Australia's coal mining emissions paradox

This report addresses the underlying paradox in Australia's coal mining industry, where production has more than doubled since 1990, but the industry's fugitive emissions have returned to their lowest levels on record.

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About

This report analyses fugitive emission trends and estimates from the National Greenhouse Gas Inventory and the National Greenhouse Accounts. It contrasts these results with calculations based on coal production data from the Office of the Chief Economist, NSW Coal Services Annual reports and Queensland's Department of Resources. Ember's analysis incorporates facility level and emission intensity reporting from the Clean Energy Regulator, and coal exploration spending data from the Australian Bureau of Statistics.

Acknowledgement of Country

Ember acknowledges the Traditional Custodians of the many nations across Australia and their enduring connection to Country and the lands, seas and skies. We pay our respects to Elders past and present and extend that respect to all Indigenous Peoples today.

Highlights

170%

Increase in coal production between 1990 and 2022

0.17%

The increase in fugitive emissions between 1990 and 2022

2-3x

Surface coal mining production has grown at twice the rate of fugitive emissions since 1990

Executive Summary

Rising Coal Production, Falling Emissions

The reduction in Australia's coal mine fugitive emissions is one of the key sectoral success stories of Australia's efforts to tackle climate change. However, a longer-term look at the coal industry reveals a more complex picture. This report outlines three critical components in this short history of Australia's coal mine emissions.

The age and safety related closure of gassier underground coal mines has inadvertently led to significant emissions reductions over the last three decades. In contrast, the corresponding growth in open-cut mining means that more of Australia's coal emissions are now estimated (rather than directly monitored) than ever before. What's more, changes to estimation approaches for surface coal mining mean that more of Australia's coal mining emissions have shifted from state-led regulatory averages, to non-verified individualised estimates, corresponding with a significant decrease in reported emissions.

> **Australia's coal industry has seen an involuntary drop in emissions over the past few years, but a number of key trends suggest that the industry is far more exposed to risk, and farther away from a sustainable transition than ever before.**

Christopher Wright
Climate Strategy Advisor - Coal Mine Methane, Ember

Key takeaways

01

170% increased coal production

Between 1990 and 2022, Australia's coal production has increased by 170%, largely due to the significant expansion of open-cut mining, growing from 201 - 542 million tonnes.

02

0.17% increased fugitive emissions

Despite significant coal production growth, coal mine fugitive emissions have increased by 0.17 per cent between 1990 and 2022, while the emissions intensity of the coal sector has decreased by 63 per cent.

03

2-3x faster than the rate of emissions

Between 1990 and 2022, open-cut coal mining grew at twice the pace as reported fugitive emissions. Since 2005, the growth rate gap between production and emissions reporting has widened to more than three times greater.

Government reported data indicates that Australia's coal industry has made progress in reducing emissions, but whether or not this reflects a sustainable trend is far from clear.

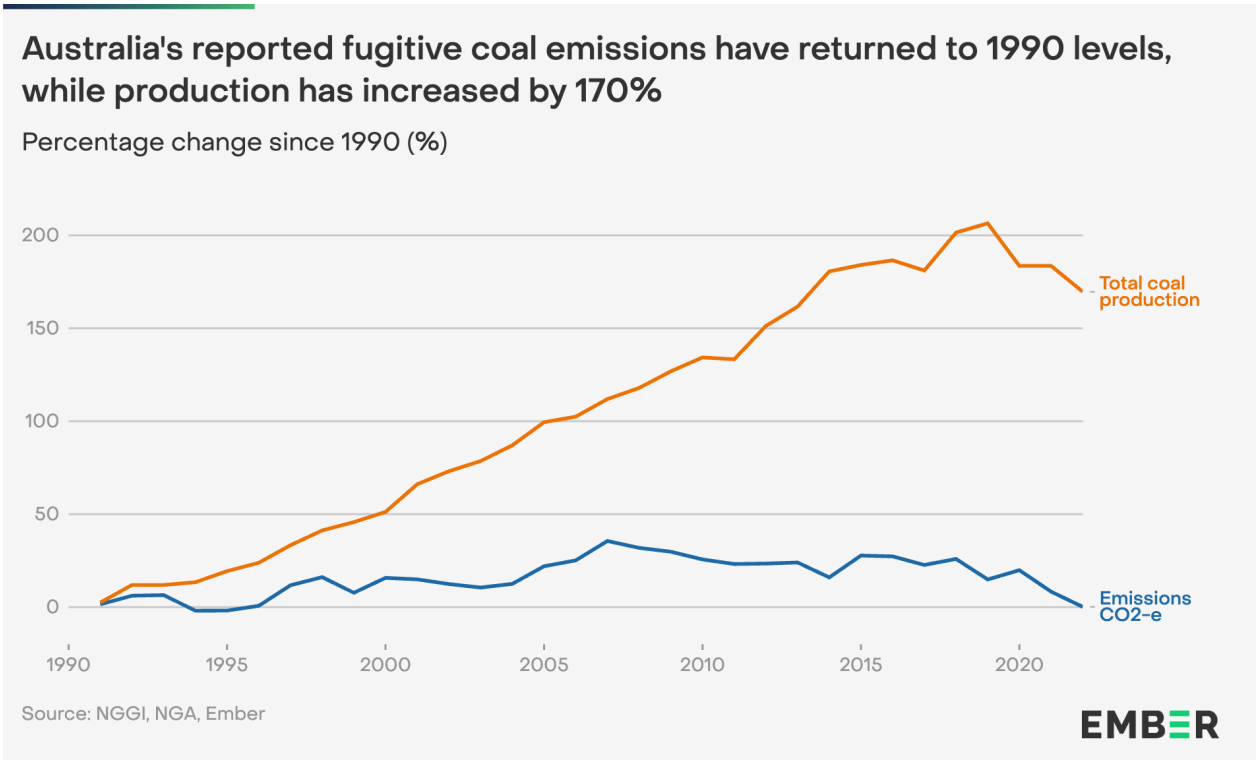
Currently there are a number of gassy, underground coal mines seeking to extend or expand their production that could seriously undermine this reporting trend. Furthermore, with the compulsory shift toward site-specific open-cut emissions reporting, this report should act as a catalyst for holistic regulatory review, and the integration of diverse emissions verification technologies.

