  

Towards Energy Neutrality - Results and Findings of Recent Research

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Metropolitan Washington Council of Governments

Introductions

Water Environment & Reuse Foundation

Alexandria, Virginia

www.werf.org

Allison Deines

Director of Special Projects

Lauren Fillmore

Senior Program Director

Deliver Balanced Research

- Manage peer-reviewed research to deliver timely, actionable results

Foster Innovation

- Convene experts and support research to accelerate the adoption of new water technologies

Create Collaboration

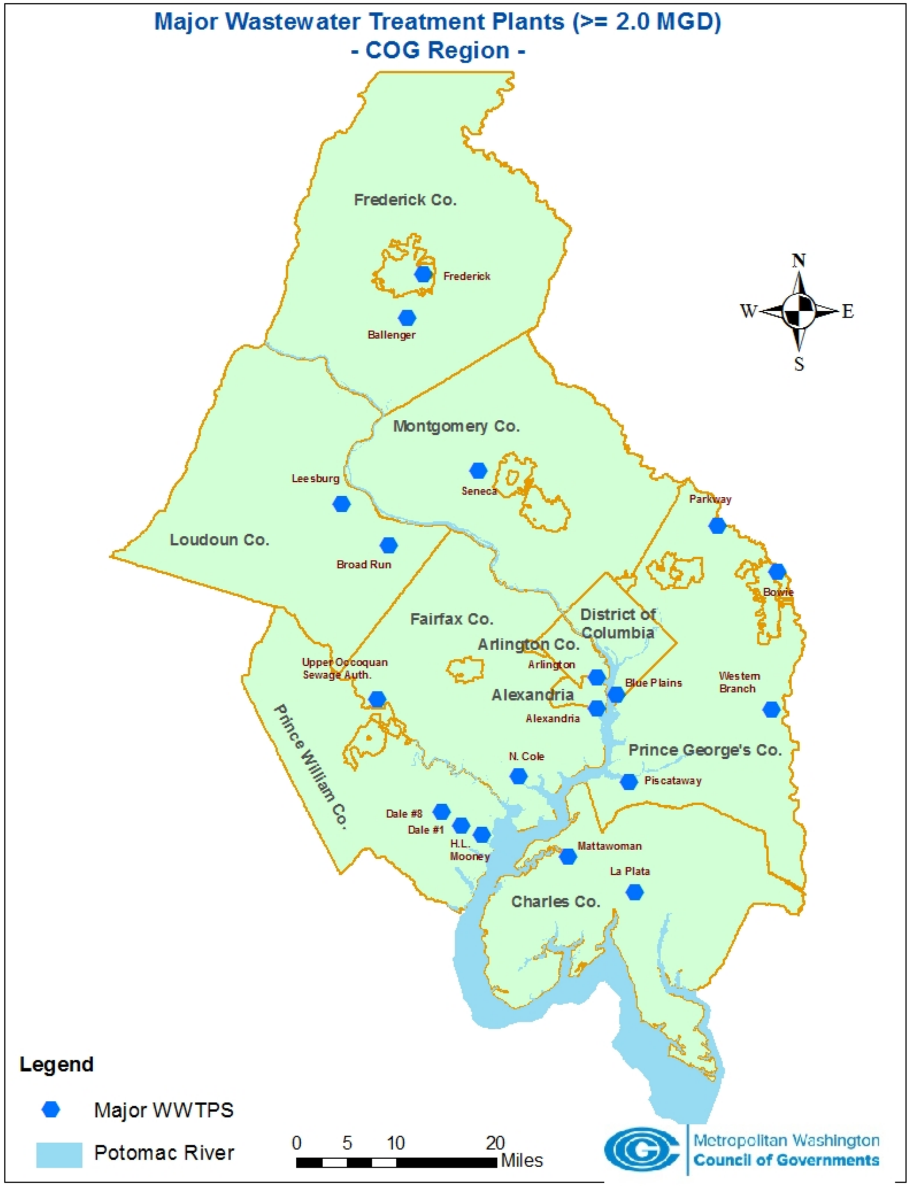
- Serve as a research hub for the water quality community (utilities, policy makers, consultants, universities, and industry)

Disseminate Results

- 35-40 reports published annually that are housed in an online, searchable database

WE&RF Subscribers are MWCOG Members:

- AlexRenew
- Arlington County
- DC Water
- Fairfax County
- Loudoun Water
- Prince Wm County Service Authority
- Washington Suburban Sanitary Commission



How much Electricity is used Annually, Nationwide by the Water Sector?

