National Renewable Energy Laboratory
Innovation for Our Energy Future

Stranded biogas decision tool for fuel cell co-production

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NREL is a national laboratory of the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy operated by the Alliance for Sustainable Energy, LLC

Overview

Timeline

Period: 12-24 months

% complete: N/A

Barriers

Eliminate non-technical barriers to the commercialization of fuel cells and hydrogen technologies (Market Transformation)

Budget

Total project funding (to date)

- $25,000

Funding received in FY08

- $25,000

Funding received in FY09

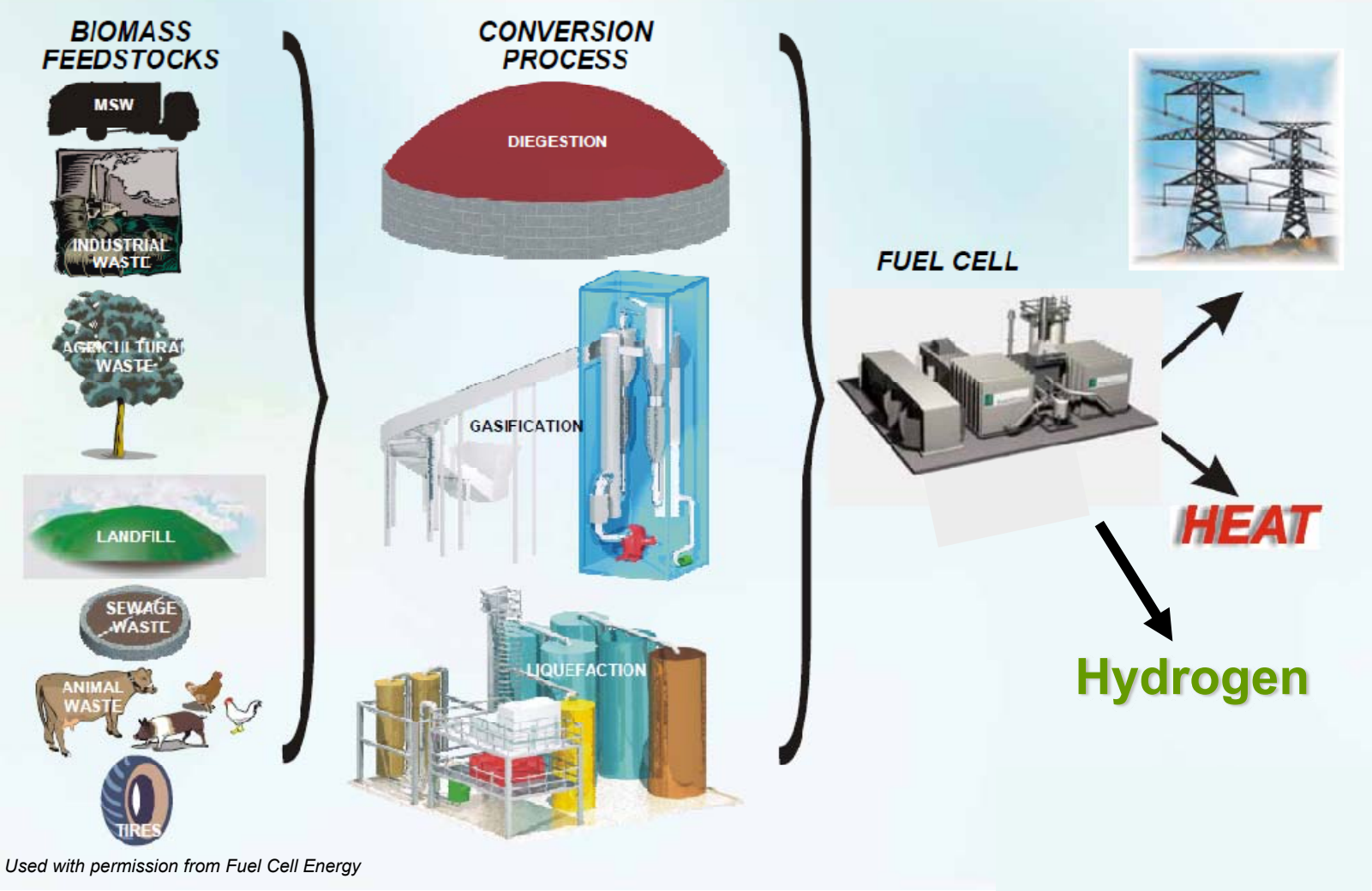
- $TBD

Funded Partners

TBD

Overview

Overall Project Concept



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Overview

Fuel Cell Value Proposition

- **Increased energy efficiency**
  - 42 to 47% net electrical efficiency
  - Cogenerate heat to offset natural gas purchase
  - Combined electric + heat ≈ 80% efficient
- **Emissions savings**
  - Low NOx and SOx
  - 40% lower GHG emissions compared to grid
- **High availability and reliability**
  - Single unit availability >97%
  - Multiple unit availability exceeds five 9's.

