How an accounting shift could conceal millions of tonnes of coal mine emissions

A proposal for open-cut coal mines to self-report their emissions, without external review, transparency, verification could further undermine reporting standards and reward coal miners in the process.

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About

This report investigates the historical implementation and potential implications of expanding the current application of company-led reporting for open-cut coal mines across Australia. It does so through an assessment of eight operating and two proposed coal mines, and a comparison of emission reporting under respective state-based emissions factors. This was conducted through reviews of individual mine Environmental Impact Statements, Greenhouse Gas Management Plans, and emissions and coal production reporting to the Clean Energy Regulator.

Highlights

8.5 Mt

Close to 8.5 Mt CO_2-e has been erased after three coal mines shifted their reporting methodology since the Safeguard Mechanism began.

135x

Company-led estimates have reported fugitive emissions up to 135x less than state-based estimates.

47 Mt

By 2050, under-regulated reporting could erase 47 Mt CO_2-e from only two coal mines if expansion plans are approved.

Executive Summary

How a methodology shift risks concealing millions of tonnes of emissions

The Australian government's proposed shift towards unverified company-led emissions estimates could render millions of tonnes of methane invisible, whilst satellite measurements continue to raise serious under-reporting concerns.

Australia's emissions reporting regime is under serious question. Following a year-long review of the national emissions reporting system, the Climate Change Authority recommended a series of integrated changes required to improve transparency, measurement approaches, and top down emissions verification at coal mines across Australia.

Currently, open-cut coal mines can choose to report their fugitive methane emissions through either state-based emissions factors (method 1), or company-led emissions estimates (method 2). Both of these approaches are estimates, and neither can accurately capture the nuances of methane emissions at an individual mine.

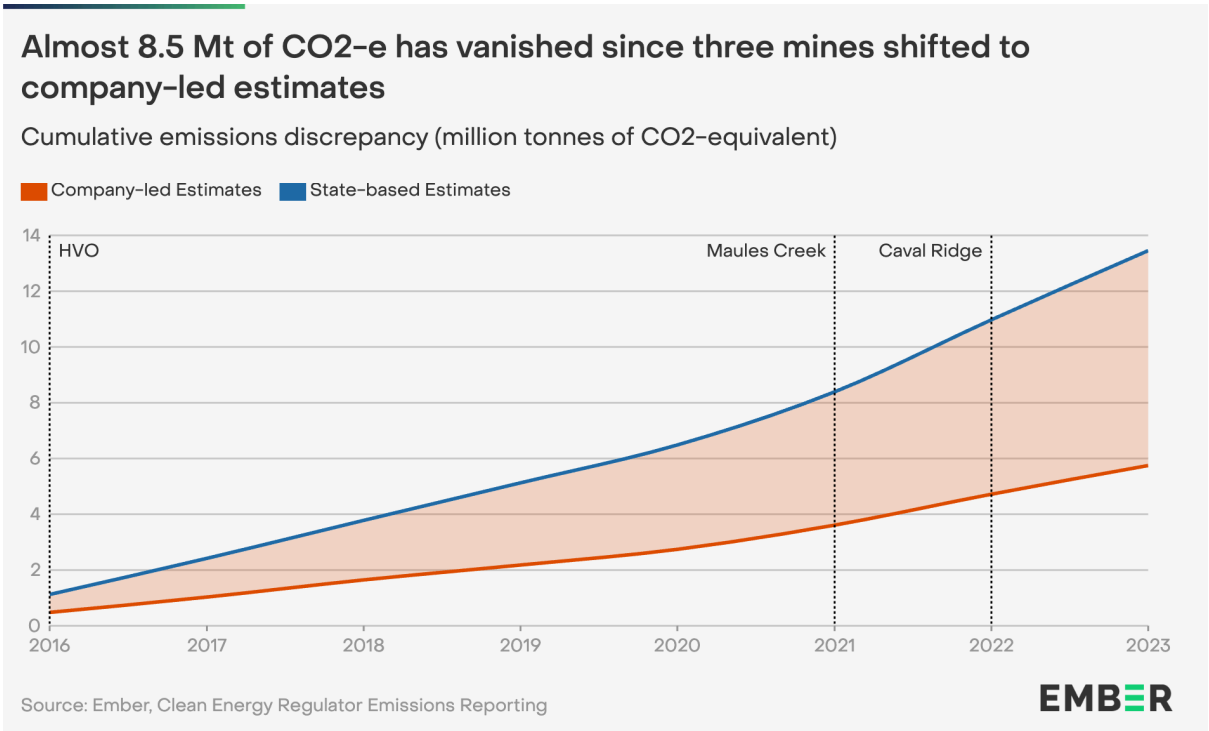
However, coal mines which have shifted from method 1 to method 2 estimates have reported dramatic reductions in their emissions reporting to date.

Through an assessment of eight currently operating and two proposed coal mines, this report will highlight how millions of tonnes of CO2-e have simply vanished from Australia's emissions inventory, as coal miners have shifted from state-based averages, to self-managed estimates. The Australian government is currently considering expanding the rollout of this reporting shift.

In 2012, when Adani considered the emissions from its proposed Carmichael mine, it **estimated emissions 135 times lower than the state based average**.

Similarly, Hunter Valley Operations coal complex have reduced their emission estimate by 5.5 Mt since shifting from state-based average in 2016. Using the same methodology shift, Caval Ridge coal mine **reduced close to half a million tonnes of CO2-e in 2021 alone**, and Maules Creek coal mine has **reduced their emissions reporting by over 1.8 million tonnes of CO2-e** since it began reporting emissions using a company-led estimate in 2021.

Collectively, these three mines may have **reduced their reported emissions by close to 8.5 million tonnes of CO2-e** since 2016. Over the last two years, when all three mines have been utilising method 2, they may have avoided an average of 2.7 million tonnes per year. This rate would be expected to increase next year, as the Queensland state emissions factor is set to increase by 35%.



These emissions estimates were all conducted through the existing reporting regime which does not have to be externally reviewed, transparently verified, and in most cases, isn't even made publicly available.

Through these examples and more, this report will highlight the risks that expanding this approach may pose, and the critical need for the government to adopt a more holistic approach to emissions measurement, reporting and verification.

Unverified company-led emissions reporting at coal mines has regularly led to an outcome you would naturally expect; the overnight erasure of hundreds of thousands of tonnes of CO2-e, without any real mitigation or a change in coal mining.

Expanding the existing, under-regulated approach to self-led reporting without holistic improvements to Australia's sovereign methane measurement and verification capacity will only further undermine the integrity of our emissions inventory, and increase sectoral unfairness across the Safeguard Mechanism.

Chris Wright
Climate Strategy Advisor - Coal Mine Methane, Ember

Holistic approach to MRV

The “urgency” of improved measurement

Australia’s approach to coal mine methane measurement and reporting needs to change, but the problem cannot be addressed with a patchwork solution.

In the last few years, Australia’s approach to measuring coal mine methane emissions has come under significant scrutiny. Following widely publicised satellite research in 2021, which suggested that open-cut coal mines could be emitting significantly more than is currently reported, there have been a wave of similar findings from Australian and international research teams.

The cumulative impact of this research has reinforced concerns that Australia's coal mining sector is severely underestimating its climate impact, especially in relation to the short term impacts of methane released during production.

Climate Change Authority review and recommended urgent updates

This came to a head last year, when the Federal government tasked the recently reinstated Climate Change Authority (CCA) to conduct a year-long review of the national emissions reporting system, with a particular focus on how coal mines currently estimate their emissions.

Their review included insights from 323 submissions, 100 meetings and three workshops with industry, science and non-governmental experts. It concluded in a scathing assessment of the existing measurement standards for coal mines, noting that “Australia has failed to keep pace with global developments and investment in methane measurement capability”.

As such, it recommended a series of integrated measures to improve transparency, measurement methodologies, and investments to develop Australia’s sovereign methane measurement capacity. Many of these recommendations were made with “urgency”.

