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Methane Emissions Reduction |
International policy and technology insights for the Australian fossil fuel sector

Final Report – August 2023

Foreword

In a world grappling with the challenges of climate change, it is crucial that nations come together to address the urgent need to reduce greenhouse gas (GHG) emissions. Methane, a potent contributor to global warming, requires particular attention as we strive to safeguard our planet for future generations.

This research report delves into the efforts made by the United States, Canada, the United Kingdom, and China in identifying and implementing policies and technologies to curb methane emissions in the fossil fuels sector. By understanding the actions these jurisdictions have taken to reduce methane emissions, it becomes evident that there is room for improvement in Australia's coal and gas sectors.

Through detailed research and analysis, this report sheds light on the methane emissions policies, regulations, and technologies adopted in these jurisdictions, offering valuable insights into their success and potential replicability in Australia. It highlights the collective responsibility of nations to confront the global methane challenge head-on and emphasises the need for Australia to catch up with its global counterparts.

As we navigate toward a net-zero emissions future, this report serves as a call to action, urging Australia to continue to develop a national plan to address fossil methane emissions through: overall and sector specific targets; more prescriptive and standardised regulations on equipment emissions standards; improved measurement, verification and reporting requirements; pricing signals for additional abatement beyond what is prescribed; and national and international public-private partnerships.

By building upon current commitments, acknowledging current policy and technology gaps, and drawing inspiration from the accomplishments of others, Australia has an opportunity to catalyse change and contribute significantly to global efforts on methane emissions reduction.

May this report encourage governments, policymakers, industry leaders, and research & development organisations to unite in a shared commitment to combat methane emissions for a more sustainable future.

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Executive summary

Methane emissions are a significant contributor to global greenhouse gas emissions, and have a high global warming potential. Action on reducing methane emissions in this decade is a crucial and cost-effective pathway to limiting global warming to 1.5°C.

The fossil fuel sector is responsible for approximately 35-40% of global methane emissions. Coordinated action with government and industry buy-in is required to ensure the sector contributes to global methane targets (such as the Global Methane Pledge).

Australia has made a commitment under the Global Methane Pledge to reduce global methane emissions but has not set a national or sectoral target.

Australia can do more to reduce methane emissions in the fossil fuel sector

Australia's fossil fuel sector contributes up to 26[1]% of national methane emissions, and Australia is lagging other developed economies in terms of fossil fuel methane action.

- Australia has not yet set a country specific (or industry specific) target for methane reduction, despite having signed the Global Methane Pledge (which is aligned to a 1.5°C pathway).
- There is a mix of state-based and federal policies governing the fossil fuel sector, with very few that are legislated or specifically address methane, along with few pricing signals to encourage industry buy-in.
- Other countries and sub-national governments with heavy sectoral involvement have made targeted actions to address methane intensity in the sector, with noteworthy emissions reductions.

Global action on methane emissions to achieve a short-term impact on greenhouse gas emissions is needed to remain within the global carbon budget.

- According to the IPCC's AR 6, more rapid and deep reductions in methane emissions are essential to achieve net-zero by 2050, given the strong influence that methane has on short-term climate change.
- Under the IEA's global Net Zero Emissions by 2050 scenario, methane emissions would need to fall by around 75% by 2030.
- These required methane emission reductions in the coal mining and oil & gas sectors have been classified as technically viable and cost-effective by the IEA.

Sources: [1] DCCEEW – National Greenhouse Accounts, National Inventory by Economic Sector 2021 (2023); IPCC – Sixth Assessment Report (2023); IEA – Tracking Methane Emissions from Oil and Gas Operations (2023); IEA – Curtailing Methane Emissions from Fossil Fuel Operations (2021)

Other fossil fuel-based economies have successfully made progress

Progress internationally is being driven by a range of direct and indirect policies…

- Fossil fuel dominated Alberta and British Columbia (in Canada) have implemented strong emissions standards on equipment and processes through legislated regulations, and similar mechanisms to Australia's Safeguard Mechanism and Emissions Reduction Fund, but with methane specific requirements.
- While the UK has declining upstream production (especially in coal), it has implemented targets on flaring and venting rates and public disclosure requirements, to drive performance in the oil and gas sector. The country has also focused on reducing mid-stream emissions through a significant pipeline replacement scheme, with added health and safety benefits.
- Amidst the backdrop of the recent federal *Inflation Reduction Act* (which includes a price on methane), individual US states have strengthened their prescriptive emissions standards across the oil & gas value chain. Long-term industry partnerships have also driven significant, cost-effective emissions reductions.
- China has focused on the extraction and utilisation of coal mine methane, partly driven by air pollution concerns, using extraction and utilisation targets, and flaring and venting restrictions.

… that have been most successfully implemented when combined, rather than standalone.

- Global experience shows there is no 'one size fits all' policy solution – a mix of prescriptive, economic, informative, and performance-based policies drives industry action and technology uptake.
- Successful implementation is underpinned by accurate, consistent and transparent emissions measurement and reporting using best practice methodologies. Increasing stipulations on Leak Detection and Repair frequency and reporting are now in place in other jurisdictions, as well as more widespread 'top down' monitoring of site emissions (through satellite or other measures).

Global jurisdictions that have successfully reduced methane emissions in the fossil fuel industry have done so through a mix of measures that have driven improvements in technologies, practices, monitoring and reporting.

International experience shows that uncoordinated or voluntary schemes alone are unlikely to lead to significant reductions.

Australia has considerable untapped potential for methane emissions reductions.

A mix of prescriptive policy and regulation coupled with appropriately considered price signals and collaborative partnerships could drive real progress towards Australia's methane reduction commitments.

Australia should leverage international experience to strengthen its approach to fossil methane emissions reduction

Australia should consider three key actions together, to drive industry action.

1. **Methane reduction targets** – specific to the gas and coal industries (supporting a national methane target), considering both input and output targets, aligned to a 1.5°C pathway.
2. **Methane emissions regulations and price signals** – a national combination of prescriptive emissions standards for equipment and practices (including monitoring, reporting and verification), and clear price signals that drive additional industry investment beyond what is mandatory. These could be delivered through the augmentation of legislated environmental protection and fossil fuel industry regulations, and the specific inclusion of methane in policies such as the Safeguard Mechanism.
3. **Collaboration** – government and industry partnerships, both nationally and internationally building upon the Global Methane Pledge, to support innovative and efficient solutions.

Emissions intensity measures should be delivered alongside the phase down of fossil fuel production to meet net-zero targets.

- According to the IEA, a global reduction in coal and gas production within this decade is required to meet international net-zero goals and limit global warming to 1.5°C.
- Methane intensity reductions alone in these sectors will be insufficient. Support needs to be provided to users of fossil fuels, domestically and internationally, to reduce the demand for fossil fuels.
- Future policy attention will be required to emissions from abandoned and decommissioned sites, which may continue to emit methane beyond their operational lifetime (beyond scope of this report).

Key actions – summary on a page

Key actions for Australia to address current gaps

1 Sector specific methane targets

"A common, 1.5C aligned goal"

Specific methane emissions reductions targets for the gas and coal industries, considering both input and output targets, aligned to a 1.5C pathway

- Sector specific targets should align to the Global Methane Pledge and IPCC goals and focus first on easy to abate parts of the coal and gas value chain.
- Sector specific targets could be a mix of input based (e.g., utilisation rate of CMM in coal mine projects) and output based (e.g., total methane emissions from coal operations), informed by scientific research and expert recommendations.
- There are currently no specific methane emissions targets for the coal and gas industries in Australia – this makes it difficult to separately focus on, and deal with, methane emissions from the fossil fuel industries as distinct from methane emissions from other sectors, such as the waste and agriculture sectors.

2 Emissions regulations and price signals

"Kickstarting industry to make changes"

National prescriptive emissions standards for equipment and practices, including measurement, reporting & verification

- Standardised and more specific emissions standards (e.g. bleed rate requirements, pre-drainage and utilisation in all coal mines) could be applied to both new and existing wells, mines and other infrastructure.
- Non-routine flaring and venting targets and regulations would align to other jurisdictions.
- A requirement to produce methane emissions baselines and report publicly on methane emissions would help to encourage methane specific emissions reductions.
- Bottom up (through LDAR), and top-down site level measurement requirements using modern best-practice methods would also provide a more accurate assessment of methane emissions, which is critical to measuring success.

Clear, methane specific price signals through the Safeguard Mechanism, Emissions Reduction Fund (ERF)

- A financial incentive through avoided Safeguard Mechanism compliance costs (ACCU and/or Safeguard Mechanism Credit purchases, fines) would encourage emissions reductions beyond those mandated through prescriptive emissions standards.
- Further financial incentives for additional abatement through the ERF would further drive voluntary reductions. Clearer guidance on the availability of existing emissions reduction programs could be developed to encourage use of existing incentive programs (e.g., 'stacking' of existing relevant ERF project methodologies).
- A price on methane (per the US IRA developments) would also promote and accelerate business cases for methane emissions reductions.

3 Collaboration

"Efficiency through working together"

Industry partnerships and collaboration, both nationally and internationally, to support innovative efficient solutions

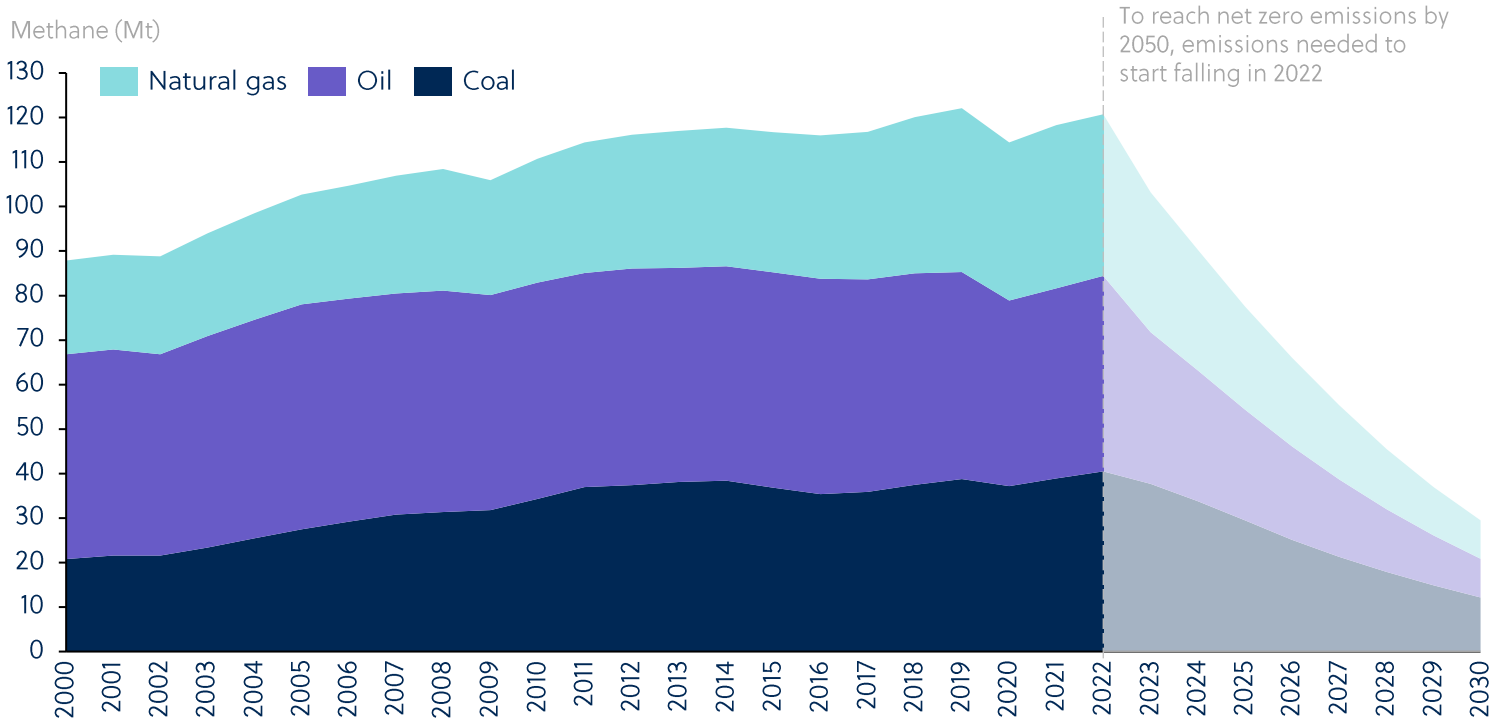
- Industry partnerships (including with Government) could support the sharing of learnings and provide the scale to implement emerging R&D or widespread monitoring programs.
- The Natural Gas STAR program was a highly successful initiative in the US that could be implemented in Australia – particularly given that many multi-national industry participants may have been historically involved.
- Government-industry partnerships could support the widespread implementation and commercialisation of coal mine methane abatement technologies (such CSIRO's technologies) to mutual benefit.
- The recent signing of the *Joint Statement on Accelerating Methane Mitigation from the LNG Value Chain* is a positive start in this direction.

Evidence from other jurisdictions show that the most successful outcomes tend to be associated with a holistic package of policies and measures. One measure or policy alone will likely not achieve the desired results in the most efficient manner – a combination of targets, economic signals and emissions regulations appears to drive the greatest industry action.

Global policy and industry context

Under the IEA's Net Zero Emissions by 2050 Scenario, methane emissions from fossil fuel operations fall ~75% by 2030

Methane emissions from fossil fuel operations in IEA's Net Zero Scenario, 2000-2030



Commentary

- The International Energy Agency (IEA) estimates that the global energy sector was responsible for nearly 135 million tonnes of methane emissions in 2022, equivalent to ~40% of total methane emissions attributable to human activity.
- In 2019, global methane emissions from energy supply, primarily fugitive emissions from production and transport of fossil fuels, accounted for ~32% of global methane emissions[1].
- Coal, oil, and natural gas operations are each responsible for around 40 Mt of emissions and nearly 5 Mt of leaks from end-use equipment. Extraction is the main source of fugitive emissions.
- According to the United Nations, methane emissions in the oil and gas sector are a consequence of extraction, processing, and delivery, either intentional (e.g., venting and flaring) or unintentional (e.g., equipment leaks).
- Typically, surface mines emit less methane than underground mines due to geological factors. The size and scale of surface operations still makes it a heavily emitting industry sub-sector.
- The IPCC estimates that between 50-80% of methane emissions from fossil fuel operations could be reduced with existing technologies[2].

Notes: [1] According to the IPCC, global methane emissions accounted for about 32% [22–42%] of global methane emissions in 2019; [2] The IEA estimates that 70% of methane emissions can be reduced with existing technologies, whereas the IPCC estimates about 50–80% of CH_4 emissions from these fossil fuels could be avoided with currently available technologies
Sources: United Nations Environment Programme – An Eye on Methane, International Methane Emissions Observatory Report (2022); Intergovernmental Panel on Climate Change – Mitigation of Climate Change, Summary for Policymakers (2022); Laconde – Fugitive emissions: a blind spot in the fight against climate change (2019).

While action is being taken at global, national, and industry levels to reduce methane emissions and strengthen reporting quality…

The Global Methane Pledge

- The Global Methane Pledge was launched at COP26 in November 2021 to catalyse action to reduce methane emissions.
- Led by the United States and the European Union, there are over 150 country participants that represent nearly 50% of global anthropogenic methane emissions, and over a third of the global GDP.
- By joining the Pledge, countries commit to working together to collectively reduce methane emissions by at least 30% below 2020 levels by 2030.
- The Pledge has brought together many important players in a joint international effort, including major energy consumers like the European Union, Japan, Korea, and major energy producers such as Iraq and Saudi Arabia.
- China has not signed the Global Methane Pledge.

Signatories to the pledge – selected jurisdictional action

Canada	In 2022, Canada published its 'Proposed regulatory framework for reducing oil and gas methane emissions to achieve 2030 target', aiming to reach at least a 75% reduction relative to 2012.
USA	In 2022, the USA published a proposal to reduce harmful emissions and energy waste[1], along with $1.55 billion in financial and technical assistance from the US EPA and a 'waste emissions charge'. The Inflation Reduction Act also contains significant actions and controls on methane.
UK	The UK has issued its 'UK Methane Memorandum, 2022' to track its progress as of 2020 in comparison to 1990 levels and outline plans to further reduce methane emissions.
EU	In 2023, the EU Parliament adopted a position on a new law to reduce methane emissions from the energy sector – this includes strengthened leak detection and repair obligations, and most importantly for Australia, energy imported from other countries would also need to meet the regulations from 2026.

Industry action

The Oil and Gas Methane Partnership 2.0

The flagship oil and gas reporting and mitigation program that provides a gold standard for companies reporting on methane.

Methane Guiding Principles

Principles to advance understanding and best practices to reduce methane emissions, and to support development of sound methane policies.

Oil and Gas Climate Initiative

A CEO-led initiative focused on accelerating action to a net-zero future, with members targeting net-zero emissions at their own operations.

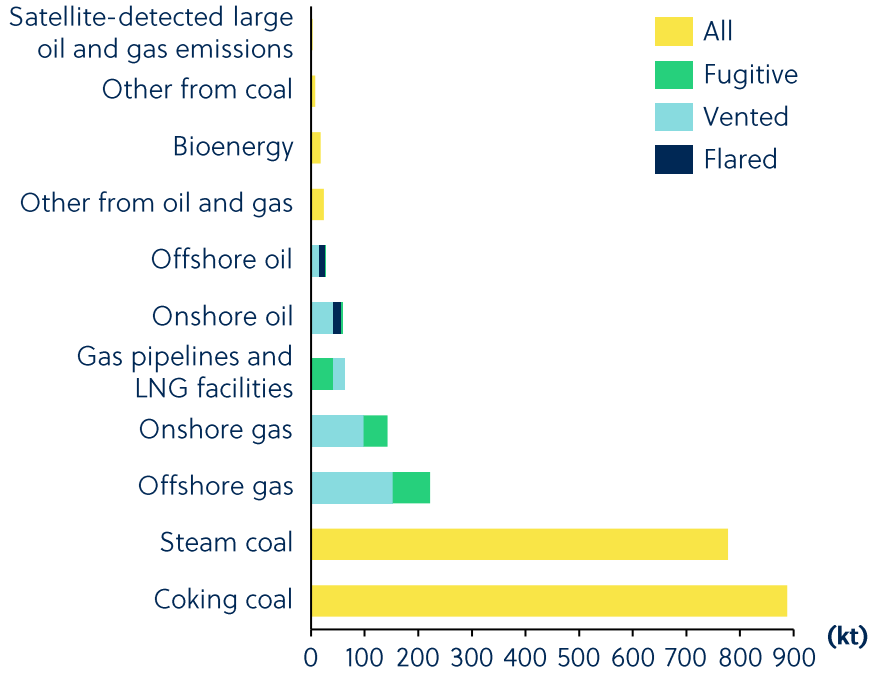
China Oil and Gas Methane Emission Control Alliance

The alliance aims to build an experience-sharing platform in the country to improve methane emissions control and engage with climate governance.

Notes: [1] The EPA Supplemental Proposal to Reduce Methane and Other Harmful Pollution from Oil and Natural Gas Operations will achieve 87% reductions in methane emissions from covered sources by 2030 from 2005 levels and will also include the creation of a "super emitter response program."
Sources: The Global Methane Pledge – Website (2023); IEA – Methane Tracker (2023); Rennie Insights and Analysis

… Australia is lagging, and needs better policies, regulations and technologies to combat fossil fuel methane emissions

Methane emissions from fossil fuel operations – Australia 2022



State-of-play of fossil methane emissions in Australia

- Alongside ~150 countries, Australia joined the Global Methane Pledge in October 2022 to reduce global methane emissions from human activity by 30% from 2020 levels by 2030 (although this target is not legislated).
- However, Australia does not currently have sector-specific methane emission reduction targets across the coal and gas industries and has faced scrutiny around its monitoring and reporting of methane emissions.
- The Institute for Energy Economics and Financial Analysis has recently stated that Australia's fugitive methane emissions from coal mining and oil and gas supply have likely been grossly underestimated to date – by about 80% for coal and 90% for oil and gas. The IEA has a more conservative estimate of 63%[1] underreporting.
- Australia needs to ensure enabling policies, regulations, and technologies are in place to meet its emission reduction targets with other signatories having recently published landmark policies and actions in methane[1].
- According to the United Nations, the main mitigation option for coal mine methane is the drainage of the methane from the mine before production (i.e., pre-drainage), which both increases safety and delivers higher-concentration streams of gas that can be destroyed or monetised.
- The other important mitigation option is destruction of Ventilated Air Methane (VAM), a technology that is already operational in several mines around the world, however uptake in Australia has been limited to date.
- Mitigation of methane emissions across the gas sector largely relate to leak detection and repair (LDAR) with satellites emerging as a leak detection technology that provides a higher quality of monitoring than current practices. Low and no-bleed equipment, gas capturing technology, and limits on flaring and venting are also common and impactful.
- Monitoring and accurate measurement of methane emissions from the coal and gas sectors will be critical in Australia reaching its methane emission reduction targets to drive targeted improvements, alongside a phasing down of fossil fuel production.

Notes: [1] Including Nigeria, Colombia and the United States. Canada and the European Union are expected to issue new methane regulations in 2023.
Sources: IEA – Global Methane Tracker (2023); United Nations Environment Programme – An Eye on Methane, International Methane Emissions Observatory Report (2022); Intergovernmental Panel on Climate Change – Mitigation of Climate Change, Summary for Policymakers (2022)

Methane intensity improvements will not be enough – global reduction in fossil fuel production over time will also be required

Understanding broader considerations and actions for methane reduction

Phasing out fossil fuels in the energy transition	• To meet global net-zero goals and limit global warming to 1.5°C, there will **need to be a global reduction in coal and gas production** within this decade, according to the IEA – methane intensity reductions in these sectors will be insufficient. • Navigating the transition will need to be **tackled with equity and consideration of national and global development needs**. AEMO's 2022 Integrated System Plan identifies a 'step change' scenario as the most likely future for the National Energy Market, with 60% of current coal generation retiring by 2030[1], and a shift from mid-merit gas generation to mostly gas-fired peaking plants with the role of gas reducing to grid stability and security. If this scenario eventuates, it will naturally influence the fossil fuel methane emissions potential from Australian demand. It is important to acknowledge that particularly developing countries) will continue to be reliant on Australian exported fossil fuels until they can transition to clean power sources. To meet ambitious climate scenarios, the emissions intensity of fuel delivered to these countries must be reduced, alongside support to transition to renewable alternatives. • Methane from fossil fuels is the second largest source of methane in Australia and has the highest mitigation potential today. There **needs to be a concerted effort across industries** to reduce methane emissions, especially where there are cost-effective and readily available solutions for both the gas and coal sectors.
Accurate measurement and reporting	• Many studies globally and within Australia have shown that methane emissions are under-reported, particularly from natural gas and coal mining facilities, and especially in open-cut coal mines. There are differences in measurement and estimation methodologies with often very different outcomes. **With new satellite and infra-red monitoring technologies, and tighter measurement and reporting requirements, this gap can be rectified**, and the full extent of methane emissions incorporated into goals and actions.
Implementing cost-effective solutions	• According to the IEA, and successful voluntary programs in the US, **there are cost-effective emissions reduction solutions available in the natural gas and coal sectors**, which come with many co-benefits. With a standardised, balanced policy environment, significant emissions intensity improvements can be made in the near-term as we work to meet this decade's methane reduction goals and keep global warming to 1.5°C. The costs and benefits of the suggested actions in this report have not been assessed.
Managing abandoned sites	• When productions and mines close, methane emissions rarely cease – **continued policy attention to methane emissions from abandoned and decommissioned coal and gas mines is also required** to manage this issue effectively (noting that this particular legacy issue is beyond the scope of this report).

