

Summary of WERF Methane and Biogas-CHP-Related Research



Methane Expo 2013



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Lauren Fillmore, Water Environment Research Foundation

March 14, 2013



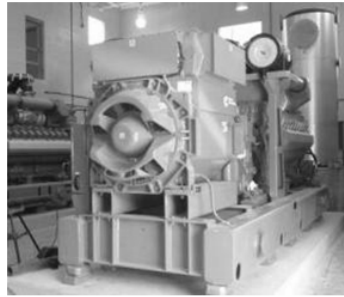
• NYSERDA • Brown and Caldwell • Black & Veatch • Hemenway Inc. • NEBRA

Today's Presentation

- Barriers to Biogas Use
- Barriers to Biogas Use Economics
- LCAMER
- Fugitive Methane Research:
 - Flare Emissions Estimator
 - Collection Systems
 - Lagoons and Ponds



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Barriers to Biogas Use

Project Overview

PHASE I

Establish Framework

- Conduct Kickoff Mtg. to Align Goals and Objectives
- Collect and mine relevant project experience
- Develop online survey content and define output requirements

PHASE II

Develop and Launch Survey

- Develop electronic survey
- Roll-out to utilities
- Analyze survey results

PHASE III

Conduct Focus Group Meetings

- Conduct meetings (over course of project)
 - **WEF Nutrient Mgmt. (Jan. 9, 2011, Miami)**
 - **NYWEA 2011 (Feb. 9, 2011 New York)**
 - **WEF R&B 2011 (May 25, 2011 Sacramento)**
 - **WEF Water & Energy 2011 (Aug. 3, 2011 Chicago)**

PHASE IV

Analyze Results/Summarize

- Analyze barriers
- Identify strategy recommendations to overcome barriers
- Summarize – Draft and Final Reports including Utility Profiles

Final Report is Available from WERF

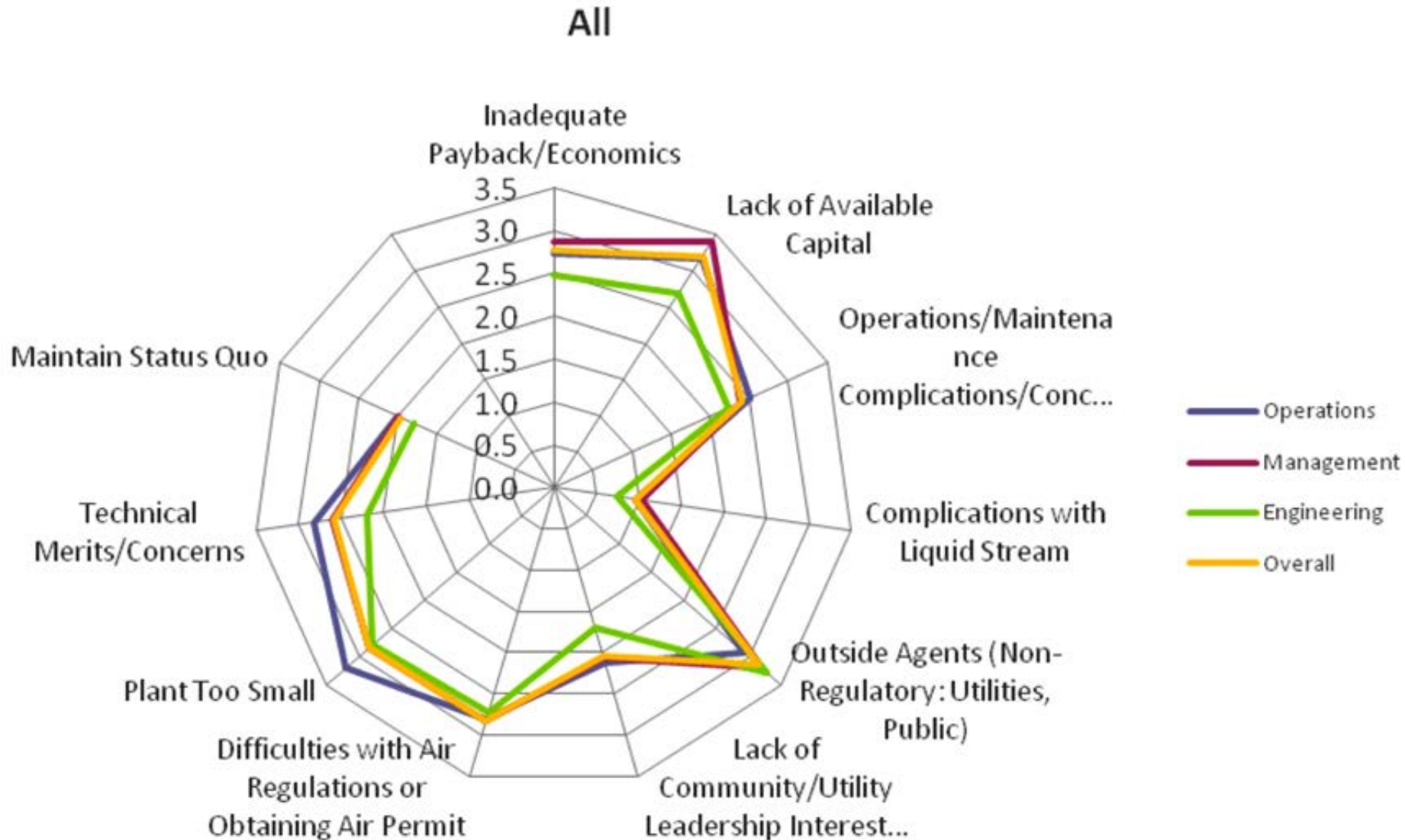
- Executive summary
- Introduction
- Biogas uses for renewable energy
- Online survey overview, results & interpretation
- Focus group summaries
- Small plant barrier mitigation
- Non-utility perspectives on barriers
- Conclusions and recommended next steps
- Plus: case studies, focus group minutes



