Coal mine methane

8.1 Production

Coal mine methane (CMM) is the term given to the gas trapped in coal seams, which has an approximate chemical composition of 70% methane, 15% carbon dioxide and 15% nitrogen. The gas is released once the seams are mined and can then escape to the atmosphere.

Internationally, the UK was the sixth largest producer of coal mine methane in 1990,[140] behind China, the former Soviet Union, the USA, Germany and South Africa. The UK submission to the UNFCCC declares that 0.24 Mt of methane were emitted from active coal mines during 2002, accounting for 12% of all UK methane emissions. Historically, the contribution of coal mine methane to the UK's methane budget was more significant when major coal fields in the UK where extensively mined for power generation and industry (Figure 20). However, the decline of the UK coal industry and subsequent large scale pit closures has resulted in far fewer mines and emissions. In 1947 there were 958 mines producing 189.6 Mt of coal annually. At present, there are just 17 deep mines and 39 open cast mines in the country, producing a total of 27.8 Mt coal in 2003.[105] The open cast mines release methane directly to the atmosphere. However, emissions from such mines are small as the seams lie close to the surface and have retained little of their original methane over geological time.[75]

Figure 20: Coal fields in the UK

Source: Bibler, 1998[140]

Why recover coal mine methane?

The primary reason for recovering coal mine methane is safety. Historically, underground mine explosions have been the cause of many injuries and fatalities, so reducing methane concentrations underground has aided mine safety operations.

Secondly, there is an economic motivation: if methane from coal mines can be captured, it can be used directly as a fuel or to generate electricity.

Lastly, there is the environmental imperative: reducing emissions of methane to the atmosphere aids the meeting of Kyoto and other targets.

Abandoned mines

In 1988, a house in the village of Arkwright in Derbyshire exploded due to contamination of the village with seeping coal mine methane. Because the ground above mined seams subsides and fissures slightly, methane can seep through the bedrock and find its way to the surface, often miles from the pit head. This incident was a key factor in alerting the industry and Government to the environmental impacts of methane emissions from abandoned mines.

A major shortcoming of the UK UNFCCC submission is that it only includes emissions from active mines. At present, the decrease in methane emissions accounts for 30% of the UK greenhouse gas emissions reductions achieved since 1990, with coal mine closure responsible for 36% of this (*i.e.* 12% of total greenhouse gas emissions reductions). Inclusion of methane emissions from abandoned mines may significantly alter these figures. Both the current figures and the 1990 baseline would be higher and, whilst emissions from the sector would still decline over this period, it would not be so pronounced as currently implied.

A suitable methodology has not yet been developed for the inclusion of abandoned mines. This is a worldwide problem, but particularly pertinent in the UK. Whilst it is true that emissions from active coal mines are higher than from disused mines because the mining process opens up pockets of methane, abandoned coal mines are still capable of producing significant quantities of methane. This is especially true in the UK where 1096 coal mines have been abandoned since 1947,[141] compared to the 17 deep mines still currently active.

Emissions of methane from abandoned coal mines are poorly quantified at present, with estimates ranging from 0.02 to 0.3 Mt per year.[64] The large range of values is an indicator of the massive uncertainty in these estimations. At the low end of this range, inclusion of abandoned coal mine methane makes a negligible contribution to UK methane emissions. The upper end of this estimate corresponds to more than doubling the methane released from coal mines and would make coal mines (active and abandoned) the second largest source of methane in the UK, responsible for 21% of UK methane emissions. The Association of Coal Mine Methane Operators (ACMMO) believes emissions from abandoned mines to be higher still, at 0.6 Mt per year, by including seepage from unvented mines as well as those with vents.[142] They estimate that 45 sites in the UK are commercially viable, capable of supporting 300 MW of electricity generating capacity and saving 0.37 Mt of methane.[142]

However, the DTI maintain that coal mine methane from abandoned mines is not a problem in the UK and use this assumption as the basis for their policy recommendations. They estimate that just 0.05 Mt of methane are emitted from sites capable of being controlled.[143] Furthermore they assert that methane seepage from mines will rapidly diminish, particularly if flooding occurs.

