Low Emission Technology Australia

Submission to the Climate Change Authority, *Fossil Methane: a near-term abatement opportunity* (the Consultation Paper)

Key points

- Low Emission Technology Australia (LETA) is a fund established in 2006 by the Australian black coal industry to invest in technologies that significantly reduce emissions and support the transition to a low emission global economy, in line with the Paris Agreement.
- LETA partners with government, research institutions, universities and industry locally and internationally to develop projects that can, over time, reduce and remove greenhouse gas emissions from large-scale industrial processes in Australia such as power generation, steel and cement manufacturing, on-site emissions reduction in mining, and future energy sources. Further information about LETA can be found on our website, at www.letaustralia.com.au.
- LETA welcomes the opportunity to provide a submission to the Authority on its Consultation Paper. LETA's submission is informed by its technical work program, best-practice reviews, and ongoing investment in the research, development and demonstration of methane abatement technologies.
- LETA also supports the submissions that has been provided to the Authority by the Minerals Council of Australia and the Australian Industry Greenhouse Network.
- Ventilation air methane (VAM) abatement is one of the most promising pathways for suitable underground coal mines, subject to site-specific safety, technical and commercial constraints. Given methane's relatively high global warming potential, reducing emissions from mine ventilation systems provides a practical opportunity for the sector to demonstrate leadership in emissions management where deployment can be achieved safely and cost-effectively.
- To date, LETA has allocated nearly $60 million to VAM abatement projects on behalf of industry, supporting critical research and development of this technology. LETA's investment in VAM abatement technology is on track to reach almost $100 million by 2030.
- LETA's investments in Regenerative Thermal Oxidisers (RTOs) and catalytic oxidation technologies are designed to build the technical and safety evidence base needed to support the deployment of emissions reduction technologies that are reliable, commercially viable, and compatible with Australia's rigorous safety standards.
- By progressing both relatively mature and emerging technologies, LETA is helping to ensure that practical emissions reduction options can be deployed across a range of mine conditions.
- Methane abatement policy should be ambitious, practical, technology-neutral and grounded in operational reality. Australia does not require a new methane-specific regulatory architecture. Existing frameworks, particularly the Safeguard Mechanism, already provide strong incentives for methane reduction and should remain the primary national policy framework.
- Policy should focus on removing barriers to deployment, rather than imposing additional mandates or methane-specific targets.
- With that in mind, LETA recommends that the Authority's advice to the Australian Government:
    - Maintains the Safeguard Mechanism as the national framework for methane emissions reduction.
    - Avoids duplicative or conflicting Commonwealth and state requirements, particularly in NSW and Queensland where methane-related measures are already being introduced.
    - Recommends co-funding demonstration projects and the early deployment of emerging technologies, particularly VAM abatement technologies, building on previous funding provided by the NSW and Australian Governments.
    - Maintains mine safety as the overriding priority in all policy and deployment decisions.
    - Rewards measured emissions reductions rather than mandating specific technologies.

INTRODUCTION

Low Emission Technology Australia (LETA) is a fund established in 2006 by the Australian black coal industry to invest in technologies that can significantly reduce emissions and support the transition to a low emission global economy, in line with the Paris Agreement.

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LETA welcomes the opportunity to provide a submission to the Authority on its consultation paper, *Fossil Methane*[1]*: a near term abatement opportunity* (the Consultation Paper). LETA also supports the submissions that has been provided to the Authority by the Minerals Council of Australia and the Australian Industry Greenhouse Network. LETA's submission is also directly relevant to the Authority's *2026 Annual Progress Advice* consultation paper, consultation for which is running in parallel to engagement on this Consultation Paper.

The following sections provide LETA's comments on relevant aspects of the Consultation Paper, including responses to the Consultation Questions posed in the paper and recommendations to inform the Authority's advice ahead of its finalisation, submission to Government, and publication.

LETA members are committed to reducing emissions across the coal value chain and advancing technologies that can deliver meaningful abatement while supporting safe and productive operations. Ventilation air methane (VAM) abatement is one of the most promising pathways for suitable underground coal mines, subject to site-specific safety, technical and commercial constraints. Given methane's relatively high global warming potential, reducing emissions from mine ventilation systems provides a practical opportunity for the sector to demonstrate leadership in emissions management where deployment can be achieved safely and cost-effectively.

To date, LETA has allocated nearly $60 million to VAM abatement projects on behalf of industry, supporting critical research and development of this technology. LETA's investment in VAM abatement technology is on track to reach almost $100 million by 2030.

An overview of LETA's methane abatement investment portfolio can be found at Attachment 1. An overview of other industry led methane abatement projects can be found at Attachment 2.

This investment portfolio, together with the Case Studies and other project examples presented in this submission and the project examples provided in the Minerals Council of Australia submission[2], collectively tell a compelling story: Australian coal producers are already reducing methane through drainage, utilisation and flaring projects; pioneering VAM technologies through demonstration projects; investing in next-generation solutions; and seeking to work with governments and researchers to overcome technical and safety barriers.

[1] Throughout this submission, LETA refers to "fugitive emissions" and "methane emissions", and does not use the term "fossil methane", which it considers to be imprecise and unnecessarily loaded.

[2] Together with LETA's submission, the Minerals Council of Australia's submission provides an overview of the history of methane abatement projects led by industry and a non-exhaustive range of methane abatement projects being assessed, planned or implemented by Safeguard Mechanism-covered facilities in response to the broader commercial and compliance environment, particularly the Safeguard Mechanism.

In methane abatement, LETA's work has focused on three areas:

1. Technical feasibility and safety: including the development of functional safety cases for VAM abatement systems connected to primary mine ventilation systems, safe connection duct architectures, isolation, flame arrest, dilution, and default-to-atmosphere arrangements in the event of equipment trips.
2. Demonstration readiness for regenerative thermal oxidisers (RTOs): including work with member companies to establish first-of-a-kind large scale demonstrations of VAM abatement at Australian mine sites.
3. Catalytic oxidation research and development: including pilot-scale work on catalysts that may oxidise methane at lower temperatures and at lower methane concentrations than are practical for RTOs.

LETA's investments in RTOs and catalytic oxidation technologies are designed to build the technical and safety evidence base needed to support the deployment of emissions reduction solutions that are reliable, commercially viable, and compatible with Australia's rigorous safety standards. By progressing both relatively mature and emerging technologies, LETA is helping to ensure that practical abatement options can be deployed across a range of mine conditions.

While a significant portion of LETA's methane abatement portfolio has focused on VAM from underground coal mines, its work program has increasingly expanded to address fugitive methane emissions across all mining methods, including open-cut operations. Through workshops, technical forums, industry collaborations and project assessments, LETA has observed growing interest in practical, cost-effective and measurable methane reduction opportunities across a wide range of operating environments. This reflects the continuing challenge of methane abatement across the Australian coal industry, where proven drainage, flaring and utilisation technologies are only suitable in certain circumstances and material emissions reduction pathways are not yet universally available or economically viable. As companies continue to evaluate emerging technologies, alternative mine planning approaches, drainage strategies and methane utilisation opportunities, policy frameworks should adopt a technology-neutral approach that rewards measured emissions reductions regardless of mining method or technology pathway, thereby supporting ongoing investment and innovation across all methane sources.

Case Study 1 highlights LETA's early involvement in VAM abatement technology development.

Case Study 1: Centennial Coal's Mandalong VAM Demonstration Project and the Foundations of Australia's Methane Abatement Program

One of the most important milestones in Australia's methane abatement journey was the demonstration-scale VAM oxidation project at Centennial Coal's Mandalong Mine in New South Wales. Developed with support from LETA, together with Coal Innovation NSW and technology developers, the project, which was undertaken during 2009-2013, was one of the first attempts globally to safely connect an RTO directly to an operating underground mine ventilation system.

The project was established not simply to test methane destruction technology, but to address the far more challenging question of how such systems could be safely integrated into Australian coal mines under some of the world's most stringent mine safety requirements.

The Mandalong project became a foundation stone for much of the methane abatement work that followed. Through LETA's investment, the project helped develop and validate concepts that remain central to Australian VAM deployment today, including functional safety cases, safe connection duct architectures, flame arrest systems, pressure relief mechanisms, isolation arrangements and fail-safe "default-to-atmosphere" operating modes. These engineering and safety principles continue to inform the work now being undertaken through LETA's methane abatement portfolio and have helped establish the technical and regulatory confidence needed for larger commercial projects.

Importantly, the Mandalong project demonstrated that methane abatement is not simply a technology deployment challenge. It highlighted the need for extensive engineering design, safety validation, regulator engagement and operational integration before commercial implementation can occur.

The lessons learned from Mandalong helped shape subsequent Australian research programs, including CSIRO's VAMMIT and catalytic oxidation technologies and the wider industry effort to develop practical pathways for reducing fugitive methane emissions from underground coal mining.
The project remains a strong example of how long-term industry investment, through LETA, has created the technical foundations required for future methane abatement deployment. More than a decade before methane became a major policy focus, the Australian coal industry was already investing in demonstration projects that sought to understand how meaningful methane reductions could be achieved safely, credibly and at commercial scale.

Perhaps most importantly, it created the technical and regulatory knowledge base that has enabled subsequent investment in large-scale VAM abatement projects and emerging catalytic oxidation technologies across the Australian coal industry.

Today, many of the safety frameworks and engineering principles emerging from the Mandalong project continue to underpin LETA's work in advancing VAM abatement technologies across the coal industry.

LETA's approach is technology-neutral. Abatement technologies should be assessed according to safety, technical feasibility, emissions impact, cost-effectiveness and real-world deployment potential. Implementation pathways must be realistic, staged, and grounded in technical and safety evidence.

LETA supports practical and measurable methane abatement, and policy settings that support the development of these technologies by reflecting the heterogeneity of emissions sources, site conditions, safety requirements, and technology readiness.

With that in mind, this submission is informed by LETA's technical work program, international best-practice reviews, and ongoing investment in the research, development and demonstration of methane abatement technologies.

LETA's central recommendation is that methane abatement policy should be ambitious but grounded in operational reality. A successful policy framework should:

- Recognise that current policies, especially the Safeguard Mechanism, already create significant incentives for methane abatement, is already encouraging action, and should remain the central national framework for emissions reduction from large industrial facilities. The Authority notes that the Safeguard Mechanism covers around 75 per cent of Australia's methane emissions, including vast majority of coal mining facility methane emissions.

- Avoid introducing Commonwealth requirements that duplicate, conflict with, or undermine existing state regulatory frameworks, particularly where decisions regarding the deployment and timing of abatement technologies must be informed by site-specific safety requirements and technical feasibility assessments. This is particularly relevant in New South Wales and Queensland, where methane abatement obligations are already established.
- Prioritise commercially ready abatement where it is technically and safely feasible, including pre-drainage, post-drainage, flaring and utilisation of drained gas and RTO deployment at suitable underground coal mines.
- Support targeted demonstration and early deployment of VAM abatement, rather than impose blanket mandates. RTOs can materially reduce VAM emissions at mines with sufficiently stable and elevated methane concentrations, but many Australian underground coal mines operate below the approximate 0.4 per cent methane threshold required for self-sustaining operation.
- Invest in next-generation catalytic oxidation technologies, which may be better suited to lower-methane-concentration ventilation streams but remain at an earlier stage of development and require further work on catalyst durability, contaminant tolerance, safety integration and mine-scale project economics.
- See governments work with LETA to co-fund development of promising VAM abatement technologies. Governments should avoid approaches that impose separate methane targets or differential declines rates for Safeguard Mechanism facilities.

LETA recommends that the Authority's advice support a nationally consistent, staged and technology-neutral approach to methane abatement that rewards measured emissions reductions, supports demonstration and innovation, and preserves mine safety as the overriding priority.

OVERALL COMMENTS ON THE CONSULTATION PAPER

LETA agrees with the Authority that methane emissions reduction opportunities warrant serious policy attention. Methane has a stronger warming effect than carbon dioxide in the near term and reducing methane emissions can deliver relatively rapid climate benefits.

However, the consultation should not be treated as evidence that action by the industry on methane abatement is inadequate or that a wholly new methane-specific regulatory architecture is required. The Authority's paper itself identifies on page 26 two different but related explanations for why more methane abatement may not already be occurring: first, commercial opportunities may be blocked by implementation barriers; and second, some opportunities may not be commercial under current policy and market settings. An additional explanation is that abatement that is not currently feasible or safe at a particular site.

That distinction is critical. If the problem is regulatory friction, methodological uncertainty, approval delay or lack of operational readiness, the best response is targeted barrier removal. If the problem is that an opportunity is technically feasible but commercially marginal, the policy question is whether its near-term climate value justifies targeted support. These two categories should not be conflated. In addition, the Authority should recognise that there will be a small number of circumstances in which methane abatement is not currently technically feasible or cannot be undertaken safely at a particular site. Any policy framework should account for these site-specific constraints rather than assume uniform abatement potential across all operations.

