

Australian Government Department of Industry, Science, Energy and Resources Office of the Chief Economist

Resources and Energy Major Projects 2021 Report

Further information

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Acknowledgements

The authors would like to acknowledge the contributions of:

Ken Colbert, Lauren Croser, Brendan Halloran, James Hutson, Jeewantha Karunarathna, Lex Macias and David Thurtell

Cover image source: Shutterstock

ISSN 1839-5007

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About this report

The *Resources and Energy Major Projects* publication is an annual review of projects which seek to extend, increase, or improve the quality of mineral commodity output in Australia. These investment projects include greenfield projects, expansions, reactivations, processing facilities, and related infrastructure. Since 1997, the publication has estimated the value of current and potential investment in the sector and provided commentary on key development trends.

From 2017 to 2019, *Resources and Energy Major Projects* was published as a chapter in the *Resources and Energy Quarterly*. The 2020 and 2021 editions, as well as pre-2017 updates, are standalone publications.

This edition of the report presents an update on project developments over the twelve months from the start of November 2020 to the end of October 2021, and is accompanied by a <u>detailed project listing</u>. This year, the list of major resources and energy projects in Australia features 367 projects.

Terminology

The full methodology is detailed in Section 8.

This report and project list is the result of a census on major resources and energy projects under development in Australia. For the purposes of this report, 'major' projects are those valued at over \$50 million, and which have the potential to reach a final investment decision (FID) within the next five years.

Projects are classified into four stages of an investment pipeline model: publicly announced, feasibility, committed and completed. Earlier stages of developing mineral projects, such as identifying deposits and exploration activities, are not included in the assessment.

Project totals at the feasibility and publicly announced stages are categorised as 'unlikely' (0 - 20% probability), 'possible' (20 - 60%) or 'likely' (60 - 100%) to progress to the committed stage.

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Key statistics

Resources and Energy Major Projects 2021

Value of resource and energy projects in the investment pipeline in the 12 months to 31 October 2021



Share of committed projects by commodity (in value terms):



367 projects in investme
20+ different represente
+24% increase i

projects in the **investment pipeline**

different commodities represented

increase in **value of commited projects** over the past year

Summary

- There are significant opportunities emerging for Australia's resources and energy sector, especially in the new energy economy.
- With the inclusion of hydrogen projects in this year's report, over the year from the start of November 2020 to end October 2021, the number of resources and energy major development projects rose to 367.
- The report now includes hydrogen, ammonia and carbon capture and storage (CCS) projects, which account for \$185 billion worth of investment. With this expanded scope, the total value of projects in the investment pipeline is at \$504 billion.
- The value of gold and battery/electric vehicle-related projects rose by 36% and 12% respectively, reflecting strong gold prices and expectations of strong growth for electric vehicles.
- The value of committed projects rose to \$54 billion, adding momentum to the investment cycle and a change in investment style.
- Committed and completed resources projects are expected to create around 25,100 construction jobs and 8,300 ongoing jobs.

1. Overview

The value of publicly announced projects surged with hydrogen's inclusion

Our outlook for resources and energy investment suggests that 2021 represented significant growth in the resources investment cycle. The value of 'committed' resource and energy projects — those where a final investment decision (FID) has been taken — increased by 24% over the past year to \$54 billion (Figure 1.1). This continuing growth in value was driven by iron ore and battery metals projects. The jump in publicly announced projects largely comes from our first inclusion of hydrogen.

Fifteen resource and energy major projects were completed over the past 12 months (Figure 1.2). The value of completed projects increased from \$2.3 to \$10.1 billion, as a number of metals projects and an iron ore project were concluded. These include the Tampia gold greenfield project and Boddington gold mine's autonomous haulage system.



■ Oct-14 ■ Oct-15 ■ Oct-16 ■ Oct-17 ■ Oct-18 ■ Oct-19 ■ Oct-20 ■ Oct-21 Notes: Value of publicly announced and feasible projects estimated as the range mid-point. Source: Department of Industry, Science, Energy and Resources (2021)

Figure 1.2: Number of projects in the investment pipeline, 2014-2021



■ Oct-14 ■ Oct-15 ■ Oct-16 ■ Oct-17 ■ Oct-18 ■ Oct-19 ■ Oct-20 ■ Oct-21 Source: Department of Industry, Science, Energy and Resources (2021)

Figure 1.1: Value of projects in the investment pipeline, 2014-2021

Of the projects for which job estimates are made, committed resources projects are expected to create about 25,100 construction jobs and 8,300 ongoing jobs. However, the total numbers are expected to rise as estimates become more comprehensive over time.

Gold and LNG projects are showing significant promise

The past year has seen a surge in reactivated gold mines, as higher gold prices draw out previously closed operations for development. Vista Gold received approval from the Northern Territory government in mid-June 2021 to recommence operations at the mothballed Mount Todd gold mine. The site has been on care and maintenance since 2006. Heritage Minerals plans to reopen the 1.6 tonnes a year Mount Morgan gold mine in Queensland in 2023. The mine was once one of the richest in the world, but was contaminated with acid water and abandoned in 1990. Four companies have previously attempted and failed to revive the historic mine site, which produced its first gold in 1882. There are now \$5.1 billion of gold projects at the 'committed' stage, likely encouraged by high Australian dollar gold prices. Seventeen gold projects (with annual capacity of about 84 tonnes) are at the 'feasibility' stage.

Since the last *Resource and Energy Major Projects* report, over \$11 billion has been committed to oil and gas/LNG projects. Most of this figure is attributed to 2 projects that reached FID in 2021 — the Barossa gas project and the Jansz-Io Compression Project. However, the impact of the COVID-19 pandemic on oil and LNG prices during 2020 led to the deferral of FIDs for several large offshore projects originally expected in 2020 or 2021. Fifteen oil and gas/LNG projects remain at the feasibility stage.

There are 37 coal projects at the feasibility stage, but many of these have been delayed (Table 1.1). There is a growing preference for expansions of brownfield sites over new greenfield investments. The growing reluctance to commit to greenfield coal projects has been impacted by an expanding list of lenders/investors who have withdrawn from financing new thermal coal projects. Some pension and equity funds are also divesting from, or limiting their exposure to, thermal coal, limiting the range of investment financing options available to coal project developers.

Table 1.1: Change in value of total projects between 2020 and 2021

Commodity	Change in value 2020-2021
Aluminium, alumina, bauxite	23%
Coal	-7%
Copper	7%
Critical Minerals	25%
Gold	36%
Hydrogen	-
Infrastructure a	22%
Iron ore	1%
Lead, zinc, silver	7%
LNG, gas, petroleum	-15%
Nickel, Cobalt	-13%
Uranium	0%
Other commodities	0%

Notes: **a** Infrastructure is limited to resource, energy infrastructure projects including CCS. Source: Department of Industry, Science, Energy and Resources (2021)

Total

By state, WA remains easily the largest destination for projects, especially in the new energy space (Figures 1.3 and 1.4). The State has large reserves of lithium and gold, which have both experienced strong prices in 2021.

50%



Figure 1.3: Total projects, by State and Territory

Notes: Value of publicly announced and feasible projects estimated as the range mid-point. Source: Department of Industry, Science, Energy and Resources (2021)

Early stage projects are increasing

There has been an increase in activity at the early stages of the investment pipeline, with the value and number of projects at the 'publicly announced' stage increasing from 2020 (Figures 1.1 and 1.2).

The value of projects at the 'feasibility' stage increased slightly. Part of the increase can be attributed to the inclusion of hydrogen and ammonia projects for the first time. However, the estimate may be understated, due to a lack of any capital cost estimates for eleven hydrogen and ammonia projects.

