Water Resources Utility of the Future
Review of Existing Literature

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Water Resources Division

By

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Conventions

WERF vs. WE&RF

The Water Environment Research and Water Research Foundations joined to form the Water Environment & Reuse Foundation (WE&RF). All references to WERF have been changed to WE&RF.

Water Resources Utility of the Future vs. Water Resource Recovery Facility

The term Water Resources Recovery Facility (WRRF) represents the same concepts and ideas as the term Water Resources Utility of the Future (UOTF).

Wastewater Treatment Plant vs Water Resource Recovery Facility

This document describes the transformation of the wastewater industry towards resource recovery. For the purpose of clarity when referred to in the present facilities will be referred to as Wastewater Treatment Plants. The Water Resource Recovery Facility is used to describe the facilities in the future.

Water Resource Recovery Facility of the Future

The term Water Resource Recovery Facility of the Future used in the Michigan Water Strategy is synonymous with the term Water Resource Utility of the Future.

Transformation

The wastewater industry is undergoing changes that may be more profound than at any time in its history. Those changes will have a major impact on the industry and those who are a part of it.

In 2013, the National Association of Clean Water Agencies (NACWA), Water Environment Federation (WEF), and the Water Environment Research Foundation (now Water Environment and Reuse Foundation (WE&RF) released the "*Water Resources Utility of the Future… Blueprint for Action.*"[1] The document was prepared in response to unprecedented challenges faced by the wastewater industry and the need to change traditional ways of thinking to meet these challenges. Water Resources Utilities of the Future (UOTF) will produce clean water, protect the Great Lakes, recover nutrients (such as phosphorus and nitrogen), generate energy, utilize green infrastructure, and contribute to the sustainability of local communities.

A successful transformation to the UOTF approach will achieve beneficial outcomes for environmental, social, and economic improvements, commonly referred to as the triple bottom line.[2] It is crucial that everyone realize that this will be accomplished without relaxation of water standards or treatment while moving Michigan to better water quality overall.

The transformation is not just a physical challenge or change, however; it is also a cultural one. The road we decide to travel will affect our industry, engineering firms, construction contractors, equipment companies, laboratories, public officials, and local communities large and small.

A Major Achievement

Today there are 393 municipal wastewater treatment plants in our state. Collectively, those who work in those plants are responsible for more than 1.364 billion gallons of wastewater daily. That's an incredible achievement. It benefits millions of us in Michigan. But we need to raise awareness of our achievement and tell others about them if we are to attract more young men and women to the wastewater treatment profession.

One way to do this is by creating a strong positive image of the UOTF as an asset to the community. A resource for Michigan facilities is the Utility Branding Network (UBN) website[3]. UBN is designed to help water and wastewater agencies build a strong, positive brand that clearly communicates the value they provide to their communities. By clearly communicating the value that your utility provides, you will increase trust and support from policy makers and the community.

Trends in society – including concern and care for our resources – as well as advances in technology and innovation, are sparking interest among countless students in primary and higher

[1] http://www.nacwa.org/images/stories/public/2013-01-31waterresourcesutilityofthefuture-final.pdf
[2] The Water Resources Utility of the Future, A Blueprint for Action, accessed http://www.nacwa.org/images/stories/public/2013-01-31waterresourcesutilityofthefuture-final.pdf
[3] The Water Resources Utility of the Future, A Blueprint for Action, accessed http://www.nacwa.org/images/stories/public/2013-01-31waterresourcesutilityofthefuture-final.pdf

education. By collaborating with educators and mentoring students, we have an opportunity to enhance successful programs that will help us create our future.

This report provides information about the activities undertaken by the Michigan Department of Environmental Quality and Michigan Water Environment Association to transform Michigan's wastewater industry to Water Resource Utilities of the Future.

Peter V. Cavagnaro, P.E.
Lead author and editor: Water Resources Utility of the Future – Review of Existing Literature

Chapter 1: Introduction

A review of readily available literature on the subject of the Water Resources Utility of the Future was conducted to inform the core team of existing published reports to avoid duplicating information that was already available.

