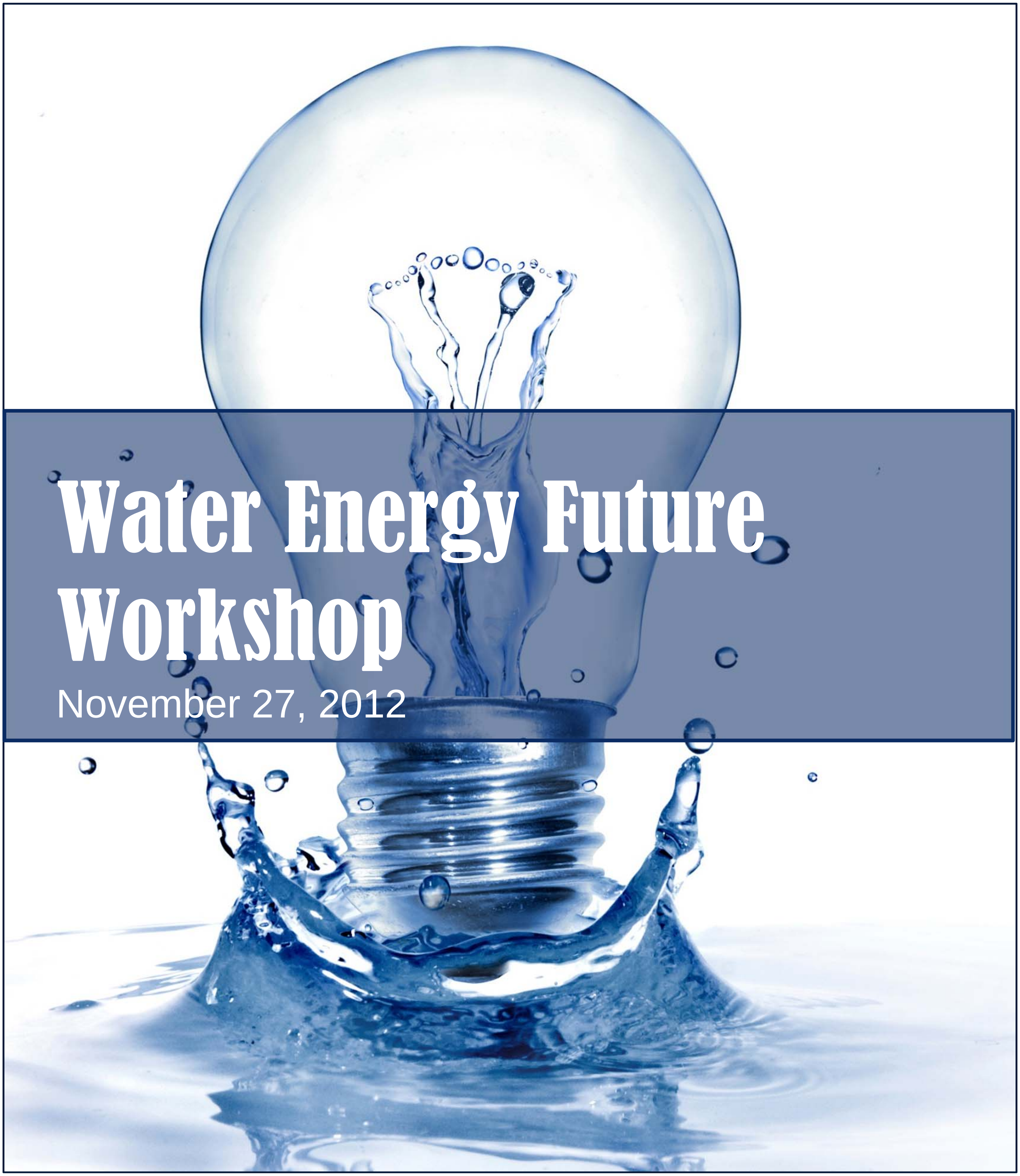
Water Energy Future Workshop

November 27, 2012



This report was developed from the Water Energy Future Workshop, a meeting hosted by the Water Environment Federation, Danfoss and the Alliance to Save Energy on November 27, 2012.

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The Water Energy Nexus

Water and energy are interdependent resources, each with a cost to the other. Energy production itself has impacts on water quality. Furthermore, the production, distribution, collection and treatment of water take a great deal of energy.

2 Introduction

On Nov. 27, 2012, the Water Environment Federation (WEF), Alliance to Save Energy (ASE), and Danfoss hosted a workshop with a broad representation of energy and water experts from federal agencies, local government, non-governmental organizations, finance, and industry.

The meeting focused on the need for coordination among stakeholders in the water and energy sector to increase energy generation and efficiency at wastewater treatment facilities. During discussions, participants identified barriers and solutions in the key areas of policy, finance, and technology. One of the goals of the meeting was also to define a set of actionable steps to advance energy efficiency and generation in the water sector.

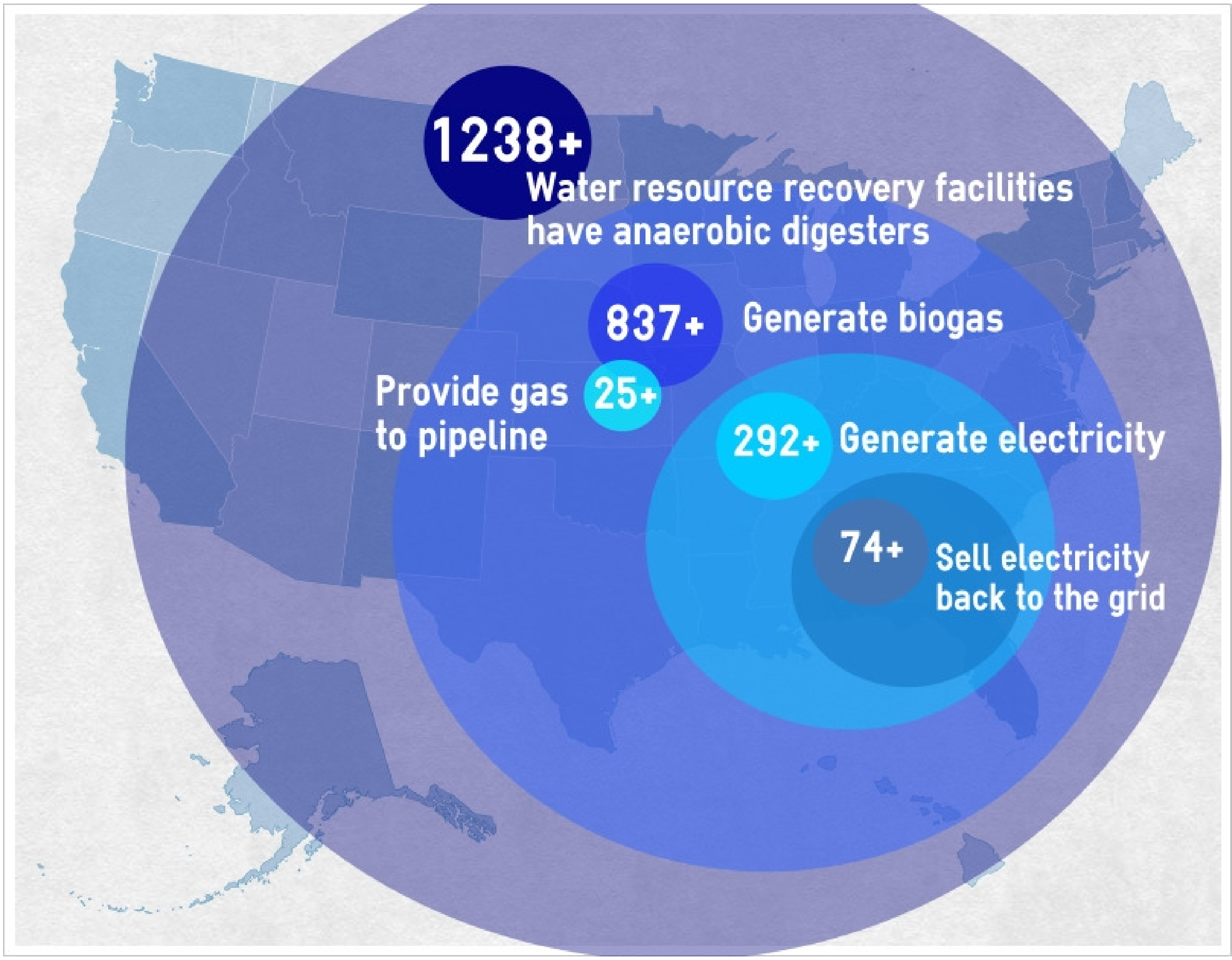
Meeting participants included senior staff from the U.S. Environmental Protection Agency (EPA), Department of Energy (DOE), U.S. Department of Agriculture (USDA), Bureau of Reclamation, and the House Water Resources Subcommittee. There were also representatives from a variety of engineering and consulting firms that specialize in energy resource recovery from wastewater.

2.1 Background

Water and wastewater facilities represent about 3-4% of U.S. electricity consumption. According to the DOE, these facilities are the third largest energy consumers, using more than 55 billion kilowatt hours per year. On the reverse side, it takes between 3,000 and 6,000 gallons of water to power one 60-W incandescent bulb for 12 hours per day over the course of a year, according to EPA.

However, there are many opportunities to improve energy efficiency at treatment facilities, from technology improvements to more efficient system design. Energy generation at wastewater facilities is already a reality. In fact, some plants are generating enough energy for onsite use and selling electricity back to the grid. The most common generation method is anaerobic digestion, which is used to create biogas. Anaerobic digestion is used at about 1,238 water resource recovery facilities (WRRFs) in the U.S. It is a process by which bacteria break down organic material without oxygen. As a result, the bacteria produce carbon dioxide and methane, also known as biogas, which can be used to generate energy. Only about 292 facilities generate energy, while many others flare the biogas without a way to harness its potential. In the U.S., WRRFs that do generate large quantities of energy generally do not use municipal waste alone. Cooperation with food or agricultural entities is often an important source of organic material. However, there are utilities in Europe and Canada that are energy neutral and use only municipal waste.

Biogas from Water Resource Recovery Facilities (2012)



DATA SOURCE: http://www.biogasdata.org

3 Presentations

This workshop is intended to identify critical issues, barriers, solutions, and immediate actions in the water an energy space.

3.1 WEF's Role in the Water-Energy Nexus

Presenter: Dr. Barry Liner, PE, Director of WEF's Water Science & Engineering Center

WEF is a nonprofit technical and educational organization for the advancement of the water sector. One of WEF's key focus areas is on resource recovery from wastewater, one of those key resources being energy. WEF's goal is to drive WRRFs to become sustainable energy consumers and producers.

Highlights

- WEF advocates that wastewater treatment plants are not waste disposal facilities, but rather water resource recovery facilities that produce clean water, recover nutrients, and have the potential to reduce the nation's dependence upon fossil fuel through the production and use of renewable energy.
- WEF's has developed an energy roadmap—a guide for WRRFs to reach energy neutrality and beyond.

In 2011, WEF hosted its first energy-specific conference. WEF's second biennial energy conference, Energy and Water 2013, will be held in Nashville May 6 – 9.

Innovation was a major theme at WEFTEC 2012—in technical programming and roundtable discussions. During meetings with EPA—an interested partner on WEF's energy initiatives—WEF members identified many barriers to energy generation at water resource recovery facilities.

- Plants using anaerobic digestion but not producing energy are flaring gas and wasting that potential energy.
- Some power utilities help with conservation, but hinder WRRFs that try to generate energy.
- Payback times are a barrier, often utilities are only doing projects with short payback periods (even as short as 2 years).
- There is money in the private sector that is not being used for water infrastructure.

WEF's Energy Roadmap is a series of steps arranged in six categories to help water and wastewater utilities plan and implement an energy program. The road map is applicable whether plants choose simply to increase energy efficiency or to build a full-scale cogeneration system. Topics range from technical needs to managerial aspects, and steps are applicable to small, medium, and large facilities.

3.2 Energy Policy and Regulation Landscape

Policies and other federal resources could be used to not only overcome barriers but to encourage and incentivize energy efficiency and generation in the water sector.

3.2.1 DOE's Role in the Energy Policy and Regulation Landscape

Presenter: Dr. Holmes Hummel, U.S. DOE, Senior Advisor, Office of Undersecretary of Energy

Efforts by DOE and the federal government to overcome barriers to energy efficiency and generation in the water sector:

Highlights

- DOE can help water and wastewater plants increase energy efficiency through the Better Plants Program.
- DOE offers support for ISO 50001
- DOE also supports funding options for improving energy efficiency as well as building codes, water reuse, and public outreach.

- Water and wastewater facilities can be part of DOE's **Better Buildings, Better Plants Program** by committing to reduce energy intensity by 25% over 10 years. Partners also have access to technical assistance and research and development from DOE.
- **ISO 50001** is the international energy management standard that provides a standard methodology for a wide range of stakeholders—industrial, commercial and institutional—to establish systems and processes to manage energy and improve energy performance transparently. DOE provides support for implementing the standard.
- In August of 2012, President Barack Obama issued an **Executive Order on Accelerating Investment in Industrial Energy Efficiency**. It calls for 40,000 MW of additional combined heat and power added to grid—led by DOE through the agency's Advanced Manufacturing Office.
- Public utilities have unique challenges with access to funding. However, about $2 billion in low cost capital is available to states in the form of qualified **energy conservation bonds**.
- DOE, the Department of Transportation and others have joined in support of an **infrastructure bank**.
- **Resilience and local energy assurance planning —** DOE has committed $50,000 to states and local communities to develop plans for emergency response. Every utility ought to have energy assurance plan. However, water resource recovery facilities aren't taken into account as critical loads. Do local authorities know what assets utilities have and their needs are?
- **Water reuse and harvesting** — why contaminate or treat more water than is necessary?
- **Building codes** can advance water and energy efficiency if users both adopt and comply with them. Codes have helped improve the energy efficiency of new buildings by 30%.
- **Public engagement and outreach** — DOE continues to work on compliance standards and public engagement (energysavers.gov). Many electric companies now offer customers easy access to their energy-use data (green button standard). Consumers deserve to have data about the resources they use in order to better manage them. Applications are also available on energy.data.gov that allow consumers to manage their energy use. This is needed in the water sector.

3.2.2 EPA's Role in the Water Policy and Regulation Landscape

Presenter: Dr. Ellen Gilinsky, U.S. EPA, Office of Water

As interconnected resources, reducing the demand of either water or energy can help conserve both resources. EPA is working to minimize the impacts of water and wastewater treatment processes on energy production and vice versa. Here are a few ways to reduce demand.

- Using programs like Energy Star and Water Sense,
- Reusing water (treatment for the appropriate use) and implementing a full cost rate structure,
- Using new technologies with improved energy and water efficiency,
- Eliminating leaks in collection and distribution systems,
- Conducting energy audits of water and wastewater facilities.

In addition to reducing demand, EPA is also focused on the potential for generating energy at WRRFs.

EPA is encouraging the water and energy sectors to move toward integrated resource management. In doing so, EPA is reviewing their policies to determine whether they have unintended consequences, such as preventing innovation.

