GRATTAN Institute

Towards net zero

Practical policies to reduce industrial emissions

Tony Wood, Alison Reeve, and James Ha

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Overview

Governments around the world are moving to 'net zero', to limit the impacts of climate change. All Australian state and territory governments have the goal of reaching net-zero carbon emissions by 2050 at the latest, and the Prime Minister says the national target is net zero, preferably by 2050.

Yet Australia is not on track to hit this target. The best way to reduce emissions in an economically efficient manner would be to introduce a single, economy-wide emissions price coupled with well-targeted support for technology development. But the political reality is that carbon pricing is out of reach, at least for now. So Australia should pursue sector-specific policies.

Australian governments can and should act now to create momentum towards the net-zero goal. This report, the second in a series on net zero, recommends policies for the industrial sector, which was responsible for 31 per cent of Australia's emissions in 2020.

Annual emissions from industry grew from 130 million tonnes in 2005 to 162 million tonnes in 2019, much of this driven by expansion of gas and coal exports. The Federal Government projects emissions will hover around this level until 2030. Current policies place little to no downward pressure on emissions, nor do they encourage development of new low- or zero-emissions industrial capacity. Only two paths exist to a net-zero industrial sector: decarbonisation driven by vigorous policy support, or deindustrialisation. The choice should be clear.

There are thousands of industrial facilities in Australia, and emissions come from thousands of sources. Each sub-sector has different options to reduce emissions. Some technologies are available now. Others require further investment from government and industry before they become commercial, meaning some companies have fewer options to quickly achieve step-change emissions reductions. Many facilities produce fossil fuels for export, and their futures will be affected more by other countries' climate change policies than by our own.

Net zero is also an opportunity. Some sub-sectors – like minerals and metals – will see increased demand as other countries decarbonise. If Australia can grow these sectors without growing emissions, we will prosper in a net-zero world.

From now on, every decision to renew, refurbish, or rebuild an industrial asset potentially locks in emissions for the coming decades. Getting these decisions right will be critical for reaching net zero.

Making progress by using the options we already have buys us valuable time, and is an insurance policy against delays in commercialisation of new technologies. Existing policies – the Safeguard Mechanism at the federal level, energy savings schemes at state levels – should be modified and expanded to deliver these immediate gains.

The scale of industrial transformation necessary for net zero will require new ways of thinking about and sharing financial and technology risk between sectors. Australia needs a mix of public and private funding that goes beyond short-term grant programs, one-off demonstration projects and project finance. The Federal Government should establish an Industrial Transformation Future Fund now to provide long-term certainty around the government's role in risk-sharing, and to reduce the risk of locking in emissions into the 2040s and 2050s.

Finally, given the scale and pace of change that will be required, state governments should support catalyst organisations in specific locations, to work with industry and governments to identify and help solve co-ordination problems and infrastructure and energy supply bottlenecks.

Recommendations

1. Ensure incentives to reduce emissions in large industrial facilities drive systemic change

- Amend the Safeguard Mechanism so all facilities use the same method to establish their baselines.
- Adjust the Safeguard Mechanism to allow below-baseline crediting, except for the electricity sector.
- Amend the Safeguard Mechanism so that baselines continue to reflect actual emissions.
- Allow third-party purchase of below-baseline credits, with government playing an underwriting role.
- Change Safeguard Mechanism baselines over time to a trajectory that contributes to meeting Australia's emissions targets. Do not exempt any facilities.
- Establish separate emissions intensity benchmarks for new Safeguard Mechanism facilities that are substantially lower than the industry average; and ensure they remain lower as the industry average improves.
- Remove administrative provisions in the Safeguard Mechanism that allow facilities to avoid consequences for breaching baselines.

2. Assist small and medium industrial facilities to reduce energy consumption and emissions

- Continue to align the four existing state energy efficiency obligations.
- State governments with energy efficiency obligations should ensure these schemes encourage greater uptake of emissions reduction opportunities in small and medium industrial facilities. If uptake is slow, governments could purchase certificates created in the industrial sector additional to scheme targets.
- States without energy efficiency obligations should develop policies to reduce emissions from small industrial facilities. This could include adopting energy efficiency obligations from other states while maintaining a mandate to innovate.
- Encourage use of the instant asset write-off to replace older industrial equipment with with newer, lower-emissions versions.

3. Put in place the building blocks of large-scale industrial transformation in the 2030s and 2040s

- Establish an Industrial Transformation Future Fund to generate the government funding that will be required to close the risk gap for transformational industrial investment.
- Put in place policies to ensure access to finance for investments in low- and zero-emissions industry. This could include a public-private investment fund.
- Support catalyst organisations in specific industrial areas to identify and help solve co-ordination problems and infrastructure and energy supply bottlenecks for new clean industry.

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1 The time is right for practical climate action

Australia has suffered more than a decade of policy uncertainty on climate change. Despite increasing international ambition and increasingly urgent calls for action, political differences between and within Australia's major parties have held back progress.

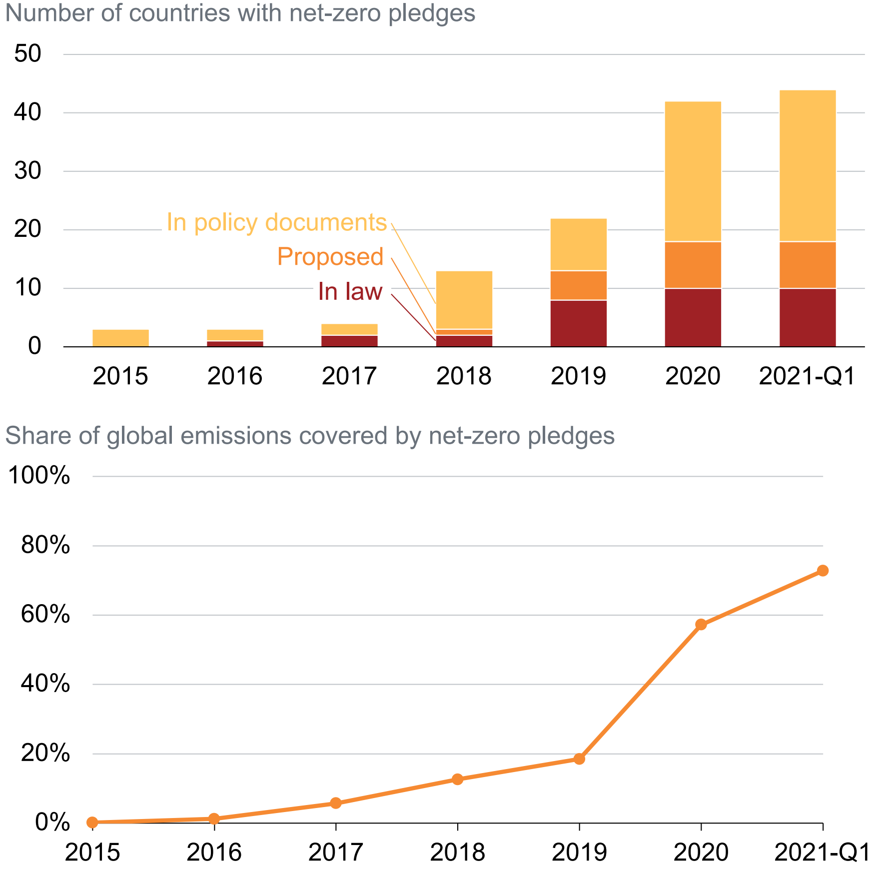
Nevertheless, converging international and domestic political pressures have created a window of opportunity for progress on climate change policy. Political reality means the best policy – a single, economy-wide emissions price – is out of reach for the foreseeable future. Therefore, the most pragmatic approach is a combination of sector-based, technology-driven policies that will create momentum towards greater ambition at a later date.

In the second half of 2021, Grattan Institute is publishing a series of five reports identifying the options for practical emissions reductions in key sectors. The first, on transport emissions, was published in July.[1] This report – the second in the series – focuses on emissions from the industrial sector.

1.1 International and domestic pressure to cut emissions is mounting

The international community has shifted towards greater climate ambition in the past 12 months (Figure 1.1). The US has rejoined the Paris Agreement and committed to reduce emissions to net zero by 2050. The EU, having already made that commitment, is considering imposing carbon costs (equivalent to those from its own emissions trading scheme) on imports from nations with inadequate climate policies.[2] Many of Australia's largest trading partners have

Figure 1.1: The international community is now serious about achieving net-zero emissions



Source: IEA (2021, p. 33).

1. Wood et al (2021b).
2. Taylor (2021).

now set net-zero targets, including China, Japan, and South Korea. All Australian states and territories have targets to reach net zero by 2050 or earlier,[3] and the Prime Minister says he wants to achieve that goal as soon as possible, preferably by 2050.[4]

Global action on climate change is overwhelmingly in Australia's national interest.[5] The Federal Government has ratified the Paris Agreement, which means Australia is committed to helping limit global warming to well below 2℃, and ideally to below 1.5℃.[6] To achieve this, there is a limit to how much carbon pollution the world can emit – a 'carbon budget'. Staying within that budget is the real objective.

Achieving net-zero emissions by about 2050 is the bare minimum to have a decent chance of limiting global warming to 1.5℃.[7] But it matters how the world – and Australia – gets there.[8] Continuing to release emissions at the current rate until 2049 – or even until 2035 – would blow the budget.[9] Cutting emissions this decade – but only slowly – would exhaust most of the budget, increasing the pressure on governments to bring their net-zero targets forward, which would require an even faster and more costly transformation of the economy.[10]

On the other hand, cutting emissions faster today will save more of the budget for the future, buying us time to ensure a smoother transition for our economy and communities. The emissions sources that are cheaper and easier to decarbonise should be targeted first; the harder-to-decarbonise sources should come later. Building momentum, coupled with R&D in low-emissions technologies, will make easier in the future what seems hard now.

3. Henry and Chandrashekeran (2021).
4. Morrison (2021).
5. Wood et al (2021a, Chapter 1).
6. UNFCCC (2015).
7. Without achieving net zero, global average temperatures will continue to rise: IPCC (2021, p. 36).
8. Hoegh-Guldberg et al (2018).
9. To have a two-thirds chance of keeping warming at 1.5℃, the world has a carbon budget of about 400 billion tonnes of CO_2 emissions from 2020: IPCC (2021, p. 38). Annual global CO_2 emissions averaged about 40 billion tonnes over the past decade, implying just ten years of budget remaining at current rates before 1.5℃ could well be breached: IPCC (ibid, p. 6).
10. Vogt-Schilb et al (2018).

Over the next decade, Australia's electricity emissions are projected to fall substantially, but the next four largest emissions sources in Australia will either grow or plateau at best (Figure 1.2 on the next page). This comes after sustained growth in emissions in several sectors since 2005. There is a market failure here: limiting global warming is in Australia's interest, but current incentives are too weak for companies and individuals to curb their emissions consistent with reaching net zero by 2050.[11]

If government policy does not bend these curves downwards this decade, Australia faces a faster, harder transition to meet this target – it will need to reduce its annual emissions by 24 million tonnes each year for 20 years (Figure 1.3 on page 9). And it will have emitted an extra two billion tonnes by 2050 compared to a trajectory of steady emissions cuts from today.

1.2 The best policy is off the table, so Australia needs a practical 'second-best' approach

The most practical approach to reducing emissions for now is a combination of sector-specific policies. While an economy-wide carbon price would be more efficient, the political reality is that Australia is unlikely to re-establish such a price any time soon (Box 1 on page 10).

11. These reports focus on policies to put Australia on the pathway to net zero by 2050 because this is the target most of Australia's governments have committed to. But international pressure to bring net zero forward is entirely possible as further evidence of climate impacts accumulates. In that case, the recommendations in this series remain valid, but stronger and more comprehensive policy will be necessary to meet earlier targets.

This industrial emissions report is the second of a series on sector-based approaches. The first was on transport, and the remaining three will cover agriculture and land use; the role of offsets; and the electricity sector. Each will analyse emissions sources; pathways and technologies for reductions; technological and economic challenges; and existing government initiatives. Each report will provide sector-specific recommendations.

The over-arching theme of these reports is that Australia needs real progress in each sector to achieve net-zero emissions economy-wide by 2050. Each sector has its own challenges and opportunities, but within each are categories of potential actions:

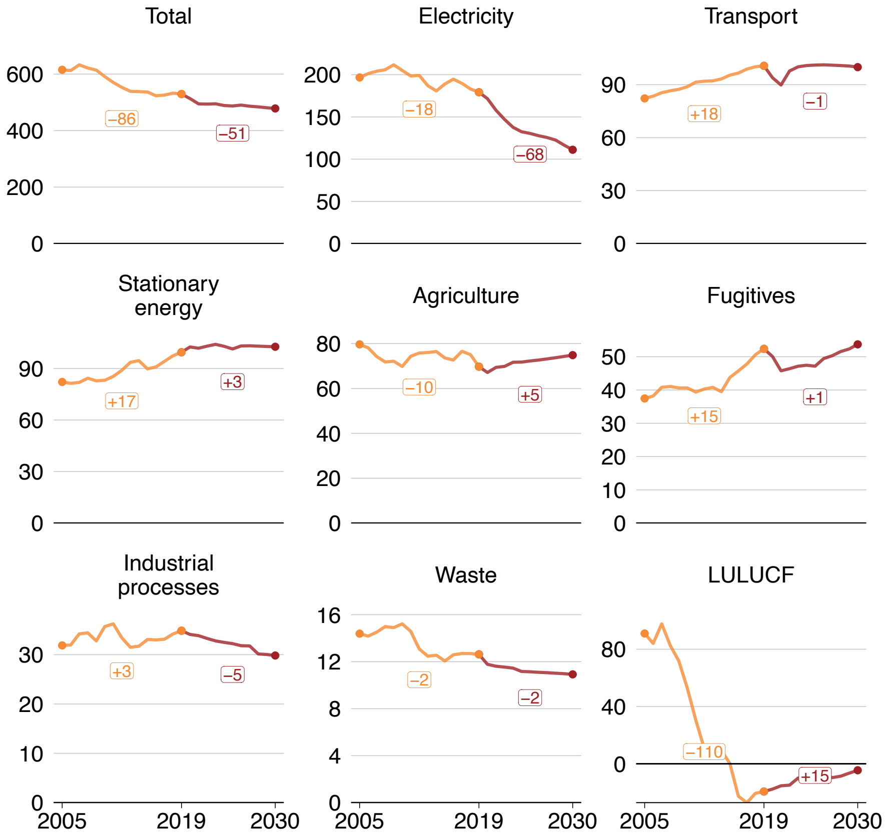
- Those where the costs are understood and either competitive or rapidly becoming so, the emissions abatement impact is clear, and policy is straightforward;
- Those where the costs are understood but expensive, and where there are barriers to implementation beyond cost; and
- Those which seem very difficult to implement and whose costs are unknown or difficult to quantify.

In the absence of an economy-wide emissions price, policy makers rather than the market must decide where to reduce emissions. In this series of reports, we are aiming for the lowest-cost, no-regrets emissions reductions in each sector first, even though this approach will be less efficient than an economy-wide market-based policy.

Generally, we will start from existing policies and orient them towards a common goal, rather than propose wholesale changes. We will prefer policies that are technology-neutral with respect to achieving the net-zero goal, except in the cases where the 'winner' is already obvious. Crucially, we see a role for technology *and* incentives *and* regulation, because a combination of the three will ensure appropriate risk-sharing between the public and private sectors.

Figure 1.2: Apart from electricity, there's very little emissions reduction expected in Australia over the next decade

Emissions per year (millions of tonnes)



Notes: 'LULUCF' = land use, land use change, and forestry. 'Stationary energy' is the use of fossil fuels for non-electricity, non-transport purposes, such as burning gas for heat in industry. 'Fugitives' are non-energy emissions released alongside the extraction of fossil fuels, such as carbon dioxide trapped in gas reservoirs. Emissions are 'carbon-dioxide equivalents', estimated using using the 100-year global warming potentials published alongside IPCC (2007).