Twenty three projects progressed from the 'feasibility' stage to the 'committed' stage.

This increase in investment activity likely partly reflects the rising importance of the new energy economy as well as the inclusion of hydrogen, despite uncertainties due to the COVID-19 pandemic. The

impacts of the COVID-19 pandemic have also been partially offset by a high gold price and the consequent reactivation of a number of gold mines.

High gold prices have driven an increase in exploration expenditure, particularly across the precious and base metals sectors (copper, zinc/lead projects with gold by-products). Australia's gold exploration expenditure reached a record high of \$1.5 billion in 2020–21, accounting for 47% of Australia's total mineral exploration expenditure.

The new energy economy

The *Resources and Energy Major Projects* report now covers the new energy economy, with the inclusion of hydrogen and ammonia projects as well as battery metals and their associated refineries (Figures 1.4 and 1.5).



Figure 1.4: New Energy projects, by State and Territory

Source: Department of Industry, Science, Energy and Resources (2021)

Hydrogen and ammonia projects are classified together in the hydrogen commodity group as ammonia projects are often used to facilitate transport of hydrogen. These projects are proposed across the nation, with significant projects listed for WA and Queensland. The production of refined lithium hydroxide in Australia commenced in August 2021 at Kwinana in WA. Refined graphite production projects for battery anodes have been proposed for WA and South Australia.





Notes: New energy economy refers to hydrogen, and battery and electric vehicle related minerals including commodities that have important inputs into rechargeable batteries and rare earth permanent magnets that are part of electric motors. Source: Department of Industry, Science, Energy and Resources (2021)

	Publicly	Announced	Feasibili	ity	Commit	ted	Complet	ted	Total		
	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	
Aluminium, Alumina, Bauxite	2	1.4	2	0.3					4	1.8	
Coal	23	21-26+	37	45-51+	8	3.7	1	2.0	69	72-82+	
Copper	9	3.0-4.2+	5	2.8-3.1	1	0.6			15	6.4-7.9+	
Critical Minerals	13	2.8-6.0+	33	8-15+	11	4.7	2	0.3	59	16-26+	
Gold	5	0.2-0.7	17	5.5-6.0+	19	5.1	2	0.3	43	11-12+	
Hydrogen	14	127-133+	6	6-52+	1	0.5			21	133-185+	
Infrastructure a	11	14-16+	9	4.0-6.7+	11	3.5	1	0.1	32	22-26+	
Iron ore	12	8-10+	12	16-22+	6	11	4	6.4	34	41-50+	
Lead, Zinc, Silver			2	0.4	2	0.5			4	0.9	
LNG, Gas, Petroleum	14	26-29+	15	65-71+	13	23	3	0.7	45	115-123+	
Nickel, Cobalt	3	0.6-0.9+	6	4.4-7.0+	4	0.5			13	5.6-8.3+	
Other Commodities b	6	0.9-2.1+	10	3.8-5.6+	3	1.2	2	0.3	21	6-9+	
Uranium	1	0.6	6	2.4+					7	3.0+	
Total	113	203-229+	160	163-243+	79	54	15	10.1	367	434-536+	

Table 1.2: Summary of projects in the investment pipeline as at 31 October 2021

Notes: a Infrastructure is limited to resource, energy infrastructure projects including CCS. A number of gas pipelines span across more than one state but have been allocated to one state for reporting purposes. b Other Commodities is limited to resource and energy commodities not elsewhere identified. c Totals may not add due to rounding at commodity level. Source: Department of Industry, Science, Energy and Resources (2021)

	Publicly	Announced	Feasibili	ity	Commit	ted	Comple	ted	Total			
	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b		
CCS	1	0-0.2	1	0.2	1	0.2			3	0.4-0.7		
Copper	9	3.0-4.2+	5	2.8-3.1	1	0.6			15	6.4-7.9+		
Critical Minerals	10	2.6-5.3+	19	6-10+	9	4.4	2	0.3	40	13-20+		
Hydrogen	14	127-133+	6	6-52+	1	0.5			21	133-185+		
Nickel, cobalt	3	0.6-0.9+	4	3.6-5.6	4	0.5			13	5.6-8.3+		
Total	37	133-143+	37	20-73+	16	6.3	2	0.3	92	159-222+		

Table 1.3: Summary of new energy economy projects in the investment pipeline as at 31 October 2021

Notes: **a** Totals may not add due to rounding at commodity level. Source: Department of Industry, Science, Energy and Resources (2021)

2. Outlook for project investment

This section discusses the outlook for future investment in the resources and energy sector. Not all projects on the list will proceed through to an FID and construction, so projects at the 'publicly announced' and 'feasibility' stages are categorised by the likelihood (likely, possible or unlikely) they will proceed (see Section 8 for the methodology). The projects included in the profile of future investment over the next six years are limited to those categorised as committed, likely or possible.

A range of projects are becoming more likely to proceed

'Possible projects' accounted for the largest share of overall projects in 2020–21, making up 152 projects out of 367. There were also 67 likely projects and 54 unlikely projects across all stages of the investment cycle.

Almost 40% of the project pipeline was categorised as 'committed' or 'likely' to proceed, up from around one-third in 2020 (Table 2.2). A marked increase in committed projects — up by 24% to \$54 billion — may reflect the increase in new projects and reactivations in the project listing, as well as ongoing expansions (Table 2.1). New projects reflect strong lithium development, with reactivations being heavily driven by gold projects. The number of completed projects rose from 10 to 15, despite the COVID-19 pandemic (Table 2.1). Mega projects and bulk commodities continue to dominate the project pipeline.

A significant uptick in resources and energy investment in late 2021 and 2022 is expected, with potential for a further expansion in the subsequent few years (Figure 2.1). There are over \$380 billion of projects at the 'publicly announced' and 'feasibility' stages that we consider 'possible' or 'likely' to receive an FID, an increase from \$217 billion in the previous year. The bulk of this potential investment comes from projects at the feasibility stage (Table 2.1).

Table 2.1: Number of projects by stage of investment and likelihood, as at 31 October 2021

	Unlikely	Possible	Likely	Committed	Completed
Publicly announced	24	70	19	0	0
Feasible	30	82	48	0	0
Committed	0	0	0	79	0
Completed	0	0	0	0	15
Total	54	152	67	79	15

Notes: Projects at the publicly announced and feasibility stages are rated as either 'unlikely' (0 - 20%), 'possible' (20 - 60%) or 'likely' (60 - 100%) to progress to the committed stage. Source: Department of Industry, Science, Energy and Resources (2021)

Figure 2.1: Outlook for project investment



Committed Likely Possible

Notes: Due to the nature of project development and information release, the decrease in investment value towards the end of the outlook period reflects a lack of information rather than a reduction in investment. The uptick in 2025 represents potential new energy projects

Source: Department of Industry, Science, Energy and Resources (2021)

This potential investment depends heavily on the progression of a number of 'mega projects' (projects involving over \$5 billion of investment), which account for half of the value of projects in the investment pipeline. The majority of these mega projects are hydrogen projects, though gas and iron ore projects also contribute.

Iron ore, coal, gas, and hydrogen projects, as well as related infrastructure, account for almost 80% of total investment expected, including almost 40% from hydrogen/ammonia projects.

Progress on most iron ore projects has been steady, with some acceleration among projects in the Pilbara region in recent months, as high iron prices improved their potential profitability. Some iron ore projects in South Australia (SA) and New South Wales (NSW) continue to face challenges, with slower progress over the past year.

Coal projects account for almost \$75 billion of expected project investment. However, the recent push against coal-fired power generation is expected to weigh on future investment decisions. Consequently, a number of coal projects were downgraded to 'unlikely'.