Report is available at:

<http://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportId=OWSO11C10>

Survey Data – Example of Data Presentation



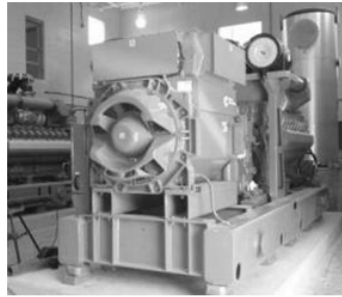
Conclusions

- The most significant barriers to biogas use are economic:
 - higher priority demands on limited capital resources
 - perceptions that economics do not justify investments
- Outside agents like power utilities can be barriers
- Air permitting can be a significant barrier in specific geographies/permitting situations
- Public agencies' decision-making practices often hinder biogas use





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Barriers to Biogas Use Economics

Simple Payback is used Too Often, but has Significant Shortcomings

- Does not consider time-value of money
- Does not consider impact on cash flow
- Criterion: Allows a sliding scale for determination of suitability

Reframing the Economics of Combined Heat and Power Projects

Creating a Better Business Case Through Holistic Benefit and Cost Analysis



One of the biggest hurdles utilities face when initiating a combined heat and power (CHP) project is the ability to communicate the costs and benefits of CHP to decision makers and the public. This is often due to the failure to use economic methods that appropriately calculate the financial outlay and long-term benefits. Without this support, decisions can be based on arbitrary factors, rather than realistically answering the simple question: Is this a good long-term investment?

Better metrics can help utilities get a more accurate picture of a project's actual costs and benefits, and ultimately make more informed decisions about moving a project forward.

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Other Options Provide more Comprehensive and Definitive Treatment

- Net present value (NPV)
- Benefit cost ratio (BCR)
- Internal rate of return (IRR)
- Equivalent uniform annual net value (EUAV)

- These Options:
 - Do consider time-value of money
 - Do consider impact on cash flow

Case Study in Factsheet shows Juxtaposition:

Table 1. Financial Results for Alternative Metrics

Item	Alternative 1 – Constant	Alternative 2 – Escalated
Capital Cost	\$4,200,000	\$4,200,000
Annual Operating Savings	\$334,257	\$367,264
Payback Period	12.6 years	11.4 years
Project Action	Dependent on utility's requirements for payback period, this value can result in the project being rejected	Dependent on utility's requirements for payback period, this value can result in the project being rejected
Present Value of Savings (or Benefits)	\$9,681,618	\$9,929,725
Present Value of Costs	\$9,299,692	\$9,162,267
Net Present Value	\$381,925	\$767,457
Project Action	NPV > 0, so consider accepting CHP project	NPV > 0, so consider accepting CHP project
BCR	1.041	1.084
Project Action	BCR > 1, so consider accepting CHP project	BCR > 1, so consider accepting CHP project
Discount Rate, i	3.5%	3.5%
IRR	4.5%	5.5%
Project Action	IRR > i, so consider accepting CHP project	IRR > i, so consider accepting CHP project
EUAB	\$681,209	\$698,666
EUAC	\$654,336	\$644,667
NUV	\$26,873	\$53,999
Project Action	NUV > 0, so consider accepting CHP project	NUV > 0, so consider accepting CHP project

???:/???

GO/GO

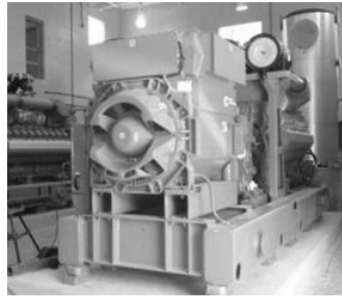
GO/GO

GO/GO

GO/GO



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LCAMER

(Slides Courtesy of Hugh Monteith, Hydromantis)

What Digestion/CHP System is Right for Me?

Plant size?

Electricity Cost?

Natural Gas Cost?

Methane Content?

Borrowing cost?

Biogas Production?

