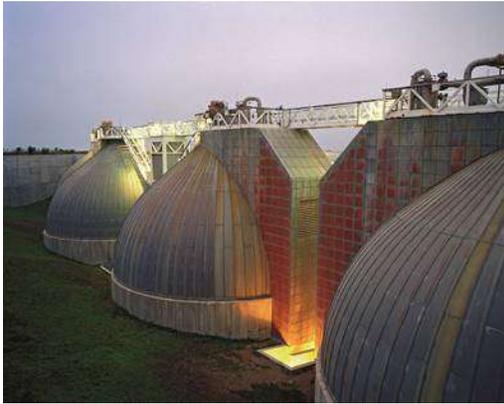


WATER ENVIRONMENT & REUSE FOUNDATION

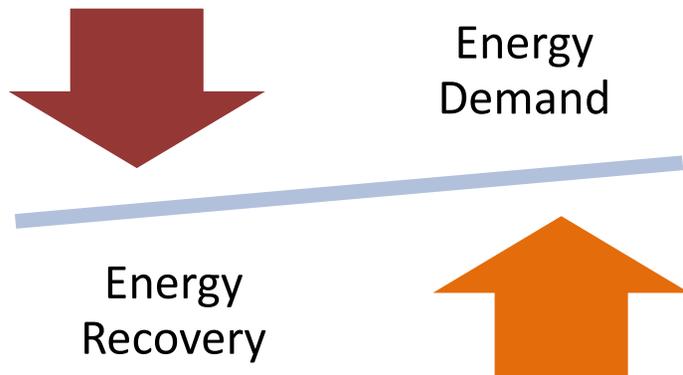
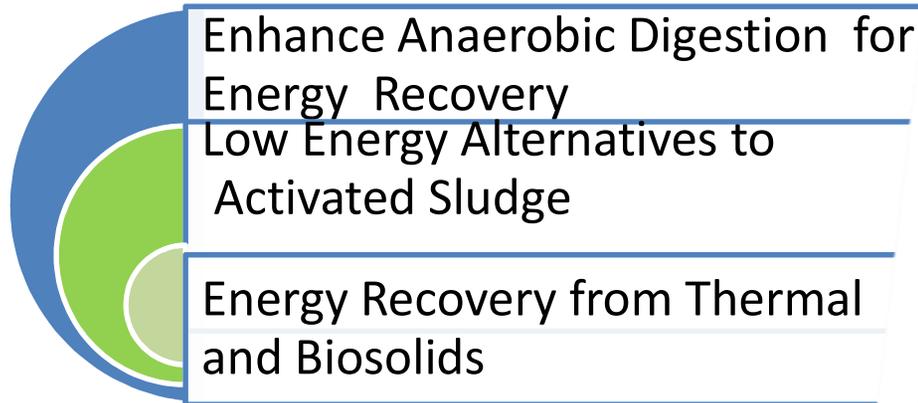


Recent WE&RF Energy Research and Action Opportunities

December 1, 2016



A Decade of Energy Research for the Water Industry



Fact Sheet

WERF
Water Environment Research Foundation
Collaboration. Innovation. Results.

Energy Production and Efficiency Research – The Roadmap to Net-Zero Energy

The energy contained in wastewater and biosolids exceeds the energy needed for treatment by 10-fold. However, our ability to harness that energy to produce energy neutral (or even net energy positive) wastewater treatment presents complex challenges based on facility size, operations, energy content of the influent wastewater, energy demand of the wastewater processes used, and where that energy will be used (i.e., either onsite or offsite). The Water Environment Research Foundation (WERF) has a new five-year research plan for energy production and efficiency with the goal of increasing the number of treatment plants that are net energy neutral and to establish energy recovered from wastewater as renewable.

This fact sheet describes what types of energy are available in wastewater, how can it be used or converted, and how to reach energy neutrality at a wastewater treatment plant (WWTP). The greatest potential for net positive energy recovery at wastewater treatment facilities occurs at larger facilities. While the larger facilities are only a small percentage of the treatment works nationwide, by switching the larger facilities to energy neutral and eventually energy positive operations, the energy resources in the vast majority of the domestic wastewater can be captured. This principle guided the domestic wastewater energy program to conduct the research needed to assist treatment facilities over 10 mgd to become energy neutral. The following material was collected by the exploratory team to inform them and direct future research efforts.

