stocktake.pdf .

Chediak, Mark 2018. "Electric buses will take over half the world fleets by 2025." 1 February. Bloomberg. Viewed 1 May 2019. https://www.bloomberg.com/news/articles/2018-02-01/electric-buses-will-take-over-half-the-world-by-2025.

Climate Council 2018a. "A Renewable Feast." Viewed 24 April 2019, https://www.climatecouncil.org.au/resources/renewables-feast/.

Climate Council 2018b. "Renewables and business: cutting prices and pollution." Viewed 30 April 2019. www.climatecouncil.org.au/wp-content/uploads/2018/05/BusinessRenewables.pdf.

Climate Proofing Australia n.d. "Climate proofing Australia: a whole-of-landscape approach to tackling climate change." Viewed 30 April 2019. www.greeningaustralia.org.au/wp-content/uploads/2019/02/CPA-Document-final.pdf.

ClimateWorks Australia 2018. "Tracking progress to net zero emissions." Viewed 26 April 2019. https://www.climateworksaustralia.org/project/tracking-progress-net-zero-emissions.

ClimateWorks Australia n.d. "Decarbonisation Futures: Buildings – could innovation in buildings help change our decarbonisation trajectory?" Viewed 1 May 2019.

https://www.climateworksaustralia.org/sites/default/files/documents/publications/decarb-futures-buildings.pdf.

CLP Group 2018a. “Climate Vision 2050.” Viewed 26 April 2019. https://www.clpgroup.com/en/sustainability/our-approach/frameworks-strategies/climate-vision-2050.

CLP Group 2018b. “Building the "Utility of the Future".” Viewed 26 April 2019. https://sustainability.clpgroup.com/en/2018/Building-the-Utility-of-the-Future.

Council of Australian Governments (COAG) Energy Council 2019. “Trajectory for Low Energy Buildings.” Viewed 26 April 2019. http://www.coagenergycouncil.gov.au/publications/trajectory-low-energy-buildings.

Coal21 2018. “2018 Annual Review.” Viewed 26 April 2019. https://coal21.com/wp-content/uploads/2018/12/Coal21Fund-Annual-Review-brochure-eFinal-131118.pdf. **Coal21 n.d.a.** “Achievements.” Viewed 26 April 2019. https://coal21.com/achievements/?doing_wp_cron=1556251707.4823689460754394531250.

Coal21 n.d.b. “Project snapshot. Centennial Coal: Methane Reduction Demonstration.” Viewed 19 June 2019. https://coal21.com/wp-content/uploads/2018/12/Coal21-Snapshot-Current-Centennial-Coal-Methane-Reduction.pdf.

Coca-Cola Amital 2018. “Annual Report 2018.” Viewed 24 April 2019. https://www.ccamatil.com/investors-and-media/media-articles/annual-reports.

Compost Revolution n.d. “About the compost revolution.” Viewed 24 April 2019. https://compostrevolution.com.au/about/.

ConocoPhillips 2017. “Climate Change.” Viewed 26 April 2019. http://www.conocophillips.com/environment/climate-change/.

ConocoPhillips n.d. “Captureing the story behind the West Arnhem land fire abatement (WALFA) project.” Viewed 29 April 2019. http://www.conocophillips.com.au/sustainable-development/walfa/.

Cranenburgh, Nadine 2018. “Electric buses are taking over public transport of the future.” 28 March. Create. Viewed 1 May 2019. https://www.createdigital.org.au/electric-buses-public-transport-future/.

CSIRO 2017. “Australia secures $1.0 billion EU canola export market.” Viewed 29 April 2019. https://www.csiro.au/en/News/News-releases/2017/Australia-secures-$1-billion-EU-canola-export-market.

CSIRO 2018a. “Solar air-conditioning for heating and cooling.” 11 December. Viewed 30 April 2019. https://www.csiro.au/en/Research/EF/Areas/Solar/Solar-cooling/Solar-cooling-air-conditioning.

CSIRO 2018b. “Lithium-ion battery recycling.” 4 September. Viewed 26 April 2019. https://www.csiro.au/en/Research/EF/Areas/Energy-storage/Battery-recycling.

CSIRO 2018c. “Digital agriculture: what’s all the fuss about?” Viewed 30 April 2019. https://blog.csiro.au/digital-agriculture-whats-all-the-fuss-about/.

CSIRO 2019. “Photovoltaics” 28 March. Viewed 29 April 2019. https://www.csiro.au/en/Research/EF/Areas/Solar/Photovoltaics.

CSIRO n.d. “FutureFeed”. Viewed 12 June 2019. https://research.csiro.au/futurefeed/

Dairy Australia 2018. "Australian Dairy Industry Sustainability Report 2018." Viewed 29 April 2019. https://www.sustainabledairyoz.com.au/.

Dairy Australia n.d. "Environment Tools." Viewed 29 April 2019. https://www.dairyaustralia.com.au/farm/land-water-carbon/environment-tools.

Debelle, Guy 2019. Climate Change and the Economy (12 March). Viewed 24 April 2019. https://www.rba.gov.au/speeches/2019/sp-dg-2019-03-12.html.

Dechezlepretre, Antoine 2016. "Why aren't we investing enough in low-carbon technologies." World Economic Forum, 31 October. Viewed 26 April 2019. https://www.weforum.org/agenda/2016/10/how-to-reverse-the-dangerous-decline-in-low-carbon-innovation/.