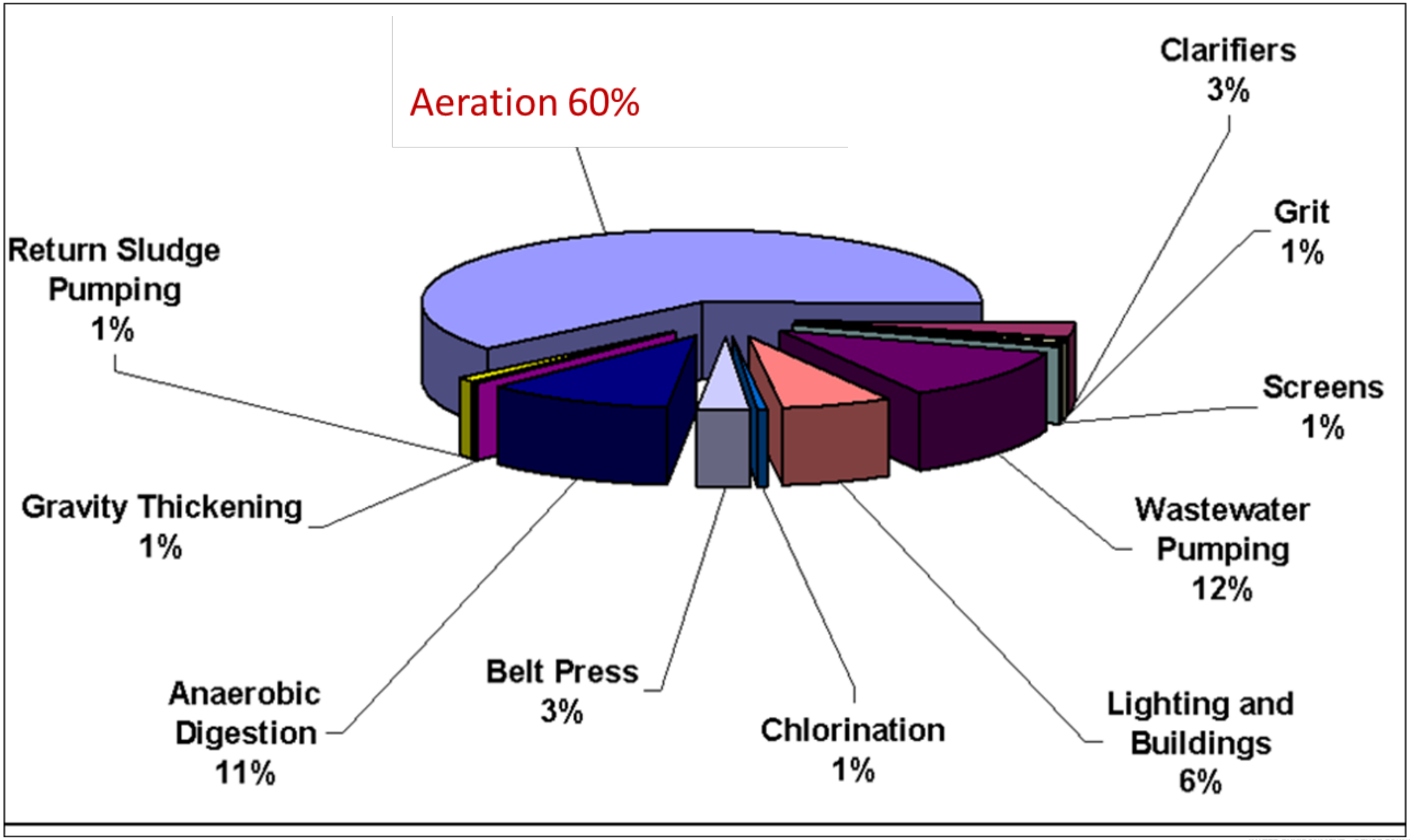
22.3 -30 billion Wh/year electric power used by WRRFs
39 billion Wh/year electric power for drinking water