The energy content of wastewater includes:

- Thermal energy** or the heat energy contained in the wastewater which is governed by the specific heat capacity of water.
- Hydraulic energy** of two types. Potential energy is the energy due to the water elevation while kinetic energy is the energy from moving water (velocity).
- Chemical (calorific) energy** or the energy content stored in the various organic chemicals in the wastewater. The organic strength is typically expressed as a chemical oxygen demand (COD) in mg/L.

Energy Content of Domestic Wastewater

Domestic wastewater, the mixture of residential and commercial sanitary waste that is flushed into collection systems by rinse and wash water to centralised treatment facilities, contains energy. The wastewater has been warmed by users of hot water, it flows by gravity or is forced through sewer mains by pumps. The water's chemical constituents, which are high in carbon, contain calories. These energy-containing qualities make wastewater an attractive medium for energy recovery. Table 1 illustrates some of the energy values of wastewater constituents.

Table 1. Energy Content of Wastewater.

Constituent	Value	Unit
Average heat in wastewater	41,900	MJ/1°C/10 ⁶ ltr of wastewater
Chemical oxygen demand (COD) in wastewater	250 – 800 (400)	mg/L
Chemical energy in wastewater, COD basis	12 – 15	MJ/kg COD
Chemical energy in primary sludge, dry	15 – 15.9	MJ/kg TSS
Chemical energy in secondary biosolids, dry	12.4 – 13.5	MJ/kg TSS

Schubert, 2009

Current Energy Requirements for Wastewater Treatment

As currently practiced, domestic wastewater treatment is an energy-demanding process. By far the most common energy demand for wastewater treatment is to provide oxygen for a biological system such as an activated sludge treatment. **Approximately 60% of the energy used at wastewater treatment facilities is for aeration.**

Other common energy uses include mechanical pumping to move water around the treatment plant. Considerable energy is lost in this process due to friction in pipes, channels, pumps, and motors. Electrical energy is also used to operate mechanical equipment in the treatment plant, including screens, scrapers, and mixers, as well as many mechanical devices in solids management (e.g., centrifuges, presses, and conveyors).