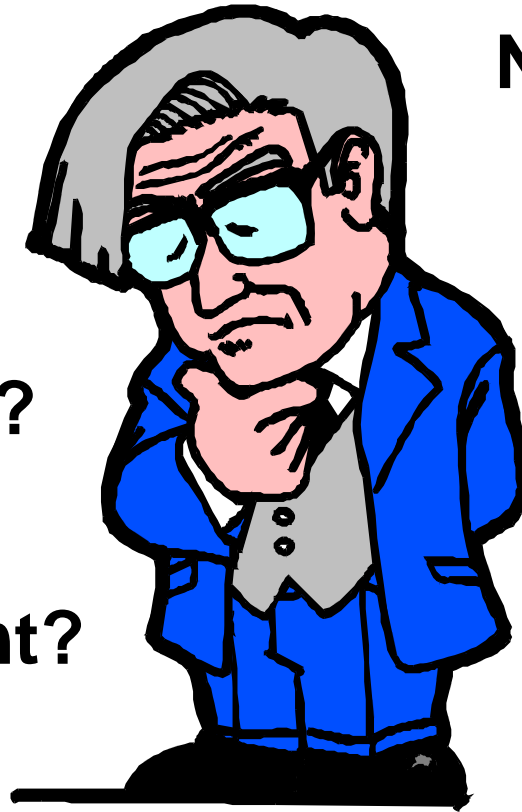
GHG Credits?

Biogas Pretreatment?

Sell electricity
or use onsite?

Emission Regulations?

Government Assistance?



LCAMER was developed to:

- Create a tool for comparing the benefits and costs of digester energy recovery over the lifetime of a WWTP
- Predict the most economically viable solids treatment and energy recovery alternatives for given data sets

LCAMER Worksheets:

- 5 worksheets non-modifiable by users
 - Info to users
 - Energy Recovery System (ERS) emission factors
 - Default temperatures for States/Provinces
 - hydrolysis constants for VSR in digesters
 - replacement costs for ERS
- 3 worksheets user-accessible
 - Basic conversion factors
 - Technical inputs and models
 - Economic inputs and models

Validation of LCAMER

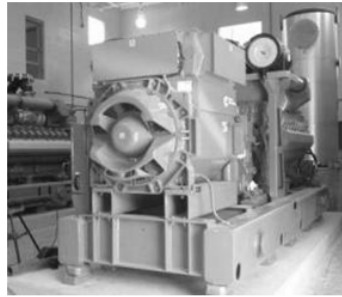
- Focus was on demonstrating the applicability, effectiveness, and areas of improvement for LCAMER
- Process variables and financial cost factors were adjusted to meet actual conditions at the 2 sites, resulting in successful implementation of LCAMER
 - Reinforced choice of ICE for CHP at Gwinnett County (GA)
 - Provided basis for choice of ICE at Pinellas County (FL)

Examples of LCAMER Uses:

- Compare economics for
 - Different energy recovery processes
 - Convert from mesophilic to thermophilic operation (same energy recovery system)
 - Use of advanced sludge treatment to enhance volatile solids reduction for increased gas production
 - Imported digester feedstocks
 - Evaluation of peak load shifting



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Fugitive Methane Research: Flare Emissions Estimator

WERF Flare Efficiency Calculator

- Model developed by University of Alberta from data collected during Flare Research Project
- Developed for digester gas and landfill gas



Flare Research Project

[Main](#)

[Flaring Facts](#)

[Flare Performance](#)

[Facilities](#)

[Current Activities](#)

[Results](#)

[Publications](#)

[Personnel](#)

[Funding Partners](#)

[Related Links](#)



University of Alberta

[Department of Mechanical Engineering](#)
[Combustion and Environment Group](#)

Model Inputs Include:

- Dry Gas CH₄, CO₂, and O₂ Fractions
- Temperature of Gas
- Relative Humidity of Gas
- Gas Flowrate and Nozzle Diameter
calculate Flare Jet Speed
- Wind Speed

- Output is Flare Efficiency

How Efficient are Conventional Flares?

- USEPA assumes 99% efficiency
- Model predicts 94.3% for

The screenshot shows the 'FlareSI' software window titled 'Flare Efficiency Estimator' with a version of 'March 12 2010'. The interface is divided into several sections:

- Inputs:**
 - Flare Gas:**
 - Dry Composition:** Methane (65%), Carbon Dioxide (34%), Oxygen (0.5%), Balance Nitrogen (0.5%).
 - Moisture Content at Flare Temperature:** Relative (100%), Flare Gas Temperature (C) (30).
 - Flare Size and Flow:** Flare Gas Rate (Volume Flow Rate (scm/s) selected at 0.025, Flare Jet Speed (m/s) at 2.644), Flare Size (Diameter (m) at 0.114).
 - Ambient Conditions:** Atmospheric Pressure (kPa) at 101.3, Wind Speed (kph) at 10.
- Results:**
 - Flare Gas:**
 - Wet Composition:** Methane (62.3%), Carbon Dioxide (32.6%), Oxygen (0.5%), Nitrogen (0.5%), Water Vapor (4.2%).
 - Energy Content:** Lower Heating Value (kJ/kg) at 19697.
 - Flare Conditions:** Volume Flow Rate (scm/s) at 0.025, Flare Jet Speed (m/s) at 2.644, Flare Diameter (m) at 0.114, Atmospheric Pressure (kPa) at 101.3, Wind Speed (kph) at 10, and **Flaring Combustion Efficiency** at 94.3%.
- Comments:** High confidence solution - all parameters in normal ranges.