The initial effort was led by Christopher Conn of the Michigan Department of Natural Resources (MDEQ), and prepared by volunteer student interns. The information formed the basis of this document, which was then expanded and assembled by the Michigan Water Environment Association (MWEA).

The purpose of this report was to identify available resources for Michigan WWTPs and communities. MDEQ and MWEA collaborated to identify, review, and summarize readily available reports and documentation from:

- Water Environment Research Foundation (WERF)
- US Environmental Protection Agency (US EPA)
- New York State Energy Research Development Authority (NYSERDA)
- State of Wisconsin, Focus on Energy
- California Energy Commission

Chapter 2: Key Documents

Energy Water Nexus

In December 2006, the U.S Department of Energy submitted a report to Congress on the interdependency of energy and water, in which the term "Energy Water Nexus" was first used. That report noted: "The continued security and economic health of the United States depends on a sustainable supply of both energy and water. These two critical natural resources are closely linked. The production of energy requires large volumes of water, while the treatment and distribution of water is equally dependent upon readily available, low-cost energy."

Biogas Utilization

The Environmental and Energy Study Institute examined biogas utilization from landfills, agriculture, and wastewater treatment plants.[4] [5] It emphasizes specific quantities of energy methane, etc., and their impact on climate change. According to the EPA, the wastewater industry uses the equivalent of 56 billion kWh per year, or approximately 3% of total US electricity consumption. There are approximately 1,000 wastewater treatment plants in the US currently processing 5 million gallons of water per day, or more. Only 106 of these plants currently utilize biogas for heat or power generation. Most wastewater treatment plants use biogas digesters as part of their cleaning process but simply flare off the gas. Biogas from sludge contains between 65% to 90% methane. Electricity generated by the burning of biogas can be cheaper than most other forms of electricity. An example was given of the Point Loma WRRF in San Diego, California, was able to use its biogas digesters to generate enough methane gas to power a 4.5 MW generator. This facility that treats up 240 million gallons per day was able to save $3,000,000 per year in energy costs and sell $1.4 million of electricity back to the grid.

WEF Renewable Energy Position Statement

In a 2011 position statement on renewable energy generation, the Water Environment Federation stated: "WEF believes that wastewater treatment plants are not waste disposal facilities, but rather 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 upon fossil fuel through the production and use of renewable energy."

WEF Energy Roadmap

In 2013 WEF published the "Energy Roadmap: A Water and Wastewater Utility Guide to More Sustainable Energy Management." The document provided a framework of six areas in which a Water Resource Recovery Facility (WRRF) would work to achieve energy efficiency:

- Strategic Management
- Organizational Culture
- Communication and Outreach

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[4] Glover, Brian. (June 2009). *Biogas Capture and Utilization: An Effective, Affordable Way to Reduce Greenhouse Gas Emissions and Meet Local Energy Needs.* Environmental and Energy Study Institute.

[5] http://www.eesi.org/files/biogas_issuebrief_061609.pdf

- Demand-Side Management
- Energy Generation
- Innovation for the Future

Perhaps most important, the document was a milestone because it emphasized that energy efficiency in particular, and sustainability in general, require development in all six areas, while recognizing that not all six will be equally important to all plants.

The Challenge of New Goals

Among its major points, WEF notes the industry is now exploring more cost-effective approaches for recovering the resources present in wastewater and reusing them by combining technology and natural processes. A range of factors, including customer expectations and financial constraints, to name just two, are factors fueling the change to resource recovery facilities.

This process is known by another name – ***innovation***. Factors that are accelerating innovation include more stringent regulatory standards, tighter budgets, and sustainability goals and benchmarks. Many facilities are already benefitting from these innovations. This transformation from waste disposal to resource production can reduce costs and generate revenue.