Sources: [1] Australian Energy Market Operator – Integrated System Plan (2022)

Research scope and approach

Rennie undertook a multi-jurisdictional review of policy, regulation and technology approaches to methane emissions reduction

SCOPE

- Undertake desktop research on fossil fuel methane emissions reduction technologies in Australia and analogous jurisdictions including the USA, Canada and the EU, and the relevant policies that have catalysed their uptake as relevant to Australian coal and gas production, transportation, storage and processing.

OBJECTIVES

- Determine the uptake of methane reduction technologies across select jurisdictions, identifying drivers for uptake.
- Identify the similarities and differences between policies, including how the policies were enacted and implemented, and taking account of their historical / environmental context.

AIM

- Demonstrate how Australia can apply learnings from other jurisdictions to meet its national emission reduction targets, by reducing methane emissions across the coal and gas sectors, specifically within production, transportation, storage and processing.

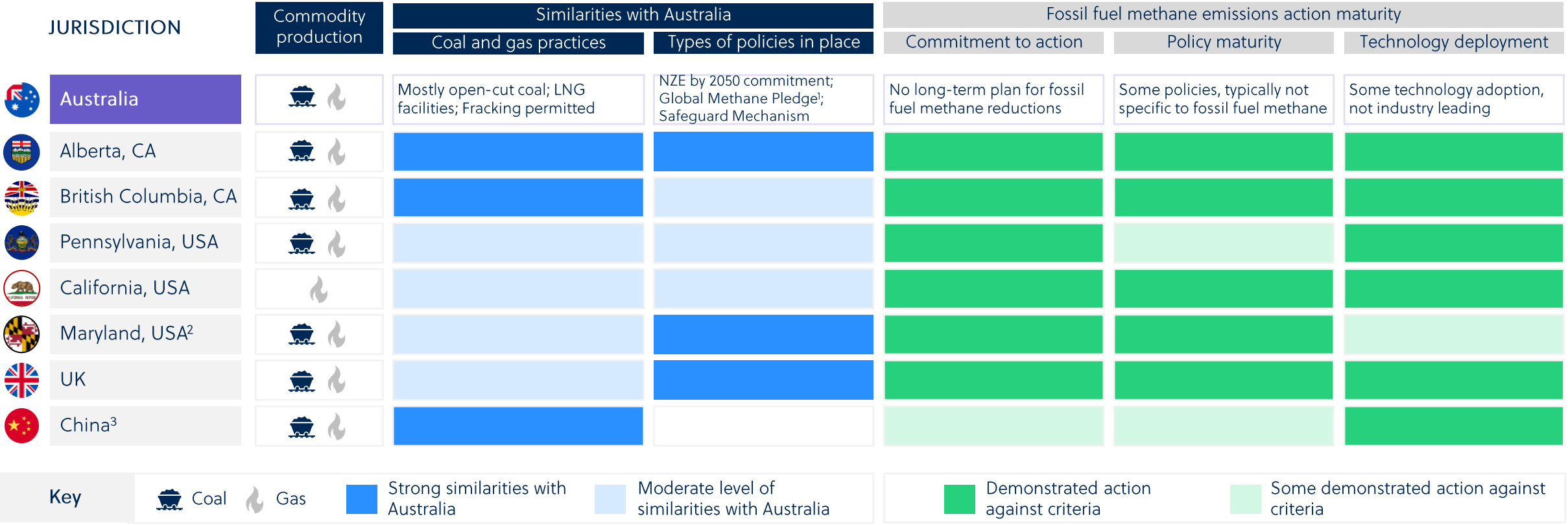
Approach

1. Develop a list of potential jurisdictions based on methane action to date and relevance to Australia
2. Develop criteria to assess jurisdictions against
3. Apply criteria to identify appropriate jurisdictions for analysis
4. Conduct secondary and primary research, including interviews with industry experts where necessary

Overview of criteria used to identify relevant jurisdictions

Commitment to action	Metrics and targets, and strategies / roadmaps.
Policy maturity	Policies and/or other instruments that are in force.
Technology use	Methane emission reduction technology deployment.
Australian relevance	Coal and gas practises, similarities in policy environments.

The review focused on seven jurisdictions with advanced methane reduction policies and practices in the coal and gas sectors



Notes: [1] The Global Methane Pledge aims to reduce methane emission from human activity by 30% from 2020 levels by 2030; [2] Maryland has very limited natural gas reserves, only producing ~5 million cubic feet of natural gas annually; [3] China is being included strictly for consideration of emission reduction technology developments
Sources: Rennie Insights and Analysis

Jurisdictional research

Canada

In line with Canada's 2030 Emissions Reduction Plan, Canada issued a Methane Strategy in September 2022 outlining reduction measures and supporting programs to reduce domestic methane emissions by more than 35% by 2030, compared to 2020.

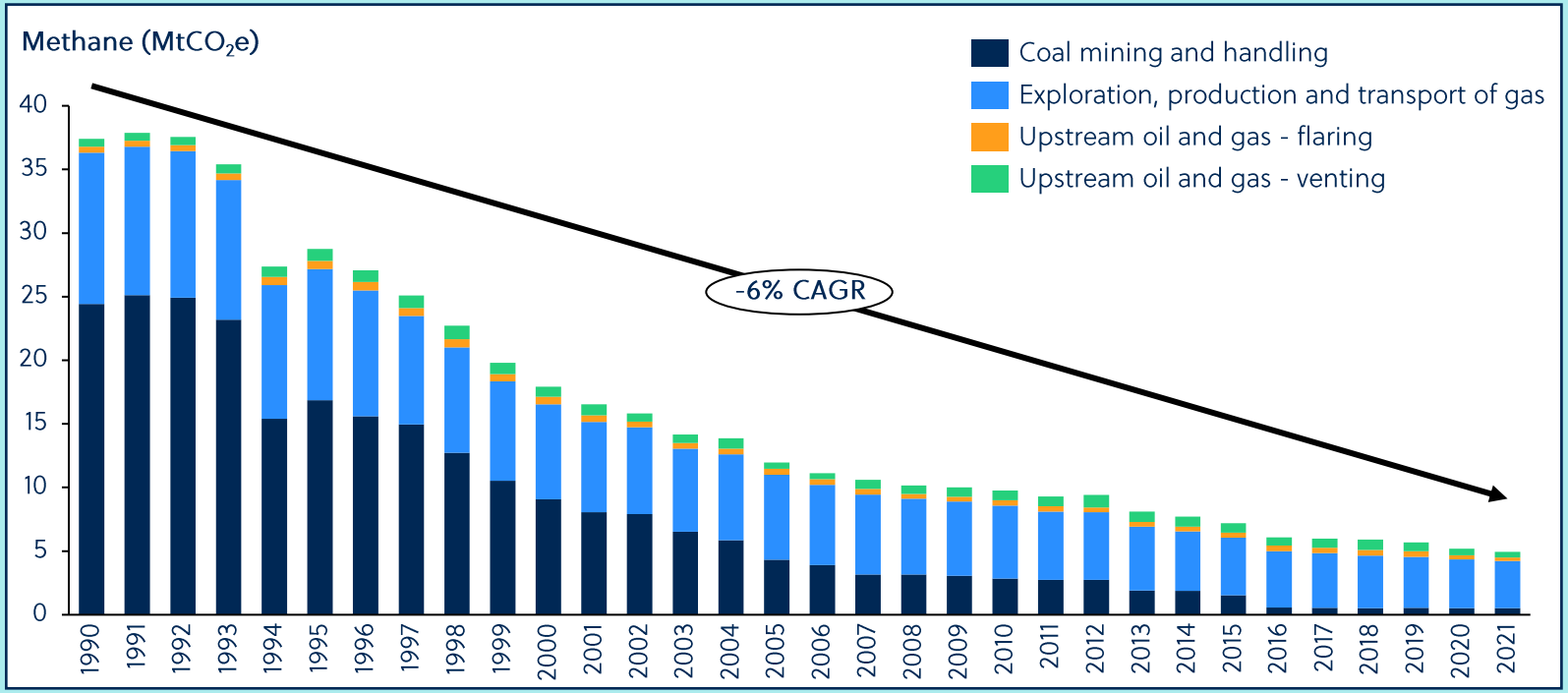
Like Australia, Canada has a federated system with an overarching national government and sub-national provinces and territories. Each level of government has different powers and responsibilities, often dictated within the Constitution. In Canada, the provinces have policy authority over natural resources within their borders (including oil, gas and coal mining). However, where policy issues have cross border or national economic implications, the federal government has authority to overrule provincial jurisdiction.

Both Alberta and British Columbia (B.C.) provide useful and relevant case studies for how they, as provinces with the greatest industry interest and influence, have made an impact on their own fossil fuel methane emissions intensity through their subnational actions.

TARGETS

- Reduce oil and gas methane emissions by at least 75% by 2030.
- Signatory to the Global Methane Pledge to reduce human-caused methane emissions by 30% below 2020 levels by 2030.

METHANE EMISSIONS FROM FOSSIL FUEL INDUSTRIES, 1990-2021



KEY POLICIES / REGULATION

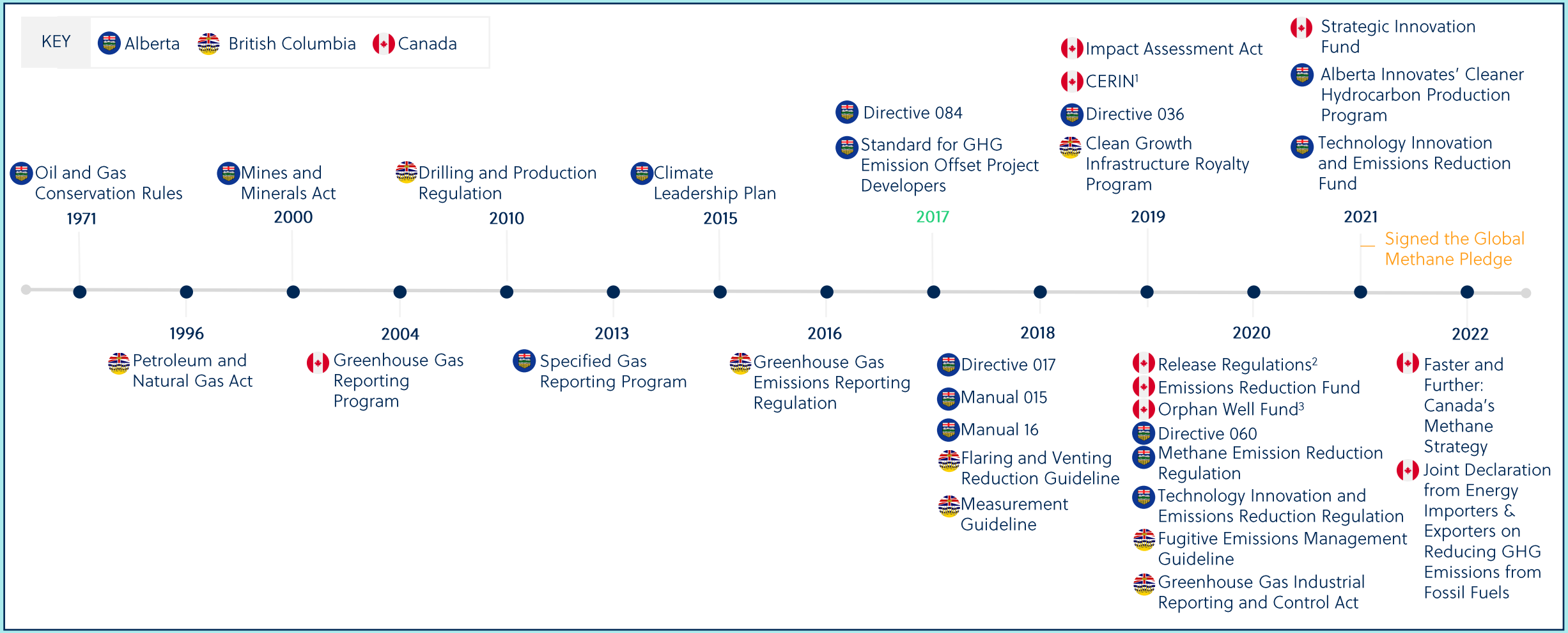
- Faster and Further: Canada's Methane Strategy
- Emissions Reduction Fund
- Canadian Emissions Reduction Innovation Network (CERIN)
- Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds
- Impact Assessment Act
- Strategic Innovation Fund
- Greenhouse Gas Reporting Program (GHGRP)
- Funding to clean up orphan or inactive oil & gas wells to create employment and reduce methane emissions

Key: Prescriptive; Performance/outcomes based; Economic; Informative

Sources: Government of Canada – GHG Inventory Data (2022); Canadian Journal of Political Science – The Ultimate Horizontal Issue: The Environmental Policy Experiences of Alberta and Ontario, 1971-1993 (1994)

Canada

POLICY / REGULATION IMPLEMENTATION TIMELINE, 1971 - 2022



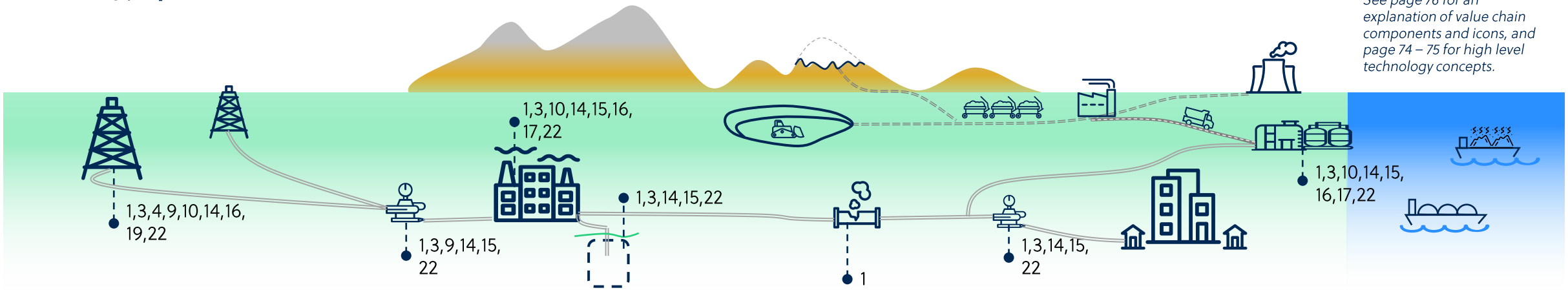
Notes: [1] Canadian Emissions Reduction Innovation Network (CERIN); [2] Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds; [3] Funding to clean up orphan or inactive oil & gas wells to create employment and reduce methane emissions

Sources: IEA – Policies Database (2023)

Canada drives mandatory and recommended emissions-limited technology upgrades via provincial grant & incentive programs

Technology uptake to date

See page 76 for an explanation of value chain components and icons, and page 74 – 75 for high level technology concepts.



Methane reduction technology and practices

- ✓1. Use of LDAR technology and practices
- 2. Pipeline replacement and repair
- ✓3. Use of electric/compressed air devices
- ✓4. Use of casing gas capture/destruction tech
- 5. Lowered gas line pressure
- 6. Use of plunger lifts in blowdown events
- 7. Use of reduced emissions well completions
- 8. Use of eductors/ejectors for flare gas recovery
- ✓9. Conversion of engines to electric alternatives
- ✓10. Use of VRUs on particular components
- 11. Use of blowdown optimisation practices/tech
- 12. Coal mine/bed methane capture and use
- 13. Ventilation Air Methane abatement practices

Industry components that emit methane

- ✓14. Use of low-bleed pneumatic devices
- ✓15. Use of reciprocating/centrifugal compressors
- ✓16. Use of flares
- ✓17. Use of storage vessels/tanks
- 18. Use of circulation tanks
- 19. Use of Glycol Dehydration Units
- 20. Use of separation systems
- 21. Use of pipeline pigging operations
- 22. Occurrence and monitoring of blowdown events

Sources: British Columbia – Coalbed Methane Brochure; Environmental Defense Fund – Best Practices on Oil and Gas Methane Emissions Regulations; Rennie Insights and Analysis

✓ Eligible for grants and/or incentives programs

- Mandatory use
- Recommended or encouraged use
- Industry trend
- May use, but minimum emissions thresholds or other limits are applied
- May use, but minimum emissions thresholds recommended
- Event and emissions reporting required only

Alberta, CA

Alberta has a highly mature natural gas industry, with some of the largest natural gas infrastructure and storage in North America. Coal mining also occurs, particularly in the Prairies and Eastern Slopes for surface mining (strip mining and open-pit respectively).

The provincial government has a target to reduce CH_4 emissions from upstream oil and gas operations by 45% by 2030 (against 2014 levels), while the Federal government has committed to a 75% reduction on 2012 levels by 2030. Alberta has reported an estimated reduction of 44% as at 2021.

Fugitive CH_4 emissions from natural gas venting is the single largest emitter of methane in Alberta, accounting for a similar amount as biogenic agricultural sources.

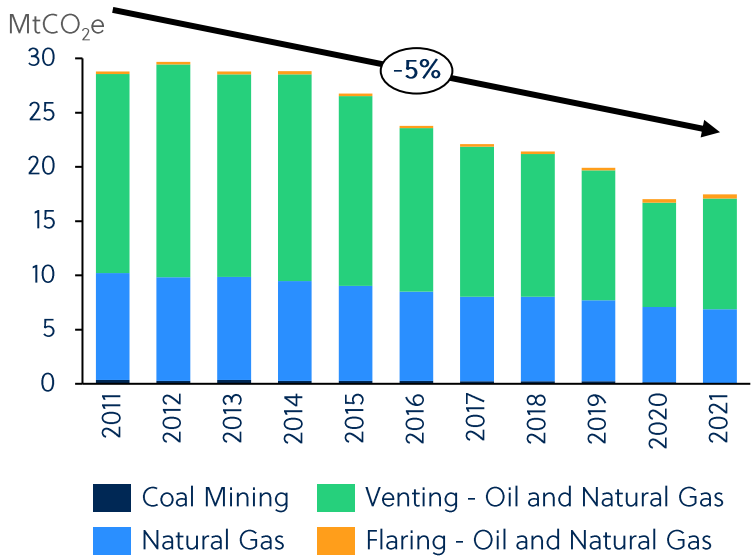
Like natural gas from conventional sources, Alberta considers coalbed methane (CBM) to be 'sweet' not 'sour' as it does not contain hydrogen sulphide[1]. As such, it is regulated in the same way as natural gas operations with Directions detailing technical specifications and operational standards.

TARGETS

- Reduce methane emissions from upstream oil and gas operations by 45% from 2014 levels by 2025.

OVERVIEW

Fugitive methane emissions from fossil fuel industries, 2011-2021



GAS TECHNOLOGY

- ✓ Onsite monitoring[2]
- ✓ Offsite monitoring[3]
- — Vapour Recovery Units
- — Early replacement[4]
- ✓ Electric/compressed air
- — Electric engines
- X Reduced Emission Completions

COAL TECHNOLOGY

- X Drainage
- X Reuse of VAM
- X VAM oxidation
- ✓ CMM utilisation
- X CMM flaring

TYPES OF POLICIES

- Prescriptive
- Performance / outcomes based
- Economic
- Informative

KEY POLICIES / REGULATIONS

- Mines and Minerals Act
- AER Directive 060
- Oil and Gas Conservation Rules
- Standard for GHG Emission Offset Project Developers
- Technology Innovation and Emissions Reduction Regulation
- AER Directive 036
- AER Directive 084
- Climate Leadership Plan
- Methane Emission Reduction Regulation
- Technology Innovation and Emissions Reduction Fund

Key: ✓ Evidence of use — Limited evidence of use — X No evidence of use

Notes: [1] Sweet natural gas is a type of natural gas containing trace amounts of hydrogen sulfide and carbon dioxide. This natural gas is non-corrosive in its pure form, and it requires little refining. Sour natural gas is a type of natural gas containing large amounts of hydrogen sulfide; [2] Includes Leak Detection and Repair; [3] Includes satellite and optical gas imaging; [4] Includes the early replacement of compressor seals and / or rods

Sources: Government of Canada – GHG Inventory Data (2022)

Alberta uses a mix of prescriptive and incentive-based policy and regulatory instruments to drive methane emissions reduction...

Regulatory approaches

Prescriptive

A staple in the Alberta gas regulations is **Directive 060** (and its supporting **Directive 017**), which sets the standards for flaring, incinerating, and venting methane at all upstream petroleum wells and facilities, along with measurement requirements.

Under the **Methane Emission Reduction Regulation** (MERR), all oil and gas licensees must adhere to these directives. Since Directive 060's inception in 1999, it has been incrementally strengthened and tightened to include more sources (such as an update in 2019 to include gas for pneumatics).

Coalbed methane (CBM) is regulated in a similar manner to natural gas operations, with detailed requirements outlined in **Directive 056 and Directive 035**. Directive 056 provides technical specifications for facility, pipeline, and well construction and operation applications. Directive 035 specifies the baseline water well testing requirements for coalbed methane wells above the base of groundwater protection.

Performance / outcomes based

Alberta's **Oil and Gas Conservation Rules** outlines the maximum rate limitations for production (MRL) as well as basic well rates (BWR), which is the lowest unpenalised production rate. This Rule gives power to several Directives in Alberta, including Directive 060 and Directive 056.

Economic

The Albertan Government has developed a suite of regulations, directives, and funding instruments to support the methane components of their 2015 Climate Leadership Plan. Similar to the Australian Safeguard Mechanism, the **Specified Gas Reporting Program** collects facility level GHG emissions, and the **Technology Innovation and Emissions Reduction (TIER) Regulation** requires facilities that emit in excess of 100 $kTCO_2e$ per year to reduce their emissions, purchase offsets, trade 'performance credits', or pay into the TIER fund.

Under this system, emissions reduction performance is incentivised by encouraging the uptake of cost-effective technologies while allowing facilities the freedom to identify efficient technologies and practices for individual circumstances. The TIER fund has also been very effective in driving the adoption of 'low-hanging fruit' emissions reduction technologies, with CAD$17million contributed to the **Alberta Methane Emissions Program** (AMEP).

Informative

Alberta publishes the **Upstream Petroleum Industry Emissions Report** annually, which includes a list of operators ranked by their flaring and venting emissions. Companies that are ranked near the top of this list may receive increased pressure from investors and other stakeholders to reduce their emissions.