The Association of Coal Mine Methane Operators claim that the DTI have seriously underestimated both the extent of the resource, the number of possible projects and overestimated the rate in decline of emissions.[144] The huge discrepancy in both the postulated resource and its longevity requires further independent research. At present, poor knowledge is likely to lead to inappropriate policy and economic support measures – particularly if the problem is not perceived as serious.

8.2 Mitigation

Non-extraction

The flow of methane from abandoned coal mines may be inhibited by blocking vents and sealing pathways where methane is detected. Alternatively, the coal mine may be flooded, providing an aqueous barrier to methane emissions.[143] Transport of methane through the water layer is prevented by its low solubility. Flooding can be an attractive option where there is no risk of aquifer contamination and where there is a suitable water resource available for the operation.

Such techniques are only applicable to sites where the risk of uncontrolled emissions is low. Because methane can seep along fissures and cracks in de-stressed bedrock many miles from its source, this is not seen as a workable option for most sites. Indeed, the Coal Authority has had to

Methane emissions from abandoned coal mines are not recognised by national inventories

install a further 40 vents at abandoned mines around the country since 1994 to cope with the hazards of new leakage points.[143]

The preferred options of methane emission mitigation revolve around recovery and conversion to carbon dioxide.

Extraction

Coal mine methane can be extracted from mines in four different ways: through an existing gas vent, a vent well, a gob gas well and a CBM well.

Existing gas vent

All active coal mines have an existing gas vent to remove methane from the mine for safety reasons. Typically this gas is merely vented to the atmosphere, although some UK collieries do utilise the methane liberated. In active mines, ventilation air methane (VAM) is the major source of methane because the throughput of ventilation air is so high. Once the mine is no longer active, the VAM can still be drawn through the vent and captured, rather than being lost to the atmosphere (Figure 21).

Vent well

The upper layers of rock above a coal mine can often subside and fissure, creating a pathway for methane to seep through to the surface. This diffuse flow is difficult to capture and can result in significant methane emissions. A vent well can be drilled into the disused mine away from the central shaft and, by pumping on the well, methane will preferentially exit by this simpler route. Methane captured here also reduces methane emissions to the atmosphere.

Gob gas well

Gas trapped in destressed coal seams near the coal face (known as gob gas) will release methane into the mine or out through porous rock strata to the atmosphere. Drilling into this seam and pumping allows the gob gas to be captured. For abandoned mines this clearly reduces methane emissions, whereas for active mines, such a process mines the gas before the coal is extracted.

CBM well

Vents can also be drilled directly down into coal seams adjacent to the coal face. Virgin coal seams are stimulated and, after removing any water, methane can be extracted from the coal seam. This is essentially a direct mining process involving the creation of a virgin coal bed methane (CBM) mine. As such it is not mitigating against methane emissions as the methane present in the coal bed would not naturally have