Buttons for 'Help!' and 'Change to Standard Units' are also visible.

Thermophilic and Windy?

- USEPA assumes 99% efficiency
- Model predicts 87.5% for thermophilic biogas with 20mph winds

The screenshot shows the 'FlareSI' software window titled 'Flare Efficiency Estimator' with version 'March 12 2010'. It is divided into several sections: 'Inputs', 'Results', and 'Comments'. The 'Inputs' section includes 'Flare Gas' (Dry Composition: Methane 65%, Carbon Dioxide 34%, Oxygen 0.5%, Balance Nitrogen 0.5%; Moisture Content: Relative 100%, Flare Gas Temperature 50 C) and 'Flare Size and Flow' (Flare Gas Rate: Volume Flow Rate 0.03 scm/s, Flare Jet Speed 3.69 m/s; Flare Size: Diameter 0.114 m). The 'Results' section shows 'Flare Gas' (Wet Composition: Methane 57.1%, Carbon Dioxide 29.9%, Oxygen 0.4%, Nitrogen 0.4%, Water Vapor 12.2%; Energy Content: Lower Heating Value 18500 kJ/kg) and 'Flare Conditions' (Volume Flow Rate 0.03 scm/s, Flare Jet Speed 3.69 m/s, Flare Diameter 0.114 m, Atmospheric Pressure 101.3 kPa, Wind Speed 20 kph, and Flaring Combustion Efficiency 87.5%). A 'Comments' box at the bottom states 'High confidence solution - all parameters in normal ranges.' A 'Change to Standard Units' button is also present.

Section	Parameter	Value
Inputs	Flare Gas	
	Dry Composition	
	Methane:	65%
	Carbon Dioxide:	34%
	Oxygen:	0.5%
	Balance Nitrogen:	0.5%
	Moisture Content at Flare Temperature	
	Relative:	100%
	Flare Gas Temperature (C):	50
	Flare Size and Flow	
Flare Gas Rate		
<input checked="" type="radio"/> Volume Flow Rate (scm/s):	0.03	
<input type="radio"/> Flare Jet Speed (m/s):	3.69	
Flare Size		
Diameter (m):	0.114	
Ambient Conditions		
Atmospheric Pressure (kPa):	101.3	
Wind Speed (kph):	20	
Results	Flare Gas	
	Wet Composition	
	Methane:	57.1%
	Carbon Dioxide:	29.9%
	Oxygen:	0.4%
	Nitrogen:	0.4%
	Water Vapor:	12.2%
	Energy Content	
	Lower Heating Value (kJ/kg):	18500
	Flare Conditions	
Volume Flow Rate (scm/s):	0.03	
Flare Jet Speed (m/s):	3.69	
Flare Diameter (m):	0.114	
Atmospheric Pressure (kPa):	101.3	
Wind Speed (kph):	20	
Flaring Combustion Efficiency:	87.5%	
Comments		
High confidence solution - all parameters in normal ranges.		

Landfill Gas and Moderate Winds?

- USEPA assumes 99% efficiency
- Model predicts 71.5% for landfill gas with 10mph winds

The screenshot shows the 'FlareSI' software window titled 'Flare Efficiency Estimator' with a version date of March 12, 2010. The interface is divided into several sections: 'Inputs', 'Results', and 'Comments'. The 'Inputs' section includes 'Flare Gas' (Dry Composition: Methane 40%, Carbon Dioxide 25%, Oxygen 0.5%, Balance Nitrogen 34.5%; Moisture Content: Relative 100%, Flare Gas Temperature 20°C) and 'Flare Size and Flow' (Flare Gas Rate: Volume Flow Rate 0.025 scm/s, Flare Jet Speed 2.507 m/s; Flare Size: Diameter 0.114 m). The 'Results' section shows 'Flare Gas' (Wet Composition: Methane 39.1%, Carbon Dioxide 24.4%, Oxygen 0.5%, Nitrogen 33.7%, Water Vapor 2.3%; Energy Content: Lower Heating Value 11600 kJ/kg) and 'Flare Conditions' (Volume Flow Rate 0.025 scm/s, Flare Jet Speed 2.507 m/s, Flare Diameter 0.114 m, Atmospheric Pressure 101.3 kPa, Wind Speed 10 kph, and a Flaring Combustion Efficiency of 71.5%). A 'Comments' box at the bottom states 'High confidence solution - all parameters in normal ranges.' A 'Change to Standard Units' button is also present.

