



**Rethinking Biogas: An Emerging Energy Source in the Midwest**

Peter J. Taglia, P.G.  
Staff Scientist, Clean Wisconsin  
Energy Center of Wisconsin Webinar, September 29, 2010

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**Midwest Food Processors Anaerobic  
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**Technical difficulties?**



**Peter Taglia**  
Clean Wisconsin

## Peter's background

- staff scientist with Clean Wisconsin
- professional geologist
- worked extensively with Governor Doyle's Task Force on Global Warming, the Midwestern Governors Association and the Wisconsin Legislative Council
- holds a B.A. in environmental geology from the University of Montana and a M.S. in hydrogeology from the UW-Madison

**Rethinking Biogas: An Emerging Energy Source in the Midwest**

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## Biogas: Clean, Versatile, Renewable... and Under-Appreciated

### Biogas

- Renewable gaseous fuel derived from biological materials
- Produced from many raw materials at countless different industries and markets at small to large scales..
- Can be used for heating, electrical production, vehicle fuel, cooling, chemical feedstock production.....

### Unfortunately.....

The potential of biogas is unrecognized in the U.S. and renewable energy policies favor solar, wind and ethanol.



## Overview

- Current Biogas Deployment
- New Approaches to Conventional Anaerobic Digestion
- New Technologies to Produce Biogas
- Versatile End-Uses
- Policies Recommendations to Level the Playing Field



Photo Credit: ELPC

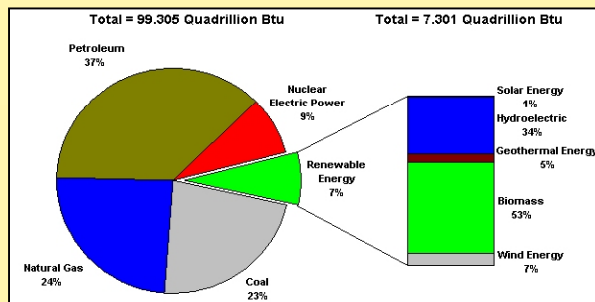


## Poll Question # 1

- How much of the U.S. total energy is supplied by biogas?
  - a) Less than 1%
  - b) 3%
  - c) 7%



## Biogas in the U.S.



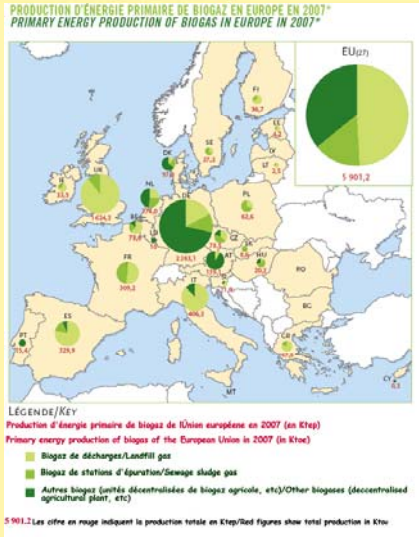
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EIA Biomass Definition: Wood-derived fuels (53%), biofuels (36%) and waste (11%). Biogas is in the waste category and includes municipal waste-to-energy.

**Biogas supplies a small fraction of 1% of the total U.S. Energy Consumption**



# Biogas in Europe



Germany has over 4,000 dedicated biogas plants producing over 1,500 MW of electricity as well as heat, renewable natural gas and vehicle fuel!

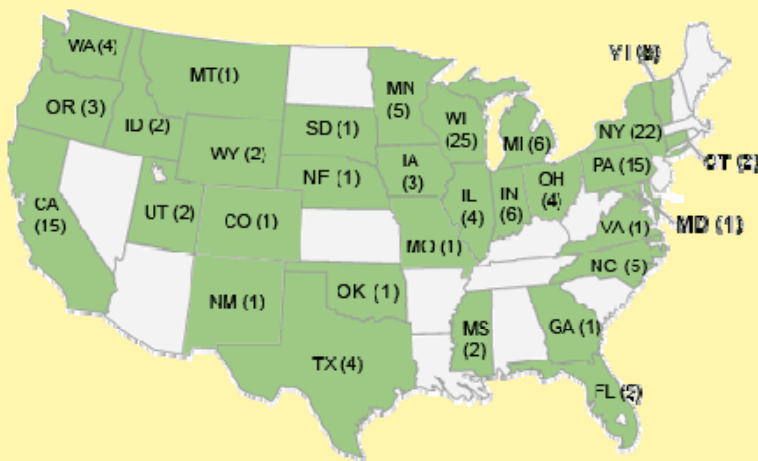
Biogas provides over 11% of Germany's renewable electricity