Chapter 1

Rising Coal Production, Falling Emissions

Australia's coal production has surged, yet reported fugitive emissions have barely increased. This emissions paradox is largely attributable to underground mine closures and emissions accounting shifts, rather than genuine emissions reductions.

Over the last 35 years, Australia's coal production has increased significantly, but officially reported estimates of coal mining emissions have effectively returned to their original levels.



In the September 2024 update to the greenhouse gas emissions inventory, Australia's net emissions were estimated to have reached 434.9 million tonnes of carbon dioxide equivalent (Mt CO2-e). This includes significant emissions reductions in the land-use sector, and is estimated to reflect a reduction of 29% compared to annual emissions in 2005, and a 32% reduction compared to 1990 (640.6 Mt CO2-e).

This reduction has been largely driven by the globally significant growth of renewable energy across Australia. Australia is now the ninth-highest absolute generator of solar and wind electricity. With over 4 million households directly invested in rooftop solar, Australia also proudly has the highest rates of rooftop solar generation anywhere in the world. As a result, the electricity sector has been the driving force of Australia's emissions reduction journey, with emissions now 23.4% lower than they were in 2005.

However, Australia's emissions reduction journey has not been linear. Total emissions reductions across the economy have stalled over the last three years, with reductions of less than 1% each year since COVID-19. This has also occurred largely as a result of significant re-calculations of the ability for land-use change to sequester carbon emissions each year.

Outside of the land-use sector, fugitive emissions from coal mining have experienced one of the most significant sectoral emission drops across the economy. In the 2024 financial year alone, reported coal mine fugitive emissions decreased by 7.6 per cent, marking one of the fastest sub-sectoral reductions across the economy. Compared to 2005, fugitive emissions in the coal sector have reduced by over 20%, marking a reported emissions reduction rate similar to that of the electricity sector.

This emissions decrease occurred during a period of dramatic increases in coal production across the country. Since 1990, raw coal production in Australia has increased by 170%, rising from 201 million tonnes to 542 million tonnes in 2022. This included a 46% increase in underground mining over this time, and a 224% increase in open-cut mining.

In contrast, the total direct emissions attributed to coal mining, known as Scope 1 emissions, have increased by 32% since 1990. This includes emissions from diesel fuel, as well as emissions from coal processing and handling. At the same time as this overall emissions increase, fugitive emissions from coal mining have only grown by 0.17%. When compared to the increase in coal production, the average fugitive emissions intensity per tonne of coal has decreased by 63% between 1990 and 2022.

During this time, there have been significant mitigation investments at several underground coal mines over the last three decades. This includes the world's first commercial scale VAM-to-power project at the West Cliff Colliery, which saw 2 million tonnes of CO2-e reduced from the Illawarra's West Cliff Mine between 2007 and 2017. It also includes up to $100 million per annum in investments in pre-mine drainage across Anglo American's steelmaking coal mines that has potentially mitigated up to 5.3 million tonnes of CO2-e compared to fugitive emissions levels in 2019. This reduction continued in 2024, but was bolstered by the closure of Grosvenor mine.

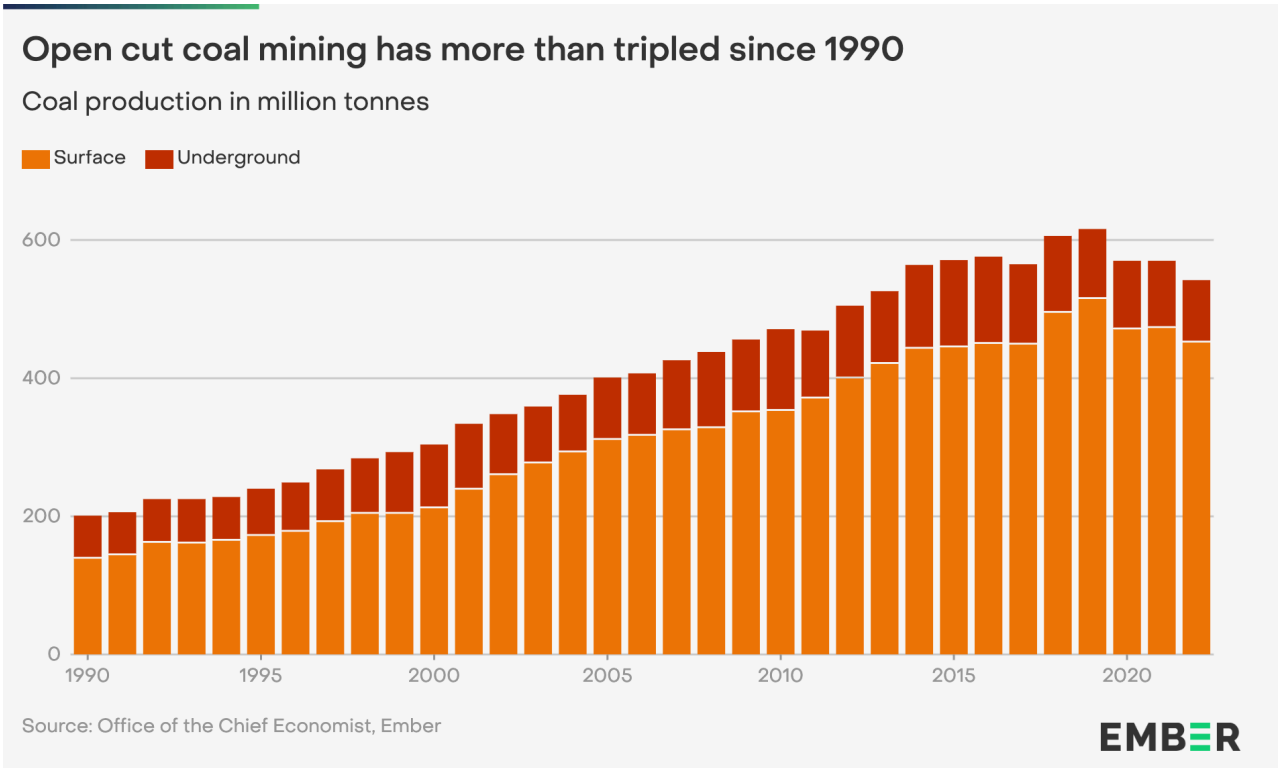
However, this report highlights three additional drivers of this significant emissions shift over the last thirty years. This includes a shift towards more open-cut mining, a decline in underground mining emissions due to the unplanned closure of super-emitting mines, and an accounting shift in the way in which open-cut mine emissions have been calculated over the last fifteen years.