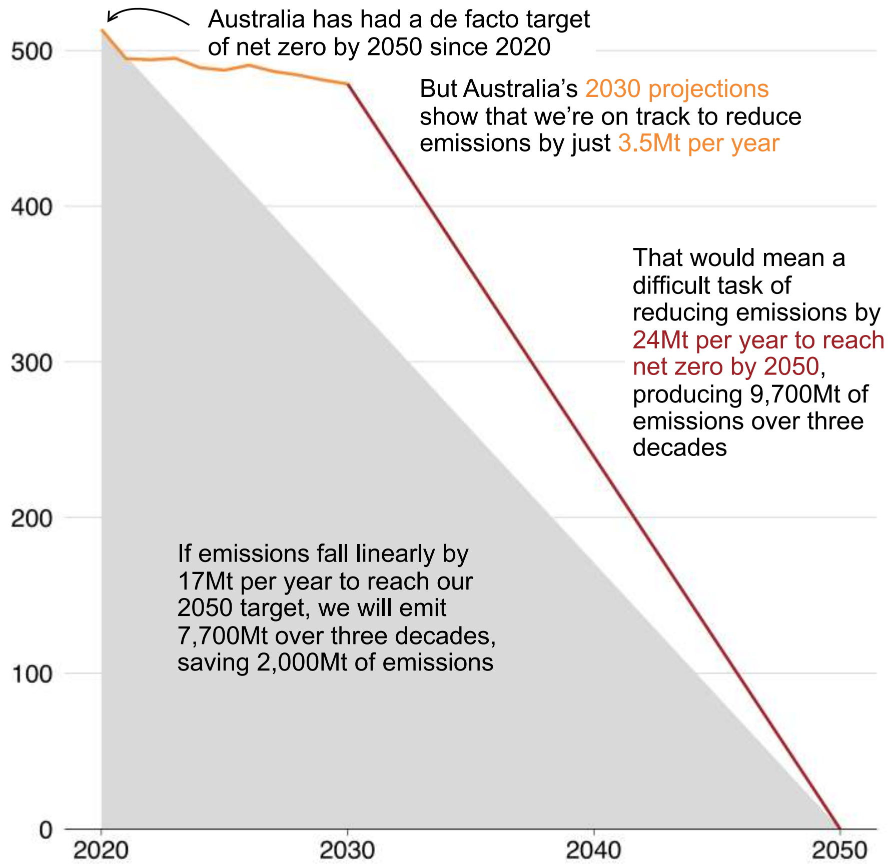
Source: Grattan analysis of DISER (2020a).

It should be possible for major parties to adopt our recommendations – whether for presentation at the international climate conference in Glasgow in November 2021, or for domestic policy platforms – but retain differentiated views on detailed policy design and the best mix.

Much public conversation on setting and achieving a net-zero goal for Australia focuses on activities and changes that are expensive and difficult. This neglects the actions that we can take now, whose successful implementation will build confidence and momentum. This report series focuses on policies that can be implemented now, with some suggestions for the longer term where relevant. None of our recommendations by themselves can deliver the full net-zero outcome, but they will all help orientate the economy in the right direction.

Figure 1.3: If there's insufficient progress by 2030, a highly disruptive economic restructuring will be needed in the 2030s and 2040s

Emissions per year (millions of tonnes)



Notes: Emissions are 'carbon-dioxide equivalents'. The two trajectories depicted do not have an equal effect on the climate, despite both reaching net zero by 2050 – it is the total amount of emissions in the atmosphere, not the annual contribution, that drives climate change. Even the straight line trajectory would exceed Australia's carbon budget for 1.5℃, requiring other nations to cut emissions faster: Reedman et al (2021).

Source: Grattan analysis of DISER (2020a).

Box 1: Why this report focuses on one sector rather than an economy-wide policy

Australia has 29 years to transform its economy if it is to reach net zero by 2050, and half this if it is to reach net zero within a carbon budget aligned with 1.5°C.[a] As Figure 1.3 on the preceding page shows, the slower we progress this decade, the steeper and more disruptive the pathway to net-zero emissions becomes.

It is well-accepted that the most economically efficient way to achieve large emissions reductions across the economy is through a carbon price.[b] Done well, economy-wide carbon pricing ensures that the sectors most able to make cheaper emissions reductions do so; the result is emissions reduction at lowest cost. Carbon pricing is supported by the business community and economists.[c] It should form the bedrock of an effective suite of policies to achieve net zero.[d]

But carbon pricing has a long and difficult history in Australia: a price was taken to election by both parties in 2007, introduced in 2012 (though it was far from perfect, with many compromises to appease political and vested interests), and repealed in 2014 after being successfully labelled as a 'tax' by then-Opposition Leader Tony Abbott. A carbon price is now not seen as politically feasible by either major party, and the current Federal Government has ruled out any new policy that resembles a 'tax'.[e]

If Australia is to meet its climate objectives, policy is needed to reduce emissions now, sector by sector. This is a more costly way to reduce emissions than a carbon price because governments, not the market, have to decide where to reduce emissions. Nonetheless, governments should be able to meet their climate targets reasonably efficiently if they target the lowest-cost abatement opportunities in each sector.

Sector-based policies have delivered emissions reductions and survived political battles. For example, the Renewable Energy Target (introduced by the Howard Government in 2001 and reviewed and amended by successive governments since) has been so successful in increasing the renewable share of the electricity sector at reasonable cost[f] that many argue it is no longer necessary.

Starting with sector-based policies does not rule out a future economy-wide policy. In the meantime, it is better to start bending the emissions curve downwards with sectoral policies. Making sectoral progress would build momentum and confidence that the task of reaching net zero is possible. Once we are moving, it will become easier to move faster.

a. Reedman et al (2021, p. 38).
b. Wood et al (2016, p. 10).
c. BCA (2020); and Wood (2020).
d. A carbon price would need to be complemented by support for low-emissions technologies development and regulation in sectors with barriers to adoption. For example, there is a split-incentive problem in buildings where emissions from gas heating would be paid by tenants, but only the building owners can authorise upgrades to lower-emissions electric heat pumps. In this case, minimum building efficiency standards would probably be a more effective policy.
e. Wood (2021).
f. CCA (2014).

2 Where we are today in the industrial sector

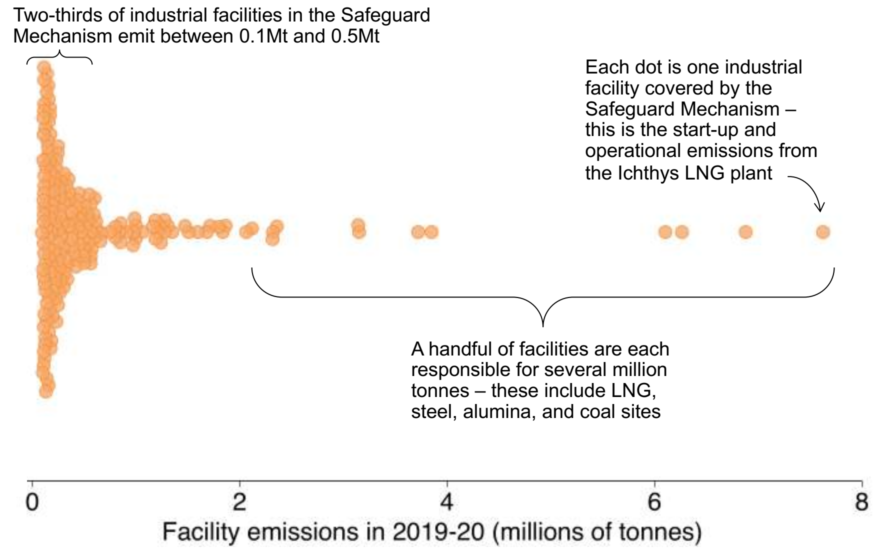
The industrial sector was responsible for 31 per cent of Australia's emissions, or 162 million tonnes, in 2019. Industrial facilities vary widely in their size, activity, and location. 194 large facilities (that each emit more than 100,000 tonnes of emissions per year) were collectively responsible for about 130 million tonnes of emissions in 2019 (Figure 2.1).[12] There are also tens of thousands of mines and manufacturing facilities, which together with the construction sector contributed the remaining 30-or-so million tonnes of industrial emissions in 2019.[13]

We can divide these facilities into three broad groups: those which extract and process coal, oil, and gas; those which extract and process other minerals and metals; and those which manufacture other products. Within these groups, emissions come from more than 50 processes,[14] but there are three main sources: emissions that escape to the atmosphere when fossil fuels are extracted (fugitive emissions); emissions from combustion of coal, gas, and petroleum products; and emissions released through chemical reactions during manufacturing processes (process emissions). A breakdown by source and activity is shown in Figure 2.2 on the following page.[15]

Each group can take action today to start moving towards net zero. The options available are as diverse as the sector, and some industries have more options than others. Many industrial commodities are exported, and future emissions from industries that serve export

Figure 2.1: There are a handful of mega-emitters, and many smaller emitters

Emissions in 2019-20 from industrial facilities that report under the Safeguard Mechanism



Notes: Power stations and transport facilities (such as airlines and rail) are excluded. Two Incitec Pivot facilities had their emissions withheld in 2019-20. Only facilities with 100,000 tonnes of emissions or more are covered by the Safeguard Mechanism.

Source: Grattan analysis of CER (2021a).

12. Excluding power stations and transport facilities.
13. ABS (2021a).
14. DISER (2021a).
15. In this report we do not consider emissions related to transport in the industrial sector, or emissions related to electricity consumed by the industrial sector. A more detailed breakdown of industrial emissions sources is provided in Figure C.1 on page 48.

markets will be affected as much by decisions of other governments as by Australian policies and choices. To reach net zero by 2050, industrial emissions will need to decline by more than 8 million tonnes every year in the 2030s and 2040s (Figure 2.3 on the next page). This rate of decline is equivalent to shrinking emissions nearly four times as fast as they grew between 2005 and 2020.

2.1 Fossil fuel extraction dominates industrial emissions

Gas, oil, and coal extraction and oil refining together accounted for more than half of Australia's industrial emissions in 2019 (87 million tonnes), and have grown by more than 50 per cent since 2005, as can be seen in the top row of Figure 2.2.[16] This growth was largely driven by export demand for coal and gas:[17] in 2019-20, 68 per cent of Australia's natural gas production, and 86 per cent of saleable coal, were exported.[18]

Emissions from fossil fuel extraction are projected to grow by at least 4 million tonnes between 2020 and 2030. Much of this growth comes from LNG.

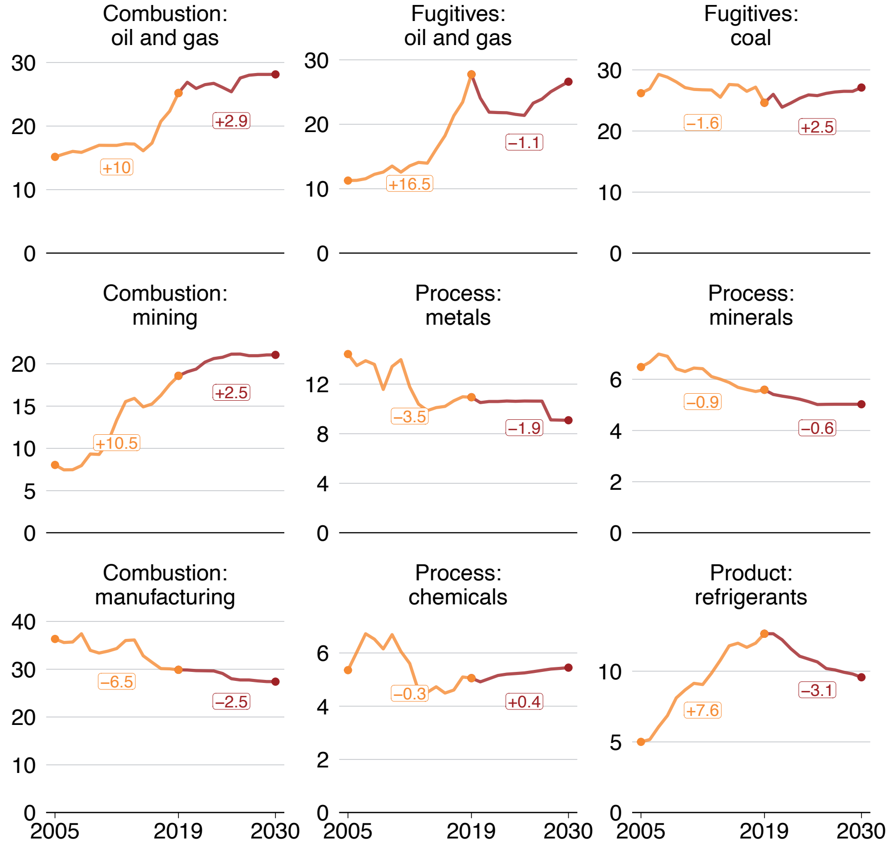
Immediate options to reduce emissions from fossil fuel extraction include replacing gas and diesel with renewable energy, flaring, efficiency gains, and (in some facilities) carbon capture and storage.

Future emissions will be strongly affected by demand for fossil fuel exports, as other countries make their own decisions about achieving net zero.

16. Combustion emissions for coal mining are included in the 'mining' category in the second row: coal mining was responsible for half of all mining combustion emissions in 2019.
17. DISER (2021b, p. 40).
18. DISER (2021c, pp. 49, 60, 73). Saleable coal is the product of processing raw black coal. Brown coal (lignite) is not saleable – virtually all Australian brown coal is produced and used within Victoria: DISER (2020b, Table D, Table P).

Figure 2.2: Fossil fuel extraction dominates industrial emissions, but fuel combustion is also significant

Emissions per year (millions of tonnes)



Note: 'Combustion: mining' includes both coal mining and other mining. In 2019, coal mining was responsible for half of these emissions (9.3 million tonnes). Emissions are 'carbon-dioxide equivalents', estimated using using the 100-year global warming potentials published alongside IPCC (2007). Some small sources of emissions are not shown (e.g. industrial wastewater emissions, 1 million tonnes in 2019). A more detailed snapshot is available in Figure C.1 on page 48.

Source: Grattan analysis of DISER (2020a).

2.1.1 LNG and other oil and gas production

Current emissions profile

Extracting and processing oil and natural gas for use here and overseas produced 52 million tonnes of emissions in 2019. Of these, 21 million tonnes resulted from combustion, 28 million tonnes were fugitive emissions, and 3 million tonnes came from oil refining.[19]

Trends to 2030 and options for action

Emissions from gas and LNG production are projected to start growing again from 2026, as new LNG facilities come online. Oil refining emissions are projected to remain flat, but this will depend on Australia's two remaining oil refineries continuing to operate. Currently neither has made commitments to remain open beyond 2027,[20] and both may find it more profitable to convert to import terminals as other Australian refineries have done.

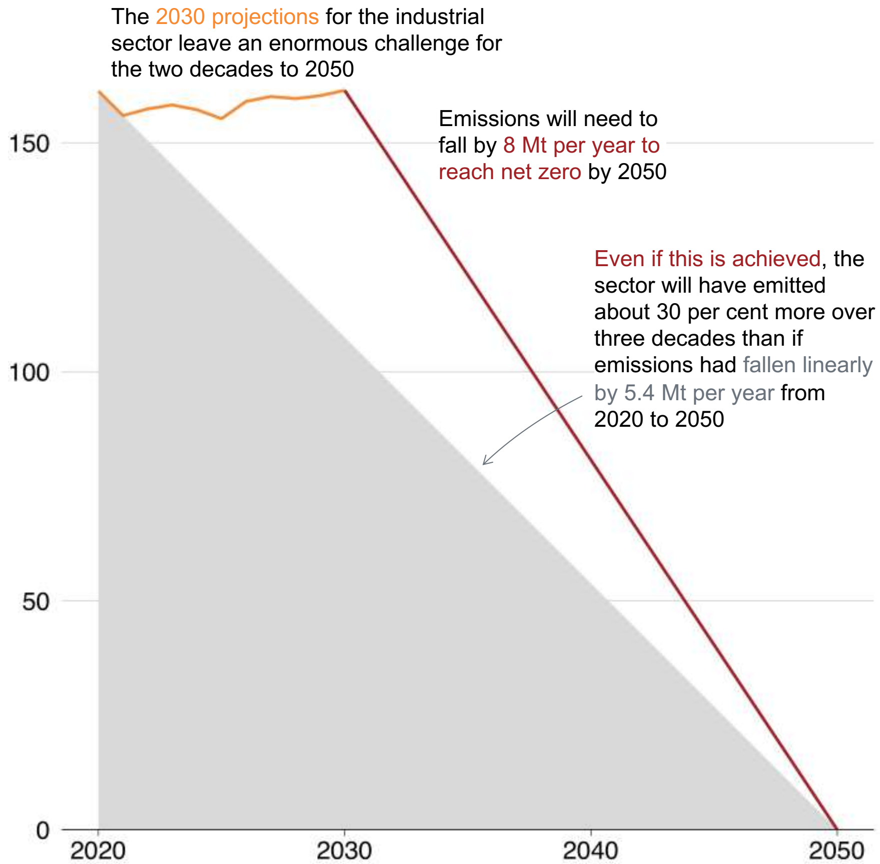
To reach an Australian net-zero target by 2050, the LNG sector would need to eliminate an additional 1.2 million tonnes per year starting now, or 2.1 million tonnes per year from 2030 onwards.[21] Immediate opportunities to reduce emissions from gas production include emissions management (such as flaring), combustion efficiency, using renewables, and carbon capture and storage.

Flaring removes the more potent greenhouse gases from waste gas during processing, converting them to carbon dioxide.[22]

19. DISER (2020a).
20. Jose and Paul (2021).
21. Based on the LNG industry emitting 36 million tonnes in 2020, and 42 million tonnes in 2030: DISER (2020a, p. 39).
22. Fugitive emissions from fossil fuel extraction include high amounts of methane. Methane is 28 times more potent as a greenhouse gas than carbon dioxide. Flaring converts methane to carbon dioxide, resulting in a considerably lower warming effect.

