Using Biogas for Heat Recovery

Biogas: Scaling up biogas production in North America
San Francisco, California

October 1-2, 2009

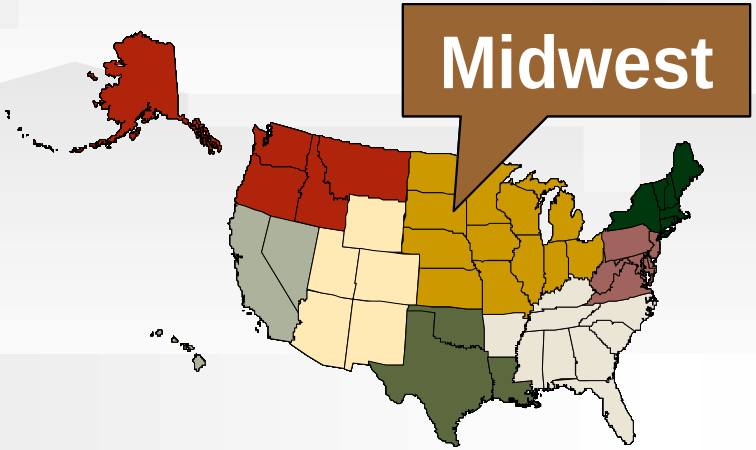
Cliff Haefke
U.S. DOE Midwest Clean Energy Application Center
Energy Resources Center
University of Illinois at Chicago

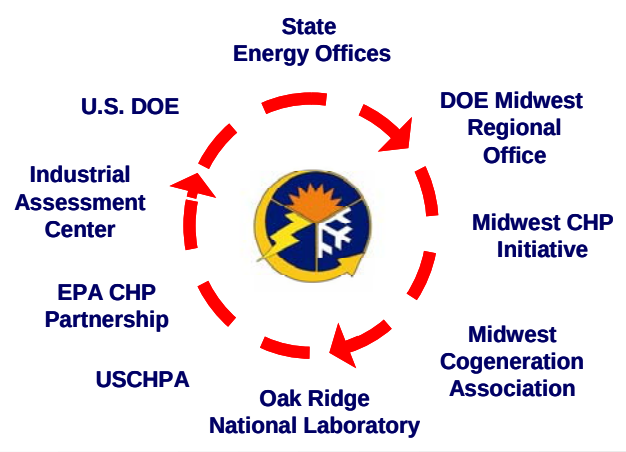
Topics to be Covered

- Biogas and Heat Recovery Applications
- Feasibility Evaluations and Technical Challenges
- Example Heat Recovery Applications
- Outlook and Market Potential

U.S. DOE Midwest Clean Energy Application Center

- Originally established in 2001 by US DOE to support DOE CHP Challenge
- Today the center advocates CHP, District Energy, and Waste Heat Recovery
- Located at University of Illinois at Chicago (UIC)
- Provide targeted education, unbiased information, and technical assistance to 12 state Midwest region
- Work closely with state energy offices
- 7 other Regional Application Centers established since 2003





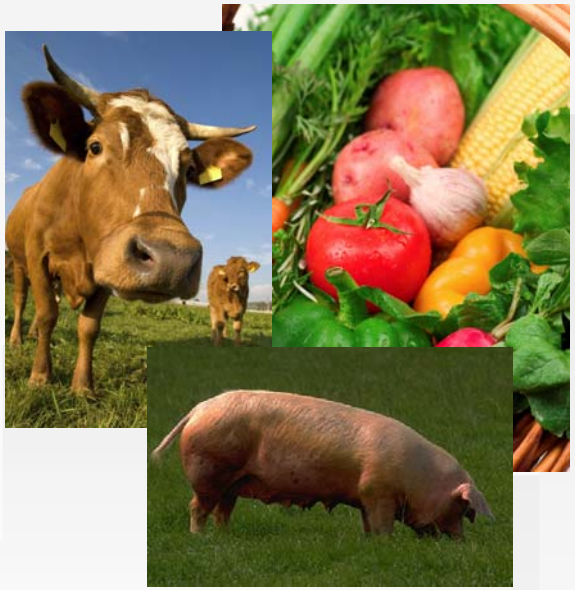
What is Biogas?

- According to wikipedia…
  - *Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen.*
  - *Biogas originates from biogenic material and is a type of biofuel.*

Source: http://en.wikipedia.org/wiki/Biogas

What Resources are Producing Biogas?