Delta Electricity n.d.a. "Sustainability." Viewed 29 April 2019. http://www.de.com.au/sustainability.

Delta Electricity n.d.b. "Solar Project." Viewed 29 April 2019. http://www.de.com.au/sustainability/projects/solar-project.

Delta Electricity n.d.c. "Goat Hill project." Viewed 29 April 2019. http://www.de.com.au/sustainability/projects/goat-hill-project/goat-hill-project.

Delta Electricity n.d.d. "Post combustion carbon capture pilot project." Viewed 29 April 2019. http://www.de.com.au/sustainability/projects/post-combustion-carbon-capture-pilot-project.

DNV GL 2018. "Green corridor JIP delivers innovative bulk carrier designs for a low emissions future." 19 September. Viewed 29 April 2019. https://www.dnvgl.com/news/green-corridor-jip-delivers-innovative-bulk-carrier-designs-for-a-low-emissions-future-130453.

Ecovantage 2017. "NABERS assessments – benefits of NABERS." Viewed 24 April 2019. https://www.ecovantage.com.au/nabers-assessments/.

Edie Newsroom 2019. "CDP: Consumer goods giants prioritising plastic alternatives over low-carbon innovation." 26 February. Viewed 29 April 2019. https://www.edie.net/news/7/CDP--Consumer-goods-giants-failing-to-deliver-low-carbon-innovations-amid-plastics-action/.

Energetics 2019. "Corporate renewable energy PPA deal tracker." Viewed 24 April 2019. https://www.energetics.com.au/insights/knowledge-centres/corporate-renewable-ppa-deal-tracker.

Energetics 2018. "NSW Guide to Corporate Purchase Power Agreements." Viewed 24 April 2019. https://www.energetics.com.au/media/1825/wwf1452-updated-nav-corp-ppas-web-21.pdf.

EnergyAustralia n.d. "Go carbon neutral" Viewed 24 April 2019. https://www.energyaustralia.com.au/home/bills-and-accounts/go-neutral.

EnergyAustralia pers. comm 2019.

Energy Efficiency Council (EEC) 2016. "Australian Energy Efficiency Policy Handbook: Save Energy, Grow the Economy." Viewed 24 April 2019, http://www.eec.org.au/uploads/Documents/Platofrm%20Documents/Australian%20Energy%20Efficiency%20Policy%20Handbook%20%E2%80%93%20July%202016.pdf.

EEC 2018. "Navigating a dynamic energy landscape: A briefing for Australian businesses." Viewed 24 April 2019, https://www.energy.gov.au/news-media/news/navigating-dynamic-energy-landscape-briefing-australian-businesses.

EEC 2015. “National Energy Efficiency Awards 2015.” Viewed 26 April 2019. http://www.eec.org.au/events/national-energy-efficiency-awards/2018-award-winners#/2015-awards.

Ernst and Young 2016. “Building responsible and resilient supply chains.” Viewed 26 April 2019. https://www.ey.com/Publication/vwLUAssets/EY-building-responsible-and-resilient-supply-chains/$FILE/EY-building-responsible-and-resilient-supply-chains.pdf.

ESCOSA. n.d. REES Overview. Viewed 26 April 2019. https://www.escosa.sa.gov.au/industry/rees/overview.

Finkel, A 2018. “Proposal for a national hydrogen strategy.” Presented to COAG Energy Council. Viewed 29 April 2019. http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/DIIS%20-%20Hydrogen%20Proposal%20-%2020181219.pdf.

Follow This 2019. “Follow this files fifth climate resolution at Equinor”. 21 December 2018. Viewed 29 April 2019. https://follow-this.org/en/news/5-equinor/.

Fresner et al 2017. “Energy efficiency in small and medium enterprises: Lessons learned from 280 energy audits across Europe.” *Journal for Cleaner Production* 142 (2017) 1650-1660. Viewed 1 May 2019.

Future Farming 2018. “Precision farming could help reduce climate gas emissions.” Viewed 31 May 2019. www.futurefarming.com/Smart-farmers/Articles/2018/3/Precision-agriculture-helps-reduce-climate-gas-emissions-266218E/.

Gaines et al, Linda 2011. “Life-cycle Analysis of Production and Recycling of Lithium Ion Batteries.” Transportation Research Record: Journal of the Transportation Research Board (Transportation Research Board of the National Academies) 2252: 57-65. Viewed 26 April 2019. https://journals-sagepub-com.virtual.anu.edu.au/doi/pdf/10.3141/2252-08.

Genesis Now 2015. “Winner-National Industrial Energy Efficiency Award.” 18 November. Viewed 26 April 2019. http://genesisnow.com.au/winner-national-industrial-energy-efficiency-award/.

Geoscience Australia 2019. “Australian Energy Resources Assessment.” 9 January. Viewed 26 April 2019. https://aera.ga.gov.au/.

Geoengineering Monitor 2018. “Direct Air Capture,” Viewed 1 May 2019. http://www.geoengineeringmonitor.org/2018/05/direct-air-capture/.

Gilbert and Tobin 2019. “Green bond market in Australia and overseas.” Viewed 24 April 2019. https://www.gtlaw.com.au/insights/green-bond-market-australia-overseas.

Glencore 2019. “Furthering our commitment to the transition to a low-carbon economy.” 20 February. Viewed 24 April 2019. https://www.glencore.com/en/media-and-insights/news/Furthering-our-commitment-to-the-transition-to-a-low-carbon-economy.