0.6% from wastewater
1.4% from drinking water

Top Electric Power Using Sectors	Percentage
Chemicals	5.21
Forest products	3.74
Food and beverage	2.26
Water and Wastewater combined	**2.0**
Iron and Steel	1.66
Transportation equipment	1.50
Petroleum refining	1.47
Plastics	1.40

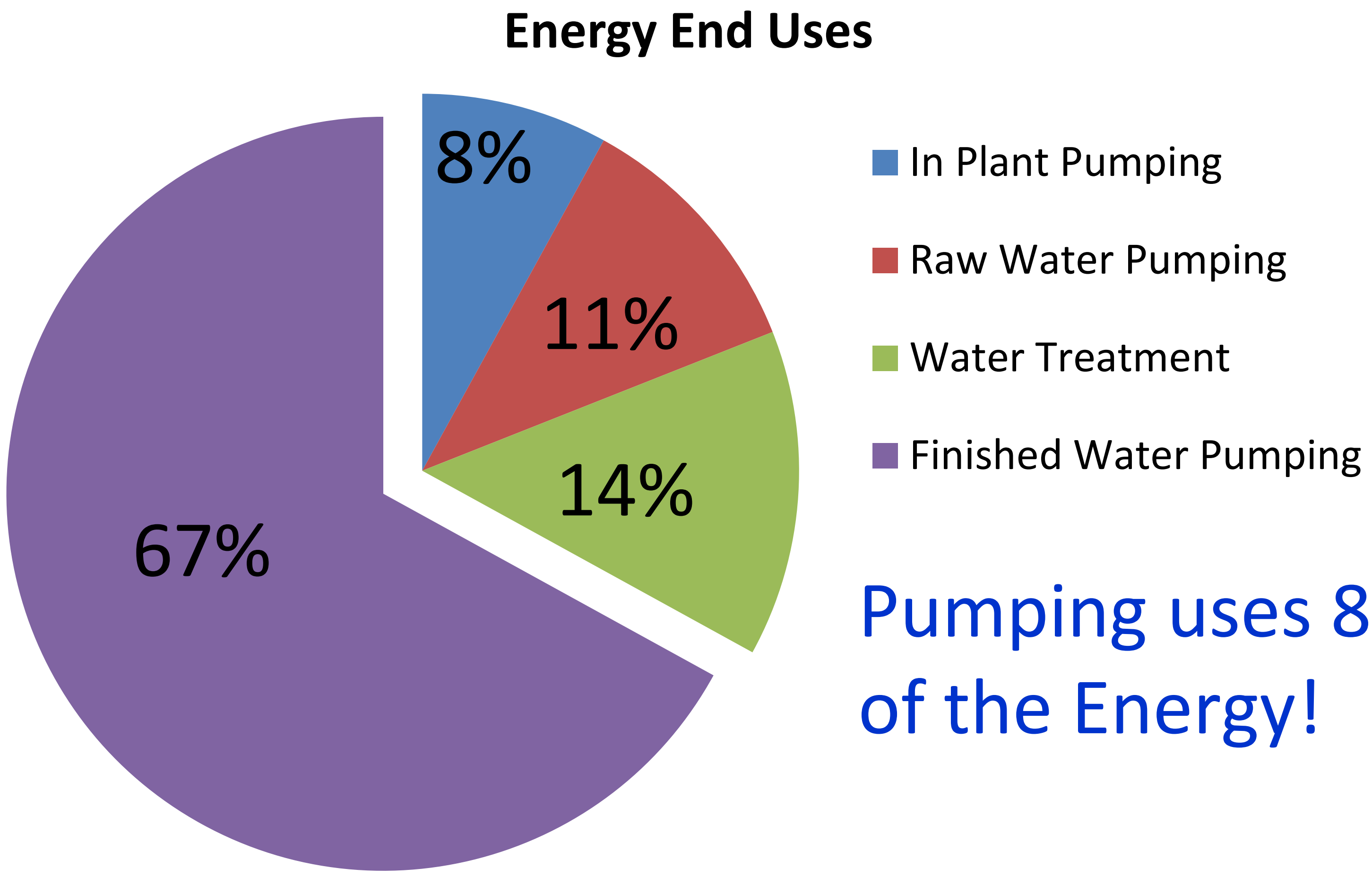
How Energy is Used for Wastewater Treatment