LETA therefore encourages the Authority to structure its advice around:

- A clear diagnosis of barriers.

- Differentiation between mature, near-term, emerging and demonstration-stage technologies.
- Policy coherence with the Safeguard Mechanism and state regulatory frameworks. The co-funding arrangements recommended by LETA, as outlined below, should be structured to support compliance with the Safeguard Mechanism and align with existing state regulatory requirements, thereby promoting a consistent and efficient policy framework for methane abatement.
- Technology-neutral and site-specific policy design.
- Targeted enabling measures rather than new prescriptive obligations.

The first policy question should be whether methane abatement is being held back by market failure, regulatory friction, methodological uncertainty, approvals delay, or site-specific constraints. The Authority's advice should recommend against any new methane-specific obligations.

RESPONSES TO CONSULTATION QUESTIONS

With that in mind, the following sections provide responses to each of the questions posed on page 7 of the Consultation Paper.

Question 1

Do current policies and measures adequately cover the material sources of methane emissions in Australia?

Current policies and measures already provide a comprehensive framework for managing methane emissions from Australia's coal, oil and gas sectors, including through the National Greenhouse and Energy Reporting (NGER) Scheme, the Safeguard Mechanism, and state-based regulatory frameworks, as acknowledged on page 22 of the Consultation Paper. The Authority notes that the Safeguard Mechanism covers around 75 per cent of national methane emissions, including the vast majority of coal mine facility emissions, underscoring its role as the principal national policy instrument for driving methane abatement across these sectors.

Agriculture – which, as the Authority notes on pages 5, 8 and 14, is by far the largest source of methane emissions – is the clear exception to this coverage. It should be the urgent focus on the Authority's future work on methane emissions abatement.

For the coal industry, State regulation is also directly relevant. In New South Wales, climate change licence requirements for coal mines were announced in March 2026[3], including requirements relating to drained gas, old workings and VAM abatement in certain circumstances. At the same time, the NSW Government announced its *NSW Coal Industry 2026-50* strategy[4]. The strategy sets out NSW's new coal policy position, with the objective of supporting mining, jobs and net zero emissions by 2050. Queensland also has controls affecting coal mine waste gas and gas flaring and the Low Emissions Investment Partnerships[5] (LEIP) program provide additional drivers for methane emissions abatement.

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[3] NSW Environment Protection Agency (2026), *Greenhouse Gas Mitigation Guide for NSW Coal Mines: March 2026*, (available at www.epa.nsw.gov.au/sites/default/files/2026-03/Greenhouse%20gas%20mitigation%20guide%20for%20NSW%20coal%20mines.pdf). LETA's media release in response to the Guide's release is available at letaustralia.com.au/media-releases/nsw-climate-rules-must-deliver-real-methane-abatement-not-duplicate-national-regulation.

[4] NSW Government (2026), *NSW Coal Industry 2026-50* (available at www.nsw.gov.au/regional-and-primary-industries/nsw-coal-industry-2026-50).

[5] See www.treasury.qld.gov.au/policies-and-programs/investment/leip for further information.

These announcements, all of which are directly relevant to the issues under consideration by the Authority, receive relatively limited attention in the Consultation Paper (pages 6 and 23). When considered alongside the primacy of the Safeguard Mechanism, they demonstrate that methane emissions from coal mining facilities are already subject to extensive policy and regulatory scrutiny, unlike those sectors where comparable coverage does not exist.

For abandoned and decommissioned sites, the appropriate next step is a focused evidence assessment of emission magnitude, persistence, ownership and control, mitigation options, and monitoring feasibility. Policy should be proportionate and grounded in evidence rather than unsupported assumptions about the scale or controllability of emissions from all legacy sites.

Question 2

To what extent will Australia's current policy settings drive near-term methane abatement?

Australia's current policy settings will drive near-term methane abatement, with the extent to vary by sector, facility, emissions source and jurisdiction. The Safeguard Mechanism provides significant incentives for large facilities to reduce net emissions, including methane emissions. Facilities are responding through a range of compliance options, and onsite methane abatement is the clear focus. As outlined above, State-based measures, particularly in NSW and Queensland, will also drive abatement.

The main limitation is that some of the largest abatement opportunities, particularly VAM, are not yet broadly deployable. RTOs are the most mature VAM abatement technology but are suited only to mines with methane concentrations and flow stability within a relatively narrow operating envelope. LETA's investigations indicate a practical self-sustaining threshold of approximately 0.4 per cent methane in inlet air for RTO treatment. Below this, auxiliary fuel is required, which can undermine cost-effectiveness and emissions reduction benefits.

Therefore, current policy settings will likely drive near-term abatement where:

- Drained methane can be flared or utilised. Case Study 2 provides an example of a leading industry project, reflecting one of several initiatives across the industry that have been implemented or are being developed where site-specific resource characteristics and operating conditions make such projects feasible.
- Equipment can be upgraded or replaced.
- VAM concentrations are sufficiently high and stable for RTO deployment.
- Regulatory approvals and safety cases can be completed in time.

Case Study 2: Stanmore Resources: Transforming Fugitive Methane into Energy at South Walker Creek

Supported through Queensland's LEIP program[6]*, Stanmore Resources is developing a first-of-its-kind methane utilisation project at its South Walker Creek metallurgical coal mine in the Bowen Basin.*

[6] See www.treasury.qld.gov.au/policies-and-programs/investment/leip/#current-partnerships for more information and additional examples.

The project will capture coal seam methane that would otherwise be released as fugitive emissions and use it to fuel a new 20 megawatt (MW) power station at the mine. Scheduled for operation from 2027, the project will provide a long-term, self-sufficient electricity supply while reducing mine emissions through the productive use of methane.

By applying gas capture techniques traditionally associated with underground coal mines to an open-cut operation, the project has the potential to establish a new abatement pathway for the broader Australian coal industry and demonstrates how targeted government-industry partnerships can accelerate practical emissions reductions using proven technologies.

The ability to utilise drained methane in this way reflects the unique resource characteristics of South Walker Creek. Given that these characteristics may not exist at other mining operations, it should not be assumed that projects of this kind can be replicated across the industry.

Beyond the specific circumstances of South Walker Creek, the project highlights a broader policy issue for open-cut methane abatement by demonstrating that, in suitable geological settings, methane capture and utilisation can provide a credible emissions reduction pathway while delivering operational benefits through the productive use of captured gas. It also shows that innovation in methane management is occurring across the coal industry and is not limited to underground mining or methane destruction technologies. While projects of this nature will not be suitable for every operation, they provide evidence that open-cut fugitive methane emissions should not be regarded as an intractable emissions source.

Accordingly, policy settings should encourage investment wherever measurable and verifiable emissions reductions can be demonstrated and ensure that emissions reductions achieved through drainage, capture, utilisation or other methane mitigation activities are appropriately recognised within Australia's emissions accounting and Safeguard Mechanism frameworks.

A technology-neutral approach that rewards genuine abatement outcomes would support further assessment and investment in open-cut methane mitigation opportunities while allowing operators the flexibility to pursue solutions best suited to local geological, operational and commercial circumstances.

VAM abatement should be regarded as a staged, medium-term abatement opportunity. During the remainder of this decade, policy should focus on demonstration, safety validation and regulatory approvals. Subject to successful demonstration outcomes, broader deployment of RTO technology is expected to commence in the early 2030s. Emerging catalytic oxidation technologies have the potential to extend VAM abatement to lower-concentration ventilation streams and may become commercially deployable during the mid-2030s.

Policy should therefore prioritise enabling deployment pathways, demonstration support and technology development rather than technology mandates or near-term sector-wide deployment requirements.

Accordingly, the Authority should distinguish between:

- Abatement that is commercially rational but delayed by practical barriers.
- Abatement that is technically feasible but not commercially viable without support.
- Abatement that is not currently feasible or safe at a particular site.

This distinction (which is explored further in answers to questions below) should guide any future policy recommendations.

Question 3

What methane abatement technologies and practices are commercially ready, or likely to be viable in the near term in Australia?

As noted above, the commercially ready and near-term viable technologies differ by source.

Coal mining

Underground coal mines

For underground coal mines, pre-mining drainage, post-mining drainage, flaring and utilisation of drained methane are established practices. The Authority notes that pre-mining drainage is already utilised for managing safety at underground mines and also to reduce emissions where drained gas is flared, used onsite for electricity generation, transported for offsite generation or otherwise managed.

For VAM, RTOs are the most mature technology, but are not universally deployable. RTOs oxidise methane over ceramic beds at around 1,000°C, converting methane into carbon dioxide and water. They can achieve destruction efficiencies above 90 per cent where methane concentrations and flow rates are within the design range.

However, RTOs generally require inlet methane concentrations around 0.4 per cent to operate without supplemental fuel. At around 0.2 per cent methane, continuous self-sustaining operation is not realistic with current materials, insulation systems and ductwork, because the system would require extremely high heat recovery efficiency. This means VAM oxidation should be regarded as selectively viable, not universally ready.

Catalytic oxidation technologies are likely to be medium-term rather than near-term. These systems aim to oxidise methane at lower temperatures, around 500°C, potentially enabling abatement at lower methane concentrations than RTOs. However, they must still demonstrate catalyst durability, contaminant tolerance, safe integration with ventilation systems and acceptable mine-scale project economics.

Open-cut coal mines

For some open-cut mines, pre-drainage of coal seams may provide a practical means of reducing fugitive methane emissions prior to mining. Where geological conditions are suitable, gas drainage can reduce the volume of methane released during mining while creating opportunities for flaring, utilisation or other management pathways.

However, the feasibility of these approaches is highly site-specific and depends on factors including geology, mine planning, gas composition and flow rates, infrastructure access, remaining mine life and overall project economics. Projects currently being assessed across the industry suggest these opportunities warrant further investigation.

Consistent with a technology-neutral approach, policy frameworks should focus on recognising and rewarding measured and verifiable emissions reductions rather than assuming the universal applicability of any particular technology or abatement pathway.

A credible policy framework should therefore distinguish between:

- Mature options deployable now.
- Options viable only in certain operational contexts.
- Opportunities needing targeted enabling support.
- Emerging technologies requiring further demonstration.

Question 4

What methane abatement activities have Safeguard entities planned, started or completed since the commencement of the Safeguard Mechanism reforms?

As noted above, while LETA has been investing in VAM abatement technologies for many years, the Safeguard Mechanism reforms have motivated increased activity across the industry.

It remains the case however, that the Safeguard Mechanism, in its current form, has only been in place since 2023-24 and has been subject to only two years of public reporting through the Clean Energy Regulator. Given this short period, and the significant, capital-intensive scale of investment, coordination, regulatory approvals and community consultation required, it is unrealistic to expect significant completed action to have been taken at this stage.

The Government should allow sufficient time to evaluate the effectiveness of these reforms and their impact on emissions reduction, investment decisions and operational practices.

Future policy changes should build on existing frameworks where possible, rather than creating parallel processes – especially in the absence of compelling evidence of market failure. However, as noted above, the Authority should expect that a range of Safeguard Mechanism-covered facilities have assessed and planned methane abatement activities, and will continue to implement such activities over time, in response to the broader commercial and compliance environment, particularly the Safeguard Mechanism.

These activities may include:

- Equipment upgrades and replacement.
- Improvements to gas drainage, flaring and utilisation systems.
- Feasibility studies and front-end engineering work for VAM abatement.
- Site-specific engineering studies for RTO deployment.
- Catalytic oxidation research and development.

As noted above, in addition to direct action by industry, LETA has played a leading role on behalf of the industry, allocating nearly $60 million to VAM abatement projects, with total investment expected to approach $100 million by 2030. These investments include RTOs, catalytic oxidation technologies, and functional safety case development for systems connected to primary mine ventilation networks.

Question 5

What are the main barriers preventing uptake of methane abatement opportunities in Australia?

Barriers to methane abatement are material and varied. They should be the central focus of the Authority's advice.

Importantly, different barriers require different policy responses. As noted by the Authority on page 26 of the Consultation Paper, the key barriers stem from a range of technical, safety, economic and commercial, supply chain, regulatory and approval, market-related, and site-specific factors.

Technical barriers

For VAM, the most significant barrier is the mismatch between available technology and the operating conditions of many Australian underground mines. As noted above, RTOs require relatively stable flows and methane concentrations, with a practical self-sustaining threshold of around 0.4 per cent methane. Many mines experience concentrations below this level for long periods, and concentrations vary with panel position, seam gas content, drainage practices, barometric conditions and production schedules.

Safety-related barriers

Safety is the overriding priority on any mine site. Any technology connected to a primary mine ventilation circuit must maintain statutory ventilation requirements and avoid increasing risks of explosion, fire or asphyxiation. Australian regulations and industry practice appropriately requires conservative connection infrastructure, long safe connection ducts, isolation, flame arrest, dilution, pressure relief and default-to-atmosphere behaviour during abnormal conditions.