In contrast, the U.S. has 150 on-farm biogas plants.

Source: BIOGAS BAROMETER – MAY 2007, [http://www.energies-renouvelables.org/observ-er/stat\\_baro/observ/baro179\\_a.pdf](http://www.energies-renouvelables.org/observ-er/stat_baro/observ/baro179_a.pdf)



# Operational On-Farm Anaerobic Digestion Projects



Source: U.S. EPA AgStar Program, April 2010. <http://www.epa.gov/agstar/accomplish.html#ky>



## Wastewater treatment facilities

- 16,000 wastewater treatment facilities nationwide
  - 544 utilize anaerobic digestion to treat waste
  - Only 106 use biogas for electrical production or cogeneration.



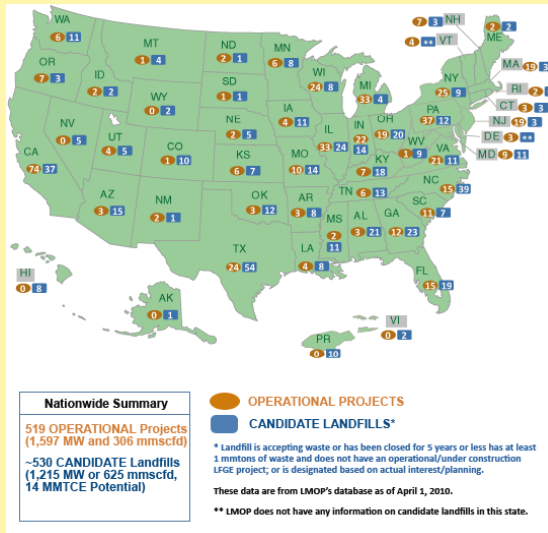
Source: U.S. EPA

- Some opportunities to expand, but many logistical hurdles and cleaner alternatives for some wastes



## Landfill Gas Recovery Projects

- 519 landfills capture biogas for energy
  - Most large landfills already deploy biogas to energy systems
- 530 landfills have potential, but tend to be smaller
- Landfills have many environmental and GHG issues even with biogas to energy



Source: U.S. EPA, Landfill Methane Outreach Program  
<http://www.epa.gov/landfill/projects-candidates/index.html>



## Future Biogas Expansion

- Further landfill and wastewater treatment expansion in the U.S. are already driven by water and air quality concerns.
- Biogas growth in the U.S. is likely to come from dedicated biogas energy facilities, similar to Europe

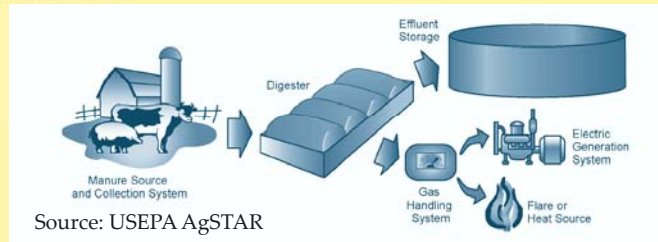


German Biogas Installation (Left Axis) and Electrical Output (Right Axis)

- The Midwest is a global leader in the agricultural productivity, food processing and manufacturing sectors that can drive biogas growth.