The project pipeline for battery metals and precious metals is growing

There are about \$35 billion of precious metal, base metal, critical mineral and other commodity projects at the 'publicly announced' and 'feasible' stages that are categorised as 'likely' or 'possible' to receive an FID. This is up from \$33 billion in 2020.

Developments in battery technology and expectations of growing electric vehicle manufacturing, continue to spur investment in Australia's nickel, cobalt, rare earths and lithium resources. 60 projects categorised as possible or better are now publicly announced, feasible or above, with a combined value of around \$29 billion. A number of development projects are investing in processing facilities to produce battery cathode precursors in the form of lithium hydroxide. The Tianqi and Independence Group joint venture produced its first lithium hydroxide product at their Kwinana lithium hydroxide refinery in August 2021.

Overall, our outlook for mining investment indicates very significant opportunities are emerging for Australia's resources and energy sector, particularly in the new energy economy.

Table 2.2: New and expansion projects by rating, as at 31 October2021

	Unlikely	Possible	Likely	Committed	Completed
New project					
A\$ billion	55.4	307.0	42.3	26.6	2.4
Number	45	119	46	32	8
Expansion					
A\$ billion	3.6	8.1	20.7	27.1	7.8
Number	8	24	20	41	7
Reactivation					
A\$ billion	0.1	2.0	0.1	0.7	0
Number	1	9	1	6	0

Source: Department of Industry, Science, Energy and Resources (2021)

3. Exploration

Exploration encompasses expenditure aimed at improving knowledge about the location, type, quantity and quality of deposits. This spending helps inform future development. Before making a decision to undertake exploration, companies balance the benefits of exploration with a range of factors, including commodity prices, the regulatory environment, geological prospects and tax/royalty arrangements.

Exploration expenditure increased in 2020-21

Australian exploration expenditure increased by 3% to \$4.1 billion in 2020–21 (Figure 3.1). This growth was driven by mineral exploration, a trend consistent with previous years. Mineral exploration expanded by 19% to \$3.0 billion in 2020–21. Petroleum exploration declined from \$1.2 billion to \$1 billion in 2020–21, and exploration in energy commodities (uranium) also decreased.

Growth driven by minerals exploration

In 2020–21, mineral exploration expenditure was primarily on existing deposits. However, expenditure on new deposits has picked up in recent years, accounting for more than a third of mineral exploration expenditure in 2020–21 (Figure 3.2). Mineral exploration expenditure represented 60% of total exploration expenditure in 2021, a rise from five years prior, when it represented about 45% of total exploration expenditure.

Gold continues to draw the largest interest in mineral exploration

For the last five years, gold has attracted the most mineral exploration expenditure, overtaking iron ore in 2015–16. In 2020–21, gold expenditure increased to \$1.5 billion, up 32%, accounting for almost half of Australia's mineral exploration expenditure (Figure 3.3). Exploration activity has been encouraged by high Australian dollar gold prices.

Figure 3.1: Mineral and energy exploration expenditure



Source: ABS (2021) Mineral and Petroleum Exploration, Australia, 8412.0



Figure 3.2: Mineral exploration by deposit type

Source: ABS (2021) Mineral and Petroleum Exploration, Australia, 8412.0

Coal exploration expenditure fell after growing for the last three years

Coal exploration expenditure decreased by 22% to \$235 million in 2020–21. Despite the decline, this value is still higher than the levels of coal exploration expenditure in the four years prior to 2019–20 (Figure 3.3).

Iron ore prices continue to incentivise exploration

Iron ore expenditure expanded by 31% to \$473 million in 2020–21, a growth rate much higher than the previous year. While far from the peak of \$1.2 billion attained in 2011–12, this is the highest level of exploration expenditure since 2013–14. High iron ore prices — supported by constrained Brazilian supply and robust demand from China — continue to encourage exploration in mineral-rich areas of WA (Figure 3.3).

Figure 3.3: Annual exploration expenditure by commodity



Notes: Base metals also include silver and cobalt.

Source: ABS (2021) Mineral and Petroleum Exploration, Australia, 8412.0

Modest decrease in base metals expenditure, driven by copper

Base metals exploration expenditure decreased by 4% to \$651 million in 2020–21. This marked the first year of decrease since 2015–16 in base metals exploration expenditure (Figure 3.3). Nickel and cobalt expenditure stabilised, while silver, lead and zinc exploration expenditure increased. Copper exploration decreased by 10% over the year to \$377 million.

Nickel and cobalt expenditure remained around \$200 million in 2020–21, consistent with the last four years, as expectations of future market shortages were balanced with low prices. On a world scale, Australia accounts for the largest share of exploration activity, with over a third of total nickel exploration spending.

Silver, lead and zinc expenditure increased by 10% to \$65 million.

Petroleum exploration supported by onshore activity

Petroleum (oil or gas in solution) expenditure remained close to decade lows in 2020–21, declining to \$900 million (Figure 3.4). A 5% decrease in onshore exploration expenditure occurred alongside a 36% decline in offshore expenditure. Onshore exploration expenditure was higher than offshore expenditure in 2020–21, and has exceeded it since the December quarter 2019.

Global oil and gas prices fell dramatically in the first half of 2020, due to the impacts of COVID-19. These price declines drove significant cost cutting in the petroleum industry, including the deferral of exploration spending. Offshore exploration expenditure consequently fell to a two decade low in 2019–20. Over the same period, onshore petroleum exploration grew modestly to reach a five-year high. A tighter domestic gas market could support ongoing growth in onshore petroleum exploration, with the Australian Energy Market Operator (AEMO) forecasting a possible shortfall of natural gas on the Australian east coast market by 2024.



Figure 3.4: Petroleum exploration expenditure, quarterly

Source: ABS (2021) Mineral and Petroleum Exploration, Australia, 8412.0





Source: ABS (2021) Mineral and Petroleum Exploration, Australia, 8412.0. Data is seasonally adjusted and excludes petroleum spending.

Western Australia leads exploration expenditure

Exploration in WA accounted for 65% of total exploration in 2020–21. Growth in WA has supported a steady recovery in overall exploration from a relative low in 2015–16 (Figure 3.5). In recent years, the growth in WA exploration has been primarily driven by copper, nickel and lithium. However, the increase in 2020–21 is primarily due to gold exploration. In 2020–21, exploration in Queensland edged up by 1%, while exploration in NSW fell by 12%.

Market conditions lead to stronger drilling results

A total of 12 million metres was drilled in 2020–21, up from 10 million metres in the previous year. The share of drilling on new deposits has declined modestly in recent years, and now sits at 30% (Figure 3.6).





Source: ABS (2020) Mineral and Petroleum Exploration, Australia, 8412.0; Department of Industry, Science, Energy and Resources (2021)

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4. Projects at the publicly announced stage

Over a quarter of all projects are at the 'publicly announced' stage

Of the 367 projects on this year's list, around 113 are at the 'publicly announced' stage. The value of these 113 projects in October 2021 is estimated to be between \$206 billion and \$229 billion. Around one third of these projects are in WA, and are largely gas, hydrogen or iron ore projects. Queensland has 30% of publicly announced projects, with the 38% being coal projects and 24% new energy projects (Table 4.1).

Over 40 per cent of projects are in our largest commodity exports

Many projects at the publicly announced stage remain uncertain, and may or may not progress in the near term. A number of infrastructure projects, large LNG/gas, hydrogen and coal projects, make up most of the projects at the publicly announced stage (Figure 4.1). The large number of LNG and coal projects at this stage of the investment pipeline may partly reflect the low costs associated with getting a project to this stage of development. The outlook for hydrogen is not yet determined but significant effort is being undertaken.