Chapter 2

Shift to open-cut Coal Mining & impact on emissions estimate

Open-cut mining now dominates Australian coal production, but its emissions are largely estimated rather than measured, raising concerns about the accuracy of reported reductions.

One of the most important shifts in Australia's coal mining industry over the last thirty years has been the rapid expansion of open-cut coal mining, which now makes up more than 85% of all coal mine production.



Underground mining production more than doubled between 1990 and 2015, peaking at 125 million tonnes in 2015 and 2016. Since then, the total volume of underground mining production has contracted to 89 million tonnes. However, its relative share of total coal production has shifted from more than 30% of all coal mined in 1990, to just over 15% of total production, where it has remained relatively steady since 2018.

Surface or open-cut coal mining has significantly expanded over the past 30 years. In 1990, approximately 190 million tonnes of coal was produced in open-cut mines. By 2003, open-cut mining had doubled its output to 278 million tonnes. A decade later, the growth in open-cut mining had only accelerated, reaching 422 million tonnes in 2013, before peaking at 516 million tonnes in 2019. By the end of 2022, open-cut mining had grown by an incredible 224%.

This rapid expansion has been driven by the expansion of higher efficiency and lower costs of open-cut mining in shallower seams, particularly in central Queensland. Total production has more than tripled over this time, as the relative share of total coal production has risen from just under 70% in 1990, to more than 85% of all coal production nationally by 2022.

More of Australia's coal mine fugitives are now estimated than ever before

The shift has significant implications for Australia's estimated fugitive emissions profile. Underground mines, which directly measure their fugitive emissions, have historically been associated with higher emissions due to the nature of their mining process, releasing methane trapped within deeper, higher pressure coal seams. On average, the IPCC estimates that underground mines release 12.5 times more fugitive methane in their mining process than open-cut mines. However, these estimates are largely based on modelled emissions profiles aggregated from global samples, rather than direct emissions monitoring at specific sites.

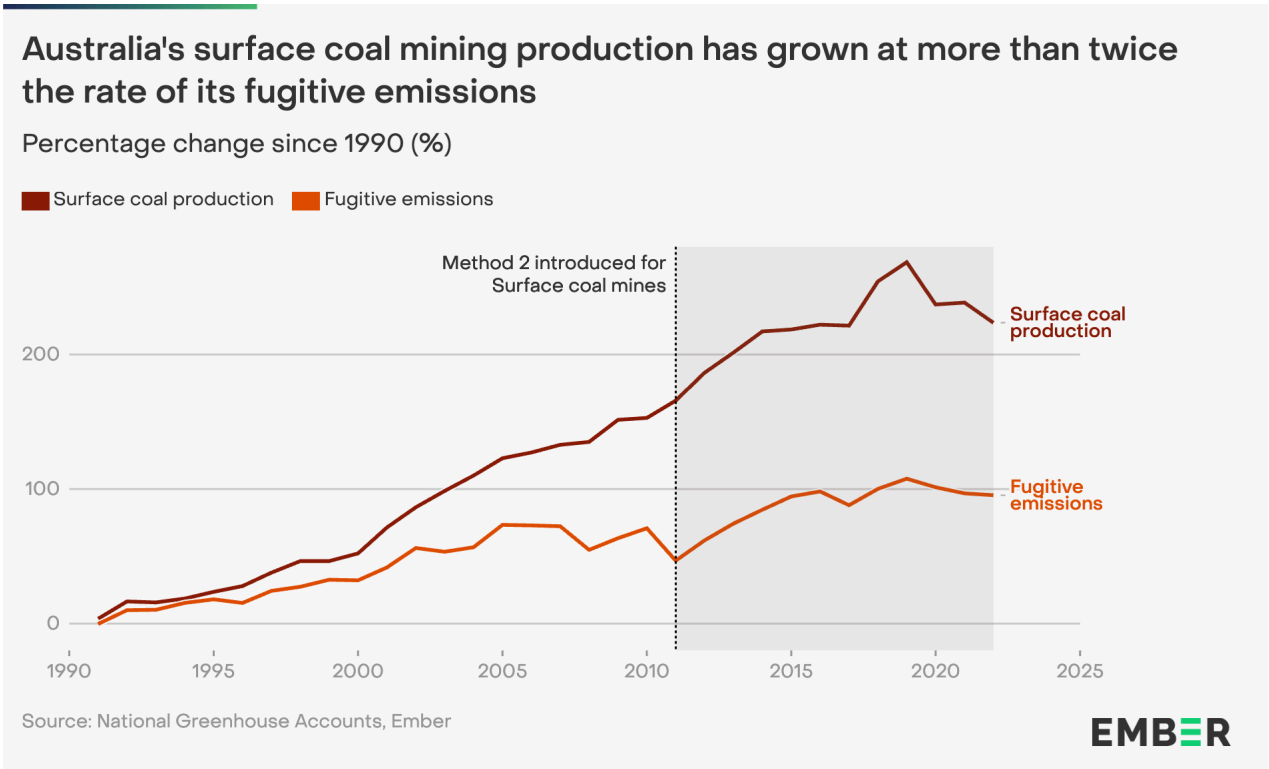
As a result, the shift towards a greater share of production from surface mining has meant that Australia's fugitive emissions reporting now rely on estimated

emissions levels more than ever. Underground mines currently measure emissions using a well-supported direct measurement approach, though this method is largely applied on a periodic basis. In contrast, open-cut coal mines estimate their fugitive coal mine methane based on gas models originally developed in 1991, rather than direct measurement.