## Biogas Benefits Agriculture



### Non-energy benefits of manure digesters

- Improved odor control
- Reduced pathogens
- Stabilized nutrients, nitrogen readily available for uptake by plants
- Reduced total oxygen demand in digested manure – helps protect water quality



## Biogas Benefits Agriculture

### Economic Benefits

- Sale of carbon credits from GHG destruction
- Utilize separated digested fibers for bedding
- Sale of renewable electricity or renewable gas

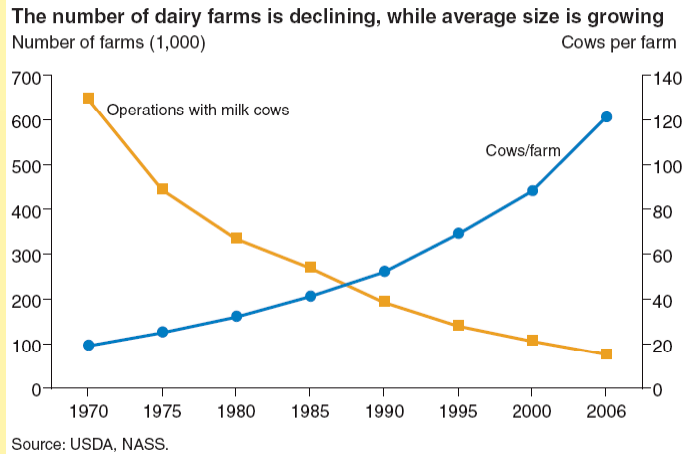


## Poll Question # 2

- How many large farms in the U.S. does the EPA consider candidates for conventional anaerobic digester systems?
  - a) 600 Farms
  - b) 1,900 Farms
  - c) 8,000 Farms



## Larger Farms: Dairy Farm Trends in the U.S.



Do Anaerobic Digesters Encourage Expansion and Consolidation in the Livestock Industry?



## Factors driving this trend

- Shrinking profit margins
  - Contracted feed production
  - Hired labor
- Small family size
- Aging rural population
- Increased availability of technology and mechanization
- Other regulations



## Will Biogas Policies Drive More Consolidation?

- Recent biogas expansion is coming from diverse resources
- Biogas policies (e.g., FITs) and nutrient policies can be designed to incentivize smaller producers
- Clean energy legislation that expands biogas will also incentivize other sustainable agricultural practices (tillage, buffer strips, cover crops, etc.)



## Answer to Poll Question #2

- How many large farms in the U.S. does the EPA consider candidates for conventional anaerobic digester systems?
  - a) 600 Farms
  - b) 1,900 Farms
  - c) 8,000 Farms**



## Conventional Anaerobic Digester Potential in the U.S.

EPA estimates approx. 8,000 farms are good candidates for capturing and using biogas.

If all 8,000 farms implemented biogas systems:

- Methane emissions reduction of 34 million tons CO<sub>2</sub>-eq per year, roughly equal to the annual emissions from 6.5 million passenger vehicles.
- Over 1,500 megawatts of renewable energy.

What About Smaller Farms?



## Midwest Livestock Farms By Size

Midwestern Dairy Farms	
# of Animals	# of Farms
<b>1,000 +</b>	<b>270</b>
500-999	436
200-499	1,918

Midwestern Poultry Layers Farms	
# of Animals	# of Farms
<b>100,000 +</b>	<b>202</b>
50,000-99,999	84
20,000-49,999	94

Midwestern Swine Farms	
# of Animals	# of Farms
<b>5,000 +</b>	<b>2,291</b>
2,000-4,999	4,439
1,000-1,999	3,263

**Bold Farm Categories are Most Suited to *Current* Anaerobic Digester Designs**

Source: USDA National Agriculture Statistics Service (NASS) 2007



## New Approaches to Conventional Anaerobic Digestion

- Community Digesters Aggregate Manure from Multiple Farms
  - Manure/biogas pipelines
  - Water treatment potential
  - Link smaller farms
- Small Digesters for Small Dairies (150 – 250 cows)
- Co-Digestion of Food Processing Waste
  - Boost biogas production from individual digesters



**Community Manure Digester in Dane County Wisconsin:** Two large and one medium-sized dairy, 2 MW of electricity and phosphorus removal system