source: EPRI 2013; WERF 2014



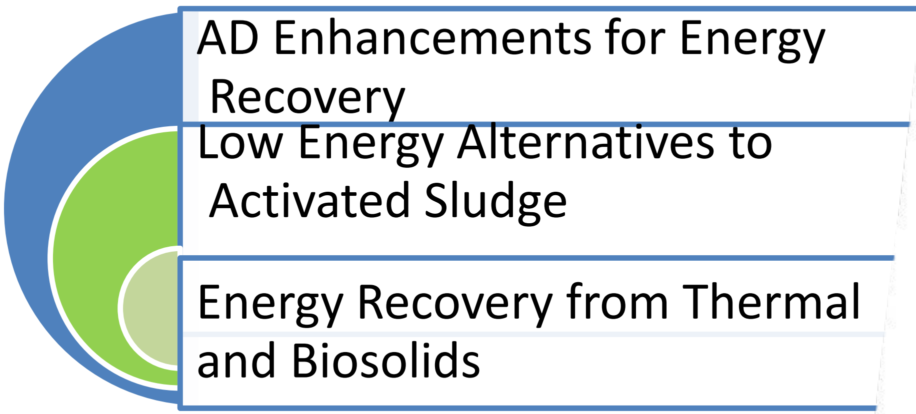
How Energy is Used for Drinking Water Treatment & Supply

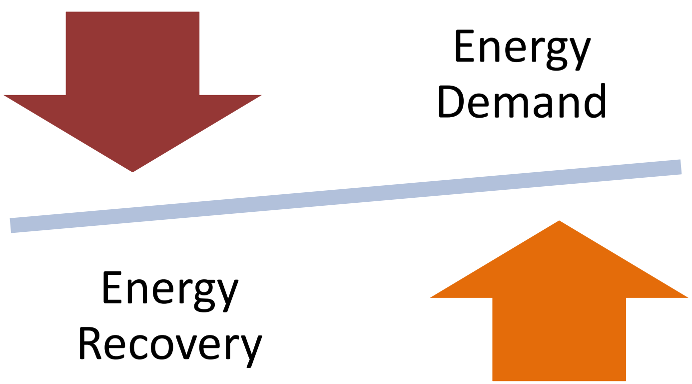
source: EPRI 2013;



Pumping uses 84% of the Energy!

A Decade of Energy Research for the Water Sector





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 waste-water 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 a WERF exploratory team to prepare a 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 collections systems by rinse and wash water to centralized treatment facilities, contains energy. The wastewater has been warmed by the 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	[illegible]
Chemical oxygen demand (COD) in wastewater	250 – 800 (430)	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