To mitigate climate change, water conservation and comprehensive energy reforms must be taken. Achievable goals for utilities to meet include reducing energy usage by 20% in five years, eliminating flaring within 10 years, and producing as much renewable energy as the utility consumes, also within 10 years.

Reaching New Goals

It is important leaders in a utility focus on an energy vision and aligning that vision that is shared by everyone on the team, along with staff development. Communication with customers, communities, regulatory and legislative agencies are important and must be a part of an overall strategic plan.

Staff at all levels must understand how a utility uses and is charged for electricity. Along with this is a need to develop benchmarks for measuring electric power and control and monitoring both in real time.

Understanding all these processes will help utility managers evaluate performance and baseline energy use. Incorporating management's loading plan and strategic plan will ultimately reduce energy and maximize potential energy production.

Benefits of Achieving New Goals

The WEF report emphasizes that significant savings can be achieved with careful analysis of previous utility bills and shifting away from peak hour usage. That shift can be achieved by operating large motors in pumps for shorter periods of time along with simple changes to the timing and/or speed of motors which can reduce demand (and the energy bill) without adversely affecting operations.

WEF's report also points out that activated sludge typically consumes the largest amount (more than 50%) of a WRRFs electricity. Analysis are encouraged for each facility to determine the best opportunities for savings.

Other Potential Energy Sources

According to WEF, many energy sources exist on site that can be harnessed. For example, drinking water operations often provide opportunities for hydroelectric power.

Some WRRFs use water inflow, the influent, as a heat source. Depending on the scale of the operation and other factors, biogas can be used for electricity, heating, or fuel which can be sold and/or used to power fleet vehicles.

Boilers and micro-turbines can capture combusted biogas for electricity, or perhaps power motorized equipment directly via internal combustion engines.

Facilities that want to increase biogas production may choose to add food waste and/or grease to their digesters.

In some locations, solar panels or wind turbines may provide an additional source of renewable power.

The Water Resources Utility of the Future

In 2013, The National Association of Clean Water Agencies (NACWA, the Water Environment Federation (WEF), and the Water Environment Research Foundation (WERF), released the "Water Resources Utility of the Future… Blueprint for Action." The document was prepared because of the unprecedented challenges faced by wastewater agencies and the need to change traditional ways of thinking to meet these challenges. This document has led the way to acceptance of the term Water Resources Utility of the Future.[6]

Early studies have concluded that there are significant benefits that UOTFs provide. From a business standpoint, UOTFs reduce costs, increase revenues, and contribute to building local economies.

- Momentum for UOTFs is growing, but there are financial considerations and regulatory requirements to consider.
- Strengths of UOTFs are bold leadership, analytical rigor, triple-bottom line, decision-making, and stakeholder engagement. Other strengths are creating a brand and creating a need for stakeholders to buy in to the opportunities of UOTFs.
- Factors such as regulation, fiscal pressure, and climate change will drive the integration of UOTFs into the utility market.
- The government is a key to innovation because it helps set standards for utilities, targeted grants, technical assistance, and permitting.

Electric Power Research Institute Update

In November 2013, the Electric Power Research Institute published "Electricity Use and Management in the Municipal Water Supply and Wastewater Industries," updating a document

[6] http://www.nacwa.org/images/stories/public/2013-01-31waterresourcesutilityofthefuture-final.pdf

first published in 1996, which has been cited extensively by those discussing the connection between wastewater and energy.[7]

WEF Water Resource Recovery Facilities

In 2014, WEF issued a special publication titled "Moving Toward Resource Recovery Facilities," providing a more complete discussion on resources that can be discovered, with considerations on the identification, evaluation, and implementation of projects towards achieving the goal of WRRFs. This publication was instrumental in presenting the concept of the nutrient, energy, water recovery (N-E-W) paradigm.[8]

EPA Position on Food Waste

In September 2014, the EPA published "Food Waste to Energy: How Six Water Resource Recovery Facilities are Boosting Biogas Production and the Bottom Line." This is important to Michigan because of the challenge in diverting food waste from landfills to meet targets for increasing the recycling rate for residential household waste from 15% to 30%.[9]

Wastewater treatment plants have been harnessing the power of biogas since the 1920s to use for heat and power.[10] [11] With the transition from the wastewater treatment to the water resource recovery facility (WRRF), anaerobic digestion used to harness the biogas for heat and power are being used at an increasing level.