Sources: IEA – Policies Database (2023); IEA – Methane Tracker (2023); Alberta Energy Regulator – Upstream Petroleum Industry Emissions Report (2021); Rennie Insights and Analysis

...which have encouraged technology improvements in oil and gas operations to help reduce fossil fuel sector emissions

Technology uptake to date

Coal

- There is limited evidence of widespread deployment of methane emissions reduction technologies in the Albertan coal sector. This is likely due to the minimal activity from the sector and the presence of surface mines rather than underground mines (in which methane emissions abatement practices are less commonly required).
- Ventilation units are also only used in underground mines, so ventilation air methane (VAM) abatement technologies do not apply in Alberta.

Gas

Since the late 1990s, a range of upstream methane emissions technologies have been required under D60, D17, and D36 regulations, with increasing scope and stringency. This has included stipulations on new and existing activities and operations, which drives technology uptake.

Prescribed components include:

- Pneumatic devices and pumps – in particular non-emitting requirements for new devices and emissions limits on existing ones
- Venting limits on compressors and gas wellheads
- Bleed-off to flare systems, with minimum flare specifications
- LDAR inspection requirements

Many of these technologies have also been supported by the Methane Technology Implementation Program (MTIP) grants, as well as other best practice and low cost per abatement technologies (such as instrument to air conversion, storage tank Vapour Recovery Units (VRU), and surface casing technologies).

Alberta considers coalbed methane to be a commodity that is a form of natural gas and is extracted by drilling a well into a coal seam, applying similar techniques used for other natural gas wells. As such, use and extraction of this gas is a form of coal mine methane (CMM) utilisation.

Sources: Alberta Energy Regulator – Coalbed Methane (2023); Rennie Insights and Analysis

Alberta's combination of regulation and incentives provide choice in abatement technologies, with minimum standards applied

Outcomes, challenges and opportunities

The combination of specific operational requirements, and financial incentives that allow for flexibility in technology investment choice has resulted in significant reductions in methane emissions in an efficient and whole of industry manner.

To date, this has largely addressed the easy to abate methane emissions sources in the oil and gas value chain. The remaining emissions sources – where Federal focus in Canada is now shifting – are more costly to abate, and in some cases, there is no technology ready to be able to meet the standards being proposed (e.g., engine methane emissions of 1g/kWh, or addressing methane slip).

A re-orientation of existing R&D and abatement implementation incentives could be needed to drive the next phase of emissions reductions in the gas sector.

Provincial government has typically been the main driver of methane regulation and incentives. As the issue gains increasing Canadian Federal Government attention, the challenge will be to ensure that local differences can be addressed.

Key takeaways

The prescriptive process and equipment emissions standards could be included in a federal set of prescriptive regulations for the Australian fossil fuel industry.

There are similarities between some of the Albertan programs and the reformed Safeguard Mechanism.

- There are a mix of prescriptive, performance, economic, and information policies in place, providing a 'carrot and stick' approach. They allow companies to invest in the emissions reduction programs that have the most cost-effective outcomes, while setting minimum standards and expectations.
- The reforms to the Safeguard Mechanism are similar to the Albertan TIER. Aspects of the MTIP are similar to the Powering the Regions Safeguard Transformation Stream, but with a specific focus on methane and on a smaller scale.
- These include the Specified Gas Reporting Program (information), the Technology Innovation and Emissions Reduction Regulation (TIER) (performance/economic), the MTIP (economic), and Directives 017 & 060 under the Methane Emissions Reduction Regulation (MERR) (prescriptive).
- Prescribed technology standards and process and equipment emissions standards cover pneumatic devices and pumps, venting limits on compressors and gas wellheads, and bleed-off flare systems.
- Methane abatement specific technologies include Vapour Recovery Units, and LDAR technologies and inspection requirements.
- Technology uptake is either directly a result of prescribed process and equipment emissions standards or implemented to take advantage of economic and performance incentives (e.g., emissions credits and cost savings).
- The revenue from emissions penalties is used in part to fund specific methane technology grants programs (e.g., MTIP).

British Columbia, CA

Similar to Alberta, British Columbia (B.C.) has a well-developed and regulated natural gas and coal industry (with natural gas being particularly significant).

British Columbia has committed to reducing methane emissions from upstream oil and gas to 75% below 2014 levels, and cleaning up 100% of un-used and abandoned oil and gas wells. This is in the face of expanding production and investment in heavy pipeline and LNG facilities over the next decade.

Coal mining is much more extensive than neighbouring Alberta, and is predominately open-cut, mountain-top removal mines in the Rockies.

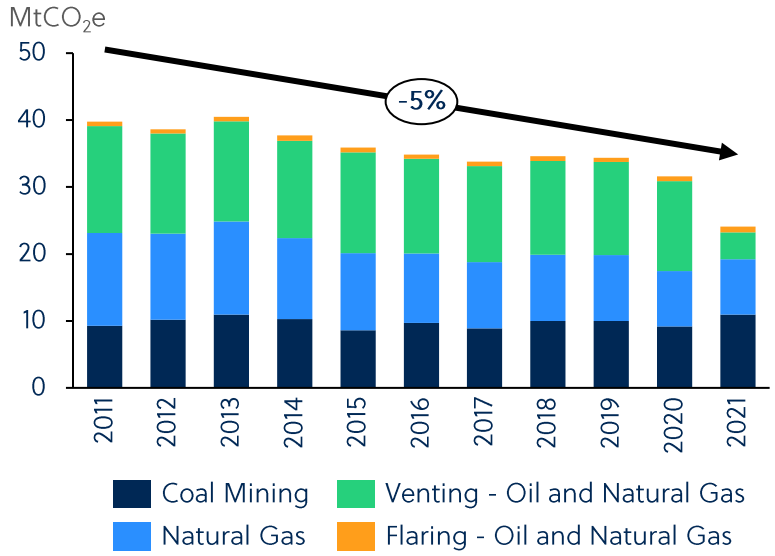
The Government has identified opportunities for coalbed methane production, however there is limited commercial scale activities currently.

TARGETS

- Reduce methane emissions in the upstream production of natural gas by 75% by 2030, relative to 2014 levels.

OVERVIEW

Fugitive methane emissions from fossil fuel industries, 2011-2021



GAS TECHNOLOGY

- ✓ Onsite monitoring[1]
- ✓ Offsite monitoring[2]
- ✓ Vapour Recovery Units
- — Early replacement[3]
- ✓ Electric/compressed air
- X Electric engines
- X Reduced Emission Completions

COAL TECHNOLOGY

- X Drainage
- X Reuse of VAM
- X VAM oxidation
- X CMM utilisation
- X CMM flaring

TYPES OF POLICIES

- Prescriptive
- Performance / outcomes based
- Economic
- Informative

KEY POLICIES / REGULATIONS

- Petroleum and Natural Gas Act
- GHG Emissions Reporting Regulation
- Clean Growth Infrastructure Royalty Program
- Measurement Guideline for Upstream Oil and Gas Operations
- Drilling and Production Regulation
- Flaring and Venting Reduction Guideline
- Fugitive Emissions Management Guideline
- Greenhouse Gas Industrial Reporting and Control Act

Key

✓ Evidence of commercial scale adoption — — Limited evidence of use (some isolated examples found) — X No evidence of use

Notes: [1] Includes Leak Detection and Repair; [2] Includes satellite and optical gas imaging;[3] Includes the early replacement of compressor seals and / or rods

Sources: Government of Canada – GHG Inventory Data (2022)

Historic divergences in environmental values and policy has led to different approaches between Alberta and B.C.

Differences in approaches to coal: Alberta vs B.C.

Mountain-top removal coal mining in the Rocky Mountains is prevalent in B.C., whereas it is rarely used in Alberta – despite sharing the same mountain range and coal deposit, B.C. produces 10x the volume of metallurgical coal as Alberta.

Until the mid-20th century, the neighbouring provinces had similar approaches to coal mining and environmental protection. This shifted in the 1970s when landmark policy restricting coal mining on the eastern slopes was enacted – citing environmental concerns and the effect on the potential for recreation and tourism. This was also driven by the judgement that oil was a more valuable resource to be developed.

At the same time, the B.C. government made strong pro-coal announcements, and metallurgical coal projects shifted west.

Today, different approaches continue and are reflected in the values of the residents. The major coal mining operations in the Rocky Mountains are far removed from the majority of the B.C. population, while in Alberta the mountain range environment is on the doorstep of major urban centres and is seen as part of the Albertan sense of identity. There are far more protected areas on the Albertan side of the border, while B.C. environmental agendas are more focused on the coast.

Climate policy in B.C.

- Contextually, events in 2007 created a receptive environment to climate policy – the economy was growing, unemployment rates were at the their lowest in 32 years, The Inconvenient Truth was generating substantial public interest, and the UK Stern Review generated policy-maker interest.
- The Carbon Tax, introduced at a similar time to the Clean Electricity Standard (CES) in 2008, immediately led to the cancellation of the construction of two new coal-fired and one new gas-fired electricity plants.
- The Low-Carbon Fuel Standard (LCFS) was introduced shortly after in 2010 and was inspired by a similar policy previously introduced in California, including their Global Warming Solutions Act.
- These policies had big effects on the electricity and transportation emissions reductions at the time.
- Both used performance goals rather than specific compliance pathways, allowing the flexibility to choose the lowest-cost technology pathways.

Sources: British Columbia Government – Websites (2023); Review of Policy Research - A Tale of Two Taxes: The Fate of Environmental Tax Reform in Canada (2012); Policy and Practice Reviews - Climate policy in British Columbia: An unexpected journey (2023); Rennie Insights and Analysis

Today, B.C. has extensive methane specific regulations in place for oil and gas facilities, often exceeding Federal regulations

Regulatory approaches

Prescriptive

British Columbia has established regulations for the flaring, incinerating, and venting of natural gas. The **Flaring and Venting Reduction Guideline** provides procedures for obtaining approvals, modelling dispersion, and reporting gas emissions. It applies to well sites, facilities, and pipelines regulated under the **Oil and Gas Activities Act 2008**.

In 2018, amendments were made to the **Drilling and Production Regulation 2010** to address methane emissions. These amendments included requirements for plugging abandoned mines, reducing venting and flaring, and recovering natural gas in specific situations.

The British Columbia Oil and Gas Commission (BCOGC) has also implemented **LDAR programs**. These programs mandate monitoring and inspection of equipment, pipelines, and infrastructure to detect and rectify methane leaks, reducing fugitive emissions and ensuring gas facility integrity.

Performance / outcomes based

British Columbia's **Drilling and Production Regulation 2010** is the key performance-based policy in the region, and includes provisions to restrict methane venting and flaring. Flaring is limited to 50,000 m3/year, or as permitted, with operators required to notify regulators for flaring exceeding 10,000 m3. The regulation also mandates a recovery rate of 95% for facilities utilising hydrocarbon gas conversion equipment.

Economic

The **Greenhouse Gas Industrial Reporting and Control Act 2020** mandates reporting and introduces emissions offset units. Operators receive one unit per tonne of reduced emissions credited to them. The Act also establishes an emissions offset project.

The **Clean Growth Infrastructure Royalty Program** (CGIRP), launched in 2019, offers incentives for capital investment in oil and natural gas infrastructure to reduce methane emissions. It provides financial benefits through royalty reductions, covering up to 50% of the project's estimated capital investment cost. For emissions reduction projects, half of the reduction is deferred until an Emissions Reduction report is accepted after one year of operation.

The **CleanBC Industrial Incentive** (CII) Program supports operators in reducing carbon tax costs by demonstrating low emissions levels compared to facilities worldwide. Operators achieving this distinction receive significant reductions in their Carbon Tax obligations.

Informative

Under the **Greenhouse Gas Emissions Reporting Regulation 2016**, British Columbia details the greenhouse gas reporting requirements for operators who emit more than 10,000 tonnes of CO_2 equivalent per year. The regulation stipulates the format of the reports (e.g., requires a process-flow diagram) and establishes verification bodies to evaluate reports from operators.

Sources: IEA – Policies Database (2023); IEA – Methane Tracker (2023); Rennie Insights and Analysis

Grants have been well utilised to facilitate the equipment-based emissions requirements expected of gas industry operations

Technology uptake to date

Coal	Gas
• There is no evidence of widespread deployment of methane emissions reduction technologies in the British Columbia coal sector. This is mainly due to the dominance of surface mines rather than underground mines, which typically have less methane emissions abatement requirements.	Between 2019 and 2022, the most common funded projects under the CleanBC Industry Fund involved replacing natural gas devices with **electric equivalents** to reduce unintentional methane venting. The capture and re-use or sale of vapour or otherwise vented emissions was also common. Other projects include: • Replacing natural gas driven compressor engines with more efficient models • Recovery of vented methane for use as a fuel (e.g., through a VRU) • Replacing pneumatic devices to run on air to eliminate venting • Recovery of vented methane to transport gas by-products for sequestration to reduce flaring/venting • Waste gas flare gas capture from completion flowback processes using pressurised gas storage and compression technology • Small diameter piping installation to capture and utilise blowdown methane events • High to low bleed pneumatic device replacement • Flaring automation, etc.[1] In addition, the fund also has supported the following innovation accelerator projects: Continuous Methane Detection and Measurement; Satellite-based methane detection technologies; Pressure energy recovery from NG contained in production wells or storage reservoirs and conversion to electricity; Methane pyrolysis to zero emissions carbon. These technologies or process changes provide clear co-benefits (lower fuel costs, increased revenue options), which when supported by government grants create a strong incentive for uptake.

Sources: Province of British Columbia – Funded Projects (2023)

There has been a notable reduction in methane venting in B.C. due to a combination of policies and associated technology uptake

Outcomes, challenges and opportunities

In British Columbia, regulatory measures and incentive programs have driven the adoption of methane reduction technologies in the industrial sector.

Steady reductions in methane emissions were seen between 2011 and 2020, but a more significant drop was reported between 2020 and 2021, largely driven by a fall in venting from oil and natural gas operations.

This coincides with the introduction and maturation of a number of policies:

- The 2018 amendments to the Drilling and Production Regulation came into effect, which included flaring and venting requirements
- The first tranche of the 2019 Clean Growth Infrastructure Royalty Program projects would have begun to come into operation
- The Greenhouse Gas Industrial Reporting and Control Act 2020 came into effect, incentivising methane reductions as offset projects

2022 emissions data (when available), will be informative in confirming the effectiveness of these policies. These reductions have been achieved despite increasing oil and gas outputs.

Reducing coal mine methane and methane emission from non-venting or flaring sources will require further attention to achieve the same reduction results.

Key takeaways

More comprehensive and consistent requirements around methane emissions in the industry in Australia could increase technology adoption.

These could be coupled with similar grant and incentives programs, which could be integrated into existing programs.

- Amidst the backdrop of a Carbon Tax, predominately prescriptive and economic policies have been implemented, with some performance elements supported by the informative GHG Emissions Reporting Regulation.
- The majority of technologies being deployed are to replace natural gas driver compressors, generators, and pneumatic devices with electric powered equivalents.
- Other common projects include efficiency improvements, recovery of vented methane for re-use, and using air in pneumatic devices.
- Since 2019, the CleanBC Industry Fund had awarded funding to 35 projects directly related to fossil fuel industry methane emissions reductions.
- These projects, while supported by the CleanBC Industry Fund, make steps towards compliance with recent regulations and access to offset incentives. They would also support a lower carbon tax liability – a demonstration of carrot and stick policy development.

United Kingdom

The fossil fuel industry in the UK has shifted significantly over the last two decades and is changing further due to geopolitical developments. There are now only a handful of surface coal mines in operation, and no underground mining (although a deep coking coal mine was recently approved).

Approximately 50% of the UK's gas usage comes from its own North Sea resources, which are expected to be depleted by 2030. As part of a bid to secure ongoing energy amidst changing Russian gas dynamics, and depletion of North Sea reserves, the Government lifted a moratorium on shale gas production and fracking in 2022.

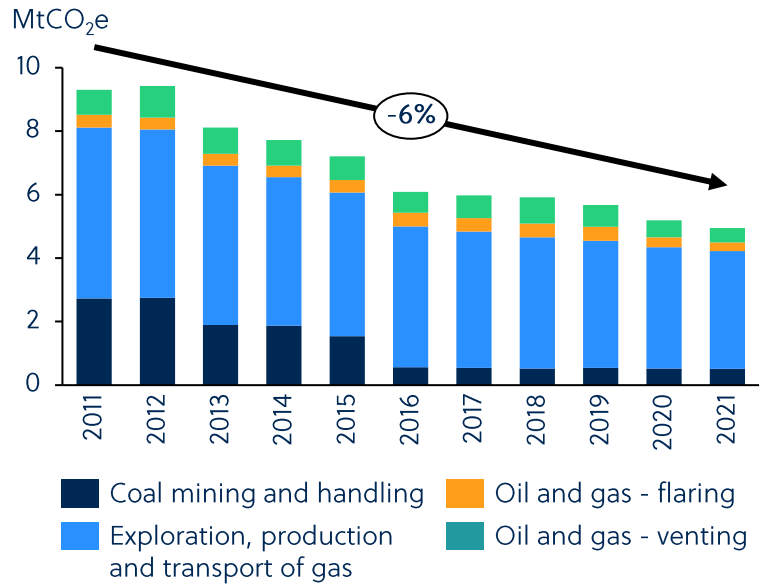
With the decline in coal and North Sea oil and gas production, methane emissions from the energy sector have reduced by 84% in 2020 compared to 1990 levels. Currently, they account for about 11% of the country's methane emissions. The majority of methane emissions in the energy sector are now fugitive emissions from fuels (in particular, leakage from the gas distribution system).

TARGETS

- Signatory to the Global Methane Pledge to reduce human-caused methane emission by 30% below 2020 levels by 2030.
- Aims to achieve zero routine flaring and venting targets by 2030 or sooner.

OVERVIEW

Methane Emissions from fossil fuel industries, 2011-2021



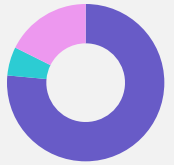
GAS TECHNOLOGY

- X Onsite monitoring[1]
- ✓ Offsite monitoring[2]
- X Vapour Recovery Units
- X Early replacement[3]
- X Electric/compressed air
- X Electric engines
- X Reduced Emission Completions

COAL TECHNOLOGY

- ✓ Drainage
- X Reuse of VAM
- ✓ VAM oxidation
- ✓ CMM utilisation
- X CMM flaring

TYPES OF POLICIES



- Prescriptive
- Performance / outcomes based
- Economic
- Informative

KEY POLICIES / REGULATIONS

- Energy Act 1976
- Methane memorandum
- Climate Change Act 2008 as Amended
- Gas Safety (Management) Regulations
- The Offshore Combustion Installations (Pollution Prevention and Control) (Amendment) Regulations 2013, amended 2018
- Petroleum Act 1998
- Guidance for Flaring and Venting
- Pipelines Safety Regulations
- The Environmental Permitting Regulations 2010

Key

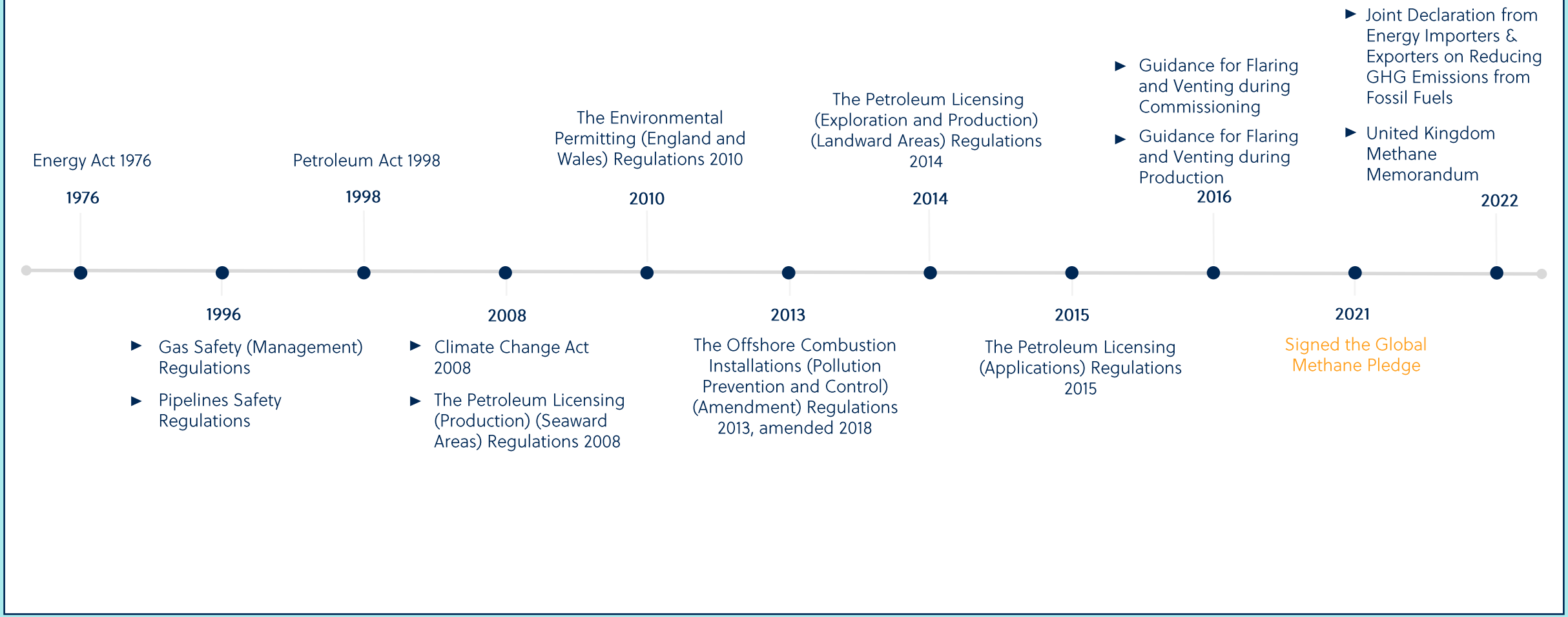
✓ Evidence of commercial scale adoption — Limited evidence of use (some isolated examples found) — X No evidence of use

Notes: [1] Includes Leak Detection and Repair; [2] Includes satellite and optical gas imaging;[3] Includes the early replacement of compressor seals and / or rods

Sources: United Kingdom – GHG Emissions Tables (2021)

United Kingdom

POLICY / REGULATION IMPLEMENTATION TIMELINE, 1976 - 2022

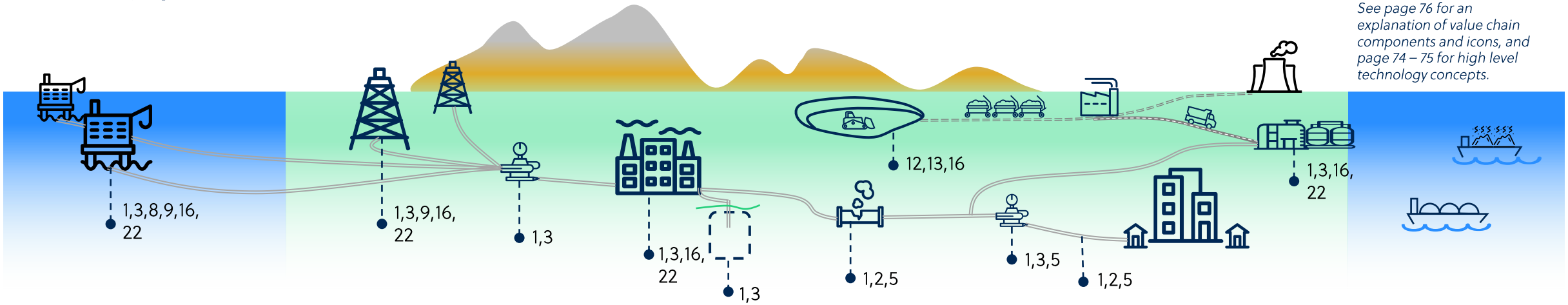


Sources: IEA – Policies Database (2023)

Evidence of widespread abatement technology uptake in the UK is limited, largely due to a lack of targeted policies and incentives

Technology uptake to date

See page 76 for an explanation of value chain components and icons, and page 74 – 75 for high level technology concepts.