EPA is also working to improve public outreach on the connection between water and energy and the value of both resources and the agency's efforts.

EPA's Six Principles for an Energy Water Future

1. Efficiency in the use of energy and water should form the foundation of how we develop, distribute, recover, and use energy and water.
2. The exploration, production, transmission and use of energy should have the smallest impact on water resources as possible, in terms of water quality and water quantity.
3. The pumping, treating, distribution, use, collection, reuse and ultimate disposal of water should have the smallest impact on energy resources as possible.
4. Wastewater treatment facilities, which treat human and animal waste, should be viewed as renewable resource recovery facilities that produce clean water, recover energy and generate nutrients.
5. The water and energy sectors – governments, utilities, manufacturers, and consumers –should move toward integrated energy and water management from source, production and generation to end user.
6. Maximize comprehensive, societal benefits.

3.3 Treatment Technologies and Strategies

Technologies exist that can improve energy efficiency at water utilities and allow water resource recovery facilities to become energy neutral.

3.3.1 Meet Strict BNR Limits at Net "0" Energy

Presenter: Elena Bailey, PE, Ovivo Water, Director Business Development North America

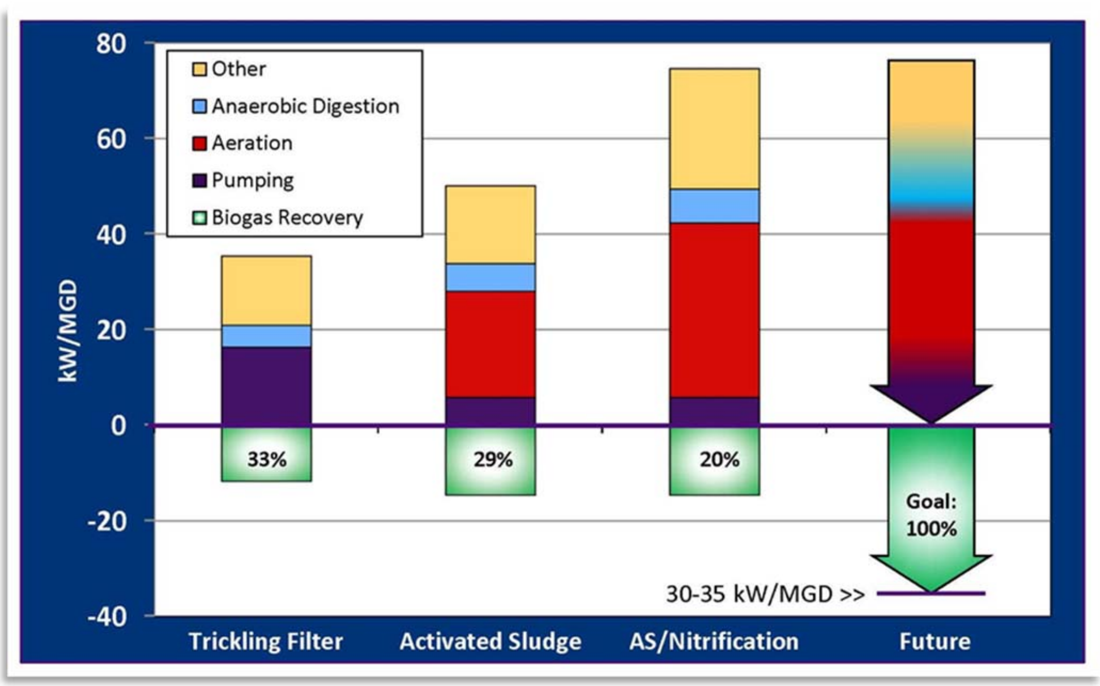
Highlights

- Energy demand increases as treatment requirements become more stringent.
- Processes and technologies exist to allow water resource recovery facilities to become energy neutral using municipal waste alone.
- There are no incentives to generate energy in the U.S.

WRRFs are constantly improving to meet more stringent treatment standards, such as biological nutrient removal limits. ***In general, treating wastewater to a higher standard requires more energy***. The challenge is meeting new strict water quality regulations and using less energy doing so. Everything in a WRRF uses energy, yet anaerobic digestion is generally the only process that generates energy. Most plants are not using anaerobic digestion because it is not incentivized.

While there are no plants in the U.S. that are entirely energy neutral using only municipal waste, there are some in Europe and Canada. This means the technology and the processes exist to accomplish energy neutrality. However, it requires WRRFs to change their processes by thinking outside of the box, for example, abandoning the conventional norm that uses biological processes to remove carbon.

Furthermore, becoming energy neutral using municipal waste does not cost much more. Yet, operators are typically evaluated by one key criterion — achieving permit requirements. So, there are no incentives to innovate. Another issue is that the value of water in the U.S. is artificially low.



A graph from Elena Bailey's presentation showing that, historically, processes at water resource recovery facilities require an increasing amount of energy. The data is from WEF's Energy Conservation in Wastewater Treatment Facilities (MOP FD-2, 1997)

3.3.2 Energy Systems Technologies and Strategies

Presenter: John Masters, Danfoss, Vice President

Highlights

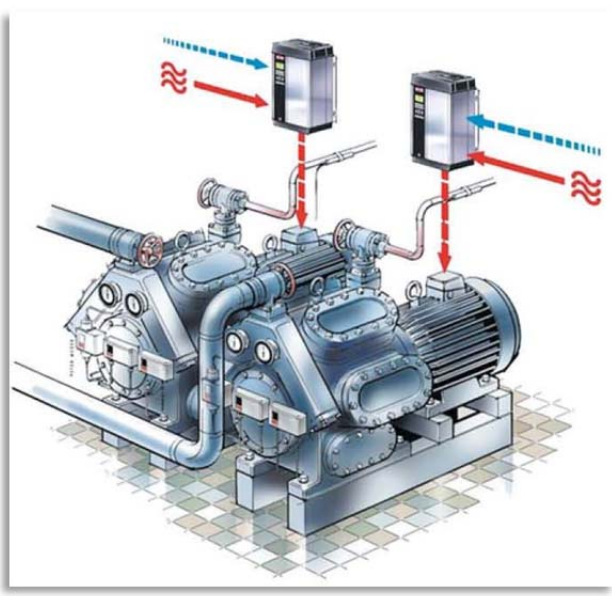
- New and existing technologies are available to improve energy efficiency at in the water sector.
- We need to accelerate the adoption of existing technology in order to encourage innovation.
- Variable speed and frequency drive technology and motor efficiency upgrades offer huge energy saving potential.

Technology improvements offer huge potential for energy savings in water, wastewater, and irrigation, particularly through motor efficiency upgrades, improved control schemes, and variable speed control. For example, water leakage accounts for 30% net revenue water loss in some cities. Variable speed technology can help reduce water loss through better process control. In addition, process optimization and improved system design can also improve energy efficiency. Intelligent process controls can use the amount of energy necessary based on demand.

However, new technologies require EPA and state regulatory approval. Therefore, ***regulatory acceptance of new technologies is a barrier to innovation***, and this situation makes it difficult for venture capitalists to invest in water technologies because the technologies are not easy to implement.

In addition to new technologies, there is also a group of proven technologies and retrofits that are easily implemented and offer major areas for savings. For example, aeration is one of the most energy intensive processes at a water resource recovery facility, so properly sizing, improving blowers, and using intelligent controls can significantly reduce energy demand.

Municipalities typically invest their money into large infrastructure upgrades, so municipality budget constraints are a major barrier to innovation. In addition, there is a lack of financing models and incentive programs. ***Technologies exist today, but remain under-deployed in the U.S., where energy and water are comparatively cheap***.



This image from John Masters' presentation represents how variable speed technology can improve aeration efficiency. According to the presentation, this aeration control can result in energy cost savings of 60% or more.

3.4 Financing Mechanisms

Infrastructure projects are costly. However, there are grants and other alternative financing mechanisms available.

3.4.1 Private Financing Strategies

Presenter: Thad Wilson, M3 Capital Partners

Highlights

- Costs and avoiding risk can be barriers to implementing new processes or technology for energy efficiency and generation.
- M3 can help fund small, short-term projects through public-private partnerships for municipalities.
- M3 offers another financing alternative that can alleviate risk and help remove barriers to innovation.

Most large infrastructure investments come from private funds. However, much of that capital is not well suited to the U.S. water sector. Investing in municipalities can be difficult due to the local decision making process for improvements. Most investment companies are looking for $200–$500 million projects with a horizon of 5–7 years. This cost is generally too high to match with a municipality's needs. ***Costs and avoiding risk can be barriers to implementing new processes or technology for energy efficiency and generation***.

The M3 approach offers a better match up for the municipal water sector. M3 offers public-private partnerships with long-term investments (25-30 years) for smaller projects. M3 focuses on water infrastructure and the specific needs of municipalities and service providers. Therefore, energy efficiency is a driver for the types of investments M3 is looking to make.

M3's interest rates are higher than municipal bonds, but they offer life cycle cost benefits and other community benefits not offered by the bonds. The company is not looking to privatize the utility but simply to deliver a project (new pipeline, upgrade, etc.), which M3 manages over the investment period. However the treatment plant retains long-term ownership and maintains control over rate setting.

The M3 option offers an accelerated launch and streamlined approach that is more quickly implemented than other financing options. It can also drive down operating costs over the life of the project. M3 puts its equity in and is at risk for the project. Therefore, they have incentive to deliver projects on time and on budget and are required to meet set performance requirements.

3.4.2 ESCOs and Performance Contracting

Presenter: Greg Miller, Johnson Controls

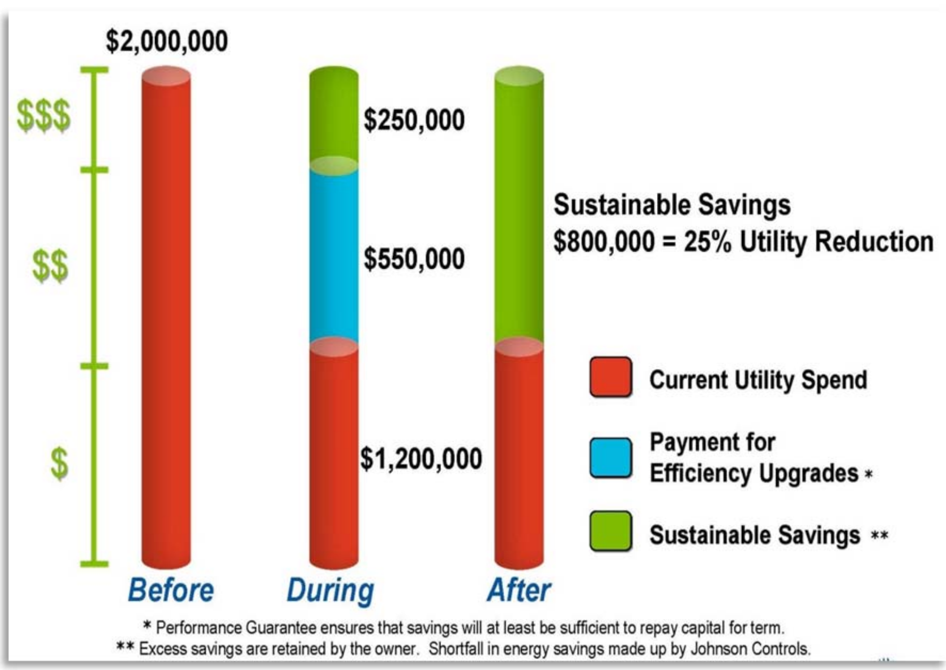
Highlights

- Energy performance contracting is another financing option for utilities.
- Municipalities partner with an energy service company (ESCO), and future savings are leveraged to pay for the improvements.
- The ESCO assumes liability for the project, and transactions are handled through a third party Escrow.

There is a large funding gap in the amount of money available for water infrastructure and the amount it will cost to upgrade that infrastructure. Most water resource recovery facilities have aging facilities and equipment, so they are spending reactively rather than proactively.

Energy performance contracting is another financing option available to utilities. Energy performance contracting is a partnership between a municipality and an energy service company (ESCO), such as Johnson Controls. Through this partnership utilities will determine ways to save energy and implement those projects. The projected energy savings are leveraged to pay for energy efficiency improvements. In addition, the ESCO assumes the risk, and utilities have the option to select equipment with the best efficiency and value rather than the lowest bid. The municipality sets up an agreement with a financial institution to establish an Escrow through which authorization and funds are funneled.

Currently, 48 states, excluding Alaska and Wyoming, have some form of performance contracting legislation. However***, in many states water and wastewater facilities are not identified for service provider opportunities.*** So, there is some need for standardization.



This graph from Greg Miller's presentation shows how energy performance contracting looks in terms of financing over the life of the project.

4 Plenary Discussion- Issue Identification

After the presentations, a plenary discussion was held where barriers were identified and clarified. In general, these issues were categorized into four areas: Economics & Payback; Policy & Permitting; Technology Performance; and Partnerships, Public Outreach & Communication.

The following four exhibits discuss the barriers and potential actions the water sector could consider, based on the suggestions from the workshop participants.

4.1 Economics & Payback

Key Potential Actions

1. Incentivize energy efficiency and energy generation at water and wastewater facilities.
2. Provide cost data on improving energy efficiency and implementing an energy generation program.
3. Provide easily accessible information on funding options.
4. Quantify nonfinancial benefits and document energy-related costs and payback for use in education campaigns.

Barriers

- There is a lack of incentive for utilities to be energy efficient or to generate energy.
- Utilities are typically risk averse.
- Infrastructure projects are costly, and often focused on upgrading outdated equipment and facilities (competing priorities).
- Most municipal projects do not attract private investors due to project size and cost. Private investment is further hampered by the local decision making process and slow regulatory acceptance of new technologies.
- There is not very much data on project costs for energy generation or energy efficiency improvements. Data needs to show that this makes economic sense. Net benefit payback, market-based benefits, and life-cycle benefits would be helpful.
- Anaerobic digesters are only cost effective if you can sell electricity back to the grid.
- Utility managers have limited time to devote to energy issues with many other competing issues. Consultants and technology purveyors could facilitate energy efficiency implementation.
- Funding sources may not be available or are not well known, particularly local sources. Funding could help minimize risks to the investor and provide for capital investment.
  - Sources of funding could include: the private sector; water and wastewater rates and bonds; federal state revolving fund; Green Project Reserve; and grants.
  - In some states, electric customers pay a public benefits charge to fund energy efficiency improvements called for in a state's energy efficiency portfolio standard. Adding such a charge on water/wastewater treatment bills could fund efficiency improvements in the water sector.
  - Electric utility incentives could ease the burden on wastewater utilities.

4.2 Policy & Permitting

Key Potential Actions

1. Provide guidance for improving energy efficiency and implementing energy generation at water treatment facilities.
2. Encourage policy and integrated planning that supports a permit process incentivizing energy efficiency and energy generation in the water sector.
3. Offer grants, tax credits, state revolving funds, public private partnerships, or other options to help with financing the energy transition.
4. Work to harmonize ESCO legislation in all 50 States

Barriers

- There is little guidance from the federal level down to the state. A framework that is useful for local officials, operators, and others is needed. This framework should be interwoven with the permit process, and actions like an energy efficiency analysis could be a state-driven requirement. Looking at the state permitting process could help identify opportunities to innovate.