Overseas designs and operational experience cannot be directly adopted in Australia, as some international projects employ shorter duct runs and less conservative connection arrangements than would be acceptable under Australian mine safety requirements.

Case Study 3 highlights work undertaken through a combination of Commonwealth and industry resources and involved collaboration between universities, mining companies and engineering partners. This model is important because the knowledge generated, particularly around safety guidelines and testing data, has benefits beyond any single mine or company. Such sector-wide enabling work is difficult for an individual operator to justify alone, especially where the benefits include regulatory confidence, standardised design guidance and reduced risk for future projects.

Case Study 3: University of Newcastle VAM Abatement Safety Project

The University of Newcastle Ventilation Air Methane Abatement Safety Project[7] was a major government, industry and research collaboration designed to address a key barrier to large-scale VAM abatement: the safe integration of abatement plant with underground coal mine ventilation systems.

[7] See www.newcastle.edu.au/research/centre/energy/research/ventilation-air-methane-abatement-safety-project for more information.

The project commenced in July 2013 and concluded in March 2018. It had a total budget of about $26.95 million, funded 50 per cent by the Commonwealth and 50 per cent by LETA with partners including (then) South32 and Glencore.

Its purpose was not simply to prove that methane could be oxidised. Rather, it aimed to determine the critical science and engineering issues underpinning the safe operation of VAM capture ducts, particularly explosion hazards and the control measures needed to manage them.

Its key contribution was the development of a large-scale test facility and associated safety research to support validated design guidance for VAM capture ducts and related explosion mitigation systems. A major output was a 100-metre VAM capture duct/test facility at Londonderry in western Sydney, designed to replicate mine ventilation conditions and allow controlled testing of gas and gas-particulate hazards, explosion behaviour, protective devices and mitigation strategies.

The key finding was that broad VAM deployment depends on more than reactor performance. The safety-critical interface between the mine ventilation system, capture duct, abatement unit, sensors, isolation systems and emergency controls must be demonstrably safe and regulator-acceptable. The project therefore sought to develop validated safety design guidelines and functional safety requirements to support industry uptake.

The principal lesson for policy is that emissions reduction in underground coal mining requires an integrated approach to technology, safety, regulation and commercial incentives. Public and industry co-funded research, development and deployment can play a critical role in de-risking these systems, but broad deployment will also require durable policy settings, clear crediting or compliance value, and pathways for translating safety guidance into mine-level approvals and investment decisions.

The Case Study is highly relevant to current efforts to reduce fugitive methane emissions. It demonstrates that VAM abatement is not simply a matter of selecting a technology and installing it at a ventilation shaft. Rather, deployment requires validated safety design guidelines, large-scale testing data, regulator and operator confidence, mine-specific engineering integration, clear allocation of responsibility for operational and emergency controls, and a durable policy or market signal, including the Safeguard Mechanism and co-funding arrangements, that supports investment.

The project also demonstrates the value of collaborative research, development and deployment in addressing barriers that are too large, too specialised or too safety-critical for individual companies to tackle in isolation. This is precisely the type of work in which LETA invests.

Economic and commercial barriers

Capital costs for VAM abatement are driven by oxidiser size, connection duct length and specification, foundations, acoustic treatment, stacks, instrumentation and environmental controls. Operating costs include auxiliary fuel, fan power, monitoring and maintenance. At low methane concentrations, auxiliary fuel can become the dominant operating cost and reduce or reverse emissions benefits. Project economics also depend on utilisation pathways for captured gas, plant uptime, equipment maintenance, carbon pricing assumptions, baseline treatment, crediting arrangements, grant support and remaining asset life.

Supply chain barriers

Some technologies face constraints relating to vendor capacity, Australian deployment experience, trained workforce availability, and local fabrication or service capability. Broad VAM deployment would require significant supply chain development, including expanded manufacturing capacity, local fabrication partnerships, trained installation and maintenance teams, and reliable spare parts supply. These capabilities cannot be developed immediately and will require time to mature.

Regulatory and approvals barriers

VAM plants may involve visible plumes, noise, stack height requirements and other potential community impacts. Deployment also depends on environmental approvals, community engagement and mine safety approvals, each of which can materially affect project timing.

How barriers could be overcome

These barriers mean the Authority should treat VAM as an important but site-dependent opportunity. Policy should avoid presuming universal viability and focus on reducing and removing barriers.

Barriers could be reduced through:

- Co-funding for demonstrations and early deployments[8]. LETA is already investing in projects and stands ready to work co-operatively with Government to co-fund projects.
- Clear, coordinated approval pathways across environmental and safety regulators.
- Technology-neutral, site-specific arrangements.
- Co-investment in catalytic oxidation and other next-generation technologies.
- Support for local supply chain development.
- Staged implementation timelines aligned with technology readiness and mine safety validation.

Question 6

What factors are constraining broad deployment of VAM abatement in underground coal mines in Australia?

As noted above, VAM abatement represents a significant opportunity and is the focus of LETA's investment portfolio. However, broader near-term deployment is constrained by technical, operational, safety, commercial and supply-chain factors. Some of these factors were also considered in LETA's response to Question 5 above. Addressing these constraints through collaboration with industry, researchers and technology providers is the focus of LETA's investments and broader industry initiatives.

[8] Such a co-funding initiative could build on existing and previous funding initiatives, such as those offered in NSW through Coal Innovation NSW (www.resources.nsw.gov.au/geological-survey/projects/coal-innovation-nsw/fugitive-methane-emissions-from-coal-mines) in Queensland through LEIP (www.treasury.qld.gov.au/policies-and-programs/investment/leip) and at the national level through the Powering the Regions Fund (business.gov.au/grants-and-programs/powering-the-regions-fund-safeguard-transformation-stream-round-1 and business.gov.au/grants-and-programs/powering-the-regions-fund-safeguard-transformation-stream-round-2).

Methane concentration

The most important constraint is methane concentration. RTOs typically require around 0.4 per cent methane in inlet ventilation air to remain self-sustaining. Below this level, auxiliary fuel is needed. At around 0.2 per cent methane, the thermal margin becomes extremely tight and sustained operation is not realistic with current technology.

Many Australian underground coal mines have methane concentrations below this threshold for extended periods. At lower concentrations, auxiliary fuel demand rises and can undermine both cost-effectiveness and emissions benefits.

Case Study 4 highlights the role methane concentration plays in the application of RTO technologies.

Case Study 4: BHP Mitsubishi Alliance's Broadmeadow Mine Highlights the Need for Next-Generation Technologies

BHP Mitsubishi Alliance's Broadmeadow underground mine illustrates why a technology-neutral approach remains essential. While the Goonyella Broadmeadow Mine (GBM) already captured and flared drained methane where safe and practical, publicly reported information provided under the Safeguard Mechanism indicates that the mine's relatively low ventilation air methane concentrations are not currently suitable for the VAM abatement technologies most likely to be deployed commercially in Australia over the medium-term.

This demonstrates that not all mines can utilise the same methane reduction technologies and reinforces the importance of ongoing investment in emerging options such as catalytic oxidation.

The GBM example also highlights why future policy should focus on enabling innovation and supporting deployment where technologies are technically feasible, rather than assuming a one-size-fits-all solution across all underground mines. The technical knowledge generated through the project has informed subsequent methane abatement initiatives supported by LETA and the broader Australian coal industry.

In information provided to the Clean Energy Regulator in early 2026[9]*, BMA noted:*

> *There is limited fugitive emissions abatement technology available for the relatively low coal seam methane intensity of current open cut operations at GBM. A seam gas resource characterisation drilling and testing program is being undertaken to identify potentially viable sites and seams for future pre-mining gas drainage. BMA Co, through BHP, is also participating in research and development of novel techniques for open cut fugitive abatement.*

Flow and concentration variability

Mine ventilation airflows and methane concentrations are dynamic. They change with mining activity, panel position, production stoppages, sealing, drainage performance and weather conditions. RTOs are designed for defined operating envelopes; too little methane extinguishes the reaction, while too much methane risks overheating and damaging ceramic media.

[9] See cer.gov.au/document/2024-25-30-explanation-letter-goonyella-broadmeadow-mine for more information.

Integration with primary ventilation

VAM abatement systems must be integrated without compromising ventilation integrity. Any VAM abatement system connected to a primary ventilation circuit must maintain statutory ventilation quantities and must default to restoring the original ventilation pathway if equipment fails. Designs must be air-loss neutral, fail-safe and compatible with Australian mine safety regulations.

Safety case requirements

Australian mine safety standards appropriately require layered protections, including flame arrest, dilution, quench, isolation, pressure relief, hazardous area controls, and fast-acting shutdown systems. These requirements are essential to maintaining mine safety. However,, they also increase complexity, project footprint, cost, and approval timeframes. As noted above, overseas designs that rely on shorter duct runs cannot be directly transferred to Australian mining operations.

Site constraints

Suitable space near ventilation shafts may be limited. RTO projects require safe connection ducts, access for construction and maintenance, stack infrastructure, plume management, noise mitigation and community engagement. These constraints are site-specific and can materially affect project cost and timing.

Technology readiness and supply chain

RTOs are mature in principle but not broadly demonstrated under Australian mine conditions at commercial scale. Catalytic oxidation is promising but remains in development and, subject to successful demonstrations, may be broadly deployable in the mid-2030s. Even where technically feasible, VAM projects may remain commercially marginal given capital cost, uncertain utilisation, auxiliary fuel risk, maintenance requirements and remaining mine life. The limited depth of vendors with Australian mine-scale VAM experience, considered above, is also a constraint.

Accordingly, VAM should not be treated as an "off-the-shelf" solution. Policy should support demonstration under Australian safety settings, and support investment in catalytic systems that may be better suited to lower-concentration environments.

Question 8

What practical policies and measures could drive more methane abatement than existing policy settings would deliver?

As noted on page 26 of the Consultation Paper, the first priority should be to address implementation barriers within or alongside the existing framework. Practical policies and measures should complement, not duplicate or undermine, the Safeguard Mechanism. They should focus on unlocking abatement that is technically feasible but not yet occurring because of risk, uncertainty, coordination costs or insufficient commercial incentive. With that in mind, LETA recommends the following measures.

Targeted co-funding for demonstrations and early deployment

As noted above, Government co-funding can reduce first-mover risk for VAM abatement and other methane abatement technologies. This is particularly important for RTO demonstrations conducted under Australian safety requirements and for catalytic oxidation pilot projects.

LETA has previously recommended co-funded demonstration projects to build the evidence base and accelerate practical deployment. While LETA's investments have accelerated, and can continue to accelerate, technology development, a co-funding model that builds on previous funding programs and brings together industry, through LETA, and government would further support technology maturation, demonstration, and ultimately broader deployment across the industry.

Streamlined and coordinated approvals

Environmental, planning and mine safety approvals should remain rigorous, but governments should improve coordination and clarity. VAM projects require both environmental and safety approvals, and uncertain approval pathways can delay or deter investment.

Technology-neutral performance standards

Policy should focus on measured abatement outcomes rather than mandating specific technologies. This is important because RTOs, catalytic systems, drainage, flaring and utilisation may each be appropriate in different circumstances.

Supply chain and workforce support

Governments could support local manufacturing, fabrication, construction and maintenance capabilities for methane abatement technologies, particularly for mine-scale VAM systems.

Interaction with the Safeguard Mechanism

Practical measures could include:

- Targeted demonstration and early deployment co-funding, especially for RTO projects at suitable mines and catalytic oxidation pilots.
- Streamlined and co-ordinated approvals, while maintaining rigorous mine safety and environmental assessment.
- Clear methodological guidance, so that methane reductions are recognised in NGER, Safeguard and state-based frameworks.
- Better coordination between Commonwealth and state regulators, particularly in NSW and Queensland.
- Support for local supply chains and capability, including fabrication, installation, maintenance and monitoring capacity.
- Technology-neutral performance approaches, rewarding measured abatement rather than mandating specific technologies.

These measures should interact with the Safeguard Mechanism by enabling practical onsite abatement without undermining the predictability or integrity of the Safeguard Mechanism framework. LETA again cautions against duplicative methane-specific compliance obligations that sit on top of the Safeguard Mechanism.

KEY PRINCIPLES FOR FUTURE POLICY DESIGN

1. Maintain policy architecture stability

Australia already has a substantial emissions reduction framework. The Authority's advice should not add to, fragment or destabilise, existing architecture.

2. Adopt a technology-neutral and site-specific approach

Methane sources vary widely. Policy should avoid assuming universal availability or economic viability of any technology, especially VAM oxidation.

3. Coordinate across jurisdictions

Commonwealth measures should be designed in close coordination with state frameworks, particularly in NSW and Queensland, to avoid duplication and inconsistent obligations.