On April 29th this year, The Department of Climate Change, Energy, the Environment and Water, **proposed to take forward only one of a series of integrated recommendations**; to

phase out the widely utilised approach to estimating methane emissions from open-cut coal mines using state-based averages, known as method 1.

This approach was developed following initial gas samples taken in 1991, with state-based averages established in 1993. Since then, the NSW state-based emission factor has increased twice, and on three occasions in Queensland. The most recent emissions factor increase in Queensland was developed after analysing more than 1000 drill samples from the Queensland Government's Petroleum Exploration Dataset, selected to exclude samples from outside active coal mine fields.

While the phase out of state-based emissions factors was clearly recommended by the CCA, they also noted that the existing company-led approach to estimating methane emissions known as method 2, is "disorderly", and needs to be reviewed "as a matter of urgency".

Instead of simply replacing one for the other, the CCA report highlighted that the key challenge for the government is not only to improve bottom-up estimates, but to institutionalise mandatory top-down verification systems across Australia's coal mining industry.

To develop this system, the CCA recommended that a panel of experts should have already been commissioned ("in the first quarter of 2024") to develop the necessary guidelines, methods and standards for "making transparent, repeatable and credible top-down measurements" across the coal industry.

Unfortunately, the government's current proposal is to phase out state-based averages, and simply expand company-led reporting (method 2) across all open-cut coal mines. This is without clarity on the recommended method 2 review, and without any changes to the existing methodology, technology or transparency.

At the same time, there is no clarity on whether any of the interrelated improvements, investments or recommended transparency changes that could vastly improve Australia's sovereign methane monitoring capacity will be undertaken. Some of which are already running late.

In this report, Ember provides the first known review of the potential impact of this shift to expand method 2, six months after the Climate Change Authority recommended the methodology be urgently reviewed due to the serious risks of selective sampling by coal miners.

Winchester South & Caval Ridge

The outlier risk of shifting to company-led estimates

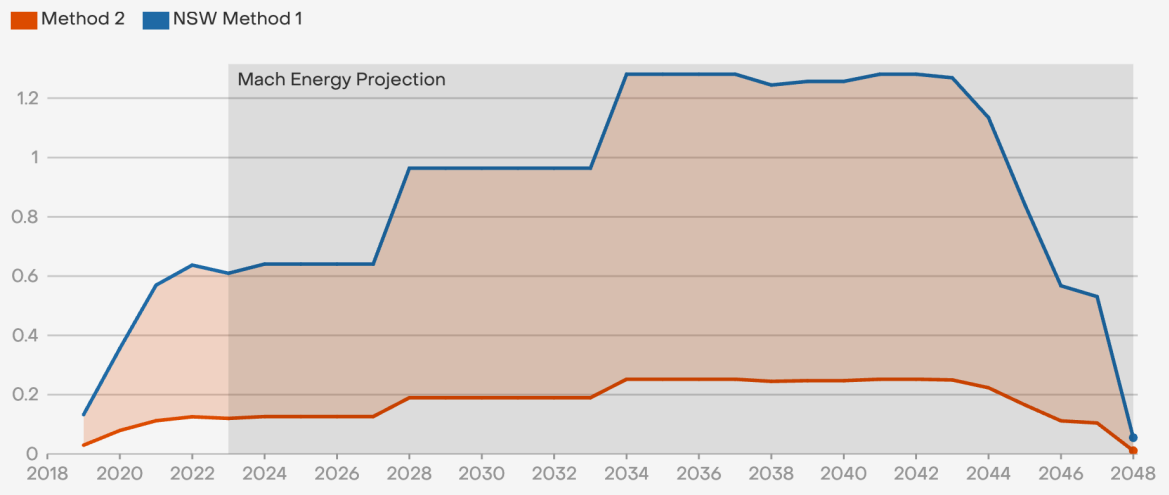
The track record of self-led reporting shows unverified emission levels far lower than state based averages; with some mines reporting over 100 times less.

The current recommendations for conducting self-led methane estimates on coal mines were developed by the Australian Coal Industry's Research Program (ACARP) and implemented in 2011.

Since that time, open-cut mine owners can choose to estimate the methane content of their mines using pre-existing state-based averages, or to individually collect as few as three borehole samples from their own mine, and develop a facility-level 3D model to estimate emissions during production.

Mt Pleasant coal mine could avoid reporting over 20 Mt of CO2-e, using an emissions estimate they did not conduct

Fugitive methane emissions (million tonnes of CO2-equivalent)



Source: Mach Energy Projection, Ember

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Companies can estimate these emissions without independent review, top-down verification, or external validation.

The results do not have to be shared publicly and are not externally reviewed. While there are recommendations for companies to reassess their estimates as mining progresses into coal seams with the potential for highly variable gas content and permeability; **Ember has yet to see a clear example of a coal mine which has voluntarily re-assessed their methane content upwards** during production.

Case Study: Mount Pleasant

In some cases, such as Mach Energy's Mount Pleasant coal mine, fugitive emissions were estimated using samples collected and analysed by a previous mine owner, 12 years before Mach Energy began mining onsite. Mach Energy was not asked to reassess their mine's gassiness, and instead uses these historical estimates to report fugitive emission levels **five times lower than the NSW state emission factor.**

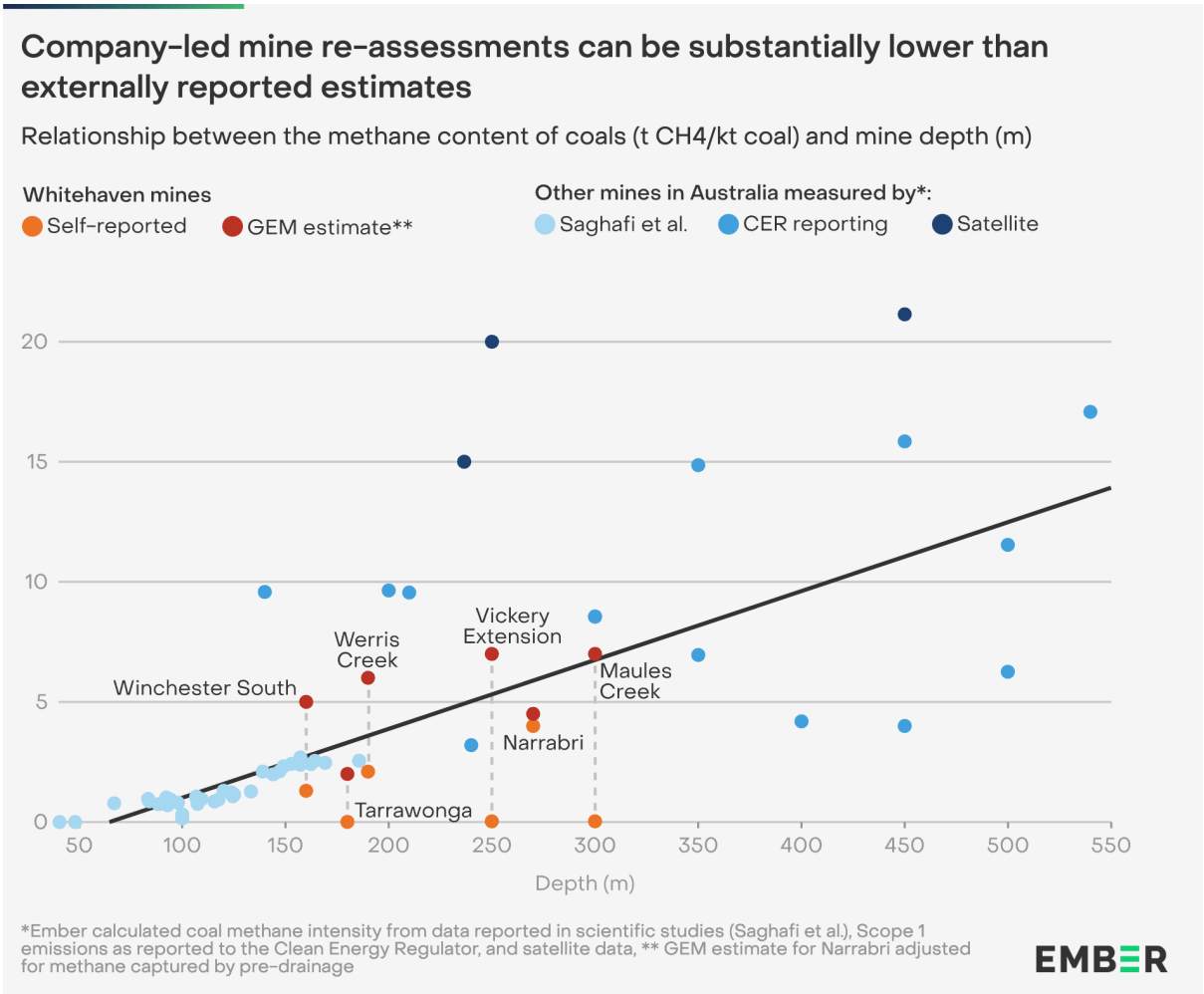
If Mach Energy had been using a State-based emission factor since they began operations in 2018, they would have reported an additional 1.8 Mt Co2-e. Over the next twenty five years, Mach Energy projections suggest their use of a method 2 emissions factor could **avoid over 20 Mt of lifetime emissions reporting,** compared to the NSW method 1. This is regardless of the fact that they did not sample, calculate or duplicate their emissions estimate at the time of reporting.