Section	Parameter	Value
Inputs	Flare Gas	
	Dry Composition	
	Methane:	40%
	Carbon Dioxide:	25%
	Oxygen:	0.5%
	Balance Nitrogen:	34.5%
	Moisture Content at Flare Temperature	
	Relative:	100%
	Flare Gas Temperature (C):	20
	Flare Size and Flow	
Flare Gas Rate		
<input checked="" type="radio"/> Volume Flow Rate (scm/s):	0.025	
<input type="radio"/> Flare Jet Speed (m/s):	2.507	
Flare Size		
Diameter (m):	0.114	
Ambient Conditions		
Atmospheric Pressure (kPa):	101.3	
Wind Speed (kph):	10	
Results	Flare Gas	
	Wet Composition	
	Methane:	39.1%
	Carbon Dioxide:	24.4%
	Oxygen:	0.5%
	Nitrogen:	33.7%
	Water Vapor:	2.3%
	Energy Content	
	Lower Heating Value (kJ/kg):	11600
	Flare Conditions	
Volume Flow Rate (scm/s):	0.025	
Flare Jet Speed (m/s):	2.507	
Flare Diameter (m):	0.114	
Atmospheric Pressure (kPa):	101.3	
Wind Speed (kph):	10	
Flaring Combustion Efficiency:	71.5%	
Comments	High confidence solution - all parameters in normal ranges.	

How Significant is the Difference?

- WWTP in Georgia treating 34 mgd:
 - EPA at 99% assumed efficiency = 116 MT CO₂e/year
 - Flare tool estimated efficiency of 94.5% = 638 MT CO₂e/year
- WWTP in Tennessee treating 80 mgd:
 - EPA at 99% assumed efficiency = 205 MT CO₂e/year
 - Flare tool estimated efficiency of 96.6% = 693 MT CO₂e/year

Flare Emissions Estimator is Housed at NYSERDA.NY.gov

- Energy Efficiency and Renewable Program
- Commercial and Industrial
- Municipal Water and Wastewater
- Final Reports
- Barriers to Biogas
 - Flare Calculator



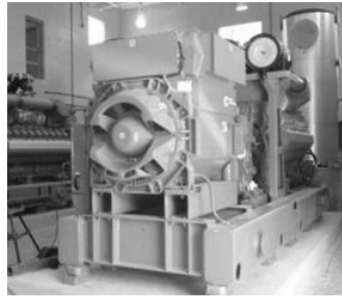
The screenshot shows the NYSERDA website interface. At the top, there is a navigation bar with 'New York State' and 'State Agencies'. The NYSERDA logo is prominently displayed with the tagline 'Energy. Innovation. Solutions.'. Below the logo, a menu bar contains several categories: 'Energy Efficiency and Renewable Programs' (circled in red), 'Energy Innovation and Business Development', 'Energy Education and Workforce Development', 'Energy and the Environment', and 'Energy Data and Analytics'. A secondary navigation bar includes links for 'Home', 'About', 'Events', 'Funding Opportunities', 'Publications', 'Contractors', 'All Programs', 'Contacts', and 'New'. The main content area features a sidebar with a tree view of categories such as 'Agriculture', 'K-12 Schools', 'Municipal Water & Waste Water Facilities', and 'Final Reports for Water and Wastewater Technology Development Demonstration Projects'. The central content area displays a section titled 'Final Reports for Water and Wastewater Technology Development Demonstration Projects' with a table of reports. The right sidebar contains 'Announcements' and 'Funding Opportunities'.

Report Title	Report Number	Owner	City
Proof-of-Concept for Co-Digestion of Food Waste, Fats, Oil and Grease, and Wastewater Sludge Cake to Create Renewable Energy [PDF 2.7MB]	12-22	--	--
Assessment of Biochemical Process Controls for Reduction of Hydrogen Sulfide Concentrations in Biogas from Farm Digesters [PDF]	12-20	--	--
The UV Validation and Research Center of New York [PDF]	12-13	--	--
Barriers to Biogas Use for Renewable Energy [PDF]			

- [Fact Sheet: Reframing the Economics of Combined Heat and Power Projects](#) [PDF]
- [Biogas System Flare Calculator: Calculates Flare Efficiency and Emissions](#) [ZIP|151MB]
 1. Download all four files to the same directory.
 2. Run the Matlab "installer" (this takes a while)



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Fugitive Methane Research: Collection Systems

WERF Collection-System Methane is Centered in Two, Sequential Projects

- Results of First Project are published in



IWA affiliate

**Global Water
Research Coalition**

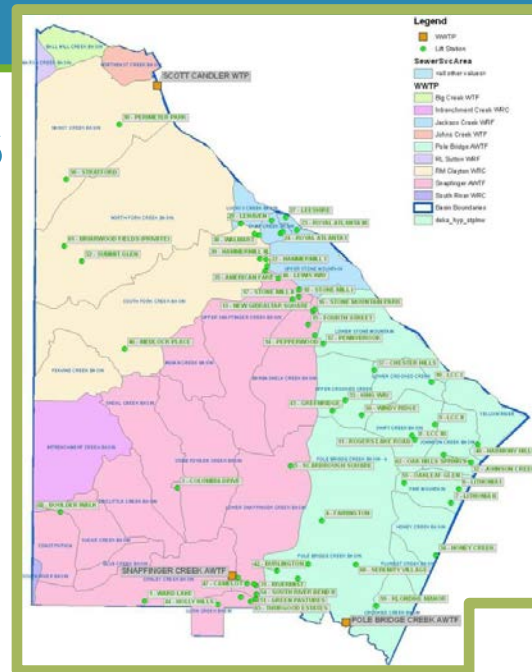
**N₂O and CH₄ Emission from Wastewater
Collection and Treatment Systems**