- Regulations are not streamlined and often mandate other priorities over energy efficiency and power generation from anaerobic digestion in combined heat and power systems. Sometimes regulations even present barriers to innovation (RICE rule, emissions permits, FERC regulations). Integrated planning (water quality, energy savings, air quality, etc.) is needed.

- At federal level, energy generated from biosolids and biogas is not included in renewable energy portfolio standards. If it were, calls for 80% renewable energy by 2035, coupled with market forces, could boost energy generation in the water sector. Standardization of eligible sources is needed.

- Utilities need the flexibility to innovate while meeting permit requirements.

- Some members of congress are already knowledgeable about energy-water issues. However, there is a need to further educate congress and provide them with concrete action items. A common voice across congress with recommendations would be helpful.

- Selling excess electricity back to the grid is sometimes hindered by tariffs and interconnection policies.

- Standardization is needed for the state definition of energy service companies – WRRFs and their energy streams (biogas/biosolids) should be included.

4.3 Partnerships, Public Outreach and Communication

Key Potential Actions

1. Cultivate partnerships to bring feed stock from agriculture, stores, universities, and others to WWRFs.
2. Provide education and training for water professionals on energy efficiency and generation, and facilitate peer-to-peer training.
3. Create a messaging and information campaign for the public and decision makers including case studies of successes and provide a platform for feedback
4. Develop a recognition program for sustainable energy use at water and wastewater utilities.

Barriers

- Training, certification, and recognition programs are necessary in the water-energy nexus. Utilities that have already implemented programs should help communicate best practices.
- The public and decision makers are unaware of energy opportunities in the water sector.
- Sometimes energy generation requires complex relationships with food processing companies. There is a lack of incentive for anaerobic digestion partners, such as dairy farmers, because it is cheaper to take their waste to a landfill. Policy could incentivize or require feedstock to go to WRRFs.
- Operators must go beyond the mindset of meeting regulatory requirements. It is important to communicate the importance of energy programs and an understanding of technology deployment at all levels of utility personnel (utility managers to operators).
- Utilities need a path forward, peer networking on energy issues, and guidance—for example, on benchmarking for energy efficiency.
- There is a lack of awareness of funding and financing opportunities along with other helpful energy-related programs.
- Sometimes there is direct hindrance by electric companies to selling electricity back to the grid. Engaging electric utilities as potential partners would be helpful.
- Giving customers easy access to their water use data, along with an awareness of the amount of energy used to generate that water (green button option).

4.4 Technology Performance

Key Potential Actions

1. Increase the practice of energy benchmarking and the adoption of energy efficient technologies.
2. Use processes that maximize the effective use of carbon for energy generation and water quality benefits.
3. Streamline the approval process for new technology.
4. Develop a framework for identifying reference installations for new technologies to speed adoption
5. Create an integrated data set for the water sector to facilitate prioritization of efforts as well as benchmarking

Barriers

- Carbon is a necessary source of energy for bacteria in aerobic nutrient removal and anaerobic processes. Getting enough carbon for both aerobic and anaerobic processes can be problematic. More carbon can go to the anaerobic treatment process if a lower retention time is used during the aerobic processes.
- Water quality improvements require more energy. As nutrient regulations have become more stringent, plants must use more energy for aeration in nutrient treatment.
- Operators do not know how much energy is being used by specific treatment processes. Reporting requirements and benchmarking could help. This would give facility owners a starting point in terms of energy efficiency and would allow them to track their improvement over time.
- Technologies exist for energy efficiency and generation but are underdeveloped or not deployed because of the other barriers mentioned.
- Regulatory acceptance and permitting of new technologies takes time and hinders innovation.
- New technology can be expensive, but can be implemented during routine upgrades.
- Water resource recovery facilities in Canada and Europe are generating energy using 100% municipal waste. Their process and technology is not being adopted in the U.S. due to other barriers identified here.

4.5 Specific Actions Items

Economics & Payback

- Document energy-related costs and payback
- Provide grants an financing opportunities for research and technology adoption
- Quantify non-economic benefits

Policy & Permitting

- Congressional briefing
- Organize Capitol Hill visits
- Identify options for inserting energy into the permitting process
- Creation of guides and decision tools both for utilities and policy makers
- Promote awareness at the state and local level
- Water-Energy 101 Video
- Create a joint association-government water/energy committee
- Messaging Campaign to increase support by decision makers and rate payers
  - Job creation
  - Many facets/benefits of energy efficiency and renewable energy
- Build on EPA's sustainability framework
- Incorporate energy efficiency with permits and building codes
- Create draft policies, permits and/or minimum efficiency standards

Partnerships, Public Outreach, Communication

- Continuing education and training from peers
  - Conferences
  - Joint energy webcasts
  - Incorporate with operator certification requirements

Technology Performance

- Create guidelines with a checklist of treatment technologies and benchmarking guidance.
- Incorporate benchmarking and consideration of technology upgrades into the permit process, operational status reports, or applications for funding (or other triggers, such as rate increases).
- Devise a system for better determining plant's overall energy use as well as that of specific systems

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- Increase public-private partnerships
- Harmonize ESCO legislation
- Utilize funds from electric utilities for reduced demand
- Create an infrastructure bank
- Direct SRF funds toward energy-water developments

- Improve awareness of existing opportunities in energy technology
- Identify innovative case studies and offer a platform for feedback
- Recognition program and sustainability awards
- Benchmarking and data collection
  - Need a centralized and standardized information system
  - Include biosolids
  - Create a survey of utilities—update DOE baseline data

5 The Path Forward

One of the goals of the workshop was to define a set of actionable steps to advance energy efficiency and generation in the water sector. As such, the participants will develop Action Teams for Education and Outreach; Policy and Permitting; and Technology Adoption. These teams will include a number of stakeholder groups to address some of the more complex initiatives. However, participants are implementing some actions immediately as shown below:

Issue	*Action*
Identifying reference installations for new technologies to speed adoption	Leaders Innovation Forum for Technology (LIFT) (http://www.werf.org/lift) is a joint WEF/WERF innovation initiative The LIFT Technology Evaluation Program (TEP) is a new program that provides: • A credible, well-documented vetting system to screen new technologies and processes by facilitating collaboration among facilities for the evaluation and testing of new technologies. • Ability to more rapidly deploy new technologies and remove existing impediments such as the mitigation of risk and cost of innovative technology deployment through collaborative partnerships.
Framework to help utilities move towards sustainable energy management	WEF's Energy Roadmap is a series of steps arranged in six categories to help water and wastewater utilities plan and implement an energy program. The road map is applicable whether plants choose simply to increase energy efficiency or to build a full-scale cogeneration system. Topics range from technical needs to managerial aspects, and steps are applicable to small, medium, and large facilities. Watergy™ (http://www.watergy.org) is a program by the Alliance to Save Energy to help cities realize significant energy, water and monetary savings through technical and managerial changes in water supply systems, providing consumers with quality water while using a minimum amount of water and energy.
Education regarding Performance Contracting & ESCO	At the Energy & Water 2013 Conference in May (www.wef.org/energy), WEF will be presenting a workshop on Performance Contracting 101 in addition to technical sessions on Alternative Service Provision. The Alliance to Save Energy is a co-sponsor of the conference and Danfoss is an exhibiting sponsor.
Recognition Program	WEF has begun developing the framework for a utility recognition program to promote innovation and sustainability in the water sector. The details will be announced at WEFTEC 2013 (www.weftec.org).
Education on Resource Recovery	This virtual tour of a WRRF discusses how these facilities recycle water, recover nutrients, and generate energy. http://www.youtube.com/watch?v=A2FmNrEmowE
Identification of Potential Stakeholders and participants	In order to better promote energy issues in the water sector, communication and outreach to an extended group of stakeholders is needed. The Action team for Education and Outreach will work with a number of organizations, potentially including U.S. EPA, U.S. DOE, US Conference of Mayors, National Government Association, National Association of State Energy Officials, Association of Clean Water Administrators, U.S. Green Building Council, USDA, Water Utility Climate Alliance, Consortium for Energy Efficiency, Association of State Drinking Water Administrators, International Association of Plumbing and Mechanical Officials, and others

6 Appendix A: Presentations

6.1 Meet Strict BNR Limits at Net "0" Energy

Elena Bailey, Ovivo Water

OVIVO
Bringing water to life

Elena Bailey, M.S., P.E.
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Meet Strict BNR Limits at Net "0" Energy
The New Math in BNR: 3:0.03:0

OVIVO
Bringing water to life

Part A. Real Solutions for Net-Zero Energy Wastewater Plants

The Current State of Net-Zero

Meeting Net Zero by Taking the 'B' out of BNR

Part B. Technologies Targeting energy self-sufficiency in wastewater

A sustainable and efficient aeration system:
>50% of the power is used for aeration

Zeolite Ammonia Removal (ZAR)
and Recovery Technology

Anaerobic Digestion Optimization Processes

OVIVO
Bringing water to life

The Current State of Net-Zero

Wastewater Treatment … An Energy Pig!

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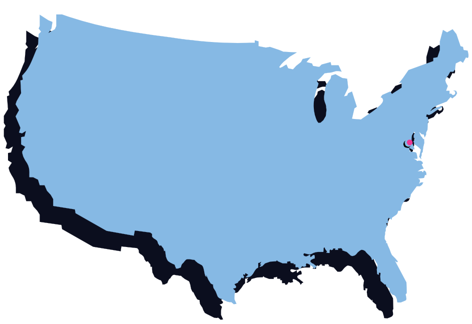
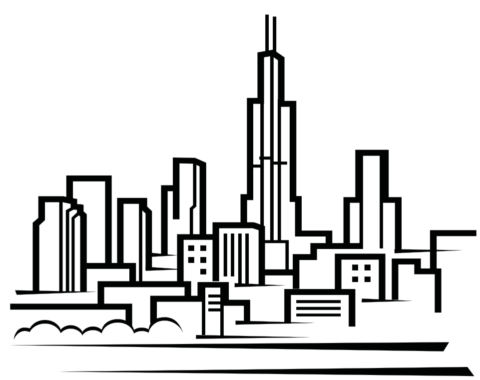
Bringing water to life

Fraction of National Electrical Use:



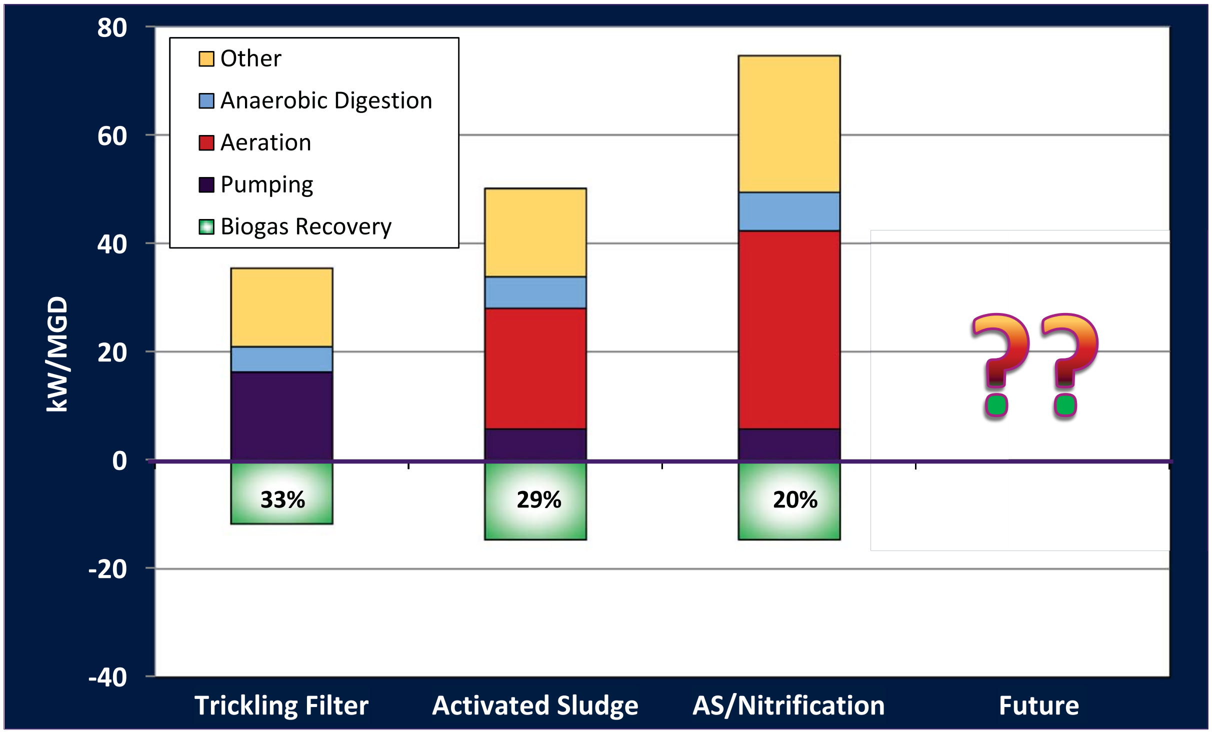
4%

Fraction of Municipal Electrical Use:



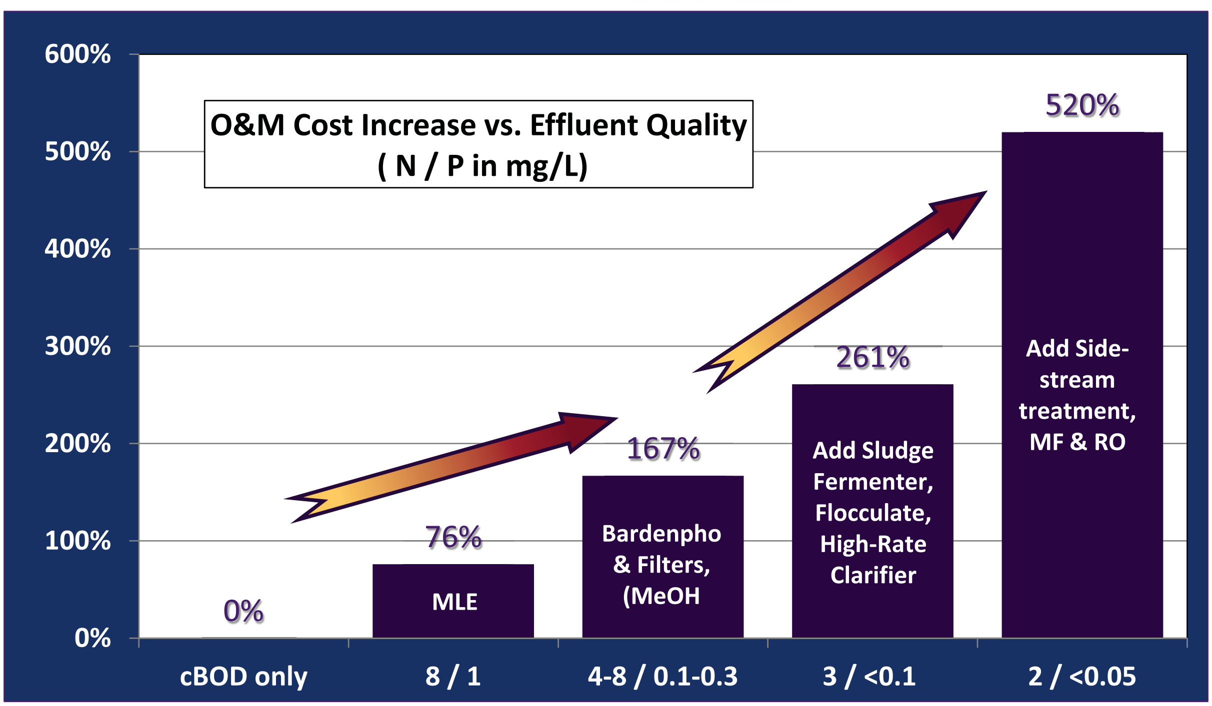
50%

How Did We Get Here?
Historical Unit Process Electrical Demand



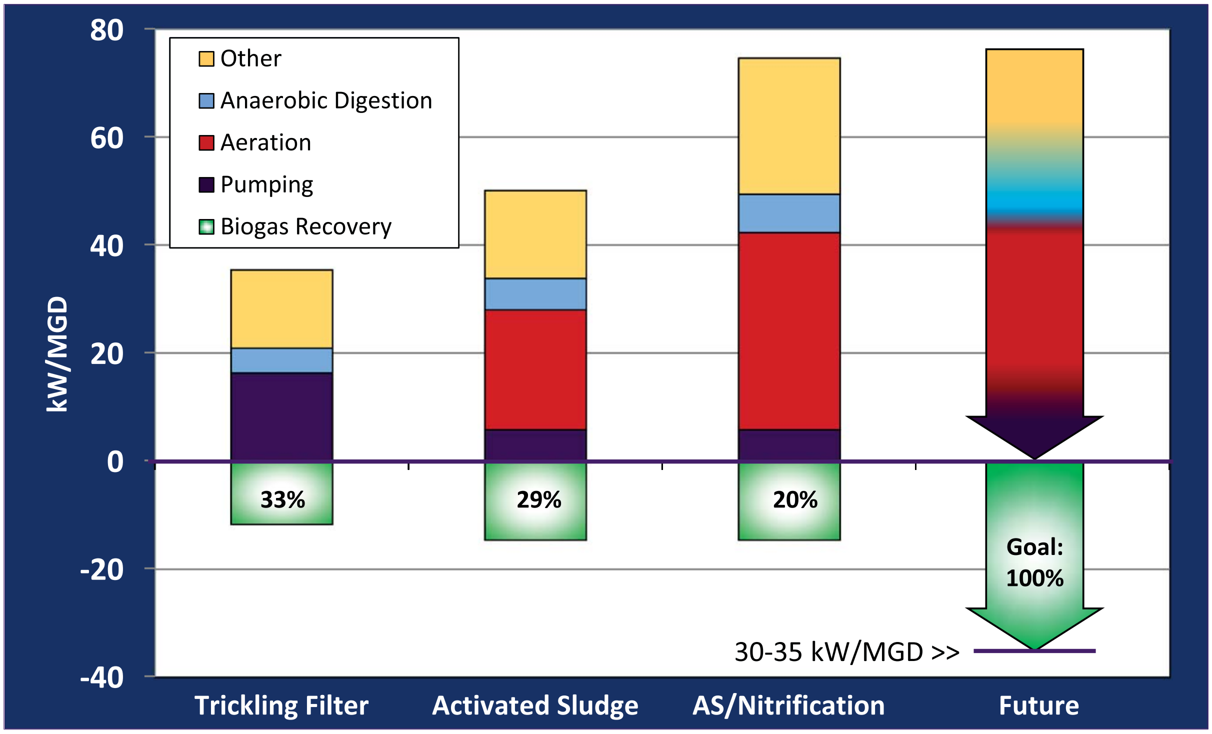
Source: WEF MOP MFD-2 (1997)

Into the Future …
Energy vs. Nutrients



Source: Striking a Balance Between Nutrient Removal and Sustainability by Falk, Reardon & Neethling. ©WEF 2011 (Based on 10 MGD treatment plant)

The Challenge …



Source: WEF MOP MFD-2 (1997)

General Strategies for Net Zero Energy: Equipment Changes / Improvements

- Aeration: increased oxygen transfer efficiency & DO control
- Blowers: increased efficiency & turndown (single stage, turbo)
- Pumping: more efficient pumps and motors
- Mixing: anaerobic & anoxic zones
- Mixing: anaerobic digesters
- Building lighting / HVAC

Energy for Wastewater Treatment … Could There Be a “Free Lunch”?

Anaerobic Biological Processes:
$C_xH_yO_z \rightarrow CH_4$ (+ biomass) $\rightarrow CO_2$
Electricity, steam, or drying

Limitations:
-- Low temperature
-- Biomass retention
-- Effluent limits

Physical Processes:
$C_xH_yO_z \rightarrow C_xH_yO_z$ (separation)
Gravity, adsorption, membranes

Aerobic Biological Processes:
$C_xH_yO_z \rightarrow CO_2$ + biomass
$NH_3 \rightarrow NO_3$ (+ biomass)
Energy lost as heat

Energy Production ← | → Energy Use

Treatment Plants Approaching/Achieving Net Zero Energy

<u>European</u> Experience: Denmark

- Very aggressive pursuit of co-digestion:
  -- Municipal sludge, industrial wastes (fisheries),
  -- Manure from nearby farms,
  -- Municipal solid waste

Treatment Plants Achieving/Approaching Net Zero Energy

US Experience: Sheboygan, WI (Design/average flows = 18.4/11 MGD)

- Extensive liquids treatment improvements … DO control, blowers
- Co-digestion: whey, food processing & ethanol wastes
- Microturbines: 700 kW

US Experience: Fort Worth, TX (166/110 MGD)

- Improved aeration and DO control
- Digester mixing and co-digestion
- Steam generation & steam-driven blowers

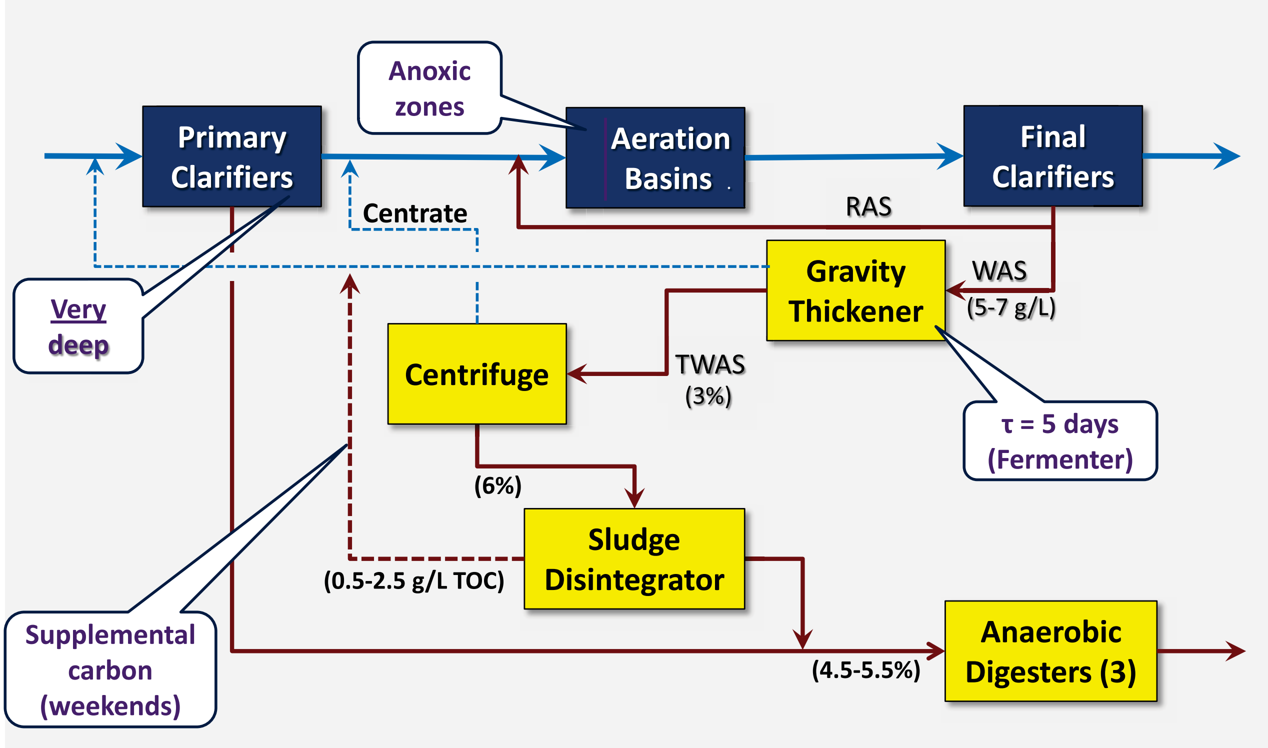
Treatment Plant Achieving Net Zero Energy – Without Co-Digestion

European Experience: Bamberg, Germany

- Design: 230,000 PE
- Actual: 280,000 PE (Q = 14.8 MGD)
- Effluent NH_3-N limit = 6 mg/L
- Effluent Total N limit = 14 mg/L
- Influent NH_3-N = 60 mg/L (from rendering plant)

Treatment Plant Achieving Net Zero Energy – Without Co-Digestion

European Experience: Bamberg, Germany



Treatment Plant Achieving Net Zero Energy – Without Co-Digestion

Energy performance of Bamberg plant:

Operating Period	Monthly VS Destruction	Energy Production/Use
Baseline: pre-2004	34-37%	- - -
30% disintegration	37-56%	66-80%
90% disintegration	51-64%	80-88%
2nd biogas engine	63-74%	**105-110%**

5 KW Disintegrator Unit

Nitrogen removal

- Fermenter and sludge disintegrator (on weekends) supply carbon
- Effluent TN = 10.3 mg/L … from influent NH_3-N of 60 mg/L

Additional disintegrator benefits:

Increased digester capacity & elimination of foaming

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Meeting Net Zero by Taking the 'B' out of BNR

New Flowsheet Objectives

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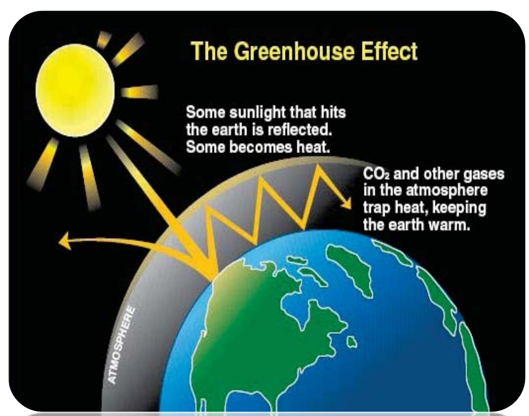
Bringing water to life

- To treat wastewater as a resource for *water, energy and nutrients.*
- Minimize residual solids production *(i.e., biomass).*
- Minimize release of *GHG emissions*.
- Minimize treatment system *complexity* in terms of the number of unit processes and their operation requirements.



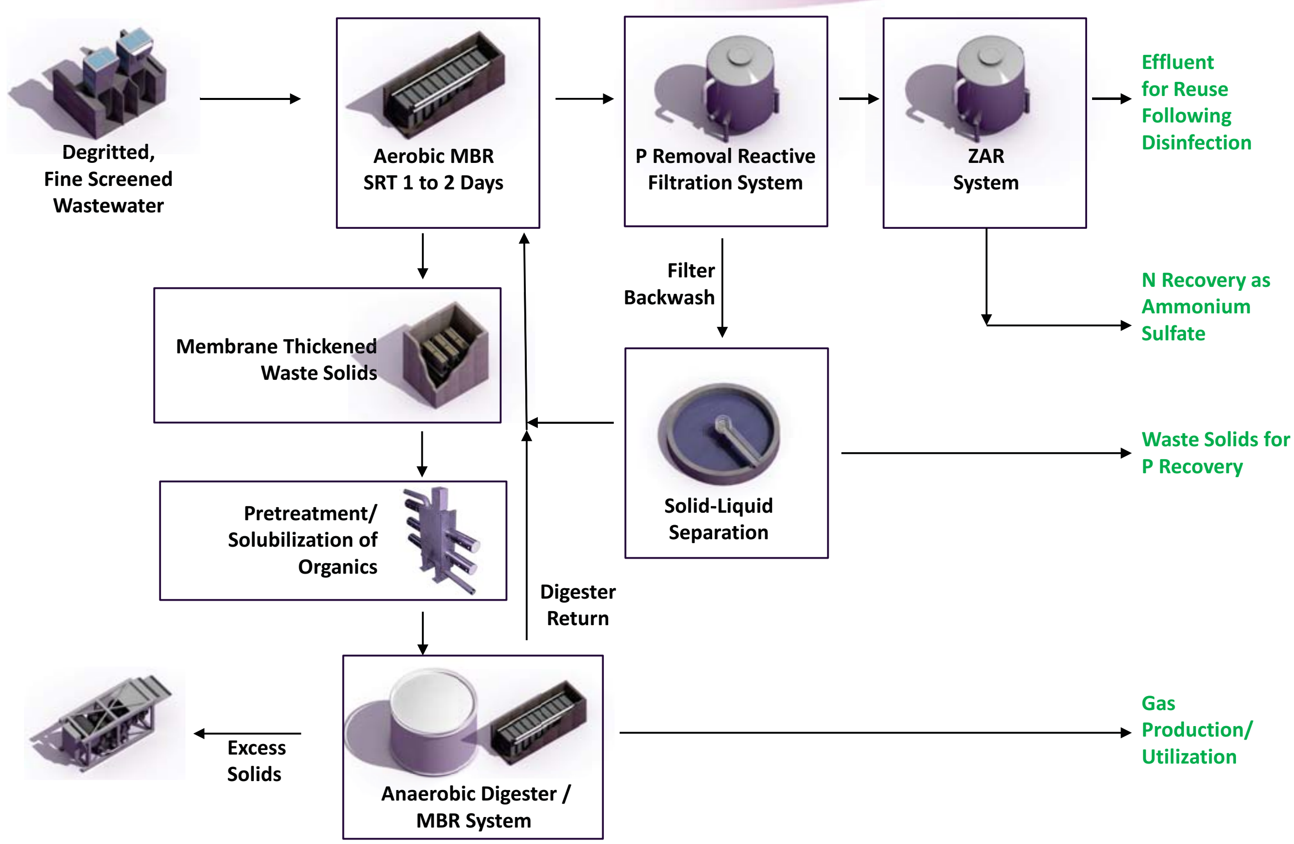
Principles and Resulting Benefits

- ***Abandons conventional norm*** **stating wastewater organic carbon best removed through biological oxidation, and P and N are best removed through BNR processes.**

- **Derives energy** ***by shunting*** **a large fraction of the wastewater** ***organic carbon*** **to a particulate form and treating the organic particulates anaerobically.**

- **Use of** ***physical-chemical technologies*** **for phosphorus and ammonia-N removal capable of allowing for P and N recovery.**