Figure 2.3: Without action to reduce industrial emissions in the 2020s, the path to net zero by 2050 becomes even steeper

Emissions per year (millions of tonnes)



Notes: Emissions are 'carbon-dioxide equivalents', estimated using the 100-year global warming potentials published alongside IPCC (2007). Non-linear paths to net zero are likely, but it is the area under the curve that represents total emissions (and therefore total contribution to global warming).

Source: Grattan analysis of DISER (2020a).

Combustion can be made more efficient by using hybrid electric/gas turbine drives on compressors.[23] Compressors burn gas in order to move gas from gas fields to processing facilities and for liquefaction.

Onshore gas extraction facilities generate combustion emissions from diesel and gas engines used to supply electricity for equipment. Over time, these could be replaced by cost-effective renewables and storage, though some residual diesel or gas use may remain for back-up.

Carbon capture and storage (CCS) is suitable for some emissions from LNG and gas production but not others. Economic CCS requires a sufficient volume of carbon dioxide to make investment in capture and storage worthwhile, and short distances to move this carbon dioxide to a storage site. Finding a site with suitable geology close to the source of emissions makes a large difference to the overall cost. CCS also requires energy to compress and inject the carbon dioxide into the storage site. Unless this electricity is from a zero-emissions source, using CCS will generate emissions elsewhere.[24]

Gas processing creates a concentrated stream of carbon dioxide with fewer other gases mixed with it. If the gas source has relatively high amounts of carbon dioxide mixed with the methane, gas processing emissions are ideal candidates for capture and storage.[25] Combustion emissions from compressors or electricity generation are less suited. Exhaust gases are difficult to capture, and contain a mixture of different gases, which must be scrubbed from the carbon dioxide before storage. While there are technologies available to do this, they are very expensive. Eliminating compression emissions will require a vast improvement in post-combustion carbon capture technology, or shifting to a different sort of compressor – such as a fully electric one – that can do the same job without burning gas.

Long-term trends in emissions from oil and gas extraction

Emissions from oil and gas extraction will be affected by four factors: export demand for LNG, domestic demand for gas, the transition to renewables in the electricity sector, and the trend towards electrification of transport.

Of these, export demand for LNG is by far the most important. The other three factors are discussed in Box 2 on page 16.

In 2019-20, 85 per cent of LNG exports went to countries that have made net-zero emissions commitments.[26] Current government projections for future emissions (see Figure 2.2 on page 12) do not take these commitments into account,[27] but the choices these countries make about their pathways to net zero will have a much larger impact on emissions from LNG than will Australian policy decisions. For example, Australia's biggest LNG customer, Japan, has announced

23. APPEA (2020, p. 11).
24. CCS requires between 250 kilowatt hours (kWh) and 300 kWh per tonne of carbon dioxide for capture and between 80 kWh and 120 kWh per tonne captured for compression: Jackson and Brodal (2019). On an offshore LNG platform, the only way to get this electricity would be by burning more gas, or using a high-voltage electrical cable to connect to land-based renewable generation. Generating this electricity using solar PV would require about 200 megawatts for every million tonnes of carbon dioxide sequestered in a year, not accounting for transmission losses or firming capacity.
25. Australia's only operational carbon capture and storage project, which is associated with LNG processing emissions, achieved capture and storage of about 3.3 million tonnes in 2020, offset against its emissions of about 8.8 million tonnes: Chevron Australia (2020) and CER (2021a). The estimated cost of the project so far is about $3 billion, and to the end of 2020 to project had captured a total of 4.05 million tonnes.
26. Grattan analysis DISER (2021c).
27. In the Federal Government's projections, long-term commitments to net zero by other countries are not expected to affect Australia's fossil fuel exports over the next decade unless additional short-term policies are also announced by Australia's major trading partners: DISER (2020a, p. 7).

its intent to reduce the percentage of LNG in its energy mix from 37 per cent in 2019 to 20 per cent in 2030.[28]

These choices, and the pace at which technology alternatives become available and commercial, could play out in many different ways. We can get some sense of possible pathways by considering the two most extreme scenarios: that destination markets do not take any further steps to reduce fossil fuel use, relying only on carbon capture and offsets to reduce emissions; or, they eliminate use of fossil fuels almost entirely, and no alternative markets emerge for Australian exports. Figure 2.4 shows two possible versions of these scenarios, using projections from the International Energy Agency (IEA).

In the first scenario, in the absence of any policy action, Australian emissions from fossil fuel extraction are likely to continue to grow as Australia expands its production to meet international demand. To achieve our net-zero target, the LNG industry would need to implement all the solutions discussed in Section 2.1.1 on page 13, and still undertake considerable offsetting for emissions that are not amenable to reduction.

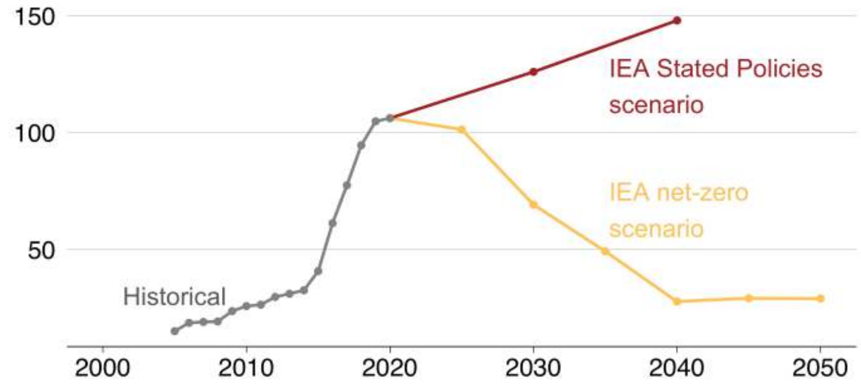
In the second scenario, as the world pursues emissions reductions pathways compatible with achieving net zero by 2050, exports of coal and LNG would fall substantially across coming decades. In 2050, there would be only a small amount of activity whose emissions would need to be offset or eliminated for Australia to reach a net-zero goal.

Regardless of which scenario eventuates (and reality will probably fall somewhere in between), encouraging investment now to reduce emissions from existing facilities and minimise those from any new ones, will make the task of achieving net zero easier. Willingness to invest is likely to decrease as markets decline, so governments should prefer early action.

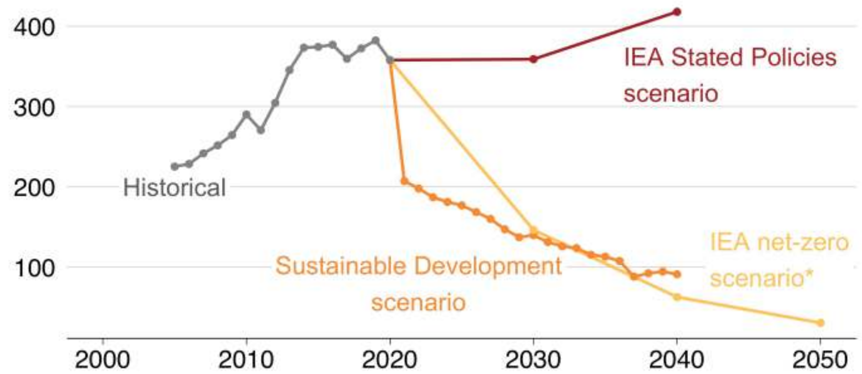
28. Tsukimori (2021).

Figure 2.4: If the world pursues strategies to reach net zero, domestic emissions from Australian fossil fuel exports could shrink dramatically

LNG exports (billion cubic metres)



Coal exports (million tonnes of coal equivalent)



Notes: (*) International Energy Agency (IEA) net-zero scenario includes forecasts for the global market value of coal – this path assumes Australia's coal exports fall at the same rate as the global market. Australian coal exports are forecast explicitly to 2040 in the Sustainable Development scenario (which would limit warming to well-below 2°C) from Auger et al (2021). The Stated Policies scenario is based on 2019 forecasts in the absence of any further global policy to reduce emissions.

Source: Grattan analysis of DISER (2020b), DISER (2021c), IEA (2021) and IEA (2019).

2.1.2 Coal mining

Current emissions profile

Mining and processing coal for the Australian and export markets produced 34 million tonnes of emission in 2019. Of these, 9 million tonnes came from fuel combustion, 18 million tonnes were fugitive emissions from underground mines, and 7 million tonnes were fugitive emissions from open-cut mines.[29]

Trends to 2030 and options for action

Fugitive emissions from coal production are projected to rise slightly between 2019 and 2030, by 2.5 million tonnes. No projection is available for combustion emissions. To reach net-zero fugitive emissions, the coal industry would need to eliminate 1.1 million tonnes each year, starting now. Options are limited to using renewables, and flaring for underground mines.

Renewable electricity with cost-effective storage could replace burning fuel (diesel or gas) to provide electricity for equipment such as excavators, conveyors, draglines, and processing plants. Some residual diesel or gas use may remain for back-up generation.

Flaring is common in underground mines, where the high concentration of methane in released fugitives can be dangerous. Flaring converts methane to carbon dioxide, which is less explosive and a less potent greenhouse gas than methane, reducing but not eliminating the climate impact. Some Australian coal mines have installed waste coal mine gas generators, which burn fugitive emissions from underground mines

29. Fugitive emissions do not vary whether thermal coal (for making electricity) or metallurgical coal (for making steel and other metals) is being extracted. Fugitive emissions do vary with geology, and Queensland and NSW mines tend to be 'gassier' than their counterparts in other states: DISER (2021d, p. 21) and DISER (2021b, p. 126).

Box 2: What about domestic gas, coal, and fuel use?

Achieving net zero will mean eliminating use of fossil fuels across the economy, or using offsets for the emissions from any residual gas, coal and petroleum consumption.

For most household consumers, electricity is already a cheaper option than gas, and will soon be a cleaner option too.[a] Gas used in manufacturing is discussed in Section 2.3. In electricity, some gas may still be needed for a few decades as low-cost 'backstop', providing power during prolonged periods of low renewable generation.[b] How much gas will depend on absolute demand for electricity (which will grow as electrification is used to eliminate other fossil fuel emissions) and on advances in load management, grid management, and zero-emissions electricity firming alternatives.

Most domestic demand for thermal coal will fall away as coal-fired power stations close over the coming decades. Other coal use is also discussed in Section 2.3.

Liquid fuels are mainly used for transport. Reaching net zero in the transport sector will require phasing out most internal combustion engines.[c] If governments put in place policies to reduce transport emissions consistent with achieving net zero by 2050, nearly all vehicles will come to use domestically-produced electricity, hydrogen, and renewable fuels. Residual petroleum needs could be met through imports, making more use of storage if security of supply is a concern. There will be no need for remaining refiners to continue making petroleum: they can convert to import terminals or switch to making renewable fuels.

a. Wood and Dundas (2020).
b. Wood and Ha (2021).
c. Wood et al (2021b).

to generate electricity.[30] In open-cut mines there is no way to capture fugitive methane emissions to flare them, and so they are all released.

Carbon capture and storage is not an option for open-cut coal mines because of the difficulty of capturing gas from an open pit.

Long-term trends in emissions from coal mining

Emissions from coal extraction will be affected by demand for coal-fired electricity and demand for coal for steel-making, here and overseas. Overseas demand will be more important: 86 per cent of black coal produced in Australia in 2019-20 was exported.[31]

In 2019-20, at least 74 per cent of Australia's thermal coal exports, and 54 per cent of metallurgical coal exports, went to countries with net-zero targets.[32] Current government projections do not take these commitments into account. As with LNG, we can consider two scenarios at the extremes of possibility: one where export markets rely on carbon capture and storage and offsetting, and one where they eliminate as much fossil fuel use as possible (Figure 2.4 on page 15).

The future of large-scale, widespread use of coal looks doubtful. Thermal coal is already being replaced around the world by renewable or nuclear energy, or by gas-fired power which produces fewer emissions. Japan – Australia's largest thermal coal customer – is aiming to reduce reduce coal consumption from 32 percent to 19 per cent of its energy mix between 2019 and 2030.[33] In Australia's National Electricity Market, the last coal-fired power station is expected to close by 2051 if no further emissions policies are enacted.[34]

30. EDL (2021).
31. Australia's brown coal production is less than 10 per cent of all coal production by mass, and is not exported: DISER (2020b).
32. DISER (2021c).
33. Tsukimori (2021).
34. Wood and Ha (2021, p. 6).

Metallurgical coal can be replaced by gas (again with fewer emissions), and zero-emissions steel using hydrogen is being trialled.

Underground mines will continue to produce fugitive emissions even when operations cease.[35] These emissions will need to be managed or offset long after the mines have closed.

We should not wait for declining export demand to bring about reduced emissions from coal production. Declining overseas markets for coal will mean fiercer competition for remaining market share. Our remaining producers should reduce emissions at low cost where they can, particularly where these reductions come from efficiency gains which will help them stay competitive.

Australia should actively plan for a future without coal. We should focus on existing and sunrise industries where we have a comparative and strategic advantage in a net-zero world.

2.2 Mining, minerals, and metals are also a significant source of emissions – and opportunity

Emissions from minerals extraction, minerals processing and refining, and metals production are shown in the second row of Figure 2.2 on page 12. Excluding coal mining, these emissions have increased from 24 million tonnes in 2005 to 26 million tonnes in 2019. Largely, this was because of the mining boom, which resulted in Australia's minerals exports increasing steeply. Emissions come from combustion (9.3 million tonnes in 2019), minerals processing (5.6 million tonnes), and processes to make metals (10.9 million tonnes).[36]

35. Kholod et al (2020).
36. These combustion emissions relate only to mining. Combustion emissions associated with processing metals and minerals cannot be disaggregated from the overall manufacturing sector, discussed in Section 2.3 on page 19.

Trends to 2030 and options for action

Emissions overall are expected to stay flat to 2030. An increase in combustion emissions will be offset by falls in those from minerals processing and metals.[37]

The most immediate opportunities to reduce emissions are efficient operations and better control systems around combustion, and renewable energy to replace diesel and gas for powering equipment on mine sites and remote minerals processing plants.

Long-term trends in emissions from mining, metals, and minerals

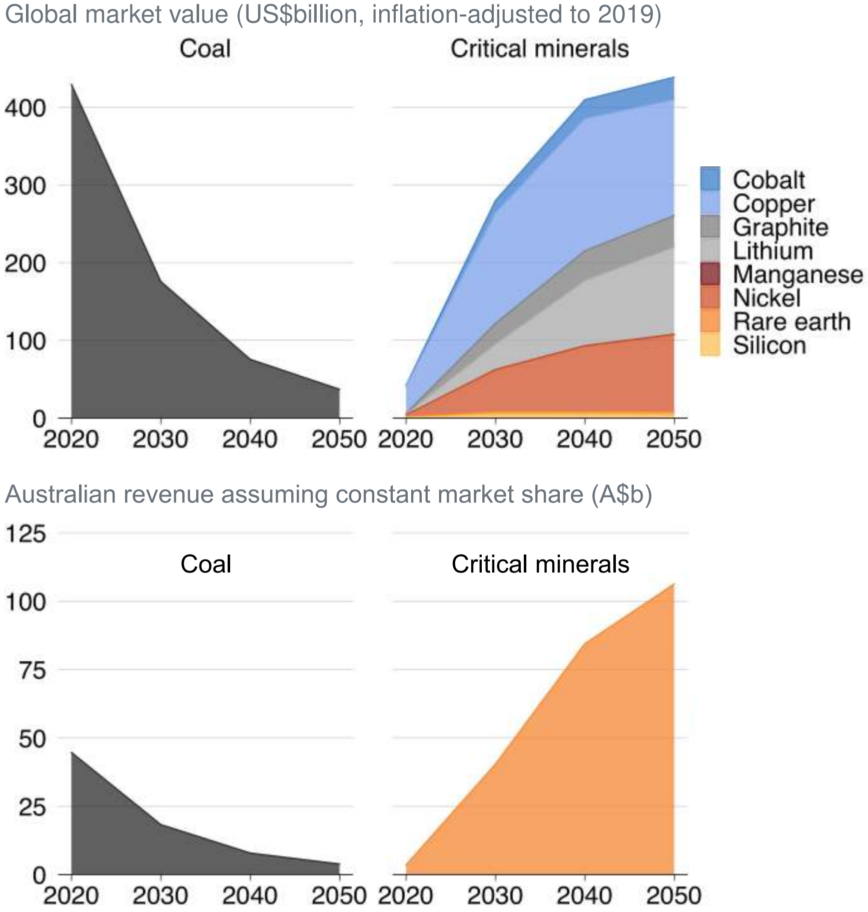
Like gas and coal, future growth or decline of emissions from mining, minerals processing and metals will be affected by climate change policies in other countries. Most of the minerals and metals extracted and refined in Australia are exported;[38] and demand for minerals and metals is expected to increase sharply as the world moves towards net-zero emissions. This increase is projected to almost exactly mirror the decline in demand for coal. But if Australia maintains a constant market share of the critical minerals market as it grows, this market will be worth roughly double what coal is worth today (Figure 2.5).