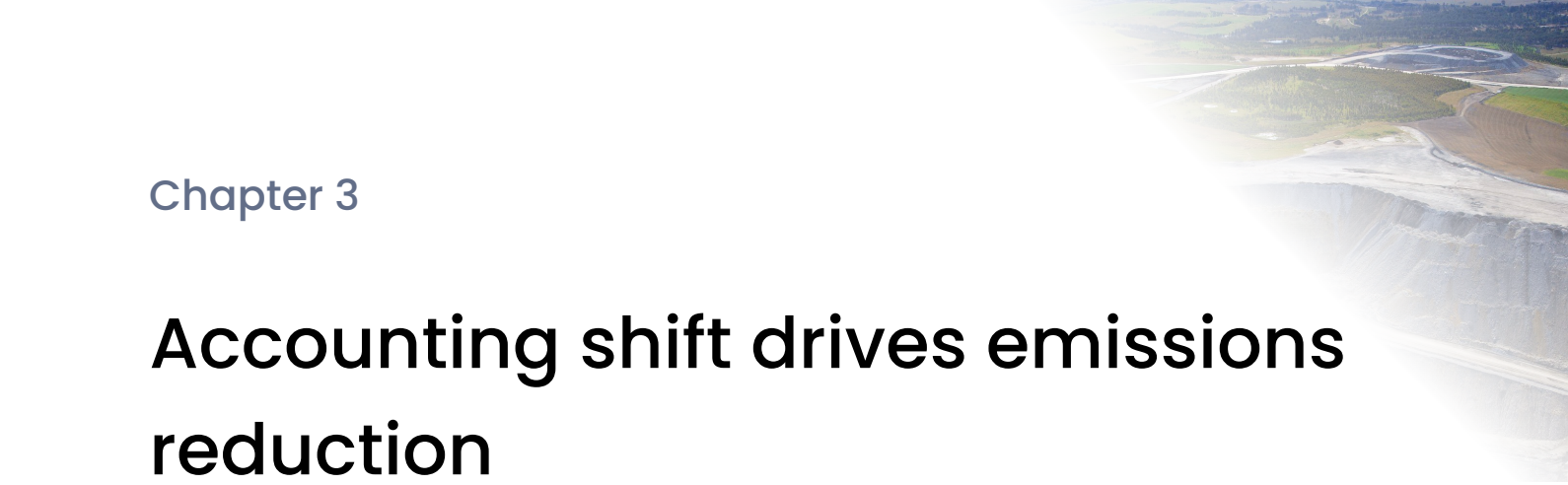
While the rise in open-cut coal mining has decreased the reported emissions intensity of Australia's coal sector, it has done so largely based on emissions estimates. These emissions estimates have been repeatedly questioned by a diverse array of peer-reviewed satellite comparisons as well as a year-long review of the national emissions reporting system from the Climate Change Authority. As such, the shift in coal production towards open-cut mining has not only led to a decrease in reported emissions intensity, but it has also led to a parallel increase in the volume and share of fugitive coal emissions that Australia's coal industry is no longer directly monitoring, but simply estimating.

Open-cut coal expansion at 2-3 times the rate of emissions growth

While open-cut coal mining production grew by approximately 224% between 1990 and 2022, the growth in reported fugitive emissions has simply not kept up. By 2003, fugitive emissions from open-cut mines had grown by 53%, rather than doubling. Then, by 2013 fugitive emissions had only increased by 74% with negative emissions growth between 2010 and 2013. Then, by the end of 2022, fugitive emissions from surface coal mines had increased by 95%, less than half the rate of growth in production.



This rate of change is even more significant when compared to Australia's international emissions baseline of 2005. Since that time, open-cut coal production has increased by 45% but fugitive emissions from this same sector have only increased by 13%. As such, since Australia's emissions baseline was set, surface mining fugitive emissions have grown at less than a third of the growth rate of production.



Chapter 3

Accounting shift drives emissions reduction

A shift from state-based to site-specific emissions estimates may have led to a significant reduction in officially reported emissions especially in NSW, raising concerns about transparency and accountability of this methodological shift, and the real emissions rates.

Open-cut coal mines in Australia do not measure their fugitive methane emissions. Instead, a fugitive emissions factor is estimated based on bore-hole coal samples, which is then multiplied by annual coal production. This approach was first developed at the state level in 1991, with specific emissions factors applied for NSW and QLD in 1993. Due to the complexity of gas models and limited number of gas samples available at the time, this approach was first implemented as state-based average emissions factors are known as Method 1, under the National Greenhouse and Energy Reporting Scheme.

Since then, state-based emission factors have been periodically reviewed and regularly increased, to align with a larger sample size and improved scientific understanding of the warming impact of methane on the atmosphere. The NSW state-based emission factor has increased twice, and the emissions factor in Queensland has increased on three occasions.
The most recent emissions factor increase in Queensland last year, was developed after analysing more than 1,000 drill samples from the Queensland Government's Petroleum Exploration Dataset, selected to exclude samples from current and expanding active coal fields.

In the late 2000s, the Australian Coal Industry's Research Program (ACARP) began working on a methodology for developing an approach to estimating fugitive methane emissions that individual companies could implement in a site-specific manner. This site-specific approach was first implemented in 2011, and is known as Method 2, under the National Greenhouse and Energy Reporting Scheme.

Since that time, open-cut mine operators have been able to individually estimate the methane content of their facilities using either a state-based average, or a site-specific estimate based on as few as three borehole samples per mining domain.

In 2024, Ember's assessment of eight currently operating and two proposed coal mines identified millions of tonnes of CO2-e reductions that had occurred as a result of this accounting shift towards site-specific measurement. Additional research from energy insights firm Reputex has since evaluated the impact of recent accounting shifts on open-cut coal mines across the country. Their findings estimate that recent shifts from state-led emissions factors to company-led estimates have consistently decreased reported fugitive methane emissions reporting by 65 – 70%. This shift has significant implications on a mine's obligations under the reformed Safeguard Mechanism.