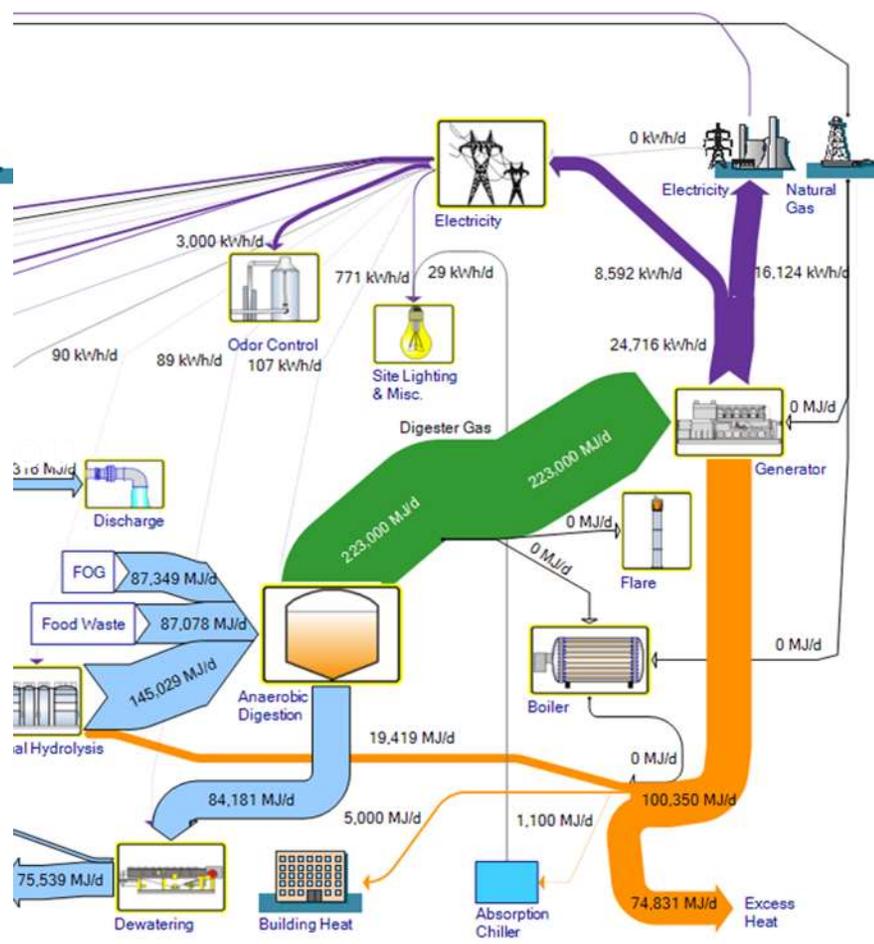
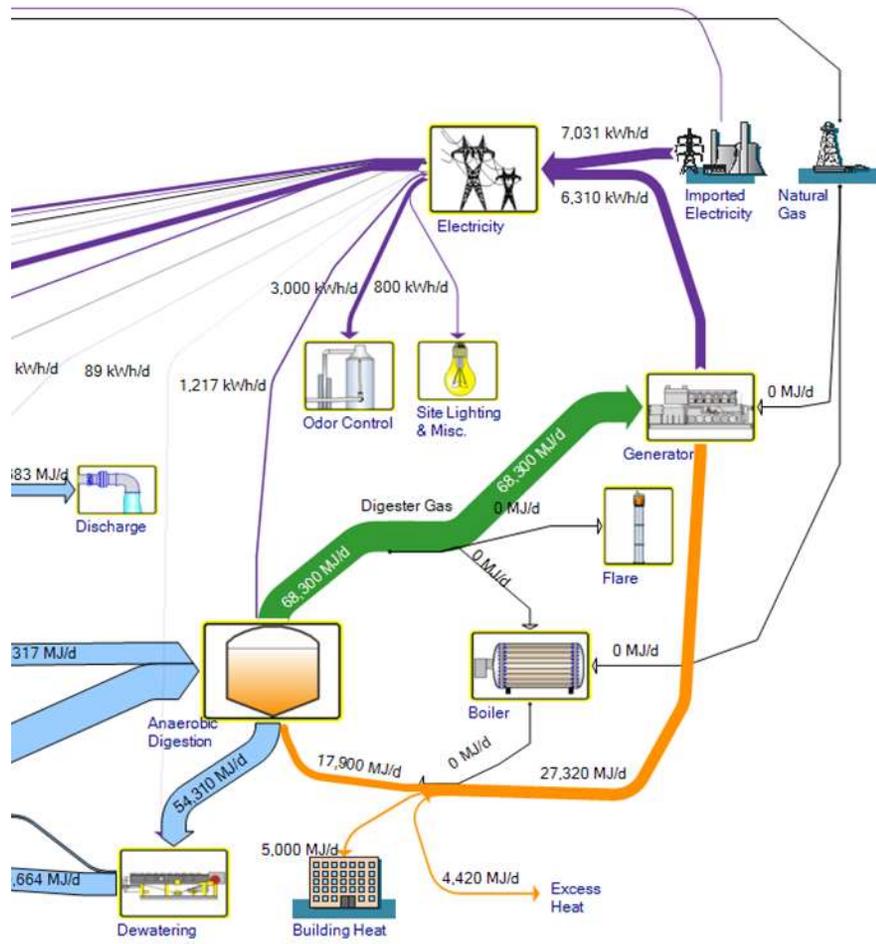
WERF
WATER ENVIRONMENT RESEARCH FOUNDATION

What is the Estimated Potential for Biogas Production Nationwide from Water Resource Recovery Facilities (WRRFs)?