Sources: Dane County (WI) Public Works



## New Approaches to Conventional Anaerobic Digestion (continued)

- Large-scale organic waste digesters for urban, commercial, institutional and industrial food and food processing wastes
- Much greater landfill diversion than composting, more convenient curbside collection opportunities
- Very Large Biogas Production Potential



**Curbside Organic Digester**  
Sources: CCI Bioenergy (Ontario)

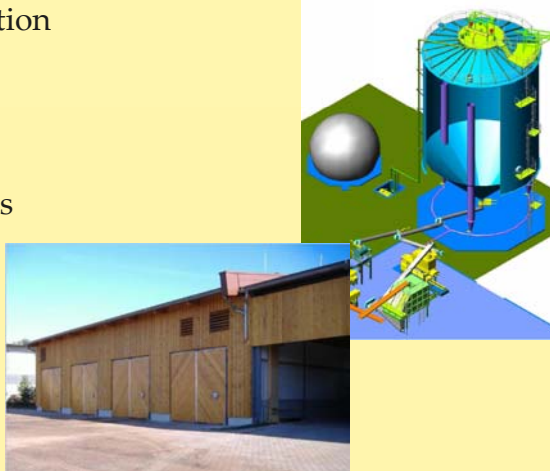


## Dry Digesters Expand the Resource Potential

### New Resources for Digestion

- Solid Manure
- Crop Residuals
- Food Processing Wastes
- Cafeteria Waste
- Yard Waste

Nutrients Preserved  
 Pathogen Reduction  
 Lower Water Use



**Silo-Style Dry Digester (TOP) and Dry Fermentation Digester (BOTTOM)**

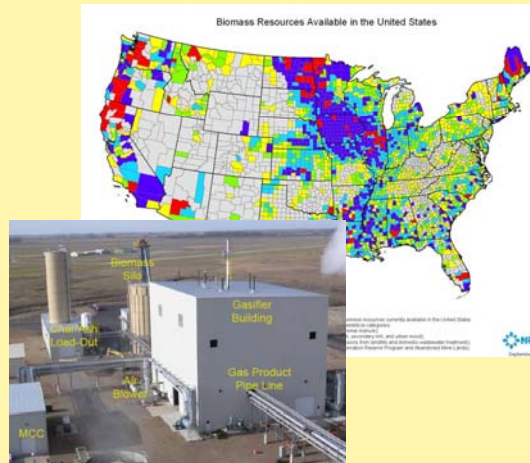
Sources: Organic Waste Systems and BIOFerm