State of the Science Report

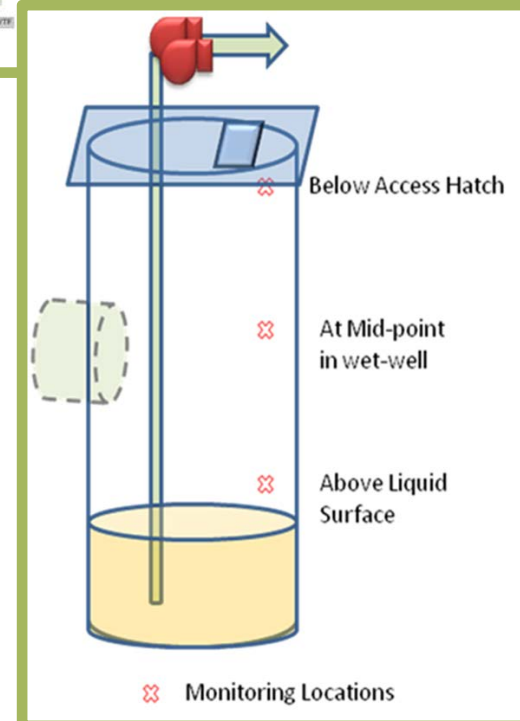
Global Water Research Coalition
www.globalwaterresearchcoalition.net