Tchobanoglous, 2009

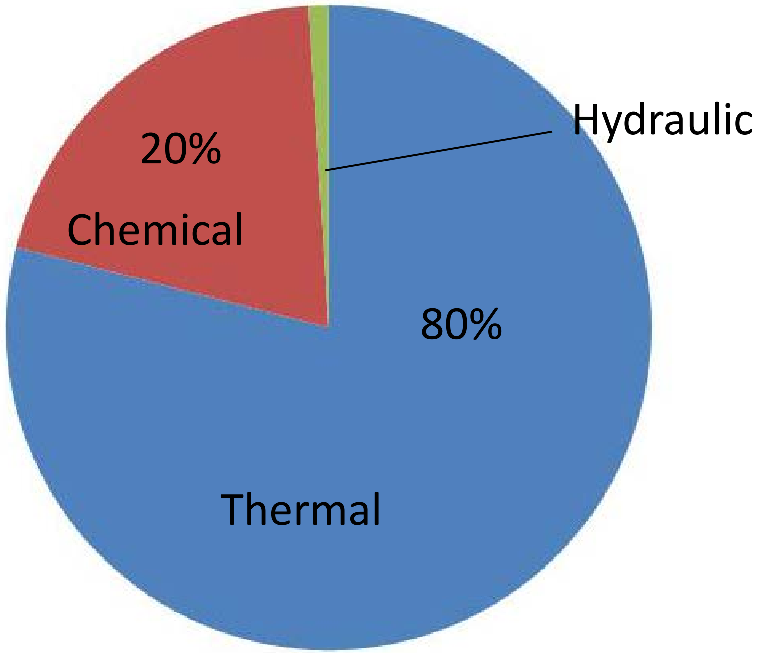
Current Energy Requirements for Wastewater Treatment

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).

What is the Nationwide Potential to Recover Energy from the Wastewater Sector?

- There is more energy in wastewater than is needed for treatment – **about 5X more**
- Total energy potential is 851 trillion BTU/year.



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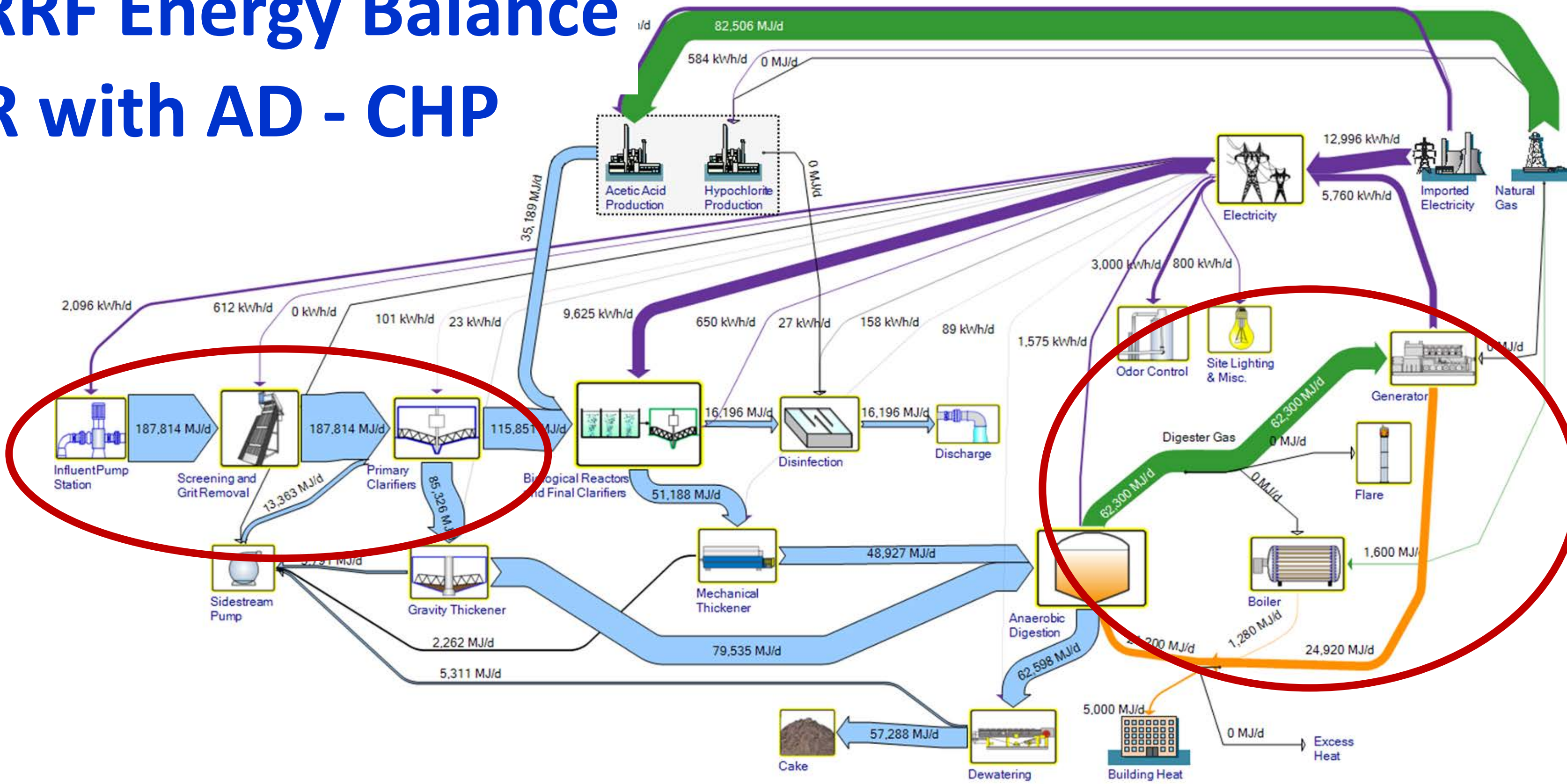
What is the Estimated Potential for Biogas Production Nationwide?
For thermal energy recovery from WRRFs?