While data transparency in this environment is challenging, Ember's assessment of all known coal mines utilising company-led methane sampling and reporting approach, has **not identified a mine that has clearly chosen to estimate emissions higher than State-based emission factors**.

Case Study: Whitehaven's open-cut mines

In an assessment of five open-cut coal mines all owned by Whitehaven coal, Ember compared the reported emissions factors of Maules Creek, Tarawonga, Werris Creek, Vickery Extension and Winchester South coal mines to that of their respective state-based averages.

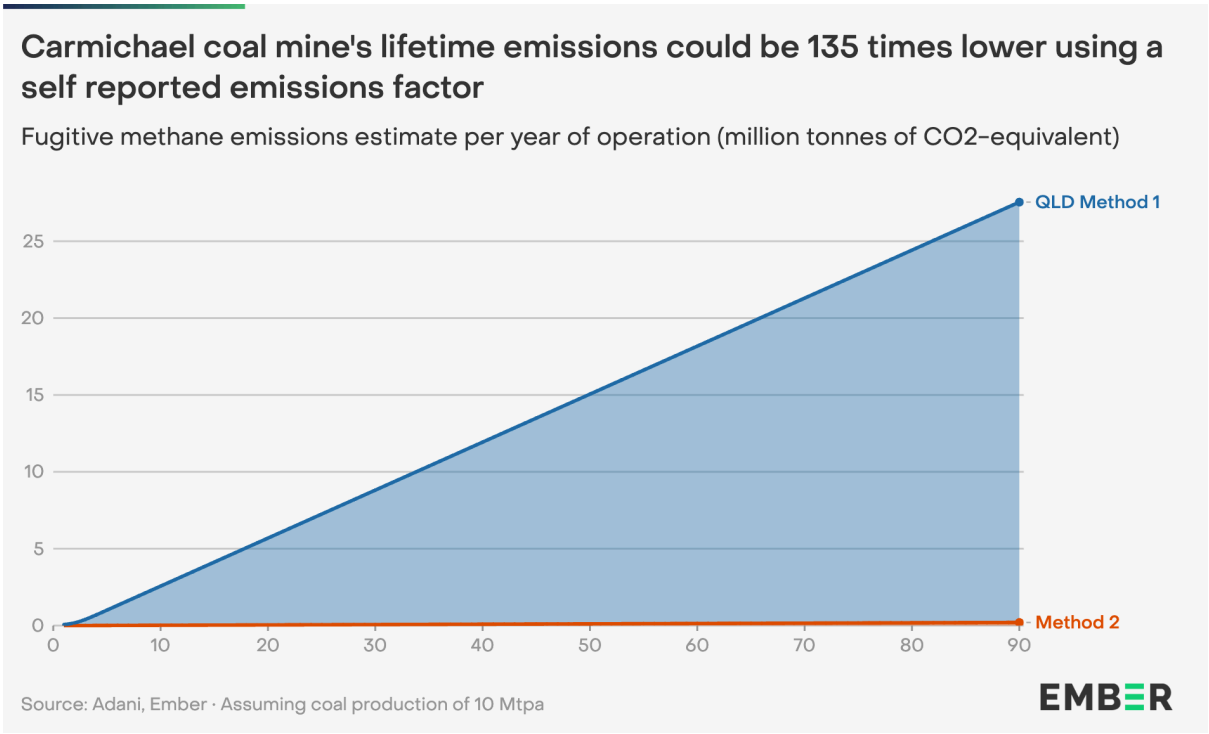
All of these mines estimate their methane emissions using method 2, which cannot be externally verified, independently reviewed or in many cases, is not even publicly available.



Through a comparison of Whitehaven's publicly reported emissions factors, EIS assessments, and an inverse assessment of their emissions factors utilising MC2M methodology developed by Kholod et al. we identified that all of these mines reported emissions well below their respective state-based emission factors. We also identified that some of these mines report emissions factors **60 times lower than the default emission factor for the region**.

Carmichael Mine

Carmichael mine, originally developed by the Adani Group, and now operated by its subsidiary Bravus, utilises an emissions estimate that is now **135 times smaller than the recommended state-based average in Queensland**.



The mine was originally approved to produce up to 60 million tonnes of coal per year, including underground operations, for 90 years. It is located in the Northern Galilee basin, which The Department of Industry and Resources identifies as having “great potential” for gas, and thermal coal production.

In their initial Environmental Impact Statement, the mine’s fugitive emissions were estimated to be 0.00023 t CO2-e/t ROM. Currently the state-based emissions factor for open-cut mines in Queensland is 0.031.

As such, their estimate is 135 times smaller than what they would be reporting if they were to use the state based emission factor.

The emissions assessment was conducted in 2012, and utilised an outdated formula for comparing the climate impacts of methane to carbon dioxide. Companies utilising self-led emissions estimates do not have to publicly share how their emission factors were generated. They also are under no obligation to keep track of new developments in climate science, and update their emissions estimates accordingly.

To the best of our knowledge, the operator is currently approved to apply this emissions factor throughout its operational life.

We have no reason to believe that the Adani Group or their Australian subsidy, Bravus, have conducted these assessments in a manner inconsistent with the recommendations of the Australian Coal Industry's Research Program. There is however, no requirement to publicly share the sampling results, methodology or algorithm applied to estimate emissions.

Comparing self-led estimates to State-based average emission factors

Utilising current production and emissions reporting data for 2022 and 2023, Ember estimated the potential impact of different estimation methods on actual emission reporting. However, the lack of clarity on how production could increase into the future, and the impact this will have on emission levels, makes forward projections challenging. This is a concern not just for independent assessments, but also for state and federal regulators charged with managing emissions levels.