Relevance

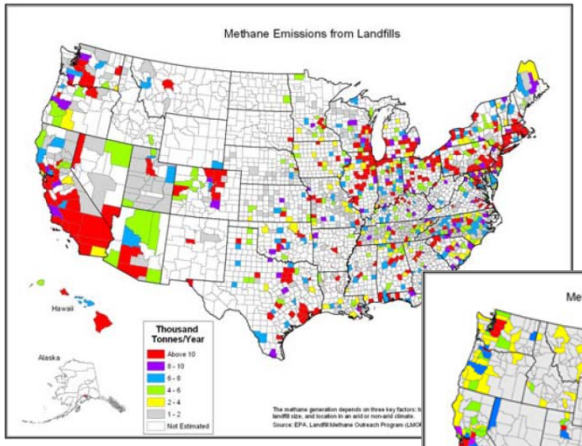
Policy Drivers

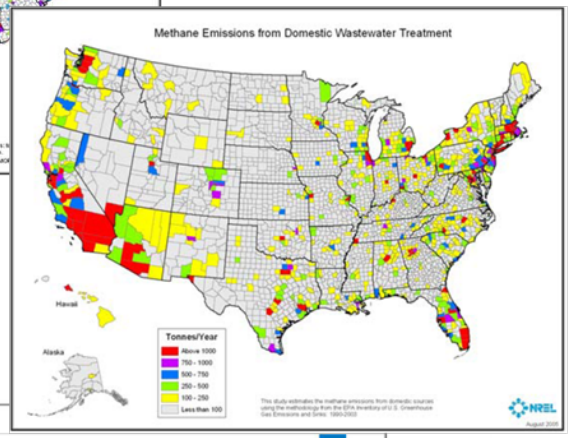
- American Recovery and Reinvestment Act of 2009:
  - A fueling facility tax credit, which increases the dollar cap of the 30% hydrogen fueling infrastructure tax credit from $30,000 to $200,000.
  - Grants for energy property (in lieu of tax credits), which allow facilities with insufficient tax liabilities to apply for grants instead of claiming investment or production tax credits. Only entities that pay taxes are eligible.
  - A manufacturing credit, which creates a 30% credit for investment in property used for manufacturing fuel cells and other technologies.
  - A residential energy-efficiency credit, which raises the investment-tax-credit dollar cap for residential fuel cells in joint occupancy dwellings to $3,334/kW.
- Emergency Economic Stabilization Act of 2008:
  - Investment tax credits for fuel cells—30% of qualified fuel cell property or $3,000/kW of the fuel cell nameplate capacity (i.e., expected system output), whichever is less.
  - Investment tax credit of 10% for combined-heat-and-power-system.
- Section 9007 of Farm Bill of 2008:
  - Rewards farmers, ranchers, and rural small businesses for installing renewable energy projects
- New Administration emphasis on CO_2 avoidance and job creation

Relevance

Availability

- 12.4MM tons of methane emitted from 540 landfills in US
- 0.5MM tons of methane emitted from 17,000 waste water treatment plants (WWTPs) in US
- Other sources: breweries, industrial food processing, animal farms and processing, soft drink production, bakeries, pulp and paper mills





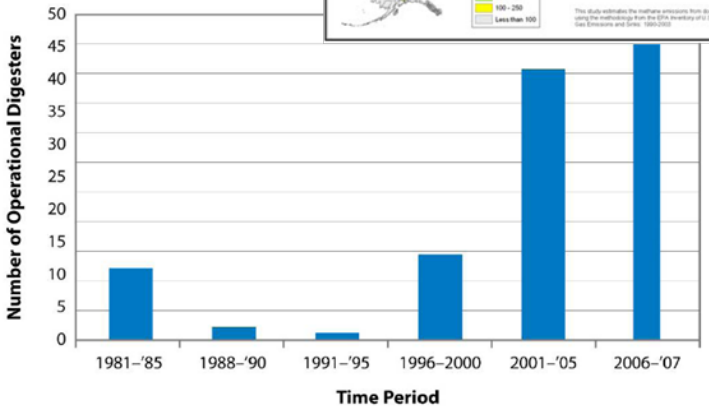


Figure 2. Number of On-Farm Anaerobic Digestion Systems in the United States* (EPA AgStar)