- Nationwide volumetric biogas production potential.
  - 113 billion cubic ft/year.
  - 67.8 trillion BTUs/year
- Thermal energy estimated at 691 trillion BTUs/year.
  - Recoverable heat from 17 major cities is potentially 412 trillion BTU per year.

WRRF Energy Balance
BNR with AD - CHP



- 31% of influent chemical energy remains in dewatered biosolids.
- 33% of influent chemical energy converted to digester gas.
- Supplemental Carbon for BNR requires significant energy to produce (2.3 times energy in per COD energy out).

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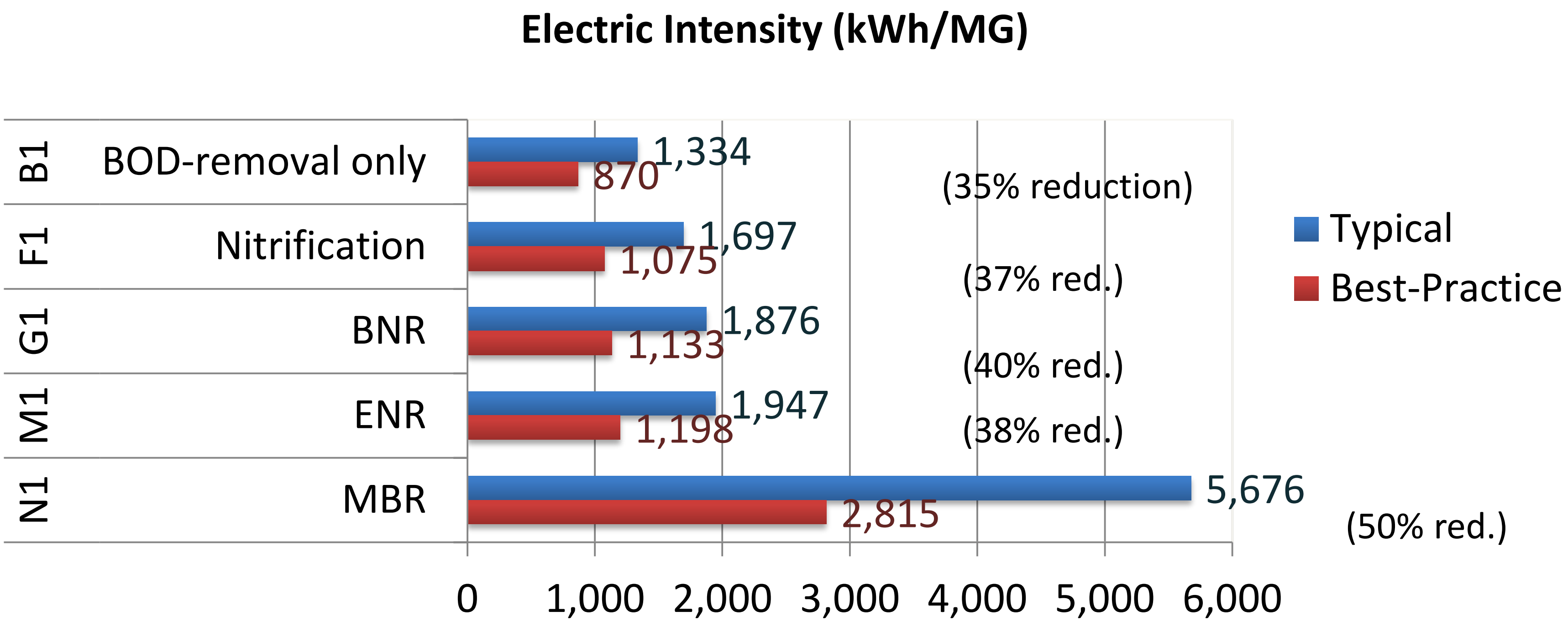
A Guide to Net-zero Energy Solutions for WRRFs