Landfill Gas



Anaerobic Digesters

Livestock Waste

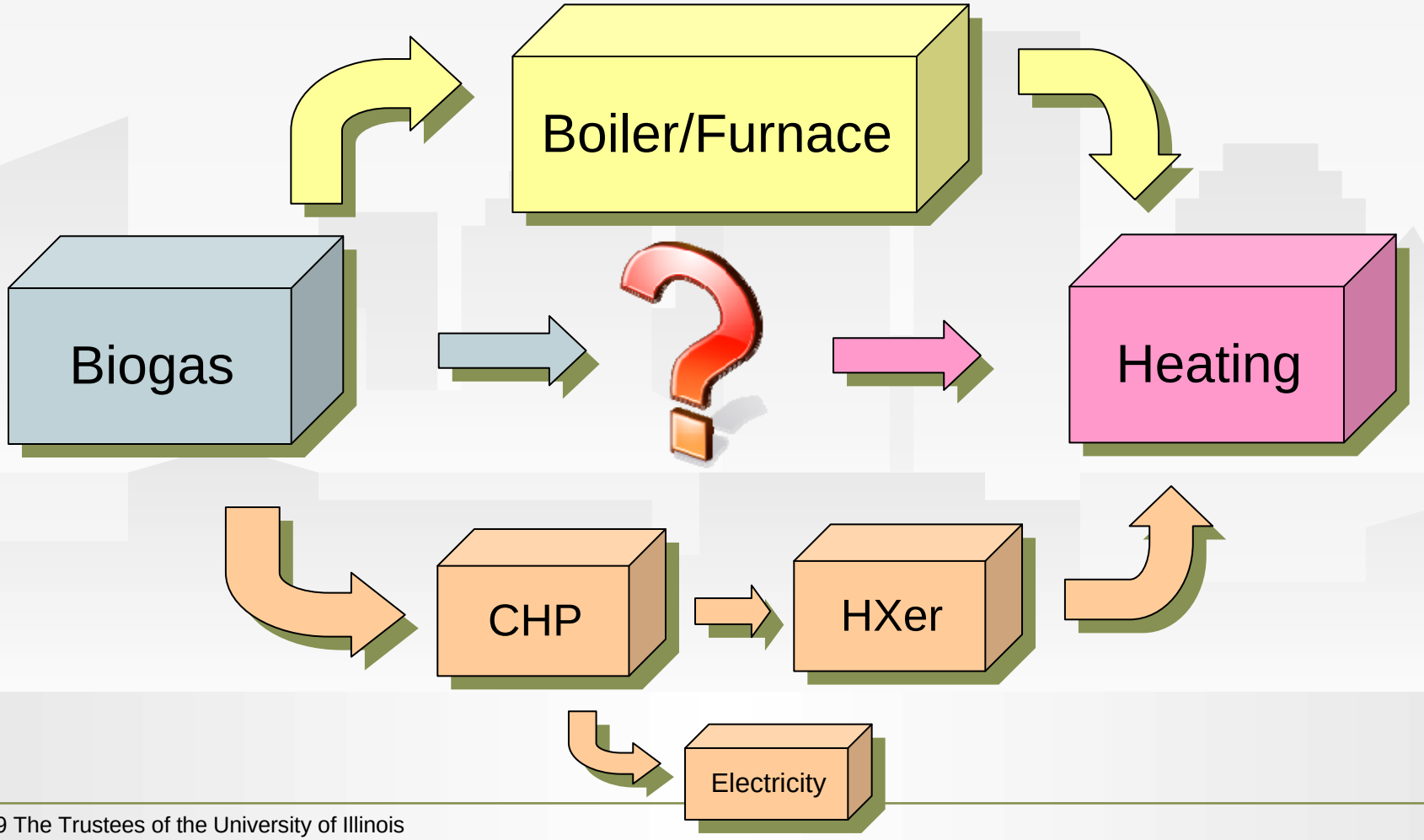
Food Processing

Wastewater Treatment

Gasification

Biogas to Heat Recovery

- How is heat delivered from a biogas resource?



Generating Heat from Biogas

- Typical Heat Generating Technologies
  - Boiler (hot water, low pressure steam, high pressure steam)
  - Furnace
  - Dryer
- CHP Heat Generating Technologies
  - Direct Exhaust Gases
  - Heat Exchanger (hot water)
  - Heat Recovery Steam Generator (HRSG)