Table 6. Characterization of U.S. Waste Water Treatment Facilities

Waste Water Treatment Facilities	Number
Total	16,583
Using Anaerobic Digestion	3,500
Large Facilities (>5 million Gallons per Day)	1,000
Using Anaerobic Digestion	544
Using Anaerobic Digestion to generate electricity and/or Combined Heat and Power (CHP)	106

Relevance

Case Study: City of Tulare, CA, WWTP

- Facility size: 11.5 million gallons per day
- Biogas generated: 600,000 SCF per day
- Fuel cells: Three - 300 kW units[1]
- Gas cleanup: Applied Filter Technology

Startup: September 2007

Total cost: $7 million

State & Federal Incentives: $4.05 million

Cost to city: $2.95 million

Payback period: 4.5 years

Photo courtesy of City of Tulare.

[1] Fuel Cell Energy

Relevance

Project objectives

- Use NREL GIS capabilities to determine facility location and volume of methane based biogas.
- Evaluate three different scenarios for methane production and fuel cell delivery.
- Develop a biogas submodel to the discounted cash flow H2A model that will also serve as a prototype customer adoption/decision tool for fuel cell utilization of stranded biogas.

Desired outcomes

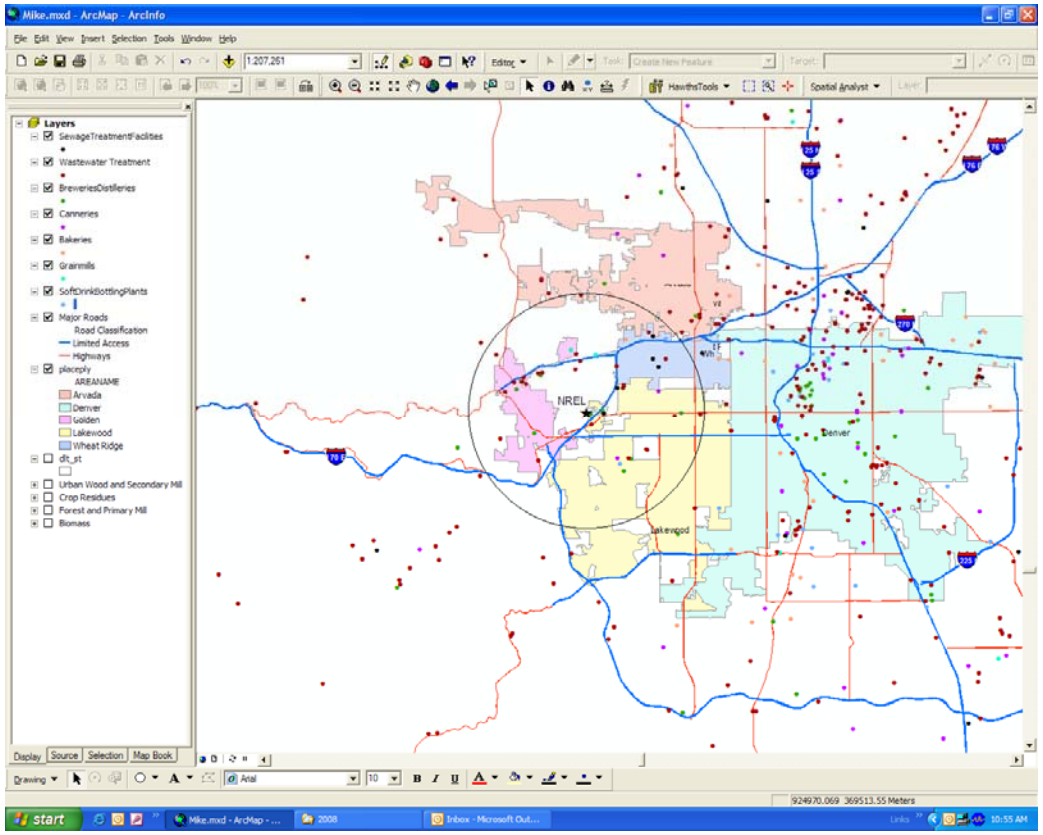
- Support fuel cell industry and create American jobs
- Improve energy security by reducing the load on strained US electricity transmission system and using renewable resources
- Reduce emissions of GHGs
- Take advantage of the economic and environmental benefits of using stranded renewable resources for on site generation of electricity and hydrogen.