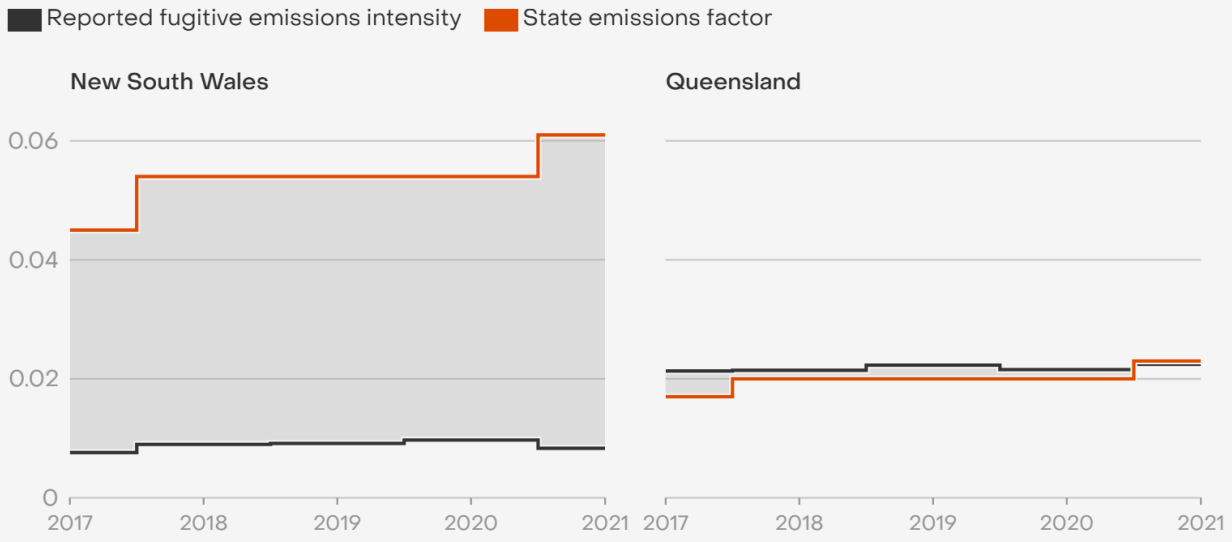
The influence of this reporting shift is especially poignant in NSW. In 2023, the official state-based emissions factor for NSW was 0.061 tonnes of methane per tonne of coal (t CO2-e/t ROM). In Queensland, the equivalent emissions factor was increased in 2023 from 0.023 to 0.031 t CO2-e/t ROM. As such, coal mines in NSW have had a much higher official state-based emissions factor as their respective baseline, and far more coal mines have selectively adopted a company-led, site-specific emissions factor. In 2023, The Climate Change Authority estimated that 75% of currently reported coal mine methane emissions from Queensland and 25% from NSW are estimated using this site-specific emissions accounting approach.

In this report, we have utilised the National Greenhouse Accounts, to compare collectively reported fugitive emissions for surface coal mines, against annual coal production estimates, reported at the state level. This allows us to compare an estimate for fugitive emissions intensity across both states, and how it has changed over the last 5 years. To note, this approach would incorporate reported

fugitive emissions from facilities utilising both state-based emissions factors, and those utilising site-specific emissions estimates.

NSW open cut fugitive emissions intensity is six times lower than state-based estimates

Fugitive emissions intensity (t Co2-e/ROM t) compared to state emissions factor



Source: National Greenhouse Account, Queensland annual coal statistics, NSW Coal Services Annual Report

Fugitive emissions intensity is ratio of reported fugitive emissions to coal production in NSW open cut coal mines.

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This comparison highlights that fugitive emissions reporting across coal mines in Queensland is largely in line with what would be expected under the state-based emissions factor. In NSW however, where the use of site-specific emissions estimates is far more widespread, we find that the reported fugitive emissions intensity of open-cut mines is six times lower than the state-based emissions factor. It would also be significantly lower than the state-based emissions factor estimate for QLD.

This highlights a clear mismatch between collectively assessed emissions factor averages, compiled by state environmental regulators, and individually reported emissions estimates, compiled by individual mine operators. These results raise the urgent need for in-depth regulatory and methodological review, as highlighted by the Climate Change Authority in 2023.

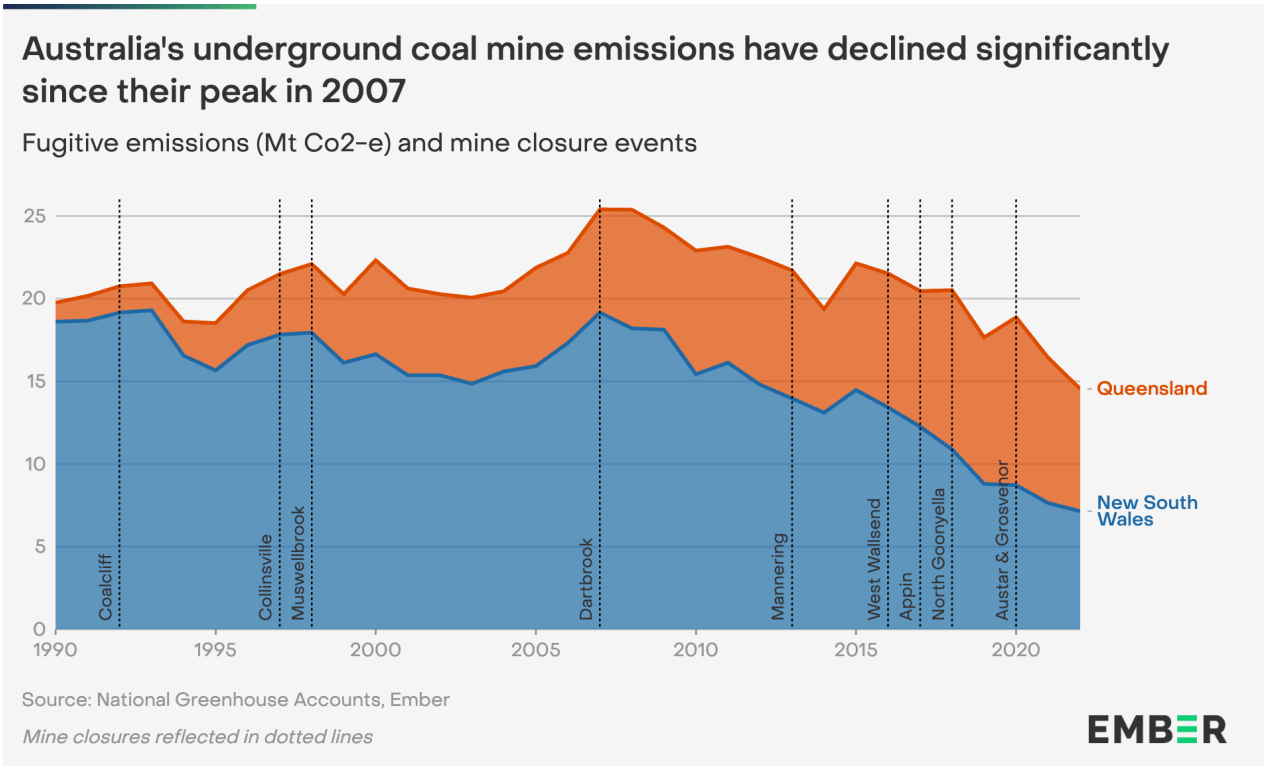
Chapter 4

Underground coal mine closures - a historic win, but future risk

The biggest driver of fugitive emissions reductions has been underground mine closures, but new expansions threaten to reverse these gains.