At a downscaled coal production average of 10 million tonnes per year, the cumulative difference between the existing method 2 estimate for Carmichael mine, versus Queensland's state-based average, would result in a reduction of **over 27 million tonnes of CO2-e over the licensed lifetime of the mine.**

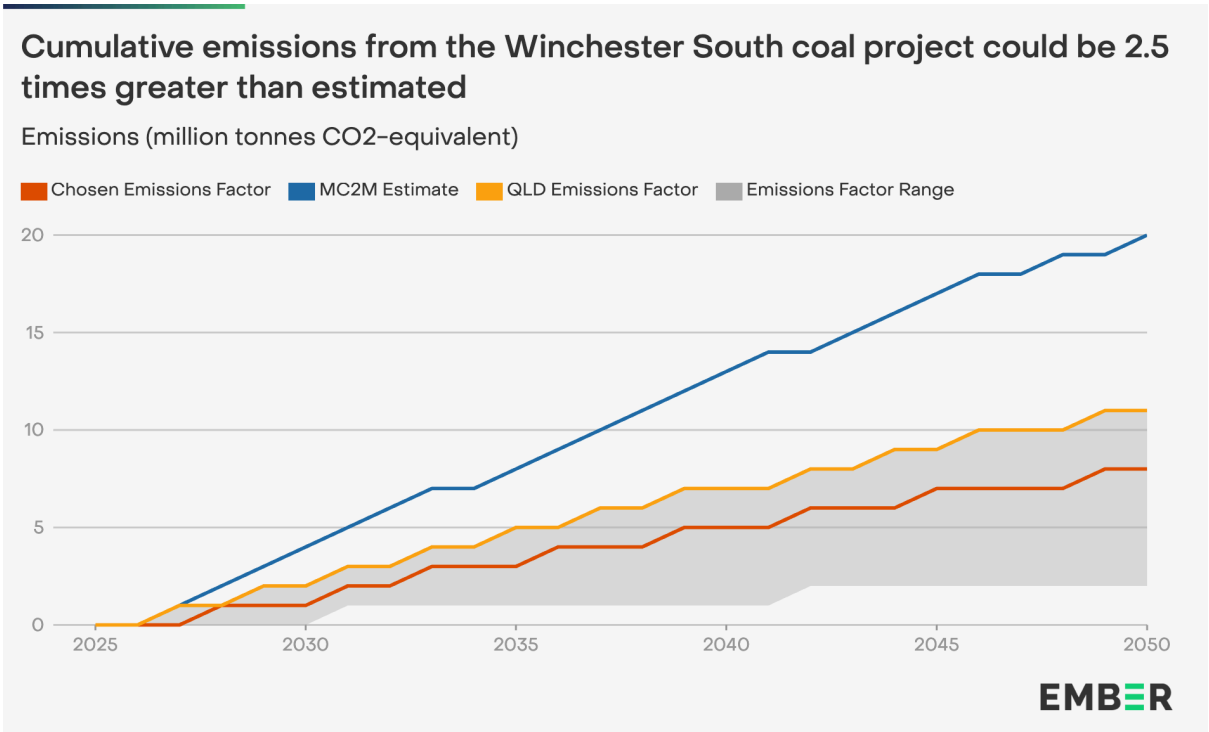
However**,** if coal production were to increase at the growth rates projected in Adani's latest earnings call, and reach the originally estimated production levels, **the difference in cumulative emissions reporting could exceed 100 million tonnes of CO2-e**.

Winchester South & HVO

The risk of approving unverified emissions

The lack of transparency relating to the current Method 2 framework for company-led estimates raises grave concerns around the impact that new mines could have on both Australia's national carbon budget and the reformed hard cap on emissions under the Safeguard Mechanism.

These concerns are highlighted in Whitehaven's use of Method 2 emission estimates at the proposed Winchester South coal mine in Queensland. If approved, Winchester South could become one of the biggest open-cut coal mines in Australia.



In June, 2021, Katestone Environmental Pty Ltd provided an estimate of Winchester South's fugitive gas emissions on behalf of Whitehaven Coal. This was based on a "geological sampling program" that Katestone Environmental did not conduct themselves, and is not publicly available. At the time, they provided a "conservative estimate" that the coal mine would release fugitive methane emissions at an average of 290,000 tonnes of carbon dioxide equivalent per year, over a 29 year operation.

This estimate shows no significant differentiation in relation to the mine's geology, even though methane emissions can differ significantly as operations expand across different sections of a coal seam, or open up new seams.

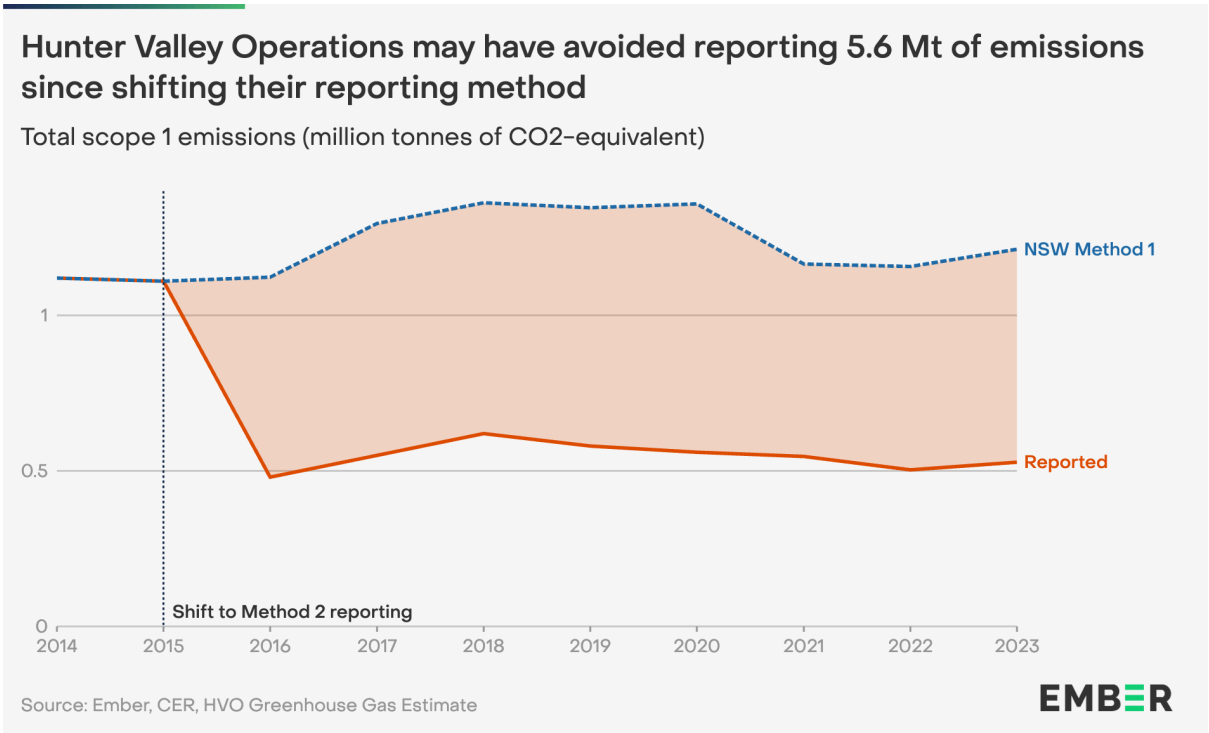
The fugitive emissions factor estimated in the Environmental Impact Statement is presented as a range between 0.006 to 0.031 tonnes of CO2-e/ tonne of ROM coal.

The difference between the upper and lower range is a factor of 5, and could lead to a yearly fugitive emissions estimate **as low as 80,000 t/CO2-e or as high as 414,000 t/CO2-e**. A full and transparent publication of the sampling and modelling methodology has not been provided, and it is unclear how the range was calculated.

Using a peer-reviewed model for calculating coal mine methane (MC2M), we estimate that **the cumulative fugitive emissions could be 2.5 times greater than originally estimated**, and demonstrate the range of variability between the lower, upper and chosen emission factors.

Hunter Valley Operations

In 2015, Hunter Valley Operations (HVO), partially owned by Yancoal and Glencore, shifted to a company-led sampling and emissions reporting regime. The mine is one of the biggest coal mines in the world, and produced over 20 million tonnes of coal between 2016 and 2017. At the same time, **its reported annual emissions dropped by 600 thousand tonnes.**



The consulting firm hired to initially assess their potential environmental impact, estimates the mine's current emissions factor to be 0.014 t CO2-e/ t ROM coal. This estimate is "based on historical NGERS reporting using method 2" and has not been updated, verified or publicly assessed ahead of its proposed expansion.