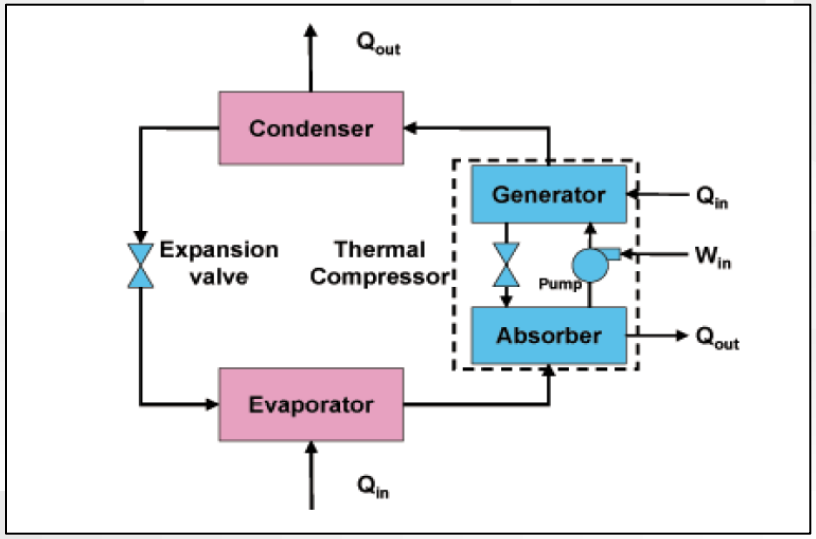
Heat Recovery from CHP Prime Movers

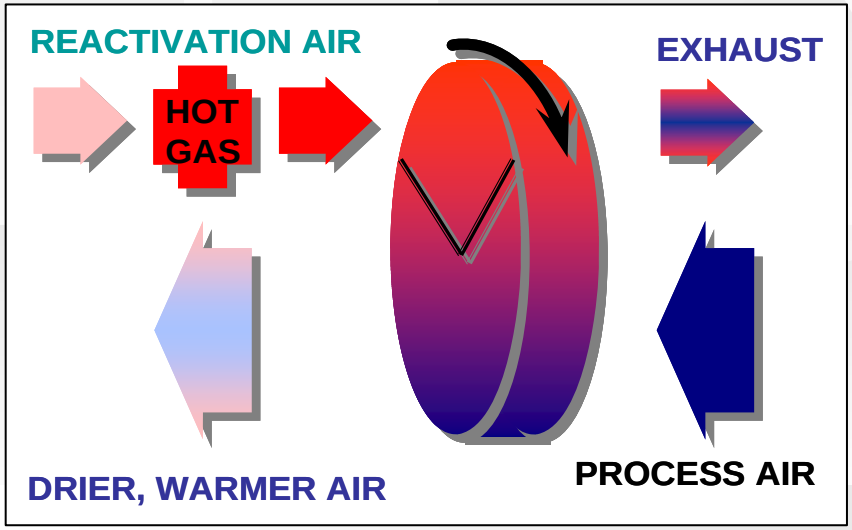
Prime Mover	Pic	Size Range	Heat Recovery
Reciprocating Internal Combustion (IC) Engines		< 5 MW	Jacket Water: 200-265degF Exhaust: 850-1200degF Hot water, Low Pressure Steam Exhaust
Gas (combustion) Turbines		> 2 MW	High Grade Heat Available (up to 1,200 psig and 900degF) Low Pressure Steam High Pressure Steam
Microturbines		30 – 250 KW	Exhaust Temp: 400-600degF Hot water, Space Heating, Thermally Activated Equipment
Fuel Cells		< 2 MW	Hot Water, Space Heating, and Low Pressure Steam
Steam Turbines		> 50 kW	Ability to Meet Various Required Steam Loads and Pressure

Source: http://www.epa.gov/chp/documents/catalog_chptech_full.pdf

Thermally Activated Systems

- Absorption Chiller
- Desiccant Dehumidification
- Steam or Hot Water Heating Loops
- Steam Turbines (Bottoming Cycles)





How is Heat being utilized from Biogas? Thermal Applications

- Specific Heating Applications utilizing Biogas
  - Space Heating and Cooling
  - Process Heating and Cooling
  - Potable hot water
  - Steam (low and high pressure)
  - Direct Exhaust
  - Desiccant Dehumidifiers
  - CHP Heat Recovery

Energy Considerations for Utilizing Biogas

- Evaluate type of energy used at facility
- Evaluate how much energy used and when
- Consider electric generation and/or heating
  - Heating is usually a seasonal operation
  - Is there a year-round thermal process?
  - Lower volumes of biogas more suitable for heat recovery only
  - Electricity generation is convenient (year-round)
  - Purchased price of energy