Outside the shift towards surface coal mining, the biggest driver of actual emissions reductions in the coal sector has been the recent decline in underground mine production and the closure of a sample of high emitting, gassy coal mines. This highlights the opportunity of strategic coal mining closures of super-emitting underground mines as a short-term opportunity for significant emissions abatement.

In 1990, total underground coal mine production for that year was estimated at 61 million tonnes. Since then, total underground coal production has grown significantly, with a peak of 125 million tonnes of underground coal production in 2015. Since this peak, annual underground coal production has been in decline each year, driven especially by coal mine closures and production impacts such as COVID-19 restrictions and floods in years since; but production was still 46% higher in 2022 compared to 1990.



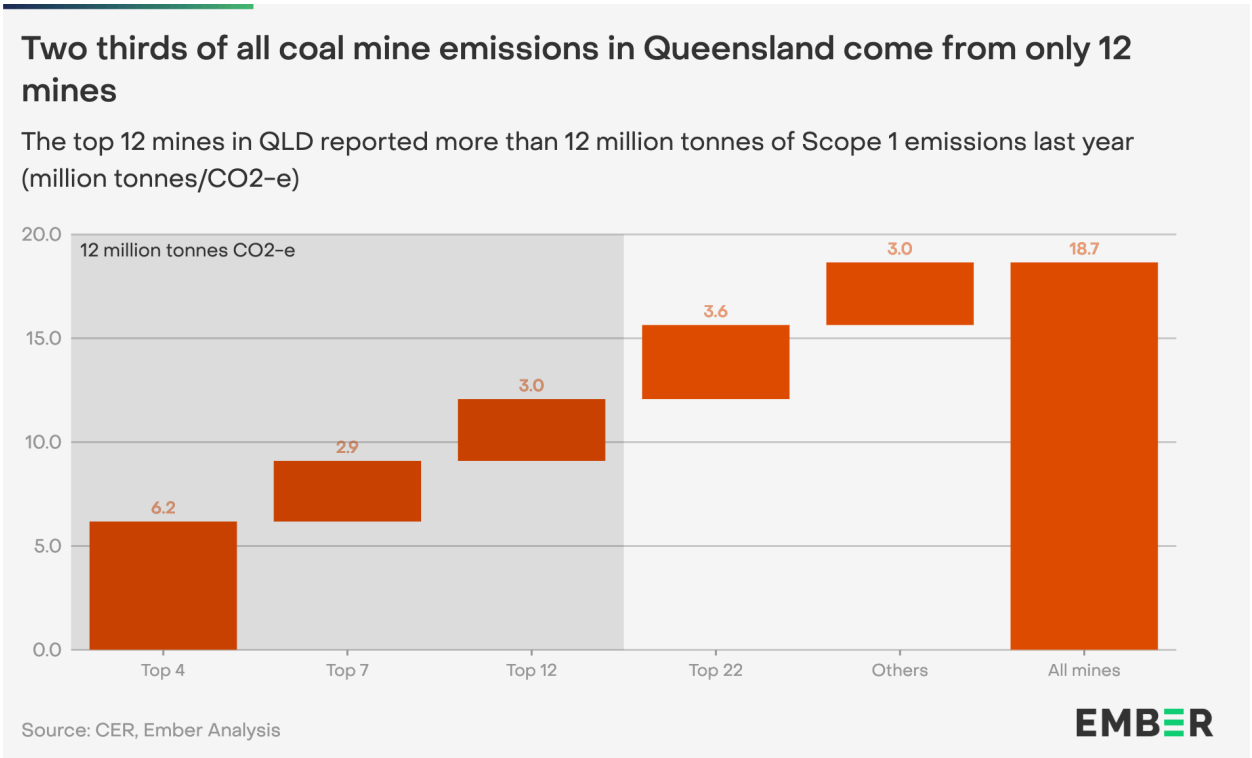
Underground mining plays a particularly significant role in Australia's coal mine methane emissions. This is largely due to the nature of underground mining itself. As mining operations go deeper, particularly when extracting higher-grade metallurgical coals, substantial amounts of methane trapped in the coal seam are released.

As a result of mine design, underground mines release the majority of their methane through the mine's ventilation shaft. This is a source that can be significantly reduced through strategic investments in methane capture technology, both prior to, and during mining.

While underground mining now makes up approximately 15% of all coal production in Australia, it makes up approximately two-thirds of total fugitive emissions from coal mines. Of this, a small handful of highly gassy mines make up the lion's share of emissions.

In Queensland for example, of all large emitters reporting to the Safeguard Mechanism, only four large underground mines contribute up to one third of all estimated scope 1 emissions in the coal sector. In 2023, only 12 underground and mixed mines reported 65% of the state's reported scope 1 emissions under the