DeKalb County (GA) was First Project Site

- Serves over 600,000
- 64 sanitary sewage lift stations

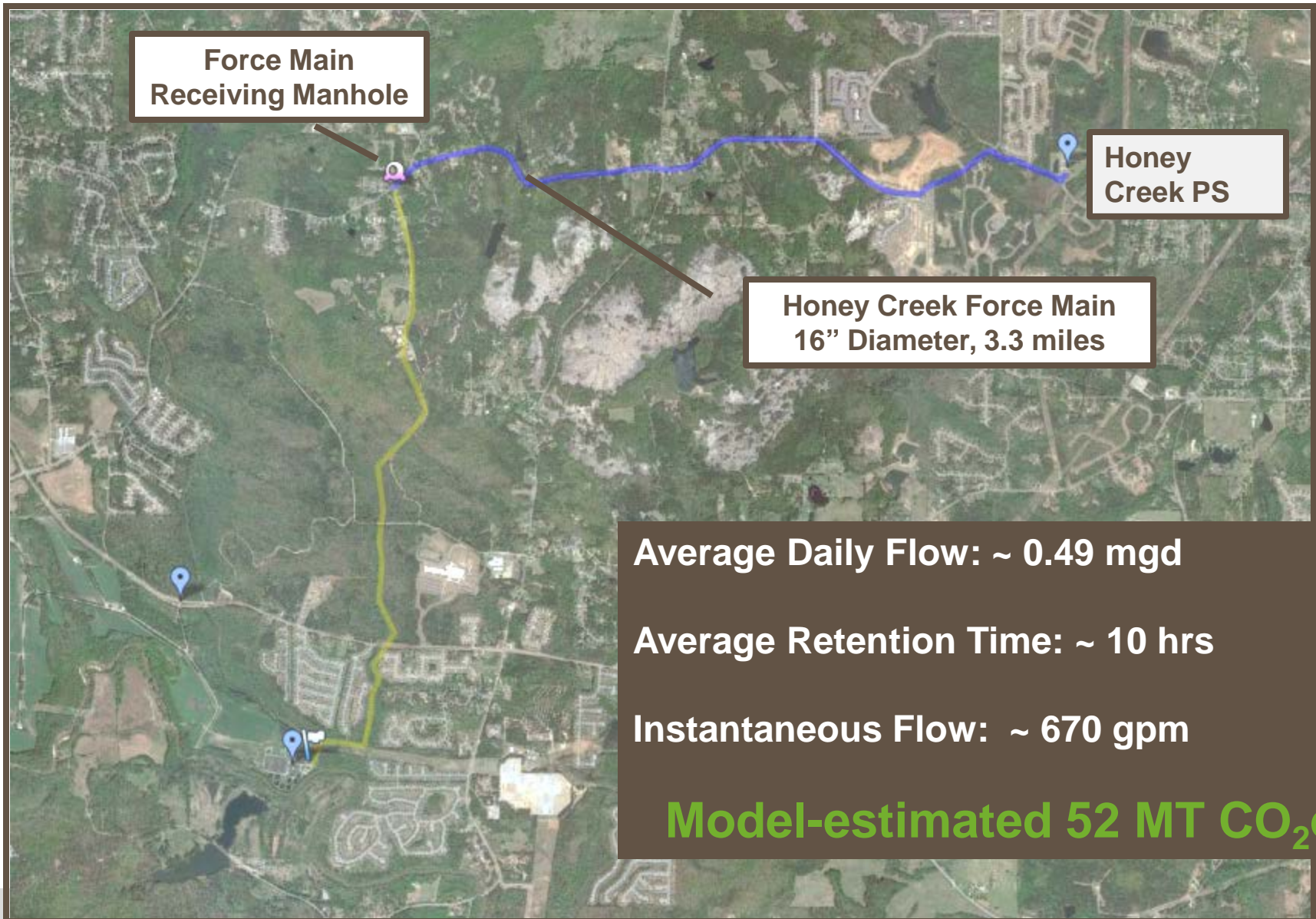


	Summer CH ₄ (lb/half yr)	Winter CH ₄ (lb/half yr)	Annual CH ₄ (lb/yr)	Annual CO ₂ e (lb/yr)	Annual CO ₂ e (MT/yr)
Totals:	75,110	23,371	98,481	2,068,107	940



- Found to have 940 MT CO₂e/yr of CH₄

Honey Creek PS and FM



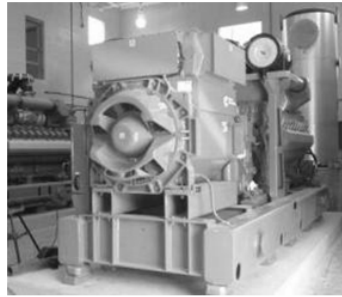
New Project (CAPS) will Model DCWater's Collection-System-wide CH₄ Emissions

- Calibration of
 - Potomac Interceptor
 - Potomac Forcemain
- Estimation of system-wide emissions
- Parallel H₂S investigation
- Calibration/testing of mitigation chemicals