Some Australian mineral commodities could move up the value chain by reducing emissions and increasing income. Green steel production, for example, could generate up to $65 billion in revenue in 2050.[39]

Growing demand for minerals will place corresponding upwards pressure on Australia's domestic emissions unless demand growth is decoupled from fossil fuel combustion, and new processing technology is found to reduce process emissions (Figure 2.6 on the next page).

37. The Federal Government projects that process emissions from metals and minerals will fall slightly due to technology changes in the steel-making process and lower domestic production of clinker: DISER (2020a, p. 43).
38. DISER (2021c).
39. Wood et al (2021a).

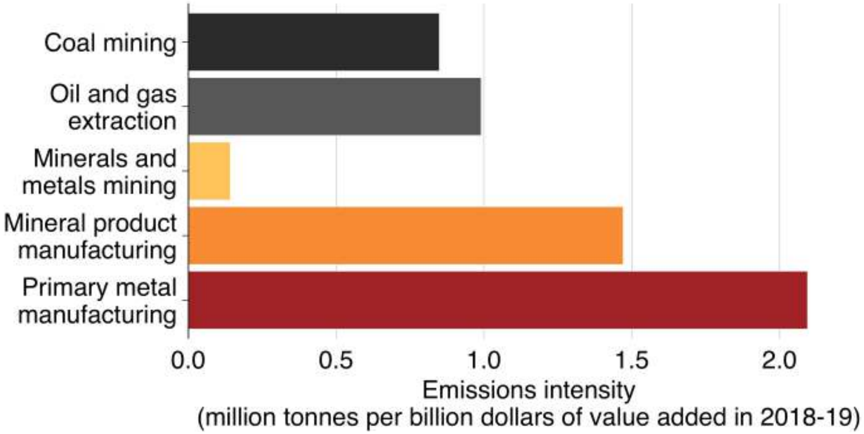
Figure 2.5: Minerals critical to low-emissions technologies are expected to be in high demand over coming decades



Notes: Includes total revenue for coal and for selected critical minerals used in clean energy technologies. The prices of critical minerals are based on conservative assumptions about cost increases (about a 10-to-20 per cent increase from current levels to 2050). Australia's share of the global coal market is taken from IEA (2020), and minerals from Bruce et al (2021). Exchange rate is assumed to be 0.73 USD per AUD.

Source: Grattan analysis of IEA (2021, p. 163).

Figure 2.6: Mining metals and minerals is not very emissions-intensive, but processing them often is
Industrial subsector



Note: Emissions intensity measures scope 1 emissions only, and does not include emissions associated with electricity use or final product consumption.

Sources: Grattan analysis of ABS (2021b) and DISER (2021e).

Decoupling growth in mining, minerals, and metals from growth in emissions will require finding substitutes for the coal and gas currently used to provide high-temperature heat for processing. Hydrogen may be one option, concentrated solar power may be another, although neither is cost-competitive yet.

2.3 Emissions in the manufacturing sector

Current emissions profile

Combustion emissions in the manufacturing sector totalled 30 million tonnes in 2019 (Figure 2.2 on page 12).[40] These combustion emissions come from diverse industries, such as basic chemicals (6 million tonnes), food, beverages, and tobacco (3 million tonnes), and cement (3 million tonnes).

An additional 5 million tonnes were released from chemical processes – not combustion – within the chemicals industry, such as the ammonia-making process (2 million tonnes) and the nitric acid process (2 million tonnes).

Trends to 2030 and options for action

Combustion emissions are expected to decline to 27.4 million tonnes in 2030, with chemical process emissions remaining fairly flat.[41] If gas prices remain high, this may reduce production and competitiveness for ammonia facilities, which use large amounts of gas for feedstock and energy.

Combustion emissions can be reduced or eliminated through fuel efficiency and fuel switching. For example, some cement facilities still use coal for combustion, and could reduce emissions substantially by switching to gas – provided the gas price is not prohibitive.

Where low-temperature heat is needed (for instance, to heat water in the food and beverage industry), electrification is a readily-available alternative to combustion. Electric heat pumps are highly efficient, and current models can provide heat up to 160℃.[42]

For high-temperature heat, there are a range of possible options, but generally they are not yet cost-competitive with burning fossil fuels.[43]

40. Some of these emissions are associated with the manufacture of metals and minerals: see Figure C.1 on page 48 for a more detailed snapshot.

41. As noted above, some combustion emissions are associated with the manufacture of metals and minerals.
42. ARENA (2019, p. 45).
43. Some technologies, such as resistive electric heating, are well-established: ARENA (ibid, p. 46). Others are much less mature, such as concentrated solar thermal or small modular nuclear reactors. Nuclear energy for high-temperature process heat is at demonstration phase globally, but it cannot be established in

Zero-emissions hydrogen is one potential substitute if the costs fall substantially.[44]

Some chemical process emissions can be reduced in the near term. Ammonia is combined with nitric acid to make ammonium nitrate, which is used for fertiliser and explosives. Nitric acid production generated 2.2 million tonnes of carbon dioxide-equivalent emissions in 2019, as nitrous oxide.[45] This potent greenhouse gas can be removed using a scrubber, which also removes nitrogen oxides that contribute to air pollution.[46]

Long-term trends for manufacturing emissions

Many chemical process emissions are very difficult to eliminate, because they occur in fixed proportion to the amount of end product. Some reductions can be achieved through process efficiency, but elimination relies on the invention of substitute processes that produce the same end product (or a substitute product with equivalent performance) without creating greenhouse gas emissions. For example trials in Europe have shown that substituting hydrogen for gas in cement kilns can reduce combustion emissions,[47] but eliminating the process emissions in a cement kiln requires using alternatives to limestone, or carbon capture and storage (provided the storage site is not too far from the cement plant).

Decoupling ammonia production from emissions requires replacing natural gas as both feedstock and fuel. Some efficiency gains are possible, but a better longer-term option for ammonia production is to shift to using zero-emissions electricity for all processes, and zero-emissions hydrogen as a feedstock.[48]

Use of refrigerant gases also contributes to industrial emissions (Figure 2.2 on page 12).[49] The Kigali Amendment to the Montreal Protocol commits countries to achieving an 80 per cent reduction in consumption of these gases globally by 2047.[50] Australia has ratified and is implementing the Kigali Amendment, and use of these gases is projected to decrease at a rate consistent with being close to net zero in 2050.[51] We therefore do not analyse this source further in this report.

The remaining sources of emissions are small, but few have identified changes to processes to eliminate emissions. Offsets may be the only solution for these emissions.

Australia while the *Environment Protection and Biodiversity Conservation Act 1999* prohibits it: WNA (2020).

44. The Commonwealth Government's stretch target for the cost of producing low-emissions hydrogen is $2/kg, which is equivalent to $17/GJ energy: DISER (2020c). This is still relatively expensive energy compared to gas with no carbon price, which on average cost between $8/GJ and $11/GJ for commercial and industrial customers on the east coast of Australia between 2017 and 2020: ACCC (2020).
45. Nitrous oxide, also known as a laughing gas, traps more than 200 times as much heat as carbon dioxide: CER (2021b).
46. Nitrogen oxides, sometimes called NOx, are less potent greenhouse gases but are ingredients in smog and acid rain. Most developed countries place controls on NOx emissions. Non-selective catalytic reduction (NSCR) devices react hydrogen, natural gas or naphtha with NOx and nitrous oxide and reduce them to pure nitrogen: AEA Technology Environment (1998, p. 42).
47. FuelCellWorks (2021).
48. Smith et al (2020).
49. These gases include all substitutes for ozone-depleting substances, including aerosols. Their use accelerated in the 1990s because of their minimal impact on atmospheric ozone, but they are much more potent greenhouse gases than carbon dioxide.
50. UNIDO (2021).
51. DISER (2017). Australia, as a developed nation, has committed to reduce its use of these gases by 85 per cent by 2036.

2.4 How the remainder of this report is structured

Where there are immediate options to reduce industrial emissions, governments should put in place policies to act on these opportunities. Chapter 3 explores policy changes to bring about immediate emissions reductions in large industrial facilities. Chapter 4 does the same for smaller facilities.

Where options for emissions reductions are under-developed or not yet commercial, governments need to spend the next decade setting up the tools that will be required to bring those opportunities to fruition from 2030. Chapter 5 suggests new policies to support transformation of the sector in the 2030s and 2040s. Chapter 6 considers the impact of our recommendations on other sectors of the economy.

3 What governments should do about large facilities

Most parts of the industrial sector have immediate opportunities to reduce emissions through fuel efficiency, process efficiency, and fugitive emissions management. Maximising uptake of these opportunities will help maintain competitiveness of Australian industries as carbon begins to be priced into global supply chains. It will reduce the pressure to achieve high levels of emissions reductions or very fast cost reductions with new technology; and it will act as an insurance policy, keeping Australia on a net-zero pathway in the event that breakthrough technology takes longer than predicted to reach commercial viability.

Using only subsidies to maximise uptake of these opportunities would require a major long term commitment to on-budget funding by future governments. The Federal Government should adjust existing broad-based policies such as the Safeguard Mechanism to produce emissions reductions across the diverse range of options and sources at lower cost.

The Federal Government should also set stringent emissions intensity standards for new industrial facilities, to avoid locking in emissions that will need to be offset later to achieve net zero. This will also encourage new, cleaner facilities that can transform the industrial base to one that is low- or zero-emissions.

3.1 Immediate action will position the economy for a net-zero world

Options to achieve net zero in the industrial sector fall into three categories. Immediate reductions (for example through process or fuel efficiency) can come from technology and practices that are available now. Large, one-off reductions will happen if an entire facility moves to using a completely new process, or if an old facility is replaced with a new low- or zero-emissions one. And facilities that are unable to find markets in a net-zero world – such as refineries or coal mines – will close.

Australia's current pathway looks closest to a combination of the second and third of these. Governments are investing in early-stage technology development that, if successful, could deliver large emissions reductions later. And investor pressure is leading to facility closure.

But this pathway has risks. As discussed in Chapter 2, it outsources management of a substantial part (more than 10 per cent) of our national emissions to governments in our export markets – who will make decisions in their national interests, not Australia's.

Some facilities, such as steel smelters, cement kilns, and ammonia plants, do need new technology and we must make good use of this decade trialling and commercialising it. But developing, testing, and commercialising new technology may take longer than expected. And the longer we wait, the faster we will need to change – and the more difficult and expensive it will become – to reach net zero (Figure 3.1 on the next page).

Firms that reduce emissions now with the options available today will be able to wait an extra year or two for new technology to prove itself or for costs to fall, and may be more satisfied with technologies that are only partial solutions. As well, efficiency gains should make Australian industry more competitive, particularly in global supply chains where embedded emissions are factored in.[52] Firms that wait may find they become unviable or face large and ongoing offset burdens. In any

52. AiG (2021).

case, firms that are part of global supply chains may find use of offsets restricted by other governments.

Governments' role is to ensure policies encourage firms to make gains wherever possible now, to minimise the overall cost to the economy of reaching net zero by 2050.

3.1.1 Diverse emissions sources require broad-based policy

Individually targeting each of the sources of industrial emissions would be inefficient and ineffective. Emissions from a facility rarely come from just one source, and a single source (for example, gas combustion to provide heat) will come from a variety of different equipment types. Broad-based policy that leaves it to firms to identify what best works for their facilities will be more effective at achieving the lowest-cost emissions reductions.

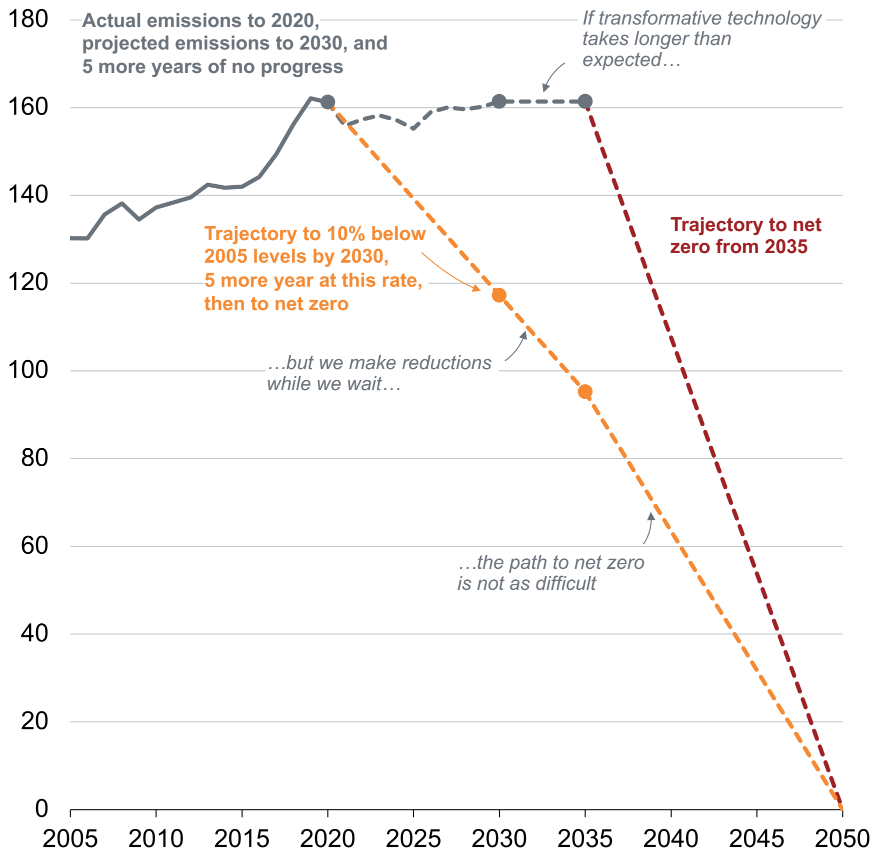
Some Australian governments already have broad-based policies that target industrial energy and emissions. The Federal Government's Safeguard Mechanism (Box 3 on the following page) covers large facilities; and NSW and Victoria have energy efficiency schemes that target large and small facilities (discussed further in Chapter 4).

3.2 The Safeguard Mechanism does not put downward pressure on emissions

The Federal Government's original design intent for the Safeguard Mechanism was that 'emissions reductions contracted through the Emissions Reduction Fund are not offset by significant increases in emissions above business-as-usual levels elsewhere in the economy'.[53] While there have been more Australian Carbon Credit Units issued each year through the Emissions Reduction Fund than excess emissions above baselines, industrial emissions from facilities covered

Figure 3.1: Immediate emissions reductions across the coming decade reduce the effort required to achieve net zero and buy time to develop new technologies

Emissions (millions of tonnes)



Notes: Emissions are 'carbon-dioxide equivalents'. The two trajectories depicted do not have an equal effect on the climate, despite both reaching net zero by 2050 – it is the total amount of emissions in the atmosphere, not the annual contribution, that drives climate change.

Source: Grattan analysis of DISER (2020a).

53. Hunt (2016).

by the Safeguard have increased by 12 million tonnes between 2016-17 and 2019-20.[54] Most of this increase came from fossil fuel extraction.

The way Safeguard baselines are set is not linked to achieving Australia's national emissions targets. When the Safeguard Mechanism commenced in 2016, most facilities had baselines reflecting the historic high-point of their emissions between 2009-10 and 2013-14. This created considerable 'headroom' between their actual and allowable emissions, which meant they had no incentive to reduce emissions (Figure 3.2 on the next page).

Over time, emissions grew as facilities took advantage of this headroom. But because more facilities shifted to using calculated baselines, or sought exemptions and adjusted baselines, the gap did not narrow. Of the 184 facilities whose 2020 baselines are known, 140 have room to increase emissions by 10 per cent or more before breaching their baseline. For the industrial emissions trajectory to bend downwards towards net zero, this gap needs to close.

3.2.1 Recent design changes and commitments will not be sufficient to reach net zero

From 1 July 2021, all facilities have moved to using baselines calculated using an emissions intensity value. These values define how many tonnes of emissions are produced per tonne of product created. For example, the emissions intensity for alumina is 0.545 tonnes of CO_2-e per tonne of alumina and alumina equivalent tonnes of alumina trihydrate. Facility baselines are calculated by multiplying the relevant emissions intensity value by the annual volume of product.

Facilities may use either an industry average emissions intensity value published in legislation, or they may use a site-specific emissions intensity value instead (provided they applied to do so in the 2019,

54. CER (2021a); and CER (2021c).

Box 3: The Safeguard Mechanism

The Safeguard Mechanism applies to all facilities emitting more than 100,000 tonnes annually. It identifies 90 'production variables' (outputs, inputs, or intermediate products in industrial processes), each of which has a defined emissions intensity value (in tonnes of carbon dioxide-equivalent per tonne of production). Facilities are required to keep the emissions below a 'baseline', which is determined by multiplying the volume of production variable they produce in a given year by the emissions intensity for that production variable.