Simplified Flowsheet Schematic



New Flowsheet Versus Conventional Treatment

- **Achieve effluent TSS, TP and TN of less than 5, 0.03 and 3 mg/l, respectively.**
- **Wastewater flow 10 mgd day and typical municipal wastewater concentrations.**
- **Conventional treatment; MBR based BNR system without primary treatment.**

Energy Balance For Flowsheets

Energy Value	Energy Produced or Required, kWh/day	
	New Flowsheet	Conventional BNR MBR Flowsheet
Thermal Energy		
Recovered From Digester Gas	8000	0
Required For Waste Solids Heating	-752	0
Thermal Energy Balance	7248	0
Electrical Energy		
Recovered From Digester Gas	8000	0
Influent/Headworks Pumping	-1923	-1923
Aerobic MBR/BNR System	-7821	-23,974
Reactive Filtration CBFs	-1491	-
ZAR System	-21	-
Aerobic Digester Aeration & Thickening	-	-5996
Waste Solids Membrane Thickening	-774	-
Anaerobic Digestion System	-715	-
Interstage Pumping	-1582	-
Excess Solids Centrifugation	-78	-90
Electrical Energy Balance	-6405	-31,983
Total Energy Balance	843	-31,983

Flowsheet Capital Costs

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Item 	Cost, $ x 1000	
	New Flowsheet	Conventional BNR MBR Flowsheet
Headworks and Plant Wide Odor Control	6970	6970
Aerobic or BNR MBR System	22,370	32,235
Reactive Filtration System	7585	-
ZAR System	3451	-
Anaerobic Digester-Thickening System	-	1949
Membrane Thickening System	1392	-
Anaerobic Digester System	2177	-
Centrifuge Solids Dewatering System	5780	6676
Subtotal	49,725	47,830
Site Work@ 20 %	9945	9566
Electrical @ 14 %	6962	6996
Instrumentation & Control @ 10 %	4973	4783
Total	71,604	68,875
Contingency @ 20 %	14,321	13,715
Total With Contingency	85,925	82,650

Flowsheet Comparison Summary

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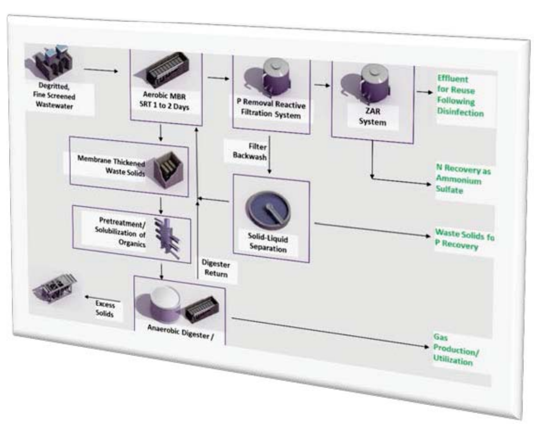
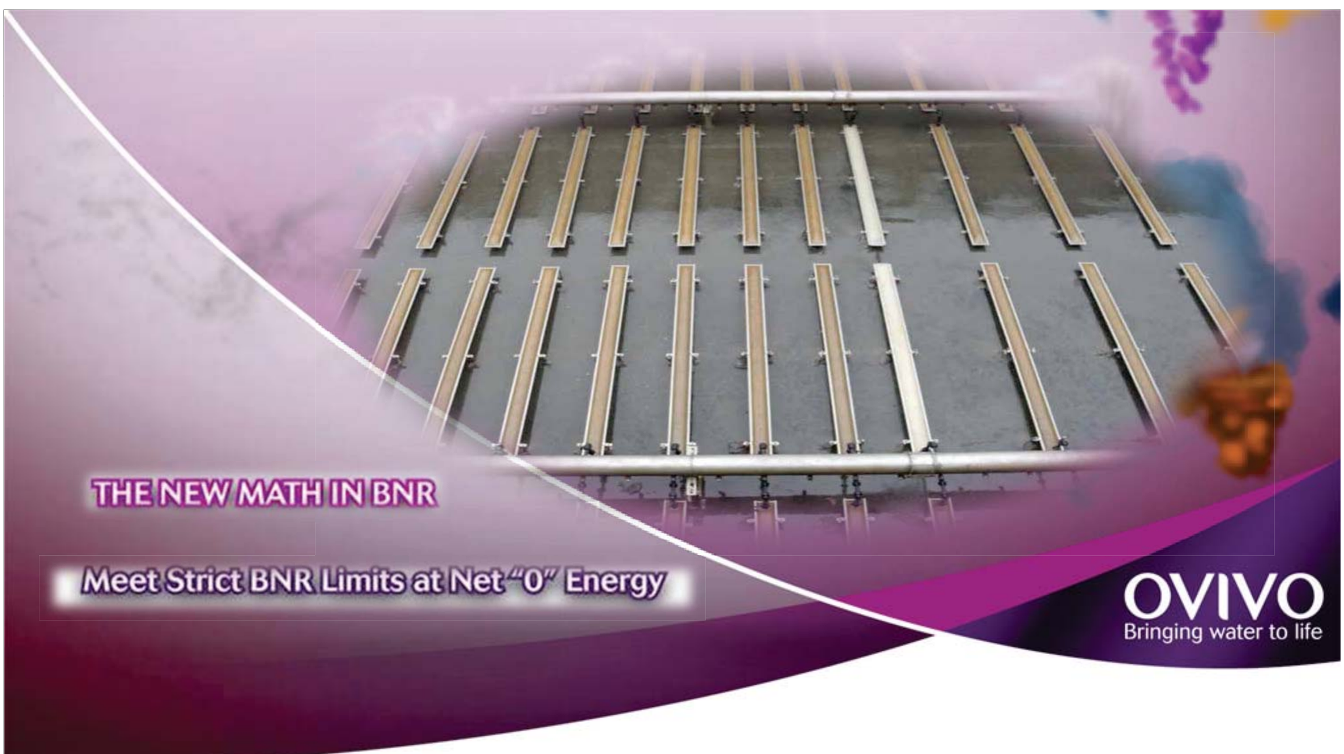
- ✓ **Total vessel/tank volume reduced by *40 – 50%.***
- ✓ **Treatment plant site plan/space requirement reduced by *20- 25%***
- ✓ **Comparable Capital costs.**
- ✓ **Mass of excess solids requiring disposal reduced by *20 – 40%***
- ✓ ***Energy Produced > Energy Used!***

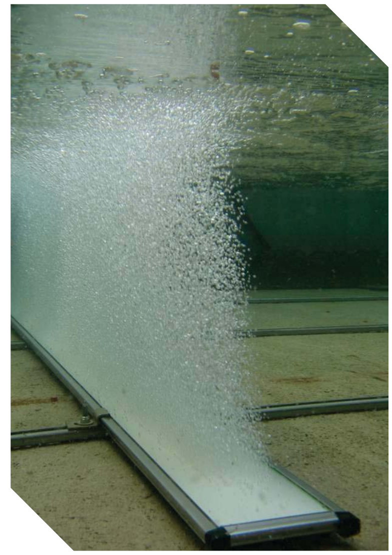


Technologies Targeting Energy Self-Sufficiency in Wastewater



A sustainable and efficient aeration system:
>50% of the power is used for aeration

Aerostrip Ultra-Fine Bubble Aeration: Sustainable Solution



Zeolite Ammonia Removal (ZAR) and Recovery Technology

Zeolite Ammonia Removal (ZAR) and Recovery Technology

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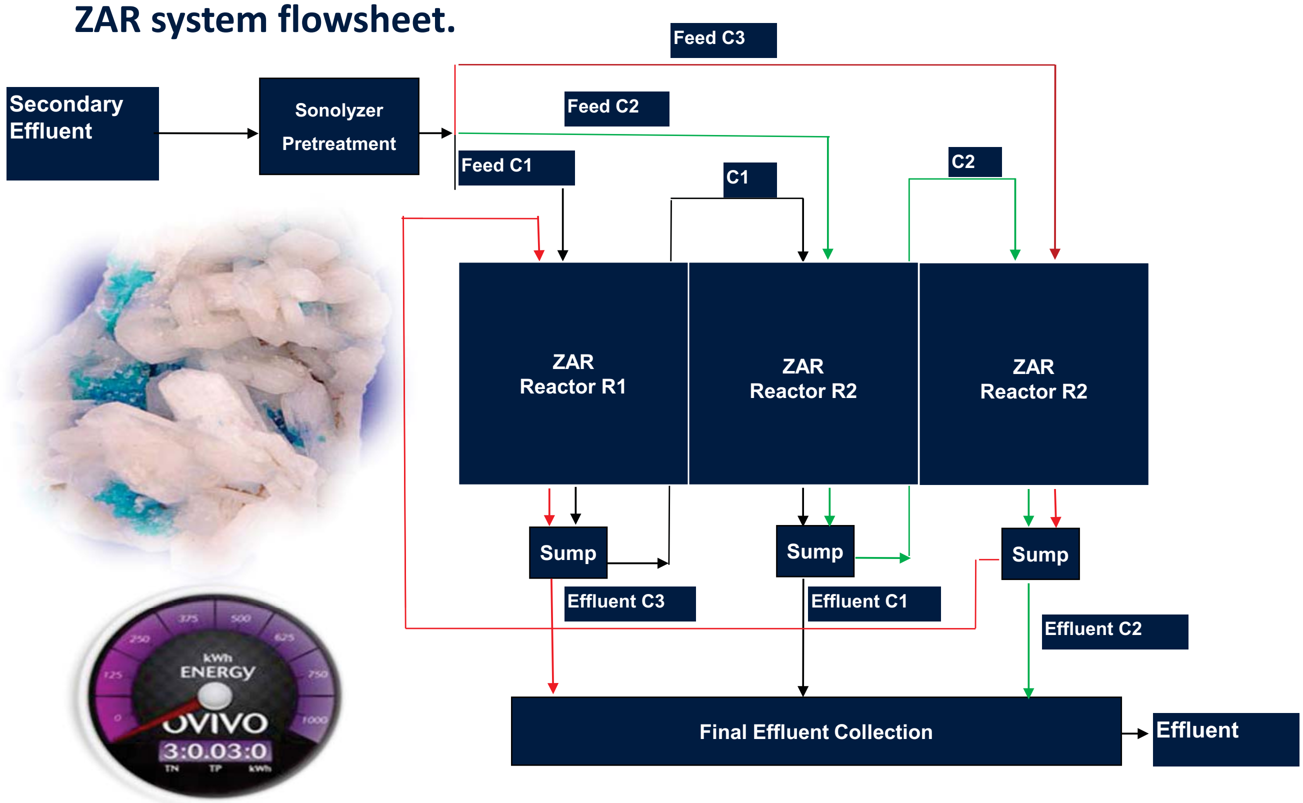
ZAR system flowsheet.



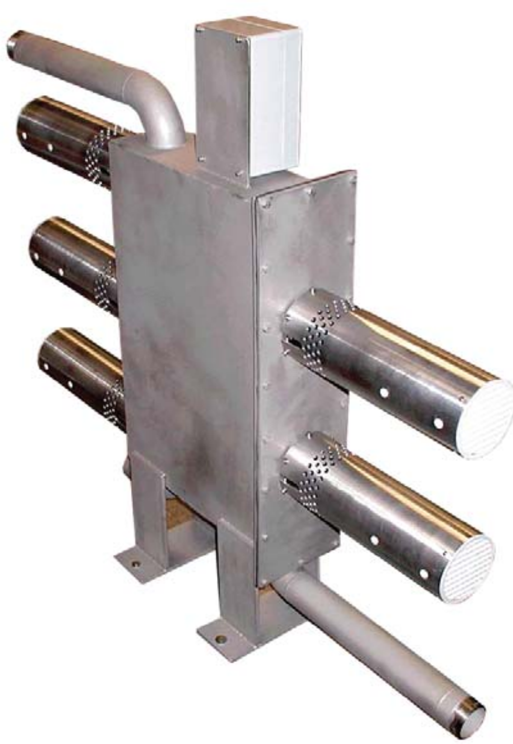
Anaerobic Digester Optimization Processes

Anaerobic Treatment Optimization: Maximizing the Payback

Anaerobic Biological Processes:
$C_xH_yO_z \rightarrow CH_4 + (\text{biomass}) \rightarrow CO_2$
Electricity, steam, or drying

- **Process selection:**
  Acid/gas, thermophilic, etc.
- **Co-digestion**
- **Substrate pretreatment:**
  Thermal hydrolysis, sonication, cavitation, electric pulse
- **Digester optimization:**
  Mixing, heating, foam prevention
- **Biogas management:**
  Storage, treatment, generation (electricity and/or steam)

Ovivo Sonolyzer™



What is it and how does it work?

- Ultrasonic treatment of thickened WAS
- Lyses (ruptures) cells to more degradable organics
- Supplies supplemental carbon for BNR
- Increases VSS destruction in digesters … less sludge and more biogas!

LM™ Mixer Features

- **Oscillating (up/down) disk w/ simple moving parts**

- **Lower capital & maintenance costs**
- **Significant reduction in energy use**

  30% to 50% reduction in mid-sized tanks.

  50% to 70% reduction in large tanks.