Between 2016 and 2023, we estimate that HVO would have reported over 5.5 million tonnes more Scope 1 emissions had it been using the NSW state-based emissions factor.

HVO is currently proposing to extract an additional 716 million tonnes of coal from deeper, and potentially far gassier coal seams. Its current proposal originally estimated the potential

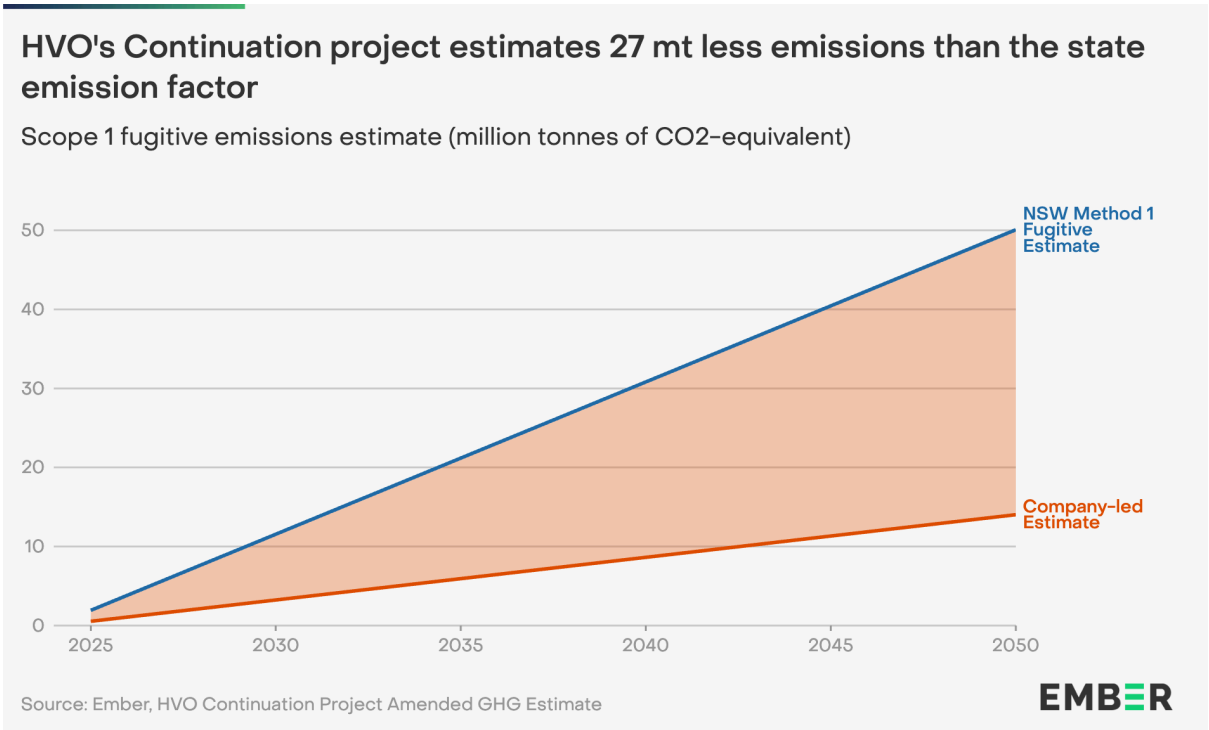
Scope 1 methane emissions from this mining using the original emissions factor applied since FY2016.

It is the largest coal mining proposal in the history of NSW, and if approved, it could be the largest coal mine expansion since the Paris Agreement.

A recent amendment to this proposal estimates an average fugitive emissions factor of 0.02 t CO2-e/t ROM across the lifetime of the proposed expansion.

Correspondence between the NSW EPA and HVO representatives this year indicates that multiple emissions factors may have been developed to estimate methane content. While not entirely clear in publicly available documents, this is an important step, as proposed mining aims progresses toward a coal seam that could be 260m deep and HVO has indicated it may have a gas content of up to 0.13328 t CO2-e / ROM t.

Over the lifetime of the mine, total fugitive emissions are still projected to be 3 times lower than the current NSW state average emissions factor.



Maules Creek & Caval Ridge

Method 2 estimates since the Safeguard Mechanism began

Two coal mines have shifted their emissions reporting since the Safeguard Mechanism began, erasing over 1 million tonnes of CO2-e per year.

Once a coal mine begins operations, emissions can vary significantly. This depends on a range of factors, but can include the gassiness of the particular section of the coal mine, permeability of the coal, pressure changes, and the unexpected release of methane through natural fractures in neighbouring seams and overburden strata.

Neither state-based emissions factors or the current implementation of guidance around method 2 reporting appropriately account for these nuances in mining. This is one of many reasons why the CCA recommended that Australia adopt a diverse, bottom-up and top-down approach to coal mine emissions measurement and verification.

Without a verifiable, ongoing approach to measuring emissions from their inception, one-off company-led samples conducted after production begins could overlook significant emissions releases in the mine's recent past, and future.

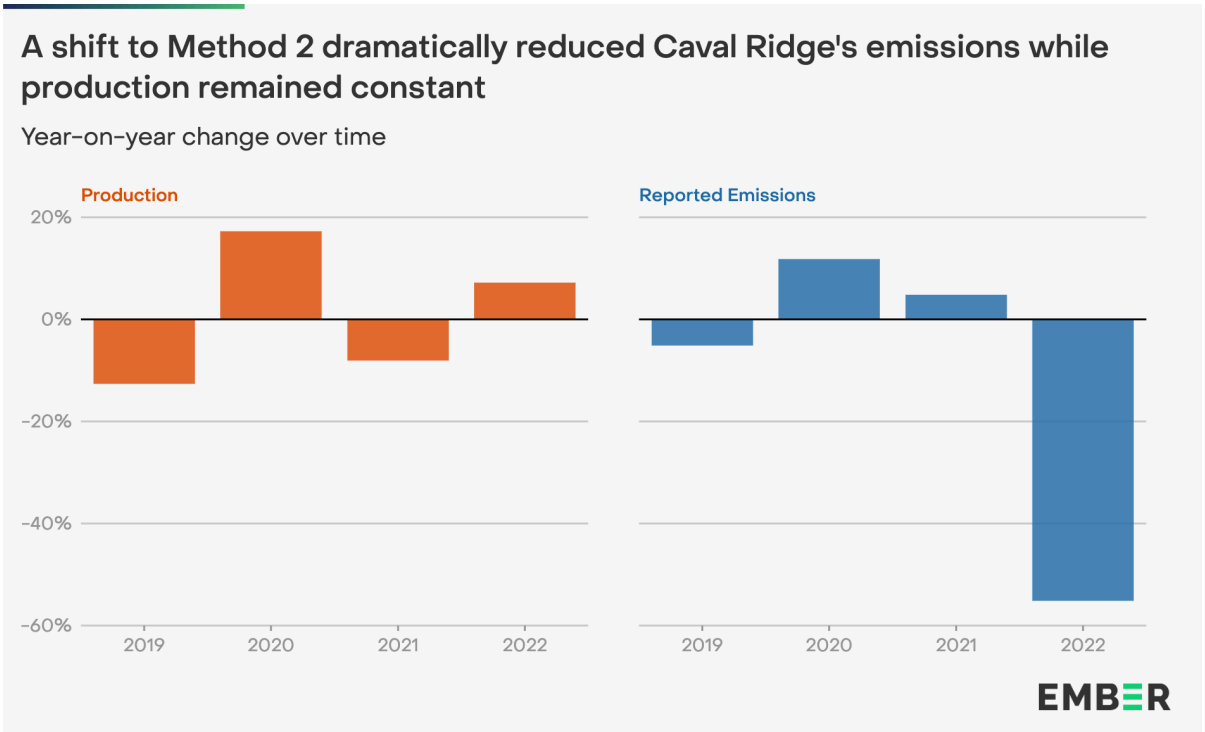
Since the Safeguard Mechanism began, there have been two coal mines that have shifted their fugitive emissions reporting approach from a state-based emissions factor to a method 2 estimate. These are Maules Creek and Caval Ridge coal mines.

