4.1.4 ADVANCES IN COAL MINE VENTILATION AIR SYSTEMS

Technology Description

Lean fuel turbine running off of ventilation air methane and drained gas. (Courtesy of Energy Developments Ltd.)

Ventilation air methane equipment (Megtec Vocsidizer) in Australia. (Courtesy of BHP Billiton Ltd).

Gassy underground coal mines emit more than 35 million tonnes (metric tons) of CO_2 equivalent (MtCO2e) of methane through their ventilation shafts. Until recently, because of the very low concentration (typically below 1%) of methane in ventilation air, coal operators had no technically proven option to recover this gas for its energy value. However, during the past decade, technologies have been developed and adapted that offer the promise of mitigating most of these emissions at low cost. One family of technologies being developed is the catalytic and thermal flow reversal reaction of ventilation air methane. These technologies may use up to 100% of the methane from ventilation shafts, and the byproduct heat may be used for the production of power or to satisfy local heating needs. Another prospective technology allows for the direct use of air mixed with down to 1% methane to produce power in gas turbines. This approach may require enriching the concentration of the air flow but may be a lower capital cost means of producing power.

System Concepts

Flow Reversal Reactors

Both catalytic and thermal-flow reversal technologies employ the principle of regenerative heat exchange between a gas and a solid bed of heat-exchange medium. Ventilation air flows into and through the reactor in one direction, and its temperature increases until the methane is oxidized. Then the hot products of oxidation lose heat as they continue toward the far side of the bed, until the flow is automatically reversed.

- Thermal reactors operate above the auto-ignition temperature of methane (1,000ºC). Catalytic reactors reduce the auto-ignition temperature significantly.
- Both types of reactors produce heat, which, through use of heat exchange technologies, may be transferred for local heating needs or for the production of power in steam or gas turbines.

Lean Fuel Turbines

- Some lean-fuel turbine concepts employ catalysts to aid the combustion.
- Others take place in an external combustor without catalysts but at a lower temperature than with normal turbines.
- Depending on the methane concentration, these technologies may use ventilation air for more than 80% of all fuel if concentrations are high, or less than 20% with low concentrations.

Representative Technologies

- Thermal-flow reversal reactors require a higher auto-ignition temperature that may require more sophisticated heat-exchange technologies.

- Catalytic flow reversal reactors have a lower auto-ignition temperature that may make heat exchange less costly, but they require catalyst material.
- Lean-fuel turbines under development include microturbines and larger scale turbines.
- Ancillary uses for ventilation air methane exist, such as the use of some ventilation air methane as the combustion air for power projects. This approach is technically straightforward and commercially proven, but the greenhouse gas reduction potential is limited.

Technology Status/Applications

- The Environmental Protection Agency (EPA) has identified and evaluated two specific flow reversal reaction technologies. Based on laboratory and field experience, both technologies may sustain operation with ventilation air with methane concentrations as low as 0.1%.
- These reactors have been applied for oxidation of volatile organic pollutants and have been successfully tested at small scale with ventilation air methane. In addition, the thermal reactor has been tested at field-scale in Australia. The first commercial thermal oxidation project is in development and should in operation by the fourth quarter of 2005. Both thermal and catalytic flow reversal technologies may be used for the simple oxidation of methane (reducing methane emissions); and for the heat product, which may be used for production of power, direct heating or cooling.
- The EPA is working with technology vendors to identify viable lean fuel turbines and to improve their applicability for real-world ventilation air methane projects and identifying sites and partners for field demonstration. The EPA is also exploring an array of technologies for the use of ventilation air methane.

Current Research, Development, and Demonstration

RD&D Goals

- First commercial-scale field unit to demonstrate oxidation-only in 2005, and in the US in 2006 and 2007.
- First commercial-scale field unit to demonstrate oxidation and heat recovery (power) in 2007 and 2008.
- A program of market penetration to be undertaken 2005-2010, ultimately leading by the end of the program to the majority of ventilation air methane emissions mitigated.

RD&D Challenges

- The first commercial-scale thermal oxidation unit is expected to be in operation by fourth quarter 2005 in Australia, but there have not been any commercial-scale catalytic oxidation unites designed or demonstrated on a field or commercial scale.
- Heat-recovery technologies must be adapted from other industries for application at mine ventilation shafts.
- Safety design issues need to be addressed.

RD&D Activities

- Several technology developers/vendors are working with the coal industry, EPA, and DOE to develop the first commercial-scale projects.
- Evaluate performance of first commercial project in Australia.
- EPA is providing technical support for technology vendors in identifying markets, performing safety analyses, and supporting project development.
- EPA and DOE are working with CONSOL Energy, a large coal operator, to demonstrate thermal oxidation of ventilation air methane using Megtec's Flow Reversal Reactor.

Recent Progress

- A project in Australia commercially employed ventilation air methane as feed air in internal combustion engines. The ventilation air methane provided approximately 7% of the total energy for the project at nominal cost.
- Tests prove that flow-reversal reactors can successfully sustain reactions down to a methane concentration in air of 0.1%.
- Small-scale demonstrations at coal mines have shown that ventilation air methane can be safely deployed at noncommercial scale, and that heat recovery is technically viable.

Commercialization and Deployment Activities
• Project vendors and developers are working with coal operators to develop ventilation air methane projects in the United States. **Market Context** • Majority of emissions in the United States at fewer than 30 very gassy ventilation shafts. • Heat recovered likely will interest power generators. Potential for more than 450 MW of power production available and equipment market of over $1 billion. • Markets for these technologies exist worldwide in countries with gassy coal seams and coal mining industries such as Australia, China, India, Mexico, Ukraine, Russia, Kazakhstan, Germany, United Kingdom, and Poland.