- **Very effective mixing … demonstrated by third-party tracer studies.**

Sustainable Solutions in Mixing

Better Degradability + Better Mixing
→→ Key Factors for Better Biogas Production

Organic waste

Inlet gas quality:
- CH4 – Methane
- CO2 – Carbon Dioxide
- O – Oxygen
- N – Nitrogen
- VOC – Volatile organics
- H2S – Hydrogen Sulfide

H2S Removal

Heat exchanger | Compressor | Glycol chiller

Biogas conditioning system

Siloxane Removal

Biogas

- CH4-Methane
- CO2-Carbon Dioxide
- O-Oxygen
- N-Nitrogen

Turbines

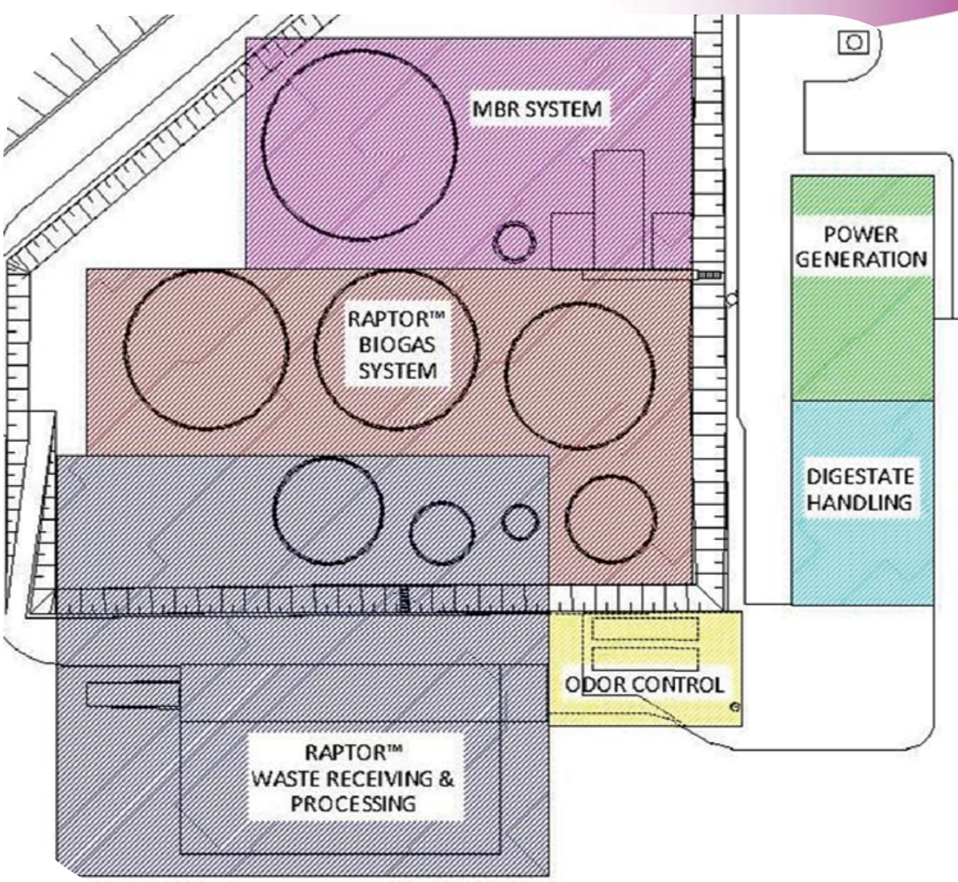
Tech 3 Solutions-Cogeneration

Industrial Processes that Create Value in Water

Raptor Organic Waste to Energy System

- A pretreatment-enhanced multi-step biological fermentation process
- A powerful liquid state anaerobic digestion process that converts almost any organic residue or energy crop into biogas, electricity or heat
- Three major application sectors; industrial/agricultural/municipal

Raptor Organic Waste to Energy Project, Ontario, Canada



First of it's Kind in North America

Organic Feedstock from 25 different sources

6.2 Energy Systems Technologies and Strategies

John Masters, Danfoss

Water-Energy Future Workshop – November 27, 2012

VLT® THE REAL DRIVE

Danfoss Overview

- A leading technology-based global manufacturer
- $6 billion sales; facilities in 100 countries; 25,000 employees
- USA $1.2 billion sales; 12 factories
- Technologies: VFDs, major components, compressors, controls, heat exchangers for water, industry and HVAC sectors

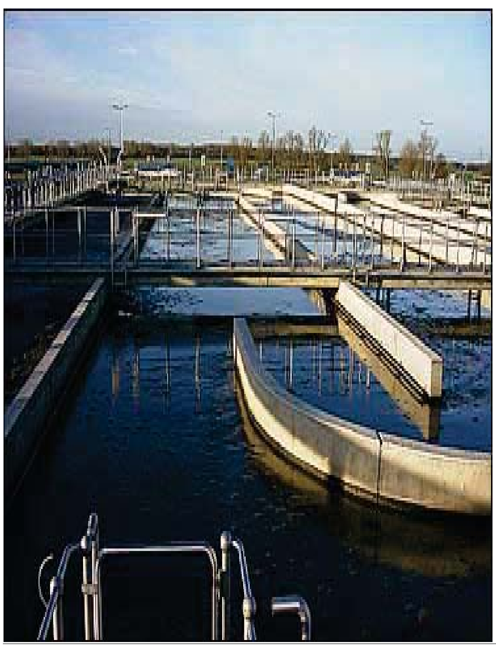
VLT® THE REAL DRIVE

Energy and Water Efficiency

Water/Waste Water/Irrigation

- DOE estimates 3rd largest consumer of energy
  - >55 Billion kWh/yr
- DOE estimates potential savings of 11-18%
  - Improved system design
  - Matching component size to load
  - Motor efficiency upgrades (potential 2 Billion kWh/yr savings)
  - Variable speed technology (additional 3-10 B kWh/yr savings)
- Municipal water and irrigation account for 90% of water usage in US
- >35% of municipal energy use in water and waste water facilities

Innovative and Alternative Technologies

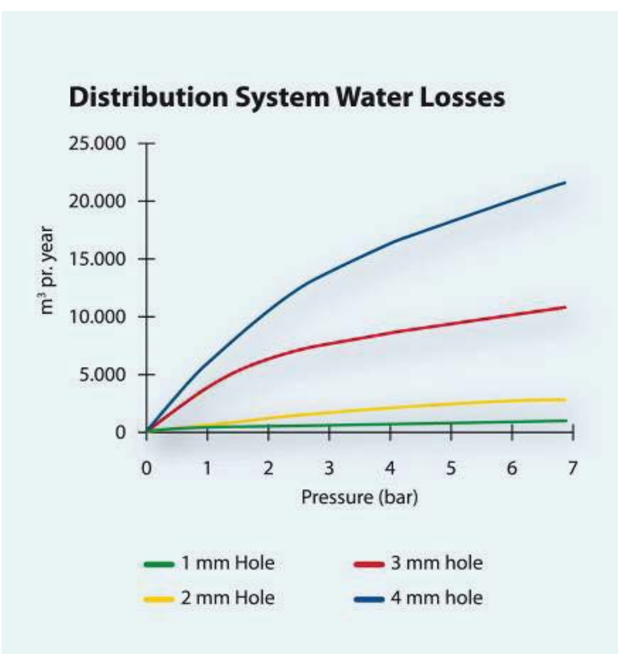


- New Plant Designs or Upgrades
- Accepted I and A Technologies
  - Design standards established
  - EPA Approved (State approvals?)
  - Readily adaptable
  - Case histories
- New I and A Technologies
  - May require EPA/State Approvals
  - Unproven performance
- Solar and Wind Technologies
  - Off-grid pumping solutions
- Smart Grid
  - Controlled power grid
  - Off-peak power advantages
  - VFD technology

Retrofit – Proven Technologies

- Easily Implemented
  - Process adjustments
  - Blower sizing/technology improvements
  - Pump sizing improvements
  - Intelligent pump control
  - Motor efficiency upgrades
  - Variable speed technology
    - Easiest implementation
    - Biggest energy saving potential
- Proven Energy Efficient Technologies
  - Case histories
  - EPA/State approval typically not required

Energy and Water Efficiency



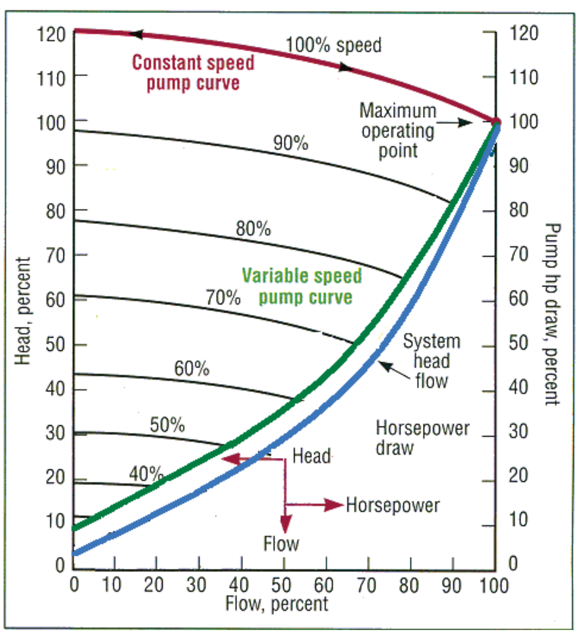
Water Systems

- Water and energy are interdependent
  - Net revenue water losses of up
  - to 30%
    - Wasted energy pumping
    - Wasted energy treating
  - Repairs costly (not realistic)
  - Constant pressure control
  - schemes can reduce losses
    - Flow compensation
    - Reduction from 75 PSI to 60 psi = 530,000 gal/yr

Intelligent Pump Control

- Constant speed pumps operate at maximum performance and efficiency for only a percentage of each day
    - It's often more efficient to use a number of pumps staged to meet demand
- Cascade controller (shown) receives the pressure feedback signal, stages on additional pump drives as required, and provides a master speed reference signal to all pumps, ensuring they are all providing matched pressure and flow
- VFDs provide variable speed which can save up to 20% on electrical costs and 30% on water usage annually

Affinity Laws for Pumps and Fans



- FLOW ∝ RPM
- HEAD ∝ RPM2
- POWER ∝ RPM3

RPM	FLOW	HEAD	POWER
100%	100%	100%	100%
90%	90%	81%	73%
80%	80%	64%	51%
70%	70%	49%	34%
60%	60%	36%	22%
50%	50%	25%	13%
40%	40%	16%	6%

OSWEGO, NY WTP - Case Story

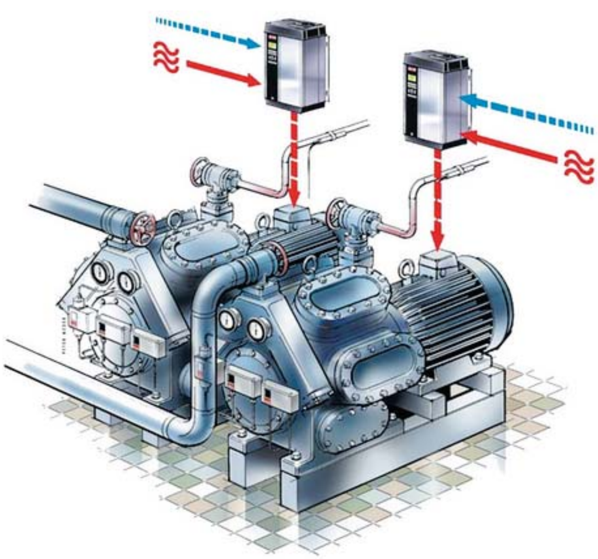
The improvements included:

- Rebuilding two 450 Hp finished water vertical turbine pumps
- Rebuilding one 350 Hp finished water vertical turbine pump
- Providing new motors and variable speed drives at the finished water and raw water pump stations (7 motors from 125 to 450 Hp)
- An automated control system was also provided that modulates pump speed to maximize energy efficiency
- PLC based SCADA system with remote telemetry system
- Upgrade of filter valve actuators
- Upgrade of coagulant chemical feed system
- Lighting system replacement

- Annual Energy Use and Costs Prior to Implementation:
  - Electric: 5,800,000 kWh, $694,378 annually
- Guaranteed Annual Savings
  - Electric: 1,306,646 kWh, 1,332 kW, $88,505
  - Operation & Maintenance: $61,800
- **Actual Annual Savings**
  - **Electric: 1,474,664 kWh, 1,463 kW, $95,892**
  - **Operation & Maintenance: $58,528**

Information provided by:Wendel Duchscherer Architects & Engineers, PC

Waste Water Systems

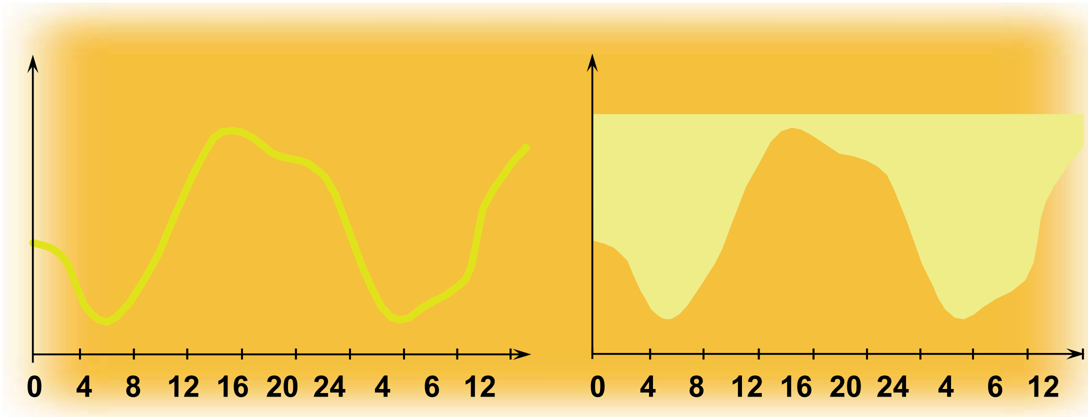


Aeration Control

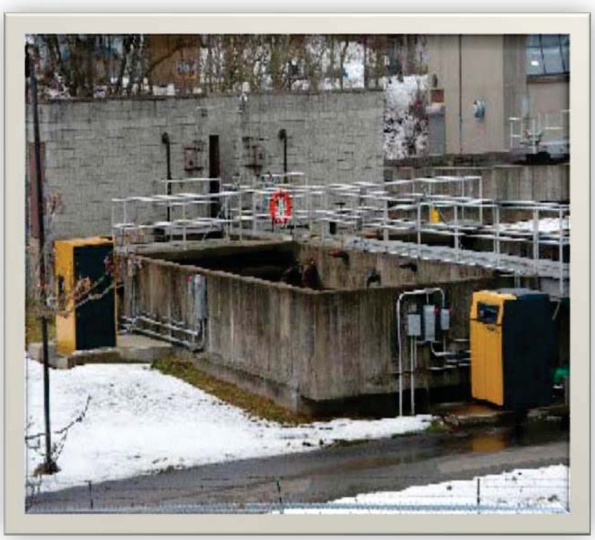
- 60% or more energy cost savings can be realized by using a VFD rather than fixed speed operation in compressor applications
- In wastewater applications it truly is a systems approach requiring accurate and reliable input signals
- Multiple schemes available for control of aeration depending on facility

Blower Applications - Wastewater Fluctuations in the biological load…

- A typical WWTP can experience load fluctuations by as much as a factor of 5 over a 24 hour period
- Manually controlling the aeration can cause excess energy consumption by as much as 50 to 65%



Moundsville, WV WWTP



- Original installation – 3 each 75 HP centrifugal blowers
  - 2 supplying air to four aeration basins (1 unit as a spare)
  - Dissolved Oxygen levels varying 0.5 ppm to 6 ppm over 24 hours
- Final Installation – 1 ea. 100 HP and 1 ea. 50 HP Rotary Lobe blower with Danfoss VLT AQUA Drives installed on both
  - Provides maximum flexibility controlled from Dissolved Oxygen meters
  - Dissolved oxygen levels maintained at 2.2 ppm throughout the day
- **Energy saved = $50-60,000 per year**

Major Barriers to Innovation

- Overcoming first-cost investment challenges
- Municipality budget constraints
- Lack of financing models and incentives programs
- Lack of policy/regulatory mandates
- Regulatory acceptance of new technologies

Summary and Policy Implications

- Proven technologies are available
- Deployment rates are low in US where energy is cheap
- Steps are needed to induce deployment
  - Price signals
  - Rebates or credits to retrofit existing facilities
  - Standards, promotion and education, to encourage that new facilities are designed with modern equipment
- Accelerating deployment of existing technologies would create systems to encourage rapid deployment of future technology developments
- Still many hurdles for Innovative and Alternative technologies due to regulatory issues

6.3 ESCOs and Performance Contracting

Greg Miller, Johnson Controls

Be a leader. Use less energy. Use smart energy.