WRRFs are more efficient in terms of operation cost, sustainability, and public health. Some WRRFs are reaching energy neutrality and becoming energy positive in terms of their use. WRRFs are doing this by using a combination of energy efficiency measures and the addition of outside organic wastes. The addition of fats, oils, and grease to digesters is enhancing this practice and becoming more common. Agricultural production and food processing facilities byproducts, along with municipally collected food scraps, are not as commonly used food waste.

Using these types of food waste is called co-digesting and is becoming more common. The process of anaerobic digestion and co-digestion help WRRFs tap into excess capacity and lower costs as energy prices rise and tighter regulations cost more money. In this report, the process of WRRFs collecting and using these materials is completely outlined, along with the benefits, strategies, and case studies.

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[7] http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002001433

[8] http://www.e-wef.org/Default.aspx?TabID=251&productId=38340520

[9] http://nepis.epa.gov/Exe/ZyNET.exe/P100LDEL.TXT?ZyActionD=ZyDocument&Client=EPA&Index=2011+Thru+2015&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C11thru15%5CTxt%5C00000013%5CP100LDEL.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL

[10] Environmental Protection Agency Office of Research and Development. (2014), "Food Waste to Energy: How Six Water Resource Recovery Facilities are Boosting Biogas Production and the Bottom Line."

[11] http://www.nacwa.org/images/stories/public/2015-01-16epa-food-energy.pdf

Effective Utility Management

Utilities face significant challenges when trying to improve the quality and the cost of their services. The Environmental Protection Agency (EPA) and North American organizations representing water and wastewater utilities are aware of these challenges and attempt to address them through appropriate Effective Utility Management (EUM) practices.[12][13]

Seven organization came together to create the Effective Utilities Management Collaborating Organizations (EUMCO) with the intent to promote EUM and develop framework for effectively managed water utilities. To accomplish this, the EUMCO created a steering committee that prepared a combination of findings and recommendations on strategies for future water utilities. The basis of the strategy was centered on the Ten Attributes of effectively managed Water Sector Utilities.

The abundance of EUM-related documents available provided no specific recommendations on how utilities would develop and implement the attributes. The Water Research Foundation found a way to build upon the work by Primer and AWWA QualServe program by focusing on components not previously included in these endeavors. The team executed the project in two phases.

The first phase identified the important metrics and practices associated through a literature review and utility surveys, and developing a benchmark framework utilizing a tool created by the team. In the second phase, the EUM framework, methodology, and tool were tested with water and wastewater utilities. EUMCO recruited additional utilities, used benchmarking tests, made refinements to the benchmarking framework, and developed recommendations. Based upon feedback from the utilities, the tools developed during the project were found to be very useful. Many utilities have expressed an interest in further development and research to refine the tools, identify appropriate performance targets within some of the practice areas, and possibly include additional performance measures.

WE&RF Report on Five Champions of Change

In February 2015, the Water Environment Research Foundation published "*Demonstrated Energy Neutrality Leadership: A Study of Five Champions of Change* (ENER1C12b)." This document presents five case studies on key facilities that achieved or made significant advances towards becoming net zero energy facilities.[14]

WEF Nutrient Roadmap

The goal of the organization is to identify steps to develop a roadmap toward implementing a nutrient management vision, primarily for nitrogen and phosphorus. The "Nutrient Roadmap"

[12] Matichich, Michael, Hasit, Yakir., et al. (2014), "Performance Benchmarking for Effectively Managed Water Utilities". Water Research Foundation.