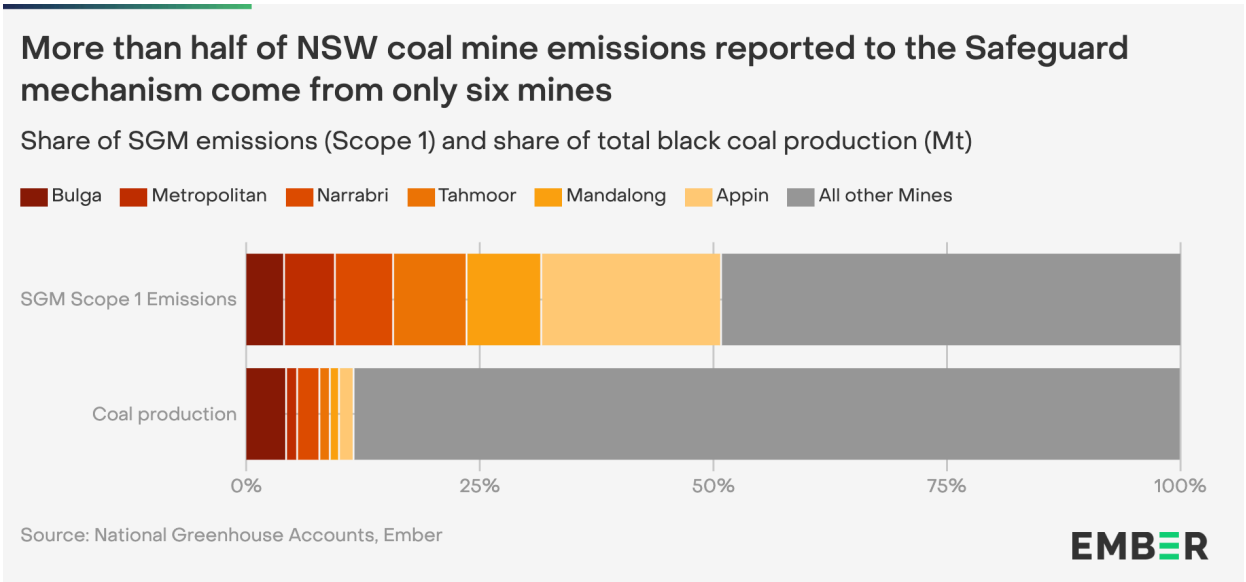
Safeguard Mechanism. While these reflect overall scope 1 emissions rather than fugitives alone, for many underground mines, more than 90 per cent of their scope 1 emissions share comes from "fugitive" methane alone.



Similarly in NSW, only three large underground mines contributed more than one third of all coal mine emissions reported to the Safeguard Mechanism in 2023. More than half of all scope 1 emissions reported that year came from only 6 underground mines that contributed only 14% of overall coal production in the state. Considering that there are fewer Safeguard reporting coal mines in NSW than in QLD, and a number of the state's open-cut mines have reported extremely low emissions after shifting their emissions reporting to site-specific fugitive measurement, we expect that an even greater proportion of the state's reported fugitive emissions are contained within a small number of underground mines.

As a result, a handful of super-emitting coal mines can have a significant impact on the state and country's coal mining emissions. If one of these super-emitting mines closes, or production in those mines decreases, that would result in a significant reduction of overall coal pollution. Similarly if strategic investments are made to reduce their emissions while not impeding on production levels, fugitive

emissions at many of these super-emitting mines could be decreased by between 70-80%.



In the case of Australia's most recent underground fugitive emissions decrease, there have been strategic mitigation investments. Anglo American, which previously owned super-emitting metallurgical mines such as Moranbah North, Grosvenor, Aquila and Grasstree, invested in "excess of USD $100 million per annum, in methane capture infrastructure" in pre-mine drainage over the last few years. As a result, it reported capturing and mitigating up to 60% of its potential methane emissions last year, compared to a baseline of 2019.

However, the large majority of emissions reductions have come as a result of unintentional emissions decreases as a result of the closure of older, super-emitting coal mines. This includes the closures of Coalcliff mine in 1992, underground mining at Muswellbrook and Collinsville in 1997, Dartbrook in 2007, Mannering Colliery in 2013, West Wallsend Colliery, which closed after 47 years of operation in 2016, and Austar coal mine, which closed after 100 years of mining in 2020.

It also includes the partial closure of many super-emitting mines due to methane-related incidents and explosions. In 2017, Appin coal mine, the highest emitting coal mine in the country, was partially closed and production significantly reduced for two years due to unsafe gas levels. In 2018, North Goonyella coal mine closed after a fire following months of rising methane levels.

That was followed by Grosvenor coal mine which experienced a major methane-related fire in 2020, following 27 recorded methane exceedances in the year prior. The mine was re-opened only to experience a massive explosion last year. A similar history of coal mine methane-related incidents led to the closure of Russell Vale coal mine last year.

While investments in emissions abatement have partially contributed to the downward trend in fugitive emissions reporting across Australia's underground mines, it is clear that the closure of super-emitting coal mines has had a far more significant impact on overall emissions trends. This not only reinforces the value of strategic closures of super-emitting underground mines as a short-term opportunity for significant emissions abatement, but the critical pollution risk of extending and expanding these mines.

Future Risks and expansion concerns

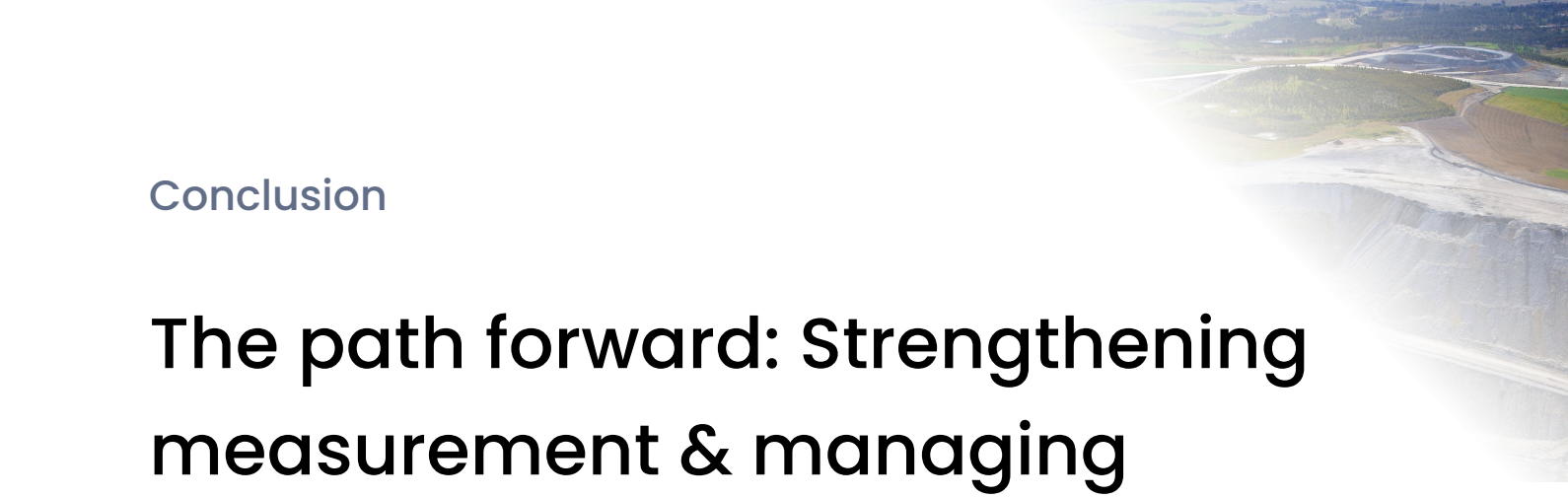
Going forward, the CSIRO has estimated that an additional 44 coal mines are scheduled to close by 2040. This should include super-emitters such as Aquila (2029) resulting in ongoing emissions reductions. These are already built into Australia's forward emissions estimates, which assume that "from 2029 emissions are projected to decline due to reduced demand for Australian thermal coal, increased on-site abatement activities induced by the Safeguard Mechanism, and the closure of several large, gassy underground mines."