Methane reduction technology and practices

1. Use of LDAR technology and practices
2. Pipeline replacement and repair
3. Use of electric/compressed air devices
4. Use of casing gas capture/destruction tech
5. Lowered gas line pressure
6. Use of plunger lifts in blowdown events
7. Use of reduced emissions well completions
8. Use of eductors/ejectors for flare gas recovery
9. Conversion of engines to electric alternatives
10. Use of VRUs on particular components
11. Use of blowdown optimisation practices/tech
12. Coal mine/bed methane capture and use
13. Ventilation Air Methane abatement practices

Industry components that emit methane

14. Use of low-bleed pneumatic devices
15. Use of reciprocating/centrifugal compressors
16. Use of flares
17. Use of storage vessels/tanks
18. Use of circulation tanks
19. Use of Glycol Dehydration Units
20. Use of separation systems
21. Use of pipeline pigging operations
22. Occurrence and monitoring of blowdown events

✓ Eligible for grants and/or incentives programs

- Mandatory use
- Recommended or encouraged use
- Industry trend
- May use, but minimum emissions thresholds or other limits are applied
- May use, but minimum emissions thresholds recommended
- Event and emissions reporting required only

Beyond its flaring & venting regulations, the UK's NZE target and carbon budget do not yet contemplate sector-specific targets

Regulatory approaches

Prescriptive

The UK has prescriptive policies aimed at reducing methane emissions in the petroleum, oil, and gas sectors. These policies focus on restrictions and permitting requirements for flaring and venting activities. Under the **Energy Act 1976** and the **Petroleum Act 1998**, operators must obtain consents for flaring and venting of hydrocarbons during commissioning and production operations. In 2020, new guidance was released that no new developments should have routine flaring and venting, with a zero routine flaring by 2030 target for all North Sea platforms.

Supplementary regulations introduced permitting requirements. One regulation of note is the **Environmental Permitting Regulations 2010**, which requires oil refineries to obtain a GHG emissions permit. This includes VOCs (and methane) emitted from storage and handling facilities, oil/water separation systems, other vents, and flare systems.

Informative

The UK's **Energy Act 1976** mandates operators to obtain consent for flaring or venting activities. Consent is not needed for unforeseen events related to worker safety, but operators must promptly inform the regulator.

The **Environmental Information Regulations 2004** require public authorities to share publicly held information and promote data accessibility. Authorities are also obliged to provide information upon request, with exceptions for certain circumstance such as national security and protection of personal data.

Economic

The UK's **Climate Change Act 2008** (as Amended in 2019) is the region's primary economic policy. The Act provides for a system of carbon budgeting and confers powers to establish trading schemes for the purpose of limiting GHG emissions or encouraging activities that reduce or remove GHG emissions from the atmosphere. Methane emissions are fully accounted for in the UK's carbon budgets, however the Act is economy-wide and mostly focuses on the agricultural and waste sectors.

Broader regulatory programs, such as price controls on regulated assets, include incentives to spend on hydrogen-ready pipeline replacement, and pressure decreases to reduce methane leaks. Administered by Ofgem, the gas distribution network's current price control period, RIIO-GD2, runs until 2026. Ofgem wrote to all network and system operators ahead of RIIO-GD2, to inform them of new expectations about how Business Plans should support UK's net-zero targets, and committed to work towards adaptive regulation, as the most cost-effective pathways to net-zero are often unclear.

Performance / outcomes based

The UK's **Climate Change Act 2008** was amended in 2019 to legislate a long-term, economy-wide target to reach net-zero greenhouse gas emissions, including methane, by 2050. While there is a target, it is not sector specific with no targets for the coal and gas sectors.

The Iron Mains Risk Reduction Program is another example of outcome-based programs.

Sources: IEA – Policies Database (2023); IEA – Methane Tracker (2023); UK Parliament - Carbon Budgets: Methane Flaring (2023); HM Government – The Carbon Plan: Delivering a Low Carbon Future (2011); Ofgem – RIIO-2 Final Determinations (2021); Ofgem - RIIO-2 response to Committee on Climate Change's Net Zero Report (2019)

While the North Sea natural gas industry has been declining, reductions from flaring and venting alone have been material

Technology uptake to date

Coal

- Drainage systems have been implemented across the UK as part of safety measures.
- One company in the UK, HEL East Ltd., has also tested a commercial-scale VAM Regenerative Thermal Oxidation (RTO) unit at an operating coal mine. However, widespread adoption is not evident.
- As of October 2017, there were 13 abandoned mine methane (AMM) projects in operation. Active AMM projects in the UK utilise about 58% of total methane emissions from abandoned mines. According to the United Nations Framework Convention on Climate Change, AMM emissions in the UK decreased from 1.4 Mt CO_2e in 2000 to 0.441 Mt CO_2e in 2015.

Gas

- The Oil and Gas Authority (OGA) describes the majority of emissions reductions post-2018 have come from proactive improvements to flare and venting management (less cold flaring), leaky seal replacement, and investment in flare gas recovery systems.
- Industry has also demonstrated the use of 'eductors' (specialist pumps) to minimise flaring on offshore oil and gas facilities.
- Flaring cuts in 2020 (in volume and intensity) have been partly attributed to the increasing use of flare reduction technology on some platforms. One highlighted case was a flare gas recovery unit on one platform cutting out routine flaring all together, reducing the volume of flared gas by around 60% in that year.
- Upgrading distribution pipelines to PVC has been (and will continue to be) widespread, which significantly reduces methane leaks in an aging network, as well as having financial and safety co-benefits.

Commentary

- Information on the use of methane emissions reduction technologies in the UK's upstream gas sector is limited, and compared to other jurisdictions there is limited evidence of emissions thresholds being placed on equipment. However, the OGA has described where technology and process induced improvements have been seen.
- Between 2018 and 2019, there was a 34% reduction in venting from offshore facilities, and a 4% reduction in flaring. The OGA has noted that flare/vent volumes were prioritised by industry as day-to-day KPIs.
- Additionally, Ofgem's regulatory framework RIIO-GD2 Final Determination strongly encouraged hydrogen readiness by distribution networks when implementing the IMRRP in the new regulatory period and allowed flexibility in repex structures to support this. It also included rewards and penalties (based on performance targets) for reducing methane emissions through reducing shrinkage.

Sources: United Nations Economic Commission for Europe – Best Practice Guidance for Effective Methane Recovery and Use from Abandoned Coal Mines (2019); North Sea Transition Authority – News (2023); Rennie Insights and Analysis

Current activities highlight the health, safety, and financial co-benefits that can be achieved through simple technology changes

Case study: Upstream gas in the North Sea

The **Oil and Gas Authority** (OGA) Strategy amends the **Maximising Economic Recovery Strategy** (MER UK Strategy), and places an obligation on the oil and gas industry to assist the Government to meet 2050 net-zero emissions targets.

Under **UK's Methane Memorandum**, the UK aims to achieve zero routine flaring and venting targets by 2030 or sooner. Oil and gas operators are currently required to seek approval to conduct these activities, which are assessed by the regulator.

The OGA began including flaring and venting in expanded monthly benchmarking activities from 2020, which it expects to drive improved performance across the industry. In 2020, flaring in the UK North Sea fell by 22% on 2019 figures.

Case study: Iron Mains Risk Reduction program (IMRRP)

Not all methane reducing technologies are complex – a highly effective practice in the midstream gas network is replacing old gas mains with plastic pipes to reduce leakage, improve safety, and increase asset resilience to new gas sources (e.g., H2, biomethane).

The **Iron Mains Risk Reduction Program (IMRRP)** in the UK was originally introduced in 2002 to address safety concerns around the failure of aging iron gas mains infrastructure, with an objective of replacing all cast iron mains within 30m of property with plastic alternatives by 2032 (the '30/30 programme').

This has resulted in significant reductions in midstream methane emissions (methane emissions from gas leakage have fallen by 50% since 2000), along with improved network reliability and financial savings from less gas leakage.

The energy regulator, **Ofgem**, uses network price controls to incentivise gas distribution companies to invest in this infrastructure and achieve the target. These are agreed through the RIIO regulatory submissions. Ofgem also provides financial incentives to Distribution Network Operators to lower system pressure and improve gas conditioning levels, which are expected to reduce midstream GHG emissions by 66% on 2014 levels by 2032.

Sources: The North Sea Transition Authority – The OGA Strategy (2021); The UK Government – United Kingdom Methane Memorandum (2022)

While not as stringent as some, the UK's primarily economic approach has enabled emissions reductions beyond coal exits

Outcomes, challenges and opportunities

While fossil fuel methane reduction has noticeably occurred, much of that has been from the fall of the coal industry, with moderate reductions observed elsewhere.

The UK's methane reduction programs in the fossil fuel sector originated from health and safety concerns, which later expanded to include environmental considerations. As this has grown, the UK's methane policies in the fossil fuel sector are being tailored to the country's broader efforts to address climate change and reduce greenhouse gas emissions.

Beyond domestic regulation, how the UK reacts to changing energy security concerns in the region may change the methane emissions profile of the fossil fuel sector purely through changes to production levels. However, the progress to date (when taking into account declining production), shows that regulatory incentives and controls can be effective in delivering widespread change, such as midstream gas network improvements.

The OGA has noted that technology implementation and associated emissions reductions will face challenges associated with the maturity of the basin and its assets. While there are ambitious projects and goals on the horizon (for example, the electrification of offshore assets under the North Sea Transition Deal), the ability to achieve these will be constrained by the cost and technical aspect of retrofitting aging assets.

Key takeaways

Ofgem's statements requiring industry to support net-zero goals is similar to the Australian government's new addition to the National Energy Objective to include emissions reduction. Addressing the emissions in the midstream gas network are cost effective and provide many co-benefits.

Routine flaring and venting targets from offshore platforms are in place, which is a common emerging theme among jurisdictions.

- The UK's policy and regulatory actions are primarily economic, supported by some prescriptive, performance based, and informative approaches. Overall, these policies are not as expansive or stringent as those observed in other jurisdictions.
- Where the UK stands out is the use of price controls and signals from the energy regulator that enable investment in pipelines and clearly articulate the responsibility of regulated asset owners to contribute to the Government's environmental goals.
- The use of eductors and other flare and venting management technologies and processes (such as recovery systems and less cold flaring) has been observed in offshore oil and gas facilities.
- The replacement of iron gas mains with PVC equivalents has also been widespread.
- There is a clear link between the Iron Mains Risk Reduction Program and associated regulatory incentives and the widespread installation of PVC piping.

Sources: Ofgem – Decarbonisation Programme Action Plan (2020)

United States of America

The US is one of the world's top producers and consumers of coal, and has also recently experienced a boom in natural gas production, primarily driven by advancements in hydraulic fracturing.

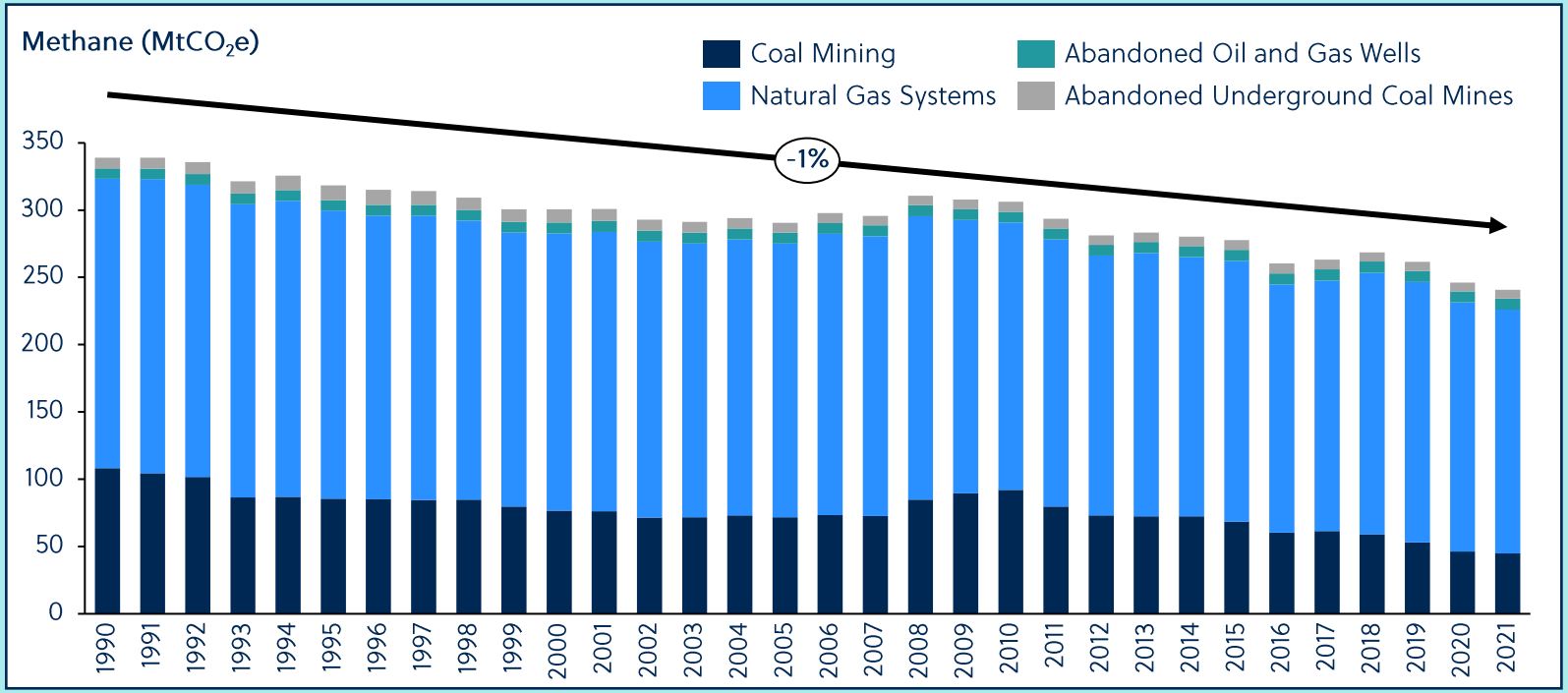
Like Australia and Canada, the US has a federated system with an overarching national government and sub-national states. States have policy authority over natural resources within their borders, including oil, gas, and coal mining, however, in matters where policy issues extend across state borders or have national economic implications, the Federal Government has the authority to overrule state jurisdiction.

California, Pennsylvania, and Maryland provide useful and relevant case studies for how they continue to make an impact on fossil fuel methane emissions, whilst experiencing a boom in the natural gas industry.

TARGETS

- Signatory to the Global Methane Pledge to reduce human-caused methane emission by 30% below 2020 levels by 2030.

EMISSIONS FROM FOSSIL FUEL INDUSTRIES, 1990 - 2021



KEY POLICIES / REGULATIONS

- Inflation Reduction Act 2022
- Clean Air Act
- Greenhouse Gas Reporting Program
- Transportation of Natural and Other Gas By Pipeline
- Mandatory Reporting of GHG
- Emission Standards for New, Reconstructed, and Modified Sources
- Protecting Our Infrastructure of Pipelines and Enhancing Safety
- New Source Performance Standards and Emissions Standards for Hazardous Air Pollutants
- Notice to Lessees and Operators of Onshore Federal and Indian Oil and Gas Leases

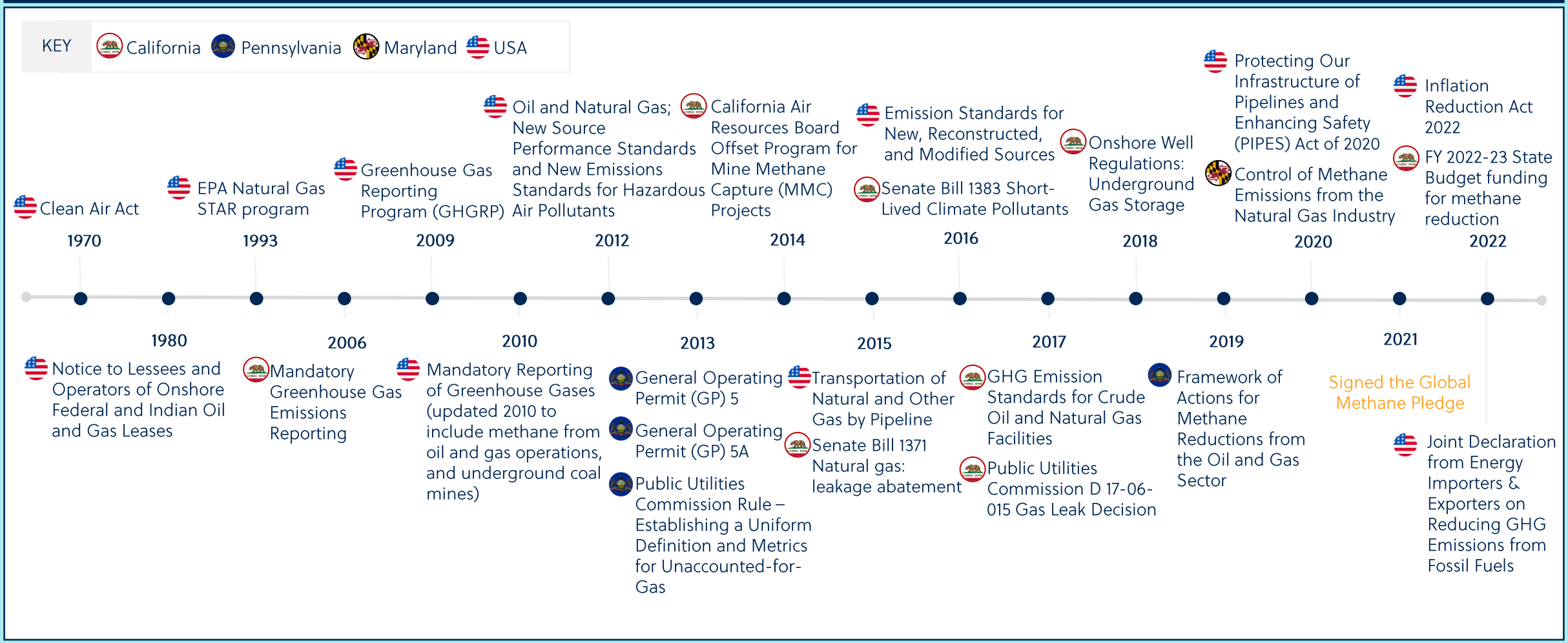
Key

Prescriptive | Performance/outcomes based | Economic | Informative

Sources: United States Government – GHG Inventory Data (2022)

United States of America

POLICY / REGULATION IMPLEMENTATION TIMELINE, 1970 - 2022



Sources: IEA – Policies Database (2023)

The Inflation Reduction Act is a landmark development in US action on climate change

The *Inflation Reduction Act* (2022) is a broad piece of US legislation that seeks to tackle energy security, rising inflation, and climate change. Through targeted investment and cross industry measures, it aims to achieve a reduction in GHG emissions of 40% by 2030 and reduce the cost of energy.

Section 60113 and Section 50263 specifically tackle methane emissions. In 2024, a charge of US$900 per tonne of methane emitted will apply to most oil and gas operations (to rise to US$1,500 per tonne in 2026).

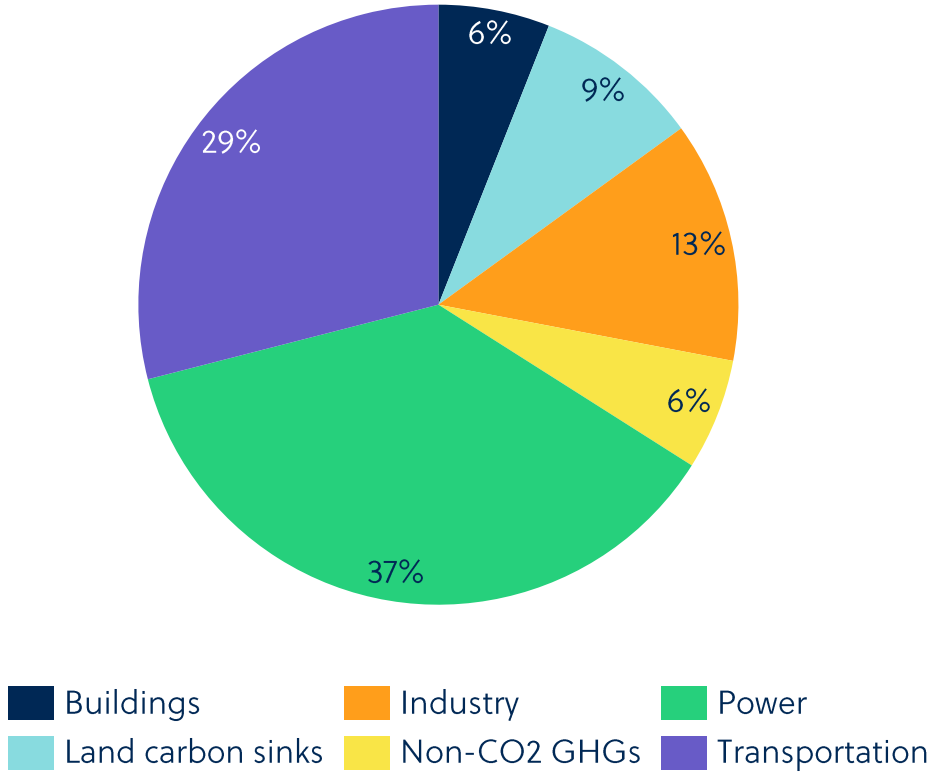
The other key component will be royalties from natural gas production, including gas vented, flared or otherwise lost from non-emergency operations. There will also be significant funding to the EPA to fund and provide technical guidance for methane abatement in the sector.

The scale of this investment and scope of the regulations is unprecedented and will change the GHG emissions environment significantly.