In the process, **these two coal mines have collectively reduced their reported emissions by close to 1 million tonnes per year.**

Caval Ridge Coal Mine

BMA's Caval Ridge is Australia's largest metallurgical coal mine, producing an average of 14.5 million tonnes of some of the highest calorific coal in Australia. This indicates that the coal has a high potential to release significant amounts of gas when mined.

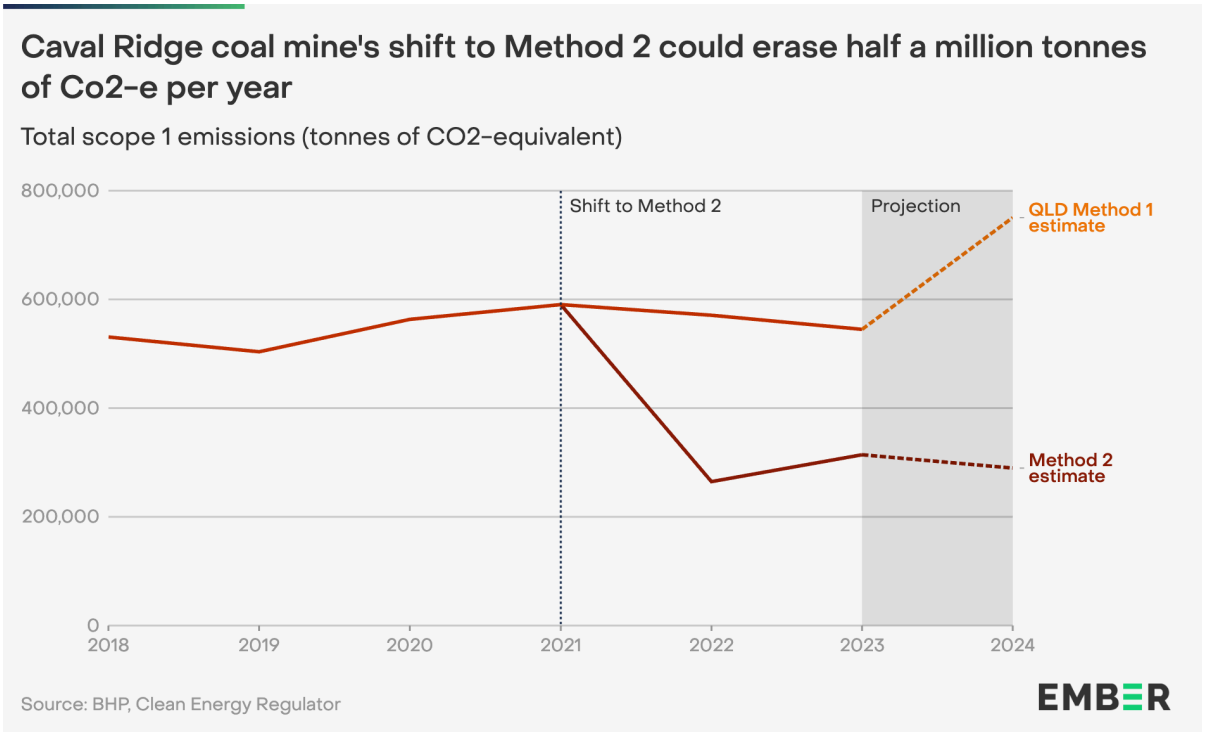
Between 2018 and 2021, Caval Ridge coal mine utilised the Queensland method 1 emissions factor to report an average of 550 thousand tonnes of CO2-e per year. This incorporates not only their fugitive methane emissions, but all Scope 1 emissions converted to carbon dioxide equivalent. This placed them as one of the highest emitting open-cut coal mines in Australia.



In 2021, Caval Ridge chose to shift from using method 1 to use a company-led, method 2 estimate for the 2021-22 reporting year. This led to a dramatic reduction in the mine's reported emissions and emissions intensity which dropped by half while production actually increased by 1 million tonnes of coal.

The mine is estimated by GEM to currently be mining at a depth of 60m. According to the IPCC's guidelines on fugitive methane (based on NGERs sampling from 2009 - 2017), they would recommend utilising a "High CH4 Emission Factor" of 2 m3/t ROM for a mine of this depth. This is equivalent to a recommended emissions factor of 0.038 t CO2-e/ t ROM coal.

In the months before BMA decided to reassess the methane emissions factor, the operator set a world record for the largest electronic blast, which shifted 4.7 million cubic metres of overburden. This amount of overburden removal and strata disruption was almost certain to cause significant levels of methane desorption across the surface mine, which raises significant concerns around the timing of the methane reassessment.



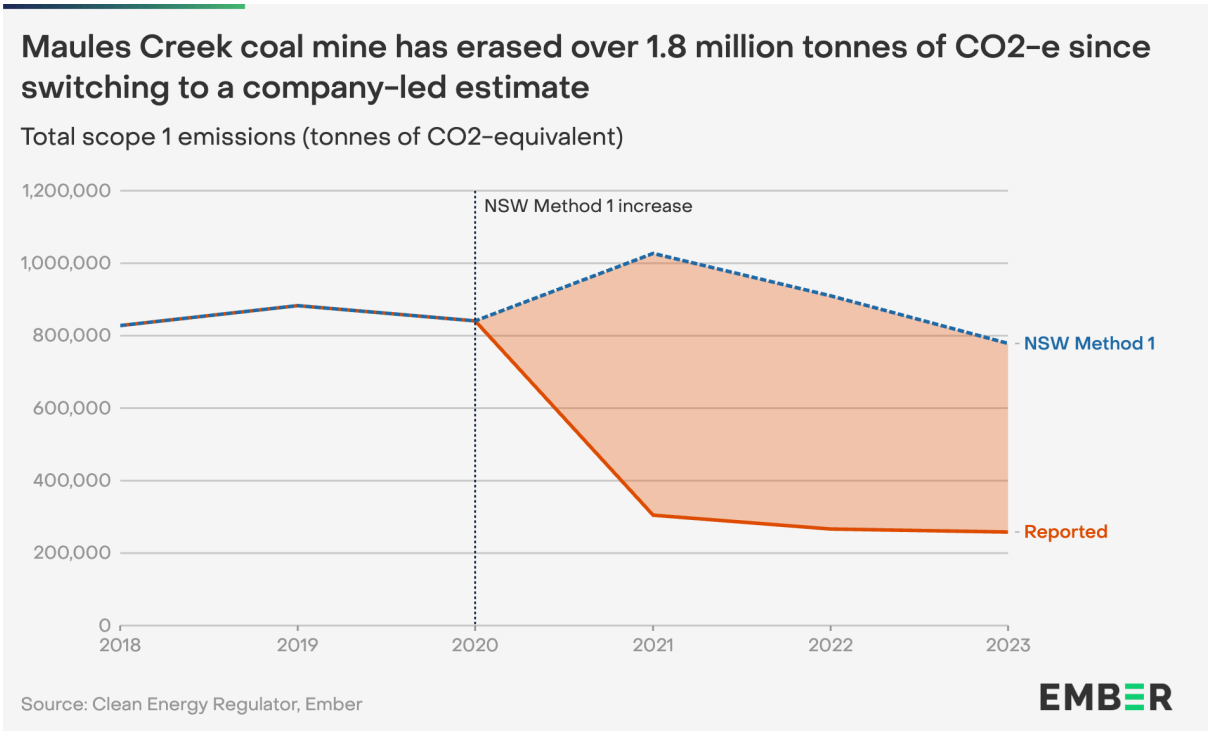
Had BMA not shifted its emissions estimation methodology in 2021, we estimate that it would be reporting close to 750 thousand tonnes of CO2-e in 2024, assuming average production since 2020 and incorporating the updated Queensland emissions factor for fugitive methane.