Wastewater Treatment Plant
Energy Efficiency Solutions

Wastewater Treatment Plant
Energy Efficiency Solutions

Agenda

- Performance Contracting 101
- Recommended Solutions
- Review Current Situation
- Overview Johnson Controls
- Next Steps

Wastewater Treatment Plant
Energy Efficiency Solutions

Typical challenges associated with energy efficiency investments

- Decreasing tax revenues
- Inadequate funding to upgrade infrastructure
- Deteriorating equipment and infrastructure
    - *reactive spending vs. pro-active spending*
- Administrative costs and time managing capital improvement project(s)
- Managing project's financial and operational risk
- Developing revenue stream to pay for improvements

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Wastewater Treatment Plant
Energy Efficiency Solutions

What is Energy Performance Contracting

- Energy Performance Contracting is a partnership between the municipality and an Energy Service Company (ESCO) to:
    - Identify and guarantee energy, operational, and resource savings opportunities
    - Implement energy efficiency and infrastructure improvement projects
    - Guaranteed energy and operational savings are leveraged to pay for energy efficiency improvements
- Performance contracting is a funding vehicle wherein the **verifiable savings** that can be identified for a project are **guaranteed** by Johnson Controls

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Wastewater Treatment Plant
Energy Efficiency Solutions

Why Energy Performance Contracting as Solution?

- Redirects existing budget dollars to improve infrastructure
- No rate/bond/debt increases to address infrastructure needs
- Single point of accountability for entire project
- Demonstrates fiscal and managerial responsibility to public and political constituencies
- Improves employee & constituent overall satisfaction with municipal infrastructure

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Wastewater Treatment Plant
Energy Efficiency Solutions

Guaranteed Energy Savings and Performance Contract Legislation

- Allows municipalities to select an ESCO to implement conservation measures tied to guaranteed savings.
- Competitive Selection process typically involves advertising for RFQ/RFP responses.
- More Flexible contracting method – gives municipalities choices: manufacturer, subcontractor, vendor…..
- Project funded through savings
- ESCO assumes Risk – You have one point of accountability

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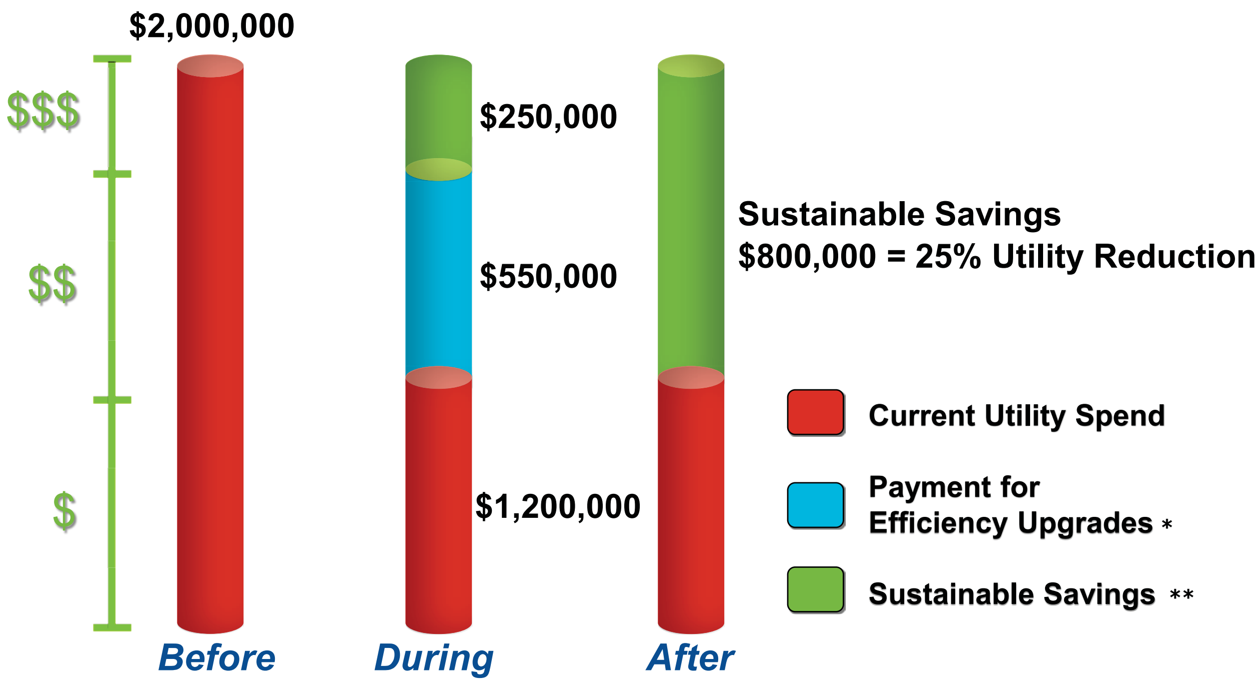
Wastewater Treatment Plant
Energy Efficiency Solutions



* Performance Guarantee ensures that savings will at least be sufficient to repay capital for term.
** Excess savings are retained by the owner. Shortfall in energy savings made up by Johnson Controls.

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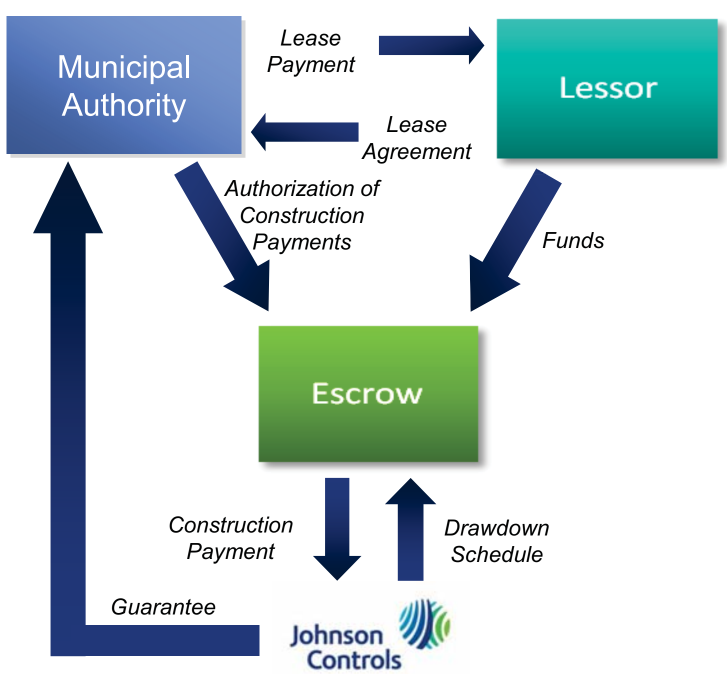
Wastewater Treatment Plant
Energy Efficiency Solutions

Performance Contracting Financial Model



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Wastewater Treatment Plant
Energy Efficiency Solutions

Contrast Between Traditional and Performance Contracting

Financial /Risk Factors	Traditional Bid /Specs Method	Performance Contracting
Financial Source	Capital outlay	Current budget
Rate Increase	Yes	No
Savings Guarantee	No	Yes, up to 20 years
Performance Guarantee	No	Yes, up to 20 years
Cost Guarantee	No	No change orders
Design Guarantee	No	Yes, up to 20 years
Equipment Selection	Low bid	Best efficiency/value
Contractors	Low bid	Most qualified
Risk	Municipality	ESCO

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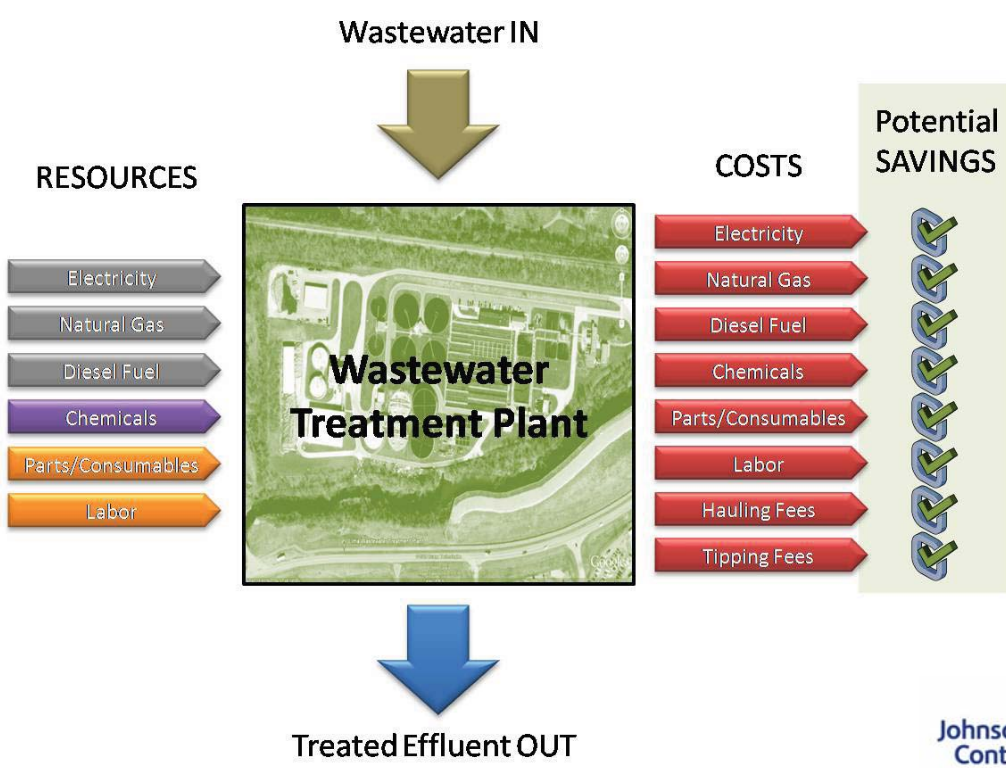
Reducing Energy Costs with
Municipal Wastewater Solutions

Applications for WWTP – Opportunity Model



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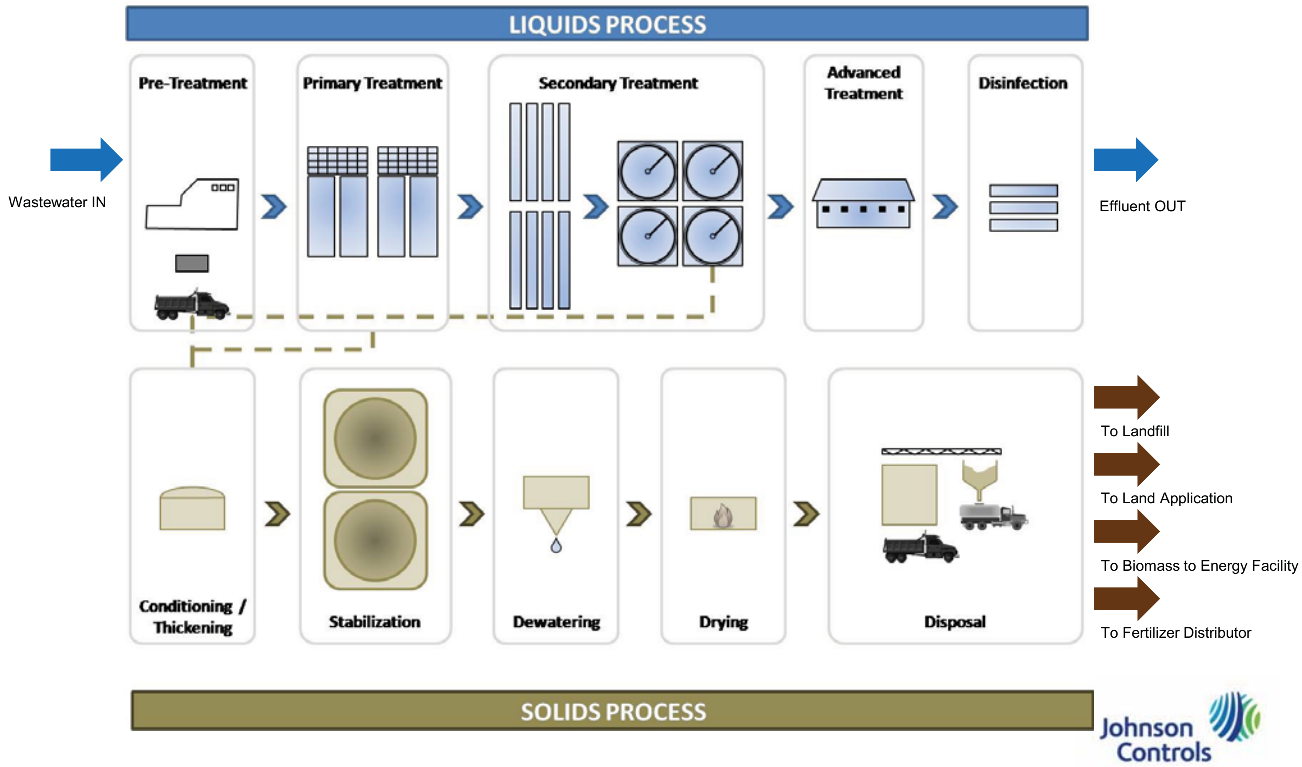
Reducing Energy Costs with Municipal Wastewater Solutions

Applications for WWTP – Process



Reducing Energy Costs with Municipal Wastewater Treatment Plant Solutions

Applications for WWTP – Energy Efficiency

- Reduce the amount of energy consumed on site by updating older inefficient technology with new more efficient technology.
- Potential solution projects:
  - Retrofit diffusers with fine bubble type
  - Integrate variable speed drives
  - Replace existing motors with premium efficiency motors
  - Replace aged equipment with new technology
  - Retrofit plant lighting with LED lighting

Reducing Energy Costs with Municipal Wastewater Treatment Plant Solutions

Applications for WWTP – Biosolids Management

- Reduce the cost of biosolids disposal by further removal of water from sludge
- Potential solution projects:
  - Integrate dewatering technology
  - Integrate drying technology
  - Dry biosolids and sell as fertilizer or biofuel

Reducing Energy Costs with Municipal Wastewater Treatment Plant Solutions

Applications for WWTP – Biogas to Energy

- Harness the potential energy from wastewater treatment plant biogas as “free fuel” to generate electricity and thermal energy
- Energy produced can be used to:
  - Offset the cost of electricity purchased from the grid
  - Offset the cost of natural gas
  - Further process biosolids

Reducing Energy Costs with
Municipal Wastewater Treatment Plant Solutions

Traditional Energy Conservation Measures

- Building automation and controls
- Building envelope and insulation improvements
- Energy efficient lighting retrofit
- Heat recovery opportunities
- Network integration
- Renewable energy opportunities
- Roof improvements/replacement
- Security & Fire upgrades
- Window replacement

Wastewater Treatment Plant
Energy Efficiency Solutions

Who is Johnson Controls?