Global CCS Institute 2018. “Global Status Report” Viewed 29 April 2019. https://www.globalccsinstitute.com/resources/global-status-report/.

GMA Garnet 2017. “GMA Garnet to deploy a 3MW Solar, Wind and Battery System in Western Australia.” 20 October. Viewed 26 April 2019. https://www.gmagarnet.com/en-au/info-hub/news-events/gma-garnet-to-deploy-a-3-mw-solar,-wind-and-batter.

Government of Western Australia 2019. "Construction of Kwinana waste to energy plant to create 800 jobs." 8 March. Viewed 26 April 2019. https://www.mediastatements.wa.gov.au/Pages/McGowan/2019/03/Construction-of-Kwinana-waste-to-energy-plant-to-create-800-jobs.aspx.

Green Building Council Australia (GBCA) 2017. "A Carbon positive roadmap for the built environment." Viewed 26 April 2019. https://gbca-web.s3.amazonaws.com/media/documents/a-carbon-positive-roadmap-v1-%28writable%29-distributed.pdf.

GBCA 2019. "Rating system." Viewed 26 April 2019. https://new.gbca.org.au/green-star/rating-system/.

GBCA and EY 2015. "Mid-tier commercial office buildings pathways." Viewed 26 April 2019. https://www.gbca.org.au/uploads/97/36449/Mid-Tier%20Commercial%20Office%20Buildings%20Pathway%20report.pdf.

Grain Research and Development Corporation (GRDC) 2018. "Understanding the European biofuel market for Australian Canola." Viewed 1 May 2019. www.australianoilseeds.com/__data/assets/pdf_file/0010/11431/EU_Canola_Certification_-_GRDC_Fact_Sheet.pdf.

Green Energy Markets 2018. "Small-scale technology certificates data modelling for 2018 to 2020." Viewed 24 April 2019. http://greenmarkets.com.au/images/uploads/GEM%20Reports/Industry%20Reports/GEM_2018_STC_modelling_Final_Report_with_Att.pdf.

Greencollar n.d. "Reef credits." Viewed 29 April 2019. https://greencollar.com.au/reef-credits/.

Greig et al, Chris 2016. "Energy Security and Prosperity in Australia: A roadmap for carbon capture and storage." The University of Queensland. Viewed 26 April 2019. https://energy.uq.edu.au/files/2274/UQE003_CCS_report_HR.pdf.

GRESB n.d. Viewed 26 April 2019. https://gresb.com/.

Heath, R, L Darragh, and A Laurie 2018. "The impacts of energy costs on the Australian agriculture sector." Research Report, Australian Farm Institute. Viewed 29 April 2019. https://farminstitute.worldsecuresystems.com/LiteratureRetrieve.aspx?ID=163636.

Hemmerdinger, Jon 2019. "Boeing unveils trussed wing capable of jet speeds." 9 January. FlightGlobal. Viewed 30 May 2019. https://www.flightglobal.com/news/articles/picture-boeing-unveils-trussed-wing-capable-of-jet-454898/.

HESC 2019. "About HESC." Viewed 26 April 2019. https://hydrogenenergysupplychain.com/about-hesc/.

Hughson, Lindy 2019. "Coca-Cola Australia ups recycled plastic use to 70 per cent." 16 April. Packaging News. Viewed 26 April 2019. https://www.packagingnews.com.au/latest/coca-cola-australia-ups-recycled-plastic-use-to-70.

Hume City Council n.d. "Business Efficiency Network: Supporting business in a changing climate." Viewed 26 April 2019. https://www.hume.vic.gov.au/files/sharedassets/hume_website/business/tri-tech_chemicals-_case_study.pdf.

Hurtley SC, Noel, and Sebastian Hartford Davis. 2019. “Climate Change and Directors Duties.” Viewed 24 April 2019. https://cpd.org.au/2019/03/directors-duties-2019/.

Hydrogen Strategy Group 2018. “Hydrogen for Australia's future.” briefing paper. Viewed 26 April 2019. https://www.chiefscientist.gov.au/wp-content/uploads/HydrogenCOAGWhitePaper_WEB.pdf.

Hydro Tasmania 2018. “Battery of the Nation - Tasmanian pumped hydro in Australia's future electricity market.” Concept study. Viewed 26 April 2019. https://www.hydro.com.au/docs/default-source/clean-energy/battery-of-the-nation/pumped-hydro-knowledge-sharing-report.pdf?sfvrsn=de58e528_4.

IEA & CSI 2018. “Technology Roadmap: low-carbon transition in the cement industry.” Viewed 26 April 2019. www.wbcsd.org/Sector-Projects/Cement-Sustainability-Initiative/Resources/Technology-Roadmap-Low-Carbon-Transition-in-the-Cement-Industry.

Insurance news 2018. “QBE to review model on fossil fuels.” 10 December. Viewed 26 April 219. https://www.insurancenews.com.au/corporate/qbe-to-review-model-on-fossil-fuels.

International Energy Agency (IEA) 2018. “Tracking clean energy innovation progress.” Viewed 26 April 2019. https://www.iea.org/tcep/.

IEA 2017. “Energy Efficiency 2017.” Viewed 29 April 2019. https://www.iea.org/publications/freepublications/publication/Energy_Efficiency_2017.pdf.

