



FuelCell Energy
World Leader in Ultra-Clean Power

R&D needs and Opportunities

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DOE-ANL Fuel Cleanup Workshop
Chicago
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reliable, efficient, ultra-clean



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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**

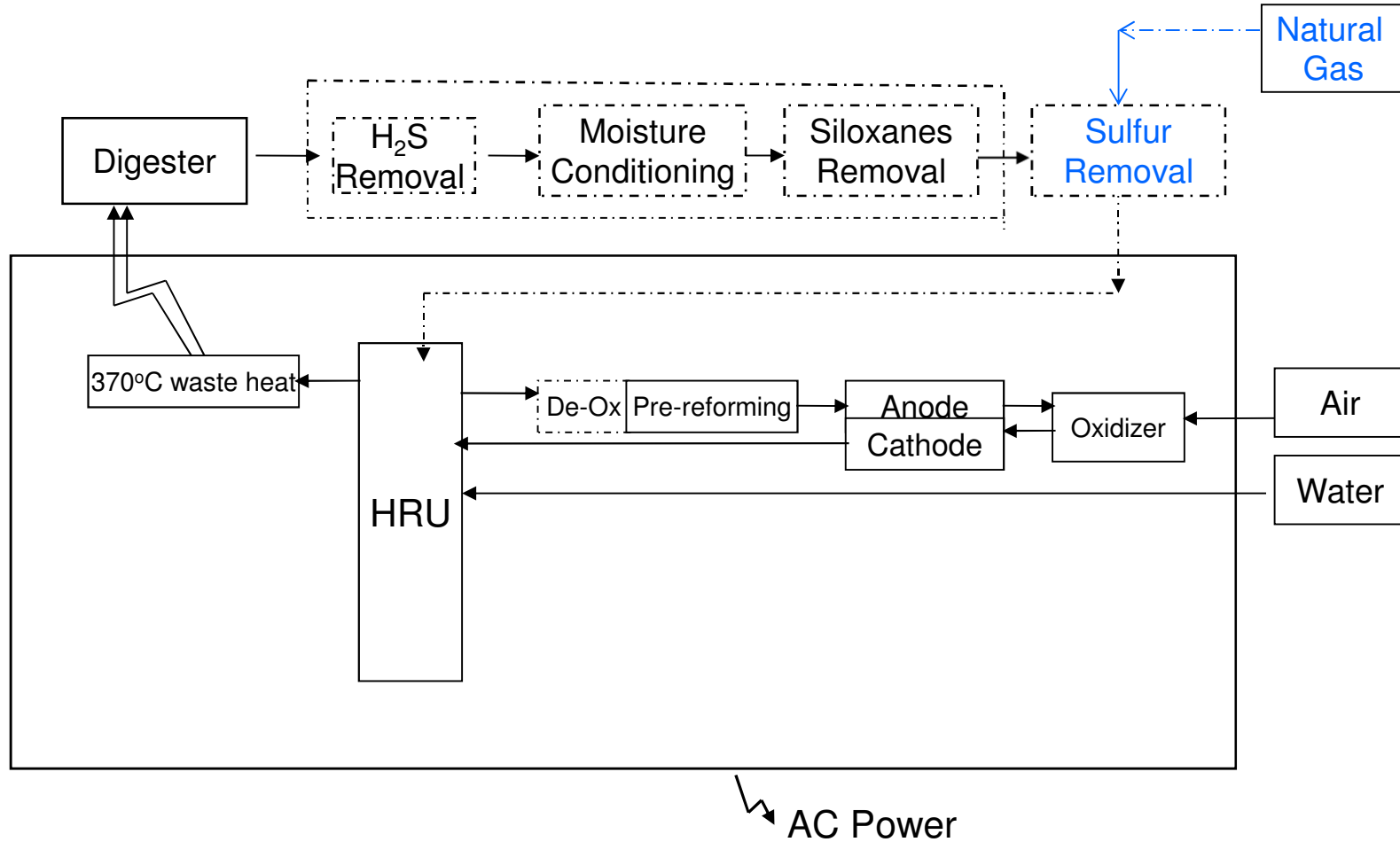


clean-up system desired attributes and opportunities

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





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On-line sulfur detector to lower cost of sulfur detection

- **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**





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Technology Improvement Opportunities

1. An efficient, low cost media or reliable system that is effective on:
 1. non-H₂S sulfurs, such as trace COS, CS₂, 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-H₂S 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



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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
7. Leverage Resources: Federal-State, US- Canada, US-EU, US-India