As a recent development, the effects of this Act on technology uptake are yet to be realised; however, it is clear from the research that this policy is intended to push methane emissions 'laggards' into action, at least to adopt low-hanging fruit options. It may also have cross-border effects, particularly where technology availability and cost are indirectly improved.

The US also signed the **'Joint Declaration from Energy Importers and Exporters on Reducing GHG Emissions from Fossil Fuels'** with the EU, Japan, Canada, Norway, Singapore and the UK in 2022. This is an example of cross-country collaboration, with actions including eliminating routine venting and flaring, regard LDAR campaigns, coal practices, and putting requirements around the emissions associated with fossil fuel imports.

Estimated emissions reduction by 2030 under the US *Inflation Reduction Act 2022*

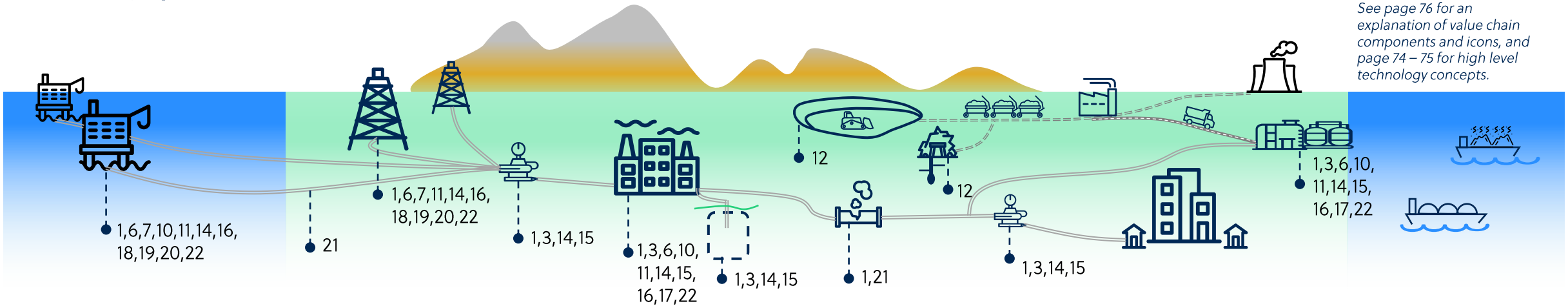


Sources: Rapid Energy Policy Evaluation and Analysis Toolkit – Preliminary report: The Climate and Energy Impacts of the Inflation Reduction Act of 2022 (2022); US Department of State – Joint Declaration from Energy Importers and Exporters on Reducing Greenhouse Gas Emissions from Fossil Fuels (2022); Rennie Insights and Analysis.

Methane emissions limits on gas industry equipment, supported by grants and incentives, has supported technology uptake

Technology uptake to date

See page 76 for an explanation of value chain components and icons, and page 74 – 75 for high level technology concepts.



Methane reduction technology and practices

1. Use of LDAR technology and practices
2. Pipeline replacement and repair
3. Use of electric/compressed air devices
4. Use of casing gas capture/destruction tech
5. Lowered gas line pressure
6. Use of plunger lifts in blowdown events
7. Use of reduced emissions well completions
8. Use of eductors/ejectors for flare gas recovery
9. Conversion of engines to electric alternatives
10. Use of VRUs on particular components
11. Use of blowdown optimisation practices/tech
12. ✓ Coal mine/bed methane capture and use
13. ✓ Ventilation Air Methane abatement practices

Industry components that emit methane

14. Use of low-bleed pneumatic devices
15. Use of reciprocating/centrifugal compressors
16. Use of flares
17. Use of storage vessels/tanks
18. Use of circulation tanks
19. Use of Glycol Dehydration Units
20. Use of separation systems
21. Use of pipeline pigging operations
22. Occurrence and monitoring of blowdown events

Sources: California Environmental Protection Agency - Compliance Offset Protocol Mine Methane Capture Projects (2014); VERRA – California Offset Project Registry (2023)

✓ Eligible for grants and/or incentives programs

- Mandatory use
- Recommended or encouraged use
- Industry trend
- May use, but minimum emissions thresholds or other limits are applied
- May use, but minimum emissions thresholds recommended
- Event and emissions reporting required only

Equipment emissions requirements are a common factor, with comprehensive coverage across material emissions sources

Common prescriptive approaches in the natural gas value chain

Approaches	Jurisdiction examples
Methane emissions standards for particular pieces of equipment	*California - GHG Emission Standards for Crude Oil and Natural Gas Facilities 2017* – The regulation establishes GHG emissions (including methane) standards for onshore and offshore oil, natural gas production sites; crude oil, condensate, and produced water separation and storage; underground gas storage; and natural gas gathering and boosting stations, processing plants, and transmission compressor stations. *Maryland – Control of Methane Emissions from the Natural Gas Industry: 2020* – New device bleed rate (the rate of methane releases from valve) requirements were staged, with devices with a bleed rate greater than 6 cubic feet per hour phased out by 1 Jan 2022, and all devices converted to electric or compressed air-powered devices by 1 Jan 2023. Reciprocating compressors were also regulated, with re-routing or replacement required to meet a prescribed emissions threshold. *Pennsylvania – General Operating Permit 5A 2018* – Controls air pollution (methane indirectly) from sources at new or modified unconventional natural gas well sites and remote pigging stations. There are also specific requirements placed on a range of components, including Glycol Dehydration Units, flares, VRUs, Natural Gas-Fired Engines, Reciprocating Compressors, storage vessels, Pneumatic Pumps, plunger lift systems, and soaping and swabbing practices.
Leak detection and repair (LDAR)	*California – Onshore Well Regulations – Underground Gas Storage 2018* – There are LDAR requirements on all underground natural gas storage facilities, which must be approved by the regulator. *Maryland – Control of Methane Emissions from the Natural Gas Industry 2020* – LDAR requirements were prescribed (including the methods and technologies included), and leaking components were required to be replaced within 30 days of discovery. *Pennsylvania – General operating Permit 5 (GP5)* – GP-5 was the first general permit in the nation to require LDAR programs for mid-stream gathering and compression facilities.
Measurement and reporting	*California - Mandatory GHG Emissions Reporting 2006* – A list of industries, including petroleum and natural gas systems which equal or exceed 10,000 metric tons CO_2e in a calendar year, as well as the power generation sector, are required to report at least annually to the California Air Resources Board. Specific calculation methods and emissions required are given. Operators are also subject to verification and recordkeeping obligations.

Over 100 oil and gas operators have voluntarily collaborated on methane emissions reduction opportunities for the past 30 years

Natural Gas STAR Program accomplishments (1990-2020) across the value chain, with key technologies and practices

Voluntary partnerships, where taken seriously, can help fossil fuel companies to address the increased scrutiny from stakeholders to act on climate change, where the expectation often to exceed minimum government requirements. There are operational cost benefits in many of the methane reduction actions being taken. In the gas sector, leakages are a direct balance sheet loss and it is cost effective to remedy this – regardless of the environmental or safety benefits.

The Natural Gas STAR Partnership was a U.S. EPA-run voluntary commitment to evaluate, implement, and share cost-effective methane emissions reduction opportunities. Over 100 oil and natural gas operators across the US were a part of the collaboration. In 2022, this program transitioned to the Methane Challenge Partnership.

Emissions improvements along the O&G value chain, 1993-2020

	Gathering and Processing	Production	Transmission	Distribution
Partner reported emissions reductions since 1993	▼25,843,768 Mt CO_2e	▼594,869,903 Mt CO_2e	▼186,059,468 Mt CO_2e	▼18,494,338 Mt CO_2e
Technologies and practices implemented	#59	#102	#58	#37

Note: these are self-reported emissions reductions; [1] For hydraulically fractured wells; [2] Directed Inspection & Maintenance; [3] Ranked by emissions reduced from technologies

Sources: USA EPA – Natural Gas STAR Program Accomplishments; Rennie Insights and Analysis

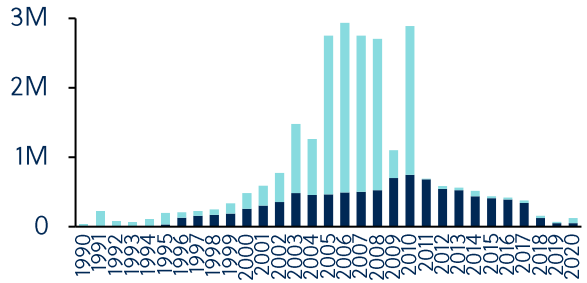
The reporting of voluntary methane reduction activities acts as a proxy for the resulting technology adoption

Natural Gas STAR Program accomplishments (1990-2020) across the value chain, with key technologies and practices

Ongoing Reductions | New Reductions

Gathering and Processing

Methane ($MtCO_2e$)

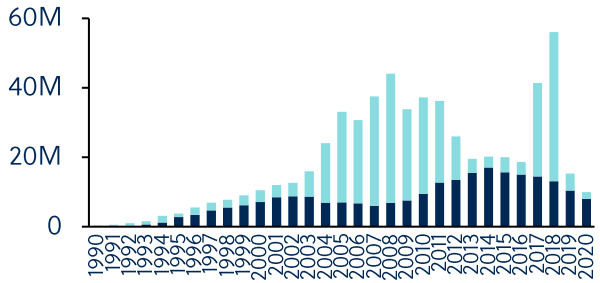


Top 5 ranked reduction technologies[3]

- Ariel leak detection using laser and/or infrared
- Redesign blowdown/alter ESD practices
- Nitrogen rejection unit optimisation
- Eliminate unnecessary equipment / systems
- Flash tank separators on glycol dehydrators

Production

Methane ($MtCO_2e$)

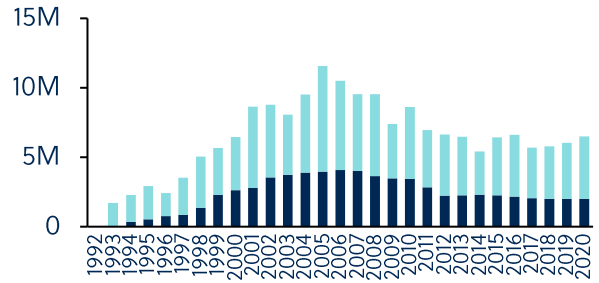


Top 5 ranked reduction technologies[3]

- Reduced emission completions[1]
- Installing plunger lifts
- Foam agents to reduce blowdown frequency
- Install vapour recovery units on storage tanks
- Install flares

Transmission

Methane ($MtCO_2e$)

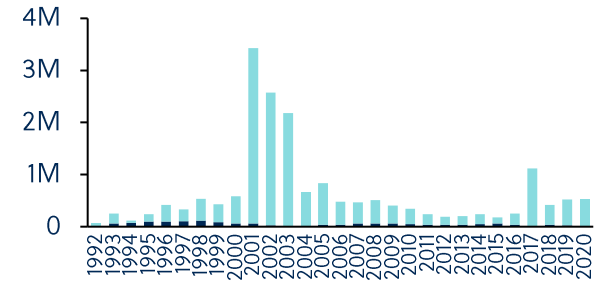


Top 5 ranked reduction technologies[3]

- Pipeline pump-down to lower gas line pressure
- Use of turbines at compressor stations
- DI&M[2] at compressor stations
- Use composite wrap repair
- Replace wet compressor seals with dry seals

Distribution

Methane ($MtCO_2e$)



Top 5 ranked reduction technologies[3]

- DI&M[2] at surface facilities
- DI&M[2]: survey and repair leaks
- DI&M[2] at gas stations and surface facilities
- Replace high-bleed pneumatic devices
- Use automated systems to reduce pressure

Note: these are self-reported emissions reductions; [1] For hydraulically fractured wells; [2] Directed Inspection & Maintenance; [3] Ranked by emissions reduced from technologies

Sources: USA EPA – Natural Gas STAR Program Accomplishments; Rennie Insights and Analysis

Land management and royalty concessions encouraged coalbed methane in the US, but was ultimately a boom-bust industry

Zoning and mining leases

In some instances, there are conflicts between the rights to recovery and economic benefit of natural gas and coal (including CMM) on federal leases ('split estates'). This can hamper the extraction and use of coal-bed methane, which leads to excessive venting and associated environmental impacts.

In the early 2000s, the US Federal Bureau of Land Management intervened to resolve certain development conflicts, with the purpose of:

- Optimising the recovery of coal-bed natural gas and surface coal to secure the maximum return to the public in revenue and energy production;
- Prevent avoidable waste of the public's resources utilising authority under existing statutes, regulations and lease terms;
- Honour the rights of each lessee, subject to the terms of the lease and sound principles of resource conversation; and
- Protect public health and safety, and mitigate environmental impacts.

'Conflict Administration Zones' (CAZ) were established around each active coal mine or Lease-By-Application area that had a potential for conflict with CBM development in Wyoming and Montana. These would last for 10 years, and CBM operators were encouraged to extract as much CBM in that time as possible to allow uninterrupted mining operations. A 50% reduction on royalty rates were also offered on production from CBM wills within the CAZs.

Case study: Wyoming – zoning and royalty discounts

The North Antelope Rochelle Mine took advantage of the South Pod CAZ in Wyoming in 2002, drilling 47 wells and developing a gathering system within the operating mine permit boundary, ahead of surface mining operations commencing. The recovered methane was then sold into the gas market.

The project was also registered with the Verified Carbon Standard between 2007 and 2009, generating nearly a million tonnes of Voluntary Carbon Units. A second phase was also established, named the 'Porcupine Project', producing gas from an additional 26 wells.

Common industry equipment were used. Methane concentrations ranged from 67-95%, requiring the methane to be blended with high quality gas produced by third party operators.

The Powder River Basin in Wyoming and Montana, accounted for half of the surface mine methane emissions in the US in the 2000s-2010s. This area had a significant interest in CBM development, and had a 'boom-bust' experience of the industry. The practice did lead to significant impacts from direct saline water discharge into streams (banned in Montana and restricted in Wyoming from 2010) and the abandonment of thousands of wells once fracking in other states entered the market and CBM lost competitiveness.

If CMM utilisation was to be promoted as a means of emissions reductions in Australia, water discharge concerns should be considered in the regulations (per existing ventures in Australia, more commonly known here as coal seam gas). CMM utilisation should not be promoted as a justification for new coal mining operations.

Sources: Pennsylvania Energy Development Authority - The Pennsylvania Energy Development Plan Investing in Pennsylvania's Clean Energy Future (2008); Alternative Energy Portfolio Standards Act of 2004 – Compliance for Reporting Year 2021-22 (2022); US EPA – Surface Coal Mine Methane Recovery Project Opportunities (2008); US EPA – Methane Recovery at Surface Mines in the U.S. Case Study; Bulltail, Walter – Impacts of Coal Resources Development on Surface Water Quality in a Multi-Jurisdictional Watershed in the Western United States (2020)

California, USA

California is a high energy consumption state, consuming more natural gas than any other US state besides Texas. About 92% of that demand is imported, with the remainder produced in the state (onshore and offshore) as of 2017. There are no LNG imports, and biogas injection is emerging.

There are also several natural gas storage fields located in the state, serving northern and southern California. This reduces the need for additional pipeline capacity to meet peak gas demand.

The state is working towards a goal of 40% reduction of methane emissions from in-state oil and gas operations by 2025, with that increasing to 45% in 2030. In 2021, 26% of point source methane emissions were from the oil and gas supply chain, with 80% of that associated with production activities.

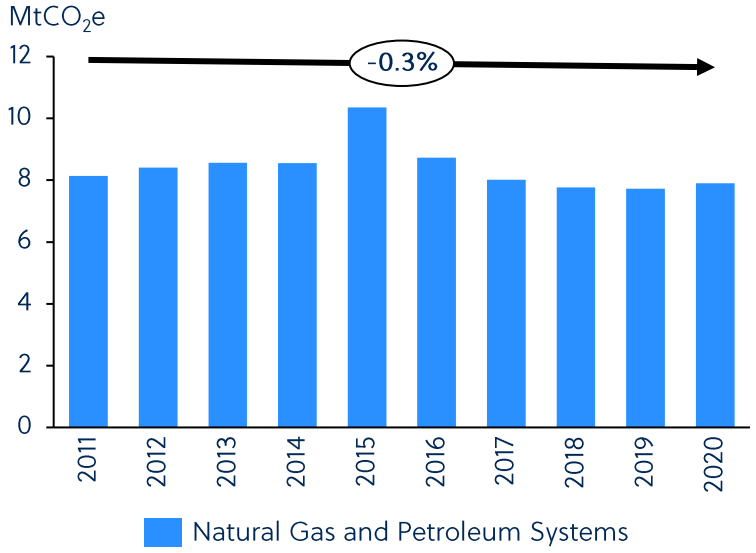
There is no coal mining activity in California, and electricity produced from coal fired power is minimal.

TARGETS

- Reduce methane emissions from in-state oil and gas operations by 40% by 2025, ramping up to 45% by 2030.

OVERVIEW

Methane emissions from fossil fuel industries, 2011-2020



GAS TECHNOLOGY

- ✓ Onsite monitoring[1]
- ✓ Offsite monitoring[2]
- ✓ Vapour Recovery Units
- ✓ Early replacement[3]
- ✓ Electric/compressed air
- X Electric engines
- ✓ Reduced Emission Completions

COAL TECHNOLOGY

Not Applicable

TYPES OF POLICIES

KEY POLICIES / REGULATIONS

- Mandatory Greenhouse Gas Emissions Reporting
- Senate Bill 1371 Natural gas: leakage abatement
- GHG Emission Standards for Crude Oil and Natural Gas Facilities
- Onshore Well Regulations: Underground Gas Storage
- Offset Program for Mine Methane Capture (MMC)
- Senate Bill 1383: Short-Lived Climate Pollutants
- Public Utilities Commission D 17-06-015 Gas Leak Decision
- FY 2022-23 State Budget funding for methane reduction

Key

✓ Evidence of commercial scale adoption — Limited evidence of use (some isolated examples found) — X No evidence of use

Notes: [1] Includes Leak Detection and Repair; [2] Includes satellite and optical gas imaging;[3] Includes the early replacement of compressor seals and / or rods

Sources: California Energy Commission - The California Methane Survey (2020); California – GHG Inventory Data (2022)

California has been a leader in environmental action, and there is strong midstream action in reaction to public safety events

Regulatory approaches

Prescriptive

California has a range of prescriptive requirements on gas industry participants. In the midstream[1], the **Onshore Well Regulations – Underground Gas Storage 2018** include strict methane monitoring. The regulations require operators to measure and record well pressure at least once a day, conduct real-time data gathering, follow an approved LDAR regime, and notify the regulator of any unintended gas release.

More midstream requirements are detailed in **Senate Bill 1371 Natural Gas Leakage Abatement 2014**, which directs the Public Utilities Commission to issue rules for the "avoidance, reduction, and repair of leaks and leaking components" along pipelines. These should include establishment of best practices for leak surveys, repair, and emissions quantification.

Other prescriptive natural gas industry equipment requirements which are common across California, Pennsylvania and Maryland are detailed on page 42.

Performance / outcomes based

California's Public Utilities Commission, in **Decision D 17-06-015 Gas Leak Decision 2017**, establishes a 'soft' target to reduce methane emissions in pipelines and storage infrastructure by 40% from 2013 levels by 2030. This target was adopted from **Senate Bill 1383 Short-Lived Climate Pollutants 2016**, which set this goal for the entire California economy.

Notes: [1] Midstream activities include the storage, processing, and transportation of petroleum products.

Sources: IEA – Policies Database (2023); IEA – Methane Tracker (2023); Rennie Insights and Analysis

Economic

An emerging area of action is government-conducted remote methane emissions monitoring. Typically, this is conducted and reported by the emitting parties.

The California legislature approved a funding request of $100 million for methane reduction measures in the 2022-2023 fiscal year state budget. The funding, requested by the California Air Resource Board (CARB), will expand the frequency and area covered by remote sensing and satellite technology to monitor methane emissions.

From a coal mining perspective, in 2014 CARB developed and released a methodology and eligibility of Mine Methane Capture (MMC) projects in active and abandoned coal mines, under its carbon offset program in the cap-and-trade system. The protocol applies to any mine located on federal lands and in theory, should encourage existing and abandoned mine operators across the US to invest in coal-mine or coal-bed methane capture, use, or flare technologies. However, it could have the perverse effect of encouraging prolonged coal mine operations, or for the industry to advocate against prescribed flaring requirements (as it would no longer be eligible if made mandatory).

Informative

While often combined with other approaches, the majority of California's methane emission reduction policies are informative. These policies include reporting requirements, emissions estimates, quantification, and public disclosure. The **Mandatory Greenhouse Gas Emissions Reporting 2006** is a key example, requiring a list of industries, including petroleum and natural gas, to report at least annually to CARB.

Methane emissions reduction outcomes are varied across industry, but expected to decrease with demand changes

Outcomes, challenges and opportunities

Despite strong regulation on methane emissions, there has not been a clear reported reduction in methane emissions from natural gas and petroleum systems, and there is limited data available regarding the sector specific sources of those emissions (e.g. flaring, leaks). This limited decline in emissions could be due to consumption demand for natural gas for 42% of the state's net electricity. Natural gas production is declining, however, and currently only accounts for 10% of the state's consumption – indicating strong import demand.

There have been some NASA aerial surveys of the Los Angeles area, which have observed reduced numbers of methane plumes in 2020 compared to 2016-17 (i.e., 11 plumes from fives sources versus 48 plumes from 33 sources). While these reductions in emissions are likely partly due to reduced gas demand during COVID-19, some of these improvements are due to leak abatement improvements following the Decision D 17-06-015 Gas Leak Decision 2017.

The focus on midstream emissions abatement has similarities to midstream practices in the UK. Like the Iron Mains Risk Reduction Program, the requirements for underground storage monitoring were born from safety concerns but also provide environmental benefit.

As California transitions to greater concentrations of renewable energy, as per the state's energy commitments, methane emissions are expected to decrease (or be shifted to export related emissions).

Sources: U.S. Energy Information Administration – California State Profile and Estimates (2023)

Key takeaways

California's strong attention to emissions standards in the upstream and midstream natural gas operations, similar to other jurisdictions, is of note to Australia.

There is also evidence of top-down measurement practices used which provide more accurate and real-time data.

- California has prescriptive regulations on upstream and midstream operations, as well as performance-based policies regarding leaks in pipelines and storage infrastructure.
- There are also economic policies, including government funding, for expanded measurement and monitoring programs, as well as mine methane capture offset eligibility.
- LDAR technology is required across the value chain, as is the use of electric/compressed air devices, reduced emissions well completion and VRUs on particular equipment.
- There are also emissions standards on most equipment in the gas value chain.
- While some regulations were born from responses to health and safety concerns, they have strong environmental co-benefits.

Pennsylvania, USA

Pennsylvania is a major coal and natural gas producing state – producing the second highest amount of natural gas, and the third most coal among the US states. It is a net gas, coal, and electricity exporter, using only a fifth of the natural gas produced. It also has the most underground natural gas storage (48 facilities).

The coal industry has been in a state of flux, with declines in demand now reversing due to the high price of natural gas. As of 2020 there were more than 40 underground coal mines active, as well as more than 5,000 abandoned underground mines. Surface mining is less common and declining (less than 25% of production).