- Nationwide volumetric biogas production potential from domestic WRRFs:
- From 5 mgd size upwards – 1027 facilities which can produce biogas
 - **113** billion cubic ft/year.
 - **67.8** trillion BTUs/year



Energy Flow Diagram Comparison



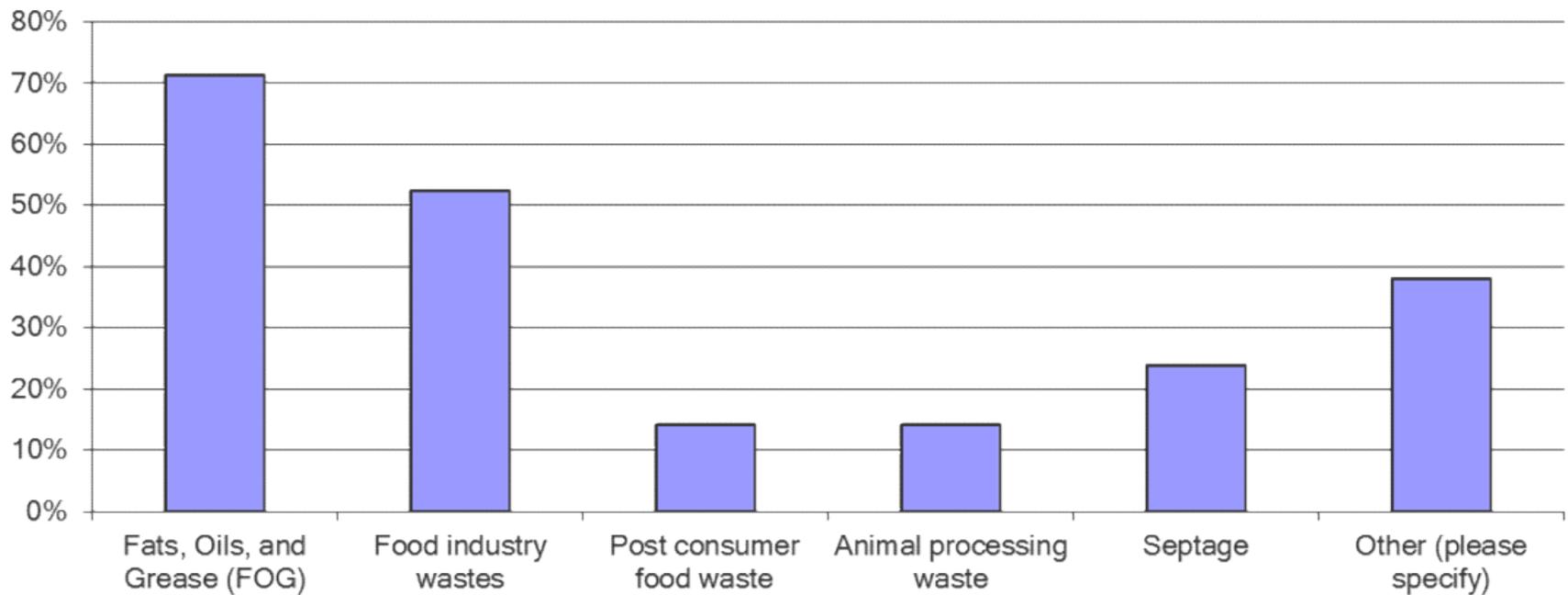
Food Waste – Co-Digestion Feedstock

- USEPA (2015) estimates that 35.2 MM tons of food waste are discarded annually with an energy content of 132 T BTUs
 - Source separated organic food waste
 - Food industry waste streams (such as yogurt factory waste)
 - Grease trap and restaurant / institutional wastes



WE&RF Survey Results:

Co-Digested High Strength Organic Wastes (HSWs)