[13] http://www.waterrf.org/publicreportlibrary/4313b.pdf

[14] http://www.werf.org/CMDownload.aspx?ContentKey=f149efbe-9d17-42c1-8e1e-1d6ec088ed08&ContentItemKey=e69bb4f3-3b39-4ba2-964e-0f92bf10cc45

would serve as a short-term need for achieving smarter nutrient removal and recovery at water resource recovery facilities (WRRF).[15]

The need for change in nutrient removal processes is derived from factors such as population growth, environmental concerns, society's demand for cleaner water, and enhancing economic benefits. When developing the nutrient roadmap, it must adhere to existing regulatory and water quality standards and set short-term and long-term goals. Factors and goals are to determine treatment levels, nutrient recovery/removal, energy use, and budgets.

Education of staff and communities is also a critical component of the Roadmap. Reducing nitrogen and phosphorus discharges below current levels is not a simple process. With global population still growing, the wastewater treatment industry will play a key role in providing water, electricity, fertilizer, and waste disposal to both developed and developing nations.

Most of the worlds phosphorous is mined from mineral rocks and is a finite resource; therefore, extracting phosphorous from wastewater offers a critical solution. Implementing upgrades to wastewater treatment facilities must take into account many factors such as capacity, location, cost of water and power, local market conditions, and regulations.

A goal is to reduce the quantity of bio-solids that need disposal by at least 40%; digestion of bio-solids can also provide methane, which can be captured and used to generate heat and electricity. The effluent water can be used for irrigation, cooling power plants, or even as potable water. Biological treatment methods are the most cost-effective way to deal with domestic wastewater. Nitrification and phosphorous removal are two processes that can be done using biological treatment. The main elements of nutrient management include waste load allocations, integration of nutrient recovery side stream technology, wet weather management, advanced and natural treatment systems, and water recycling.

Many utilities struggle to find ways to remove enough organic pollutants to meet regulatory requirements. Society is also struggling to find ways to reduce energy consumption and waste, and meet the growing demand for fertilizer. Many of the strategies currently used for nitrogen removal return it to the atmosphere as dinitrogen, leaving only about 15% to 25% available for land application. Wastewater also is mineral rich, which can potentially reduce the need to mine minerals such as boron, calcium, magnesium, and sulfur while providing a source of revenue for the WRRF. Creating a "nutrient roadmap" can be an extremely valuable tool in reducing nutrient waste and increasing efficiency.

WERF Report on Net Zero Energy Solutions

In May 2015, WERF published the results of a study, "*Net-Zero Energy Solutions for Water Resource Recovery Facilities"* (ENER1C12). This effort studied energy-efficient best practices to moving WRRFs closer to achieving energy neutrality. This effort contributed to the industry's understanding of challenges that WRRFs face as they strive for energy neutrality.

[15] Nutrient Roadmap Task Force of the Water Environment Federation. (2015), "The Nutrient Roadmap", Water Environment Federation. Alexandria, VA. Book.

WERF Best Management Strategies

Water Environment Research foundation (WERF) researchers have constructed a series of best management strategies to reduce overall energy demand in handling wastewater.[16] [17] These include: enhanced anaerobic digestion, increased carbon solids capture, using a low energy nitrogen treatment, and finding processes to recapture heat and remnant energy from dewatered bio-solids.

Economic factors are currently the major obstacles to using more efficient processes which would lead to more energy recovery. However, there are indirect restrictions such as current environmental and industrial regulations that do not account for carbon footprints resulting from that energy use. Other factors include side effects of litigation and a reduced cultural recognition of water as a valued resource.

The amount of time it takes for new technologies to be used depends strongly on the success of pilot programs and demonstrations of that technology. One proposed solution is for WERF/WEF to create a venue (Leaders Innovation Forum for Technology or LIFT) to more coherently test and assess new technologies in tandem with private sector companies. Overall, the LIFT initiative would focus on the following seven areas: short cut nitrogen removal, P-recovery, enhanced digestion, shifting bio-solids to energy, collecting energy from wastewater, improving collection systems, and integration with green infrastructure. This cost and risk sharing could help bring more companies to use the improved technologies sooner.