## Biomass Gasification

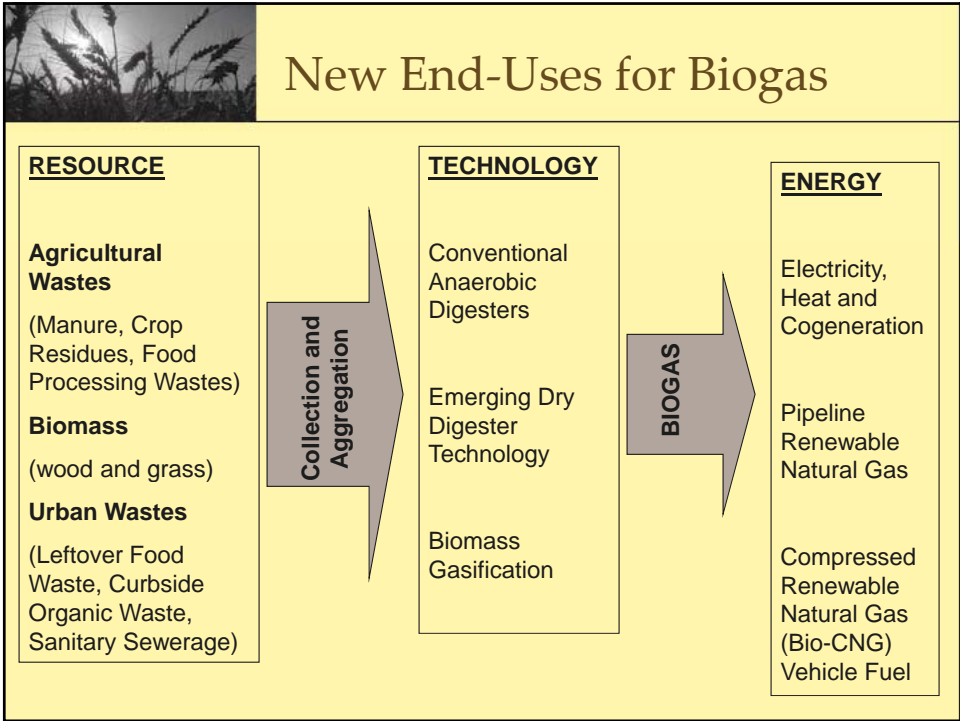
### Forestry and Agriculture Waste

- Very Low Emission Profile
- Feedstock Diversity
- Large-scale Opportunities



**Biomass Resources of the U.S. (TOP) and Biomass Gasifier at Chippewa Valley Ethanol Facility (BOTTOM)**

Sources: NREL and Frontline BioEnergy



## Biogas: Heating, Cooling, Electricity and Cogeneration

Biogas Versatility Enables High Efficiencies

- Cogeneration (a.k.a. Combined Heat and Power or CHP) Opportunities
- Heating Applications
- Cooling Applications With Absorption Chillers
- Scalable: Commercial-Size Fuel Cells, and Farm-Sized Microturbines

**Electrical Power**

Category	Percentage
Waste	67%
Electricity	33%

**CHP Heat**

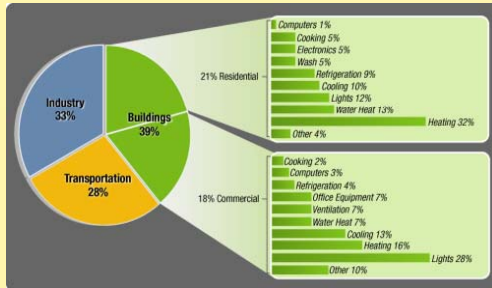
Category	Percentage
Waste	45%
Electricity	30%
Thermal	25%

**Energy Comparison**  
Source: Biomass Energy Resource Center



# Renewable Natural Gas

- Natural Gas is the second largest primary energy source in U.S.
- Renewable Natural Gas: Biogas upgraded to pipeline standards
- Large Potential From Anaerobic Digestion and Biomass Gasification
  - Resource potentials of 5 to 40% of total natural gas consumption in California, Germany and U.K.



**Natural Gas End Use in U.S. (TOP) and Renewable Natural Gas (BOTTOM)**  
Sources: Lawrence Berkeley National Lab and Michigan Gas



# Renewable Natural Gas

- No major state or federal policies incentivize renewable natural gas
- Lost opportunities:
  - High efficiency co-generation or combined-cycle power plants
  - Ultra-low emission fuel cells (e.g., Bloom)
  - Tankless water heaters
  - Sites with inadequate electrical lines



**Highly Efficient Natural Gas Combined Cycle Power Plant (TOP), Natural Gas Cogeneration Plant (RIGHT), Tankless Water Heater (LEFT)**

Credit: We Energies (top), MGE (right), US DOE (left)



### Poll Question #3

- Which Transportation Fuel has the Lowest Carbon Footprint?
  - a) Sugarcane Ethanol
  - b) Dairy Biogas CNG
  - c) Landfill Biogas CNG
  - d) Soybean Biodiesel
  - e) Electric Vehicles



### Biogas Compressed Natural Gas (CNG) Vehicle Fuel

- Passenger and Fleet Vehicles
- Scalable (100 Transit Buses to 5 Work Trucks)
- Add-ons to Existing Biogas Systems
- No major policy recognition (except CA)