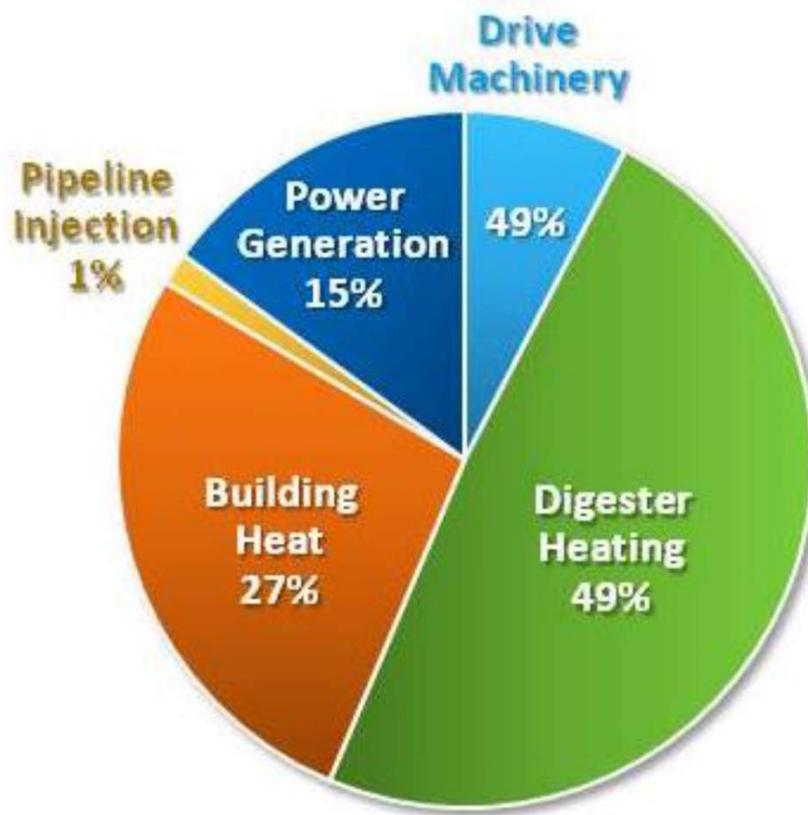


Average amount – 20 MG/year

Glycerin,
Aircraft Deicing
Fluid

Beneficial Use of Biogas

- 85% of WRRFs with anaerobic digestion use their biogas in some manner (WEF, 2012)