4. Use targeted enabling measures

Where abatement is promising but commercially marginal or blocked by practical barriers, targeted enabling measures will deliver faster and more credible reductions than prescriptive regulation.

RECOMMENDATIONS

The Authority should support a practical, staged and nationally consistent policy framework that maintains the Safeguard Mechanism as the central national policy framework, avoids duplicative or inconsistent state and Commonwealth requirements, supports targeted deployment of commercially ready technologies, co-funds demonstrations for emerging technologies and ensures mine safety remains the overriding priority.

With that in mind, LETA recommends that the Authority's advice to the Australian Government:

1. **Recognise the Safeguard Mechanism as the central national framework for industrial methane emissions reduction.**
2. **Support a targeted methane-enablement package, including demonstration funding, streamlined approvals and supply chain development.**
3. **Treat VAM abatement as site-specific, prioritising deployment at suitable high-concentration mines and supporting continued catalytic oxidation research.**
4. **Promote Commonwealth-state coordination, particularly with NSW and Queensland methane-related requirements.**
5. **Avoid prescriptive technology mandates and instead reward measured, safe and cost-effective abatement.**

CONCLUSION

LETA welcomes the Authority's focus on methane as a near-term abatement opportunity. Methane reductions can deliver meaningful climate benefits, and methane presents practical opportunities where emissions are concentrated, measurable and technically addressable.

However, the path forward must be disciplined and evidence-based. Methane policy should be shaped by real-world operating conditions, regulatory coherence, technology readiness, commercial viability and safety.

LETA supports practical and measurable methane abatement, but urges the Authority to avoid blunt or duplicative policy responses. The most effective next step is **<u>not</u>** to create a separate methane policy architecture, but to identify and remove the barriers preventing credible abatement from proceeding under, and alongside, existing frameworks.

A targeted, technology-neutral and site-specific approach – supported by stable policy architecture, coordinated regulation and strategic enabling measures – will deliver better outcomes than one-size-fits-all mandates. LETA would welcome further engagement with the Authority as its advice is developed.

ATTACHMENT 1

LETA'S METHANE ABATEMENT TECHNOLOGY INVESTMENT PORTFOLIO

LETA's investment portfolio demonstrates sustained industry commitment to developing practical methane abatement options for Australian coal mines. To date, LETA has allocated nearly $60 million to VAM-related projects, with investment expected to approach $100 million by 2030.

As noted in the LETA submission, this portfolio has focused on three linked priorities:

- Establishing the safety and engineering foundations for connecting abatement systems to primary mine ventilation circuits.
- Supporting demonstration readiness for RTO technologies at suitable mines.
- And advancing catalytic oxidation technologies that may be better suited to lower-concentration methane streams.

The portfolio shows that VAM abatement is an important medium-term opportunity, but also that deployment is highly site-specific and depends on methane concentration, ventilation stability, mine layout, safety approval, technology readiness and commercial viability. This supports a policy approach based on targeted co-funding, demonstration, safety validation and measured emissions reductions rather than blanket mandates or methane-specific targets.

LETA's earlier leadership in the development of VAM abatement technologies in Australia was highlighted in Case Studies 1 and 3 of the main body of the LETA submission.

This Attachment provides details of some of LETA's current and future investment portfolio, focussing on the Mining3 CATCH4 Program and AngloAmerican Steelmaking Coal's VAM Abatement Project. Project overviews have been provided by the respective proponents, AngloAmerican and Mining3. A summary of the projects is presented below, followed by detailed project overviews, provided to LETA by the project proponents.

AngloAmerican Steelmaking Coal's VAM Abatement Project

AngloAmerican Steelmaking Coal's VAM Abatement Project demonstrates that significant emissions reductions from underground coal mining are technically achievable, but that deployment is currently constrained by safety, engineering and commercial challenges. Following extensive global technology assessments, RTOs were identified as the only commercially mature technology capable of abating ventilation methane at the scale required for underground mines.

The project has focused on developing and independently verifying a fail-safe control and isolation system to ensure RTOs can operate safely in the presence of variable methane concentrations, with this work being undertaken in partnership with the University of Newcastle's Newcastle Institute for Energy and Resources (NIER).

The first deployment phase aims to safely treat emissions from a single ventilation shaft and abate approximately 550 kt CO_2-e per year. While concept and prefeasibility studies have been completed and the project is progressing through safety system verification and detailed design, key lessons include the critical importance of methane characterisation and ventilation management, as well as the ongoing challenge posed by low methane concentrations, which can significantly increase RTO capital and operating costs while reducing abatement efficiency.

Subject to completion of verification and detailed design activities, the project is expected to be execution-ready on a single site as a demonstration by the end of 2026.

Mining3 CATCH4 Program

The Mining3 CATCH4 Program provides an evidence base for a staged, technology-neutral approach to methane abatement policy. The program demonstrates that catalytic oxidation is a credible emerging pathway for treating low-concentration ventilation air methane from underground coal mines, particularly where conventional thermal oxidation technologies may be technically or commercially constrained.

However, CATCH4 also confirms that VAM abatement is not an off-the-shelf solution. Future deployment depends on successful pilot validation, long-duration catalyst performance, contaminant tolerance, mine safety integration, regulatory approvals, supply chain capability and mine-scale economics.

The program therefore supports policy settings that co-fund demonstration and early deployment, streamline approvals, reward measured emissions reductions and avoid prescriptive technology mandates before technologies are commercially mature.

AngloAmerican

Ventilation Air Methane project

Anglo American's Ventilation Air Methane (VAM) Abatement project was established in its Australian steelmaking coal business to assess technologies that could reduce methane emissions from underground coal mine ventilation systems while maintaining the highest safety standards.

About the project

In 2020, Anglo American commenced a review of available technologies for the abatement of VAM emissions from its underground coal operations. The assessment involved technical specialists from across the business, external consultants and research partners. Following this review, Regenerative Thermal Oxidisers (RTOs) were identified as the most mature technology currently available that could be considered for large-scale VAM abatement.

Ventilation Air Methane remains one of the most challenging emissions sources to address in underground coal mining due to the very large air volumes involved, low methane concentrations and the need to maintain the highest safety standards. While technologies exist, demonstrating their safe integration into underground coal mining operations remains a significant industry challenge.

A key consideration for the deployment of RTO technology in underground coal mining applications is safety. RTOs operate by oxidising methane within a high temperature ceramic bed. Directing VAM across one of the two ceramic beds is exothermic and the bed heats up, once the active bed reaches circa 1,200 degrees Celsius, VAM is directed to the second bed. As Bed 1 cools, with the introduction of VAM at around 30 degrees C, bed 2 is heated by the exothermic reaction of VAM. As part of this process, the system must be capable of rapidly identifying and responding to abnormal methane concentrations and other process upsets to prevent ignition risks and maintain safe operating conditions.

To support this objective, Anglo American has undertaken a multi-year program to identify, evaluate and verify safety-critical components and control methodologies. This work has focused on the development of safety systems designed to achieve a safe operating state under abnormal conditions and provide independent layers of protection between the underground mine and the RTO system. The program has included collaboration with the University of Newcastle's Newcastle Institute for Energy and Resources (NIER) and other technical specialists. The current verification phase is intended to demonstrate the performance of the proposed safety systems and support future engineering, regulatory and investment decisions.

The concentration of methane within the ventilation air stream remains an important consideration for the deployment VAM abatement technologies. RTO systems typically perform most effectively within a defined methane concentration range. At lower methane concentrations, larger equipment and additional energy inputs may be required, affecting capital costs and overall abatement efficiency. As a result, site-specific ventilation characteristics play a significant role in determining the technical and commercial viability of VAM abatement projects.

What makes this project innovative

While Regenerative Thermal Oxidiser technology has been demonstrated in other jurisdictions, its application within an Australian underground coal mining context requires the development and verification of a robust safety architecture capable of achieving fail-safe operation under a range of abnormal conditions.

Anglo American's approach combines multiple independent layers of protection, extensive testing and staged verification activities designed specifically for underground mining applications.

The project's focus on validating safety-critical systems at representative scale represents a significant step towards the potential deployment of VAM abatement technologies in Australian underground coal mines.

Project aim

The first stage of Anglo American's VAM project is intended to demonstrate the safe capture and treatment of VAM from a single ventilation shaft located at one of its underground coal mines.

The proposed configuration comprises two trains of four RTO units and has the potential to abate approximately 550,000 tonnes of CO_2e annually, subject to mine operating conditions, methane concentrations and system availability.

Project investment and collaboration

Since commencing in 2020, the project has involved a multi-disciplinary team of ventilation engineers, process engineers, functional safety specialists, project professionals, researchers and external technical advisors.

Significant effort has been invested in technology assessment, safety system development, testing, engineering studies and stakeholder engagement activities. Collaboration with the NIER has been a critical component of the programme, supporting the development and verification of safety-critical systems and testing methodologies.

Current status

Following completion of concept and prefeasibility studies, the project is currently progressing two parallel workstreams:

a. Safety System Verification
b. Detailed design

Safety System Verification

Safety System Verification (SSV) is a key workstream focused on validating the performance of the project's critical safety functions.

The first stage of verification (SSV1) identified and assessed key components of the safety system, including:

- Gas detection systems

- Process sensors
- Isolation and control devices/valves
- Mitigation devices.

These activities were undertaken in collaboration with NIER, drawing on experience from previous VAM research and demonstration projects.

Equipment was subjected to testing at NIER's detonation tube under a range of operating conditions designed to replicate real-world conditions. Testing considered variables including air flow rates/velocities, methane concentrations and dust loads, as well as abnormal operating scenarios relevant to the safety assessment.

The second stage of verification (SSV2) involves the construction and operation of a purpose-built, at-scale (1.5m) facility at NIER. This facility has been designed to assess the performance of key safety components/devices at representative scale and provide a platform for ongoing engagement via LETA with mine regulators, workforce representatives and other stakeholders.

Detailed Design

Anglo American has completed preliminary designs of the process system, including valves, instrumentation and ducting, between the ventilation shaft top and the proposed RTO units. Functional safety assessments have been undertaken in accordance with recognised international standards for process safety systems including AS61508 and AS61511. The assessment process has included:

- Hazard Identification (HAZID)
- Hazard and Operability Study (HAZOP)
- Control Hazard and Operability Study (CHAZOP)
- Layer of Protection Analysis (LOPA)
- Cyber Security Assessment
- Safety Integrity Level (SIL) Assessment

The detailed design phase will further develop the functional and integrity requirements of the system including vendor-specific safety functions. These requirements will be validated through subsequent stages of the functional safety lifecycle. Subject to the successful completion of safety verification, detailed design and relevant approvals, the project is targeting execution readiness by the end of 2026. Construction and commissioning are currently estimated to require approximately two years.

Key outcomes to date:

- Selection of RTO technology following assessment of available VAM abatement options.
- Completion of concept and prefeasibility studies.
- Identification and testing of critical safety system components.
- Validation of testing methodologies through collaboration with NIER and technical specialists.
- Development of an at-scale verification facility to assess safety system performance under representative operating conditions.
- Completion of multiple functional safety studies including HAZID, HAZOP, CHAZOP, LOPA and SIL assessments.

Lessons learned

Assessment of available methane abatement technologies identified RTOs as the most mature technology currently available for consideration in high-flow rates underground mine ventilation applications.

Operational experience from safe, long-running projects in several jurisdictions, including China, the US and Australia, has contributed to the industry's understanding of RTO performance and deployment considerations. RTO technology works by passing VAM over a hot bed of media (~1,000°C) where it is oxidised at a temperature that ensures >97% conversion of methane (CH_4) to carbon dioxide (CO_2) and water vapour (H_2O).

A key lesson from the project has been the importance of VAM Characterisation. VAM Characterisation is the process to review and assess the sources of VAM from the underground mine ventilation data identifying the splits between longwall (LW), Development (DV), and Outbye (OB). Understanding flow rates, methane concentrations and the availability of different ventilation circuits is critical to assessing technical feasibility, potential abatement outcomes and project economics. All ventilation scenarios should be modelled in VentSIM software by qualified Ventilation Officers (VOs).

The project has also highlighted the significance of methane concentration in determining project viability. Lower methane concentrations typically require larger ceramic bed systems and may increase both capital and operating costs while reducing overall abatement efficiency. Consequently, site-specific ventilation characteristics remain a key factor in the assessment and deployment of VAM abatement technologies.

A key lesson from the programme has been that successful deployment of VAM abatement technology requires much more than the selection of an abatement technology. Early investment in ventilation characterisation, safety verification, stakeholder engagement and functional safety assessments is essential. These activities can significantly reduce project risk and support more informed engineering, regulatory and investment decisions.