Most of the infrastructure projects at the publicly announced stage are gas pipelines, along with some port infrastructure servicing the coal export sector. Several of the gas pipelines aim to connect proposed LNG import terminals or new domestic basins to the east coast gas market, or to extend existing infrastructure in the east coast gas market.

There were several offshore oil and gas projects announced this year. Beach Energy announced they are planning further development of the Bass offshore natural gas reserves, commencing front end engineering design (FEED) activities on their Trefoil Project in late FY21. Emperor Energy is assessing the feasibility of a project at the Judith Gas Field in the Gippsland Basin.

Figure 4.1: Number of projects at the publicly announced stage



Notes: a Infrastructure is limited to resource, energy infrastructure projects including CCS . b Other Commodities is limited to resource and energy commodities not elsewhere identified. Source: Department of Industry, Science, Energy and Resources (2021)

The development of gold projects will depend on market conditions

There are five gold projects at the publicly announced stage, with a combined value of \$450 million.

Battery minerals activity is growing

Most of the copper projects on this year's list are at the publicly announced stage. Of the nine publicly announced projects, most are new projects, with one reactivation (Cyprium's Nifty mine). Most are under active development, and are dependent on persistent relatively high copper prices. With supportive market conditions, some of the new mines could be online by 2023.

The Kathleen Valley lithium refinery project was announced as a part of a scoping study by Liontown Resources. The mine intended to supply spodumene concentrate to the refinery is due to make a FID in 2022. After successfully shipping its first commercial shipment from Butcherbird Stage 1 (see Section 7), Element 25 Limited has announced it will progress the Pre-Feasibility Study for Butcherbird Stage 2.

	NSW		Qld		WA		NT		SA		Vic		Tas		Total	
	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b
Aluminium, Alumina, Bauxite			1	1.3	1	0.1									2	1.4
Coal	9	3.1- 4.3+	13	15.7- 16.4+					1	2.5-5.0					23	21-26+
Copper	1	0-0.2	1	0.5-1.0	5	2.0- 2.3+	1	0.2	1	0.3-0.5					9	3.0-4.2+
Critical Minerals			2	0.2-0.7	7	2.0- 4.0+	1	0-0.2+			3	0.5- 1.0+			13	2.8-6.0+
Gold			1	0-0.2	3	0.2	1	0-0.2							5	0.2-0.7
Hydrogen			5	20+	4	106- 111+			1	0-0.2	2	0.7+	2	0.7+	14	127-132+
Infrastructure ^a	2	0.7- 0.9+	5	7.5+	2	6.0-7.0					2	0.1- 0.4+			11	14-16+
Iron ore					8	7.4-9+	1	0-0.2	2	0.8			1	0.1	12	8-10+
Lead, Zinc, Silver															0	0
LNG, Gas, Petroleum			3	2.0- 2.2+	5	20+	1	2.5- 5.0+			4	0.9+	1	0.5+	14	26-29+
Nickel, Cobalt	1	0- 0.2+	1	0.5	1	0.1									3	0.6-0.9+
Other Commodities	1	0.1+	1	0.2-0.5	2	0.2- 0.7+	1	0-0.5					1	0-0.2	6	0.9-2.1+
Uranium			1	0.6											1	0.6
Total	14	4-6+	34	49-51+	38	144- 155+	6	3-6+	5	3-6	11	2-3+	5	1.2- 1.5+	113	206-229+

Table 4.1: Summary of projects at the publicly announced stage, as at 31 October 2021

Notes: a Infrastructure is limited to resource, energy infrastructure projects including CCS. A number of gas pipelines span across more than one state but have been allocated to one state for reporting purposes. b Other Commodities is limited to resource and energy commodities not elsewhere identified. c Totals may not add due to rounding at commodity level. Source: Department of Industry, Science, Energy and Resources (2021)

5. Projects at the feasibility stage

Around 40 per cent of projects are at the feasibility stage

The value of projects at the feasibility stage increased by 20% to about \$222 billion in the 12 months to October 2021. Iron ore projects remained high in Western Australia. "Gas" projects increased with the first time inclusion of hydrogen, despite 23 projects progressing from the feasibility stage to the committed stage. 160 projects are listed at the feasibility stage — around 40% of our Major Projects list this year (Table 5.1). Coal projects account for 23% of the number of projects at the feasibility stage, while LNG/gas/petroleum/hydrogen projects account for 13%. Critical minerals contributed 21%, while 'other commodities' contributed over 10% (Figure 5.1).

40 per cent of all projects are in our largest commodity exports

The number of coal projects at the feasibility stage decreased to 37 from 45 over the 12 months to October 2021, with a value estimated at \$47 billion (Table 5.1). The elevated number of coal projects currently at the feasibility stage is likely the result of FIDs being delayed by the uncertain outlook for coal, with some financial institutions seeking to reduce their involvement in coal projects. A number of the mines listed as feasible have proponents announcing they are transitioning out of coal — notably BHP — raising doubts about some coal projects advancing to the committed stage.

There were 15 oil and gas/LNG projects at the feasibility stage as at the end of October 2021, worth over an estimated \$65 billion. Weak oil and LNG prices experienced in 2020 led to the deferral of FIDs for a number of projects. However, several large offshore projects (and associated processing infrastructure) are expected to reach FID by the end of 2021 or early 2022. Woodside's Scarborough project and Pluto expansion reached FID in November 2021 (after the cut-off for this report) – this will be reflected in the 2022 report. Woodside's Browse to North West Shelf project — the largest project on the list at over \$30 billion — has been delayed to 2023.

Figure 5.1: Number of projects at the feasibility stage



Notes: **a** Infrastructure is limited to resource, energy infrastructure projects including CCS . **b** Other Commodities is limited to resource and energy commodities not elsewhere identified. Source: Department of Industry, Science, Energy and Resources (2021)

Figure 5.2: Projects at the feasibility stage, by State and Territory



Source: Department of Industry, Science, Energy and Resources (2021)

Around 10 per cent of all projects are in gold, as price drives development

There are seventeen gold projects at the feasibility stage, with a combined capital expenditure of around \$5.6 billion. Several companies have indicated that their projects may be close to progressing further. These include Newcrest and Greatland's \$529 million Havieron gold project in WA, Newcrest's \$1280 million Cadia PC 1-2 gold project in NSW, and Karora Resources' \$50 million Higginsville Mill expansion project in WA.

Around 20 per cent of projects at the feasible stage are driven by demand for commodities used in rechargeable batteries

The largest proportion of projects at the feasibility stage are in WA, including a number of prospective nickel-cobalt projects (Figure 5.2, Table 5.1). Expectations of higher demand — propelled by growing battery manufacturing — are driving investment in mine capacity and processing facilities. There are six nickel/cobalt projects at the feasibility stage, with a combined worth of \$4-7 billion. These projects are expected to exploit Australia's high quality nickel sulphide resources, and to allow access to secure cobalt supplies. The largest of these is Sunrise Metals' Sunrise project in NSW, which is expected to produce battery-grade refined products, including nickel for batteries for 1 million electric vehicles.