International Monetary Fund 2019. “IMF Country Report No. 19/55.” Viewed 24 April 2019. https://www.imf.org/en/Publications/CR/Issues/2019/02/13/Australia-2018-Article-IV-Consultation-Press-Release-Staff-Report-and-Statement-by-the-46612.

Kirkwood, Ian 2018. “Comsteel at Waratah has a centenary celebration.” 12 March. Viewed 18 June 2019. https://www.theherald.com.au/story/5278698/comsteels-100th-birthday/

Knight, Eric 2011. “The sun king.” The Monthly. June. Viewed 26 April 2019. https://www.themonthly.com.au/eric-knight-shi-zhengrong-sun-king-eric-knight-3363.

Latimer, Cole 2018. “GE to build the world's largest offshore wind turbines.” The Sydney Morning Herald, 19 March. Viewed 26 April 2019. https://www.smh.com.au/business/the-economy/ge-to-build-the-world-s-largest-offshore-wind-turbines-20180319-p4z520.html.

Lawton, G 2019. “Welcome to the age of wood.” New Scientist, 16 March: 33-37.

Lend Lease 2014. “Lend Lease’s Forté takes environmental excellence award at API awards.” Viewed 29 April 2019. https://www.lendlease.com/-/media/llcom/investor-relations/media-releases/2014/20140913-lend-leases-fort-takes-environmental-excellence-award-at-api-awards.pdf.

Lend Lease 2018 “Lend Lease wins big at the Urban Taskforce Development Excellence Awards.” Viewed 24 April 2019. https://www.lendlease.com/au/company/achievements-and-awards/2018-urban-taskforce-awards/.

Liberty 2018 “Liberty in Australia.” Viewed 18 June 2019. https://www.libertygfg.com/media/278821/liberty-in-australia-brochure.pdf.

Linfox 2019. “Delivering Sustainability.” Viewed 26 April 2019. https://www.linfox.com/about/sustainability-centre/.

Locke, S 2017. “Carbon abatement helping farmers but not doing much for emissions.” ABC Rural News, 9 April. Viewed 29 April 2019. , http://www.abc.net.au/news/rural/2017-04-09/carbon-farming-no-solution-toreducing-australias-emissions/8409900.

Logic 2019. “XLAM Cross Laminated Timber Plant.” Viewed 29 April 2019. https://logicwodonga.com.au/tenants/20189434698.asp.

Macdonald-Smith, Angela 2018a. “Industry signs up for green power as bills soar.” Australian Financial Review. 19 August. Viewed 24 April 2019. https://www.afr.com/business/energy/electricity/industry-saves-40pc-on-power-by-going-green-20180817-h143v4.

Macdonald-Smith, Angela 2018b. “AGL Energy's Loy Yang A to host $500m hydrogen pilot project.” Australian Financial Review. 11 April. Viewed 26 April 2019. https://www.afr.com/business/mining/coal/agl-energys-loy-yang-a-to-host-500m-hydrogen-pilot-project-20180411-h0ym0k.

MacDonald-Smith, Angela 2017. “Woodside Petroleum, BHP Billiton to study fuelling iron ore ships with LNG.” Australian Financial Review. 27 January. Viewed 26 April 2019. https://www.afr.com/business/energy/gas/woodside-petroleum-bhp-billiton-to-study-fuelling-iron-ore-ships-with-lng-20170127-gtzvbr.

Market Forces 2018. “CommBank: All talk, still no walk on fossil fuel finance.” 7 November. Viewed 26 April 2019. https://www.marketforces.org.au/commbank-2018-agm/.

Market Forces 2019. “Investing in the Dark.” Viewed 24 April 2019. https://www.marketforces.org.au/wp-content/uploads/2018/06/MF-Investing-in-the-Dark-FINAL-A4.pdf.

Macquarie 2019. “Macquarie and climate change.” Viewed 20 May 2019. https://static.macquarie.com/dafiles/Internet/mgl/global/shared/sf/pdf/climate-change-approach.pdf.

Matasci, Sara 2019. “How solar panel cost and efficiency has changed over time.” Energysage. 4 January. Viewed 30 April 2019. https://news.energysage.com/solar-panel-efficiency-cost-over-time/.

Mazengarb, Michael 2019. “Bank Australia becomes first Australian bank to purchase 100% renewables.” RenewEconomy. 6 May. Viewed 20 May 2019. https://reneweconomy.com.au/bank-australia-becomes-first-australian-bank-to-purchase-100-renewables-10093/.

McDonalds n.d. “Climate Action.” Viewed 29 April 2019. https://corporate.mcdonalds.com/corpmcd/scale-for-good/climate-action.html.

Mercer, Daniel, and Peter Milne 2018. “Chevron gets lifeline on delayed Gorgon carbon capture.” The West Australian, 17 October. Viewed 26 April 2019. https://thewest.com.au/business/energy/chevron-gets-lifeline-on-delayed-gorgon-carbon-capture-ng-b88992451z.

Millington, B 2019. “Coal ash has become one of Australia's biggest waste problems — and a solution is being ignored.” ABC. 10 March. Viewed 30 April 2019. www.abc.net.au/news/2019-03-10/coal-ash-has-become-one-of-australias-biggest-waste-problems/10886866.

Mineral Products Association Cement n.d. “Climate change.” Viewed 30 April 2019. https://cement.mineralproducts.org/current_issues/climate_change.php.

