CBM REVIEW

What next for VAM?

Jayne Somers, US Environmental Protection Agency, US, and Clint Burklin, Eastern Research Group, US, provide a brief update on the world VAM destruction technology market.

Methane, a powerful greenhouse gas (GHG), is often found in coal seams and significant quantities of methane gas can be released into underground mine workings as part of coal mining operations. Because concentrations above 5% are explosive in air, mines must ensure that methane does not build to dangerous levels within the mine. This is accomplished in part through the use of large-volume ventilation air systems that dilute and remove methane from the mine. Although the concentration of exhausted methane in ventilation air is quite low (typically <1%), the volume of mine air that ventilation systems move is so great that they actually constitute the largest global source of methane emissions from underground coal mines. Five countries make up over 75% of ventilation air methane (VAM) emissions[1]:

- China (40%).
- US (15%).
- Ukraine (15%).
- Australia (5%).
- Russia (5%).

Having a global warming potential of 21 times greater than an equivalent weight of CO_2, the annual VAM emissions from these five countries is equivalent to over 225 million t of CO_2, or approximately 38% of global coal mine methane (CMM) emissions. In 2010, global methane emissions from coal mines were estimated to be approximately 584 million t of CO_2 equivalent, accounting for 8% of total global methane emissions.[2]

Several manufacturers began pilot-scale demonstrations of technologies for the destruction of VAM in the 1990s. These VAM destruction technologies are based on the same technologies used for many years for the destruction of volatile organic carbon (VOC) emissions. The demonstrations were successful and led to three manufacturers/project developers now operating five commercial-scale projects (Figure 1). These commercial projects have operated since 2007 in Australia, China, the UK and the US. As a result of these projects, the technical and economic performance of the technologies is relatively well documented and the technical risk is considered relatively low.

All three companies are offering technologies based on regenerative thermal oxidation (RTO) and are demonstrating >95% destruction of methane with a >90% availability. Although RTO technology will destroy methane at levels as low as 0.2%, the most ideal sites for these technologies are ones that have VAM concentrations ranging from 0.5 – 1.9% methane in ventilation flows of 100,000 ft^3/minute, or more. Ideally, the ventilation shafts should have a life of more than six years and access to stable electrical supply at reasonable cost. The companies offering VAM destruction technologies also offer a wide range of financial agreements, ranging from sale of a turnkey facility to various lease agreements, profit sharing arrangements or simple royalty payments.

The key factor limiting more widespread application of VAM destruction technology is the lack of economic market or regulatory drivers for VAM destruction. The primary drivers for the current VAM projects have been the carbon markets for

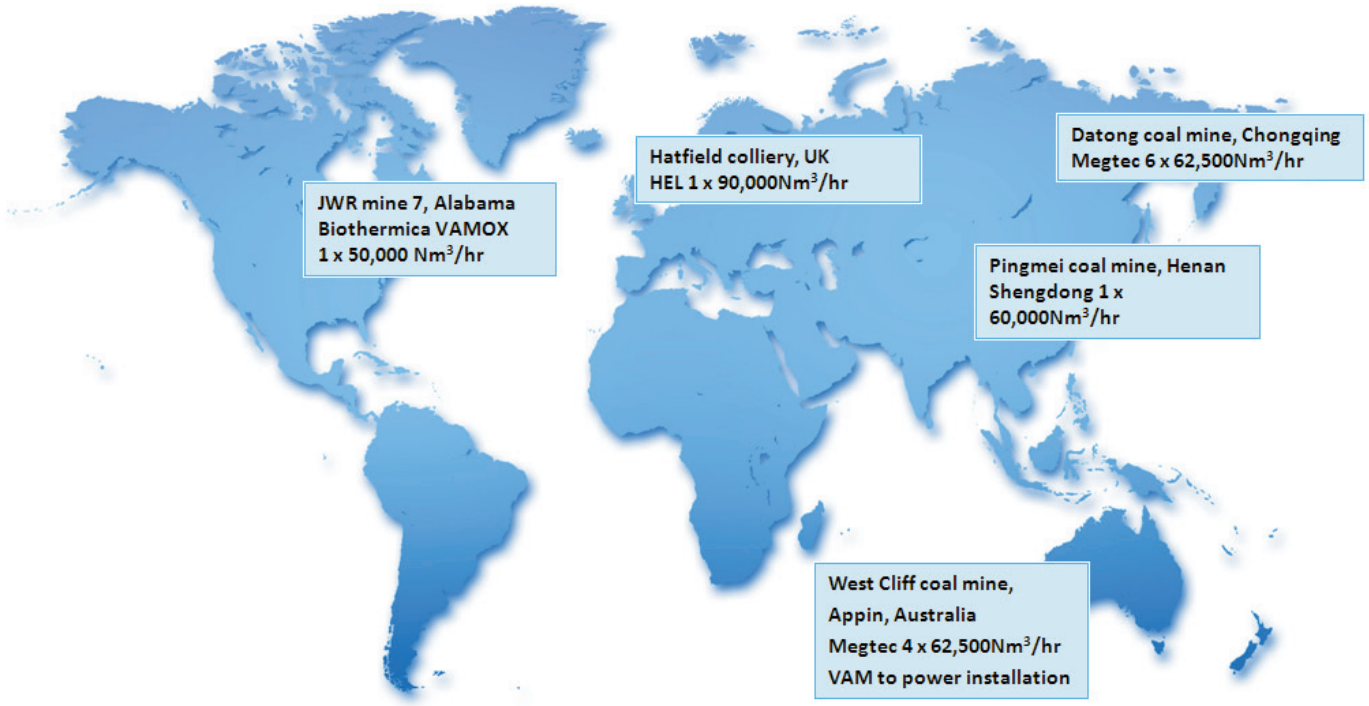

Figure 1. Current worldwide VAM projects.