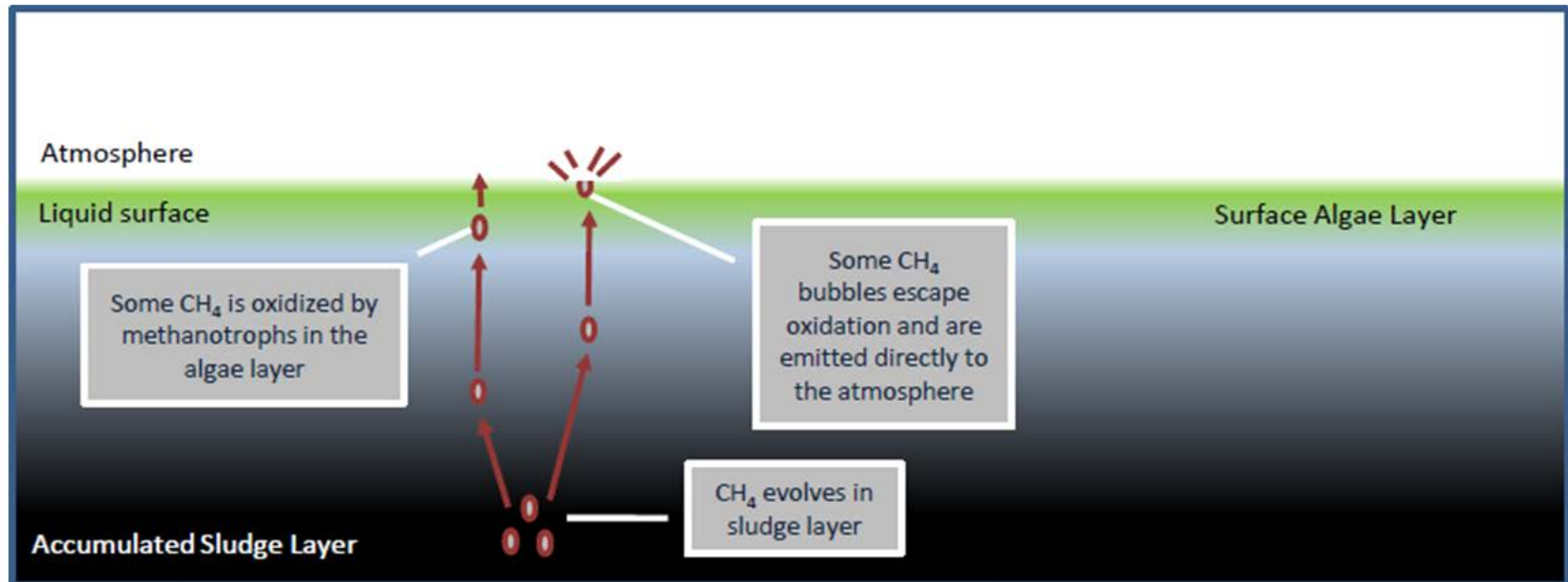
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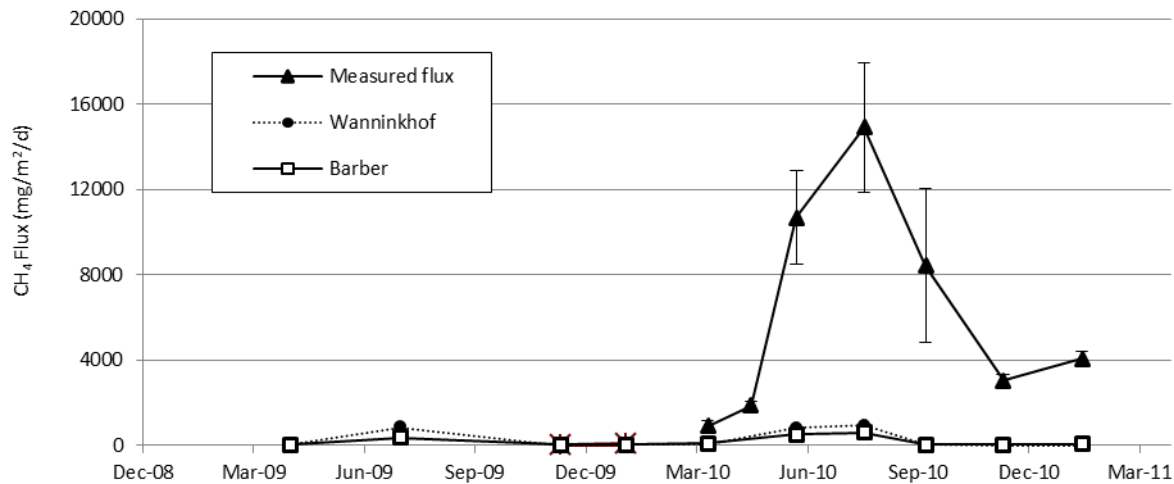
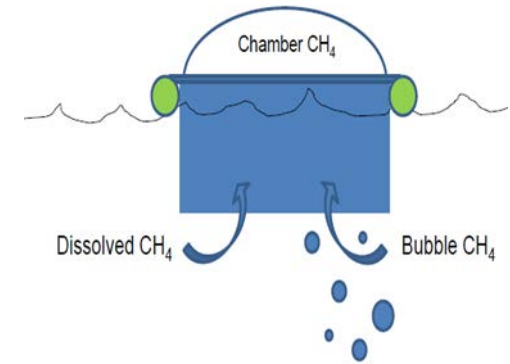
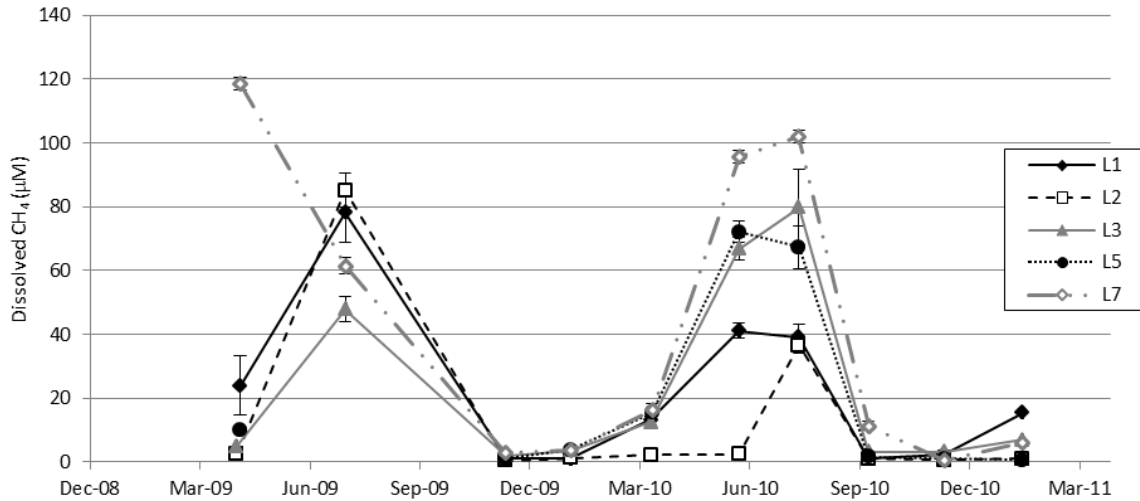
Fugitive Methane Research: Lagoons and Ponds

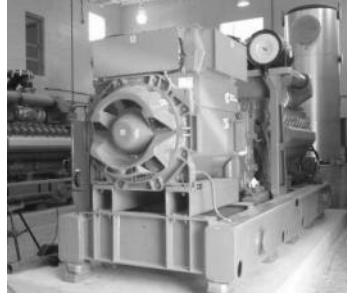
Explored Methane Evolution, Processing and Emissions from Low-Energy Treatment Processes

- Teamed with Ames (NASA)
- Tested Photosynthetic Oxidation Ponds and Facultative Sludge Lagoons (fed from digesters)



Results to be Published in next 6 months





Summary

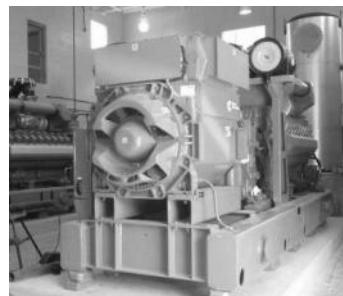


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Summary

- WERF has been doing quite a bit of wastewater treatment research on:
 - How to Enhance Energy Production from Wastewater Treatment
 - Determination of Greenhouse Gas Emissions
- Log-on to www.WERF.org and become a subscriber





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