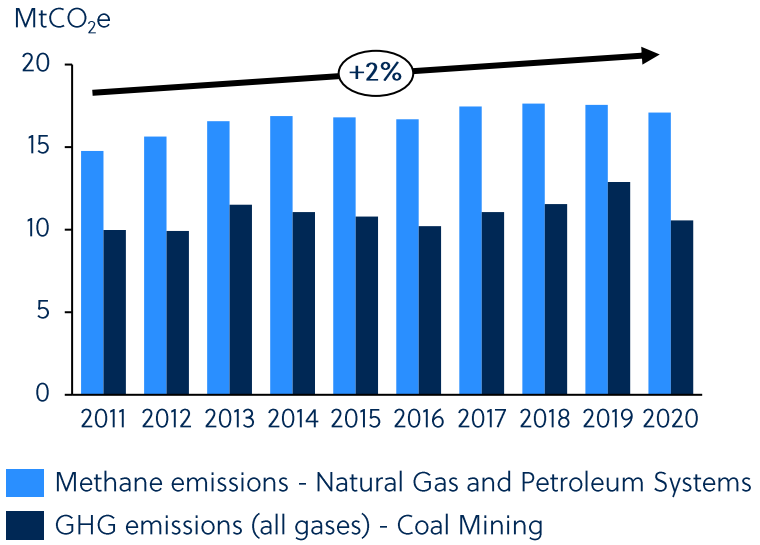
Reducing methane emissions from oil and natural gas have been identified as a major environmental initiative, with a target of 26% reduction by 2025 and 80% by 2050 from 2005 levels. This is underpinned by Pennsylvania's Climate Action Plan 2021. The majority of policy focus has been on gas emissions, rather than the coal sector.

TARGETS

- Reduce greenhouse gas emissions by 26 % by 2025 and 80% by 2050 from 2005 levels.

OVERVIEW

Methane emissions from fossil fuel industries, 2011-2020



GAS TECHNOLOGY

- ✓ Onsite monitoring[1]
- ✓ Offsite monitoring[2]
- X Vapour Recovery Units
- ✓ Early replacement[3]
- ✓ Electric/compressed air
- X Electric engines
- ✓ Reduced Emission Completions

COAL TECHNOLOGY

- ✓ Drainage
- X Reuse of VAM
- X VAM oxidation
- ✓ CMM utilisation
- ✓ CMM flaring

TYPES OF POLICIES

KEY POLICIES / REGULATIONS

- General Operating Permit (GP) 5
- General Operating Permit (GP) 5A
- Framework of Actions for Methane Reductions from the Oil and Gas Sector
- Public Utilities Commission Rule (52 PA. Code Ch. 59) – Establishing a Uniform Definition and Metrics for Unaccounted-for-Gas

Key

- ✓ Evidence of commercial scale adoption
- – Limited evidence of use (some isolated examples found)
- X No evidence of use

Notes: [1] Includes the early replacement of compressor seals and / or rods

Sources: Pennsylvania Department of Environmental Protection - Pennsylvania's Surface Mining Control and Reclamation Act Funded Abandoned Mine Lands Program: Past, Present, and Future (2019); U.S. Energy Information Administration – Pennsylvania State Profile and Estimates (2023); Department of Environmental Protection – Website (2023)

Maryland, USA

At the other end of the spectrum to Pennsylvania, Maryland has very limited coal and natural gas production. It is an energy importer, although has one of few US LNG liquefaction terminals at Cove Point.

The majority of natural gas needs are met through interstate imports, with an extensive transmission network. 80% of the gas on that network passes through Maryland to other state markets.

Almost all coal mines in Maryland are surface mines.

As of 2020, 93% of fossil fuel CH_4 emissions were attributed to the natural gas industry. Flaring and venting accounted for 55% of these emissions, with distribution the next biggest source with 35% of emissions.

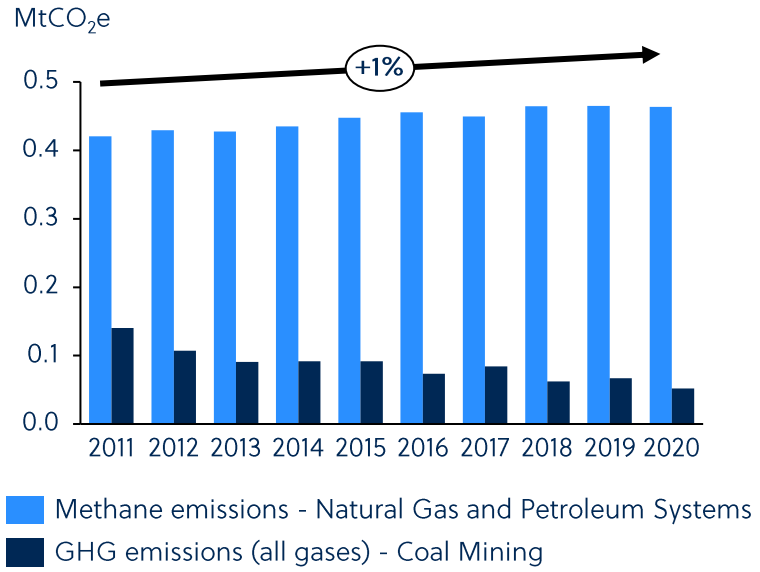
Maryland' fossil fuel methane reduction policies are focused on upstream gas measures. There has also been voluntary buy-in to the national Natural Gas STAR Methane Challenge Program for midstream improvements.

TARGETS

- Reduce statewide GHG emissions 60% by 2031 and net-zero emissions by 2045.

Overview of findings

Emissions from fossil fuel industries, 2011-2020



GAS TECHNOLOGY

- ✓ Onsite monitoring[1]
- – Offsite monitoring[2]
- X Vapour Recovery Units
- ✓ Early replacement[3]
- ✓ Electric/compressed air
- X Electric engines
- ✓ Reduced Emission Completions

COAL TECHNOLOGY

- X Drainage
- X Reuse of VAM
- X VAM oxidation
- X CMM utilisation
- X CMM flaring

TYPES OF POLICIES

Key state frameworks

Control of Methane Emissions from the Natural Gas Industry

Key ✓ Evidence of commercial scale adoption – Limited evidence of use (some isolated examples found) X No evidence of use

Notes: [1] Includes the early replacement of compressor seals and / or rods

Sources: U.S. Energy Information Administration – Maryland State Profile and Estimates (2023); USA - Natural Gas STAR Methane Challenge Program Implementation Plan (2019)

Pennsylvania's energy output is Maryland's throughput and input, and as such, their approaches to gas are relatively aligned

Regulatory approaches (Pennsylvania & Maryland)

Prescriptive

Maryland: In 2020, new Maryland regulations came into force under the Control of Methane Emissions from the Natural Gas Industry. This action established requirements to reduce vented and fugitive emissions of methane from both new and existing natural gas facilities in the State of Maryland. Affected facilities include all new and existing natural gas compressor stations, natural gas underground storage facilities and LNG facilities. Pennsylvania's equivalent to this is the General Operating Permits 5 and 5A.

Under the regulations, LDAR requirements were prescribed (including the methods and technologies included), and a range of other components were required to meet new methane emissions requirements. This staging (which began with LDAR monitoring on natural gas-powered pneumatic devices) allowed time for facilities to make necessary changes and investments over time. Reciprocating compressors were also regulated, with re-routing or replacement required to meet a prescribed emissions threshold.

Maryland banned fracking by legislative action in 2017, the first US state with proven gas reserves to do so.

Pennsylvania: In late 2021, the Pennsylvania Environmental Quality Board introduced the Control of VOC Emissions from Oil and Natural Gas Sources rules, which would indirectly reduce methane emissions by an estimated 213,564 TCO_2e per year (mostly from the replacement of pneumatic controllers to electric or air equivalents). The rule provides emissions requirements for storage vessels, pneumatic controllers, natural gas driven pumps, compressors, and fugitive emissions components. It also requires LDAR inspections at up to quarterly frequency. Where this standard differs from most other state rules is that the restrictions apply to old wells, as well as new ones.

Sources: Pennsylvania Energy Development Authority – The Pennsylvania Energy Development Plan (2008); Alternative Energy Portfolio Standards Act of 2004 – Compliance for Reporting Year 2021-22 (2022); Maryland Department of the Environment – Minimizing Methane Emissions from Natural Gas Compressor Stations and other Related Equipment (2019); Montrose Environmental – The Proposed Pennsylvania Methane Rule for Oil and Gas Explained (2021); Department of Environmental Protection – Protection of Natural Resources, Article 3 Air Resources, Annex A; Air Quality Technical Advisory Committee - Control of VOC Emissions from Oil and Natural Gas Sources (2021)

Economic

Pennsylvania is one of six US states that includes CBM or CMM in the alternative energy standards that direct electricity providers to generate or obtain minimum percentages from eligible sources (similar to the Renewable Energy Target in Australia). In this case, it is treated as similar to landfill gas. In Pennsylvania it is treated as a Tier I source under the Alternative Energy Portfolio standard – launched in 2004, the Act required that 8% of retail electricity must be met by Tier I sources, and 10% by Tier II sources by 2021.

The intent of this legislation was to encourage investment in clean, local energy resources. Coal Mine Methane accounted for 3.0% of Tier I Alternative Energy Credits (AECs) retired in 2022, although it appears these originated from a Virginian facility. In 2022, there was no in-state, certified, active CMM facilities generating AECs – however, a 620MW facility in Greene PA is under construction and is certified.

In Pennsylvania, the right to CBM or CMM is held by the owner of the coal resource that it sits in, which makes this practice easier than in other jurisdictions (such as Australia and Canada) where the rights are not as simple.

Informative & Performance / outcomes based.

Other than informative practices built into other approaches, there are limited purely informative or performance based approaches used.

The cost of implementation of the emission reduction requirements are relatively low, and apply in both production and export states

Outcomes, challenges and opportunities

Since 2018, methane emissions from the natural gas and petroleum systems in Maryland have stabilised, despite 2022 LNG export from Cove Point at 171.8% the volume of 2018 figures. Maryland made the conscious action in 2020 as federal methane emissions reduction policies were being wound back, to ensure progress was not undone in the state. This is despite being a minor contributor to methane emissions, and a net energy importer.

These changes were projected to reduce the release of methane emissions from existing sources from between 40 to 80%. The Department estimated that facilities would be required to spend US$25,000 (2018) annually on leak surveys, and capital investment ranging from US$10,000 – US$100,000 depending on the age and design of existing and proposed equipment.

Pennsylvania's Control of VOC Emissions from Oil and Natural Gas Sources rules were introduced in 2022, and as such there is no data yet to determine effectiveness. However, as the emissions requirements are placed on components for which there are cost effective and commonly adopted alternatives and mitigation technologies, it would be anticipated that there will be strong uptake.

Key takeaways

Similar to other jurisdictions, gas operations are subject to stringent equipment emissions requirements, with Pennsylvania also applying new regulations to existing sites.

- Pennsylvania and Maryland have predominately prescriptive natural gas policies, regulating the emissions allowed from equipment and components. The enforced requirement to implement low emissions equipment is expected to encourage technology uptake in the gas sector, including in existing sites (which are not normally covered by regulations).
- Technologies to reduce emissions from tanks, pneumatic devices, wells, pumps etc. are required. Maryland estimates of these costs are relatively small.
- In Pennsylvania CMM is economically incentivised by being recognised as a Tier I alternative energy source under the Alternative Energy Portfolio requirements – although in-state uptake of this incentive appears limited. The current development of a new facility in Pennsylvania may be incentivised by the ability to generate and sell energy credits.
    - CMM facilities were previously permitted to participate in Australia's Renewable Energy Target scheme (ended in 2020). They are now able to participate in ACCU schemes, but the failure rate under this method has been very high.
    - Given the low uptake of the practice in both Australia and Pennsylvania, this may be an ineffective incentive for methane emissions reduction. Changes to make it more attractive may have perverse outcomes, extending the life of otherwise uneconomical coal mining activity (which would counter climate goals).

Sources: IEA – Policies Database (2023); Maryland Department of the Environment - New Regulations under new Chapter COMAR 26.11.41, Control of Methane Emissions from the Natural Gas Industry (2019); U.S. Energy Information Administration - Natural Gas Exports and Re-Exports by Point of Exit (2022); Pennsylvania Department of the Environment - A Pennsylvania framework of actions for methane reductions from the oil and gas sector (2016)

China

China stands as the largest global consumer of coal, claiming 56% of the total coal consumption in 2020.

China's natural gas production has been increasingly rapid to meet growing demand. However, China faces significant natural gas import dependency due to high demand and limited domestic production capacity.

As such, the majority of China's methane emissions originate from the coal industry which accounted for around half of the global methane emissions in 2022. However, China was also the second largest methane emitter from oil and gas imports in 2021.

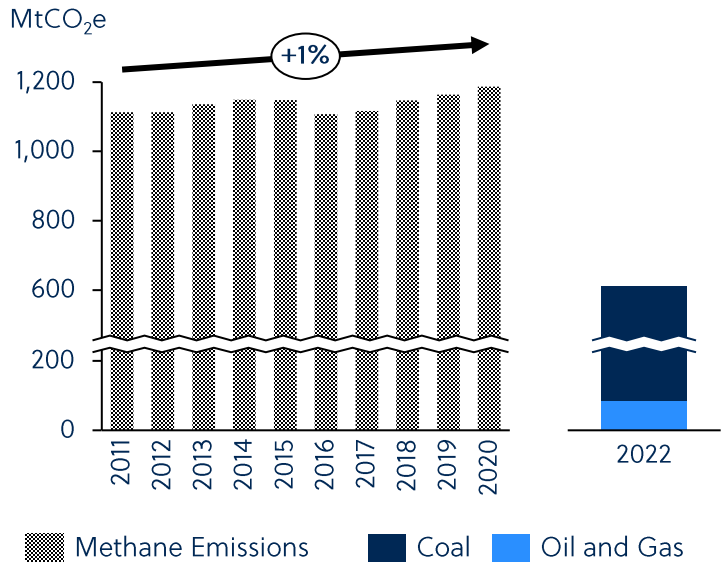
China has implemented policies and initiatives aimed at emission reduction, energy efficiency improvement, and cleaner technology promotion. To reinforce these efforts, China has committed to developing a National Methane Action Plan, which is expected to be unveiled in 2023. The plan targets substantial control and reduction of methane emissions, setting the stage for meaningful progress in emission mitigation throughout the 2020s.

TARGETS

- The China Oil and Gas Methane Alliance has set a target to reduce the average methane intensity in natural gas production to below 0.25% by 2025.

OVERVIEW

Total historical methane emissions and recent segment emissions, 2011-2020; 2022



GAS TECHNOLOGY

- ✓ Onsite monitoring[1]
- – Offsite monitoring[2]
- X Vapour Recovery Units
- ✓ Early replacement[3]
- ✓ Electric/compressed air
- X Electric engines
- ✓ Reduced Emission Completions

COAL TECHNOLOGY

- X Drainage
- X Reuse of VAM
- X VAM oxidation
- X CMM utilisation
- X CMM flaring

TYPES OF POLICIES

KEY POLICIES / REGULATIONS

- Mineral Resources Law
- Oil and Natural Gas Pipeline Protection Law
- Refinancing loan to support the clean and efficient use of coal
- Emission Standard of Coalbed Methane/Coal Mine Gas (trial)
- Regulation on the Safety of production of Offshore Oil
- Oil and Natural Gas Pipeline Protection Law
- 13th FYP on Coalbed Methane Extraction and Utilization
- Emission Standard of Air Pollutants for Onshore Oil and Gas Exploitation and Production Industry
- Law on Air Pollution Prevention and Control

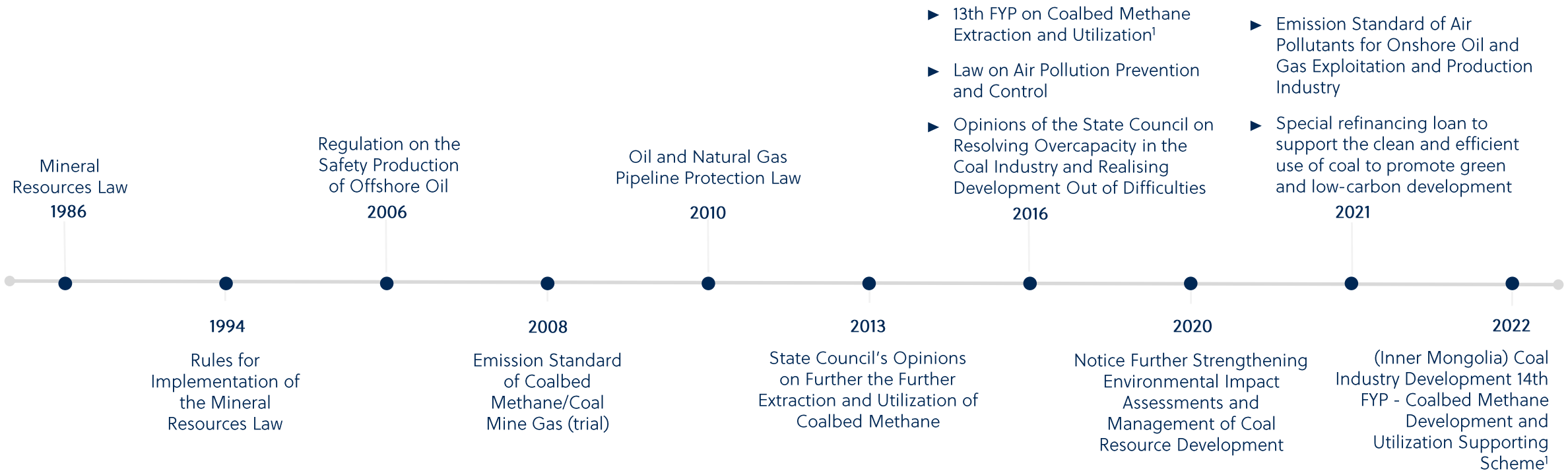
Key

✓ Evidence of commercial scale adoption | – Limited evidence of use (some isolated examples found) | X No evidence of use

Sources: IEA – Policies Database (2023); IEA – Methane Tracker (2023); The World Bank – Methane Emissions (kt of CO_2 equivalent), China (2023)

China

Policy / program implementation timeline

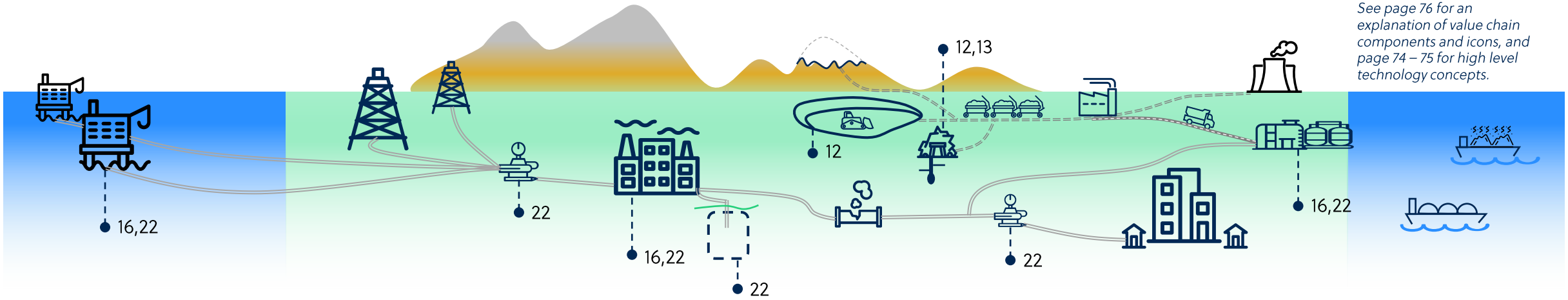


Sources: IEA – Policies Database (2023)

Information on technology uptake in China is limited, other than some indication of coal mine methane abatement progress

Technology uptake to date

See page 76 for an explanation of value chain components and icons, and page 74 – 75 for high level technology concepts.



Methane reduction technology and practices

1. Use of LDAR technology and practices
2. Pipeline replacement and repair
3. Use of electric/compressed air devices
4. Use of casing gas capture/destruction tech
5. Lowered gas line pressure
6. Use of plunger lifts in blowdown events
7. Use of reduced emissions well completions
8. Use of eductors/ejectors for flare gas recovery
9. Conversion of engines to electric alternatives
10. Use of VRUs on particular components
11. Use of blowdown optimisation practices/tech
12. ✓ Coal mine/bed methane capture and use
13. Ventilation Air Methane abatement practices

Industry components that emit methane

14. Use of low-bleed pneumatic devices
15. Use of reciprocating/centrifugal compressors
16. Use of flares
17. Use of storage vessels/tanks
18. Use of circulation tanks
19. Use of Glycol Dehydration Units
20. Use of separation systems
21. Use of pipeline pigging operations
22. Occurrence and monitoring of blowdown events

✓ Eligible for grants and/or incentives programs

- Mandatory use
- Recommended or encouraged use
- Industry trend
- May use, but minimum emissions thresholds or other limits are applied
- May use, but minimum emissions thresholds recommended
- Event and emissions reporting required only

Sources: United States Environmental Protection Agency – EPA Global Methane Initiative Grants

While still in development, China is introducing incentive-based approaches to encourage technology uptake

Regulatory approaches

Prescriptive

China's **Emission Standard of Coalbed Methane/Coal Mine Gas**, enacted as a "trial" regulation since 2008, is the country's first regulation that directly regulates methane emissions from the coal and gas sectors. Despite its trial label, the standard has been essentially enforced. It establishes specific requirements for technology, equipment, permitting, and monitoring related to mine gas and coalbed methane emissions.

Similarly, China's **Emission Standard of Air Pollutants for Onshore Oil and Gas Exploitation and Production Industry 2021** is the country's first pollution emission standard for the oil and gas industry. The standard went into effect on 1 January 2021 for new facilities and 1 January 2023 for existing facilities. While the regulation mostly targets volatile organic compound and sulfur dioxide emissions, some of the rules influence controlling methane emissions and mostly involve setting flaring and venting restrictions.

Performance / outcomes based

While not a policy, China's **13th Five-Year-Plan on Coalbed Methane Extraction and Utilisation 2016** is a guiding framework for industry development that has set specific quantitative targets for coalbed methane extraction and utilisation, aiming for a utilisation rate of 50% by 2020 compared to 35.3% in 2015.

It should be noted that the plan is for the period 2016-2020 and a more updated version is yet to be published.

Economic

China has been actively involved in the extraction and utilisation of coalbed methane since 2006 when it introduced its **11th Five-Year-Plan Coalbed Methane Development and Utilization Supporting Schemes**. Although not considered policies, the most recent plan, the **13th Five-Year-Plan (2016-2020)**, has identified several policy options to support coal mine methane utilisation, including the provision of financial subsidies and the implementation of preferential taxes.