Figure 2. RTO Installation at the DaTong coal mine in Chongqing municipality, China.
Image courtesy of MEGTEC.

the reduction of GHG emissions under the UN Framework Convention on Climate Change (UNFCCC) and other voluntary initiatives. The Kyoto Protocol, created and adopted under the UNFCCC, is an international regulatory framework that defines clear emission reduction commitments using flexible mechanisms, such as the clean development mechanism (CDM) and joint implementation (JI), that have laid the foundation for the development of the international carbon market. The voluntary carbon market was established primarily by companies, individuals and events that buy emission reductions to reduce their carbon footprint. Currently, both the CDM and JI carbon markets are driven by commitments under the Kyoto Protocol that are undefined after expiration of the protocol at the end of 2012. Such uncertainty in the compliance carbon market creates financial hurdles that reduce investment opportunities. In addition, as a result of the global economic recession, the current monetary value and interest in purchasing voluntary carbon reductions is very low, which also limits investment in VAM destruction. Table 1 summarises the world market for VAM destruction technologies.

Although the current market for VAM destruction is soft, before 2008 – when carbon prices were as high as US$ 20/t – the 300 million tpa of CO_2 equivalent of VAM emissions potentially represented a US$ 6 billion/year market. But in recent years, carbon prices have declined and become subject to increased volatility. Several factors could reduce the economic risk of investing in VAM technologies and improve the VAM destruction market. An extension of the Kyoto Protocol beyond 2012, or some other form of regulatory mechanism, would send a clear market signal and revive the price of carbon reductions for signatory countries. As an alternative, countries can take unilateral measures like China, which has extended the value of carbon reductions implemented in China by offering letters of approval (LOA) under the CDM that honour the sale of carbon reductions through 2020. Australia has recently adopted a carbon tax on significant GHG sources that could create a market for VAM destruction at gassier mines. Currently, the EU does not include methane or methane reductions in countries within its mandatory GHG reduction program. Broadening the EU GHG trading programme (EU ETS) to include methane would greatly expand the VAM market to European mines. Countries and organisations can also provide incentives for VAM destruction. Grants such as those provided by Australia, the

Table 1. The world market for VAM destruction technologies.

China	China is the world's largest underground coal producer, with an output of 2.66 billion t in 2009. VAM emissions are estimated at 18.3 billion m^3 2009. A CDM mechanism is in place, with carbon value extended until 2020 to enable a return on investment.
Australia	The country produced 117 million t of coal from underground mining in 2009, with VAM calculated at 1.3 billion m^3 for that year. The recent adoption of a carbon tax could provide a mechanism for return on investment.
Mexico	Mexico only produced 11.5 million t of coal, but the majority of its coal mines use modern longwall mining techniques and exhibit favorable VAM abatement characteristics such as large volumes and high VAM concentrations. CDM and VCM mechanisms are in place with carbon value until 2020 to enable a return on investment.
Russia, Ukraine and Kazakhstan	These three countries collectively produced 300 million t of coal in 2009, with VAM emissions calculated at 6.2 billion m^3. A wide range of mining techniques, mining conditions and levels of mechanisation are found in these countries. There is significant potential for VAM abatement projects.
India	India produced 529 million t of coal in 2009, the majority from opencast mining. Most underground mines are small scale and not gassy, currently offering poor conditions for VAM abatement. However, Coal India Ltd plans to dramatically increase coal production by 2020.
US	The US produced 378 million t of coal from underground mines in 2009, with calculated VAM emissions of 2.8 billion m^3. Large gassy coal mines give favourable conditions for VAM abatement projects, but a weakened global voluntary carbon market (VCM) presents high financial risk hurdles. The State of California's market-based GHG emission reduction may provide opportunities in the future.
South Africa	Some 250 million t of coal were produced in 2009, but South Africa's coal mines tend to be shallow, thus not gassy. However, the country has good future potential as coal mines access deeper reserves.
Western Europe	The EU Emission Trading Scheme (ETS) does not recognise methane as a GHG, thus no commercial mechanism exists to enable return on investment.

province of Quebec, Canada, and the US greatly facilitated the BHP West VAMP, J.R. Walters Black Warrior and Consol Windsor projects.

In summary, coal mine ventilation air is a significant global source of methane emissions from mining activities, and the destruction of this methane offers a significant GHG mitigation opportunity. Oxidation technology for the destruction of VAM has matured through the success of multiple long-term full-scale demonstration and commercial projects implemented across several continents. Based on the estimated quantity of VAM emissions, the world market for VAM destruction technologies has a potential value of several billion dollars. However, as the world's focus temporarily slips away from climate change to international financial stability, the lack of medium-term clarity for the carbon market means that these technologies are not being implemented as quickly as the opportunity deserves. In response, there are also several measures that Governments and organisations can take to boost the VAM destruction market including financial incentives, and regulatory and market based programmes.

REFERENCES

1. US EPA, "Assessment of the Worldwide Market Potential for Oxidizing Coal Mine Ventilation Air Methane" (EPA 430-R-03-002; 2003).
2. US EPA, DRAFT: Global Anthropogenic Emissions of Non-CO_2 Greenhouse Gases: 1990–2030 (EPA 430-D-11-003; 2011). Available at: www.epa.gov/climatechange/economics/international.html.

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