Mission Innovation 2019. Overview. Viewed 26 April 2019. http://mission-innovation.net/about-mi/overview/.

Meat and Livestock Australia (MLA) 2017. "Red meat industry can be carbon neutral by 2030." Viewed 24 April 2019. https://www.mla.com.au/news-and-events/industry-news/red-meat-industry-can-be-carbon-neutral-by-2030/

Morgan, Elysse 2018. "Woodside boss Peter Coleman calls for Australia to introduce a carbon price." ABC News, 14 November. Viewed 26 April 2019. https://www.abc.net.au/news/2018-11-14/woodside-ceo-peter-coleman-argues-for-carbon-price/10494026.

Nathan G, Suenaga M, Kodama T, Tourbier D, Zughbi H, Dally B, Stechel E, Sattler C, Cochrane D, DeGaris R, Lovegrove K, Hooey L, Jeanes S, Metha G, Arjomandi M, Matthews C 2019. "HiTemp Outlook 2018. Transforming high temperature minerals processing: a multi-stakeholder perspective on pathways to high value, net-zero CO_2 products for the new economy." Adelaide: University of Adelaide. Viewed 12 June 2019. https://www.adelaide.edu.au/hitemp/system/files/media/documents/2019-04/HiTeMP-Outlook-2019.pdf

National Academies of Sciences, Engineering and Medicine 2018. "Direct aire capture and mineral caerbonation approaches for carbon dioxide removal and reliable sequestration." Viewed 30 May, 2019. https://www.nap.edu/read/25132/chapter/1.

National Farmers Federation (NFF) 2018. "NFF releases 2030 Roadmap to guide industry growth." 17 October. Viewed 29 April 2019. https://www.nff.org.au/read/6187/nff-releases-2030-roadmap-guide-industry.html.

National Geographic 2017. "5 advances that will change air travel." 2 May. Viewed 26 April 2019. https://www.nationalgeographic.com/environment/urban-expeditions/transportation/green-aviation1/.

National Institute for Forest Products Innovation n.d. "Commitment to innovation." Viewed 29 April 2019. https://nifpi.org.au/.

Natural Marketing Institute (NMI) 2017. "2017 State of sustainability in America." Viewed 29 April 2019. https://www.nmisolutions.com/research-reports/sustainability-reports/2017-state-of-sustainability-in-america.

Neoen 2018. "Hornsdale Power Reserve." Presentation by Clément Viaudto the ARENA Insights forum, 30 November 2018. Viewed 18 June 2019. https://arena.gov.au/assets/2019/02/hornsdale-power-reserve.pdf.

New Zealand Agricultural Greenhouse Gas Research Centre (NZAGGRC) 2017. "Methane Research Programme." Viewed 29 April 2019. https://www.nzagrc.org.nz/methane.html.

Nielson 2015. "The sustainability imperative." Viewed 29 April 2019. http://www.nielsen.com/us/en/insights/reports/2015/the-sustainability-imperative.html.

NSW Government DECCW 2010. "Environmental benefits of recycling." Sydney: Department of Environment, Climate Change and Water NSW. Viewed 26 April 2019. https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/warrlocal/100058-assumptions.pdf.

Oil and Gas Climate Initiative 2018. "Oil and Gas Climate Initiative." Viewed 26 April 2019. https://oilandgasclimateinitiative.com/.

Origin 2018. "2018 Sustainability Report." Viewed 26 April 2019. https://www.originenergy.com.au/content/dam/origin/about/investors-media/documents/Origin_2018_Sustainability_Report.pdf.

Orora 2018. "Annual Report 2018: The promise of what's inside." Viewed 24 April 2019. https://www.ororagroup.com/ckeditor_assets/attachments/276/18_09_14_orora_annual_report_2018_interactive.pdf.

Parkinson, Giles 2017a. "WA's biggest pig farm about to go 100 per cent renewable energy." 24 August. RenewEconomy. Viewed 29 April 2019. https://reneweconomy.com.au/biggest-pig-farm-go-100-per-cent-renewable-energy-52164/.

Parkinson, Giles 2017b. "Nectar Farms on 100% renewables: "Why would you do it any other way?"" 28 June. RenewEconomy. Viewed 24 April 2019. https://reneweconomy.com.au/nectar-farms-on-100-renewables-why-would-you-do-it-any-other-way-79279/.

Paulka, Charles 2019. "IKEA deliveries to be all electric by 2025. Transport and Logistics News, 15 March." Viewed 26 April 2019. https://www.tandlnews.com.au/2019/03/15/article/ikea-deliveries-to-be-all-electric-by-2025/.

Planet Ark n.d. "The benefits of wood." Viewed 1 May 2019. https://makeitwood.org/benefits/.

Plouffe, Jim 2019. "Renewable hydrogen power plant step closer in Port Lincoln." RenewEconomy. 7 February. Viewed 10 May 2019. https://reneweconomy.com.au/renewable-hydrogen-power-plant-step-closer-in-port-lincoln-67209/.

Pork CRC 2016a. "Bioenergy Support Program, Talking Topic 1 - Collecting the biogas benefits of pig manure." Viewed 29 April 2019. http://porkcrc.com.au/wp-content/uploads/2013/11/Bioenergy-Support-Program-Talking-Topic-1.pdf.

Pork CRC 2016b. "Bioenergy Support Program, Talking Topic 4 - Cleaning piggery biogas." Viewed 29 April 2019. http://porkcrc.com.au/research/program-4/bio-energy-support-program/talking-topics/.