However, research from civil society groups such as Lock the Gate and The Australia Institute highlight that there are currently 27 proposed coal mining projects that have not yet been incorporated into forward emissions estimates and could have a significant impact on forward emissions estimates.

In September last year, Narrabri underground coal mine was granted an extension to its operations licence from 2030 to 2044. Then in December, Lake Vermont Meadowbrook project was granted an expansion request to develop a new underground coal mine, which could transition the mine to becoming the third highest emitting coal mine in the country by 2028 if its fugitive emissions are not proactively mitigated. Finally Tahmoor coal mine is currently seeking approval

to modify its current underground mining approach, potentially increasing its annual emissions increase by 57% in the next year alone if granted.

This concern is supported by the NSW Net Zero Commission, who notes that while NSW is about half way towards achieving the state's legislated 2030 emissions reduction targets, it was specifically concerned about the "risks to the state's targets from increased emissions in the resources sector." A similar concern was raised at the national level by the Climate Change Authority, who noted that new coal and gas projects were undermining the viability of Australia's climate targets.



Conclusion

The path forward: Strengthening measurement & managing expansion risk

Fugitive emissions reporting across Australia's coal sector is at its lowest levels on record, but urgent regulatory change is needed to ensure these results are sustainable.

Over the last three decades, Australia's coal mine production has more than doubled but reported fugitive emissions from the sector have hardly shifted. When compared to Australia's emissions reporting baseline under the Nationally Determined Contribution, Australia's reported coal mine fugitive emissions have reduced by over 20%, marking a reported emissions reduction rate similar to that of the electricity sector.

This incredible shift in reported emissions intensity is largely due to significant emissions reductions across gassy underground mines in NSW, which have either permanently or temporarily closed due to safety concerns. This highlights the potential value in strategically closing or limiting production in gassy, underground coal mines. However, the reported emissions shift has also been due to a seismic shift in the proportion of Australia's coal that is produced from open-cut mines, and the corresponding share of the industry's fugitive emissions coming under direct measurement.

In this report, we have highlighted the potential risk embedded within both of these key emissions reporting trends. Despite the CSIRO projections estimating that close to 44 coal mines are scheduled to close by 2040, a significant proportion of some of the gassiest underground mines are currently applying for extensions, and a number of mixed or surface mines are applying to expand into underground mining. What's more, governmental projections highlight that critical opportunities in onsite mitigation may be overlooked due to the relative opportunity cost of offsets under Australia's reformed Safeguard Mechanism.

This report also raises concerns about the significant reductions in reported fugitive emissions from open-cut mines. The shift to site-specific emissions estimates, particularly in NSW, has led to a marked decrease in reported emissions, effectively disconnecting surface mine production growth from emissions reporting. This raises serious questions about the accuracy and transparency of the data provided, and its non-alignment with previously estimated state-based emissions factors, compiled and periodically reviewed by state and federal regulators. A thorough and transparent regulatory review of this discrepancy is essential to ensure transparency and accuracy.

This is especially pertinent considering the Climate Change Authority's year-long review of Australia's methane reporting system. In their review, the Authority noted that the "disorderly process" of emissions reporting "will erode confidence in the National Greenhouse and Energy Reporting (NGER) scheme". In response the government has now made site-specific emissions factors compulsory for all open-cut coal mines, and promised to establish an Expert Panel to provide advice on atmospheric measurement of fugitive methane emissions in Australia.

The Authority's review, and these regulatory shifts highlight the urgency of improving Australia's approach to fugitive emissions reporting. However, this report calls into question the industry-wide shift towards site-specific emissions reporting, which may increase the emissions reporting risks identified in this report. While a parallel review of Method 2 is currently underway, this report reinforces the critical role of this review in not only re-establishing long term confidence from the coal industry, but international supply chains and observers alike. This is especially relevant in the context of increasing international trade and regulatory standards, such as the European Union's Carbon Border Adjustment Mechanism, and its regulatory requirements for Australia's metallurgical coal exports.

The last three decades of coal mine emissions reporting has shown that the sector's emissions can be significantly reduced through the closure of high emitting facilities. However, this opportunity will require proactive engagement from state and federal regulators if historical emissions declines are to continue. It will also require the proactive implementation of emerging best practice in emissions measurement, reporting and verification. If not, the coal sector's ongoing expansion risks reversing this historical emissions decline, while undermining confidence in Australia's inventory at the same time.

Supporting materials

Methodology

This report analyses fugitive emission trends and estimates from the National Greenhouse Gas Inventory and the National Greenhouse Accounts. It contrasts these results with calculations based on coal production data from Office of the Chief Economist, NSW Coal Services Annual reports and Queensland's Department of Resources.

Acknowledgement

Contributors: This report was prepared with significant input from Dody Setiawan, Sabina Assan, Reynaldo Dizon and Shiyao Zhang

Cover image: Aerial view of coal processing facility in the Hunter Valley NSW Australia. The Hunter Valley is one of Australia's largest coal mining areas.

Credit: redbrickstock.com / Alamy Stock Photo