Assuming that the average reported fugitive emissions intensity since 2022 remains constant, we estimate their potential company-led reporting of scope 1 emissions next year will be closer to 289,757 t CO2-e in 2024.This amounts to **an annual emissions gap of over 460 thousand tonnes**.

Maules Creek Coal Mine

Maules Creek coal mine produces over 10 million tonnes of coal per year, including a significant proportion of metallurgical coal and the "highest quality high energy thermal coal".

Between 2016 and 2018, Maules Creek utilised the NSW State-based emissions factor. As a result, it was one of the highest emitting mines in Australia. In 2019 Whitehaven voluntarily undertook an internal re-estimation of the methane intensity of Maules Creek Mine, and estimated that the mine-specific emission factor to be **65 times lower than the regional (NSW) default emission factor.**



Safeguard

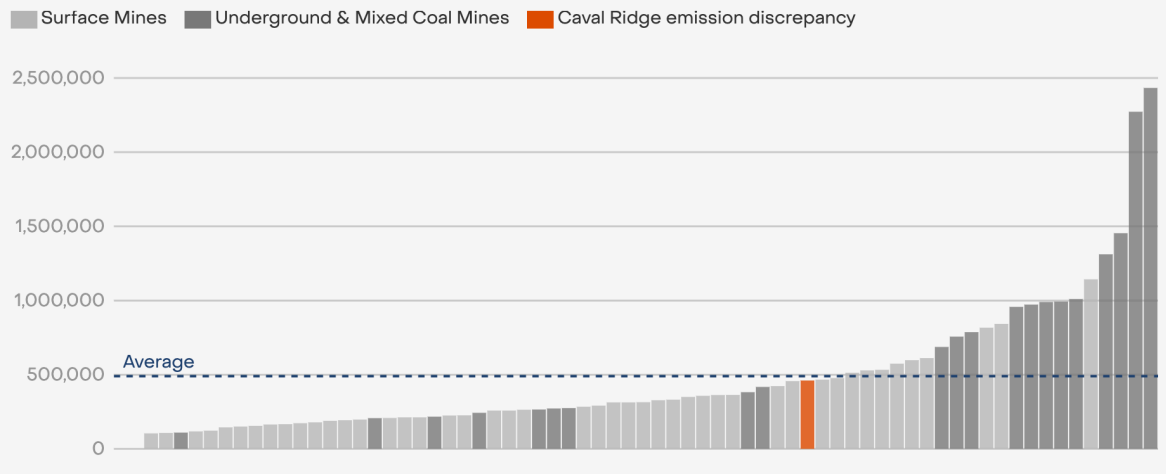
Impacts on the Safeguard Mechanism

Locking in a company-led emissions reporting regime without critical bottom-up adjustments and top-down verification could undermine the integrity of the Safeguard Mechanism for years to come.

Last year, 68 coal mines reported under the Safeguard Mechanism, with a wide range of emissions per facility. Some of Australia's biggest emitting coal mines, such as Appin colliery and Moranbah North, both reported in excess of 2 million tonnes of carbon dioxide equivalent each. As underground mines, both coal mines have to measure their methane directly, with periodic measurement at their ventilation shaft.

Caval Ridge's methodology shift alone erases the equivalent emissions of an entire coal mine

Reported coal mine emissions under the Safeguard Mechanism (CO2-e)



Source: Ember, CER 2022-2023 · Each bar represents a coal mine

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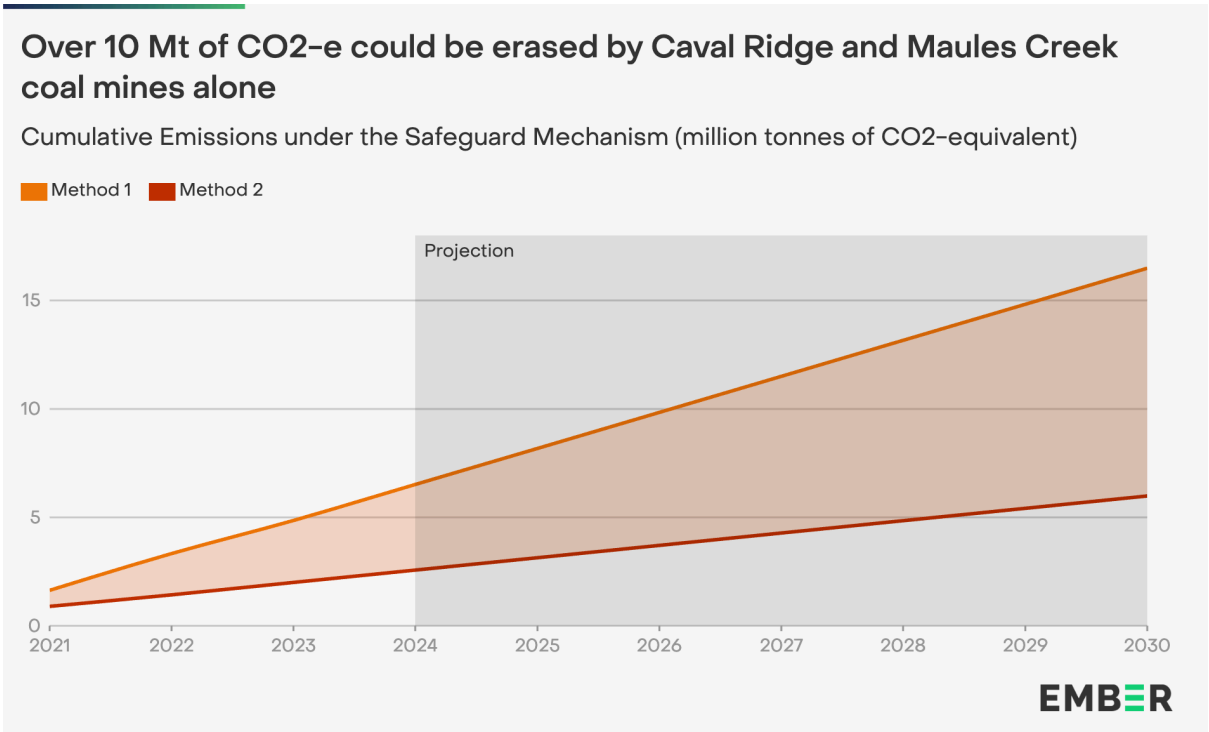
The average emissions across all coal mines reporting under the Safeguard mechanism in FY23 was 489,597 t CO2-e. The median emissions reported was 320,857 t CO2-e.

We estimate that the difference between BMA's Caval Ridge coal mine utilising state-based method 1 and company-led method 2, could be an emissions reporting shift equivalent to 460,859 t CO2-e.

As a result, **this reporting shift alone is equivalent to erasing more than the annual median emissions for a coal mine reporting to the Safeguard Mechanism**, and very close to erasing the average emissions reported by coal mines in 2023.



Over the course of a decade, the scale of emissions downscaling highlighted by Caval Ridge and Maules Creek has a material impact on the Safeguard Mechanism's total reporting.

The Climate Change Authority estimates that 75% of currently reported coal mine methane emissions from Qld and 25% from NSW are estimated using method 1. If the government's current proposal goes ahead, it would shift a significant number of coal mines across to method 2, which we estimate, would dramatically add to the cumulative emissions erasure displayed above, unless significant amendments are made to prevent it.

Conclusion

We need to get reporting right

A simplistic shift toward company-led reporting without a critical tightening of existing regulations risks further underestimating Australia's coal mine methane, and undermines efforts to actually reduce real emissions.