Electric Power Demand Typical vs. Best Practice



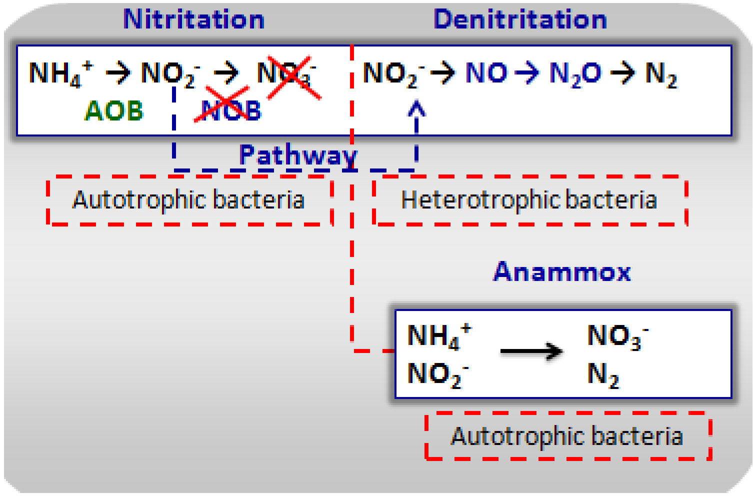
- **40% average reduction from typical operations to best practices**

Energy Recovery Potential By Adding Emerging Technologies

Facility Process (Anaerobic Digestion with CHP for Biosolids Management)	Before Best Practices	Electric Neutral	Primary Energy Neutral
BOD removal only with CEPT, THP and Co-digestion added	85%	139%	139%
Nitrification with CEPT, THP, Codigestion and Sidestream deammonification		110%	110%
BNR with CEPT, fermenter, THP, Co-digestion	13%	61%	61%
ENR with CEPT, fermenter, THP, Co-digestion		49%	39%

What is Short-cut Nitrogen Removal?

- Reduces nitrogen while using less energy and supplemental carbon
- Established as sidestream treatment
- Emerging research for mainstream treatment
- Includes two process types:
  - Nitritation – Denitritation
  - Partial Nitritation - Anammox = Deammonification