Facilities that exceed their baselines have several options available to them. They can apply for a new baseline that accommodates their current operations. They can apply for a multi-year monitoring period, so their compliance is assessed on average over multiple years rather than annually. Or they can purchase and surrender Australian Carbon Credit Units (ACCUs) to offset their excess emissions. In the event they do not use one of these options, the scheme regulator may apply an enforceable undertaking, issue an infringement notice, or initiate court proceedings to seek an injunction or civil penalties. Penalties are not linked to excess emissions.

Electricity generators connected to the five main grids that supply public electricity are collectively subject to a sector-wide baseline of 198 million tonnes per year. If this baseline is exceeded, each generator will be treated as an individual facility, with its own baseline, similar to other Safeguard facilities.

2020 or 2021 financial years). A site-specific value is likely to be more attractive to a facility whose emissions are above average, because it will make its baseline less stringent. Facilities whose emissions intensity is better than average are not rewarded.

As part of its response to the King Review,[55] the Federal Government has committed to implement 'below-baseline crediting', to create a greater supply of offsets and to reward facilities that undertake activities to perform better than average.[56] Below-baseline crediting would allow facilities that make improvements to their emissions intensity to claim 'credit' for each tonne of avoided emissions that results. The Federal Government has set aside up to $280 million over the next 10 years to purchase these credits.[57] Alternatively, the facility could surrender credit if it goes above its baseline in the future.

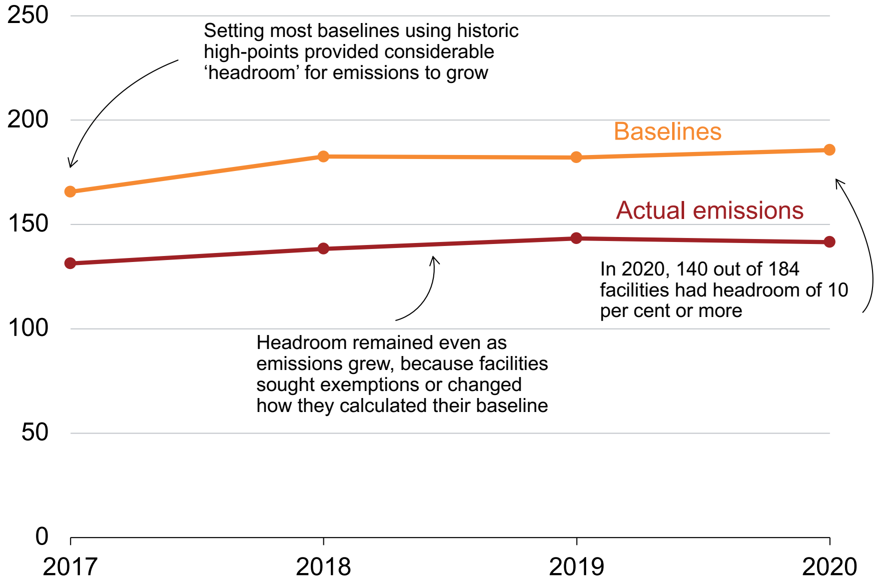
$280 million by itself will not be sufficient to set the industrial sector on a net-zero trajectory. Annual emissions from the sector are projected to average 160 million tonnes across the next decade. If the Government purchases credits at $10/tonne (substantially below current prices), the below-baseline credit will be sufficient to reduce emissions by only 3 million tonnes each year.

3.3 Making the Safeguard Mechanism more effective

Four changes to the Safeguard Mechanism would incentivise immediate emissions reductions using available technology. First,

Figure 3.2: Safeguard baselines did not encourage facilities to cut their emissions

Emissions per year (millions of tonnes)



Notes: Emissions are 'carbon-dioxide equivalents'. Data for each year includes all Safeguard facilities that reported a baseline and emissions.

Source: Grattan analysis of CER (2021a).

55. The Expert Panel examining additional sources of low-cost abatement (known as the King Review after its chair, Grant King) was asked to provide the Federal Minister for Energy and Emissions Reduction with recommendations on incentives for low-cost abatement opportunities across the economy, focusing on the industrial, manufacturing, transport, and agriculture sectors, and energy efficiency. These recommendations were published in May 2020: DISER (2021f).
56. At the time of writing no detail was available on the mechanics of crediting and purchasing.
57. Treasury (2021, p. 138).

the Government should move all facilities to using industry average emissions intensity values to set their baselines. Second, it should design below-baseline credit to encourage additional emissions reductions for each dollar it spends, and plan to step back from purchasing credit. Third, all Safeguard emissions intensity values should start to decline. And lastly, new facilities must achieve much better performance than existing ones, to avoid locking in emissions over the longer term.

3.3.1 Set baselines using industry-average emissions intensity values

Allowing facilities to use site-specific emissions intensity values on an ongoing basis will not give them an incentive to reduce emissions. Older facilities with worse emissions intensity will face penalties if they increase their production, but there is no incentive for them to reduce emissions. Facilities with better emissions intensity than average have room to increase production beneath their baseline. Overall, the volume of the commodity produced is likely to increase, and emissions with it.

The government should set a time limit on the use of site-specific emissions intensity values, after which facilities using them should transition to using industry averages to determine baselines. This will mean facilities with above-average emissions intensity will need to manage their emissions, by adjusting production volumes, adjusting their processes using some of the options described in Chapter 2, or using offsets.

3.3.2 Below-baseline credit could produce greater emissions improvements

Below-baseline credit should encourage industrial facilities with immediate options to reduce emissions to do so. But there is not sufficient subsidy on offer for every firm with opportunities to be paid. Reflecting subsidised emissions reductions in industry average emissions intensity values would encourage every facility to reduce their emissions.

Instead of the current fixed industry average emissions intensity values for each production variable, the Safeguard regulator could publish trajectories, setting out the values that apply for the next three years. Each year, the emissions intensity values for the third year would be recalculated to take account of improvements. Improvements could be the result of below-baseline credit projects, or from other activities or practices. Firms would have time to adjust to new baselines (or to secure offsets), but also an increased incentive to stay ahead of the declining curve. Appendix A shows a worked example.

In sectors where no below-baseline credit projects took place, emissions intensity values could remain unchanged. In this way, only sectors where there are significant opportunities for immediate reductions would be affected by declining baselines. Of course, because the aim of making this policy change is to start towards net-zero industrial emissions, emissions intensity values should not be allowed to increase even if industry averages worsen.

These changes would create a virtuous circle: government offers incentives to firms to reduce their individual emissions, firms take action to do so, the emissions intensity value ratchets down, encouraging other firms to take up government incentives, and, over time, emissions fall (Figure 3.3 on the following page). The methodology and process should be set out in the Safeguard Rule, so there is full transparency on how adjustments are made.

Over time, government should step back from purchasing below-baseline credit

The King Review proposed below-baseline credit either being purchased by government or used by the facility to meet a future Safeguard obligation should its emissions grow above its baseline again.

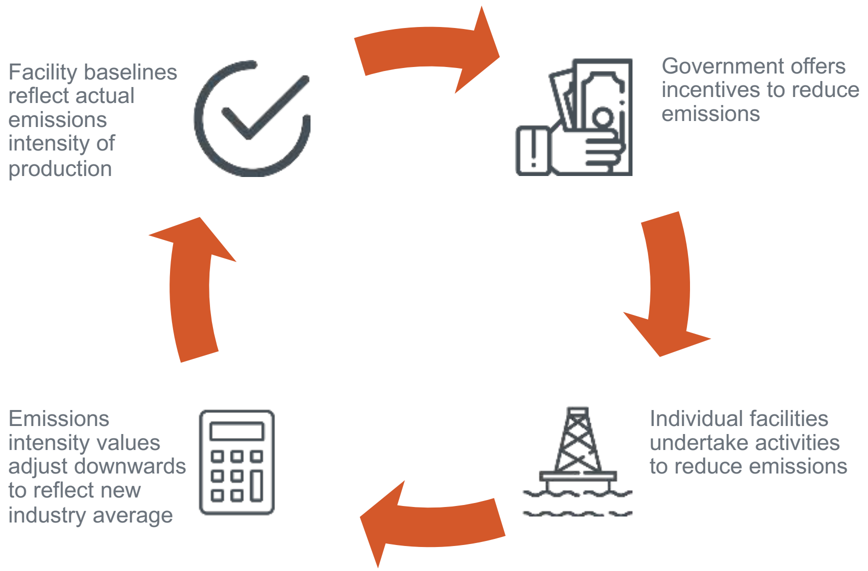
If emissions intensity values are adjusted each year to reflect declines in emissions, demand for offsets may increase. Allowing below-baseline credit to be transferred between facilities would help meet this demand.

The King Review suggested creating a 'Safeguard Mechanism Credit', which could be sold by the creator.[58] This would be one way to transfer credit between facilities. Alternatively, the Government could allow firms to reach their own contractual arrangements to share credit between facilities. Firms could present the Safeguard regulator with auditable proof, which could then be reflected in their obligations. The Government could remain as a buyer of last resort: this would provide underwriting support for facilities to undertake projects, and would be similar to the role already taken in the Emissions Reduction Fund through optional delivery contracts.[59]

3.3.3 Over time, all baselines should start to decline, bending the emissions curve downwards

If the three steps outlined above – below-baseline credit, adjusted production variables, and transfer of credit between firms – prove successful, a future government could consider gradually lowering all emissions intensity values across all Safeguard facilities, with the rate of decline linked to achieving the national emissions goal. Credit

Figure 3.3: Combining below-baseline credit with baselines set using industry-average emissions intensity values can reduce emissions in some sectors over time



Source: Icons from flaticon.com.

58. DISER (2021f, p. 80).
59. CER (2021d).

transfer would support those facilities with less capacity to lower emissions to meet new, lower baselines. At that time, turning 'credit' into tradeable 'credits' would be a more efficient way to share effort across facilities. If all baselines are declining, the government should step out of underwriting below-baseline credit altogether, so that the incentive to make the least-cost improvements is not distorted.

A clear trajectory for baseline decline will also assist firms to make decisions around the future of facilities, particularly where those facilities are coming to the end of their design life. This is discussed further in Chapter 5.

3.3.4 New facilities should achieve substantial emissions reductions compared to incumbents

Transforming the industrial sector to net zero requires avoiding emissions lock-in: making commitments in the next decade that leave long legacies of emissions. On average, new industrial facilities add about 2 per cent per year to emissions covered by the Safeguard Mechanism.[60] This seems small, but if the trend continues to 2030, emissions would be about 30 per cent higher than when the Safeguard commenced.

Currently, new facilities and significant expansions are expected to calculate their baselines using benchmark emissions intensity.[61] The Government's stated intent was for these new facility benchmarks to 'encourage facilities to achieve and maintain best practice',[62] but as yet, no benchmark emissions intensity values have been published.[63]

If industrial emissions are to trend towards zero, it is imperative that new facilities have substantially lower emissions intensity than incumbents. If they merely match current performance then the emissions curve will continue to trend upwards as production increases.

The Government should immediately establish benchmark emissions intensity values for new facilities which represent a substantial improvement on current practice. Because some sub-sectors have more options for improving emissions intensity than others, benchmark emissions intensity values should be set as a percentage of existing facilities' emissions intensities.[64]

This will signal to investors that Australia wants to encourage low- or zero-emissions industrial development; and will reduce emissions lock-in. It may mean some new facilities have offset obligations from the beginning of their operations. New facilities should not be exempted from any future carbon liability on the basis of having met a lower emissions intensity value.

3.3.5 Don't shield emissions-intensive trade-exposed industries from declining baselines

Some national and state climate and energy policies protect emissions-intensive trade-exposed (EITE) industries from the cost impacts of the policies, because these companies faced competition from other countries where similar facilities did not have equivalent costs.

More than 70 per cent of global emissions now take place in countries with net-zero pledges (Figure 1.1 on page 6). Carbon border adjustment mechanisms such as those proposed in the EU and US and under consideration in Japan, and corporate net-zero pledges, are driving greater consideration of emissions intensity in global

60. Grattan analysis of CER (2021a).
61. *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015*.
62. Department of the Environment (2015, p. 7).
63. *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015*.
64. The baselines for facilities that use the benchmark should also reduce as the industry average falls.

supply chains. While most countries with carbon constraints provide some assistance to local industries to remain competitive, the case for continued protection is weakening, and in some cases continued protection may be counter-productive. Firms that are shielded from the impacts of carbon pricing at home may face higher carbon border taxes abroad than those that are not.

Declining emissions intensity variables over time (rather requiring all emissions to be offset) is a form of competitiveness assistance, equivalent to the EITE free allocation in the former carbon price but more broadly available. No further shielding should be needed.

If the goal is net zero, it is not possible to exempt any sector of the economy from reducing its emissions. Doing so merely pushes more effort onto other sectors, and as shown in Figure 2.3 on page 13, all sectors of the Australian economy other than electricity (and land use) are facing a difficult adjustment to reach net zero.

It is inevitable that some older facilities will be unable to compete in a world where emissions are constrained. Rather than subsidising these inefficient producers indefinitely, and asking more efficient producers to shoulder more of the task of emissions reductions, governments should focus on ensuring newer, cleaner facilities take their place – ones that exploit Australia's competitive advantages in a low-carbon world and can support long-term employment and zero-carbon economic growth. Recommendations to this end are discussed further in Chapter 5.

3.3.6 The electricity sector should be treated differently

The Safeguard Mechanism currently has little to no effect on most of Australia's electricity generators. Sectoral emissions are about 20 per cent below the sector cap and trending downwards.[65]

Stronger economic signals coupled with state and federal policies are decarbonising the National Electricity Market (NEM), as renewable energy has become the cheapest form of new generation. And emissions in WA's Wholesale Electricity Market (WEM) are projected to fall about 40 per cent over the decade.[66]

As noted in Box 3 on page 24, electricity generators connected to the NEM's five main grids are covered by a sector-wide baseline. Below-baseline crediting for new renewable and gas generators under the electricity Safeguard would reward business-as-usual activity. Rewarding upgrades to coal plants would prolong the life of these plants, slowing the transition to a near-100 per cent renewable grid. For these reasons, facilities covered by the electricity Safeguard should not be allowed to participate in below-baseline crediting.

There are more than 150 electricity generators not connected to the main grids (Figure 3.4 on the following page). Six that have emissions above the Safeguard threshold of 100,000 tonnes are treated as single facilities instead of being subject to the electricity sector baseline.[67] These six generators – all of which use gas – largely supply energy to one or two industrial users, often owned by the same company. Because they are intrinsic to the operation of other Safeguard facilities, they should be allowed to participate in below-baseline crediting. Given their locations, remote from the grid and in an area with good renewable resources, it seems likely that any below-baseline credit would come from renewable generation.

3.4 A meaningful penalty for not complying with the Safeguard

All the changes described above will only make the Safeguard Mechanism an effective tool for reducing emissions if participants are

65. Grid-connected electricity generators produced 164 million tonnes of emissions in 2018-19, 17 per cent below the sector cap of 198 million tonnes: DISER (2020a) and CER (2019).

66. DISER (2020a).

67. The remaining, smaller, off-grid generators are not subject to either the sectoral or individual baselines.

penalised for non-compliance, and these penalties are linked to excess emissions.

Currently facilities that exceed their baselines have several options available to avoid paying any penalty (see Box 3 on page 24). Since the Safeguard began, between 10 and 15 facilities have breached their baselines each year.[68] But the number of facilities using multi-year monitoring has grown from six in 2016-17 to 32 in 2019-20.[69] The multi-year baseline allows for compliance to be assessed across multiple years, rather than every year, giving facilities a chance to offset baseline breaches in one year through reductions in another year. Data on how many facilities have applied for new baselines are not available.

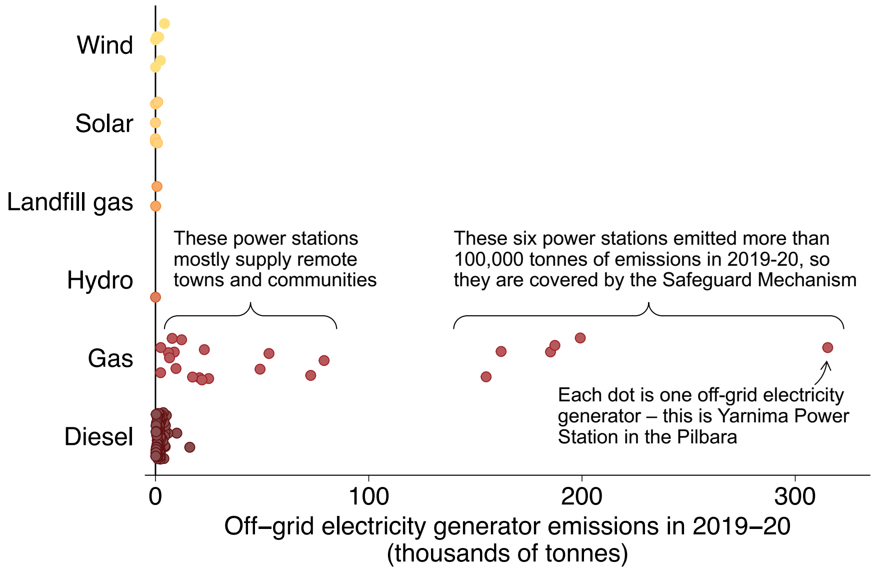
The Federal Government should immediately phase out multi-year monitoring periods for non-compliant facilities, and should not allow facilities to apply for new baselines if they exceed their old ones. Removing multi-year monitoring periods will drive demand for offsets, and will encourage facilities to weigh up the costs of purchasing these versus the costs (and productivity benefits) of taking some of the immediate actions available described in Chapter 2, rather than using administrative provisions to avoid reducing emissions. Implementing below-baseline crediting will provide an alternative way for facilities to manage multi-year cycles in their emissions intensity.