State-based emissions factors are simply too coarse, and out of place in the emissions inventory of an advanced economy. Method 1 is unable to account for the nuances of methane emissions at each individual mine. The lack of data specificity also disincentives mitigation opportunities, such as the capture and beneficial use of open-cut waste mine coal gas from operations. Considering the incredible advancements in site and source-based emissions reporting over the last thirty years, it is certainly appropriate to to improve or replace this approach.

However, its broad application does currently ensure that Australia's coal mine emissions reporting remains within the range of the IPCC's recommended emission factors. Over time, it has also been able to gradually account for updates and improvements in sampling in both NSW and Queensland.

In contrast, the historical implementation of method 2 has enabled individual coal mines to estimate emission factors more than 100 times lower than state averages. In contrast to method 1 companies applying the self-monitored approach have not actively sought to improve estimations since originally outlined in 2011 .

More so, the lack of specificity, transparency and diversity around coal sampling requirements not only brings the methodology into question, but makes assessing these emission factors incredibly difficult. The lack of requirements to regularly update sampling approaches, or to have samples and estimation calculations reviewed by independent third parties are also clear gaps in the existing reporting legislation. Finally, the inability for any of these estimates to be adjusted over time, as reporting and verification methodologies improve, has and will continue to undermine the integrity of Australia's coal mine emissions inventory. These are all regulatory shifts that could be easily made to improve the accuracy,

transparency and trust in both the existing and any expanded company-led reporting approaches going forward.

With growing satellite evidence, it is becoming increasingly clear that Australia's open-cut coal mine methane emissions may already be significantly underestimated. The historical trend towards further under-reporting utilising method 2 should therefore be a cause for serious concern.

Without significant transparency amendments to the reporting methodology, the diversification of bottom up sampling, and the crucial back-stop of top-down verification, there is no reason to believe that this trend will not continue.

An expansion of this approach without significant regulatory improvements, would likely not only undermine the integrity of our emissions inventory, but challenge the sectoral fairness of the Safeguard Mechanism. Ahead of Australia's bid to host COP31, it would also directly contradict our commitments to improving emissions reporting under the Global Methane Pledge.

In the analysis above, we have highlighted how method 2 has been implemented across seven operating and two proposed coal mines. All of these case studies raise serious concerns in both the existing implementation, transparency and end results of utilising a coarse, unverified approach to company-led emissions reporting.

The shift to a reporting regime for open-cut coal mines exclusively utilising method 2-led measurement without conducting a thorough review of the implications and opportunities for improving company-led emissions reporting, poses material risks to the integrity of Australia's coal mine emissions inventory. This should not be undertaken without further review, and a timely and holistic implementation of the Climate Change Authority's remaining recommendations.

Supporting Materials

Disclaimer

The findings in this report are based on publicly available reported emissions and estimates pursuant to Australia's greenhouse and energy reporting scheme. That scheme adheres to UNFCCC reporting requirements recommended by the IPCC, but does not reflect industry best practice methane measurement, reporting or verification as highlighted by UNECE, and may produce inaccurate methane emissions estimates.

We have noted where reported emissions or estimates may be substantially lower than the actual amount of methane released. This information has been prepared as information or education use only, and does not constitute financial, legal or other professional advice.

The information in this report has been prepared using the material outlined below and although the findings in this report are based on an analysis of that material, no warranty is made as to the completeness, accuracy or reliability of the statements or representations that arise from the material gathered to conduct this analysis. Ember did not have access to any of the listed companies' internal emissions data, nor emissions data that may be available to State regulators.

Methodology

Emissions Estimates

Method 1 emissions estimates were identified in Environmental Impact Statements and Annual Reports where possible, and reconstructed where not publicly available. Forward coal production projections were collected in a similar manner, particularly for greenfield mines and those seeking extensions or expansions. When not available, short term production projections were estimated based on average coal production over the last four years, and cross-checked against company estimates. If not publicly available, historical emission gaps between method 1 and method 2 were estimated based on reporting under the Clean Energy Regulator, historical method 1 emission factors, and estimated diesel emissions per tonne of coal production.

Coal methane intensity from Australian coal mines

Ember compiled methane emissions data from coal mines in Australia from the following sources:

- Scope 1 emissions from underground coal mines reporting to the Clean Energy Regulator were used to estimate mine methane intensity. Methane was assumed to be responsible for 80% of reported Scope 1 emissions.

- Gas content at open cut coal mines was compiled from the academic paper by Sagahfi et al. 2013 "Estimating greenhouse gas emissions from open-cut coal mining: application to the Sydney Basin".

- Estimates of methane emissions from satellite data were compiled from the research paper by P. Sadavarte et al., 2021 "Methane Emissions from Super-emitting Coal Mines in Australia quantified using TROPOMI Satellite Observations".

- Other satellite data was gathered from estimates of methane emissions fluxes of plumes detected in Australia by Carbon Mapper. The methane emissions detected are assumed to be constant, and calculated as yearly emissions.

Methane emission estimates were compared against best estimates for annual coal production and depth of coal per mine. Coal production and depth were determined through Annual Reports, EIS estimates and company websites.

Estimating emissions reporting from Carmichael Mine

Clarifying the current and future coal production of the Carmichael mine is challenging. In the last two years of mining, Bravus has reported producing 2.7 and 4.8 million tonnes of coal per year. On their website, Bravus also notes that the Carmichael mine has downscaled its initial production potential, to an average of 10 million tonnes of coal per year.

However, in Adani's latest earnings call for investors, Adani Enterprises Director, Mr. Vinay Prakash, noted that the "Carmichael mine production increased by 47% to 11.2 million metric tonnes" in FY24. He also noted that the mine's production would be expanding from "11.2 to 14-15 million tonnes" in the next year. At this rate of growth, they could potentially reach their originally proposed surface mining production levels of 48 million tonnes per year before 2030.

As such, the emissions estimate is developed utilising the emissions factor provided in the mine's Environmental Impact Statement, highlighting how emissions could change over the years of the mine's licensed operations. The estimate provided in the graph is utilising the conservative estimate of downscaled production currently provided by Bravus, while an additional estimate is provided taking into account current production growth rates to 2028, assuming originally proposed production levels from then on.

Estimating emissions reporting from HVO Continuation project

Current emissions for HVO have been developed using publicly available emissions reporting to the Clean Energy Regulator, as well as company documents.

Forward projections of emissions for HVO's Continuation project have been developed according to the most recently amended greenhouse gas management plan submitted by EMM on HVO's behalf.

Correspondence between the NSW EPA and HVO representatives this year indicates that multiple emissions factors may have been developed to estimate methane content. In a letter dated 17 June 2024, HVO noted that emissions are expected to increase "specifically, the deeper coal reserves in gas Domain 1, zones 3 and 4 with methane-rich gas contents between 5 and 7m3 /t." The estimate of the gas content indicates that the fugitive emissions alone in zones 3 & 4 could be between 0.0952 to 0.13328 t CO2-e /ROMt.

Clarity on these emission factors is not publicly available, nor is a corresponding outline of coal production over time across potentially differing domains or zones where different emissions factors may be applied. As such, fugitive emissions have been projected using an average emission factor based on total coal production and total estimated fugitive emissions over the lifetime of the proposed extension, according to the latest amended fugitive emissions update.

Global Energy Monitor Estimates

Global Energy Monitor employs its Global Coal Mine Tracker to estimate methane emissions at individual mine levels worldwide, aggregating the data on national and global scales. The tracker monitors operational coal mines producing 1 million tonnes or more per year, and smaller operations with available data, providing baseline estimates for coal mine methane emissions. These estimates utilise mine-level activity data, such as production, operating depth, methane content at depth, and emissions factors, following the peer-reviewed Model

for Calculating Coal Mine Methane (MC2M) methodology. In cases where precise coal rank and depth data is lacking, supplemental estimates are included for underground and surface operations.

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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.

Cover image

The Exevale open cut pit at Glencore's Hail creek coal mine, Australia.

Credit: The Sunrise Project