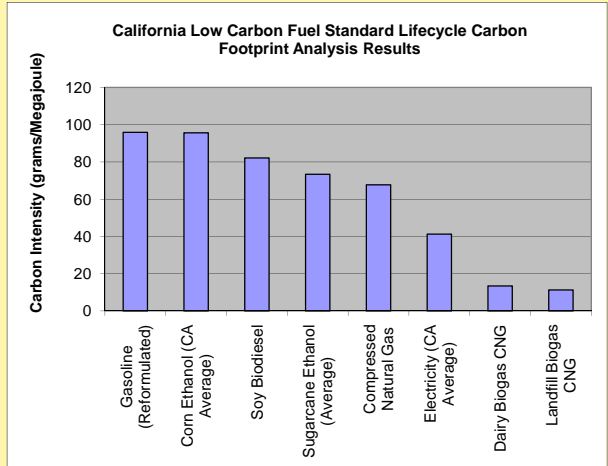
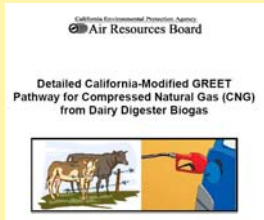


## Low Carbon Vehicle Fuel

Poll Question #3

Answer:

c). Landfill Biogas-CNG (but dairy biogas was very close)



## Biogas Economics

- Renewable Electricity Alone:
  - Biogas is Competitive with Large-Scale Wind
  - Biogas is Cheaper than Solar and Small Wind

Table 2. Hypothetical Production Costs for 10-Year Contracts (cents/kWh)

Technology	Category 1 (≤20 kW)	Category 2 (20-200 kW)	Category 3 (200 kW-1 MW)	Category 4 (1-5 MW)
Solar PV	60.6	60.0	Not analyzed <sup>1</sup>	Not analyzed
Wind	38.3	34.1	23.3	23.3
Biogas	Not analyzed	10.8	11.1 <sup>2</sup>	9.8 (1-2 MW) 8.8 (2-5 MW)
Biomass (solid)	Not analyzed	Not analyzed	Not analyzed	21.6
Landfill Gas	Not analyzed	Not analyzed	Not analyzed	4.8
Hydro	Not analyzed	Not analyzed	4.1	Not analyzed

### Renewable Electricity Cost Comparison

Source: Wisconsin Public Service Commission

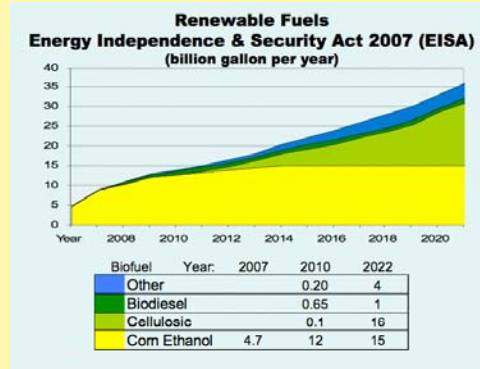
[http://psc.wi.gov/apps35/erf\\_search/content/DocumentInfo.aspx?docid=114021](http://psc.wi.gov/apps35/erf_search/content/DocumentInfo.aspx?docid=114021)

But What About the Other Benefits of Biogas?



## Giving Biogas Proper Recognition

- Recognize renewable co-generation and heat
- Provide level playing field for renewable transportation fuels
  - Renewable Fuel Standards incentivize liquid transportation fuels (e.g., ethanol, biodiesel) but fail to recognize biogas CNG.
- Lifecycle fuel policies (e.g., LCFS) are more equitable

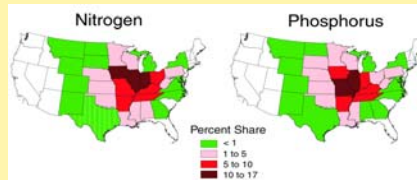


Federal Renewable Fuel Standard  
Source: GLBRC



## Giving Biogas Proper Recognition

- Provide incentives for renewable natural gas comparable with renewable electricity
- Recognize environmental services
  - Anaerobic digestion of organic wastes reduce landfill emissions and surface water pollution
  - Nutrient trading in watersheds



Nutrient Contributions to the Gulf, by State.  
Source: USGS,



## Thank You

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