Since then, the State Council announced the establishment of a RMB 200 billion special refinancing loan to support the clean and efficient use of coal to promote green and low-carbon development. Support areas include the safe, efficient, green and intelligent mining of coal, clean and efficient processing of coal, the comprehensive utilisation of coal resources and the development and utilisation of coal-bed methane.

Informative

China's **Emission Standard of Coalbed Methane/Coal Mine Gas** and **Emission Standard of Air Pollutants for Onshore Oil and Gas Exploitation and Production Industry 2021** are both prescriptive and informative policies. The policies establish measurement and reporting requirements, respectively, to improve the state of information about emissions. However, the requirements are less stringent than other jurisdictions.

Sources: IEA – Policies Database (2023); IEA – Methane Tracker (2023); Rennie Insights and Analysis

Most technological investment has been in VAM abatement, with LDAR only required where critical for air pollution control

Technology uptake to date

Coal

- China has witnessed notable progress in the extraction and utilisation of coal mine methane and the adoption of ventilation air methane (VAM) abatement technologies. These initiatives have been implemented not only in operational coal mines but also in projects focused on abandoned mines.
- When it comes to VAM abatement, Regenerative Thermal Oxidation (RTO) stands out as the only proven and commercially utilised technology on a large scale. It has been successfully implemented in both the United States and China. In Australia, RTO demonstrations for VAM abatement have been conducted on a smaller scale, but widespread adoption has not yet been achieved.
- China's technological advancements have primarily been motivated by the urgent need to combat air pollution within the country. Although policies have had limited direct impact on the adoption of methane reduction technologies, industry collaborations have played a significant role in driving progress.
- One notable organisation driving change is the China International Centre of Excellence on Coal Mine Methane (ICE-CMM). As a non-profit entity, its primary objective is to identify and evaluate opportunities for coal mine methane recovery.

Gas

- LDAR is required only in key regions determined by the central government as critical for air pollution control
- LDAR is also only required in select processing plants and terminals[1]

Case study: Pre-Feasibility Study for Methane Drainage and Utilization at the TengHui Coal Mine

In 2018, a noteworthy study conducted by the United States EPA in collaboration with the China ICE-CMM examined the TengHui Coal Mine in China's Shanxi Province.

The study conducted a pre-feasibility analysis of three scenarios: (1) implementing a dedicated CMM power plant; (2) implementing a gas drainage program and the CMM power plant; and (3) a gas drainage program alone. Installing the dedicated power plant alone resulted in highly attractive financial returns. This was primarily due to the mine's high power purchase prices, the availability of CMM subsidies, and other contributing factors. However, all three scenarios demonstrated positive financial returns.

By demonstrating the economic viability of coal mine utilisation, this study underscores the potential for profitable outcomes while promoting effective methane abatement strategies.

Sources: US EPA Coalbed Methane - Pre-Feasibility Study for Methane Drainage and Utilization at the TengHui Coal Mine, Shanxi Province, China (2019); USA EPA Coalbed Methane - Ventilation Air Methane (VAM) Utilization Technologies (2019)

Notes: [1] Includes any oil and gas centralised processing plant, natural gas processing plant, and bulk petroleum terminal meeting the conditions described in the Emission Standard of Air Pollutants for Onshore Oil and Gas Exploitation and Production Industry 2021

China has demonstrated that cost effective and profit generating technologies can encourage companies to take action

Outcomes, challenges and opportunities

China provides a clear example of the need for financial incentives and prescriptive emissions regulations and targets working in tandem to drive technology uptake.

The utilisation of coal mine resources presents lucrative profit opportunities for coal mines and offers a relatively straightforward option for adoption and abatement strategies. However, China is yet to implement prescriptive policies that require coal mines to reduce methane emissions – nor is there a clear overarching, absolute methane reduction target in place.

Although tax implementation is currently pending in China's coal and gas sectors, the country has a track record of using taxes as a mechanism to manage pollution. The 2018 Environmental Protection Tax levies varying tax rates based on the degree of pollution, resulting in higher payments for heavy polluters.

In 2020, the Ministry of Ecology, the National Development and Reform Commission and the National Energy Administration established a policy framework that standardises and optimises environmental assessments and environmental management. Importantly, it encourages the exploration and comprehensive utilisation of ventilation air methane and the utilisation of drained gas.

The challenge (and opportunity) for China is to continue economic growth while curbing absolute greenhouse gas emissions, including methane and scope 3 emissions.

Sources: IEA – Policies Database (2023); China Briefing – China's Environmental Protection Tax (2018)

Key takeaways

Financial levers can play a key role in enabling the uptake of methane emission reduction technologies, particularly in the coal sector. Introducing taxes can strengthen financial incentives and further encourage the uptake of methane emission reduction technologies.

Flaring and venting restrictions also play a part in Chinese regulations.

- There is a particular Chinese focus on methane emissions from coal mines, in particular through prescriptive and economic approaches (such as subsidies) to encouraging CBM and CMM capture and utilisation. These are supported by extraction and utilisation performance targets.
- There are some prescriptive policies on natural gas emissions, which are primarily driven by health concerns around VOC and SO_2 emissions. These mostly involve flaring and venting restrictions.
- VAM abatement technology adoption is well progressed, particularly 'Regenerative Thermal Oxidation', which is also successfully used in the US and Canada.
- CMM utilisation has also be proven to be economically viable and attractive.
- Subsidies and preferential taxes, and loans contribute to the financial feasibility of CMM projects. Natural gas practices could be better supported by more stringent prescriptive emissions standards.

Australian context

Australia

Australia is the world's largest exporter of coal. Around 90% of black coal production, and around 75% of domestic natural gas production was exported in 2020-21. In contrast, more than half of Australia's liquid fuel needs are imported.

In 2019, coal mines were responsible for 68% of Australia's methane emissions from the energy industry overall. Australia is ranked as the worlds 6th largest coal mine methane emitter.

Despite the transition to renewable energy, Australia's primary energy consumption is dominated by coal, accounting for ~75% of Australia's electricity generation, followed by gas at ~16%.

The Australian Government has published a whole-of-economy '**Long-Term Emissions Reduction Plan**' to achieve net zero emissions by 2050. However, the plan does not specifically target methane reduction across the coal and natural gas sectors.

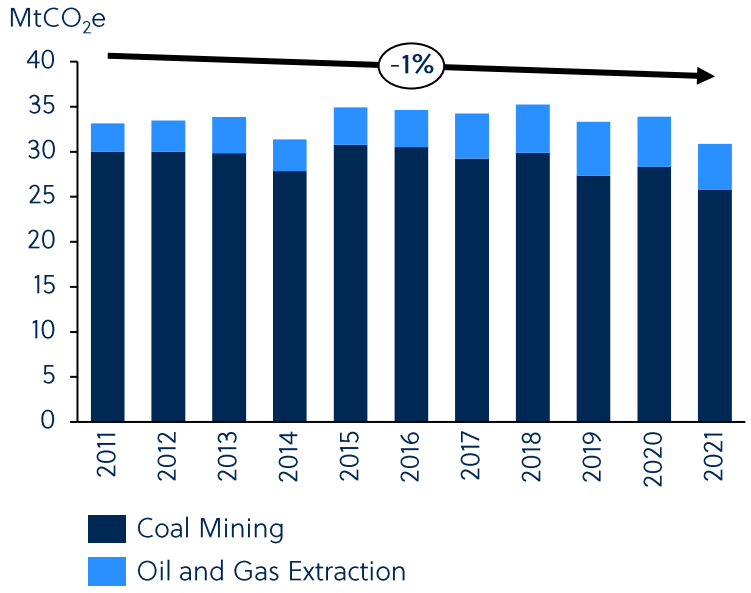
Action taken to date to reduce methane emissions has been largely driven by safety requirements (e.g., coal mine drainage) and decreasing costs (e.g., reuse of ventilation air methane).

TARGETS

- Signatory to the Global Methane Pledge to reduce human-caused methane emission by 30% below 2020 levels by 2030.
- Emission reduction targets of 43% below 2005 levels by 2030 and net zero by 2050.

OVERVIEW

Methane emissions from fossil fuel industries, 2011-2021[a]



GAS TECHNOLOGY

- ✓ Onsite monitoring[1]
- X Offsite monitoring[2]
- ✓ Vapour Recovery Units
- X Early replacement[3]
- — Electric/compressed air
- ✓ Electric engines
- ✓ Reduced Emission Completions

COAL TECHNOLOGY

- ✓ Drainage
- — Reuse of VAM
- — VAM oxidation
- X CMM utilisation
- ✓ CMM flaring

TYPES OF POLICIES

KEY POLICIES / REGULATION

- Offshore Petroleum and Greenhouse Gas Storage Act 2006
- National Greenhouse and Energy Reporting (NGER) scheme 2008
- NGER Determination 2008
- NGER Determination 2009
- Offshore Petroleum and Greenhouse Gas Storage Regulations 2011
- NGER Rule 2015
- Safeguard Mechanism (Crediting) Amendment Bill 2022
- Emissions Reduction Fund

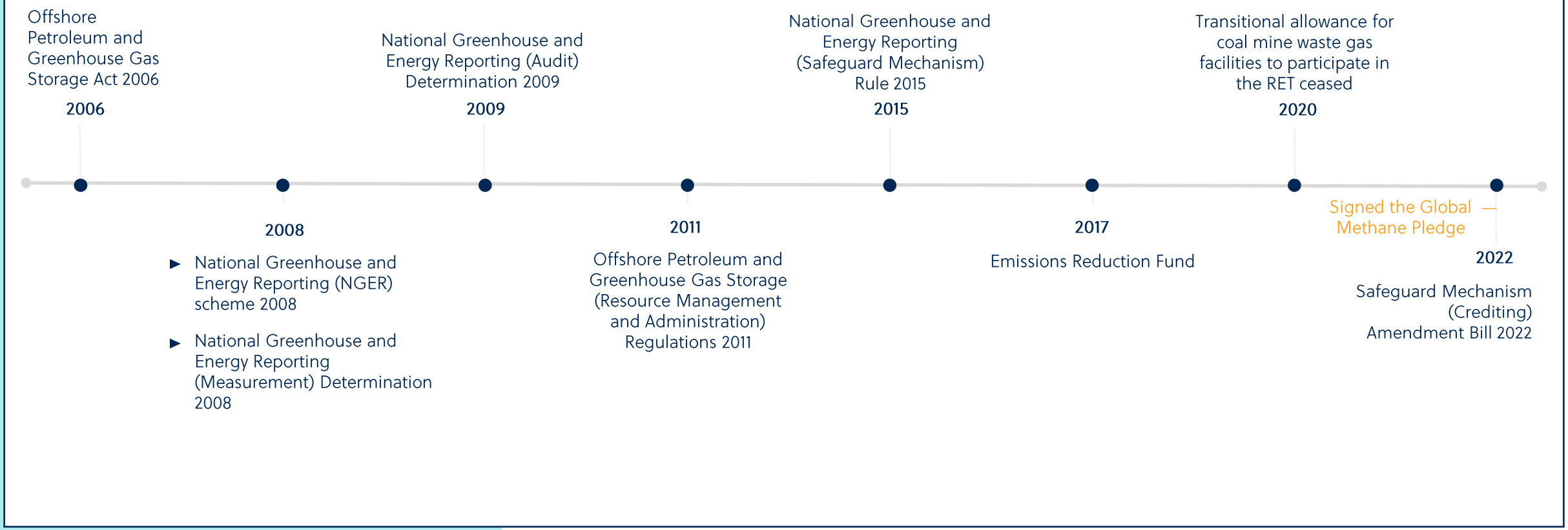
Key: ✓ Evidence of commercial scale adoption; — Limited evidence of use (some isolated examples found); X No evidence of use

Notes: [1] Includes Leak Detection and Repair; [2] Includes satellite and optical gas imaging; [3] Includes the early replacement of compressor seals and / or rods

Sources: [a] Department of Climate Change, Energy, the Environment and Water – Australia's National Greenhouse Accounts (2023); [b] Ember – Tackling Australia's Coal Mine Methane Problem (2022)

Australia

POLICY / REGULATION IMPLEMENTATION TIMELINE, 2006 - 2022

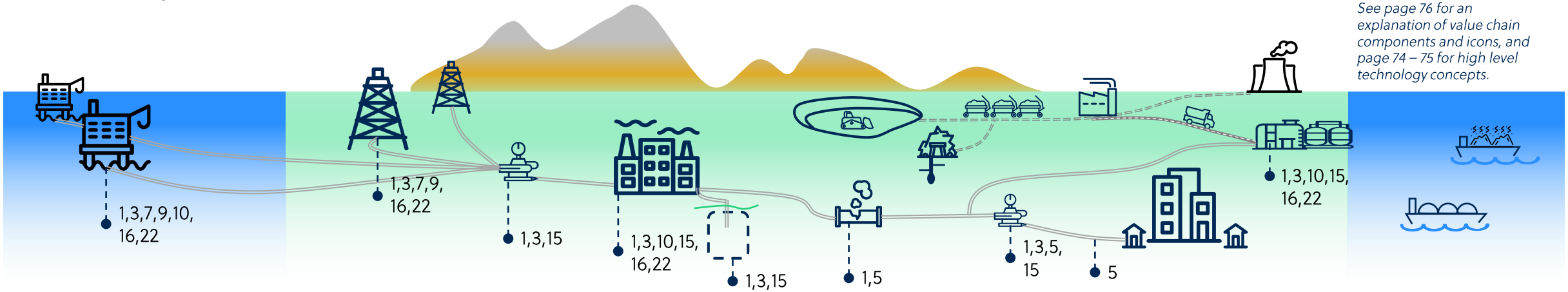


Sources: IEA – Policies Database (2023)

Adoption of methane reduction technologies are limited compared to leading jurisdictions, aligned to limited equipment regulations

Technology uptake to date

See page 76 for an explanation of value chain components and icons, and page 74 – 75 for high level technology concepts.



Methane reduction technology and practices

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9. ✓ Conversion of engines to electric alternatives
10. ✓ Use of VRUs on particular components
11. Use of blowdown optimisation practices/tech
12. ✓ Coal mine/bed methane capture and use
13. ✓ Ventilation Air Methane abatement practices

Industry components that emit methane

14. Use of low-bleed pneumatic devices
15. Use of reciprocating/centrifugal compressors
16. Use of flares
17. Use of storage vessels/tanks
18. Use of circulation tanks
19. Use of Glycol Dehydration Units
20. Use of separation systems
21. Use of pipeline pigging operations
22. Occurrence and monitoring of blowdown events

✓ Eligible for grants and/or incentives programs

- Mandatory use
- Recommended or encouraged use
- Industry trend
- May use, but minimum emissions thresholds or other limits are applied
- May use, but minimum emissions thresholds recommended
- Event and emissions reporting required only

Australia's national-level policies do not directly address methane emissions reduction across the coal or gas sectors

Regulatory approaches

Prescriptive

Australia's prescriptive policy that relates to methane emission reduction is currently the **Offshore Petroleum and Greenhouse Gas Storage Act 2006**. While this act primarily focuses on regulating the petroleum sector, it also contributes to methane emissions reduction efforts by imposing permitting requirements for petroleum exploration and exploitation activities.

However, at the national level, there is currently a need for more targeted prescriptive policies specifically addressing methane emissions from the gas and coal sectors. While some states have implemented policies aimed at curtailing methane emissions, such as imposing flaring or venting restrictions, establishing technology standards, and enforcing permitting requirements across the gas sector, including coal seam gas, the majority of these state-level policies are primarily geared towards the petroleum sector.

Performance / outcomes based

Australia's **Safeguard Mechanism** (SGM) provides a framework for Australia's largest emitters (including mining and oil and gas industries) to measure, report and manage their emissions. The SGM places legislated emissions limits, called baselines, on facilities that emit more than 100,000 tonnes of carbon dioxide equivalent per year. Facilities are required to keep their net emissions at or below their baseline, which encourages them to manage their emissions.

It should be noted that Australia's baselines are currently significantly higher than other jurisidictions, however they are decreasing every year by 4.9% to 2030 in a bid to reach the national emission reduction targets. This is anticipated to require emissions from safeguard facilities to reduce from 137 Mt CO_2-e in 2020-21 to 99 Mt CO_2-e in 2030, and constrain total emissions to 1,233 Mt CO_2-e until 2030.

Economic

In 2023, the **Safeguard Mechanism** (SGM) was reformed to include credits, encouraging facilities to surpass their baselines and contribute to emission reduction targets.

With the new reform, the SGM shares similarities with Alberta's Specified Gas Report Program, which incentivises the adoption of cost-effective technologies for emissions reduction. Both policies are supported by funds – the Technology Innovation and Emissions Reduction Regulation (TIER) in Alberta and the **Emission Reduction Fund** (ERF) in Australia – that provide financial support to methane reduction projects through auctions for **Australian Carbon Credit Units (ACCUs)** . While eligible projects include methane capture and utilisation initiatives, there has been limited evidence of successful methane reduction projects to date.

The SGM also imposes requirements for facilities that emit beyond their baselines to purchase ACCUs or Safeguard Mechanism Credits, else face fines. While this may encourage companies to target methane emission reductions due to the gas being 28 times more potent that carbon dioxide, there are no direct requirements under the SGM to reduce methane emissions across the coal or gas sectors.

Informative

National Greenhouse and Energy Reporting (NGER) scheme provides for the measurement of scope 1 and 2 GHG emissions arising from the operation of facilities as well as the production and consumption of energy arising from the operation of facilities. NGER also outlines reporting obligations for GHG emissions, however the scheme does not specifically limit methane and there is no current measurement approach that is mandatory for consistent use across the gas and coal sectors.

Sources: IEA – Policies Database (2023); Department of Climate Change, Energy, the Environment and Water – Safeguard Mechanism (2023); Department of Climate Change, Energy, the Environment and Water - Safeguard Mechanism reform consultation - factsheet 2 (2023)

State-based fossil fuel regulations and codes, with limited legislative power, lag behind North American states and provinces

State/Territory-level prescriptive approaches

	Leak detection and repair	Flaring or venting restrictions	Technology standards	Permitting requirements
WA				Petroleum and Geothermal Energy Resources Regulations 2012 Requires operators to monitor and report emissions, including operational emissions to the atmosphere.
NT	Code of Practice for Onshore Petroleum Activities Includes methane specific emission monitoring, leak detection and reporting requirements for onshore petroleum operations.	Code of Practice for Onshore Petroleum Activities Venting and flaring should be either eliminated or minimised to as low as reasonably practicable.	Code of Practice for Onshore Petroleum Activities Requirement to use reduced emission completions (RECs) where feasible, LDAR equipment, and optical gas imaging where feasible.	
TAS				Environmental Management and Pollution Control Act 1994 Outlines a general environmental duty of persons involved in projects that are likely to cause environmental harm or pollution of the environment.
QLD	Code of practice for leak management, detection and reporting for petroleum operating plant The Code sets leak inspection frequency and standards for detection methodology, instrument certification, remediation and reporting.	Petroleum and Gas (Production and Safety) Act 2004 Flaring is only authorised if it is not commercially or technically feasible to sell or use the gas. Venting is allowed only for safety reasons or where flaring is not technically possible.	Code of Practice for the construction and abandonment of coal seam gas and petroleum wells, and associated bores Requires blowout prevention across all petroleum wells, and coal seam gas wells.	Mineral and Energy Resources (Common Provisions) Act 2014 Manages the overlapping coal and petroleum resource authorities where coal seam gas (CSG) is concerned.

Key: Policy directly relates to coal / coal seam gas; Policy directly relates to gas; Policy directly relates to petroleum

Sources: IEA – Policies Database (2023)

Supportive policy and industry alliances appear to have encouraged technology adoption in the gas sector, less so in coal

Technology uptake to date

Coal

- Since 1980, Australia has utilised seam drilling and gas **drainage** techniques to proactively manage methane levels in mines, prioritising worker safety over environmental concerns. However, this practice has only been used for **underground mines** to date.
- Australia pioneered the successful commercialisation **of Ventilation Air Methane (VAM) processing and power generation** in 2007 at the West Cliff Colliery mine of BHP in NSW. However, its widespread adoption has been limited thus far.
- Similarly, there have been small scale **Regenerative Thermal Oxidation (RTO)** demonstrations for VAM abatement, but it has not yet been adopted on a large scale.
- VAM abatement technologies are primarily used in underground mines with ventilation systems, which explains the limited implementation in Australia, where surface mines are more prevalent.
- Some coal mining companies argue that VAM abatement technologies are either too expensive or pose safety risks, despite several years of CSIRO studies demonstrating their viability and the potential for substantial methane reduction.

Gas

- In addition to regulatory frameworks, industry-led initiatives and voluntary programs, like the **Australian Petroleum Production and Exploration Association (APPEA)** guidelines, have further encouraged the uptake of methane capture and utilisation initiatives in the gas sector.
- Through industry alliances and action, Australia has seen uptake of **LDAR** programs, **air driven pneumatic control** devices, use of **hybrid electric/gas turbines, lowered gas line pressure** and **reductions in flaring and venting.**
- Some of these practices are a result of policies, such as the **Queensland Petroleum and Gas Act**, however, uptake has primarily been driven by industry action.

Case study: CSIRO Ventilation Air Methane (VAM) Abatement

After more than 15 years of research, CSIRO has developed three technologies that could have important impacts on reducing fugitive emissions from coal (both domestically and overseas) through converting methane to CO_2.

- **VAMMIT** technology is a methane mitigation unit that destroys methane. The technology has been successfully demonstrated with actual ventilation air (VA) with 0.3-1% methane. It achieved greater than 96% methane oxidation efficiency, reducing methane in flue gas to below 0.02%
- **VAMCAP** technology is a capture and enrichment unit which essentially collects and separates the methane from the ventilated air using carbon composites. The technology has also been successfully demonstrated with actual VAM enriched from around 0.6% up to 36%. The enriched methane can be used to assist the operation of the VAMMIT and VAMCAT units.
- **VAMCAT** technology uses a catalytic combustion gas turbine to create electricity from captured methane. It has been fully demonstrated in real-world conditions. The VAMCAT prototype unit was operated with 0.8% actual VAM and produced 8-21kW electricity output.

Sources: Global Methane Initiative – Coal Mine Methane: Reducing Emissions, Advancing Recovery and Use Opportunities (2011); APPEA – Industry Action on Emissions Reduction (2017); CSIRO – Mine ventilation air methane abatement (2022)

Australia must evolve policies to support emissions reduction technologies, net-zero targets, sending a clear signal to industry

Outcomes, challenges and opportunities

Historically, Australia's focus on methane reduction technologies has been centred around meeting safety requirements. However, there is now a shift towards emerging technologies driven by the need to cost effectively reduce emissions from large emitters. Notably, the gas sector in Australia has shown more promising progress in adopting emerging technologies compared to the coal sector.

The coal sector faces real and perceived challenges in methane reduction due to the prevalence of surface mining. Efforts to implement methane capture and ventilation systems in underground mines have been made, but their widespread adoption remains limited as a result of claims of costs and safety hazards. The CSIRO has successfully developed three technologies that demonstrate the potential of VAM destruction and reuse in mitigating methane emissions. Stronger, and more specific methane reduction regulation (either in regulations or through mechanisms like the Safeguard Mechanism), combined with clear price signals to coal miners could drive increased uptake of available technologies and technology development funding.