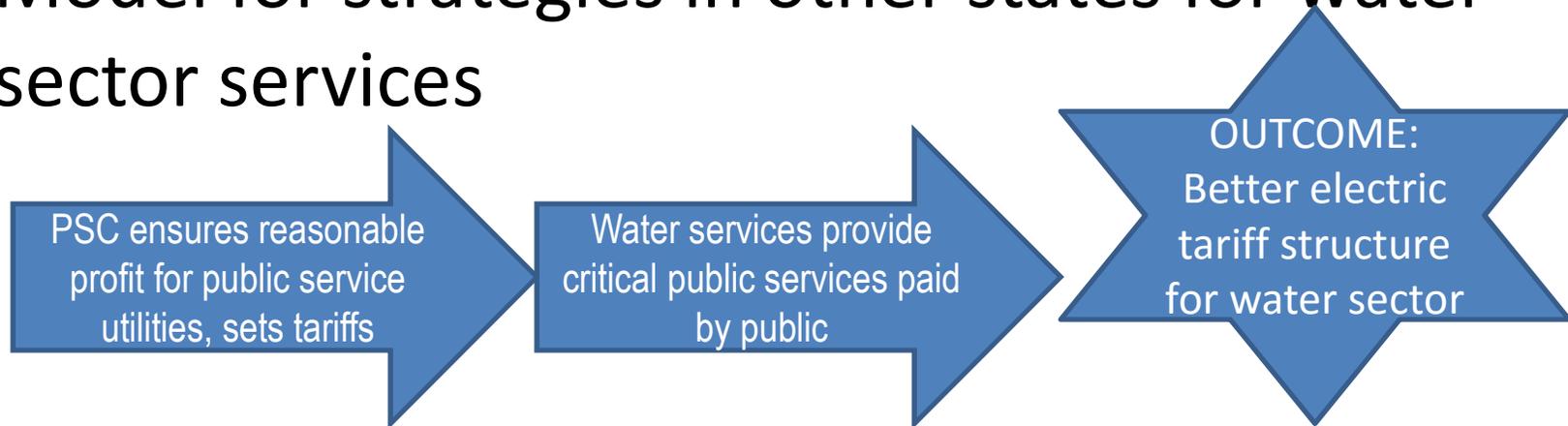


Assessing the Benefits and Costs of Anaerobic Digester CHP Projects in NY State

- Findings: **Electrical Tariff Provisions Erode CHP Project Savings – result abandoned biogas CHP projects in feasibility study phase**
 - High demand charges, fixed charges and standby fees, minimum demand thresholds
- Tariffs set differently in each state by Public Utility Commissions and state regulations
- Public Utility Regulatory Policy Act of 1978 still applies in some states. States in MISO, PJM, ISO-NE, and the NY-ISO territories which provide wholesale markets that meet the statutory criteria qualify for relief from the mandatory “must purchase” obligation. WE&RF study by Brown and Caldwell (ENER7R13e)

Advance Strategies to Enable Energy Savings and Recovery at WRRFS

- Pursue a tariff structure specifically for water sector by petitioning the NY PSC.
 - The NYSUNY system procurement group did this successfully previously, setting a NYS precedent.
- Model for strategies in other states for water sector services



Barriers and Drivers Influencing Biogas Use for Renewable Energy

Convert to Electric Power	Upgrade to RNG for Sale or Use
<ul style="list-style-type: none"> • Barriers to sale to grid as distributed power • Must use onsite • Conversion loss to electric power • Electric provider agreements reduce any cost savings even from use onsite • RECs available in some states • Must remove contaminants (water H₂S, siloxanes) 	<ul style="list-style-type: none"> • Access/market for biogas as RNG unknown but supported by AGA and RNG Coalition • Under Renewable Fuel Standard - Cellulosic RINs available when used as vehicle fuels as well as Advanced Biofuel RINs • RECs available in some states • Must remove contaminants (water H₂S, siloxanes)

Economically Better Choice

Renewable Fuel Standard (RFS) Program

- Created under Energy Policy Act of 2005 - established the first renewable fuel volume mandate in the US
- Energy Independence and Security Act of 2007 established new fuel categories and requirements
- Biogas qualifies in both D3 (cellulosic biofuel) and D5 (Advanced Biofuel) categories
- Must be used for transportation fuel

RIN Classification Codes

Category	Code	Description of Fuel
Cellulosic Biofuel	D3	Any process that converts cellulosic biomass to fuel: ethanol, renewable gasoline, biogas-derived CNG and LNG
Biomass- Derived Diesel	D4	Biodiesel, renewable diesel, jet fuel, heating oil
Advanced Biofuels	D5	Biodiesel, renewable diesel, sugarcane ethanol, heating oil, waste digester-derived CNG and LNG
Renewable Fuel	D6	Corn ethanol
Cellulosic Diesel	D7	Cellulosic diesel, jet fuel, heating oil

RIN Category	Code	Spot Price (\$)	Previous	4 week avg.
Cellulosic	D3/D7	March 2016	- WEF Biofuels Task Force	
Current Year		1.8400	1.3300	1.4575
Previous YR		1.3400	0.6400	0.8150



EPA Finalizes Increase in Renewable Fuel Volumes



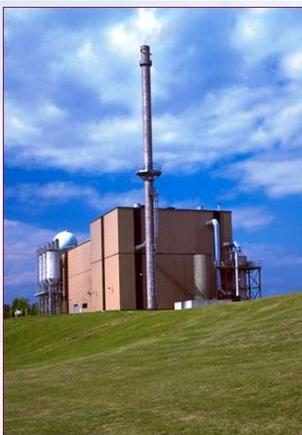
	2014	2015	2016	2017	2018
Cellulosic biofuel (million gallons)	33	123	230	311	n/a
Biomass-based diesel (billion gallons)	1.63	1.73	1.9	2.0	2.1
Advanced biofuel (billion gallons)	2.67	2.88	3.61	4.28	n/a
Renewable fuel (billion gallons)	16.28	16.93	18.11	19.28	n/a

Is the RFS here to stay?