Longer term, the penalty for not complying should be made proportionate to the scale of non-compliance. Currently, the Safeguard penalty is the same whether a facility exceeds its baseline by 10 tonnes or 10 million tonnes. Perversely, this encourages large breaches over small ones: a small breach would result from a small increase in production, potentially not sufficient to make the penalty worthwhile, whereas a large breach would probably accompany a large increase in production, which would presumably cover the cost of the penalty.

68. Grattan analysis of CER (2021a).
69. Grattan analysis of CER (ibid).

Figure 3.4: There are numerous electricity generators outside the main grids, but only a handful participate in the Safeguard Mechanism

Generator type



Note: Emissions are 'carbon-dioxide equivalents'.

Source: Grattan analysis of CER (2021e).

4 What governments should do about small facilities

There are tens of thousands of small industrial facilities in Australia. Each contributes only a tiny part of national emissions, but in aggregate these small facilities were responsible for about 30 million tonnes of emissions in 2019.

The technology to reduce these emissions is (for the most part) available now and will become cheaper over time. But because there are so many small facilities, and they are so widely dispersed, a different policy approach is needed to reduce these emissions.

State governments are better-placed than the Federal Government to assist small businesses find emissions savings. The states should consider using energy savings schemes, like those already in place in NSW and Victoria, to begin moving small industrial facilities towards net-zero emissions. This would also save each facility money, and over time place downward pressure on energy bills for all consumers.

4.1 Saving energy, saving money, reducing emissions

Improving energy efficiency, energy productivity, and energy management have long been recognised as significant sources of emissions reductions, and ones that save money in the long run through lower energy bills.[70] But there are persistent barriers to realising these savings, especially in countries such as Australia with historically cheap energy.[71] Business owners and staff often lack expertise in energy management or do not have the time to focus on it.[72] Energy efficiency equipment can cost more than conventional equipment, and this cost must be born upfront, with the savings only recouped over a number of years.

70. IEA (2015).
71. Bagaini et al (2020).
72. EEC (2016, p. 35).

Using energy efficiency as a tool to achieve net-zero emissions is also complicated. Industrial equipment lasts a long time, so choosing the wrong equipment can lock in long-term emissions, even if the equipment is more efficient. For example, installing a more efficient gas boiler will save energy, and lower emissions. But if it has a 20-year life, the new boiler locks in 20 years of emissions. Installing an electric boiler may not save as much energy in absolute terms, but it does not lock in emissions because the electricity supply is decarbonising, and the owner could choose to use 100 per cent renewable energy.

There is no comprehensive data set on the potential size of energy savings in the Australian industrial sector. We can however compare the Australian industrial sector to those in other countries. Figure 4.1 on the following page shows that on industrial energy productivity, Australia ranks 13th out of the 17 largest energy consuming countries with net-zero targets.[73] This suggests there is plenty of room for improvement.

4.2 Smaller facilities need a different approach

Emissions from smaller facilities (those where emissions are less than the Safeguard threshold of 100,000 tonnes per year) are currently unregulated, although those that emit more than 25,000 tonnes annually are required to report these under the National Greenhouse and Energy Reporting Act.

Smaller facilities' emissions are more likely to come from combustion and from industrial processes than from fugitives. As with larger facilities, combustion emissions are more amenable than process

73. ACEEE (2019). Australia has a de facto net-zero target because all states and territories have targets to achieve net zero by 2050 or earlier. Figure 4.1 is weighted for differences in economic structure between countries.

emissions to intervention, though some efficiency gains can be made in the latter.

To achieve their net-zero targets, states will need policies in the industrial sector. These policies must operate at scale, because of the large number of facilities involved. They also must be flexible enough to encourage many different activities, reflecting the diversity among facilities.

4.2.1 Energy efficiency obligations are an ideal policy – and are already in place

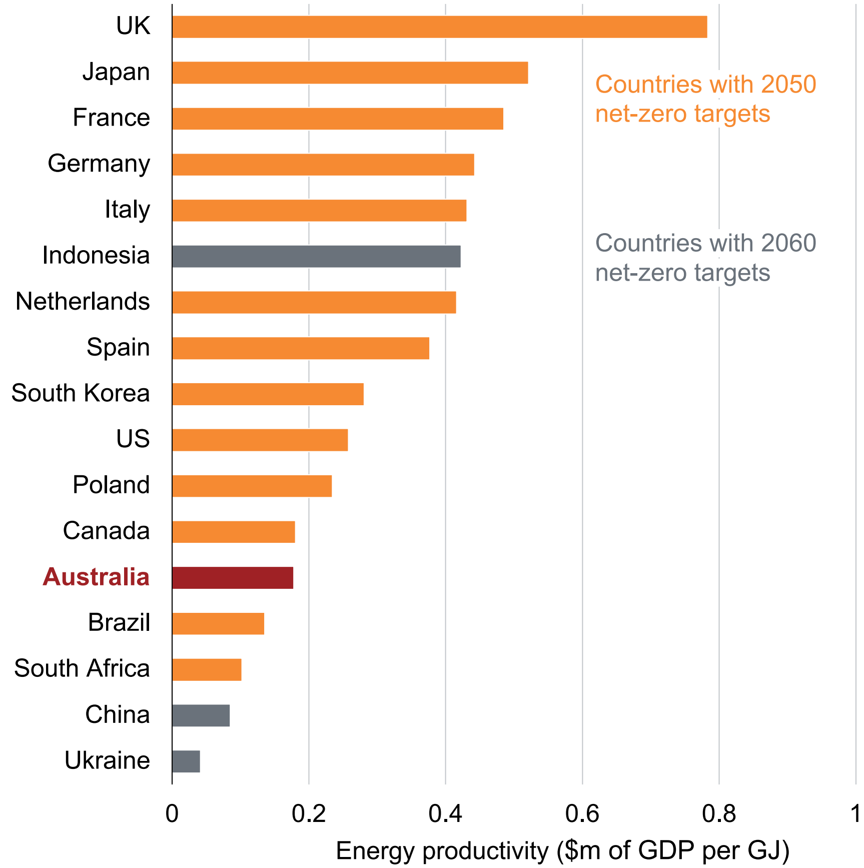
Energy efficiency obligations place a requirement on energy retailers to help customers find energy savings. A list of allowable energy savings activities is published, and each activity is issued certificates per unit of energy saved. Energy retailers must obtain and surrender certificates equal to their obligation. Four Australian states have energy efficiency obligations, and two of these – in Victoria and NSW – cover the industrial sector. Since their inception in 2009, these schemes have achieved energy efficiency improvements that equate to 32.5 million megawatt-hours (in NSW)[74] and 74 million tonnes of emissions (in Victoria).[75]

Energy efficiency obligations promote the growth of energy service providers: companies that specialise in helping energy users find and realise energy savings, in return for a share of the certificates.

If well-designed, energy efficiency obligations deliver an overall benefit to energy consumers as well as to those who undertake activities eligible for certificates. While there is a cost to energy retailers to obtain certificates, and this cost is passed through to consumers,

Figure 4.1: Australia has significant scope to cut emissions by lifting its energy productivity, compared to other countries with high energy consumption and net-zero targets

Largest energy-consuming countries with net-zero emissions targets (and Australia)



Note: Data is adjusted for economic structure.

Source: Grattan analysis of ACEEE (2019).

74. NSW Government (2021a).
75. Obtained from the Registry of Victorian Energy Efficiency Certificates: Essential Services Commission (2021).

lowering energy demand overall reduces the cost of transmission and distribution infrastructure. These costs can make up half of the average electricity bill.[76] The NSW scheme is estimated to have saved participants $1.5 billion in energy bills over 2014-2018 and to have reduced wholesale electricity prices by $2.30 per megawatt-hour in its first decade of operation.[77]

4.3 Making energy efficiency obligations work for the industrial sector

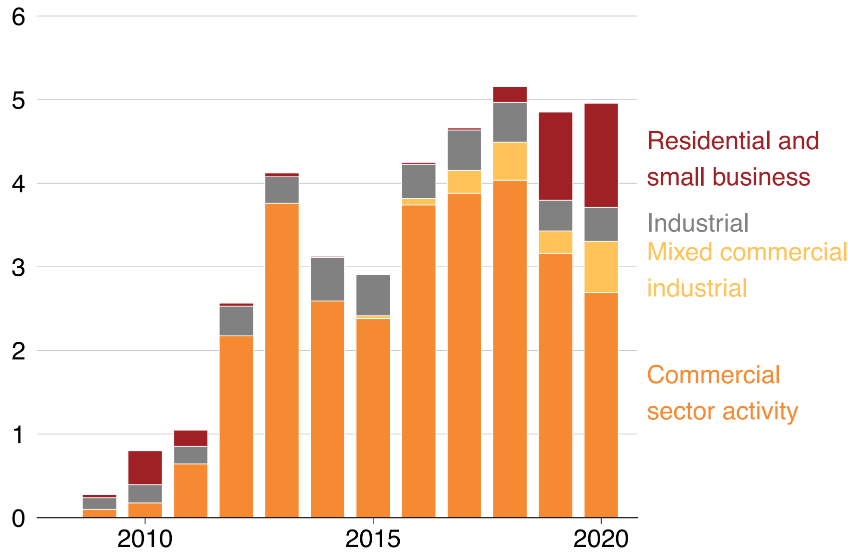
Industrial activity has been less popular in the NSW and Victorian schemes than activities such as upgrading household and commercial lighting (Figure 4.2). Many commercial and household energy efficiency measures are easy to standardise, because they involve replacing one piece of mass-produced standard equipment with another. They lend themselves to 'deeming' the certificates (issuing all the certificates related to the lifetime energy savings at the time the project is commissioned), which aligns the timing of project costs and project savings. Standardisation also makes it easier for energy service providers to carry out repeat projects, which builds efficiencies and volume through scale.

Industrial projects are often plant-specific and require a baseline against which savings are measured and certificates issued each year. This increases costs. However, these costs can be reduced by focusing on energy savings from common industrial equipment that can be repeated across multiple plants. As well, awarding some or all certificates up-front offsets some project costs immediately.

Energy efficiency obligations can be designed to encourage activity in one sector over another. A common example is setting a sub-target

Figure 4.2: Activity to save energy in commercial buildings has dominated the NSW Energy Savings Scheme

Energy savings certificates (millions)



Note: Each energy savings certificate represents one megawatt-hour of energy.

Source: Grattan analysis of IPART (2021).

76. AER (2021, p. 263).

77. Department of Planning, Industry & Environment (2020, pp. 7–9). Victoria has not conducted a similar review.

for activity in low-income households; another is creating a 'multiplier' that awards extra certificates for some activities. Both these distort the intent of using a market-based scheme to find the lowest-cost reductions.[78] Another intervention, which has been tried in NSW, is the government entering the market as a buyer of particular types of certificates. Provided there is capacity in the energy service sector to respond to increased demand without driving up prices, and the amount purchased by government is not large compared to demand from energy retailers, this increases activity in areas the government wants to preference while minimising the cost passed through to consumers by energy retailers.

NSW and Victoria both exempt large energy users from the pass-through costs of their energy efficiency obligations (for much the same reasons as discussed in Section 3.3.5 on page 28), and NSW allows them to create certificates from eligible activities. Victoria is removing this exemption, only allowing large facilities to remain exempt if they implement an energy management regime. If our recommended approach to achieving emissions reductions through the Safeguard (Section 3.3.2 on page 26) is adopted, both states (and any other state that decides to use an industrial energy efficiency obligation to achieve its net-zero target) could consider aligning exemption with the Safeguard threshold. If so, to avoid a double subsidy for one activity, both the Safeguard Mechanism and the energy efficiency obligations should force these facilities to choose between creating energy efficiency certificates, or creating below-baseline credit.

If state governments introduce, expand, or change energy efficiency obligations to achieve their net-zero targets through industrial energy savings, some or all of the following would maximise effectiveness:

78. NSW Government (2015, p. 77).

Avoid locking in emissions

- Include certificates for switching from gas or other fossil fuels to electricity or renewable or zero-emissions fuel.
- Do not include certificates for improved efficiency of gas appliances that last a long time, because this locks in gas use (and emissions).

Encourage scale

- Focus on equipment where installation and energy savings calculations can be standardised.
- As much as possible, standardise equipment eligibility across state borders.
- For non-standard equipment, or sites with multiple projects, consider using standardised impact assessment calculations (such as the NSW metered baseline and project impact assessment methods) to minimise transaction costs for participation.
- Avoid sub-targets or multipliers to skew activity towards the industrial sector. If scale is slow to develop, out-of-target auctions to purchase extra certificates created from industrial activities is a better approach.

Minimise costs and recover them effectively and fairly

- Ensure retailer pass-through costs are recovered from across the customer base.
- Exempt large energy users from pass-through costs only if the Safeguard Mechanism is providing incentives to reduce emissions, and they have effective energy management in place (for example, ISO50001 accreditation). Align exemption thresholds and conditions across states.

- Include tradeable certificates. These make it easier for small energy retailers to participate, and lead to the development of an energy services sector.[79]
- Be cautious about trying to achieve multiple objectives in a single scheme (for example, by trying to save energy at particular times or in particular locations). This adds complexity and could discourage participation.
- Minimise participation costs for energy service companies by recognising interstate accreditation, so that a company approved to participate in one state is automatically approved for all.
- Include regular reviews of equipment eligibility to ensure that energy efficient activities no longer receive certificates once they are part of normal practice.

Energy efficiency obligations are unlikely to bring about all the changes required to eliminate emissions from all small industrial facilities. They will, however, find the cheap, repeatable actions that may otherwise not get done. Governments will then be better-placed to design further policies for harder-to-abate activities.

4.3.1 Instant asset write-off could help fund small industrial emissions reductions

The Federal Government allows eligible businesses to claim an immediate tax deduction for the cost of a new asset in the year the asset is first used or installed.[80] As noted above, one of the barriers to improving energy efficiency (and achieving the associated emissions reductions) is that the costs of a new asset are paid upfront, but the ongoing savings are realised over a number of years. An instant asset write-off reduces the net upfront cost, which may make the ongoing savings more attractive.

The Federal Government should encourage smaller industrial firms to use the instant asset write-off to help finance upgrades. This should be done through targeted information campaigns, rather than by adding any special provisions to the rules around the write-off. Business taxation rules are already complicated, and complexity can create loopholes or unintended consequences.

79. Department of Climate Change and Energy Efficiency (2011, p. 24).
80. This policy is in place until July 2023: ATO (2021).

5 What governments should do to support long-term change

Transforming Australia's industrial sector to net zero will require large capital investments in new technology. Efforts to develop these technologies to commercial readiness have begun, but we don't know when they will be commercially viable in a low-emissions world or whether demand and a premium will emerge for low-emissions industrial commodities. What is more certain is that the pace of change to reach net zero will be quite rapid, even with considerable use of offsets.

Planning for asset renewals in the 2030s and 2040s will start in the 2020s. Governments should put in place measures to efficiently allocate risk between the public and private sectors, so new industrial development and transformation of the existing asset base happens smoothly.

The Federal Government should establish an Industrial Transformation Future Fund to mitigate technology risk and discourage lock-in of long-lived emissions-intensive industries. It should also start planning now for how it might use its existing concessional financing facilities to mitigate financial risk.

The scale and pace of industrial transformation is unparalleled outside of a war-footing, and will demand an unprecedented partnership between government and industry. State governments should support catalyst organisations to identify and help solve coordination problems and potential energy and other infrastructure bottlenecks in support of new and renewed facilities.

5.1 Transforming our industrial base in three decades is unprecedented

There are currently 194 industrial facilities in Australia that emit more than 100,000 tonnes a year, collectively responsible for about 80 per cent of industrial emissions. Figure 5.1 on the following page shows these facilities by sector, and by what they produce.

Not all of these facilities are candidates for transformation: some – such as thermal coal mines and oil refineries – are facing declining demand for their products, and any investment in emissions management and elimination in these facilities beyond the opportunities described in Chapter 3 must be balanced against a realistic assessment of asset life.

The mining, minerals processing, metals, and manufacturing facilities could be transformed to low- or -zero emissions operations. For some, being an early mover will allow Australian industry to capitalise on a comparative advantage and increase export volumes and values. For others, we may be content to allow other countries to take the early mover risks, and be a fast follower.

Still, the pace of change will be extraordinary. If transformation focused only on mining, minerals processing, metals, and manufacturing facilities (the top two groups in Figure 5.1), four of these would need to be renewed every year between now and 2050 to reach net zero. Or, these facilities will close, which may open up opportunities for new, cleaner facilities to take their place and expand production in areas of competitive advantage.