The number of projects in 'other commodities' decreased from 13 to 10, with the value of projects remaining around \$5 billion. Critical minerals projects decreased from 37 to 33, with the value decreasing from \$13 to \$11 billion as projects progressed to the committed stage. Among these, trial mining has commenced at the Balranald minerals sands project in NSW. An FID is pending for Hasting Technology's Yangibana rare earths deposit in WA. Nolans' rare earths project in the Northern Territory has progressed, with a FID possible in 2022 after contracts were awarded to enable FEED tenders. A feasibility study is underway on a rare earths refinery at Iluka's Eneabba operation in WA, which would reprocess tailings containing rare earths from a monazite concentrate. Studies are progressing for a number of vanadium projects, with products from mineral concentrates to vanadium electrolyte for rechargeable vanadium redox flow batteries. The Barrambie vanadium iron project in WA is considering a

concentrate product, with firm offtake agreements possible in 2022. Technology Metals' Gabanintha project has secured binding offtake for its vanadium pentoxide, with an update in the feasibility study due in late 2021. The Australian Vanadium project in WA is progressing, and a study is underway for the production of vanadium electrolyte. Independence Group are trialling vanadium redox flow batteries at its Nova operations.

Rensacor's Siviour graphite project in SA is undertaking testing, after receiving non-binding offtake agreements for twice the amount of pure spherical graphite that they planned to produce in stage 1 of the operation. The company is considering expanding the proposed operation, which was recently granted Major Project status by the Australian government. Graphite is used as an anode in rechargeable battery production. Ecograf are moving closer to an FID, with the completion of a due diligence study in order to obtain debt funding for its Kwinana based Battery Anode Graphite facility. The project awaits final regulatory approvals. The project was granted Major Project status by the Australian government.

Pilbara Minerals has plans for an expansion of the Pilgangoora mine in WA. An FID for Phase 1 for an incremental 100,000 tonnes a year of spodumene may take place in early 2022, with Phase 2 timing for an incremental 320,000 tonnes a year yet to be decided. The sell-down by Tiangi to Independence Group included a 49% interest in the Kwinana lithium refinery. Stage 2 of the Kwinana Lithium Refinery is in feasibility, with production possible in 2024. The Greenbushes mine in WA has expansion plans via its chemical grade plant (CGP 4) project, which Talison states may start in 2027, potentially adding another 0.5 million tonnes a year of spodumene concentrate. The Kathleen Valley spodumene project is progressing rapidly with a definitive feasibility due December 2021, with production scheduled for 2024 according to Liontown Resources. There is one high purity alumina project — a key input on the stability in lithium-ion batteries — in feasibility stage. Alcoa Australia and FYI Resources are jointly funding this \$202 million project, located in the Kwinana area of WA. The final investment decision is expected in 2022, subject to a completion of the feasibility study.

	NSW		Qld		WA		NT		SA		Vic		Tas		Total	
	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b
Aluminium, Alumina, Bauxite					2	0.3									2	0.3
Coal	10	4.8- 7.5+	27	40-43											37	45-51+
Copper			1	0.7	1	0-0.2			2	1.8	1	0.3			5	2.8-3.1
Critical Minerals	4	1.0- 2.2+	1	0.1	16	4.0- 7.7+	4	1.8- 2.3+	2	0-0.5+	4	0.8- 1.8+	2	0.1- 0.3+	33	9-15+
Gold	2	1.5			12	2-3+	2	1.5	1	0.1					17	5-6+
Hydrogen			2	0.5- 1.2+	3	5-51			1	0.2					6	6-52+
Infrastructure ^a	2	1.0- 1.8	5	1.5- 2.5+			1	1.0-1.5	1	0.5-1.0					9	4.0-6.7+
Iron ore	1	2.0- 5.0			9	9-13+			2	4.0- 4.2+					12	16-22+
Lead, Zinc, Silver	1	0.2			1	0.2									2	0.4
LNG, Gas, Petroleum	2	3.9+	2	8.3+	7	53-58+			1	0.2+	3	0.2-1.0			15	65-71+
Nickel, Cobalt	2	2-3	1	1.0-1.5	3	1.4-2.4									6	4.4-7.0+
Other Commodities	1	0- 0.2+	1	0.1	5	1.6- 2.8+	2	2.2					1	0-0.2+	10	3.8-5.6+
Uranium			1	0.4	4	2.0+			1	0.1					6	2.4+
Total	25	17- 25+	41	53-58+	63	79- 140+	9	6-7+	11	7-8+	8	1-3+	3	0.1- 0.6+	160	163-243+

Table 5.1: Summary of projects at the feasibility stage, as at 31 October 2021

Notes: a Infrastructure is limited to resource, energy infrastructure projects including CCS A number of gas pipelines span across more than one state but have been allocated to one state for reporting purposes. b Other Commodities is limited to resource and energy commodities not elsewhere identified. c Totals may not add due to rounding at commodity level. Source: Department of Industry, Science, Energy and Resources (2021)

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6. Projects at the committed stage

The value of 'committed' projects increased by 24 per cent

The value of projects at the 'committed' stage increased over the year to October 2021, from \$44 billion to \$54 billion (Figure 6.1). Projects to produce Australia's three largest export commodities — iron ore, coal and LNG — account for around 75% of investment at the committed stage, although 'other commodities' increased almost three-fold from its low base (Figure 6.2, Table 6.2). The location and value of projects at the committed stage is shown in Figure 6.1.

Our largest commodity exports dominate the 'committed' stage

Gas and LNG projects accounted for the largest share of committed projects by value (Figure 6.2). Four oil/gas projects progressed to the committed stage in the 12 months to October 2021. In March 2021, Santos announced an FID to proceed with the \$4.8 billion development of the Barossa gas field, offshore of the Northern Territory. The Barossa project will supply replacement gas for the Santos-led Darwin LNG project. Chevron announced the \$6 billion Jansz-Io Compression project will proceed. The project will involve installation of subsea compression technology to enhance the recoverability of the Jansz-Io field and to maintain the supply the existing LNG trains and domestic gas plant on Barrow Island, offshore from WA. The second stage of the onshore Waitsia Gas Project was also sanctioned in December 2020.

A number of gas/LNG infrastructure projects also proceeded to the 'committed' stage over the year to October 2021. APA announced investment in pipeline expansions for the East Coast grid and WA gas grid.

Construction also began this year on the Port Kembla Gas Terminal, the first of four potentially viable LNG import terminals on Australia's east coast. The Port Kembla Gas Terminal could supply more than 75% of NSW annual gas needs, and help to make up any gas shortfalls on the East Coast over the next few years.

Iron ore development projects account for the second largest share of committed projects by value. Several large iron ore projects are moving closer to completion: first ore was achieved at Rio Tinto's Robe Valley expansion (with a projected capacity of 25 million tonne per year) in August 2021, and Western Turner Syncline Phase 2 expansion was expected before the end of 2021. Rio Tinto's new Gudai Darri (formerly Koodaideri project) is also progressing, and is expected to commence production in early 2022. The mine will produce 43 million tonnes per year.

There are eight coal mines at the committed stage. Three of the committed projects are new projects, while the remainder are expansions or extensions of existing mines. New output produced by these eight projects is expected to sum to more than 20 million tonnes annually. Overall, committed coal projects increased 27% by value between 2020 and 2021.

Figure 6.1: Number and value of committed projects



Notes: The Major Projects was formerly a biannual publication released in April and October, but became an annual report in 2016.

Source: Department of Industry, Science, Energy and Resources (2021)



Figure 6.2: Value of committed projects by commodity

Notes: a Infrastructure is limited to resource, energy infrastructure projects including CCS. b Other Commodities is limited to resource and energy commodities not elsewhere identified. Source: Department of Industry, Science, Energy and Resources (2021)

Gold contributed significantly to growth of projects in the 'committed' stage

Overall, gold, nickel, cobalt and 'other commodities' grew substantially in percentage terms from 2020 to 2021. This was largely driven by expectations of high gold prices as well as anticipated growth in electric vehicles (Table 6.1).