- WRRFs and the Renewable Natural Gas industry need assurances that the RFS will stay
- There have been several unsuccessful attempts to repeal the RFS. These are ongoing and may be successful under the new administration
 - “The oil industry has made a concerted, organized, and well financed attack on the RFS. A lot of focus has been on EPA..., but the oil industry has gone to court to limit the impact of the RFS ...and to Capital Hill to curtail or restrict the RFS.”
- Tom Vilsack, US Agriculture Secretary
- *Opportunity for Advocacy to retain the RFS and thwart any repeal efforts for the benefit of biogas to RNG projects at WRRFs.*

Energy Recovery from Thermal Oxidation of Wastewater Solids: State of Science Review

WERF Project ENER13T14



Robert P. Dominak
Friar Consulting
September 27, 2016



Co-Authors: W. Hoener, G. Queiroz, J. Welp

weftec[®] 2016



TECH SESSIONS

Study - Research Approach

- Evaluate potential energy recovery from the combustion of wastewater solids and FOG in MHIs and FBIs.
- Conduct a triple bottom line analysis comparing:
 - a. The value of energy recovered from combustion of wastewater solids.
 - b. The value of energy produced from burning coal at a power plant.
- Prepare a State of the Technology document covering:
 - a. Existing and emerging technologies used to recover heat & energy.
 - b. Three case studies of POTWs that recover heat & energy from the combustion of wastewater solids.



Today's Presentation

Case Studies

- **Metropolitan WWTP**
St. Paul, MN



← **Köhlbrandhöft & Dradenau WWTPs** →
Hamburg, Germany



- **North WWTP**
Menands, NY



Outcomes of Energy Research and Information Exchange

- US Department of Energy
 - LIFT Test Bed Network



DoE Better Plants Program



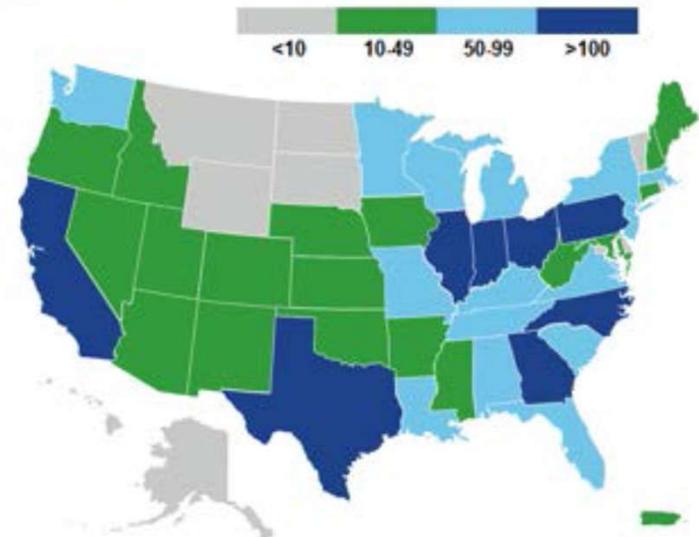
ENERGY SAVINGS AND PROGRAM FOOTPRINT CONTINUE TO GROW

<https://betterbuildingsolutioncenter.energy.gov/better-plants/special-initiatives/water-and-wastewater>

