4.0 REDUCING POTENTIAL FOR CLIMATE EFFECTS OF NON-CO_2 GREENHOUSE GASES

4.1 METHANE EMISSIONS FROM ENERGY AND WASTE

4.1.1 ANAEROBIC AND AEROBIC BIOREACTOR LANDFILLS

Technology Description

Landfill bioreactor cell, Yolo County, California

In recent years, bioreactor landfills have gained recognition as a possible innovation in solid-waste management. The bioreactor landfill is generally defined as a municipal solid-waste landfill, designed and operated in such a manner that liquids are added to the waste mass to accelerate the decomposition of the waste. There are currently two bioreactor processes – anaerobic and aerobic. Hybrids employ both methods. The primary difference between the two is that, in anaerobic bioreactors, a key objective is to enhance the generation of landfill gas (i.e., methane), by minimizing oxygen infiltration, over a shorter period of years; whereas, in aerobic bioreactors, the objective is to minimize landfill gas generation overall by introducing oxygen into the waste mass. Both methods utilize leachate recirculation and/or supplemental liquid non-hazardous waste addition as a means to control and enhance moisture levels within the landfill, thereby increasing decomposition and enhancing landfill gas production.

Current Research, Development, and Demonstration

RD&D Goals

- The first commercial full-scale anaerobic and aerobic bioreactor technology was operational in 2002. The goal is to have three-five commercial full-scale demonstration units operational by the close of 2006.
- Environmental, public-health impacts, and design and operational issues need to be further evaluated.
- Undertake a program of market penetration 2007–2012.

RD&D Challenges

- No long-term, full-scale commercial application demonstrated.
- Environmental, public-health impacts, and design and operational issues need to be addressed.
- A regulatory barrier to the deployment of the bioreactor landfill is the Resource Conservation and Recovery Act (RCRA) Subtitle D that prohibits the addition of liquids to a waste management unit from outside the unit (40 CFR 258.28). Supplemental liquid addition is critical to the operation of the bioreactor landfill.
- The construction and operation/maintenance and costs associated with bioreactor landfills are not fully known.

RD&D Activities

- At the present time, bioreactor landfills are in the early stages of full-scale field testing. In the United States, early work on anaerobic bioreactors began in the mid-1980s at landfills in Sonoma County and Mountain View, California.
- Currently, over ten anaerobic and aerobic bioreactor projects (including hybrids) are in various stages of deployment or demonstration. The Environmental Protection Agency (EPA) Project XL program is currently implementing and evaluating five bioreactor landfills and developing a database to track and record information on bioreactor landfills. EPA also funded the development of a bioreactor operations training manual and training course.
- On March 22, 2004 EPA revised the Criteria for Municipal Solid Waste Landfills (MSWLF) to allow states to issue research, development, and demonstration (RD&D) permits for new and existing MSWLF units and lateral expansions. This rule will allow Directors of approved state programs to provide Municipal Solid Waste RD&D permits for new and innovative landfill technologies, such as bioreactor landfills.
- In 2001, DOE's National Energy Technology Lab funded a study of the Yolo County Pilot Bioreactor Landfill Demonstration (9,000-ton test cell and 9,000-ton control cell) to study new ways to capture greenhouses gases from the bioreactor landfill.

Recent Progress

- Results from the Yolo County pilot-scale demonstration project showed production of landfill gas in the anaerobic cell was more than six times that of the normal range expected. A tenfold increase in methane recovery rate was observed compared to conventional landfills, which suggest a tenfold reduction in interval of methane generation. The biodegradation rate of the waste was increased thus decreasing the waste stabilization and composting time (5-10 years) relative to what would occur within a conventional landfill (30 or more years).
- Benefits include:
  - Subtitle D established a "dry tomb" sanitary landfill approach to municipal solid-waste disposal, where waste is placed and maintained in dry conditions to minimize potential leachate and gas generation and release. A concern of the "dry tomb" landfill is that the waste may pose a threat to public health and the environment well beyond the prescribed 30-year, post-closure maintenance period because the natural decomposition process is retarded. Should the "dry tomb" landfill containment be compromised, significant generation and release of leachate and gas could occur well beyond the post-closure maintenance period. In a bioreactor landfill, controlled quantities of liquid are added and circulated through waste to accelerate the natural biodegradation and composting process of the waste. The bioreactor landfill process may significantly increase the biodegradation rate, such that the waste may be stabilized in a relatively short period of time (5-10 years).
  - Reduction in air-pollutant emissions, especially criteria pollutants and methane early in the decomposition process when landfill gas is collected and combusted.
  - The anaerobic bioreactor may increase gas yields to favor more economical utilization projects in the earlier years of the landfill life while reducing the greenhouse gas burden in the subsequent years. Gas generation during conventional landfilling techniques occurs over long periods of time (more than 30 years).
  - Aerobic technology (i.e., methane elimination) could become a prime candidate technology for landfills in the United States and elsewhere that cannot generate landfill gas in sufficient quality or quantity to economically recover the associated energy. In addition, the technology also could be considered as a follow-on technology for energy-recovery projects at landfills that are no longer producing methane at economically valuable levels.

Commercialization and Deployment Activities
• Several companies, including the largest waste management company in the United States, are working with states and the EPA to demonstrate bioreactor technology. **Market Context** • Municipal solid-waste landfills represent the largest human-made source of methane emissions in the United States (approximately 32%), and account for approximately 55% of waste disposal. • All new municipal solid-waste landfills constructed in the United States are potential markets. • Based on the preliminary findings from several bioreactor demonstration projects, landfill gas recovery costs on a $/MMBtu basis will be lower for a bioreactor landfill than for a conventional landfill. The cost reduction could be 25%-50%, depending on how bioreactor costs are allocated.