Achieving this pace of change – or even half of it with considerable offsetting to compensate – will require considerable private investment in partially proven technology, with associated risks driving up the cost.

It will also require coordination along supply chains and between firms that rely on one another for inputs.

5.2 For many facilities, there's only one chance to get it right

Industrial assets have long design lives – sometimes up to 40 or 50 years. The decision process to renew, refurbish, or retire an asset begins well before the end of its life, and future emissions get locked in at the design stage for a new or refurbished plant.[81]

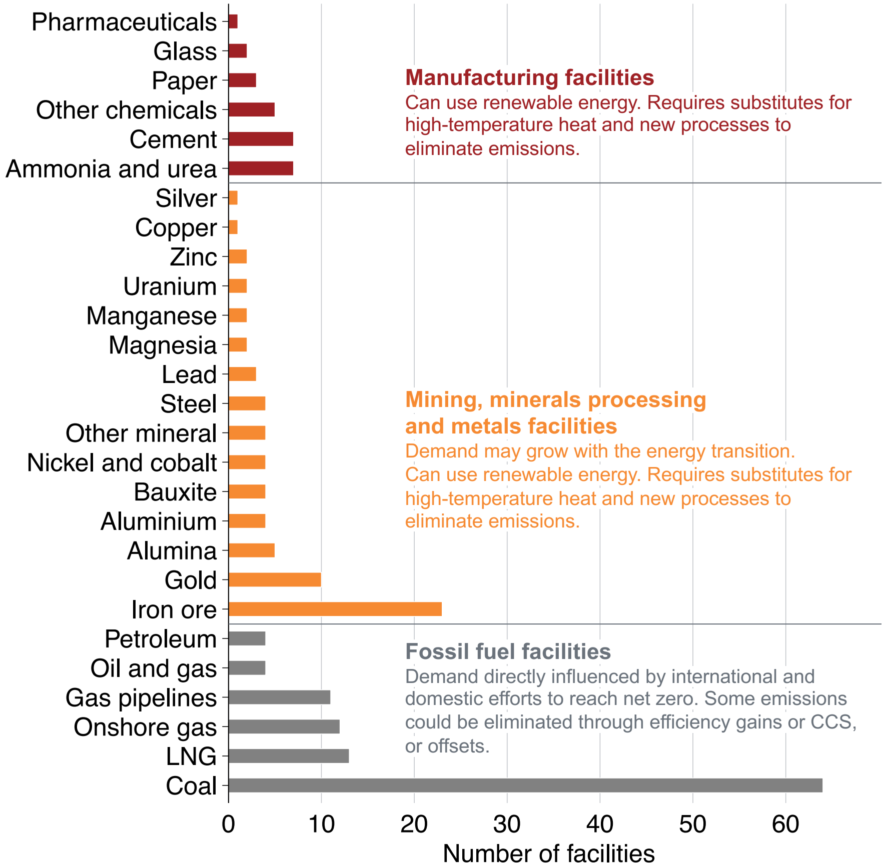
If lower- or zero-emissions technology is not technically and commercially proven when asset renewal planning starts, a firm may choose not to replace the facility and it will close at the end of its life. If the firm does decide to replace it before zero-emissions technology is available, there is a risk it will do a like-for-like replacement of an old facility, or shift to a proven but still relatively emissions-intensive process, locking in emissions for another 30 years or more. Financial markets are placing some pressure on companies to avoid like-for-like replacement, but if carbon is not priced, the risk is not removed. In such cases, government taking a share of the risk around partially commercial technology can make a big difference to emissions lock-in, as shown in Box 4 on the next page.

Committing to the goal of net zero signals to asset owners that they should consider future carbon liability, as would implementing a stringent Safeguard baseline for new facilities (see Chapter 3). An economy-wide carbon price would make these signals stronger still. The federal and state governments are investing in early-stage technology development and pilots and demonstration projects, which help inform asset replacement decisions. For example, the Federal Government has invested in a trial of renewable alumina refining;[82]

81. For example, in February 2021, BlueScope announced the beginning of a process to make decisions about a steel smelter which would reach the end of its design life somewhere between 2026 and 2030: BlueScope (2021).
82. ARENA (2021).

Figure 5.1: Not all large industrial facilities are candidates for transformation to net zero

Number of facilities producing commodity



Note: Some facilities produce more than one commodity.

Source: Grattan analysis of CER (2021a).

Box 4: Aligning asset replacement cycles, and technology and commercial readiness, can have profound impacts on emissions lock-in

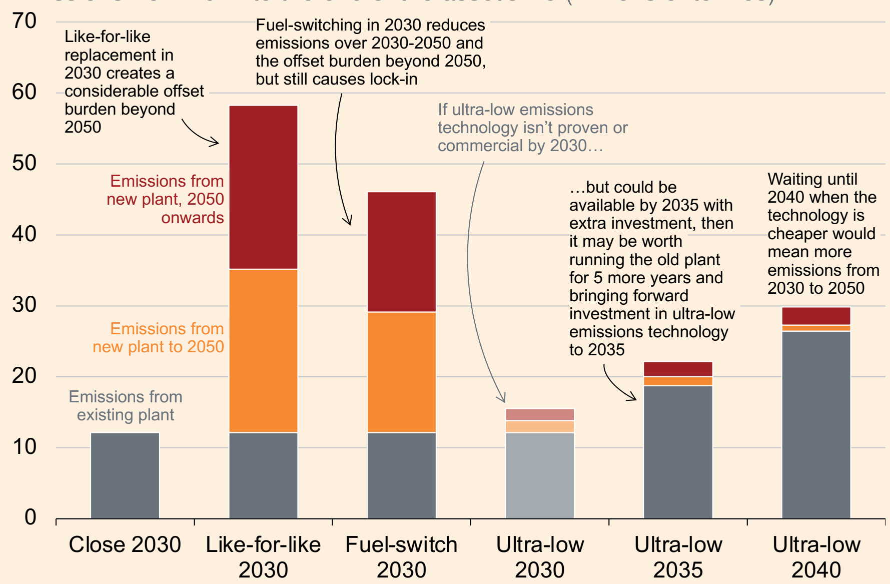
Consider an operational cement plant, fuelled by coal, which will reach the end of its design life in 2030. The owner wants to start the design process for a replacement in 2025, and is considering three choices:

- A like-for-like replacement that also uses coal but is 5 per cent more efficient. The costs and risks are well-understood because the technology is the same as the plant has used for the past 40 years.
- A new plant that uses a mix of coal and gas. This technology is in place in other plants in Australia, and the costs and risks can be forecast with some certainty.
- A new ultra-low-emissions technology that is expected to still be experimental in 2030, but commercially ready in 2040. The costs and risks are difficult to quantify, but the capital cost of the plant is expected to be higher than the alternatives, even in 2040.

Figure 5.2 shows the emissions for each option from today to the end of the design life of the new plant. In all cases, the emissions from the old plant are locked in between now and 2030. Like-for-like replacement locks in considerable emissions between 2030 and 2050, and an offset burden between 2050 and the end of the plant's life in 2070. Switching fuels reduces the lock-in and the offset burden, but they are still both material. Waiting until 2040 (and running the risk that the old plant may not have an extra 10 years life in it) means more emissions from the old plant, and more offsets after 2050. From an emissions perspective, the best decision may be to run the old plant for an extra five years, and implement the new technology before it is fully commercial, with the associated risk being shared with government.

Figure 5.2: Aligning asset replacement cycles, and technology and commercial readiness, can have profound impacts on emissions lock-in

Emissions from 2021 to the end of the asset's life (millions of tonnes)



Note: Theoretical example for a cement plant currently using coal, facing an asset renewal decision in 2030.

Source: Grattan analysis of public data for various Australian cement facilities.

and the NSW Government has a $750 million Net Zero Industry and Innovation Program targeting deployment of low-emissions technology in high-emitting industries, and development of new clean technologies.[83]

If governments prefer to stick with incentive-based approaches, these need to be supported by a long-term policy framework, so that incentives can be factored into asset renewal decisions. And they need to put this framework in place now to prevent lock-in. The International Energy Agency recommends advanced economies have a strategy in place by 2024 for incorporating zero-emissions technology into the next round of additions and replacements for steel and chemical plants – including plans for how this will be financed – such that all new capacity additions after 2030 are low-emissions.[84]

5.3 The amount of capital required is also unprecedented, but the returns may not be

The investment needed to transform our industrial asset base will be large. Nobody has estimated the likely amount for Australian industry, but one estimate for the European Union suggests expenditure of between 76 per cent and 107 per cent beyond that required for current technologies will be required.[85] Companies will have access to bond and capital markets to raise funds for such projects, but will be competing in those markets with other industrial players seeking to make similar transformations in the same timeframe.

Transformative industrial technology will have high up-front capital costs compared to conventional technology, but unless there is an ongoing green premium for the commodities produced, the future revenue stream will be similar, because commodities are not significantly different.

Higher capital outlay without the expectation of higher future revenue creates a financial risk for firms thinking of transforming their facilities. To some extent, the risk will be lower where another competitive advantage can be identified (for example Australia's proximity to iron ore, abundant cheap renewable electricity, and proximity to growing Asian markets create a competitive advantage for steel). This is why government assistance to bridge the risk gap should focus on industries where Australia has an advantage – it lessens the call on government funds and develops industries that contribute to ongoing growth.

5.4 Government will have a role in filling the risk gap to maximise private investment

5.4.1 The private sector cannot fill the risk gap alone

Private investment relies on the prospect of a return. In capital-intensive sectors, choosing a new or unproven technology can be an unacceptably high risk if returns are uncertain. If the rest of the world is moving towards net zero too, there will be competitive pressure to move towards cleaner production. But, as yet, there is little premium emerging for lower-carbon commodities. Even if a premium emerges, it may not be enough to make up for the higher capital costs to produce these commodities at scale.

Even with strong carbon pricing, a risk gap is likely to remain. When technology is new, potential users and investors (in this case, large industrial corporations and their shareholders and financiers) will have less confidence about feasibility, viability, and risks, all of which adds to the cost of capital. If this fear persists, it can create a 'risk trap', where the risk remains poorly understood and poorly priced because of lack of experience with the technology, and experience does not develop

83. NSW Government (2021b).
84. IEA (2021, pp. 130–131).
85. Material Economics (2019, p. 47).

because of lack of investment. If governments want to achieve net zero, they need to put policies in place that shorten the odds – that is, policies that reduce risk to private investment flows.

5.4.2 Choosing the right intervention for different risks

Technology risk – will it work as promised? – is largely born by the company that operates the facility, though some of the risk flows through to uncertainty about returns, and is born by shareholders and financiers. Technology risk is particularly acute in Australia's industrial sector because companies tend to have only a few facilities, meaning the cost to them of failed technology is high.

Financial risk – will it make a return? – is shared between the company that operates the facility, investors, and financiers. It is not enough for the technology to work, it must also provide similar or better returns within a reasonable timeframe. A common contributor to financial risk is the 'valley of death' – technology failing to make the leap from pilot-scale to full-scale. Another is 'first-of-a-kind' risk: early movers face high costs, low returns, and the risk of competitors free-riding on their initiative.[86] Again, the small number of facilities in Australia can make this risk more acute.

Governments will need separate but complementary policies to address technology risk and investment risk. Technology risk is more suited to grant-style assistance, because removing technology risk is likely to create positive spillovers (benefits extending beyond those who took the risk), but also because the risk of failure is high. Addressing financial risk is more suited to a financial instrument, such as concessional loans.

Ideally, there would be time to iron out technical risk before considering financial risk, as occurred with investing in renewable energy. But if the industrial sector is to achieve net-zero emissions by 2050, firms may not have that luxury. Governments need to start designing these policies now, so that firms facing decisions this decade can make those decisions compatible with a net-zero target.

5.5 Mitigating technology risk through an Industrial Transformation Future Fund

If governments decide to address technology risk with grants, the cost will be a large drain on its balance sheet over a long period. In Grattan Institute's 2020 report *Start with Steel*, we estimated that the technology risk gap for Australia's first flagship steel project could be in the order of $500 million, although this may get smaller over time as other countries experiment with the technology.

Attempting to cover risk gaps of this magnitude in future budgets represents considerable opportunity cost for taxpayers. The Federal Government could make provision for this likely future call on the budget, and encourage the development of new export industries, by establishing an Industrial Transformation Future Fund.

5.5.1 How a future fund could work

The Federal Government already has a number of future funds that use investment to generate returns which are set aside for likely future liabilities. These range from public sector pensions to drought and natural disaster assistance. Generally, these funds start with an endowment from government, which is then invested in assets, cash, securities, and equities. The returns from these investments are reinvested until the future liability emerges, after which the returns start to be drawn down to meet the liability.

Future funds have no impact on the underlying cash balance. They provide security and assurance that government subsidies will be

86. Wood and Mullerworth (2012, p. 6).

available over the longer term, but also allow future governments flexibility to set different priorities.

An Industrial Transformation Future Fund that starts in 2023 with an initial $10 billion endowment and is topped up with $1 billion each year to 2030 could, under conservative settings, generate sufficient income to fund $21.6 billion (nominal) in grants between 2031 and 2050 (Table 5.1). If inflation remains low, and returns are similar to those achieved by the existing Future Fund over the past 10 years, up to $30.8 billion could be available.

Once net-zero is achieved, the fund could be liquidated to repay the original endowment and top-ups. If desired, some of the grants could be contingent, meaning they convert to no-interest loans if the project is successful. Returned funds could then be reinvested. These scenarios and others are explored in Appendix A.

Table 5.1: Central scenario for an Industrial Transformation Future Fund

	Central
Initial endowment	$10 billion
Additional annual endowment 2024-2030	$1 billion
Interest rate	2.0%
Annual inflation rate	2.5%
Benchmark rate of return 2022-2030 (% above interest rate)	5.0%
Benchmark rate of return 2031-2050 (% above interest rate)	3.0%
Total grant funding over 2031-2050	$21.6 billion

Notes: Figures are in nominal dollars. Assumptions set out in Appendix A.

Source: Grattan analysis.

5.5.2 How a future fund should be designed

An Industrial Transformation Future Fund should be established through legislation, which would lay out the purpose for which investments are made and the purposes for which returns could be spent.[87] If it operated similarly to the existing funds, it would have an investment mandate issued by Ministers, but then would be free to decide how and where to invest and how to balance risks with returns.

The Industrial Transformation Future Fund should have clear performance metrics.

To avoid pork-barrelling and white elephants, decisions about grants from the fund must be made through an independent body at arm's length from government. This body will need to rigorously evaluate potential investments, and actively manage grant contracts to ensure the fund's objectives are being met.

Grants should go only to projects that will reduce a facility's emissions to as close to zero as possible. The facility may need to offset some residual emissions, but should not be allowed to use the grant to pay for these offsets.

Grants should be made only to facilities in industries where Australia has a long-term strategic or competitive advantage. They should not be used to prop up uncompetitive sectors. Governments should not give preference to existing facilities or existing Australian companies. Making Australia's industrial sector highly competitive in a low-carbon world requires attracting the companies most able to deliver this goal, and expanding the sector may require building new facilities rather than refurbishing existing ones. In *Start with Steel*, we suggested focusing on commodities that are energy-intensive to make, need inputs that are abundantly available in Australia, and command high prices on the world market.[88] The Federal Government's Low Emissions Technology

87. In particular, careful design will be required to ensure consistency with Australia's obligations under international trade agreements (noting that other countries are making grants of similar magnitudes).
88. Wood et al (2021a).

Statement has identified low-carbon steel and low-carbon aluminium as priorities for Australia.[89]

It is inevitable that some projects will not succeed – indeed, if no projects fail, that could be a sign that government assistance was not required. Governments should not hesitate to pull funding from projects that are not delivering, and reallocate the funding to projects that can.

An Industrial Transformation Future Fund would fulfil a different role to the Australian Renewable Energy Agency (ARENA) and the Clean Energy Finance Corporation (CEFC). It would focus on transformation rather than demonstration (unlike ARENA); and would have a strong risk appetite without the obligation to pursue returns (unlike CEFC).

5.6 Mitigating financial risk through a public-private investment vehicle

Even when technology risk is mitigated through the Industrial Transformation Future Fund, the commercial finance sector may not be willing to step in with finance, and there may be a role for government to mitigate financial risk by providing concessional finance, either as senior debt or mezzanine finance.

Government concessional finance must be designed to ‘crowd in’ the commercial sector – that is, government should only take on the last piece of financial risk once the private sector has taken as much risk as it is willing or able to take. Broadly, there are three ways to crowd in private finance via government concessional finance: taking equity, lines of credit, or a separate financing facility.[90]

A separate financing facility is the most suitable for sharing the risk of industrial transformation. Equity is better suited to start-ups that need capital injections to grow. A line of credit tends to encourage excessive commercial risk-taking.