Nineteen gold projects, worth \$5.1 billion, were at the committed stage of development over the past year. Together, these committed gold projects are expected to boost Australia's gold mine production from 328 tonnes of gold in 2020 to 394 tonnes of gold in 2023. The largest of these is Newmont Mining's \$900 million Tanami Expansion 2 project in WA, and Newcrest's \$685 million and \$175 million Cadia Stage 1 and Stage 2 Expansion projects in NSW.

A final investment decision was also made on the \$600m Wira Hoist Shaft at the Prominent Hill copper mine, extending the life of the mine until 2036.

The number of committed 'other commodities' projects rose from seven to fourteen, with the combined value more than doubling to \$6.0 billion.

Commissioning at the Kwinana Lithium Refinery (Tianqi) resumed, with completion of ramp up due in 2022. The Kemerton Lithium Refinery (Albemarle/Mineral Resources) construction in WA is progressing, with ramp up due to be completed late in 2022/early 2023. The Finniss lithium project in the Northern Territory made rapid progress from feasible to the committed stage, with first production scheduled for late 2022 at 175,000 tonnes a year of spodumene concentrate. BCI recently made a financial investment decision on Mardie Salt, with construction to start on the salt and sulphate of potash early in 2022.

Underground development began at the Abra lead silver deposit in WA with Galena Mining expecting commercial production in 2023.

Kalgoorlie Crack and Leach facility (Lynas) plans to provide preliminary processing of rare earths ore from the Mt Weld mine. Construction is underway, and the facility aims to be operational in 2023. Capital costs are estimated to be in the order of \$500 million.

Construction is underway at Iluka's Eneabba operation in WA to reprocess tailings that contain rare earths. Production of a monazite concentrate is due in 2022, which can then be directly fed into a rare earths refinery.

Independence Group reported that Greenbushes is increasing capacity, with a third chemical grade plant (CGP3). The Greenbushes mine in WA has tailings retreatment due for completion in 2022. CGP2 was completed in 2021, giving a total capacity of 1.3 million tonnes a year capacity of spodumene concentrate. CGP 3 is due to start in 2024, adding another 0.5 million tonnes capacity of spodumene concentrate.

The sell-down by Tianqi to Independence Group included a 49% interest in the Kwinana lithium refinery. The Kwinana refinery refined its first lithium hydroxide in October 2021 and is ramping up production to capacity of circa 24,000 tonnes a year.

The Mount Holland mine and its associated Kwinana lithium refinery in WA (50% Wesfarmers / 50% SQM) moved from feasible to committed, with production scheduled by the companies for 2024.

The Wodgina spodumene project, owned 40% by Mineral Resources and 60% by US-based Albemarle Corporation, is due to restart train one shortly, with a capacity of 0.25 million tonnes per annum of spodumene concentrate. The project plan is for three trains of equal capacity.

The Lake Way potash project remains at the committed stage, albeit with some delays — the project had previously been expected to make its first sulphate of potash production in June 2021.

Strandline made a FID to proceed with the full development of its Coburn mineral sands project, located in the Gascoyne region of WA. A project mining contract has been signed, with expected first production in the fourth quarter of 2022.

Table 6.1: Change in value of committed projects between 2020 and2021

Commodity	Change in value 2020-2021
Aluminium, alumina, bauxite	0%
Coal	27%
Copper	n/a
Critical Minerals	236%
Gold	31%
Hydrogen	-
Infrastructure	176%
Iron ore	-9%
Lead, zinc, silver	57%
LNG, gas, petroleum	14%
Nickel, Cobalt	-10%
Uranium	0%
Other commodities	110%
Total Notes: Copper n/a refers to a rise from A\$0m to A\$600m Source: Department of Industry, Science, Energy and Reso	24% purces (2021)

	NSW		Qld		WA		NT		SA		Vic		Tas		Total	
	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b
Aluminium, Alumina, Bauxite															0	0
Coal	4	0.8	4	3.0											8	3.7
Copper									1	0.6					1	0.6
Critical Minerals			1	0.1	9	4.6	1	0.1							11	4.7
Gold	3	1.2	2	0.3	13	2.7	1	0.9							19	5.1
Hydrogen											1	0.5			1	0.5
Infrastructure ^a			4	1.4	6	1.8			1	0.2					11	3.5
Iron ore					6	11.3									6	11.3
Lead, Zinc, Silver			1	0.3	1	0.2									2	0.5
LNG, Gas, Petroleum	1	0.3	2	2.5	8	15.0	1	4.8			1	0.1			13	22.6
Nickel, Cobalt					4	0.5									4	0.5
Other Commodities					2	1.1							1	0.1	3	1.2
Uranium															0	0
Total	8	2.2	14	7.5	49	37.4	3	5.8	2	0.8	2	0.6	1	0.1	79	54.3

Table 6.2: Summary of projects at the committed stage, as at 31 October 2021

Notes: a Infrastructure is limited to resource, energy infrastructure projects including CCS. A number of gas pipelines span across more than one state but have been allocated to one state for reporting purposes. b Other Commodities is limited to resource and energy commodities not elsewhere identified. c Totals may not add due to rounding at commodity level. Source: Department of Industry, Science, Energy and Resources (2021)

Image 6.1: Location of projects at the committed stage, as at 31 October 2021



Source: Department of Industry, Science, Energy and Resources (2021)

7. Projects at the completed stage

Number of completed projects rose in 2021

The value of projects at the 'completed' stage rose from \$2.3 billion to \$10.1 billion over the year to October 2021 (Figure 7.1). Completed projects by State and commodity type are shown in Table 7.1. The rise in completed projects value largely reflects iron ore projects. The non-iron ore projects accounted for a small portion of the total value in 2021, with low numbers also reflecting the impacts of the COVID-19 pandemic. Fifteen resource and energy major projects were completed over the past year in a variety of commodities, but iron ore dominated (Figure 7.2).

In October 2021, BHP officially opened its new \$4.6 billion South Flank iron ore mine. When fully operational, the mine is expected to produce 80 million tonnes of iron ore per year. Other major iron ore projects completed in the last year include Fortescue Metals Group's Eliwana iron ore mine (with a projected capacity of 30 million tonnes per year) in December 2020, Atlas Iron's Sanjiv Ridge, and the recent commissioning of Rio Tinto's West Angelas (Deposits C & D) expansion project. Two gold projects were completed, including Ramelius' 3.2 tonnes a year Tampia gold project in WA, and Newmont's Boddington gold mine autonomous haulage system in WA.

A large proportion of BHP's Nickel West expansion projects have been completed over the last year, including the Venus and Yakabindie deposits at Mt Keith. The Sandy Ridge kaolin and storage facility in WA was also completed, with \$62 million invested.

Independence Group reported that Greenbushes commissioned their second lithium chemical plant to produce 160,000 tonnes a year LCE. Stage 1 of Butcherbird Manganese produced its first commercial shipment of manganese concentrate in 2021 as a result of lowering its scope to take advantage of favourable market conditions. Beyondie Stage 1 (Kalium Lakes) has produced its first sulphate of potash, due to be sold during the December quarter 2021 under a pre-existing arrangement.