Ongoing VAM Abatement Initiatives: CATCH4 Program

1. WHAT THE PROJECT IS

CATCH4 is a commercialisation program advancing catalytic oxidation technology for abating fugitive ventilation air methane (VAM) from underground coal mine ventilation shafts. The technology removes methane at lower temperatures and concentrations than typical thermal abatement methods.

CATCH4 is Mining3's catalytic methane oxidation program for abating ventilation air methane from underground coal mines. The project is directed at the residual methane that diffuses in mine ventilation air stream after gas drainage. These emissions are technically difficult because the methane is highly diluted in very large ventilation airflows. Most Australian underground coal mines operate at methane concentrations below the range existing abatement technologies can economically treat, representing a liability to the industry estimated at a lot more than $100M per annum under the Safeguard Mechanism from 2030 onwards.

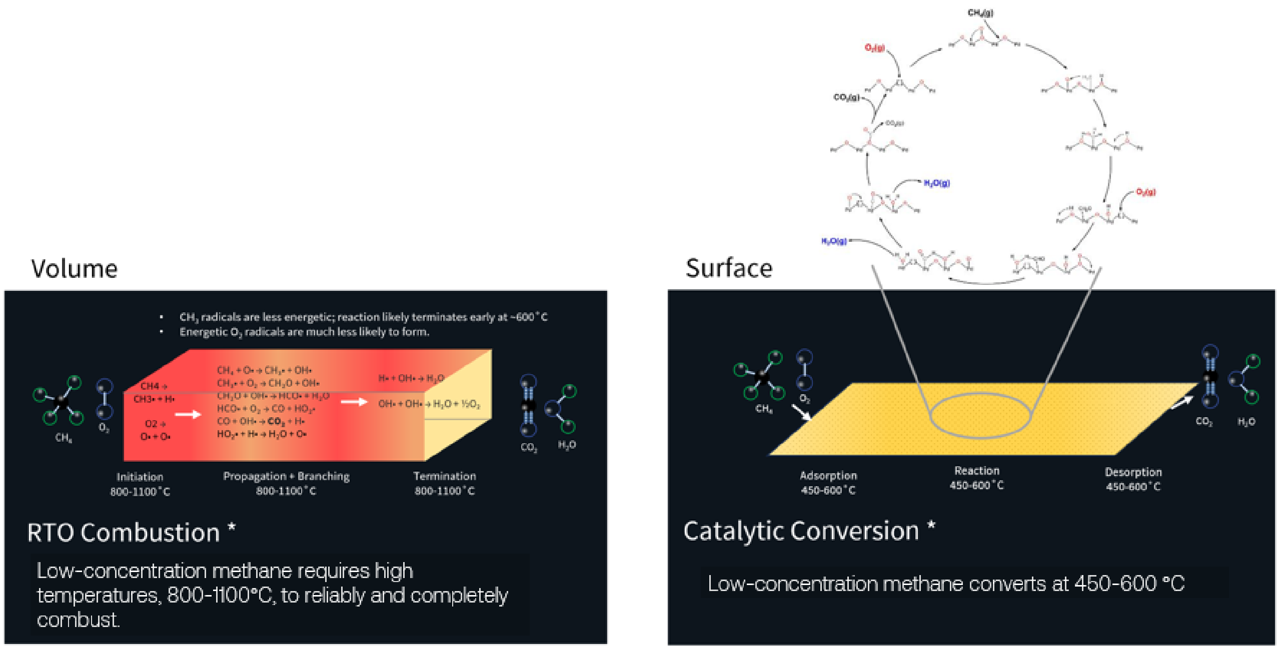
The project focuses on catalytic oxidation rather than conventional high-temperature thermal oxidation. In catalytic systems, methane conversion occurs on a catalyst surface at substantially lower temperatures than thermal oxidation, which is relevant to Australian mine conditions where VAM concentrations are commonly low. The catalytic pathway is being investigated as a potential route to lower-temperature, more deployable abatement systems.

Table 1 compares the thermal and catalytic oxidation pathways and summarises why this distinction matters for CATCH4.

Table 1: Project Rationale

THERMAL OXIDATION PATHWAY	CATALYTIC OXIDATION PATHWAY	WHY CATCH4 MATTERS
Operates at approximately 850–1,100°C; mature technology, but challenging and costly below around 0.2% CH4, and requires large footprints and substantial sweetening gas.	Operates at approximately 450–600°C; pilots are currently being tested across the 0.1–0.5% CH4 range, with a future target of reliably abating as low as 0.2% CH4 and below, at lower cost and footprint.	Seeks to mature catalytic VAM abatement from laboratory evidence toward pilot, demonstration and future commercial deployment.

This difference arises because the catalyst confines the reaction to its surface rather than requiring it to occur throughout the gas volume, allowing conversion to proceed reliably at much lower temperatures. Figure 1 illustrates this mechanism.



*not all reactions shown

Figure 1: Conversion, not combustion — catalyst-surface reaction mechanism

The program is structured as a staged technology maturation effort, progressing from catalyst and concept development through pilot-scale validation toward a first commercial-scale unit and, ultimately, full integration with mine ventilation infrastructure.

CATCH4 is a multi-faceted, international program. Mining3 has engaged and collaborated, at varying levels, with a global network of organisations — ranging from university research organisations to large commercial companies specialised in catalysts and/or clean air technology solutions — informing them of the work underway in Australia to address this challenge (Table 2). While the program is being delivered for the Australian coal industry with the support of LETA, the technology platform and the knowledge generated have relevance well beyond Australia, and beyond coal, to methane-containing industrial gas streams more broadly.

Table 2: CATCH4 global collaboration network

CATEGORY	COUNT	COUNTRIES REPRESENTED
Technology Developers	9	USA, Canada, Germany, France, UK, Denmark, Australia
Original Equipment Manufacturers (OEM)	6	USA, Canada, Germany, France, Australia
Engineering & Consulting Firms	5	Australia, Canada
Operators	5	Australia

2. WHAT THE PROJECT AIMS TO ACHIEVE

CATCH4 aims to deliver commercially deployable catalytic oxidation systems that abate fugitive methane from underground coal mine VAM, reducing the industry’s largest and most difficult-to-address source of methane *emissions. The program is progressing the technology through active field deployments and OEM partnerships that de-risk the technology for commercial-scale rollout.*

As a general rule of thumb, commercialising a new industrial abatement technology takes over a decade — moving from concept through pilot, demonstration and commercial deployment in a way that manages technical, safety and regulatory risk at each stage. CATCH4 with LETA's support is structured to compress this pathway from an indicative 15 years to around 5 years, by parallelising activities that would otherwise run sequentially — progressing catalyst development, pilot design, site engineering and regulatory engagement together rather than in series. Figure 2 illustrates the program's staged phase structure; further detail on the delivery timeline is provided in Section 4.

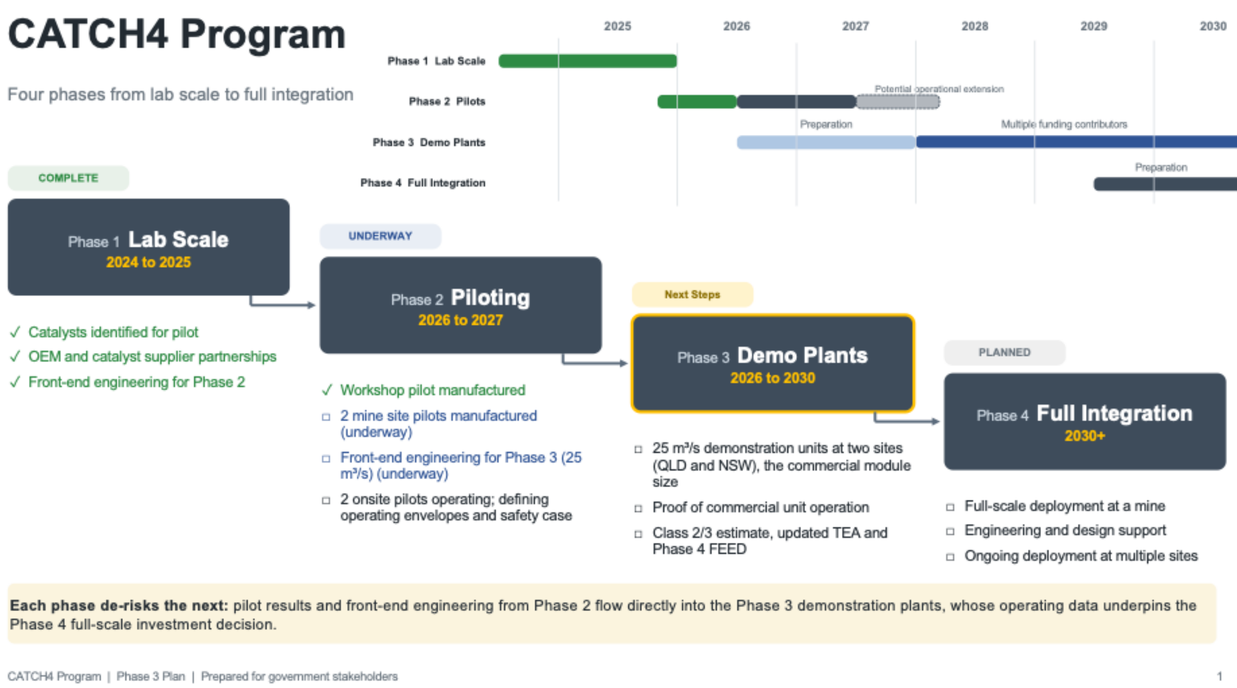


Figure 2: CATCH4 phase overview

Table 3 below sets out the program's key objectives and what each means in practice for CATCH4's delivery.

Table 3: Program derisking activities

OBJECTIVE	PRACTICAL MEANING FOR THE PROGRAM
Demonstrate low-concentration VAM oxidation	Show that catalytic systems can operate effectively in the methane concentration range relevant to Australian underground mines.
Validate performance under realistic conditions	Move beyond laboratory tests by assessing selected catalysts under moisture, particulate matter, gaseous contaminants and real mine ventilation conditions.
Reduce scale-up uncertainty	Resolve uncertainties in heat integration, thermal management, reactor configuration, catalyst durability and operating envelopes.
Prepare for demonstration scale	Generate engineering and operating data to support later demonstration-scale systems and front-end engineering for larger units.

Build deployment capability	Strengthen relationships with catalyst suppliers, OEMs, engineering firms and mine operators so the industry has a credible pathway to implementation.
Reduce total annualised cost (TAC)	Develop a catalytic solution with a total annualised cost lower than thermal oxidation alternatives, improving the economic case for industry-wide adoption.

3. THE CURRENT STATE OF PLAY

CATCH4 currently has multiple pilot-scale activities underway across its OEM partnerships. Dürr Clean Technology Systems is fabricating two pilot units — one electrically powered, one gas powered — with different reactor configurations. These units will be deployed at operating coal mine sites in New South Wales.

CoolCAT is a system designed to test full-size catalytic elements under controlled conditions. The CoolCAT system will be installed at a site in Perth, Western Australia, where recent work has focused on de-risking long-term field performance. All pilots are currently in fabrication, with CoolCAT expected to be delivered in October 2026.

CATCH4 has moved from laboratory and engineering evaluation into pilot delivery. The current phase is centred on constructing, commissioning and operating a set of complementary pilots while continuing supporting activities required for safe site integration, regulatory approval and future scale-up.

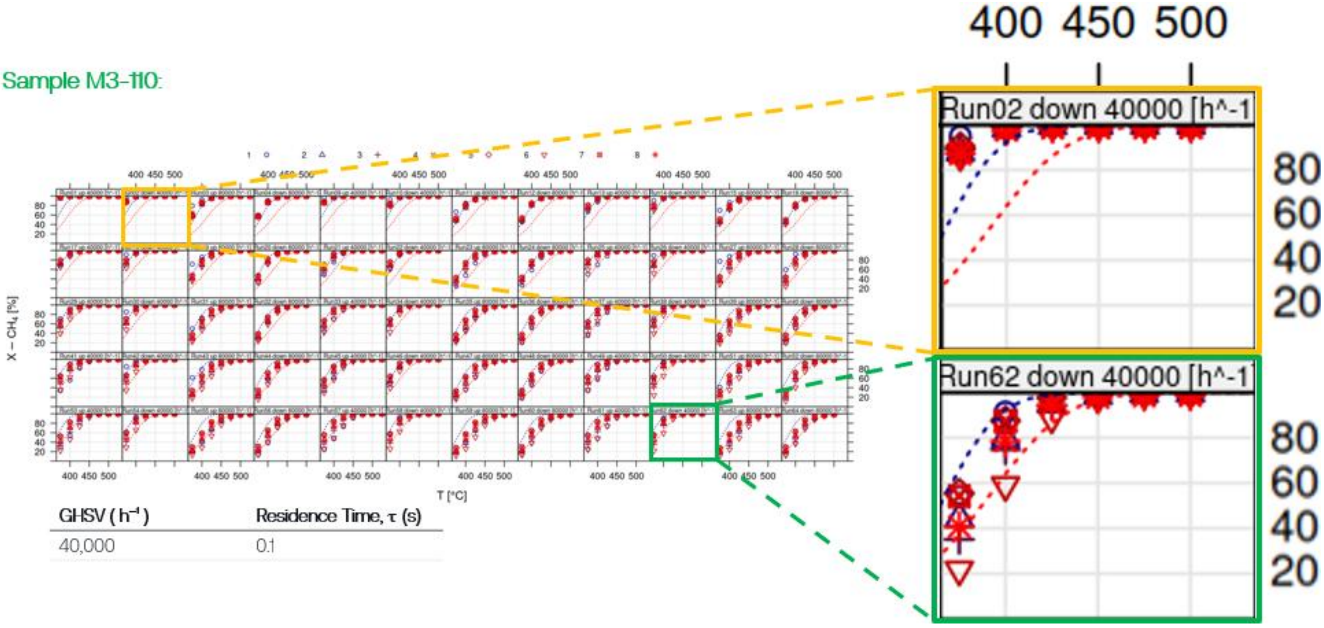
3.1. PHASE 1 DELIVERABLES

Phase 1 delivered the technical and engineering foundation for pilot-scale deployment. It screened catalyst options, assessed performance and stability, progressed modelling and reactor analyses, developed a techno-economic assessment framework, and produced pilot design concepts for the next phase.

