R&D needs and Opportunities

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reliable, efficient, ultra-clean
Need Fuel-Flexible System

• Natural Gas
• Liquefied Natural Gas (LNG)
• Propane
• Biogas (by Anaerobic Digestion)
  – Brewery
  – Municipal Waste Water Treatment
  – Food Waste
  – Animal Waste

• LFG, APG, shale gas, Coal-bed methane
Cost Reduction and Opportunities

clean-up system desired attributes and opportunities

1. Low cost-of-electricity impact
   1) Low first time cost (capital) – Process intensification
   2) Low maintenance cost- higher capacity, low $/lb-S

2. Reliability (Simplicity)– emphasize solid state subsystems

3. Low parasitic power consumption– chillers, compressors,
Opportunities for Process Intensification

- Digester
- H₂S Removal
- Moisture Conditioning
- Siloxanes Removal
- Sulfur Removal
- De-Ox
- Pre-reforming
- Anode
- Cathode
- Oxidizer

- 370°C waste heat
- Natural Gas
- Air
- Water
- AC Power
• Function: Fuel gas on-line trace level sulfur detector (< 100 ppb).

• Capabilities Verified
  – Detects low level sulfur down to 30 ppbv
  – Detects all typical sulfur species (DMS, DMDS, COS, CS2, H2S, Mercaptans, etc.)

• Low Cost

• Status: Lab test completed; field performance verification and graduation pending
1. An efficient, low cost media or reliable system that is effective on:
   1. non-H$_2$S sulfurs, such as trace COS, CS$_2$, and organic sulfides (for NG system).
   2. both wet and dry gas

2. An efficient, low cost media or system that can clean trace halogens, especially organic fluorides and chlorides (very important for landfill application).

3. A gas cleanup standardized and easily scalable system design that is:
   1. fuel flexible
      • Clean both biogas (with moisture) and pipeline gas by one system
      • Effective to all contaminants, including non-H$_2$S sulfurs and halogens
   2. low parasitic load,
   3. reliable,
   4. low-cost-of-electricity,

4. On-line monitoring of cleaned gas to lower overall cost as well as improve system reliability
Summary: Improvement Opportunities

1. Development: Materials, Technology, system and Manufacturing dev.(cold vs hot systems), scale up for cost reduction, on-line monitoring
2. Multi-purpose demonstration, efficient outreach to stakeholders-National Forum for info exchange, Center for Excellence
3. Recognition awards for innovation and accomplishments
4. Financial incentives for early adopters, Capital + O&M incentives
5. Wastewater Treatment plants: biogas plus sludge gasification
6. Shale Gas: Stranded gas utilization for value added co-products