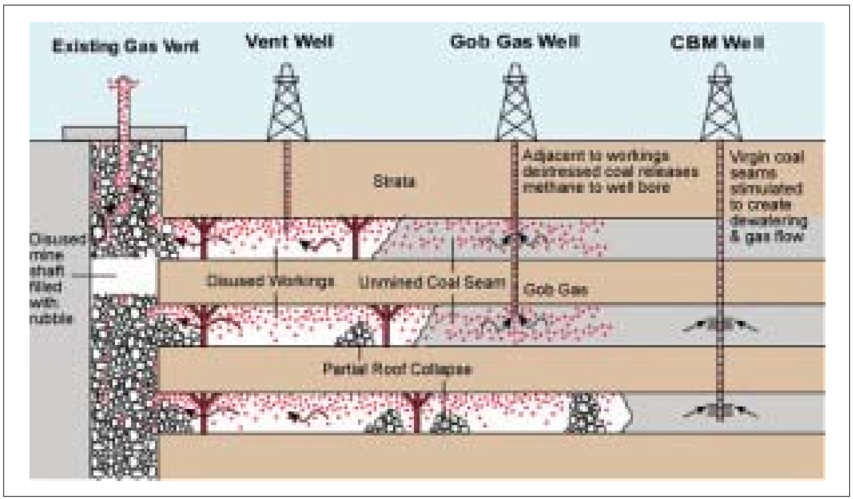

Figure 21: Recovery of methane from abandoned mines

Source: The Coal Authority, 2001[145]

escaped to the atmosphere. CBM is a fossil fuel resource and therefore is not be eligible for ROCs.

Acceleration of coal mine methane

Pumping coal mine methane results in a more rapid removal of methane from the mine than would occur naturally and possibly increases the amount of methane extracted. This lowers the pressure inside the mine and increases the desorption of methane from the coal seams. However, there is still much debate within the scientific community about the extent of acceleration.[33]

The extent of acceleration has implications for the trading of methane – does it matter that methane is being extracted from the mine faster than baseline natural emissions? Currently, it is believed that either accepting all extracted methane by ignoring the acceleration issue or allocating a fraction of output to be eligible would both be feasible methods for emissions trading.[33]

Using captured methane

Once captured, coal mine methane is either vented to the atmosphere, flared (oxidising the methane to carbon dioxide) or utilised in some form of energy recovery. The latter is the preferred environmental option but not necessarily the most economic since, as a non-renewable resource, the electricity does not qualify for ROCs. In 2003, 0.8 TWh of electricity was generated from colliery methane.[105] Methane is currently captured at seven operating sites and utilises a mixture of flares, generators and gas utilisation for boilers. Electricity is generated at six of these sites. Electricity generation from CMM also takes place at seven abandoned mines,[146] with a total capacity of 35 MW. ACMMO estimates that around 300 disused coal mines have the potential to generate electricity from CMM, which would result in an installed capacity of around 400 MW.[147]

The purity of the methane extracted varies depending on its source. Gob gas is of medium quality, typically containing 30-90% methane, which is a sufficiently high concentration to utilise abatement technologies similar to those employed in landfill.

Ventilation air methane and vent well methane are of lower purity (less than 1% methane), but more sophisticated technologies now exist that are capable of utilising this gas directly.[148] Flow reversal reactors use a bed of silica gravel or ceramic as a heat exchange medium. The bed is preheated to 1000°C to initiate methane oxidation and the VAM is passed into the bed. As the methane combusts, the temperature rises and the excess heat can be recovered from the exhaust gas. This process also causes the far side of the bed to heat up, so the direction is reversed periodically to ensure that the combustion hotspot remains in the centre of the reactor bed (Figure 22).

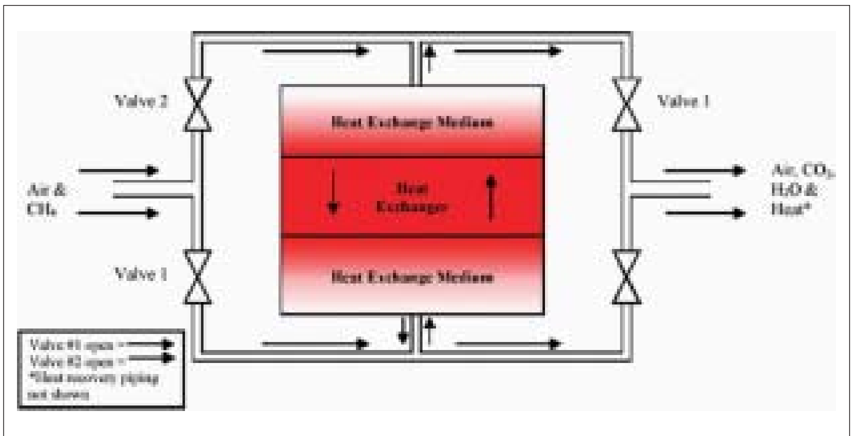

Figure 22: Thermal flow reversal reactor

Source: US EPA Coalbed Methane Outreach Program, 2003[149]

Ventilation air methane may also be utilised as combustion air – in other words it is used as a 'primed' air mix for the combustion of other fuels. In this way, the calorific value of the VAM is not lost. Such a process requires an alternate source of fuel on site.