NACWA Delivering Value to Taxpayers

Clean water utilities have become so reliable, effective, and efficient over time that most people have a view of "out of sight, out of mind." While this is a significant long-term achievement, this mindset also indicates that ratepayers and stakeholders do not pay enough attention to the role that clean water utilities play in their lives, the value to individuals and businesses, and environmental gains.[18][19]

Clean water utilities need to learn how to effectively communicate locally and nationally to tell their success stories and describe the value of clean water utilities to citizens. From an economic point of view, the investment return of clean water utilities is impressive. Investment creates employment opportunities, enhanced productivity in the private economy, higher standards of living, and a more favorable trade balance.

The environmental impact should be clear by delivering clean and safe drinking water as well as protecting the environment as a whole. The move from wastewater treatment plants to Utilities of the Future will be heightened when regulators and governing boards support the transition and acknowledge the returns possible from the UOTF.

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[16] Fillmore, L. (2015). Energy Production and Efficiency Research Program. Water Environment Research Foundation.

[17] http://www.energy.gov/sites/prod/files/2015/10/f27/Fillmore_WERF_NSF_panel.4.29.2015.pdf

[18] National Association of Clean Water Agencies Steering Committee. (July, 2014). Today Clean Water Utility: Delivering Value to Ratepayers, Communities, & the Nation. NACWA.

[19] http://www.nacwa.org/images/stories/public/meetings/2014summer-final.report.design.uotf.pdf

The investment in UOTFs should be looked at with urgency because environmental and public health outcomes will be enhanced, and emerging objectives like resource recovery, water reuse, energy efficiency, and sustainable communities will be enabled, which are ecological and cost saving.

East Bay Municipal Utility District (EBMUD)

The East Bay Municipal Utility District (EBMUD) in Oakland, California, became the first net producer of renewable energy at a water resource recovery plant in North America.[2021]

Wastewater treatment plants (WWTP) should be viewed as opportunities for resource recovery and not simply as disposal sites. These facilities produce clean water, recover nutrients from waste, and are a source for renewable energy. In the future, WWTPs could become green factories. In addition to wastewater, they would also accept food-related byproducts and turn out other useable materials such as biodiesel, fertilizers, and renewable sources of heat and electricity.

New techniques are emerging for resource recovery and energy generation at WWTPs. The NEW (Nutrients, Energy, Water) methods at WWTPs are challenging more traditional modes of renewable energy such as solar and wind power. In particular, biogas cogeneration is increasing and is a viable source for electricity and heat, in addition to being a possible clean fuel source. Biogas is created by anaerobic digestion of food byproducts (fats, oil, and grease), organic wastes, and whey.

Water treatment processing can consume large amounts of energy. This ranges from 7% of electricity worldwide to 3-4% of the U.S. supply to 19% of California's electricity. However, the amount of energy in wastewater is five times that of the energy needed to simply treat it. Sustainable management of water resource recovery facilities relies on effective planning. Effective planning could include creating a "roadmap," including topics such as strategic management practices, a culture focused on organization, conserving more water to reduce waste processing demands, increased production of renewable energy, outreach and communication with communities, and innovating to meet future needs.

The EBMUD facility in California implemented a biogas turbine that allows the facility to generate enough energy to be self-sufficient. EBMUD also continues to work on its vision of a "green factory" by collecting food waste from restaurants at several locations. This waste is pre-processed at a specially-built facility. Converting this food waste to produce energy has a variety of benefits, including: diversion of this waste from landfills, another source of renewable energy production, and obtaining greenhouse gas emission credits from using biogas instead of non-renewable energy sources.