- We are a **$40 billion** company
- Ranked **76th** in Fortune 500 for 2011
- Fortune's list of **America's most admired companies** for social responsibility and financial soundness
- $4.8 billion in **guaranteed savings** for local government customers
- **Energy Efficiency Solutions**
  - Dedicated to providing solutions to increase Energy Efficiency and Operational Performance
  - Dedicated Local Government Solutions Team

Questions?.......Contact

Greg C. Miller
Solutions Development Leader East Region
484-426-7852
greg.miller@jci.com

Johnson Controls

7 Appendix B: References

7.1 *Alliance to Save Energy's Watergy™ Program*

The term was Watergy™ coined by the Alliance to Save Energy to describe the strong link between water and energy in municipal water systems. The approach helps cities realize significant energy, water and monetary savings through technical and managerial improvements in water supply systems, providing consumers with quality water while using a minimum of water and energy.

http://ase.org/programs/watergy

7.2 *The WEF Energy Roadmap*

Wastewater treatment plants are not waste disposal facilities but are water resource recovery facilities that produce clean water, recover nutrients (such as phosphorus and nitrogen), and have the potential to reduce the nation's dependence on fossil fuels through the production and use of renewable energy and the implementation of energy conservation. A number of utilities have already taken the leap towards resource recovery and have begun this transformation, many more are peering over the edge. WEF's Roadmap to Energy Sustainability is designed to be a tool for utilities of all sizes and levels of advancement to identify areas for potential improvement, prioritize them, and then take the appropriate next steps toward increased energy independence.

http://bit.ly/W1LN5V

7.3 *ACEEE/AWE: Addressing the Energy-Water Nexus: A Blueprint for Action and Policy Agenda*

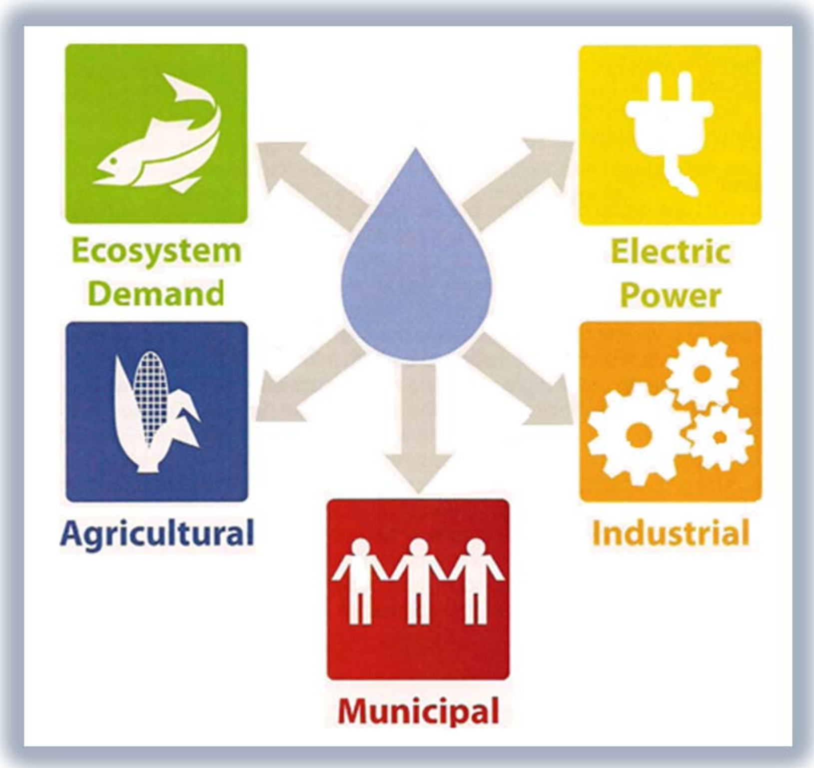
The American Council for an Energy-Efficient Economy (ACEEE) and the Alliance for Water Efficiency (AWE) secured a grant from the Turner Foundation to bring these two communities together to establish a blueprint for future joint efforts and to envision a policy agenda that could drive actions at the federal, state, local, and watershed levels.

This blueprint addresses three broad elements: policy/codes, research, and programs. In developing it, ACEEE and AWE have analyzed and consolidated contributions from approximately fifty individuals, many of whom participated in a full-day workshop in December 2010. The goal of this blueprint and policy agenda is to provide a framework for collaborative action, funding, and policy development.

http://bit.ly/XDXbEJ

8 Appendix C: Western Electric Power Sector/Water Sector Collaboration Workshop (2010)

November 8-9, 2010
Hosted by EPRI and Southern California Edison, Monrovia, California



8.1 Overview

Early in 2010, a group of western electric power organizations held a workshop to discuss the operation of the electric power sector in a water-constrained environment. The group recommended that the theme of the next meeting be collaboration between the electric power and water sectors to achieve increases in both electric power and water use efficiencies and recover energy from water sector operations. The group further suggested that participants at this meeting should include representatives from the water sector; federal/state/local governments; and national energy research laboratories. ***The Western Electric Power Sector/Water Sector Collaboration Workshop*** is the result of those discussions.

8.2 Attendees

First Name	Last Name	Company
Kathleen	Ave	Sacramento Municipal Util. Dist.
Kristen	Avery	NOAA Aeronomy Loaboratory R/E/AL
Erik	Bakken	Tucson Electric Power Co.
Alvin	Bautista	Los Angeles Dept. of Water & Power
Peter	Benenson	Peter Benenson Consulting
Dan	Burrill	Honeywell
Nicholas	Cizek	Advanced Research Projects Agency - Ener
Shonnie	Cline	Water Research Foundation
Jim	Davis	SAP Labs, Inc.
Martha	Davis	Inland Empire Utilities Agency
Henry	Day	Arizona Public Service Co.
Gary	Esslinger	Elephant Butte Irrigation District
John	Felty	Salt River Project
Lauren	Fillmore	Water Environment Research Foundation
Clark	Gellings	Electric Power Research Institute (EPRI)
Robert	Goldstein	Electric Power Research Institute (EPRI)
Michael	Greene	Public Service Co. of New Mexico
David	Halverson	Orange County Sanitation District
Ray	Hedrick	Salt River Project
Mike	Hightower	Sandia National Laboratories
Ivor	John	Ryerson Master LRQA
Richard	Karlin	Water Research Foundation
Natali	Kassis	Los Angeles Dept. of Water & Power
Delon	Kwan	Los Angeles Dept. of Water & Power
Barry	Liner	Water Environment Federation
Robert	Lotts	Arizona Public Service Co.
Jordan	Macknick	NREL National Renewable Energy Laboratory
Todd	Maki	Electric Power Research Institute (EPRI)
Raj	Manchanda	American Society of Mechanical Engineers
Cheryl	McGovern	U.S. Environmental Protection Agency
Omar	Moghaddam	City of Los Angeles Department of Public
Robert	Morton	Los Angeles County Sanitation District
Edwin	Pinero	Veolia Water North America
Jack	Sahl	Southern California Edison Co.
Elizabeth	Sands	Electric Power Research Institute (EPRI)
Shahrouzeh	Saneie	City of Los Angeles Department of Public
Alex	Schroder	
Caroline	Sherony	WateReuse Foundation
Stacy	Tellinghuisen	Western Resource Advocates
Claudio	Ternieden	Water Environment Research Foundation
Paul	Thomas	SCE
Vincent	Tidwell	Sandia National Laboratories
John	Vrsalovich	Metropolitan Water District
Barbara	Walz	Tri-State Generation & Transmission Association
Loraine	White	California Energy Commission
Robert	Wilkinson	University of California
John	Willis	Brown & Caldwell
Amy	Witherall	U.S. Bureau of Reclamation
Ernest	Yeboah	Inland Empire Utilities Agency

8.3 Ideas from the Breakout Sessions

The Energy/Water Nexus is a critical issue that is integral to the design, operation, and management of electric, water and wastewater utilities. This nexus has many diverse aspects, for example:

- Energy efficiency at water and wastewater plants and water efficiency at power plants
- Water and energy conservation at end users, from residential to agriculture
- Energy generation from wastewater, including methane from anaerobic digestion or as growth media for algae based biofuels
- Climate impacts in terms of mitigation and adaptation activities, as well as understanding both the carbon footprint and water footprint
- Urban planning impacts from water demand for power generation and use, as well as the embodied energy in water cycle for new developments

After the first day's plenary presentations, three breakout groups formed to identify opportunities for future collaboration around the energy/water nexus. The following sections summarize the issues raised and ideas presented during these discussions.

8.3.1 Establish Research Collaborative

Establish a research collaborative for Water Energy Nexus. This collaborative would not be set just to have another meeting, but to provide an organizing framework for the inventory of existing research and the identification of future research. The collaborative should have a defined mission, leadership, and formal structure. Membership would come from research organizations like Electric Power Research Institute, Water Environment Research Foundation, Water Research Foundation, WateReuse Research Foundation, Sandia National Laboratory, National Renewable Energy Laboratory, and other key players. In order to assure that neither sector is dominant in the discussion, perhaps leadership should come from an organization that spans all areas of infrastructure, such as the Western Governors' Association.

The first step should be to identify collaboration opportunities and then seek funding, not put the financial concerns first. The initial needs would include the development of an information inventory to figure out what has already been done in existing research done.

Another early task would be the formal mapping the cycle of both water and energy and establish connections and how each resource will draw on the other throughout the cycle and consider all of the externalities (e.g., CO_2 generation). Also with the mapping of cycles, the decision points should be identified (risk, season, geographical, temporal). This mapping would be used as the general principal from which to identify the "low hanging fruit," as well as for defining research opportunities.

Finally, the research collaborative would have to determine the best set of metrics for the water/energy nexus to address water and energy issues in an integrated fashion, as cost is not best normalizing method. The metrics (or approach) should help determine which are the best composite solutions that may not be the best for each component, but overall the most balanced solution for all of the issues.

8.3.2 Investigate Plant Co-Location

Heat is a major component of the water energy nexus. Power plants generate a large amount of excess heat which often uses water for cooling. Wastewater plants need heat for drying of biosolids and for ensuring that the temperatures are high enough to keep biological treatment processes going. Heat is also required for desalination processes including membrane distillation. Co-locating power, water, and wastewater plants could provide cooling water to power plants and heat to the water and wastewater plants. In addition, carbon dioxide emissions from power plants could be used in conjunction with wastewater streams to provide growth media for algae for generation of biofuels and agricultural uses.

8.3.3 Enhance Integrated Infrastructure Planning

Even combined power and water utilities have silos. The challenge is to break down those barriers within and between organizations to have a better understanding of the risk of changing regulations and attaining goals for all aspects of infrastructure. Regulations are often outdated (e.g., Section 208 of Clean Water Act encourages only pipe and treat centralized approaches), conflicting (e.g., air regulations may adversely affect water). A collaborative approach is needed for dialog with regulators to consider the net environmental benefit (or some other integrated metric) of all regulations when evaluating a proposed solution.

In addition to regulatory planning, capital plans need integration. Right of way issues with electric lines and water, sewer, and gas pipelines could be coordinated. Could a smart grid encompassing both electricity and water be built concurrently?

8.3.4 Create Public Education Campaign

Public education is key to advancing the integration issues for the energy water nexus. The message is clear: ***"When the lights are on, water is flowing somewhere*,"** but the fragmentation of the sectors creates a barrier. For example, PNM serves most of New Mexico's electric needs, serving 500 towns, while those towns are served by 500 different water systems. External forces are driving need for water and energy collaboration, but the challenged is determining how much water, energy, and money savings will a public communication campaign save, and who should or could pay for the public service announcements or ad campaign.

8.3.5 Develop Integrated Distributed Systems

If we don't take a fresh look at our infrastructure solutions, we will continue to build the same infrastructure as we have now. Existing infrastructure was built based on the needs of society 40-100 years ago. We need to look at where society will be 40-100 years in the future as we plan for the rehabilitation and replacement of our nation's infrastructure. With this approach, ***"Economy of Integration" may surpass "Economy of Scale."*** As such, infrastructure solutions are beginning to consider distributed systems as opposed to centralized solutions, there is a need to develop a vision for integrated water/energy/waste distributed systems. Building on the co-location advantages, distributed integrated infrastructure systems could provide power, energy, water, and wastewater solutions on a smaller footprint. Power generation could be accomplished through solar, biogas generation from wastewater solids, and through solid waste incineration, in addition to traditional fuels or other renewable. Cooling water could be supplied from wastewater reuse. Heat from power generation could be used in water and wastewater treatment.

Distributed (or decentralized) systems mean smaller distribution and collection networks, while the grid could provide a power backup. The redundancy could provide an infrastructure security benefit, as well, as multiple systems would exist instead of a large, centralized plant. Regulatory hurdles are potentially substantial, as the integration of water, wastewater, solid waste, and energy generation spans multiple regulatory agencies.

The concept could work well in replacement. For example, instead of replacing an old water or wastewater pump station with a new pump station, an integrated water, wastewater, and power plant could be located on the same footprint. Obviously, for greenfield development, integrated distributed systems could be planned at the beginning for the most efficient solutions with respect to all aspects of the triple bottom line of sustainability: economics, environment, and social equity. Furthermore, greenfield development could provide a test case for solutions that could benefit developing countries. Similar to the way Africa skipped the centralized land line approach to telephony and went right to cellular networks, this effort could serve as an example on how our research and knowledge in integrated distributed systems could help developing countries.

The next steps for this project would be to use a collaboration of research agencies (EPRI, WaterRF, WERF, WateReuse RF, ASME, National Labs, State government (policy), solid waste representative) to create a structure of what an integrated distributed system would look like. A number of case studies exist for portions of the project. These would be analyzed to identify potential synergies between technologies within each core silo – water/wastewater/ solid waste/energy. The collaboration should build on this definition and propose pilot studies to multiple Federal Agencies (EPA, DOE, CEQ) to demonstrate the feasibility of the approach.

8.3.6 Revenue Decoupling

Under the present rate structures in U.S. water markets, utilities' revenues depend on the amount of water they produce and deliver to consumers. This type of system theoretically makes utilities averse to conservation and efficiency measures because their implementation ultimately cuts into profits by decreasing sales (revenues).

In some areas regulated electric utilities address an analogous situation with energy by "decoupling" the revenue from consumption. Decoupling removes the pressures placed on electric utilities to sell as much energy as possible by eliminating the relationship between revenues and sales volume. Under such a compensation scheme, revenues are "decoupled" from sales and are instead allowed to adjust so that utilities receive fair compensation regardless of fluctuations in sales. For more information on revenue decoupling at electric utilities, you can visit the following link:
http://www.pewclimate.org/what_s_being_done/in_the_states/decoupling_detail

While the water and wastewater industry is mostly publicly run as opposed to the largely regulated electric utility industry, perhaps the decoupling approach could aid in managing our scarce freshwater resources.

8.3.7 Anaerobic Primary Wastewater Treatment

Anaerobic digestion produces methane from biosolids after secondary treatment. Moving the energy recovery technology earlier in the process allows a wastewater plant to "get the energy out sooner." Anaerobic primary treatment has the potential to reduce energy consumption by half at a plant while doubling the energy generation from the anaerobic processes. Research and pilot testing of these techniques needs to be undertaken.

8.3.8 Agriculture/Water/Energy: In-conduit Hydropower Generation

Hydropower generation is possible in the channels used to provide irrigation water to agriculture (the largest consumptive water user at 70% of total consumptive use). Low-head turbines could be used to generate power for use at the farms. In addition, if drip irrigation is also included, a 40 percent decrease in water use could accompany the power generation. Pilot studies need to evaluate the scalability of these potential initiatives.