Potter, Alison. n.d. "Choice: How do smart meters work and can they save you money." Viewed 26 April 2019. https://www.choice.com.au/home-improvement/energy-saving/power-meters/articles/smart-meters-how-do-they-work.

Powershop n.d. "Powershop." Viewed 24 April 2019. https://www.powershop.com.au/.

Price, John 2018. Climate Change (18 June). Viewed 24 April 2019. https://asic.gov.au/about-asic/news-centre/speeches/climate-change/.

PwC 2017. "Sustainability and Climate Change". Viewed 24 April 2019. https://www.pwc.com/gx/en/services/sustainability.html.

Qantas n.d. "Creating a sustainable future with aviation biofuels." Viewed 30 April 2019. https://www.qantas.com/travel/airlines/sustainable-aviation-fuel/global/en.

Qantas 2019. "Quantas opertes world's forst zero waste flight." Viewed 30 May 2019. https://www.qantasnewsroom.com.au/media-releases/qantas-operates-worlds-first-zero-waste-flight/.

Real Utilities n.d. "How to keep your energy real." Viewed 26 April 2019. https://www.fraserspropertyproperty.com.au/real-utilities/home.

RE100 2019. “RE100 Companies.” Viewed 24 April 2019. http://there100.org/companies.

Reef Credit 2019. “Overview.” Viewed 2 May 2019. www.reefcredit.org/

Regional Development Australia 2018. “Lithium Valley: Establishing the case for the energy metals and battery manufacturing in Western Australia.” Regional Development Australia. Viewed 26 April 2019. https://www.rdaperth.org/wp-content/uploads/2018/05/RDA4491-LITHIUM-REPORT-2018_LOWRES.pdf.

Research and Markets 2018. “Meat Substitutes Market by Type (Tofu & Tofu Ingredients, Tempeh, Textured Vegetable Protein (TVP), Seitan, and Quorn), Source (Soy, Wheat, and Mycoprotein), Category (Frozen, Refrigerated, and Shelf-Stable), and Region - Global Forecast to 2023.” Viewed 1 April 2019. https://www.researchandmarkets.com/reports/4461023/meat-substitutes-market-by-type-tofu-and-tofu

Responsible Wood n.d. “Our Standards.” Viewed 29 April 2019. https://www.responsiblewood.org.au/standards/.

Rio Tinto 2019. “Energy and Climate Change.” Viewed 26 April 2019. https://www.riotinto.com/ourcommitment/energy-and-climate-change-24291.aspx.

Rio Tinto 2018. “Our Approach to Climate Change 2018.” Viewed 24 April 2019. https://www.riotinto.com/documents/RT_Our_approach_to_climate_change_2018.pdf.

Rio Tinto 2016. “RenewAl – worlds first certified low CO2 aluminium.” Viewed 24 April 2019. http://www.riotinto.com/documents/Aluminium_RenewAl_Factsheet.pdf.

RMIT 2019. “Harnessing light for a solar-powered chemical industry.” 31 January. Viewed 26 April 2019. https://www.rmit.edu.au/news/all-news/2019/jan/solar-powered-chemical-industry.

Roads and Maritime Services (NSW) 2018. “QA Specification 3051 Granular pavement base and subbase materials. Roads and Maritime Services.” Viewed 26 April 2019. www.rms.nsw.gov.au/business-industry/partners-suppliers/documents/specifications/3051.pdf.

Rocky Mountain Institute 2017. “Positive Disruption: Limiting global temperature rise to well below 2 degrees.” Viewed 29 April 2019. https://rmi.org/insight/positive_disruption_limiting_global_temperature_rise/.

Rosengren 2016. “Biogas purification technology coming to Mississippi landfill.” 6 December. WasteDrive. Viewed 24 April 2019. https://www.wastedive.com/news/biogas-purification-technology-coming-to-mississippi-landfill/431695/.

Rural Industries Research and Development Corporation 2013. “Crude oil from green biomass.” Viewed 7 May 2019. http://biomassproducer.com.au/case_study/crude-oil-from-green-biomass/.

SACYR 2018. “Sacyr completes financing with CEFC of the waste treatment plant in Melbourne (Australia).” Viewed 24 April 2019. http://www.sacyr.com/es_en/Channel/News-Channel/news/featuresnews/2018/Adjudicacion/20180802_Financiacion_Planta_Melburne.aspx.

Santos 2019. “Climate Change Report 2019.” Viewed 26 April 2019. https://www.santos.com/media/4656/2019-climate-change-report.pdf.

Santos 2018. “Santos rolls out renewable energy in the Cooper Basin.” 18 December. Viewed 26 April 2019. https://www.santos.com/media-centre/announcements/santos-rolls-out-renewable-energy-in-the-cooper-basin/.

Science Based Targets 2019. “Science Based Targets.” Viewed 24 April 2019. https://sciencebasedtargets.org/.

Scott, Mike 2019. “Shoppers want more sustainable products, but brands are struggling to keep up.” Forbes. 26 February. Viewed 24 April 2019. https://www.forbes.com/sites/mikescott/2019/02/26/shoppers-want-more-sustainable-products-but-brands-are-struggling-to-keep-up/#4bf9abcc364a.

SEA Electric 2019. Viewed 26 April 2019. https://www.sea-electric.com/products/.