Attractive Characteristics for Biogas Heat Recovery

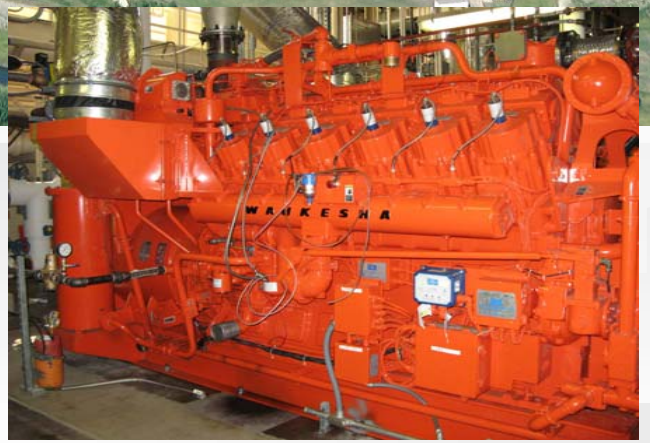
- Consistent and year-round thermal loads
  - Example loads: digester, process heating, space heating, hot water, etc.
  - Batch processes unfavorable
- Central heating/cooling facilities
- Proximity of biogas uses
- Other available waste streams (including dual fuel and/or co-firing)
- Long operating hours
- Internal champions: technical & financial
- Renovation and/or expansion of existing facilities
- Neighboring facilities requiring thermal energy
- If incorporating CHP technologies, you have “free” heat

Technical Challenges/Opportunities of Biogas Heat Recovery Projects

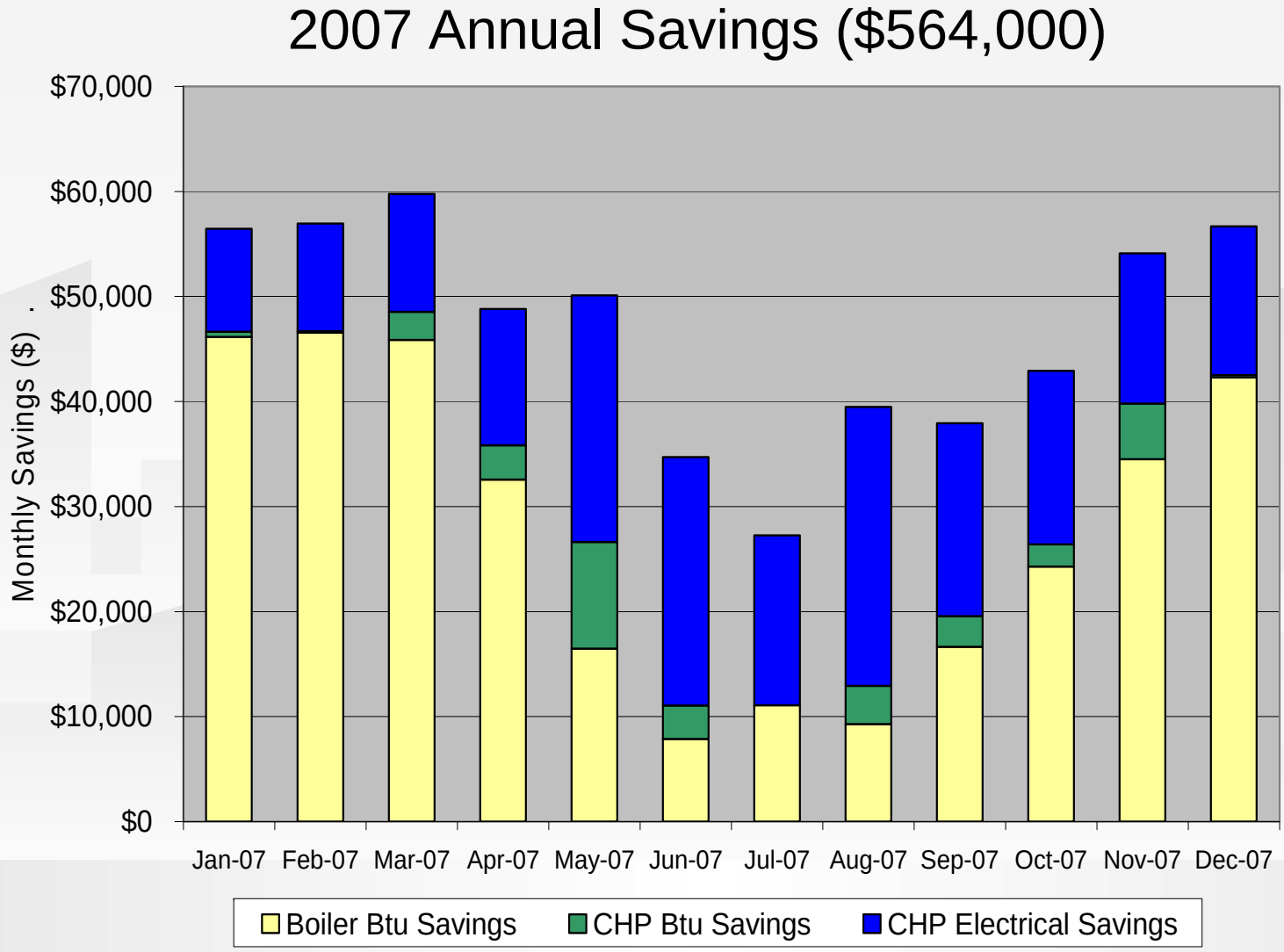
- Analyzing biogas characteristics
  - Gas composition (CH4, moisture, contaminants, etc.)
  - Flow rates (average/peak)
- Meeting equipment specifications
  - Increased maintenance vs. gas conditioning
  - Gas pressure
- Meeting emissions regulations
- Alternative uses of the resource that could affect future availability or price
- Gas storage opportunities
- Accepting other waste streams
- Electric utility a non-factor in heat only applications