Potential Energy Savings and Short-Cut Nitrogen Removal

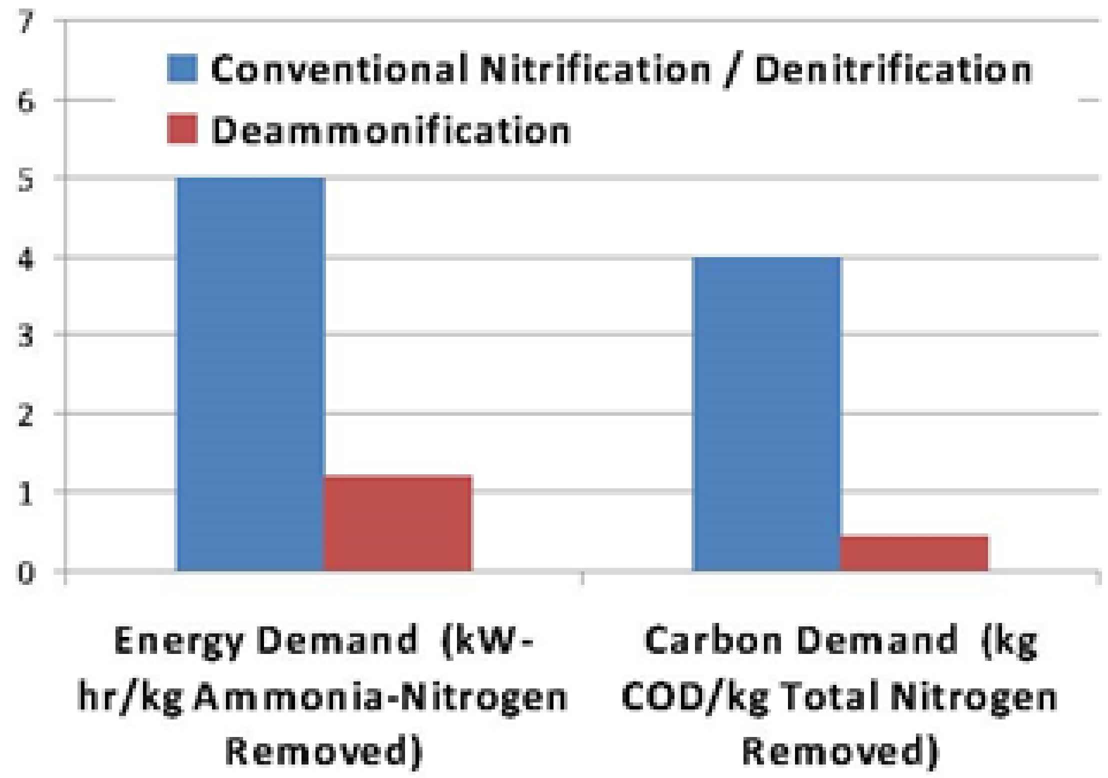


Figure 1: Energy and carbon demand comparison for nitrogen removal using deammonification and conventional nitrification/denitrification

Short Cut Nitrogen Pioneers in Chesapeake Bay Watershed

AD Digestate Sidestream Process

- *AlexRenew* – SHARON®
- *DCWater* – Blue Plains - DEMON®
- *HRSD* – James River – ANITA™ Mox
  - York River – DEMON®

Cyclone used for mainstream deammonification demonstration

Close up view of ANITA™ Mox biofilm

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WRRF *"Energy Solutions"* Results, Next Steps, and Research Needs

- ✓ Consistent ***use of Best Practices*** can reduce energy demand by 40% but it cannot achieve energy neutral
- ✓ ***Maximize carbon management*** for energy recovery or reuse. Improving primary treatment/solids capture had the greatest positive impact of those evaluated
- ✓ ***Further enhance*** Anaerobic Digestion with CHP using co-digestion to produce more biogas for energy recovery
- ✓ Investigate the potential for ***heat recovery*** from wastewater and heat reuse opportunities
- ✓ Advance ***short-cut nitrogen treatment*** development and implementation as low energy alternative treatment process
- ✓ Develop processes to ***recover remaining energy*** from dewatered biosolids

What can Drinking Water Utilities do to Recover Renewable Energy?

- Solar, wind, hydro (micro hydro) and geothermal power
- WE&RF collaboration with Water RF to expand a tool for planning level decision-making

gelcat green ENERGY LIFE CYCLE ASSESSMENT TOOL

Water Research Foundation

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Drinking Water Energy Solutions and Next Steps

- Reduce Non-revenue Water Losses
- Use of Best-Practices
- Strategic Energy Management Planning (Energy Roadmap, Gap-Analysis)
- Equipment improvements and energy efficient pump systems
- Partner with electric utility for best rates and demand management strategy

Questions? Comments?

Allison Deines
Director of Special Projects
adeines@werf.org

Lauren Fillmore
Senior Program Director
lfillmore@werf.org