- Independent catalyst testing and development of the first standardised testing protocol to investigate the operating envelope of candidate materials. The protocol included activity, kinetics, ageing, sulphur tolerance, stability, moisture-related testing and their regenerability for long-term applications.
- Identification of promising catalyst candidates for further pilot evaluation.
- Scale-up and numerical modelling to link laboratory performance to reactor and pilot design.
- CFD and thermal analysis to assess flow distribution, mixing, bed behaviour and reactor configuration options.
- Pilot design work for CoolCAT, Modified Twin Can and Dedicated Reactor concepts.
- Techno-economic framework development to inform later engineering decisions, with financial detail intentionally excluded from this stakeholder briefing.

Figure 3 shows catalyst conversion performance for two of the candidate samples, showcasing that catalysts still reached more than 95% conversion below 550°C under standard test conditions with cycling conditions for (GHSV 40,000 and 80,000 h^{-1}, corresponding to residence time 0.1 and 0.05 s, respectively). Table 4 summarises measured catalyst emissions at 500°C, confirming effective methane conversion with no nitrogen oxide, sulfur oxide, carbon monoxide or volatile organic compound emissions detected.

Sample M3-110:



GHSV (h⁻¹)	Residence Time, τ (s)
40,000	0.1

Sample M3-201:

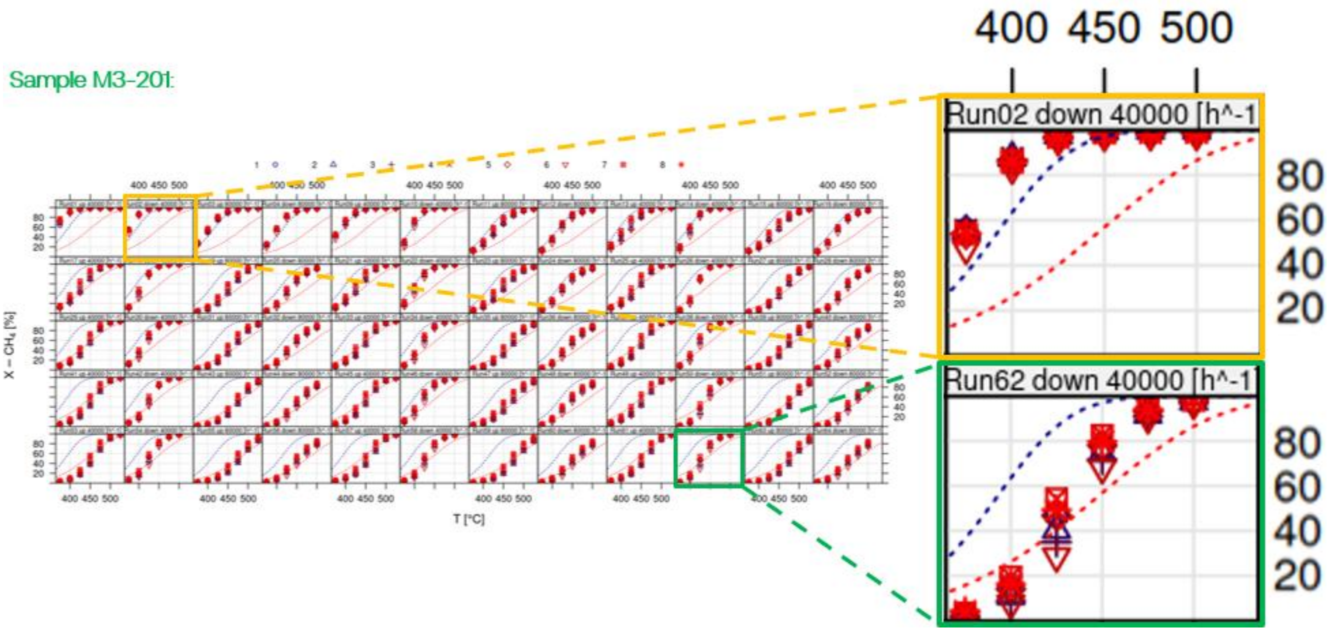


Figure 3: Catalyst conversion performance — after two months of operation at cycling conditions (M3-110 and M3-201)

Table 4: Catalyst emissions at 500°C

PARAMETER	MEASURED VALUE	NOTES / BASIS	EMISSION SIGNIFICANCE
Methane (CH_4)	6 ppm @ 500°C	Corresponds to 99.7% conversion from ~2,000 ppm inlet	Effective methane removal
Carbon Dioxide (CO_2)	0.7 vol%	Includes 0.5 vol% added in feed	Net increase consistent with oxidation; insignificant
Water Vapour (H_2O)	3.4 vol%	Includes 3.0 vol% added in feed	Benign reaction by-product

Hydrogen (H_2)	–	No indication of reforming activity	No secondary fuel or risk pathway
Carbon Monoxide (CO)	Not detected	Detection limit 1 ppm	No toxic emission risk
Nitrogen Oxides (NO_x) / N_2O	Not detected	Detection limit 1 ppm	No air quality impact
Sulfur Oxides (SO_x)	Not detected	Detection limit 1 ppm	No acid gas emissions
HAP / VOCs	Not detected	No C_1–C_2 alcohols, aldehydes or C_2^+ hydrocarbons	No hazardous emissions
Particulate Matter	Not measured	No indication from catalyst stability or deposition	No particulate emission risk

3.2. PHASE 2 PILOTS

Figure 4 summarises the three complementary pilot units — two site-based on-site pilots (Modified Twin Can and Dedicated Reactor) and one workshop-based pilot (CoolCAT) — and how each contributes to de-risking the technology.

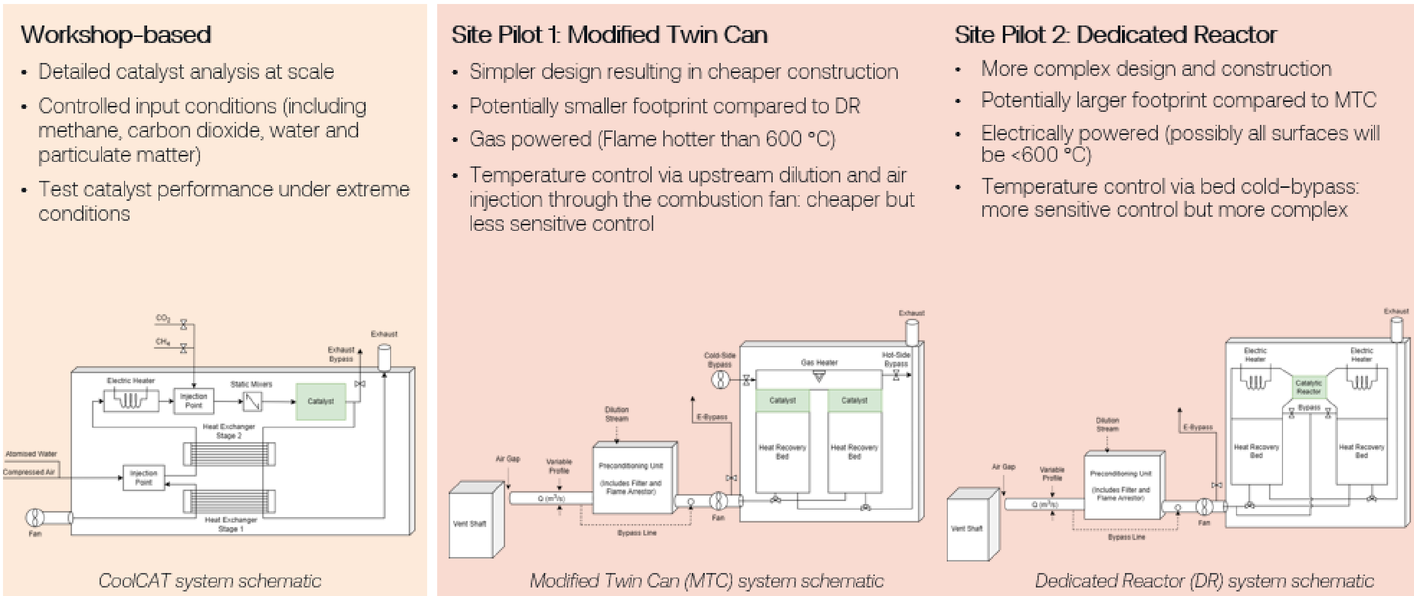


Figure 4: The three pilot units — site-based and workshop-based testing

3.2.1. GM³ APPIN VS2 SITE – HRCO MTC (MODIFIED TWIN-CAN) UNIT

The HRCO MTC unit (fabricated by Dürr) is a gas-powered system with an additional gas injection point for mixture sweetening. It is installed at GM³'s Appin VS2 site, interfacing with the existing site layout. Mine ventilation exhaust is captured from the vent shaft by a duct snorkel, supported by a free-standing frame, and a sufficient air gap, and fed through a gas analyser before travelling through a snaked duct system. It then passes through a pre-conditioning unit (comprised of a flame arrestor and a particle filter) and flowmeter, before reaching the unit.

Figure 5 shows the MTC concept model, Figure 6 shows its general arrangement within the GM[3] Appin site, and Figure 7 shows the unit during fabrication.

Figure 5: Modified Twin Can (MTC) — concept model

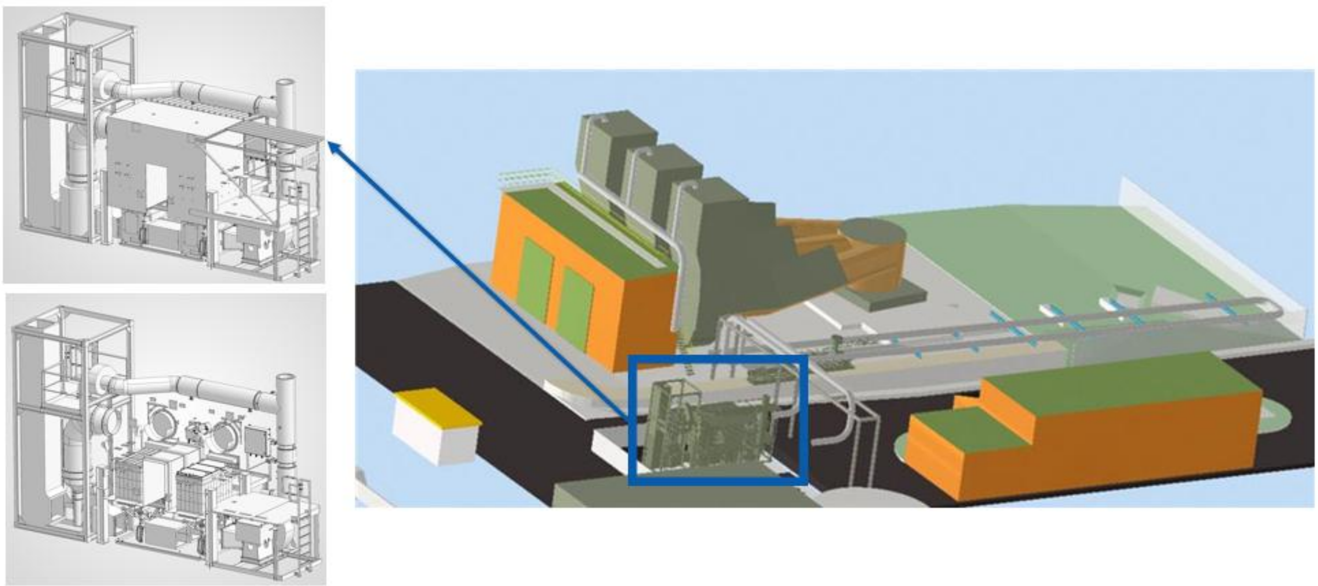


Figure 6: Modified Twin Can (MTC) — general arrangement, GM[3] Appin site

Figure 7: Modified Twin Can (MTC) unit during fabrication

3.2.2. PEABODY METROPOLITAN VS3 SITE – HRCO DR (DEDICATED REACTOR) UNIT

The HRCO DR unit (fabricated by Dürr) is an electrically powered system with a gas injection point to increase methane gas concentration in the VAM stream when required. It will be installed at Peabody's Metropolitan VS3 site. Similar to the layout at GM[3], mine ventilation exhaust is captured from the vent shaft by a duct snorkel, and fed through a gas analyser before travelling through a snaked duct system to the unit.