It should be noted that most of these technologies are typically used in underground mines. However, as surface mines in Australia are reaching comparable depths to underground mines (and getting 'gassier' as a result), the cost effectiveness of implementing existing drainage technologies in surface mines is increasing. Additionally, as further technologies are developed and commercialised (with or without government support), it is expected that costs will decrease.

Key takeaways

Australia is lacking methane reduction targets that are specific to the gas and coal sectors, that would help to achieve net zero emissions targets. There is also a lack of prescriptive national policies that regulate methane emissions from these sectors.

Coal mines may require a strong price signal or enforced emissions reduction requirements to encourage the uptake of methane abatement technologies.

- There is currently no measurement approach that is mandatory for consistent use across the gas and coal sectors.
- At the state-level, Australia has established some prescriptive approaches to encourage methane reduction in the gas sector. However, some states with heavy gas production facilities are still lacking policies, such as WA.
- Methane reduction projects are eligible through Australia's Emissions Reduction Fund, however there is limited readily available evidence of widespread successful implementation of projects.
- Australia has been a first mover in trialling coal mine methane abatement technologies, however widespread adoption of these technologies has not occurred.

Summary and insights for Australia

Prescriptive industry emissions standards, measurement and reporting are common to most of the jurisdictions reviewed

Methane reduction policies and regulations

Policies and regulations	Alberta	British Columbia	United Kingdom	California	Pennsylvania	Maryland	China	Australia
Industry emissions standards – specifying equipment allowances	Gas	Gas		Gas	Gas	Gas		Gas
Industry emissions standards – mandatory equipment/process use	Gas	Gas	Gas	Gas	Gas	Gas		Coal, Gas
CH_4 Fugitive emissions self-measurement & reporting	Coal, Gas	Coal, Gas	Coal, Gas	Gas	Gas	Gas		Coal, Gas
CH_4 Fugitive emissions independent measurement & reporting				Gas				
Public performance benchmarking								
Overall methane reduction targets								
Sector specific methane reduction targets (input and/or output)	Gas			Gas			Gas	
Direct funding (e.g. grant programs) for technology uptake	Gas	Gas		Gas				
Indirect funding (e.g. tax concessions)		Gas						
Indirect funding (eligibility for carbon offset credits for use or sale)	Gas	Gas		Coal, Gas				Coal, Gas
Indirect funding (eligibility for renewable energy credits for sale)					Coal			
Allowances for regulated asset spend on emissions technology			Gas					Gas
Resource-based land zoning (specifically to increase CMM use)					Coal			Coal

Key

Coal | Gas | Legislated requirement | Non-legislated requirement | Voluntary program | Inconsistent state based application

Note: the assessment of each policy and regulation per country is by whether there is evidence of that type of approach, and how mandatory it is. This is not an assessment of how thorough or close to best practice the policy or regulation is.

Prescriptive | Informative | Performance / outcomes based | Economic

Observations

- Six of the reviewed jurisdictions have some level of prescriptive emissions standards – either on allowable emissions rates from equipment, or mandated equipment use.
- There is a similar level of legislated buy-in for methane emissions measurement and reporting.
- Five of the reviewed jurisdictions have specific methane reduction targets are in place, and two of these have been legislated.
- The use of less 'rigid' policy types is mixed – a range of economic incentives were observed across jurisdictions, including direct technology funding and indirect mechanisms such as eligibility for carbon credits.

The use of monitoring technologies is commonly required, otherwise few methane-specific technologies are mandated

Methane reduction technology and practices

	Technologies and practices	Alberta	British Columbia	United Kingdom	California	Pennsylvania	Maryland	China	Australia
MRV	Use of LDAR technology and practices		✓						
Avoidance	Use of electric/compressed air devices (best practice)	✓	✓						✓
	Conversion of engines to electric alternatives		✓						✓
	Pipeline replacement & repair								
Reduction	Use of reduced emissions well completions								
	Use of plunger lifts in blowdown events								
	Use of blowdown optimisation practices and tech								
	Lowered gas line pressure								
Recovery	Use of Vapour Recovery Units on particular components	✓	✓						✓
	Use of casing gas capture/destruction technologies	✓							
	Use of eductors or ejectors for flare gas recovery								
	Coal mine/bed methane capture and use				*N/A*	✓	✓	✓	✓
	Ventilation Air Methane abatement practices	*N/A*	*N/A*		*N/A*				✓

Key: Coal; Gas; Mandatory use; Recommended or encouraged use; Industry trend; ✓ Eligible for grants and/or incentives programs

Observations

- Monitoring, reporting, and verification of methane reduction, through the use of LDAR technology and practices, has been mandated in 6 of the jurisdictions reviewed.
- Methane avoidance and fugitive emissions reduction technologies are the most common type to be seen in voluntary industry programs – likely due to the cost effectiveness and low payback periods.
- Coal methane capture and use is recommended and commonly eligible for grants or incentive programs in several jurisdictions but has not yet been mandated.

Sources: Maryland Department of the Environment – New Regulations under new Chapter COMAR 26.11.41 Control of Methane Emissions from the Natural Gas Industry (2019); California Air Resources Board – CARB's Oil and Gas Methane Regulation Fact Sheet (2018); Alberta Energy Regulator – Summary of Gas Limits and Fugitive Emissions Management Requirements (2022); British Columbia Government – Oil and Gas Activities Act, Drilling and Production Regulation B.C. Reg. 282/2010 (2023); APPEA – Industry Action on Emissions Reduction (2020); DCCEEW – Methods for the Emissions Reduction Fund (2023); US EPA – Oil and Natural Gas Sector: Emissions Standards for New, Reconstructed, and Modified Sources (2016)

Mandatory minimum emissions thresholds on standard equipment and practices, such as flaring, has driven technology uptake

Methane reduction standards applied to typical industry equipment

	Standards on the use of...	Alberta	British Columbia	United Kingdom	California	Pennsylvania	Maryland	China	Australia
MRV	Occurrence and monitoring of blowdown events								
Reduction	Use of flares		✓						✓
Reduction	Use of low-bleed pneumatic devices (better practice)	✓	✓						✓
Reduction	Use of reciprocating &/or centrifugal compressors	✓	✓						✓
Reduction	Use of storage vessels/tanks	✓							
Reduction	Use of Glycol Dehydration units								
Reduction	Use of pipeline pigging operations								
Reduction	Use of separator systems								
Reduction	Use of circulation tanks								

Key

Coal Gas

- May use, but minimum emissions thresholds or other limits are applied
- May use, but minimum emissions thresholds recommended
- Event and emissions reporting required only
- ✓ Eligible for grants and/or incentives programs

Observations

- Restrictions on the use of flaring are common across most jurisdictions, either through emissions limits or controls on the frequency or processes used.
- Emissions thresholds on standard gas industry equipment and devices such as compressors, pneumatic devices, and storage vessels are also regulated across most jurisdictions reviewed – likely due to the prevalence of emission's efficient equipment, and/or the existence of capture/reuse technologies that can be retrofitted.
- The UK, US, and Canada have recently committed to zero routine flaring and venting targets, typically by 2030.

Sources: Maryland Department of the Environment – New Regulations under new Chapter COMAR 26.11.41 Control of Methane Emissions from the Natural Gas Industry (2019); California Air Resources Board – CARB's Oil and Gas Methane Regulation Fact Sheet (2018); Alberta Energy Regulator – Summary of Gas Limits and Fugitive Emissions Management Requirements (2022); British Columbia Government – Oil and Gas Activities Act, Drilling and Production Regulation B.C. Reg. 282/2010 (2023); APPEA – Industry Action on Emissions Reduction (2020); DCCEEW – Methods for the Emissions Reduction Fund (2023); US EPA – Oil and Natural Gas Sector: Emissions Standards for New, Reconstructed, and Modified Sources (2016)

Informed by international precedent, a combination of approaches could drive fossil fuel methane emissions reduction in Australia

Key actions for Australia to address current gaps

1 Sector specific methane targets

"A common, 1.5C aligned goal"

Specific methane emissions reductions targets for the gas and coal industries, considering both input and output targets, aligned to a 1.5C pathway

- Sector specific targets should align to the Global Methane Pledge and IPCC goals and focus first on easy to abate parts of the coal and gas value chain.
- Sector specific targets could be a mix of input based (e.g., utilisation rate of CMM in coal mine projects) and output based (e.g., total methane emissions from coal operations), informed by scientific research and expert recommendations.
- There is currently no specific methane emissions target for the coal and gas industries in Australia – this makes it easier to deflect responsibility for methane emissions to other sectors, such as the waste and agriculture sectors.

2 Emissions regulations and price signals

"Kickstarting industry to make changes"

National prescriptive emissions standards for equipment and practices, including measurement, reporting & verification

- Standardised and more specific emissions standards (e.g. bleed rate requirements, pre-drainage and utilisation in all coal mines) could be applied to both new and existing wells, mines and other infrastructure.
- Non-routine flaring and venting targets and regulations would align to other jurisdictions.
- A requirement to produce methane emissions baselines and report publicly on methane emissions would help to encourage methane specific emissions reductions.
- Bottom up (through LDAR), and top-down site level measurement requirements using modern best-practice methods would also provide a more accurate assessment of methane emissions, which is critical to measuring success.

Clear, methane specific price signals through the Safeguard Mechanism, Emissions Reduction Fund (ERF)

- A financial incentive through avoided Safeguard Mechanism compliance costs (ACCU and/or Safeguard Mechanism Credit purchases, fines) would encourage emissions reductions beyond those mandated through prescriptive emissions standards.
- Further financial incentives for additional abatement through the ERF would further drive voluntary reductions. Clearer guidance on the availability of existing emissions reduction programs could be developed to encourage use of existing incentive programs (e.g., 'stacking' of existing relevant ERF project methodologies).
- A price on methane (per the US IRA developments) would also strongly promote the business case for methane emissions reductions.

3 Collaboration

"Efficiency through working together"

Industry partnerships and collaboration, both nationally and internationally, to support innovative efficient solutions

- Industry partnerships (including with Government) could support the sharing of learnings and provide the scale to implement emerging R&D or widespread monitoring programs.
- The Natural Gas STAR program was a highly successful initiative in the US that could be implemented in Australia – particularly given that many multi-national industry participants may have been historically involved.
- Government-industry partnerships could also support the widespread implementation and commercialisation of coal mine methane abatement technologies (such CSIRO's technologies) to mutual benefit.
- The recent signing of the *Joint Statement on Accelerating Methane Mitigation from the LNG Value Chain* is a positive start in this direction.

Evidence from other jurisdictions show that the best results are seen when each of these approaches are used together in a holistic package of works. One measure alone will not achieve the desired results in the most efficient manner – a combination of targets, with emissions regulations appears to drive the greatest industry action.

Appendix

IEA regulatory approaches

Policy / regulatory approach definitions

	Definition	Example
Prescriptive	Prescriptive requirements, also known as command-and-control measures, facilitate emissions reductions by instructing regulated entities to either perform or refrain from specific actions or procedures. These requirements can pertain to procedures, equipment, or technological specifications	Certain regulations mandate that companies adhere to particular procedures or processes concerning their operations. For instance, in various jurisdictions, companies are obligated to implement leak detection and repair programs. Additionally, prescriptive regulations may outrightly forbid specific activities.
Performance	An outcome-based or performance-based requirement sets a compulsory performance standard for regulated entities without specifying the methods to achieve the goal. These regulations are typically applied at the facility or individual equipment level, but they also have the potential to be implemented on a broader scale.	The Colorado regulation includes examples of equipment-level performance standards. For example, large storage tanks must meet a 95% VOC reduction target, and flares must be designed for 98% efficiency. Sector-wide examples include Nigeria, where a target has been set to achieve 50% reductions in fugitive emissions from production and processing and from transmission and distribution by 2030.
Economic	Economic provisions encourage action by utilising financial penalties or rewards. This may involve implementing taxes, subsidies, or market-based tools like tradable emissions permits or credits, allowing companies to select from various strategies to tackle emissions. By making undesirable behavior more expensive, economic instruments effectively influence behavior patterns.	An emissions tax, like Norway's carbon tax, serves as a straightforward illustration of such a mechanism. In Canada and the province of Alberta, they provide loans and grants to companies engaging in methane abatement projects, particularly for existing and abandoned wells.
Information	Information-based regulations are formulated to enhance the quality of information concerning emissions. Their objective is to close information gaps and furnish regulators, industry stakeholders, and the general public with more comprehensive data about critical sources of issues and potential solutions.	The simplest version of this regulation is a simple reporting requirement whereby regulated entities must quantify, either by measuring or estimating, and report their emissions to the regulator. The US EPA's Greenhouse Gas Reporting Program requires all facilities that emit at least 25 000 tonnes CO_2 equivalent per year to report their emissions.

Sources: IEA – Driving Down Methane Leaks from the Oil and Gas Industry, Regulatory Toolkit (2021)

Summary of Australian national and state/territory policy types

Methane reduction policies - Australia

Prescriptive	○	Leak detection & repair	○	Flaring or venting restrictions	○	Technology standards	●	Permitting requirements
Performance		Reduction targets		Flaring or venting standards	○	Process or equipment emissions standards	●	Facility or company emissions standards
Economic		Taxes or charges on emissions		Taxes or charges on gas disposal (flaring or venting)		Loans, grants and other financial incentives	○	Emissions trading schemes and certified reduction credits
Information	●	Measurement requirements	●	Reporting requirements	●	Emissions estimates and quantification		Public disclosure

Key	● National policies	○ State/territory-level policies only

Sources – IEA – Methane Tracker (2023)

Common equipment and practices in the fossil fuel sector – definitions

Common equipment and practices in the fossil fuel sector – definitions

Ventilation	Ventilation in coal mining refers to the deliberate circulation of fresh air throughout underground mine workings. The main purpose of ventilation is to ensure a safe and healthy environment for miners by diluting and removing hazardous gases, particularly methane, and other harmful airborne contaminants. Methane captured from ventilation systems, otherwise known as Ventilation Air Methane (VAM), can be utilised as an energy source instead of being released into the atmosphere.
Drainage	Drainage, also known as degasification, is the process of extracting methane gas from coal seams before or during mining operations. Methane is often trapped within coal deposits, and if not adequately removed, it can build up in the mine workings, leading to potential explosions or asphyxiation hazards. By degassing the coal seam, the concentration of methane is reduced, enhancing the overall safety of the mining operation. The extracted methane can also be utilised as an energy source.
Storage and tanks	In the gas and coal sectors, "storage" and "tanks" refer to facilities and containers used to store gases, liquids, or solid materials for various purposes. Gas storage includes underground storage in depleted gas reservoirs, aquifers, or salt caverns, as well as above-grand storage in tanks or pressure vessels. Whereas coal storage refers to designated areas or facilities where coal is stockpiled and stored before it is transported for further processing or consumption.
Wellheads	A wellhead refers to the equipment and structure that is installed at the opening of an oil or gas well to control the flow of natural gas or oil from the subsurface reservoir to the surface facilities. It is the point of connection between the underground reservoir and the surface gathering and processing infrastructure.
Flaring and venting	Flaring and venting are practices used in both the coal and gas sectors to manage the release of gases, particularly methane, which is a potent greenhouse gas and a safety hazard. Flaring refers to the controlled burning of gases, primarily methane, that are released during oil and gas production or processing operations, and in some cases, flaring is used to combust coal mine methane. Venting refers to the intentional release of gases, including methane, into the air without combustion.
Blowdowns	In the gas and coal sectors, 'blowdown' refers to a controlled release or discharge of gases or pressure from a system to reduce the pressure within the system or to safely vent excess gases. In the gas sector, blowdown occurs when excess pressure needs to be relieved from pipelines, storage tanks, or other gas handling facilities. In the coal sector, blowdown typically pertains to methane drainage or degasification systems used in underground coal mines.

Sources: IEA – Methane Tracker (2023); CSIRO – Mine ventilation air methane abatement; USA EPA – Coal Mine Methane Recovery: A Primer (2019); IEA – Gas flaring; USA EPA – Reducing Emissions When Taking Compressors Off-Line (2006)

Key methane emission abatement technologies

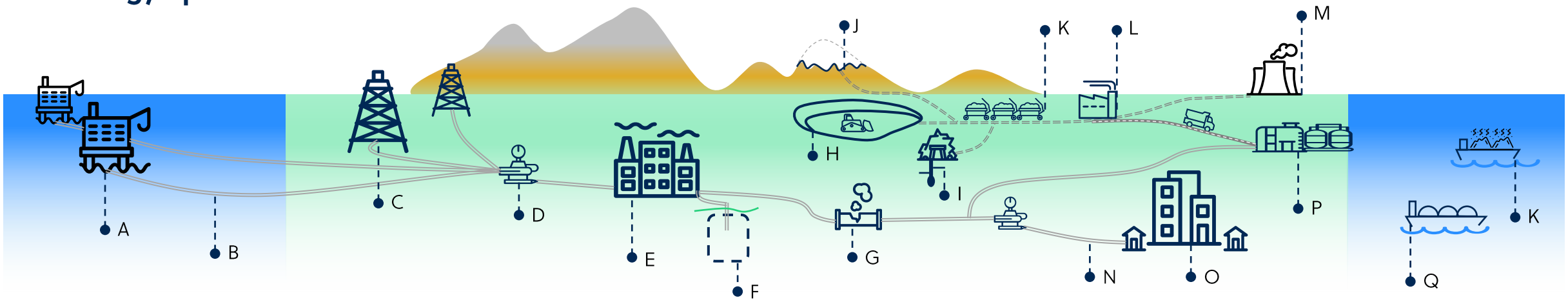
Key methane emission abatement technologies

Measurement and detection	Methane emission detection and measurement has mainly relied on "onsite" technologies like LDAR devices that are used for targeted leak detection and methane measurements. However, emerging "offsite" technologies like satellites and drones offer wider coverage, revealing higher emissions from fugitive coal and gas operations. Incomplete data and limited awareness of cost-effective solutions hinder efforts to reduce methane emissions, requiring careful data processing in many countries.
Flaring and venting	Flaring refers to the controlled burning of gases to prevent buildup and reduce the risk of explosion . Although flaring still generates CO_2 and methane emissions, it remains a more favorable option compared to directly releasing methane gas into the atmosphere. Nonetheless, most jurisdictions impose several restrictions on flaring and venting, primarily aimed at reducing the frequency of flaring. For instance, the UK has set a target to achieve zero routine flaring and venting by 2030, or even earlier.
Compressor seals and rods	Replacing rod packing systems to reduce emissions is a common way to reduce methane emissions. Reciprocating compressors use piston rods to compress gas. Rod packing is the seal that prevents gas from leaking around the rod. Compressor pressure and wear and tear on packing parts and the rod can increase emissions. The older seals are, the more likely they are to emit.
Vapour Recovery Units (VRU)	VRUs are compact compressors created to trap emissions that accumulate in various equipment along the oil and natural gas supply chains. These units then channel the captured gas towards an end-use that is less detrimental than releasing it directly into the atmosphere. For example, VRUs can effectively extract gases that collect in oil storage tanks, which would otherwise be vented periodically into the atmosphere to avert potential explosions.
Pneumatic devices	Pumps are used at well sites and across the oil and natural gas supply chains for a variety of purposes. Commonly, they are pneumatic pumps that use pressurised natural gas as a power source. Gas-driven pneumatic devices continuously release small amounts of gas, even when specified as 'low-bleed'. These devices can be replaced with 'zero-bleed' technologies that use electrical power to operate or instrument air systems which pressurise ambient air to perform the same functions without emitting methane.

Sources – IEA – Methane Abatement Options (2020)

Value chain iconography glossary

Technology uptake to date



Stages and infrastructure within the gas and coal value chains

A. Offshore oil and gas rigs, with associated wellheads, equipment
B. Gathering pipelines
C. Onshore oil and gas rigs, with associated wellheads, equipment
D. Compressing station
E. Oil or gas refinery, other treatment infrastructure
F. Gas storage, above or below ground
G. Gas transmission pipelines (note: technologies linked to gas leaks across gathering and distribution pipelines will also be indicated at this point)
H. Surface coal mining
I. Underground coal mining
J. Mountaintop removal coal mining
K. Coal transport (land or sea)
L. Coal treatment and processing
M. Coal end usage
N. Gas distribution pipelines
O. Gas end usage
P. LNG import/export terminal
Q. LNG transport

Glossary (1/3)

Abbreviation	Term
ACCU	Australian Carbon Credit Unit
AEC	Alternative Energy Credit
AMEP	Alberta Methane Emissions Program
AMM	Abandoned Mine Methane
APPEA	Australian Petroleum Production and Exploration Association
B.C.	British Columbia
BCOGC	British Columbia Oil and Gas Commission
BWR	Basic well rates
CO_2	Carbon dioxide
CAGR	Compound Annual Growth Rate
CARB	California Air Resource Board
CAZ	Conflict Administration Zones
CBM	Coalbed methane
CERIN	Canadian Emissions Reduction Innovation Network
CES	Clean Electricity Standard

Abbreviation	Term
CGIRP	Clean Growth Infrastructure Royalty Program
CH_4	Methane
CII	CleanBC Industrial Incentive
CMM	Coal mine methane
CSG	Coal seam gas
CSIRO	Commonwealth Scientific and Industrial Research Organisation
D17	Directive 017
D36	Directive 036
D60	Directive 060
EPA	Environmental Protection Agency
ERF	Emission Reduction Fund
FYP	Five Year Plan
GDP	Gross Domestic Product
GHG	Greenhouse gases

Glossary (2/3)

Abbreviation	Term
GMP	Global Methane Pledge
GP	General Operating Permit
ICE-CMM	China International Centre of Excellence on Coal Mine Methane
IEA	The International Energy Agency
IMRRP	Iron Mains Risk Reduction program
IRA	Inflation Reduction Act
LCFS	Low-Carbon Fuel Standard
LDAR	Leak Detection and Repair
LNG	Liquified natural gas
MERR	Methane Emission Reduction Regulation
MMC	Mine Methane Capture
MRL	Maximum rate limitations for production
MTIP	Methane Technology Implementation Program
NG	Natural gas

Abbreviation	Term
NGER	National Greenhouse and Energy Reporting
NZE	Net Zero Emissions
Ofgem	The Office of Gas and Electricity Markets
OGA	Oil and Gas Authority
PA	Pennsylvania
PIPES	Protecting Our Infrastructure of Pipelines and Enhancing Safety
R&D	Research and development
REC	Reduced emission completions
RET	Renewable Energy Target
RTO	Regenerative Thermal Oxidation
SGM	Safeguard Mechanism
SO2	Sulphur dioxide
TIER	Technology Innovation and Emissions Reduction
UK	United Kingdom

Glossary (3/3)

Abbreviation	Term
UN	United Nations
USA	United of America
VAM	Ventilation Air Methane
VOC	Volatile Organic Compounds
VRU	Vapour Recovery Units

Get in touch

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