8.3 Current policy

Coal mine methane emissions

The UK's current policy on coal mine methane has recently been laid out by the DTI.[33, 143] The DTI assessed a total of 18 different policy instruments on the basis of cost effectiveness, ease of implementation and political acceptability. Environmental best-practice was not considered as one of the criteria. The most important factor in deciding which policy to utilise was the assumption that the methane resource from abandoned mines is small and will reduce over time through natural processes. However, as noted earlier, this is a highly contentious statement.

The favoured policy instrument was a series of competitive bidding rounds amongst Production Exploration and Development Licence (PEDL) holders across relevant sites for the most cost-effective bids to control methane emissions. The UK Coal Authority will be responsible for overseeing this process, thereby extending its environmental duties from mine water alone to include greenhouse gases. In most cases, given the lack of financial support for electricity generation, it is likely that simple flaring will be the most cost-effective choice. This policy will work alongside existing mechanisms, including the Climate Change Levy (CCL) and emissions trading.

Of the other policies considered, neither of the other two 'front-runners' – do nothing or incorporation into the Renewables Obligation – were deemed acceptable or consistent with current Government policy. Whilst 'do nothing' is the lowest cost option, it is inconsistent with Government environmental objectives and runs contrary to the commitments made on coal mine methane within the Energy White Paper.[8] Incorporation into the Renewables Obligation was rejected on the grounds that coal mine methane is not a renewable resource and that it would infringe EU rules on state aid. Development of an 'Alternative Obligation' for encouraging non-renewable, yet beneficial, low-carbon technologies was rejected for fear of raising the 'nuclear question'.

Whilst the proposal for a competitive grant scheme is still at an early stage, it is clear that the emphasis is on control options, rather than electricity generation. Many proposed methane mining schemes are to be scrapped due to insufficient Government incentives.[150] Alkane, a major CMM company, has dropped proposals for 50 MW of electricity generating capacity in Ayrshire and is likely to take its operations abroad to Germany where economic conditions are more favourable.

Climate Change Levy

Since April 2002, electricity generated from coal mine plants has been exempt from the Climate Change Levy (CCL).[151] This full exemption was incorporated in the 2002 Finance Act, which accorded CMM renewable status for the purposes of exempting it from the CCL.[152] The Government claims that the exemption was granted on the basis that electricity generated from CMM offers both environmental gains and employment opportunities.[151] This creates a policy inconsistency where coal mine methane is eligible for Levy Exemption Certificates (LECs) but not ROCs.

Exemption from the CCL was expected to boost electricity generation from CMM with a consequent reduction in GHG emissions. However, the price of LECs is low at approximately £4/MWh; an order of magnitude smaller than ROCs. As a stand-alone policy, the Climate Change Levy will not provide a sufficient economic driver for investment in electricity generation technologies.

Capture of coal mine methane results in both safety and environmental benefits

Emissions trading

In order for the industry to continue to reduce emissions throughout the UK, the Government has offered support through other policies such as the UK Emissions Trading Scheme (UK ETS). Under the UK ETS, coal mine methane has been incorporated and rewarded for its environmental benefits through trading by UK Coal. However, trading is only allowed for emissions credits generated from active mines (either through flaring or electricity generation). Emissions from abandoned mines do not qualify for carbon credits since there is no baseline measure for these emissions and therefore no way for reductions to count.