Shapiro, Jonathan 2019. “Woolworths' green bonds trade strongly in after-market.” Financial Review. 15 April. Viewed 26 April 2019. https://www.afr.com/business/banking-and-finance/woolworths-green-bonds-trade-strongly-in-after-market-20190415-p51eda.

Shell 2019. “Sustainability Report 2018” Viewed 30 May 2019. https://reports.shell.com/sustainability-report/2018/.

Shopping Centre News 2019. “Stockland, the only Australian property company icluded on the global climate A-list.” Viewed 30 May 2019. https://www.shoppingcentrenews.com.au/shopping-centre-news/industry-news/stockland-the-only-australian-property-company-included-on-global-climate-a-list/.

SIMEC Energy Australia 2018. “Cultana Solar Farm.” Viewed 26 April 2019. https://www.simecenergy.com.au/projects/cultana-solar-farm/.

Snowy Hydro n.d. “FAQs”. Viewed 10 May 2019. https://www.snowyhydro.com.au/our-scheme/snowy20/faqs20/.

Snowy2.0 2017. “Short Feasibility Study Report.” Viewed 26 April 2019. https://drive.google.com/file/d/1gSMxMMGpHxbJLGFwiSVMXNdpVV2h9mOb/view.

South32 2017. “New Solar Farm for Cannington.” Viewed 26 April 2019. https://www.south32.net/sustainability/our-news/solar-to-power-cannington-mine.

Stevens, Mathews 2019. “Rio reject Market Forces mission creep.” Australian Financial Review. 18 March. Viewed 24 April 2019. https://www.afr.com/business/rio-rejects-market-forces-mission-creep-20190318-h1ciq3.

Stock et al, Andrew 2018. “Fully charged: renewables and storage powering Australia.” Climate Council. Viewed 24 April 2019. https://www.climatecouncil.org.au/wp-content/uploads/2018/03/Fully-Charged-Renewables-and-Storage-Powering-Australia.pdf.

Stockland 2018. “Carbon and Energy.” Viewed 30 May 2019. https://www.stockland.com.au/sustainability/downloads

Stockland n.d. “About Stockland.” Viewed 24 April 2019. https://www.stockland.com.au/about-stockland.

Summerhayes, Geoff 2019. “Financial exposure: the role of disclosure in addressing the climate data deficit” (22 February). Viewed 24 April 2019. https://www.cisl.cam.ac.uk/news/news-pdfs-or-prs/financial-exposure-geoff-summerhayes.pdf.

Suntech n.d. “About Suntech”. Viewed 1 May 2019. https://www.suntech-power.com.au/about-suntech.

Sunwiz n.d. “Can Australian PV keep up the pace set by 2017’s record breaking year.” Viewed 29 April 2019. http://www.sunwiz.com.au/index.php/2012-06-26-00-47-40/73-newsletter/429-2018-can-australian-pv-keep-up-the-pace-set-by-2017-s-record-breaking-year.html.

Sustainability Vitoria 2018. “Australia's first lithium battery recycling plant opens.” 26 April. Viewed 26 April 2019. https://www.sustainability.vic.gov.au/About-us/Latest-news/2018/04/26/04/57/Australias-first-lithium-battery-recycling-plant-opens.

Tahbilk 2018. “CarboNZero.” Viewed 29 April 2019. http://www.tahbilk.com.au/our-story/carbonbalanced.ht.

Task Force on Climate-Related Financial Disclosures (TCFD) 2017. “Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures.” Viewed 24 April 2019. https://www.fsb-tcfd.org/publications/final-recommendations-report/.

The Climate Group. 2019. “EP100 Members.” Viewed 24 April 2019. https://www.theclimategroup.org/ep100-members.

The Green Electricity Guide n.d. “The Green Electricity Guide.” Viewed 26 April 2019. https://www.greenelectricityguide.org.au/.

The International Aluminium Institute 2018. “Aluminium for future generations.” Viewed 30 April 2019. http://recycling.world-aluminium.org/home/.

Toll 2019. “Social responsibility.” Viewed 26 April 2019. https://www.tollgroup.com/about/social-responsibility/planet.

TriTech n.d.a. “Supplying Creative Chemical Solutions”. Viewed 26 April 2019. https://www.ttcc.com.au/.

TriTech n.d.b. “Energy Usage at Tri-Tech Chemical.” Viewed 26 April 2019. http://www.hume.vic.gov.au/files/sharedassets/hume_website/business/energy_usage_at_tritech_chemicals.pdf.

United Nations Global Compact 2019. “United Nations Global Compact.” Viewed 24 April 2019. https://www.unglobalcompact.org/.

University of Queensland 2018. “Revolutionising fertiliser for a healthier reef.” 4 December. Viewed 29 April 2019. https://www.uq.edu.au/news/article/2018/12/revolutionising-fertiliser-healthier-reef.

University of South Australia 2019. “Renewable energy solution for industrial heat applications.” 14 March. Viewed 26 April 2019. http://www.unisa.edu.au/Media-Centre/Releases/2019/renewable-energy-solution-for-industrial-heat-applications/.

US Environment Protection Agency 2015. “Plastics” Viewed 30 May 2019. https://archive.epa.gov/epawaste/conserve/tools/warm/pdfs/Plastics.pdf.

Veolia 2017. "A new way of treating Sydney's Waste: From kerbside collection to compost." Viewed 30 April 2019. https://www.veolia.com/anz/newsroom/new-way-treating-sydneys-waste-kerbside-collection-compost.