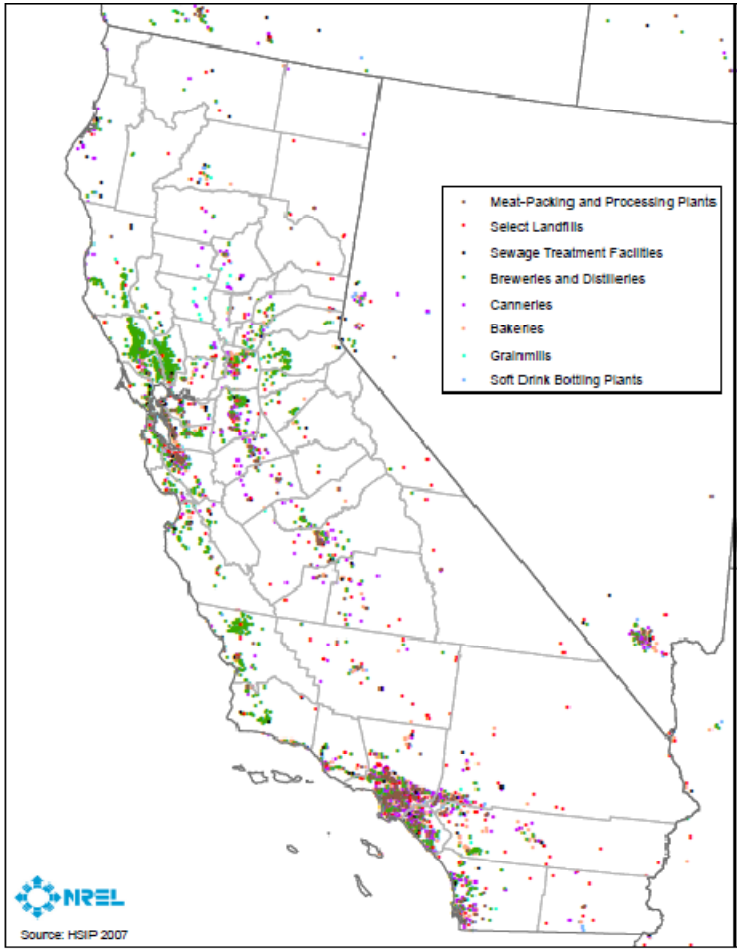
Approach

- Gather data on sources of biogas, costs of biomass conversion, clean-up, and fuel cell technologies, real-life data from existing installations, and clean-up requirements for biogas into NG pipelines
  - EPA AgStar: http://www.epa.gov/agstar/
  - EPA Landfill Methane Outreach Program: http://www.epa.gov/lmop/
  - EPA Combined Heat and Power Partnership: http://www.epa.gov/chp/
  - DHS HSIP database
- Use NREL GIS capabilities to map stranded biogas resources in CO and CA, and overlay infrastructure information to assist the evaluation of deployment scenarios
- Identify critical technical and cost parameters for each of the following scenarios:
  - fuel cell installed at source site
  - source biogas is cleaned-up on site and pumped into the natural gas pipeline
  - transport stranded biogas to a central location for clean-up and use in a fuel cell
- Identify relevant federal and state incentives and integrate into appropriate cost models
- Evaluate, select, and vet analysis tools with stakeholder roundtables and regional workshops