Figure 7.1: Value of completed projects



Source: Department of Industry, Science, Energy and Resources (2021)

Figure 7.2: Value of completed projects by commodity



Notes: **a** Infrastructure is limited to resource, energy infrastructure projects including CCS . **b** Other Commodities is limited to resource and energy commodities not elsewhere identified. Source: Department of Industry, Science, Energy and Resources (2021)

	NSW		Qld		WA		NT		SA		Vic		Tas		Total	
	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b	No. of projects	Value A\$b						
Aluminium, Alumina, Bauxite															0	0
Coal	1	2.0													1	2.0
Copper															0	0
Critical Minerals					2	0.3									2	0.3
Gold					2	0.3									2	0.3
Hydrogen															0	0
Infrastructure ^a					1	0.1									1	0.1
Iron ore					4	6.4									4	6.4
Lead, Zinc, Silver															0	0
LNG, Gas, Petroleum			2	0.5							1	0.3			3	0.7
Nickel, Cobalt															0	0
Other Commodities					2	0.3									2	0.3
Uranium															0	0
Total	1	2.0	2	0.5	11	7.4	0	0	0	0	1	0.3	0	0	15	10.1

Table 7.1: Summary of projects at the completed stage, as at 31 October 2021

Notes: a Infrastructure is limited to resource, energy infrastructure projects including CCS. A number of gas pipelines span across more than one state but have been allocated to one state for reporting purposes. b Other Commodities is limited to resource and energy commodities not elsewhere identified. c Totals may not add due to rounding at commodity level. Source: Department of Industry, Science, Energy and Resources (2021)

Box 1: Carbon Capture and Storage Projects (CCS) Commerical Project Pipeline

Carbon Capture and Storage (CCS) technologies are gaining momentum as a future means to control the release of CO₂ emissions from oil and gas, hydrogen production, heavy industry and coal-fired power generation, by capturing, transporting, compressing and then injecting into deep geological formations. The International Energy Agency's World Energy Outlook 2021, notes that globally, the capture capacity of CCS projects announced since the beginning of 2020 exceeds total capacity operating today. The Australian Government is strongly focused on commercial CCS deployment. CCS has been identified as a priority low emissions technology for future investment under the Technology Investment Roadmap, and the Clean Energy Regulator has introduced a CCS method under the Emission Reduction Fund. In Australia, there are several significant CCS projects in the development pipeline. The 2021 REMP includes four projects associated with the resource and energy sector aiming to deploy or demonstrate commercial scale CCS.

On November 1 2021, Santos and joint venture partner Beach Energy announced FID on their \$220 million Moomba Carbon Capture and Storage project in South Australia. The Moomba CCS project aims to permanently store 1.7 million tonnes of CO₂ underground each year, with first injection targeted for 2024. The project is the first CCS project to be supported by the Australian Government's Emissions Reduction Fund.

Glencore's Carbon Transport and Storage Company (CTSCo) Surat Basin CCUS Project is determining the technical feasibility of industrial-scale carbon capture and storage in Queensland's Surat Basin. The project involves development of a demonstration-scale post-combustion capture (PCC) plant located at the Millmerran Power Station. A storage component, will assess the viability of safely and sustainably storing CO2 in the Surat basin.

The CarbonNet Project is aiming to establish a commercial-scale CCS network in Victoria, where CO_2 is captured from a range of industries in the Latrobe Valley and stored in offshore locations in Bass Strait. Pending private investment and approvals, the project is anticipated to proceed to construction in the mid-2020s.

Box 2: Hydrogen

Hydrogen is gaining increasing attention as a clean fuel to help decarbonise economies. Australia's proven track record as an energy exporter — especially our expertise in exporting LNG — combined with our abundant renewable energy and suitable geological storage resources, means that the nation has strong potential to be a major hydrogen producer and exporter. The Australian Government has directly invested more than \$1.2 billion in support for the hydrogen industry, including awarding over \$100 million to three 10 MW hydrogen electrolyser projects through the Australian Renewable Energy Agency (ARENA) and the \$464 million Activating a Regional Hydrogen Industry: Clean Hydrogen Industrial Hubs program, to fund up to seven hydrogen hubs.

This edition of the Resources and Energy Major Projects (REMP) report includes hydrogen projects for the first time. The inclusion owes much to hydrogen's potential as a promising Australian energy export commodity, and the significant increase in investment that has occurred over the last 12 months. The hydrogen project list focuses on large-scale projects that are targeting the production of hydrogen for sale, either in domestic or export markets. Projects must also satisfy existing REMP criteria (see *methodology* section).

21 major hydrogen projects have been included in the 2021 report, and over \$133 billion worth of potential investment in hydrogen projects has been identified. This is 15% larger than oil and gas investment and twice the size of investment in coal. The majority of the proposed projects are for renewable hydrogen, reflecting Australia's abundant renewable energy sources available for hydrogen production.

The industry is in the early stages of development in Australia, but has huge potential. A majority of the projects are at the Publicly Announced phase, with a small number at the Feasible stage — showing the nascent nature of the commercial clean hydrogen industry in Australia. The majority of projects will not commence commercial operations until after 2025, with a significant amount commencing after 2027. If momentum is sustained, and projects are completed according to anticipated timeframes, Australia could be one of the world's largest hydrogen suppliers by 2030. Plans for clean hydrogen production is evident across all Australian jurisdictions, with project scales and targeted hydrogen enduses varying widely. The majority of potential large-scale production major

hydrogen projects are located in Western Australia (7) and, Queensland (7), three projects in Victoria and two projects located in Tasmania and South Australia respectively. The following major projects have been highlighted to give context to the sheer scope of hydrogen projects included in this year's report.

The renewable hydrogen industry in Western Australia is the largest by value, with over \$111 billion of hydrogen production projects identified. Intercontinental Energy's Western Green Energy Hub — estimated to cost \$100 billion — will be built in phases, and will produce up to 3.5 million tonnes of green renewable ammonia hydrogen, or around 20 million tonnes of ammonia, per year using a combination of wind and solar on a 15,000 square kilometre site in south-east Western Australia. It will be one of the largest energy projects in the world. NW Interconnected Power Pty Ltd is developing the Asian Renewable Energy Hub (AREH) project — targeting a 26,000 MW wind and solar hybrid renewable energy facility, which will supply both the domestic (industrial) and export markets as either renewable electricity, hydrogen and ammonia products.

In Queensland, commercial production facilities have been announced in Townsville, Gladstone and Bundaberg. Cost information was not available for Origin Energy's/Kawasaki Heavy Industries' Green Liquid Hydrogen Export Plant and Stanwell Corporation's Central Queensland Hydrogen Project, however it is assumed that based on their proposed size, these projects will exceed the funding criteria of at least a \$50 million investment.

Fortescue Metals Group and Woodside Energy Ltd are both progressing plans for "renewable green" hydrogen and ammonia plants in Tasmania's Bell Bay. The proposed 250 MW Fortescue Green Hydrogen and Ammonia Plant is targeting production of around 250,000 tonnes of green renewable ammonia per year for domestic use and international export. The H2TAS project from Woodside is targeting production of around 200,000 tonnes of green renewable ammonia per year. There are no publicly available cost estimates on the H2TAS project available at the time of writing, however, the scale of operations supports the view that it will be considerably in excess of the \$50 million cut-off.

There are large-scale feasibility studies for commercial hydrogen production facilities currently underway in most states. While not eligible for inclusion in this report based on the screening methodology, these projects should be noted as their scale has the potential to impact both the domestic and export clean hydrogen industry if they were to proceed in the future. This includes BP Australia's Geraldton Export-Scale Renewable Investment feasibility study, Origin's Green Hydrogen and Ammonia Plant feasibility study and Fortescue Future Industries/Incitec Pivot's Gibson Island Green Ammonia feasibility study. The outcomes of these feasibility studies will be monitored, and resulting projects may be included in future reports. For a more comprehensive list of hydrogen related projects and studies in Australia (regardless of scale and value), refer to the CSIRO's HyResource webpage: https://research.csiro.au/hyresource/projects/facilities.

8. Methodology

Each year, we collect information about the investment pipeline for major resource and energy projects. Information is gathered from a number of sources, including company websites, Australian Stock Exchange reports, media releases, and from direct contact with company representatives. Although there is substantial investment by mining and energy companies in replenishing equipment, plant and other property, the focus of this report is on 'major' investments — those valued at over \$50 million. Smaller scale operations are also an important contributor to the sector and the broader Australian economy, however gathering data on such projects is challenging, as many are undertaken by private companies, which have fewer obligations to report progress.