Example #1 – Seasonal CHP and Boiler Operation

- Site: Rochester Water Reclamation Plant
- Location: Rochester, MN
- Began Operation: 1982
- Operation Description:
  - 24 MGD wastewater treatment facility utilizing anaerobic digesters
- Project Description:
  - Biogas is utilized seasonally in
    - CHP system (2 MW capacity)
    - Boilers



Example #1 – Seasonal CHP and Boiler Operation (cont.)



Example #2 – Absorption Cooling using Biogas

- Site: Egan Water Reclamation Plant
- Location: Schaumburg, IL
- Operation Description:
  - Utilizes anaerobic digesters with gas storage
  - 30 MGD average flow
  - 50 MGD maximum flow
- Project Description:
  - Biogas is utilized to generate 15 psi low pressure steam
  - Steam loads required in the winter and summer months
    - Steam required for process and space heating
    - Absorption chillers aid in humidity control

Source: http://www.ihcconstruction.com

Example #3 – Biogas Heating for Drying Biofibers

- Site: Geerlings Hillside Farms
- Location: Overisel, MI
- Began Operation: 2008
- Project Developer: Phase 3 Renewables
- Operation Description: Swine Farm with 8,000 spaces wean to finish
- Project Description: Anaerobic digestion
  - Biogas utilized in two (2) 65 kW engines (CHP system) and one (1) 1 MMBtu Boiler
  - Recovered heat from engines and heat from boilers is used to dry biofibers to enable pelletization
  - Pellet mill can produce 1.5 tons per hour; pellets can be used for fertilizer, boiler fuel or horse bedding

Source: http://www.phase3dev.com

Case Study #4 – Biogas Heating for Multiple Products

- Site: DRANCO Farm
- Location: Nuestedt, Germany
- Began Operation: 2008
- Project Developer: Organic Waste Systems, n.v.
- Operation Description: Farm-based biomass energy plant
- Project Description: Anaerobic Digestion using biogas in engines and a steam boiler (year-round)
- Heat Applications – 4 MM Btu/hr:
  - Feedstock pretreatment and digester heating
  - Barn, office, farm house and neighboring house heat
  - Drying wood chips
  - Drying firewood
  - Drying dog food (“chew toys”)