Progress

Initial GIS analysis of stranded biogas sources in Metro Denver and California





Progress

Initial data gathering on related infrastructure

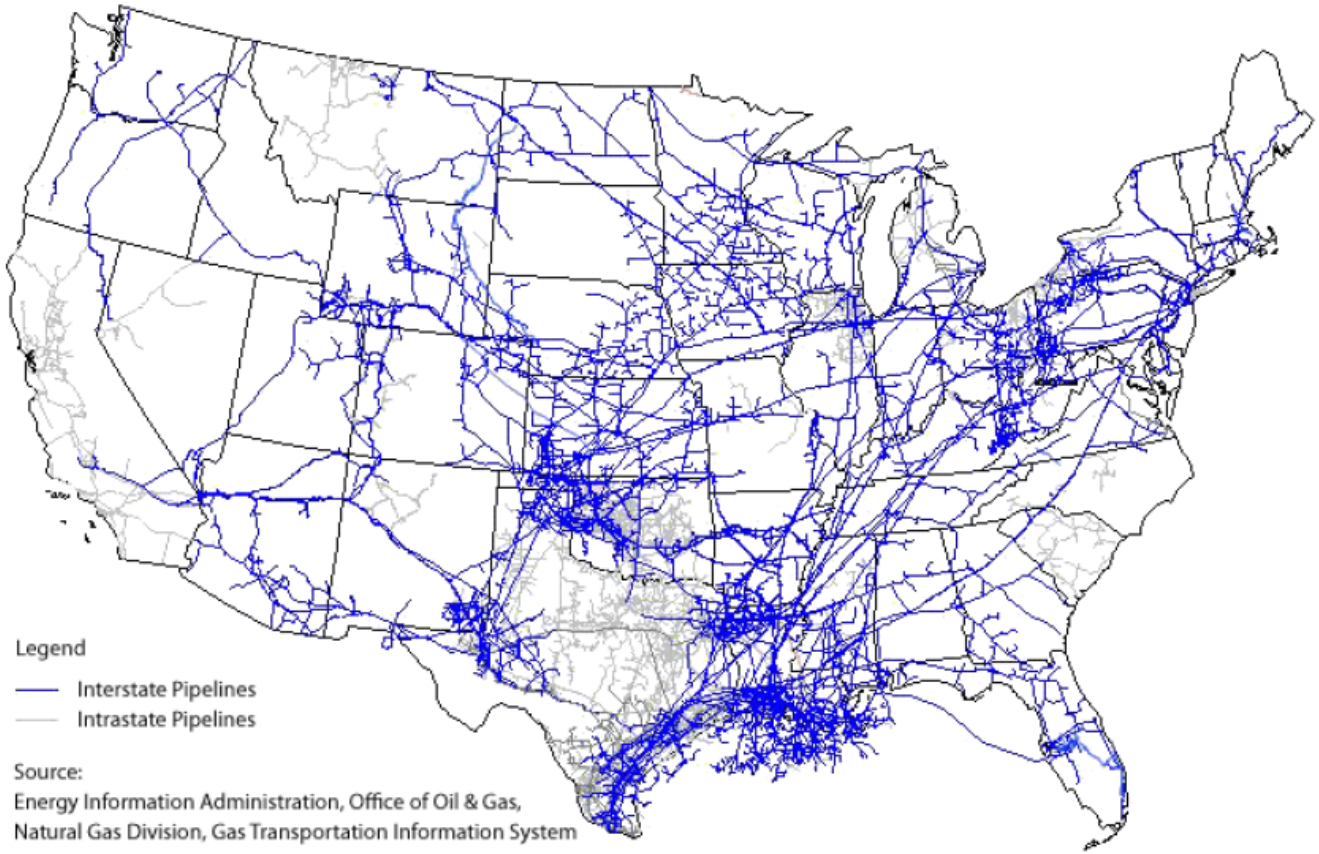


Figure 6. Natural Gas Pipeline System

Progress

- Discussions and inputs from Xcel Energy and Colorado Governor's Energy Office
- Visits and discussions with UTC Power and Fuel Cell Energy
- Initial information on impurities and required clean-up

Used with permission from UTC Power

Table 6. Basic Pipeline Standards for Major California Distributors*

Gas Component or Characteristic	Pacific Gas and Electric Co.	Southern California Gas Co.
Carbon dioxide (CO_2)	≤1%	≤3%
Oxygen (O_2)	≤0.1%	≤0.2%
Hydrogen sulfide (H2S)	≤0.25 grains/100 scf	≤0.25 grains/100 scf
Mercaptan sulfur	≤0.5 grains/100 scf	≤0.3 grains/100 scf
Total sulfur	≤1 grain/100 scf	≤0.75 grains/100 scf
Water (H_2O)	≤7 lb/million scf	≤7 lb/million scf
Total inerts	No requirement	≤4%
Heating value	Specific to receipt point	970 - 1,150 Btu/scf
Landfill gas	Not allowed	No requirement
Temperature	60 - 100° F	50 - 105° F

1 Grain = 64.8 mg

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Potential Collaborations

- EPA AgStar
- EPA Landfill Methane Outreach Program
- EPA Combined Heat and Power Partnership
- Regional CHP Partnership Office
- Xcel Energy
- Colorado Governor's Energy Office
- California Stationary Fuel Cell Partnership

Future Work

- Initiate tasks outlined in the Approach
- Use cost findings from biogas submodel in NEMS and MARKAL Hydrogen production cost analysis
- Refine customer adoption/decision tool with real data and educate stakeholders through regional workshops and roundtable meetings

Summary

- Stranded biogas is an abundant and underutilized renewable resource
- Fuel cells offer efficiency, emissions, and availability advantages for the co-production of hydrogen, heat and electricity
- Commercial fuel cells are currently being used for biogas energy conversion