Why is VAM Emission Mitigation Important?

Methane, the principal component of natural gas, is often present in deep coal seams where it presents a safety hazard to miners because it is explosive in concentrations ranging from 5–15% in air. Therefore, gassy underground coal mines employ large-scale ventilation systems. These systems dilute methane released into the mine workings as coal is extracted and remove it from the mine, thereby maintaining safe working conditions. In-mine methane concentrations must be maintained well below the lower explosive limit, so ventilation air exhausts at gassy mines carry only very dilute concentrations of methane (typically below 1% and often below 0.5%). Because flow rates are so high, ventilation air methane (VAM) constitutes the largest source of methane emissions at most mines. VAM exhausts not only waste a clean energy resource but also contribute significantly to global greenhouse gas (GHG) emissions. Methane has a global warming potential that is 23 times that of carbon dioxide, so successfully deploying technologies to convert VAM into useful forms of energy (such as electricity and heat) can result in very substantial GHG emission reductions.

VAM Utilization Technologies

Some technologies for beneficially using the energy content of ventilation air exhausts are currently available, while others are in the development and demonstration phase. One existing approach is quite straightforward and entails using VAM as combustion air, thereby supplying ancillary fuel to internal combustion (IC) engines, turbines, or industrial and utility boilers. Such VAM use in IC engines running on drained coal mine methane (CMM) has been well demonstrated. The Appin Colliery in New South Wales, Australia implemented a project employing 54 VAM/CMM driven internal combustion engines to

Available and Developing Options for VAM Utilization

- VAM used as a supplemental fuel (i.e., combustion air):
  - Internal combustion engines
  - Turbines
  - Utility or industrial boilers
- VAM used as the principal fuel:
  - Flow-reversal oxidizers, with or without energy recovery
    - Thermal
    - Catalytic
  - Gas turbines – microturbines (e.g., 30kW) and full-sized turbines (>0.5MW)
  - Hybrid rotary kiln/gas turbine
power generators producing 55.6MW of electricity for the mine. Although using ventilation exhaust as combustion air in large utility or industrial boilers has been demonstrated on a pilot scale at the Vales Point Power Station in Australia, this option is limited by the need to site the facility near enough to the mine to efficiently divert VAM to the boiler. In contrast, IC engines and turbines, are readily deployable at remote locations.

Flow-reversal oxidizers, both thermal and catalytic, are commercially available and are capable of oxidizing VAM. VAM entering oxidizers encounters a bed of heat exchange material that has been preheated to the oxidation temperature of methane (1000°C). The VAM oxidizes and releases heat, which in turn maintains the temperature of the heat transfer material at or above 1000°C, thereby sustaining the auto-oxidation process over time without requiring additional fuel input. Valves and dampers repeatedly reverse the flow of incoming VAM to keep the hot zone in the center of the oxidizer.

Catalytic and thermal systems both operate on this principal, although catalysts allow the reaction to occur at lower temperatures. When VAM concentrations are high enough, these systems can also provide excess heat energy for electricity generation. This end-use is currently being employed at the West Cliff Colliery in New South Wales, Australia. The West Cliff Ventilation Air Methane Project (WestVAMP) is the world’s first commercial scale VAM-to-power project. Building upon earlier demonstrations of VAM oxidation and steam generation in the UK and Australia, WestVAMP started operation in September 2007 and is producing 6MW of power for use by the mine. It employs a thermal flow-reversal oxidizer, the VOCSIDIZER, manufactured by MEGTEC Systems. Other flow reversal technology providers that are actively engaged in VAM applications include Biothermica, a Canadian air pollution control equipment supplier whose VAM oxidizer is called the VAMOX™, and Canada’s CANMET Energy and Technology Centre which has developed a prototype catalytic VAM oxidizer called the CH4MIN. A Biothermica VAMOX™ unit has been deployed in a successful demonstration program at the Jim Walters Resources mine in Brookwood, Alabama since March of 2009. That project is the first to operate at an active underground coal mine in the United States.

VAMCAT: Australia’s Commonwealth Scientific and Industrial Research Organisation (CSIRO) has developed a lean-fuel gas turbine that employs a catalytic combustor to run on VAM concentrations in the 1% range. In most field applications, this technology will require the availability of supplemental fuel (e.g.,
drained CMM) that can be bled in to increase the effective VAM concentration entering the turbine to ~1% methane. A 30kW micro-turbine demonstration unit has been fabricated and will be tested in late 2009 at the Huainan Mining Group’s Panyi Mine in China. As of 2008, a unit was being assembled for prototype testing.

**FlexEnergy Lean-Fuel Microturbine**: In cooperation with Capstone Turbines, FlexEnergy offers a lean-fuel microturbine (Flex-Microturbine™) that is capable of using methane concentrations as low as 1.5% for its principal fuel. The system accepts fuel at atmospheric pressure and, by employing catalytic combustion, is able to operate with very low NOx emissions (below 0.1ppm). The units can generate up to 30kW of electrical power each and in proof-of-concept testing were shown to achieve nearly full power running on fuels equivalent to <2% methane. A FlexEnergy turbine has been installed at the DCOR oilfield near Santa Barbara, California to consume oilfield gas at concentrations ranging from 1.5–4.2%, and another is running on coal process waste gas at the Western Research Institute in Laramie, Wyoming. Although no VAM field testing has been performed to date, the system would be applicable to settings where blending gas (e.g., drained methane) is available in quantities adequate to raise methane concentrations in the mine exhaust up to or above 1.5%.

**EESTech Hybrid Waste Coal and VAM Rotary Kiln**: EESTech Inc. acquired the rights to an innovative rotary kiln system that burns waste coal with VAM or drained CMM. In this application, VAM is a supplemental fuel. The mixed fuel is combusted in a rotating kiln and the exhaust gases pass through a specially designed air-to-air heat exchanger. The heated clean air then powers a turbine to produce electricity. The waste coal feed can be adjusted as necessary in response to variations in VAM flow or concentration, thereby allowing for a constant energy feed to the turbine to power electricity generation. By combusting waste coal and VAM, this technology offers the ability to mitigate methane emissions while also reducing instances of spontaneous combustion and acid runoff from waste coal piles. The technology was developed jointly by Australia’s CSIRO and Liquatech Turbine Company Pty., and a 1.2MW gas turbine pilot plant was constructed at the Queensland Centre for Advanced Technologies. EESTech is standardizing 10MW and a 30MW systems and is actively commercializing the technology in China and India. Because it avoids the water requirements of steam-cycle power generation, the hybrid coal and gas turbine (HCGT) is appropriate for remote locations where waste coal and methane are available but where water is scarce. In addition, EESTech is currently offering a steam-cycle design as well.
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Other Technical Options brochures available at:
- http://www.epa.gov/coalbed/docs/thermal_oxidizer.pdf
- http://www.epa.gov/coalbed/docs/vam_combustion_air.pdf

Contact U.S. EPA’s Coalbed Methane Outreach Program for information about this and other profitable uses for coal mine methane.

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