Example #5 – Gasification for Air Turbine and Steam

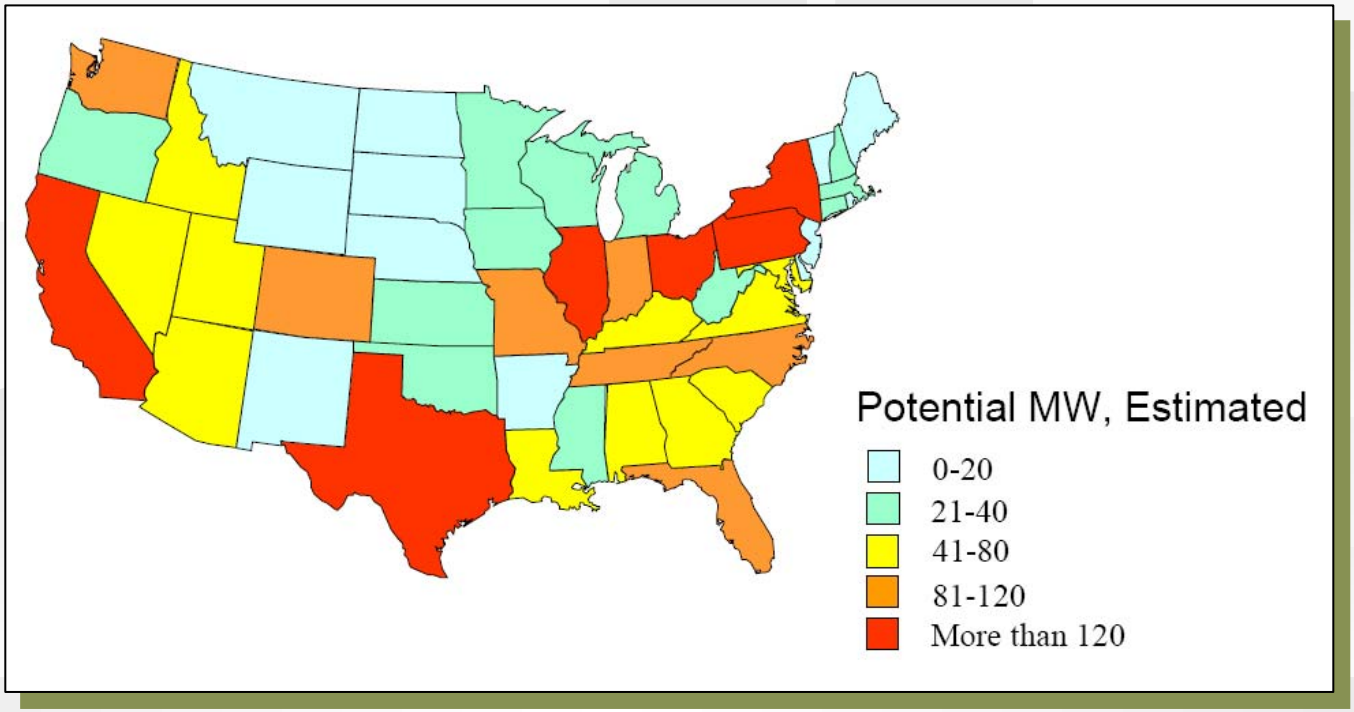
- Site: Sietsema Farms Feeds
- Location: Howard City, MI
- Began Operation: 2009
- Project Developer: Phase 3 Renewables
- Operation Description: Turkey Grower & Feed Mill
  - 1.5 million birds, five separate farm sites, 11,000 tons litter
  - Feed mill produces feed for turkeys and swine
- Project Description: Gasification, Electricity Generation, Heat and Steam
- Heat Application:
  - Syngas produced in SALT gasification facility
  - Advanced ceramic heat exchanger recovers air for use in 500kW air turbine generator
  - Metal heat exchanger recovers heat for 8,600 lbs/hr steam @ 150 psig for feed pelleting process

Source: http://www.phase3dev.com

CHP Market Potential in New LFG Projects

Of estimated 6,000 landfills in the U.S., of which at least 2,500 are active, only 350 currently utilize landfill gas for power

- 1,857 potential # of projects
- 3,006 potential megawatt (MW) generating capacity