Developers of resources and energy projects often use different planning processes and assessment methods to support an FID. Thus, there is no standard project development model with clearly defined stages and terminology that can be applied to every resource and energy project.

To broadly represent the general life-cycle of a project, we use a fourstage model of the investment pipeline to measure the potential investment in Australia's resource and energy sectors. Earlier stages of developing mining and energy projects, such as identifying deposits and exploration activities, are not included in the assessment. While these activities remain important, it is beyond the scope of this report to assess exploration activities on a project-by-project basis. Instead, a summary and analysis of aggregate exploration expenditure is provided.

The four stages in our investment pipeline model are:

- 1. Publicly announced
- 2. Feasibility
- 3. Committed
- 4. Completed

(1) Publicly announced stage

Projects at the publicly announced stage are usually very early in their development, and are typically undergoing an initial feasibility study to assess the commercial aspects of developing an identified resource. To have a project on the list at this stage, preliminary information on the project schedule, planned output or cost must be publicly available.

As they are still in the early planning stage, projects at the publicly announced stage may not have finalised the engineering designs or estimates of construction costs. Given potential uncertainty around cost estimates at this stage projects are classified into cost bands based on company disclosures. Where cost estimates have not been disclosed by the company, projects are classified into cost bands using industry averages for similar construction activities. The cost bands we use in this report for publicly announced projects are:

• \$0 – \$249m

\$1,500m - \$2,499m

\$250m – \$499m

- \$2,500m \$4,999m
- \$500m \$999m
- \$5,000m+
- \$1,000m \$1,499m

(2) Feasibility stage

This stage of the project development cycle is when the initial feasibility study for a project has been completed and the results support further development. Projects that have progressed to the feasibility stage have undertaken initial project definition studies and commenced more detailed planning work. This work includes Front-End Engineering Design (FEED) studies, Bankable Feasibility Studies, developing the final project scope, commercial plans and environmental surveys (in support of finalising an Environmental Impact Statement).

While there is an opportunity to progress projects at the feasibility stage to the committed stage, this is not guaranteed to occur, as the evaluation of commercial prospects has not yet been finalised and all regulatory approvals are yet to be received. Projects at the feasibility stage have not been committed to, and are only potential investments that may occur under the appropriate conditions. Therefore, the total value of projects at the feasibility stage cannot be directly compared to the value of the projects at the committed stage in order to forecast the future of capital investment in Australia's resources and energy sectors.

(3) Committed stage

Projects at the committed stage have completed all commercial, engineering and environmental studies, received all necessary government regulatory approvals, and finalised the financing of the project to allow construction. Such projects are considered to have received a positive FID from the owner(s). In most cases, projects at this stage of development have already started construction, as there are typically preworks undertaken as part of exploration and design activities.

Projects at the committed stage typically have cost estimates, schedules, and mine outputs that are well defined and often publicly released. Most projects that progress to the committed stage will eventually commence production. Nevertheless, post-FID, there are still technical and financial risks that, if realised, can result in delays, scope changes and cost overruns, or even affect the commercial viability of a project and possibly lead to its cancellation.

In 2019, we introduced a change to our methodology for tracking capital expenditure associated with Queensland's three LNG projects based around coal seam gas (CSG). Each year, hundreds of CSG wells are drilled in order to sustain gas production to support LNG exports — sometimes this drilling activity is announced as a specific project, but other times it is not. We therefore estimate a level of 'sustaining capex' associated with Queensland's LNG facilities that can be considered 'committed' by virtue of being required to maintain LNG production. This estimate accounts for capital expenditure associated with CSG production that is not already covered by specific projects, such as Arrow's Surat Gas Project.

A project reaches the completed stage when construction and commissioning activities are completed and the operation has reached commercial production. As many projects include multiple stages and scope elements that can be independent of each other, the timing around when a project reaches the completed stage can be difficult to assess.

Project ratings and the outlook for project investment

Not all projects that are initiated end up being progressed through to construction. Accordingly, projects at the publicly announced and feasibility stages can only be viewed as potential investment.

The Resources and Energy Major Projects employs a project-level analysis to provide a profile of possible future investment. Projects at the feasibility and publicly announced stages are categorised as 'unlikely' (0 - 20%), 'possible' (20 - 60%) or 'likely' (60 - 100%) to progress to the committed stage.

This categorisation is based on a range of factors, including market conditions and company commentary. Where data is available, projects are categorised based on their potential position on the relevant commodity's production cost curve. The timing of when projects are likely to progress to the committed stage is based on schedules announced by the project's developers. Projects that have been categorised as 'unlikely' to proceed are not included in the forward projection of the value of committed investment.

Although assessments are made at a project level, these are not made public in the Resources and Energy Major Projects data set, because some of the information used is treated as commercial-in-confidence.

9. Further information and resources

Department of Industry, Science, Energy and Resources Office of the Chief Economist publications

Resources and Energy Major Projects

Resources and Energy Major Projects provides a review of the mining, infrastructure and processing facilities projects that increase, extend or improve the output of mineral and energy commodities in Australia.

https://www.industry.gov.au/remp

Resources and Energy Quarterly

The Resources and Energy Quarterly contains the latest data, analysis and forecasts for the value, volume and price of Australia's major resources and energy commodity exports.

https://www.industry.gov.au/data-and-publications/resources-and-energyquarterly-all

Outlook for Selected Critical Minerals 2021

The outlook includes economic data to help facilitate investment in Australian critical minerals projects and greenfield opportunities. The report covers rare earths, cobalt, graphite and vanadium.

https://www.industry.gov.au/data-and-publications/outlook-for-selected-critical-minerals-in-australia-2021-report

Geoscience Australia publications and resources

Australia's Identified Mineral Resources

Australia's Identified Mineral Resources is an annual assessment of Australia's mineral reserves and resources for all major, and some minor, commodities. It provides useful indicators of potential resource life and future supply capability, comparisons of world rankings, and insights into the distribution of Australia's resources and industry developments.

https://www.ga.gov.au/scientific-topics/minerals/mineral-resources-and-advice/aimr

Geoscience Australia Portal

This provides users with a single point to access Australia's geoscience data, including a range of assessment tools such as Economic Fairways. https://portal.ga.gov.au/

Minerals and Mines Maps

Geoscience Australia produces a number of annual maps on resources and industry activity across the country. They include the operating status of the different mines and deposits, along with major infrastructure. The most recent versions of these maps can be accessed via these links:

Australian Operating Mines Map 2019: https://d28rz98at9flks.cloudfront.net/133033/133033_00_0.pdf

Australian Critical Minerals Map 2020 - link: https://d28rz98at9flks.cloudfront.net/144155/144155_00_0.pdf

Australian Mineral Exploration Review 2018-19: https://d28rz98at9flks.cloudfront.net/133031/133031_00_0.pdf

Australia's Energy and Mineral Resources Investor Guide 2020

The Australia's Energy and Mineral Resources Investor Guide 2020 is a guide for investors interested in Australian resources opportunities.

http://d28rz98at9flks.cloudfront.net/133857/133857_00_0.pdf

Australian Critical Minerals Prospectus 2020

The prospectus includes technical, commercial and geological data to help facilitate investment in Australian critical minerals projects and greenfield opportunities. The 2020 prospectus details over 200 potential investments in a wide range of critical minerals.

https://www.austrade.gov.au/ArticleDocuments/5572/Australian_Critical_M inerals_Prospectus.pdf.aspx