Victorian Government 2016. "Turning waste into renewable energy and creating jobs." Viewed 29 April 2019. https://www.premier.vic.gov.au/turning-waste-into-renewable-energy-and-creating-jobs/.

Victorian Government DELWP 2017. "Sawmill powered by wood waste." 9 June. Viewed 29 April 2019. https://www.energy.vic.gov.au/renewable-energy/bioenergy/sawmill-powered-by-wood-waste.

Visy n.d. "About us." Viewed May 1, 2019. https://www.visy.com.au/about/visy.

Vorrath, S 2018. "Gupta doubles down on green industrial plans for Whyalla, powered by cheap renewables." 10 December. Viewed 30 April 2019. https://reneweconomy.com.au/gupta-doubles-down-on-green-industrial-plans-for-whyalla-powered-by-cheap-renewables-24759/.

Waranga Green Energy n.d. "Renewable energy from waste." Viewed 2 May 2019. www.warangagreen.com.au/energy.

World Business Council for Sustainable Development (WBCSD) 2019. "Low Carbon Technology Partnerships Initiative." Viewed 24 April 2019. https://www.wbcsd.org/Programs/Climate-and-Energy/Climate/Low-Carbon-Technology-Partnerships-initiative.

We Mean Business 2019. "Remove Deforestation." Viewed 24 April 2019. https://www.wemeanbusinesscoalition.org/commitment/remove-commodity-driven-deforestation-from-all-supply-chains-by-2020/.

We Mean Business n.d. "What we do." Viewed 29 May 2019. https://www.wemeanbusinesscoalition.org/about/.

Wesfarmers 2018. "Sustainability report." Viewed 26 April 2019. https://sustainability.wesfarmers.com.au/.

Westpac Banking Corporation 2019a. "Media releases: Westpac commits to 100 percent renewables by 2025." 17 April. Viewed 30 April 2019. https://www.westpac.com.au/about-westpac/media/media-releases/2019/17-april/.

Westpac Banking Corporation 2019b. "2020 Sustainability Strategy – Half year progress update." 6 May. Viewed 30 April 2019. https://www.westpac.com.au/about-westpac/sustainability/news-resources-and-ratings/may-2019-half-year-progress-update/.

Westpac Banking Corporation 2019c. "Supporting the transition to a low carbon economy." 15 April. Viewed 1 May 2019. https://www.westpac.com.au/about-westpac/sustainability/news-resources-and-ratings/supporting-the-transition-to-a-low-carbon-economy/.

Wiedemann et al 2016. "Environmental impacts and resource use from Australian pork production assessed using life-cycle assessment 1. Greenhouse gas emissions." Animal Production Science pp.1418-1431.

Wilmot, Ben 2019. "Oil and Gas hit as Norway Exits." The Australian. 10 March. Viewed 24 April 2019. https://www.theaustralian.com.au/subscribe/news/1/?sourceCode=TAWEB_WRE170_a_GGL&dest=https://www.theaustralian.com.au/business/mining-energy/oil-and-gas-hit-as-norway-exits/news-story/b7f50036750c93fe95a1151c6d04b2d8&memtype=anonymous&mode=premium&is_sil.

Woodside 2019. “Sustainability development report 2018.” Viewed 10 May 2019. https://files.woodside/docs/default-source/investor-documents/major-reports-(static-pdfs)/2018-sustainable-development-report/sustainable-development-report-2018.pdf?sfvrsn=55694111_15.

Wood Solutions n.d. “Strength performance.” Viewed 26 April 2019. https://www.woodsolutions.com.au/articles/strength-performance.

Woolworths group 2018. “Sustainability report.” Viewed 26 April 2019. https://www.woolworthsgroup.com.au/page/investors/our-performance/reports/Reports/CR_Reports.

Woolworths Group 2019. “Woolworths Group first globally to issue Certified Green Bonds for a supermarket.” 10 April. Viewed 26 April 2019. https://www.woolworthsgroup.com.au/page/media/Latest_News/woolworths-group-first-globally-to-issue-certified-green-bonds-for-a-supermarket.

World Coal Association 2019. “Carbon capture, use and storage.” Viewed 26 April 2019. https://www.worldcoal.org/reducing-co2-emissions/carbon-capture-use-storage.

World Aluminium 2016. “Results of the 2015 Anode Effect Survey.” Viewed 26 April 2019. http://www.world-aluminium.org/media/filer_public/2016/08/08/2015_anode_effect_survey_result_2016.pdf.

Yeates, Clancy 2018. “One area where the banks are getting it right: curbing coal.” The Sydney Morning Herald. 22 January. Viewed 26 April 2019. https://www.smh.com.au/business/banking-and-finance/one-area-where-the-banks-have-got-it-right-curbing-coal-20180119-p4yymp.html.

Yonggang, Jin, and Su Shi 2018. “Proof-of-Concept Photocatalytic Destruction of Methane for Coal Mining Fugitive Emissions Abatement.” ACARP. Viewed 29 April 2019. https://www.acarp.com.au/abstracts.aspx?repId=C24061.

Yoo, Tony 2017. “South Australia just built the nation’s first electric bus.” 27 June. Tech Insider. Viewed 1 May 2019. https://www.businessinsider.com.au/south-australia-just-built-the-nations-first-electric-bus-2017-6.