Figure 8 shows the DR concept model. Fabrication photographs of the DR unit are not yet available.

Figure 8: Dedicated Reactor (DR) — concept

3.2.3. PERTH NEERABUP TEST FACILITY – COOLCAT UNIT

The CoolCAT unit is an electrically powered system, designed to facilitate a range of tests which will mimic different mine site VAM conditions. It is powered by direct connection to the site main power cabinet. It features connection points for carbon dioxide, methane, and water, which can be controlled to various injection rates. Methane is delivered in the form of natural gas by means of a dedicated service pipeline. Carbon dioxide is housed in a cryo-storage tank, entering the system as a liquid before being vaporised. The purpose of the CoolCAT unit is to test different catalytic materials, determining which ones will prove commercially viable, and how long they can be expected to last in service. There will also be a regeneration unit designed and installed onsite, which will regenerate used catalysts. This function will determine the service life of catalytic materials beyond the first maintenance interval. The CoolCAT is installed inside a factory warehouse in Neerabup, Perth. It exhausts its process gas through an exhaust flue which extends up past the roof line.

Figure 9 shows the CoolCAT system schematic, and Figure 10 shows construction progress at the Neerabup facility.

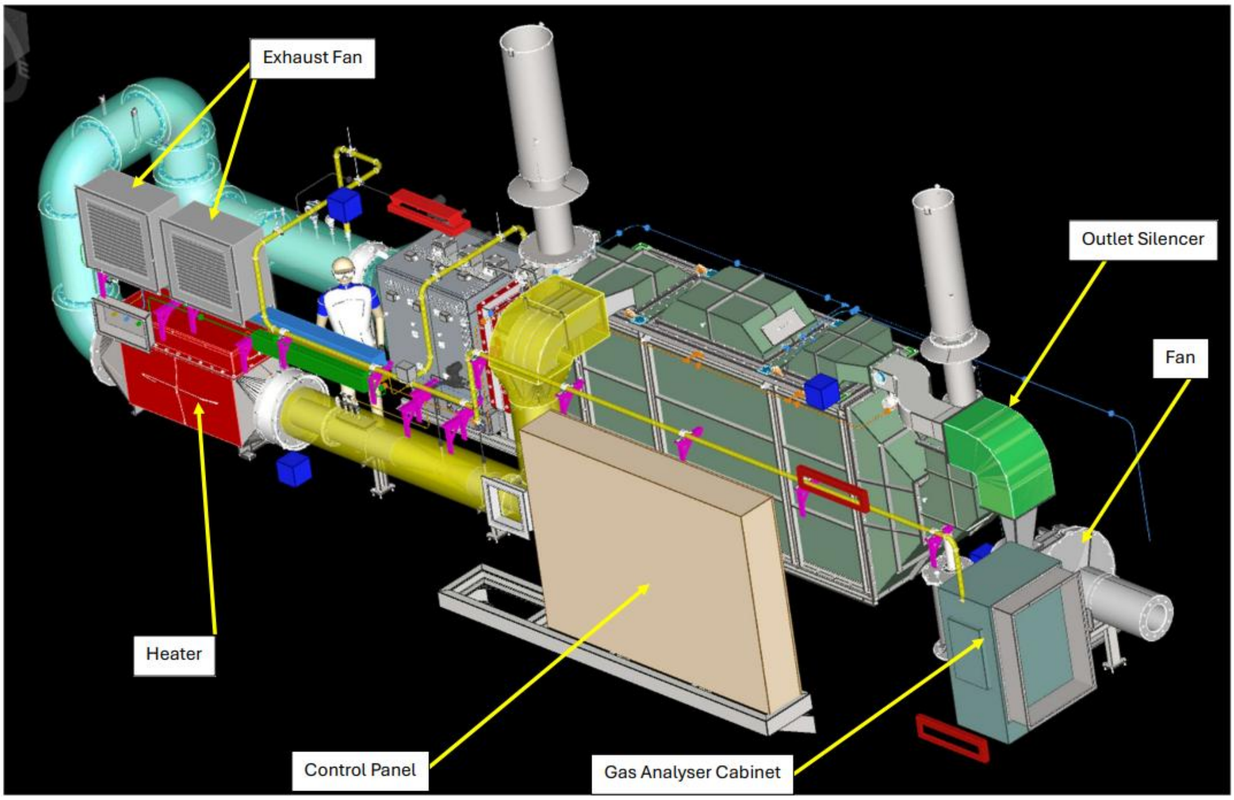


Figure 9: CoolCAT — system schematic

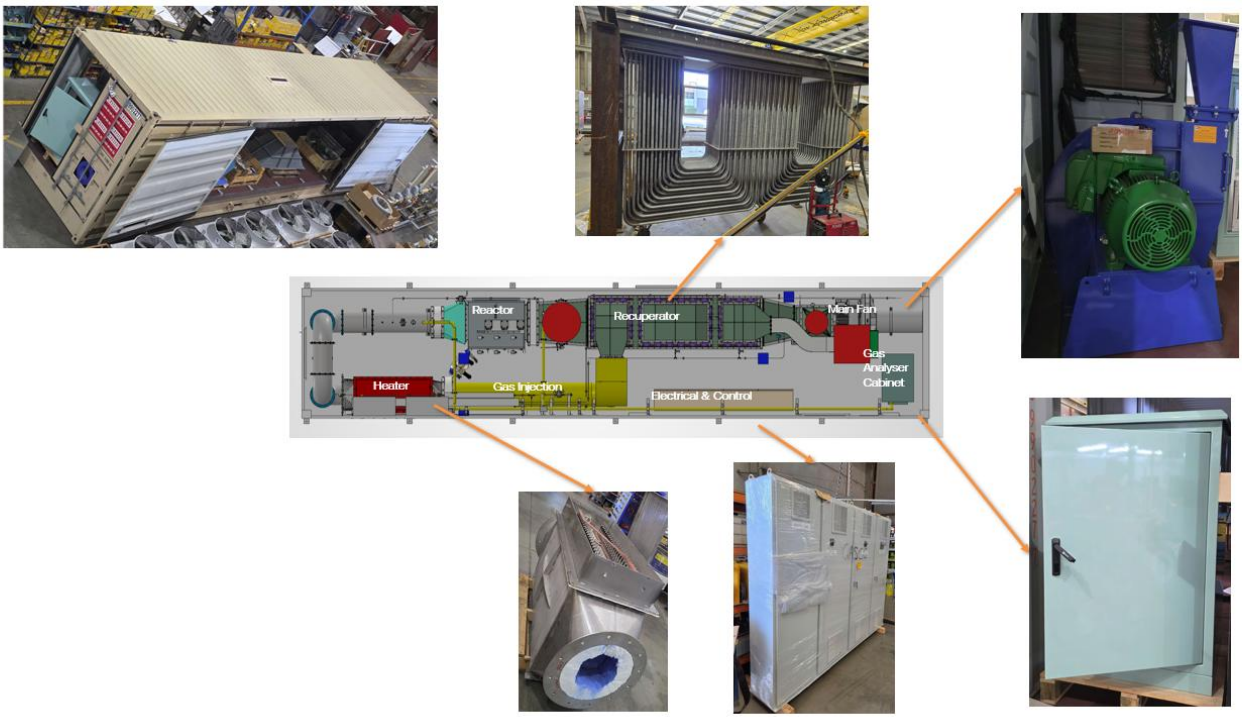


Figure 10: CoolCAT — construction in progress, Neerabup facility

Table 5 summarises the current progress and purpose of each of the three pilots.

Table 5: Pilot progress summary

PILOT	PURPOSE	CURRENT PROGRESS	WHAT IT DE-RISKS
CoolCAT workshop pilot	Off-site pilot using synthetic VAM to provide controlled and repeatable catalyst and reactor testing.	Workshop site selected; infrastructure, approvals and fabrication activities progressing; gas supply modifications and mercaptan stripping options are being worked through.	Baseline performance, reactor behaviour, dust and extreme-condition testing before broader field deployment.
Modified Twin Can on-site pilot	On-site HRCO-style pilot to test catalytic oxidation on real mine ventilation air. Gas powered, with three levers for temperature control, hot by-pass, cooling via combustion air injection and VAM dilution when required.	Detailed engineering and procurement are progressing; site compliance, earthing, cable sizing, noise and installation requirements are being resolved.	Site integration, real VAM variability, thermal management, regulatory approvals and operational constraints.
Dedicated Reactor on-site pilot	Alternative reactor configuration to generate comparative engineering and operating data. Electrically powered, both direct and indirect contact with VAM; no dilution is allowed; cold bypass mixing as the main temperature control mechanism.	Initial site access agreement has been executed, and engineering engagement is underway; preliminary HAZOP/LOPA and site engineering activities are progressing.	Comparative reactor design, mine-site operation, approvals pathway and future design choices.

3.3. PHASE 2 SUPPORTING ACTIVITIES

The pilots are supported by substantial enabling work. These supporting activities are important because catalytic VAM abatement must operate safely and reliably within mine ventilation, electrical, environmental and operational constraints.

- Site engagement and approvals, including environmental pathways, layout confirmation, plume and noise studies, and site access agreements.
- Safety and operability studies, including HAZOP, hazardous area classifications, LOPA and SIL-related work where applicable.
- OEM and supplier engagement for heat recovery systems, reactor design, catalyst manufacture, monitoring systems and detailed engineering.
- Catalyst optimisation and reactor design work, including engagement with catalyst suppliers and testing facilities.
- Regeneration capability development to better understand long-term catalyst performance and potential recovery pathways.

- Operations planning, including staffing, control philosophy, commissioning approach and operating procedures.

4. PROPOSED FUTURE ACTIONS AND TIMELINE

CATCH4's future delivery is described here in terms of phase duration and sequencing rather than fixed calendar dates, consistent with the staged approach set out in Section 2.

Following completion of Phase 2 pilot testing, CATCH4 anticipates a Phase 3 program of approximately two to three years, encompassing site selection, regulatory approvals, OEM design, and the manufacturing and installation of two first-of-a-kind 25 m^3/s commercial-scale units. This would be followed by a Phase 4 program of a further two years or more, integrating the technology fully within mine ventilation infrastructure and supporting broader industry rollout. On this basis, first commercial-scale operation is targeted for the early-to-mid 2030s, with full integration following in the mid-to-late 2030s. Figure 11 illustrates this staged delivery pathway at a program level.

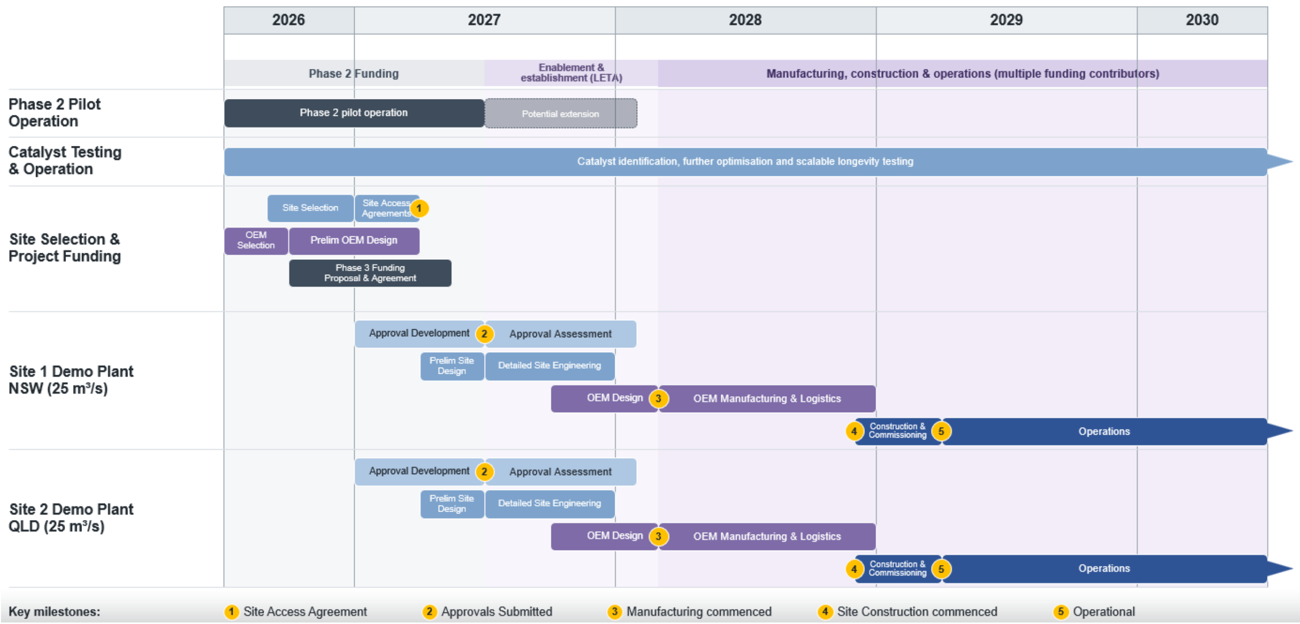


Figure 11: CATCH4 indicative staged delivery pathway

The following roadmap is limited to actions and next-phase activities identified in the supplied project materials. It presents a high-level view rather than a detailed project schedule, summarised in Table 6.