DEFRA has commissioned studies to determine a baseline for abandoned CMM emissions that could enable it to qualify for this scheme,[64, 141] although so far only a protocol for methane from working coal mines has been developed.[153]

8.4 Recommendations

The key factor in determining the importance of this sector lies in the debate around abandoned coal mines, which could shift the current policy focus. In terms of capturing CMM from both active and abandoned mines, the technology is available and ultimately it depends on the policy emphasis as to how the captured gas is then dealt with.

Abandoned coal mines

At present, only methane from active mines is recognised by international targets. As a consequence, emissions from abandoned mines are not given the same policy priority as methane emissions that actively help the UK achieve these targets. It could be that emissions from abandoned mines represent both a significant problem and resource in the UK, but there is a great deal of uncertainty surrounding current estimates. Not only does this represent a major environmental issue, in terms of possible methane emissions which are currently unchecked, it is also a potential missed

Over 27 Mt of coal was produced in the UK in 2003

opportunity – an unexploited resource which could provide both financial and environmental benefits as well as employment opportunities.

An essential first step in addressing this issue would be to quantify these emissions accurately. This would involve developing an internationally agreed methodology for estimating emissions from abandoned mines, which currently does not exist. These emissions could then be included in the UK inventory for the UNFCCC. This would affect both current and historic estimates of emissions and therefore the contribution towards the Kyoto target. Improved data quality would provide a firmer foundation on which to build policy and may require a change in policy direction. The development of a reliable baseline for abandoned mines would also be required to enable trading of these emissions. Until estimates are improved, the debate and conjecture will persist and methane will continue to be released into the atmosphere.

Policy

Methane capture

Current policy addresses capture at active sites but not from abandoned mines. Until emissions from abandoned mines are better quantified, there is unlikely to be any change in this situation.

Electricity generation

Following the recent DTI review, the emphasis in current policy is on control, most likely in the form of flaring, rather than energy recovery. Whilst this is successful in reducing methane emissions and usually the most cost-effective option, it does not maximise the environmental benefits of capturing the gas. Because methane from both active and abandoned mines is a non-renewable resource, the economic incentives are not in place to encourage the implementation of best-practice technologies. Apart from the Climate Change Levy, there are no other policies or incentives for energy recovery and the Levy Exemption Certificates do not have a high enough market value to encourage energy generation. Fiscal policies such as trading will encourage flaring rather than electricity generation, as the most cost-effective option. Other policies such as feed-in-tariffs (as in Germany) and incorporation into the Renewables Obligation have been rejected by the DTI as inconsistent with existing Government policy.

Given the lack of financial incentives, if electricity generation is to be encouraged it will require some support from the Government. This could be in the form of grants or subsidies to encourage the implementation of best-practice technology, or through legislation, similar to the EU Landfill Directive. This could have implications for trading since emissions reductions required or supported in this way may not then be eligible to trade.

New technology

There is still room for improvement in current methane capturing technology, but investment in increasing efficiency is likely to require some form of incentive. Similar to energy recovery technologies, if there are no strong financial incentives to encourage improved capture, support may be need through grants and subsidies or legislation.

Methane trading

The successful trading of methane from active coal mines on the UK Emissions Trading Scheme demonstrates the feasibility of this approach for this sector. Inclusion of emissions from abandoned mines could potentially double the size of this market, but first requires the establishment of a reliable baseline. The two year gap between the closing of UK ETS and entry of methane into the EU ETS provides a timely opportunity to establish this baseline and investigate the potential of this market. As in the oil and gas sector, with this gap in trading, the UK Government faces a choice between legislating to underpin the savings made to date or putting the process on hold for two years until trading can recommence. Similarly, any mandatory requirements will impact on the viability of the future trading market.

The current political situation in the UK means that whilst trading will aid the economics of installing capturing capacity it will only encourage capture and flaring rather than electricity generation. Other policy measures need to be put in place to promote the adoption of energy recovery, which could then be supported through trading.