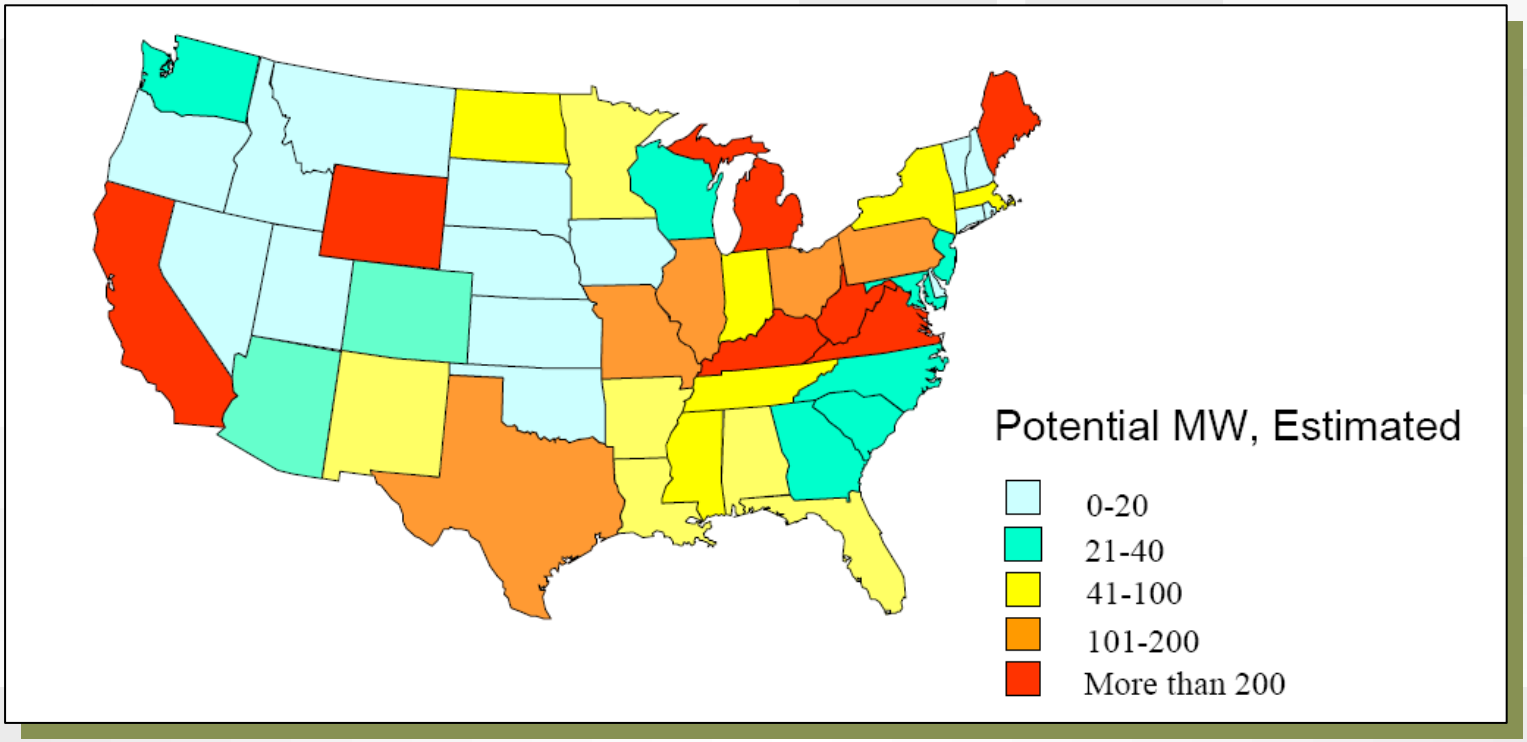


Source: Combined Heat and Power Market Potential for Opportunity Fuels, Resource Dynamics Corporation, December 2004, http://files.harc.edu/Sites/GulfCoastCHP/MarketAssessments/CHPPotentialOpportunityFuels.pdf

CHP Market Potential in Municipal WWTFs

If 1 MGD is the cut-off size limit for feasible AD/CHP applications…
(note: technically feasible, not economically feasible)

- 6,850 potential # of projects
- 4,275 potential megawatt (MW) capacity



Source: Combined Heat and Power Market Potential for Opportunity Fuels, Resource Dynamics Corporation, December 2004, http://files.harc.edu/Sites/GulfCoastCHP/MarketAssessments/CHPPotentialOpportunityFuels.pdf