[20] Ed McCormick, P. W. (2015). Moving Toward an Energy-Positive Water Sector. Presentation at Energy Positive Water Resource Recovery Workshop, Water Environment Federation.
[21] http://www.energy.gov/sites/prod/files/2015/10/f27/McCormick_4-28-2015.pdf

Anaerobic Digestion

This document[22] [23]contains many photographs and diagrams and details the process of biogas digestion at WRRFs. The main gases produced in digestion are methane and carbon dioxide. However, small amounts of hydrogen sulfide, dihydrogen, dinitrogen, and water vapor will also be present and may need to be removed. Digesters require mild amounts of heat input to speed up the process. Digesters have been used since the early 1900s in water treatment plants to reduce the volume of sludge. Digested and dried sludge can be used as fertilizer. The gas can be combusted directly into micro turbines, used to power a molten carbonate fuel cell, used to power a boiler, burned for heat, or simply flared off. Wastewater treatment is one of the greatest energy costs to municipalities, and using gas generated from anaerobic digestion can greatly reduce the cost of energy at treatment facilities.

NSF/EPA/DOE Energy-Positive Workshop

In 2015, an interagency work group composed of the National Science Foundation, United States Department of Energy, and United States Environmental Protection Agency (USEPA) published a report on an "Energy-Positive Water Resource Recovery Workshop". It noted that "As water treatment facilities, pipes, and related infrastructure in cities around the country approach the end of their expected service life, a unique window of opportunity exists to replace the aging infrastructure with the WRRF of the Future—reducing stress on energy systems, decreasing air and water pollution, building resiliency, and driving local economic activity."[24] The report also noted that aging U.S. water infrastructure is estimated to need an investment of $600 billion over the next 20 years to continue to function reliably and that the transition from typical processes of wastewater treatment offers an opportunity to apply new knowledge and technologies.

The new generation of Water Resource Recovery Facilities would efficiently recover resources, integrate with other utilities, engage and inform communities, and incorporate smart systems to monitor and track plant performance. They are being called the utility of the future. As wastewater treatment plants, pipes, and other related infrastructure across the country deteriorate, an opportunity exists to replace the aging infrastructure, with the utility of the future Water Resource Recovery Facilities in turn reducing stress on energy systems, decreasing air and water pollution, building resiliency, and driving local economic activity.

[22] "Anaerobic Digestion of Wastewater Sludge."

[23] http://engineering.dartmouth.edu/~d30345d/courses/engs37/AnaerobicDigestion.pdf

[24] http://www.energy.gov/eere/bioenergy/energy-positive-water-resource-recovery-workshop-report

Michigan Water Resource Recovery Leadership Summit

On April 8, 2016, Michigan's Water Resource Recovery Leadership Summit was conducted, under the sponsorship of the Michigan Department of Environmental Quality, Water Resources Division, and hosted by the Michigan Water Environment Association. The purpose of the summit was to:

- Introduce the concept of the Water Resources Utility of the Future (WRUOF).
- Obtain feedback from participants; and
- Identify obstacles and obtain commitment to develop solutions.

The summit's purpose was to shape the direction of the wastewater industry in the State of Michigan for the next 20 years.

Utility of the Future Today Recognition

In May 2016, a collaboration of industry leaders (National Association of Clean Water Agencies, Water Environment Federation, Water Environment Research Foundation, and Water Reuse, in collaboration with the United States Environmental Protection Agency) published an invitation to utilities that own and operate WRRFs to apply for the Utility of the Future Today recognition.[25]

[25] https://www.nacwa.org/index.php?option=com_content&view=article&id=2372&Itemid=49

Chapter 3: Resources

Wisconsin Focus on Energy

The single most useful guide / reference book for WWTPs to use to plan and implement energy conservation programs is published by Wisconsin Focus on Energy's "Energy Best Practices Guide: Water & Wastewater Industry", published in 2016. This manual is the property of the Public Service Commission of Wisconsin, but is available at no cost on the FOE web site.

New York State Energy Research Development Authority (NYSERDA)

NYSERDA is probably the single most important source of information related energy conservation and energy production at WWTPs. Their web site is https://www.nyserda.ny.gov/. Just search for "wastewater" and a number of excellent references are available at no cost.