Table 6: Indicative roadmap of near-term actions

PERIOD	ACTION IDENTIFIED IN PROJECT MATERIAL	EXPECTED ROLE IN TECHNOLOGY MATURATION
Late 2025 to 2028	Complete construction, commissioning and operation of the three Phase 2 pilot streams.	Generate controlled and field operating data across multiple catalyst and reactor pathways.
2026 to mid-2027	Confirm catalyst operating envelopes, longevity and sensitivity to real-world conditions including moisture, particulates and gas composition variance.	Establish realistic performance limits and identify practical operating protocols.
2026 to mid-2027	Improve reactor design, heat integration and pilot operating protocols.	Reduce technical uncertainty before larger demonstration-scale design.
2027 to 2028	Develop front-end engineering and design basis for the next scale-up phase.	Translate pilot evidence into requirements for larger systems.
2028 to 2030	Progress toward demonstration-scale systems, including engineering for larger catalytic abatement units.	Prove operation at a scale closer to commercial deployment.
2030 to 2031	Develop front-end engineering and design basis for the commercially sized units.	Translate pilot evidence into requirements for larger systems.
2032 onwards	Support transition toward commercially available catalytic VAM oxidation solutions.	Enable industry deployment once pilot and demonstration evidence supports viability.

The roadmap reflects the project's current maturity. While the project has advanced beyond laboratory screening, the next investment of effort is still evidence generation: proving long-term catalyst performance, confirming site integration requirements and providing a sound basis for demonstration-scale engineering.

5. CATCH4 LESSONS LEARNED

5.1. CATALYTIC VAM ABATEMENT IS TECHNICALLY FEASIBLE

Phase 1 testing (Section 3.1) and engineering work indicate that catalytic oxidation can convert methane at substantially lower temperatures than conventional thermal oxidation pathways. This supports the technical case for continued development.

5.2. COMMERCIAL VIABILITY REMAINS SEVERAL YEARS AWAY

CATCH4 has made material progress, but commercial deployment remains several years away. Sustained pilot operation, demonstration-scale engineering and further supplier and operator capability development are still required, consistent with the staged pathway set out in Section 4. Also, further supplier and operator capability development is required before broad commercial deployment.

5.3. MATURE THE BASIS OF DESIGN BEFORE IMPLEMENTATION OR CONTRACT AWARD

Lesson Learned

One of the key lessons from CATCH4 was the importance of establishing a complete and agreed Basis of Design before progressing into procurement, approvals or construction activities. Existing mine infrastructure and real estate around ventilation shafts were not originally designed with VAM abatement technologies in mind, creating significant constraints during site selection and plant integration. Additional challenges arose from differing interpretations of site requirements and the need to incorporate environmental controls, particularly noise mitigation, into the design at an early stage.

Future Proofing Opportunities

Future projects should establish a formal Design Maturity Gate before execution contract award. This gate should verify site requirements, infrastructure constraints, environmental obligations, operational requirements including development consent conditions, and all key engineering interfaces. Standardised design review workshops involving operators, OEMs, regulators and delivery partners should be undertaken early to ensure alignment and reduce rework during later project phases.

5.4. ESTABLISH THE APPROVALS AND ENVIRONMENTAL PATHWAY EARLY

Lesson Learned

The project highlighted the complexity of developing new environmental and regulatory approval pathways for emerging methane abatement technologies. Approval processes were often structured around conventional infrastructure developments, requiring a high degree of technical certainty before progression, whereas pilot-scale innovation projects would benefit from staged or conditional approval mechanisms. Regulatory agencies, including DPHI and EPA, were effectively developing assessment pathways in parallel with the project, creating uncertainty as approval frameworks continued to evolve during assessment.

As these projects sit at the intersection of mining, environmental regulation, greenhouse gas mitigation and pollution control infrastructure, differing interpretations often emerged regarding assessment scope and legislative requirements, frequently resulting in conservative assessment approaches and additional studies to manage approval risk. This also highlighted a disconnect between the environmental benefits VAM facilities deliver and the assessment requirements applied to them: despite being designed specifically to reduce greenhouse gas emissions, proponents were often required to undertake assessment programs comparable to those for conventional developments introducing new emissions sources — disproportionate to the actual environmental risk and net emissions benefit involved. More broadly, existing planning and environmental approval frameworks have largely been developed for conventional industrial and production-expansion projects, rather than decarbonisation and environmental improvement projects such as methane abatement facilities.

Future Proofing Opportunities

Future deployments should commence approvals strategy development at the concept phase rather than after technology selection, with early engagement across regulators, environmental consultants, site operators, DPHI and EPA to establish agreed assessment pathways and reduce duplication. Industry engagement should continue to encourage approval models better suited to pilot and demonstration technologies — including staged, conditional or contingent approvals — and to develop fit-for-purpose assessment requirements covering greenhouse gas accounting, air quality assessment and performance verification. Regulatory frameworks should also recognise the significant lead times methane abatement projects require across approvals, procurement, construction and commissioning, to give proponents sufficient certainty to invest in long-term emissions reduction initiatives.

5.5. EDUCATE THE INDUSTRY ON THE BENEFITS OF CATALYTIC VAM ABATEMENT TECHNOLOGY

Lesson Learned

CATCH4 demonstrated a significant opportunity to improve industry understanding of catalytic methane oxidation technology. Compared with conventional combustion systems, catalytic processes enable controlled reactions at lower operating temperatures, improving safety and reducing operating complexity. The technology also offers favourable greenhouse gas emission outcomes and has the ability to oxidise methane at lower concentration levels, opening opportunities for broader methane mitigation across mining operations.

Future Proofing Opportunities

Future projects should incorporate a structured stakeholder education and engagement program targeting mine operators, regulators, environmental groups and industry bodies. Demonstrating performance data, emissions outcomes, operational benefits and safety improvements will help accelerate adoption and reduce resistance to new technologies. Published case studies and operational performance results from CATCH4 should form the foundation of future industry engagement activities.

5.6. CATCH4 SUCCESSFULLY DE-RISKED FUTURE VAM ABATEMENT DEPLOYMENTS

Lesson Learned

A major achievement of the CATCH4 program was the successful identification and resolution of many of the technical, operational, environmental and commercial challenges associated with deploying VAM abatement technologies in live mining environments. The project brought together researchers, technology providers, site operators, contractors and regulators to work through issues that would otherwise emerge during future commercial deployments. As a result, CATCH4 has established a valuable knowledge base and practical implementation pathway for future projects.

In addition, CATCH4 has also helped establish technical, environmental and regulatory precedent for future VAM projects. As a first-of-kind deployment, the project carried a disproportionate burden in defining assessment requirements, demonstrating environmental performance and establishing confidence in emerging methane abatement technologies. The knowledge generated through this process will reduce uncertainty, lower implementation barriers for future projects and provide a foundation for more consistent regulatory assessment and approval pathways across future methane abatement deployments.

Future Proofing Opportunities

The knowledge, procedures, templates and operational experience developed through CATCH4 should be formalised into a deployment framework for future methane abatement projects. This should include standardised Basis of Design documents, approval pathways, risk registers, operational readiness frameworks, environmental management plans and lessons learned registers. By creating a repeatable delivery model, future projects can significantly reduce implementation risk, improve schedule certainty, streamline approval pathways and accelerate the deployment of methane abatement technologies across the mining industry.

Future policy and regulatory development should recognise that methane abatement projects are fundamentally emissions reduction initiatives and that project delivery timelines, including approvals, procurement, construction and commissioning, can extend over several years. Improved alignment between emissions reduction objectives and approval frameworks would help accelerate deployment while maintaining appropriate environmental safeguards.

ATTACHMENT 2

OTHER INDUSTRY-LED INVESTMENT IN METHANE ABATEMENT TECHNOLOGY PROJECTS

As noted in the body of the submission, in addition to LETA's investment portfolio, industry has since 2004 led investment in, along with governments, a range of methane abatement projects. In addition to some of those highlighted in the submission, some of these include:

- **West Cliff Ventilation Air Methane Project (WestVAMP)**[10]: The West Cliff Ventilation Air Methane Project (WestVAMP) was a pioneering greenhouse gas abatement initiative led by then BHP Billiton Illawarra Coal at West Cliff Colliery in New South Wales. Developed in 2004 with support from the Australian Government's Greenhouse Gas Abatement Program, which contributed $6 million towards the project, WestVAMP was designed to destroy methane contained in mine ventilation air and generate electricity using innovative oxidation technology. The project became the world's first commercial-scale facility to generate power solely from ventilation air methane, reducing greenhouse gas emissions by approximately 200,000 to 250,000 tonnes of CO_2-e per year while producing around 5 MW of electricity. WestVAMP demonstrated that low-concentration methane emissions from underground coal mines could be effectively abated at commercial scale. However, the technology was not widely replicated across the coal industry due to its high capital cost, the relatively small amount of electricity generated and the fact that only a limited number of mines have the methane concentrations, ventilation volumes and mine life necessary to make such projects economically viable. As a result, WestVAMP remains an important early example of successful innovation in methane mitigation and emissions reduction, despite its limited uptake.

- **Ventilation Air Methane Regenerative After Burner (VAM-RAB) technology**[11]: Coal Innovation NSW provided up to $2.2 million from 2009 to support Centennial Mandalong Pty Ltd in trialling a Ventilation Air Methane Regenerative After Burner (VAM-RAB) at the Mandalong mine. The technology was designed to oxidise more than 99 per cent of methane at approximately 1,000°C in a self-sustaining process. Although a demonstration plant was constructed, heat-up trials were unsuccessful, and the project was discontinued in 2019 by agreement between the parties. Nevertheless, the project provided valuable insights into the safety and operational challenges associated with deploying VAM abatement technology at active mine sites, informing subsequent work on safe design and installation.

- **Ventilation air methane (VAM) catalytic mitigator**[12]: Coal Innovation NSW provided up to $1.5 million in 2018 to support CSIRO's development and pilot-scale trial of a catalytic VAMMIT system at (then) South32's Appin mine. The catalytic approach was designed to operate at lower temperatures than conventional thermal systems, process lower methane concentrations and reduce input power requirements. The pilot system was tested for 476 hours using real mine ventilation air at methane concentrations of 0.08 per cent to 0.38 per cent. While efficiency was lower than thermal systems, the project demonstrated the potential for catalytic technology to treat low-concentration VAM streams.

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[10] See www.bhp.com/news/media-centre/releases/2007/09/nsw-premier-morris-iemma-opens-world-first-power-generation-project-at-bhp-billitons-west-cliff-mine.

[11] See www.resources.nsw.gov.au/geological-survey/projects/coal-innovation-nsw/fugitive-methane-emissions-from-coal-mines and majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=DA97/800-MOD-7%2120200309T074916.562%20GMT.

[12] See www.resources.nsw.gov.au/geological-survey/projects/coal-innovation-nsw/fugitive-methane-emissions-from-coal-mines and www.resources.nsw.gov.au/sites/default/files/2024-05/csiro-s32-vam-project-final-report.PDF.

- **GM³ RTO demonstration plant**[13]: GM³ has received approval to construct and operate a VAM abatement demonstration plant at Appin Mine using RTO technology, with construction commencing in 2026 and the project expected to reduce fugitive methane emissions by around 36,000 t CO_2-e per year while generating operational knowledge to support broader deployment of VAM abatement across the underground coal mining industry. Gasco has been awarded a contract by GM³ to supply and manufacture the RTO unit.

[13] See community.gm3.au/vam-project and www.gasco.net.au/hydrogen-renewable-gas-conferences-2.