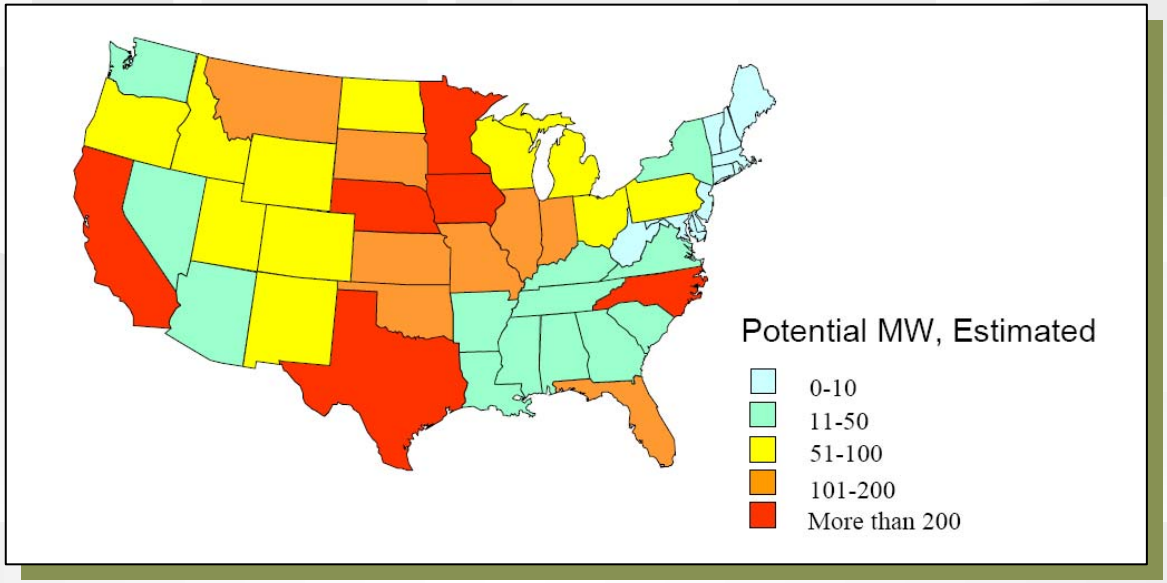
CHP Market Potential in Animal Farms

Number of farms with CHP potential

- 28,329 farms w/ over 200 beef cows
- 7,440 farms w/ over 200 dairy cows
- 11,881 farms w/ over 1,000 hogs/pigs

Total Number of Sites

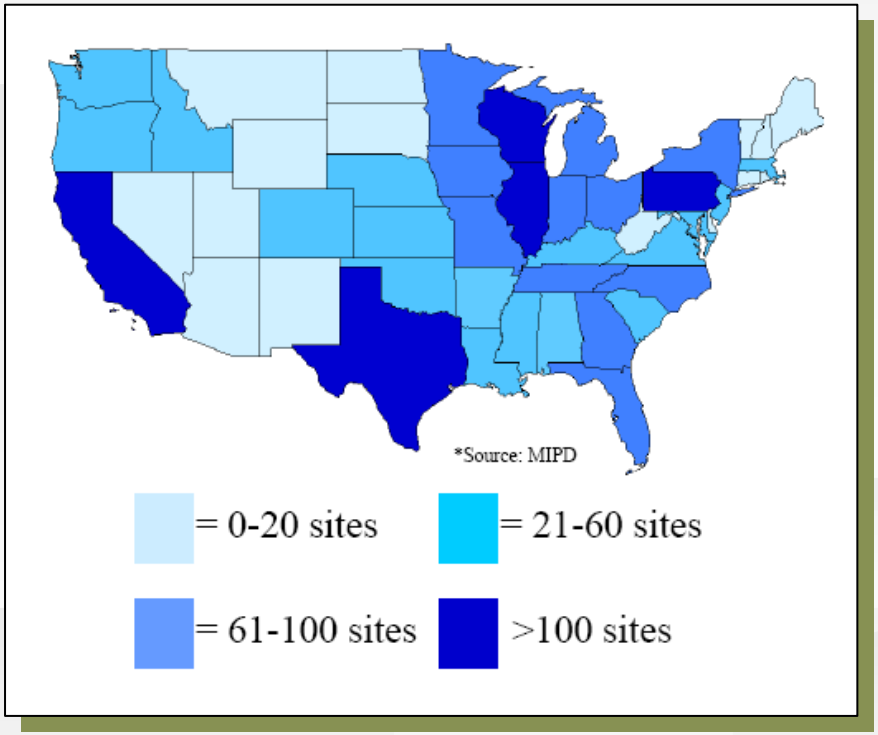
- 47,650 potential sites
- 4,554 potential megawatt (MW) capacity



Source: Combined Heat and Power Market Potential for Opportunity Fuels, Resource Dynamics Corporation, December 2004, http://files.harc.edu/Sites/GulfCoastCHP/MarketAssessments/CHPPotentialOpportunityFuels.pdf

Market Potential in Food Processing Facilities

- US food processing accounts for 26% of food processing output of the world
- There are over 10,000 food processing facilities in US
- 2,281 food processing sites in the Major Industrial Plant Database (MIPD)
- Over 200 food processing facilities utilize CHP today generating over 6,000 MW of electricity



Source: Assessment of Large Combined Heat and Power Market, Energy and Environmental Analysis, Inc. April 2004, http://www.icfi.com/markets/energy/doc_files/eea-large-chp-market.pdf

Summary Messages

- Many opportunities for biogas energy recovery projects (DG, CHP, direct-fired, pipeline, etc.)
- When considering biogas heat recovery projects…
  - Don't only consider typical heating applications
  - Also consider absorption/adsorption cooling, desiccant dehumidification, etc.
- Biogas to energy projects are not feasible for every site, but when they make technical and economic sense, there are many related benefits
- Many working examples of existing projects
  - Learn from others' experiences
  - Lessons learned, case studies, reports, etc.

Questions / Discussions

Contact Information

Cliff Haefke

Energy Resources Center

University of Illinois @ Chicago

312/355-3476

chaefk1@uic.edu

U.S. DOE Midwest Clean Energy Application Center

www.chpcentermw.org