One important document is "Water & Wastewater Energy Management" Best Practices Handbook, March 2010, Content Revised September 2010, content prepared by Malcolm Pirnie.

Environmental Protection Agency

The EPA has published many references related to wastewater treatment. Some to consider for energy efficiency efforts are:

- Ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities, 2008.[26]
- Evaluation of Energy Conservation Measures for Wastewater Treatment Facilities, EPA832-R-10-005, September 2010,
- EPA Water & Energy Efficiency in Water and Wastewater Facilities, website.[27]
- 2012 Guidelines for Water Reuse, US EPA, EPA/600/R-12/618, September 2012[28]

Water Environment Federation

The Water Environment Federation has a number of publications related to energy efficiency at wastewater treatment plants. The following is a list of a few of them:

- Energy Roadmap
- Energy Roadmap Primer (free download)
- Moving Toward Water Resource Recovery Facilities
- Energy Conservation in Water and Wastewater Facilities - MOP 32

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26 https://nepis.epa.gov/Exe/ZyNET.exe/P1003Y1G.TXT?ZyActionD=ZyDocument&Client=EPA&Index=2006+Thru+2010&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C06thru10%5CTxt%5C00000008%5CP1003Y1G.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL

27 https://www3.epa.gov/region9/waterinfrastructure/howto.html

28 https://nepis.epa.gov/Adobe/PDF/P100FS7K.pdf

Water Environment & Reuse Foundation (WE&RF)

WE&RF has a long list of research documents related to energy efficiency and sustainability at WWTPs.[29] Also, look into the Leaders Innovation Forum for Technology (LIFT) program.

Water Effective Utility Management (EUM)

Useful information for any WWTP wanting to make the transition to Water Resources Utility of the Future.[30]

Utility Branding Network for Water and Wastewater Agencies

Helpful information and advice on the concept of branding of water and wastewater agencies.[31]

National Association of Clean Water Agencies (NACWA)[32]

Lead agency for the Water Resources Utility of the Future.

California Energy Commission

- Like NYSERDA, the California Energy Commission has been active in developing factual information on which to base energy efficiency improvements at wastewater treatment plants.[33]
- Access information for wastewater treatment plants at:

American Council for an Energy-Efficient Economy (ACEEE)

- The ACEEE has prepared a website describing the resources available for energy conservation at wastewater treatment plants.[34]
- The information is available for download in PDF format, and is referenced as a "toolkit".

National Biosolids Partnership

WEF hosts a web site for the National Biosolids Partnership.[35] There is useful information on production and use of methane gas by anaerobic digestion.

[29] https://www.werf.org/
[30] http://www.watereum.org/
[31] http://utilitybranding.net/
[32] https://www.nacwa.org/
[33] http://www.energy.ca.gov/process/water/wastewater_treatment.html
[34] http://aceee.org/sector/local-policy/toolkit/water
[35] https://wrrfdata.org/NBP/Newsletter/national-biosolids-partnership/

Appendix 1: Abbreviations

CCP	Composite Correction Program
LIFT	Leaders Innovation Forum for Technology
MDEQ	Michigan Department of Environmental Quality
MGD	Million Gallons per Day
MPSC	Michigan Public Service Commission
MWEA	Michigan Water Environment Association
NACWA	National Association of Clean Water Agencies
OCWA	Ontario Clean Water Agency
PPP or P3	Public-Private Partnerships
UBN	Utility Branding Network
UOTF	Water Resources Utility of the Future [Note to reader: this abbreviation is consistent with NACWA's abbreviation of the phrase]
EPA	United States Environmental Protection Agency
WEF	Water Environment Federation
WERF	Water Environment Research Foundation
WE&RF	Water Environment & Reuse Foundation
WRD	Water Resources Division
WRRF	Water Resource Recovery Facility
WWTP	Wastewater Treatment Plant