Australia already has two financing facilities: the CEFC and the Northern Australia Infrastructure Fund. They provide capital at below-market rates on behalf of the Federal Government, to achieve a return that covers the cost of borrowing and their operations. This bridges any gap not filled by commercial lenders. This means all of the risk gap is taken on by government so that the finance sector can enjoy commercial returns – but it minimises the amount of risk taken on by government because it requires a return.

The CEFC has a well-established track record of crowding in private finance for renewable energy projects. In 2019-20, it leveraged $3 of commercial finance for every $1 of concessional finance.[91] It provides finance that the private sector can’t or won’t: for example, mezzanine equity to improve gearing ratios to the point where the private sector is willing to invest; senior debt to balance equity where market risk exposure is high; and cornerstone debt to underwrite project development for first-of-a-kind technology against which further capital can be raised.

The Federal Government has the building blocks it needs to deploy concessional finance for industrial transformation in the 2030s and beyond. For now, it need not make any further changes, but should keep close watch on the emerging shape of industrial and financial transformation, to ensure it moves at the right time to bridge any financial risk gap.

One model it could consider is establishing a joint venture finance facility that functions similarly to the CEFC, but draws on both government and private-sector funds. This would share the risk among more players, but it would require very careful design to manage the

89. DISER (2020c).
90. Hussain (2013).
91. CEFC (2020, p. 5).

balance between public benefit and commercial imperatives and fiduciary duties; and to avoid increasing risk to commercial lenders through government interference.

5.7 Beyond capital: the co-development challenge

Industrial transformation will be deeply intertwined with the transformation of Australia's energy systems. This goes beyond decarbonising electricity supply; it also requires fuel switching (from gas, petroleum, or coal, to renewable electricity, or other renewable fuel or feedstock) and a transition from a centralised electricity system to a decentralised system where loads are used dynamically to keep the system stable. And it requires constant arbitrage between energy storage, energy consumption, and energy export.[92]

As with technological change, the challenge will be the speed and scale of change in the energy system, and the amount of new infrastructure required. As well, change is needed right along supply chains: producing net-zero steel, for example, requires not just a zero-emissions steel smelter, but also a supply of zero-emissions hydrogen for the smelter, which in turn requires zero-emissions electricity. It requires land for hydrogen production and storage. And renewable energy production requires transmission lines from these renewable energy facilities to hydrogen production sites, and so on. When this needs to be repeated for half-a-dozen facilities in the same geographical area, the benefits of coordination become obvious.

Achieving scale will be essential for successful transformation. Other countries will be seeking to transform their industrial sectors at the same time as Australia, and where we are a small producer (for example, of steel, aluminium, or ammonia), individual Australian firms will be well down the queue for equipment suppliers. Integrating large

92. Australian Energy Transitions Initiative (2021, pp. 21–23).

Box 5: How not to develop multiple large projects quickly: lessons from LNG[a]

Between 2005 and 2015, Australia tripled its number of LNG liquefaction trains. While this development was impressive, and unprecedented in Australia's industrial history, it is now generally agreed that the way it was done was highly inefficient and drove up costs for all.

Concurrent activity after final investment decisions for several large projects led to massive over-building of infrastructure, such as roads, that could have been common-use. Having several large projects under simultaneous development in the one area heightened community concern and opposition, and led governments to impose more regulatory approvals, driving up costs.

Competition among projects in the one area drove up wages to astronomical levels, adding to project costs further, and with knock-on effects for host communities through increased rents and property prices. A 'get it done at any cost' mentality prevailed, where meeting construction and commissioning schedules was more important than controlling costs, and where firms tried to out-compete each other rather than their overseas competition.

In retrospect, companies acknowledged that taking a coordinated approach could have reduced the regulatory burden, delivered projects more quickly, and minimised non-recoverable costs. But they also noted that too much collaboration can border on anti-competitive behaviour. Working through an independent entity that wasn't invested in the projects themselves could have mitigated the risk of collaboration turning into collusion.

a. Reid and Cann (2016).

industrial electricity loads in the same area into demand response will allow firm, 24-7 renewable electricity to be delivered more cheaply.[93]

Lessons from rapid development in LNG in Australia highlight some of the areas where co-ordination in individual regions could decrease the costs and increase the benefits of industrial transformation (Box 5 on the preceding page). However, firms may be wary of too much co-operation, either because they fear losing market share to a competitor or because they may breach competition laws.[94]

Getting co-ordination right will make the Industrial Transformation Future Fund more effective, by keeping project costs down and project timelines under control.

Many of the issues around coordination, particularly infrastructure and energy, involve state government responsibilities. But state governments often run into trouble with coordinating large infrastructure projects, particularly when they are in a hurry, and these projects end up costing more and taking longer as a result.[95] And as the regulatory decision-makers who will approve or knock back new developments, governments cannot be deeply involved in projects themselves.

Each project will be different, and each co-ordination requirement will be different too. The critical step is to identify the specific coordination problems and who is best-placed to solve them. This should be a process of strategic collaboration between industry and government.[96] For example, this learning process might reveal collective cost reductions could be achieved through demand-response capability, transmission upgrades, new renewable generation, and power purchase arrangements. Or, it might reveal potential labour constraints because a number of facilities want to refurbish or renew facilities at the same time.

One way to create this collaboration would be to use ‘catalyst organisations’ to serve as place-based brokers and go-betweens, aggregating and sharing information that will improve coordination. These organisations would be different to consortia, industrial hubs, innovation clusters, or growth centres. Unlike consortia, they wouldn’t have members, so they could act as honest brokers between different parties. A catalyst organisation could help bring about development of a green industrial hub or innovation cluster but would not itself be a hub or cluster. And unlike growth centres, they would not focus on developing new technologies or innovation. Instead, they would concentrate on solving the problem of access to enabling physical infrastructure and services so new technologies can be deployed swiftly.

To be effective, catalyst organisations will need to be independent of, but trusted by, major industrial players in a local area, local communities, all levels of government, and smaller satellite businesses. For this reason, governments should keep the organisations at arms length and allow them to make independent decisions, though they may may want to consider funding running costs.

Governments need to be ruthless in catalysing development of new and transformed industry. Rather than worrying about being seen to ‘pick winners’, they should accept that most development is likely to take place in cities and towns that are already highly industrialised and have most of the requisite infrastructure. Governments should use catalyst organisations to work with willing industrial partners that are prepared to make long-term commitments to transforming Australia’s industrial base.

93. Ibid (pp. 21–23).
94. Reid and Cann (2016, pp. 16–17). Firms can apply to the ACCC for an authorisation – an exemption from competition laws where they can demonstrate the likely public benefits from their conduct outweigh the likely public detriment, including the reduction in competition: ACCC (2021).
95. Terrill et al (2021).
96. Rodrik (2014).

6 Implications for other sectors

Decarbonising the industrial sector has implications for other sectors.

The largest by far will be the impact on the electricity sector. Many solutions for decarbonising industry rely on electrifying it. This will increase demand for electricity, but may also have implications for demand timing and demand location. This increase in demand will take place at the same time as a potential large increase in demand from electrifying transport. Both industrial and transport demand may also help lower system costs if demand response is used judiciously.

The domestic gas market may be the biggest loser from a net-zero industrial sector. Many gas users can easily switch to electricity, but some users require high-temperature heat for which zero-emissions substitutes (like hydrogen and renewable gas) are still nascent and expensive. It is an open question whether there are enough of these users to make gas networks viable in the future.

Offsets are the only option for residual industrial emissions that cannot be eliminated through other means. Even if the residual amount is small – say 5 per cent of current emissions, or about 8 million tonnes – offsets will need to be found every year thereafter. The more each sector leaves to offsets to achieve net-zero emissions, the higher will be the demand for these, and the higher the price. Firms that are part of global supply chains may find use of offsets restricted by other governments. Conversely, if other governments allow widespread use of offsets, Australian firms may find themselves small players in a supply-constrained market, and pay a premium.

Appendix A: Safeguard baseline adjustment worked example

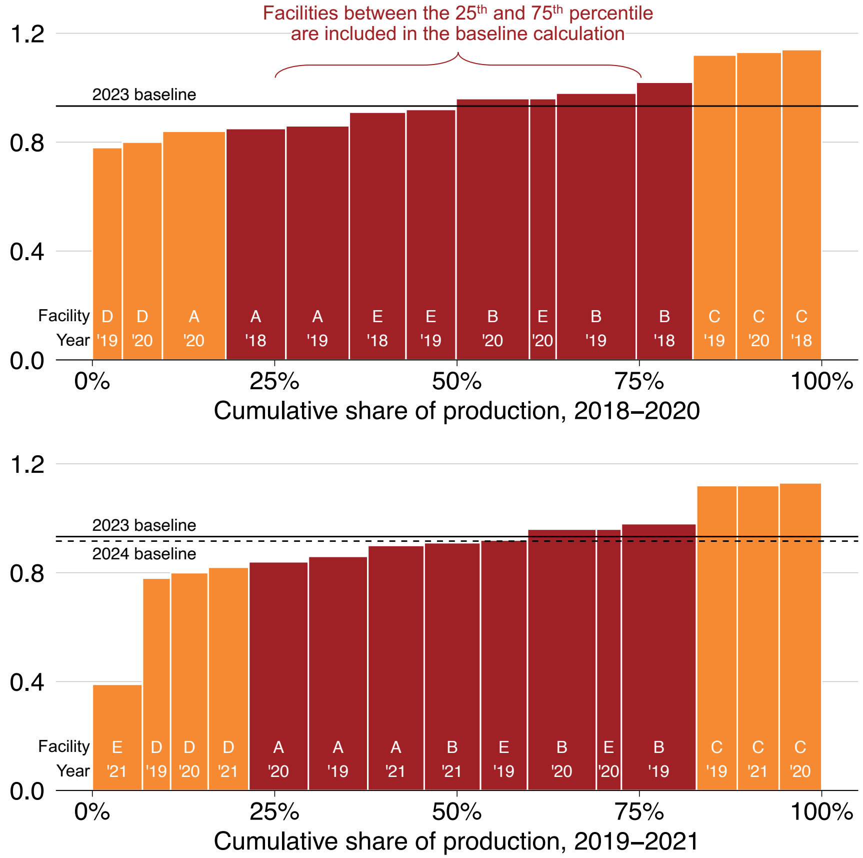
This appendix analyses how below-baseline crediting and annual baseline adjustment could work to gradually reduce emissions in industries where emissions-reduction technology can be deployed feasibly.[97]

Figure A.1 illustrates an example for an industry with five major facilities (named A to E). Data on emissions-intensity for the past three years would be used, where available.[98] The baseline in three years' time (in this example, 2023) would be set using the production-weighted average emissions-intensity, calculated using the 'middle half' of facility data centred on the median.[99]

Over time, the baseline would gradually reduce if and only if facilities adopt lower-emissions practices and technology. Emissions-intensity baselines should never be set at a higher level than the previous year's.

Figure A.1: The Safeguard Mechanism baseline should fall gradually as facilities become less emissions-intensive

Emissions-intensity of production (tonnes of CO_2-e per tonne of product)



Note: The median, 25th, and 75th percentiles of emissions-intensity are determined on a production-weighted basis.

Source: Grattan analysis.

97. This example methodology is largely based on the method described in DISER (2018, pp. 25–28), but uses three years of data rather than five.
98. In this example, facility D is a new plant and so has no data before 2019.
99. Any facility data within the inter-quartile range (between the 25th and 75th percentiles inclusively) would be included.

Appendix B: Industrial Transformation Future Fund scenarios

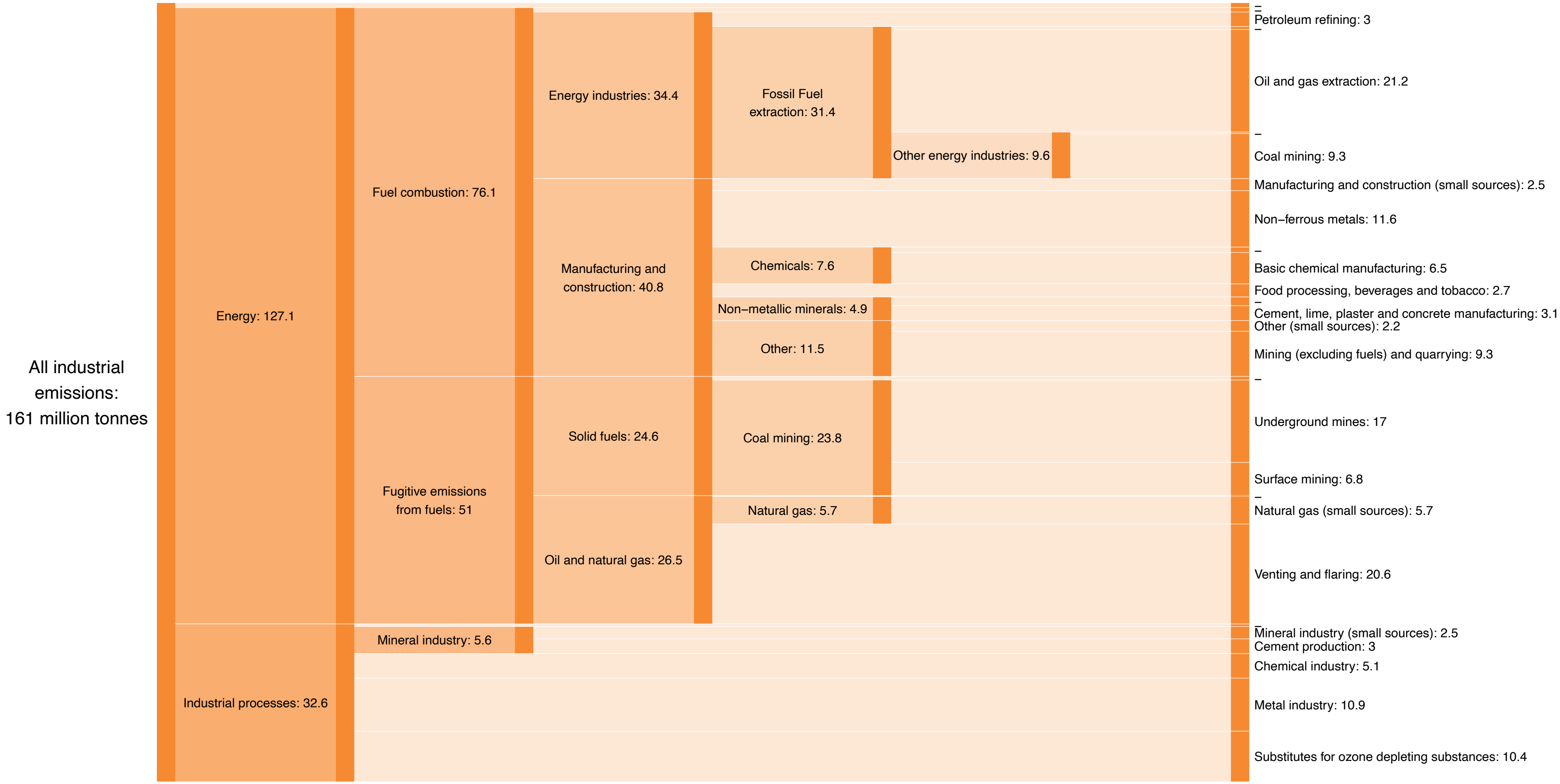
All scenarios start with an initial $10 billion endowment in 2023, and start making funds available for grants from 2031. In all scenarios, grants are paid on milestones across 5 years, with 10 per cent of each grant being paid in year 1, 20 per cent in year 2, 40 per cent in year 3, 20 per cent in year 4, and 10 per cent in year 5. The last grant is committed in 2046 and the last payment is made in 2050. The fund is liquidated in 2051 to return the endowment. In the Contingent scenario, 10 per cent of all grants are repaid, with repayments starting in 2036 and finishing in 2055. Repayments after 2050 are not included in calculations, and are assumed to be returned to consolidated revenue. All dollars are nominal dollars.

Table B.1: Hypothetical Industrial Transformation Future Fund options

	Central	Optimistic	Single endowment	Contingent
Initial endowment	$10 billion	$10 billion	$10 billion	$10 billion
Additional annual endowment 2024-2030	$1 billion	$1 billion	$0 billion	$1 billion
Interest rate	2.0%	2.0%	2.0%	2.0%
Annual inflation rate	2.5%	1.5%	2.5%	2.5%
Benchmark rate of return 2022-2030 (% above interest rate)	5.0%	8.0%	5.0%	5.0%
Benchmark rate of return 2031-2050 (% above interest rate)	3.0%	3.0%	3.0%	3.0%
Total grant funding over 2031-2050	$21.6 billion	$30.8 billion	$15.3 billion	$23.1 billion

Appendix C: Industrial emissions (detailed breakdown)

Figure C.1: There are many sources of emissions in the industrial sector, which means several technologies will be needed
Emissions in 2018-19 (million tonnes of carbon dioxide-equivalents)



Notes: Subsectors with fewer than 2 million tonnes of emissions per year have not been labelled for readability. Very minor discrepancies (generally <1Mt) may arise when comparing emissions figures from DISER (2020a) and DISER (2021a).

Source: Grattan analysis of DISER (ibid).

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