Better Plants Snapshot

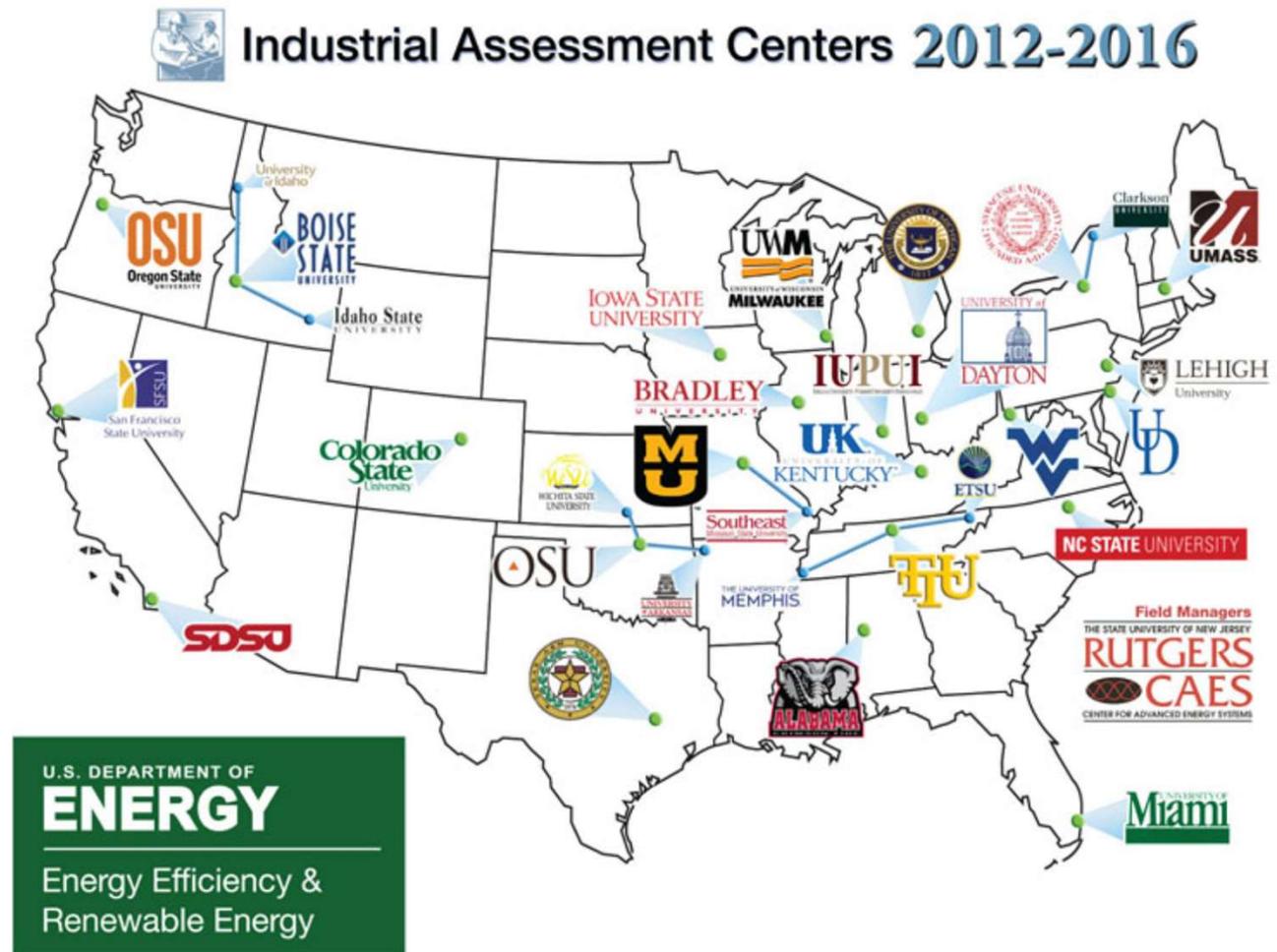
Partnership Size	Total
Number of Partner Companies	157
Approximate Number of Facilities	2,400
Percent of U.S. Manufacturing Energy Footprint	11.4%
Reported Savings through 2014	
Cumulative Energy Savings (TBtu)	457
Cumulative Cost Savings (Billions)	\$2.4
Cumulative Avoided CO ₂ Emissions (Million Metric Tons)	26.6
Average Annual Energy-Intensity Improvement Rate	2.1%

Regional Distribution of Better Plants Facilities



Industrial Assessment Centers

- Qualifying Better Plants Partners receive free energy audits from DOE's IACs
- IACs are university-based centers, led by professors and staffed by engineering students
- Typical audit uncovers savings equal to about 8% of plant-wide energy consumption



Questions? Comments?



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