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Municipal Wastewater Reuse by Electric Utilities: Best Practices and Future Directions

Workshop Report

September 12, 2012

Acknowledgements

This *Best Practices and Future Directions Workshop Report* was prepared by Lindsay Pack and Ross Brindle of Nexight Group under the guidance of Dr. Michael Tinkleman, Director, Research at the American Society of Mechanical Engineers (ASME) and Dr. Barry Liner, Director, Water Science & Engineering Center, Water Environment Federation (WEF). On behalf of ASME and WEF, we would like to express our appreciation to the participants in the Municipal Wastewater Reuse by Electric Utilities: Best Practices and Future Directions Workshop (see list at the end of this document) for their input and recommendations.

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I. Executive Summary

Impending regional freshwater shortages and increasing electricity demand in the United States has encouraged the reuse of municipal wastewater in electric utilities. Treated by municipal wastewater plants, this reclaimed water can safely meet the water needs of the power producing process while conserving freshwater for other uses. However, substantial technical, regulatory, communication, and public perception barriers among others, make projects incorporating wastewater reuse into electric utilities slow and difficult to launch.

The American Society of Mechanical Engineers (ASME) and the Water Environment Federation (WEF) jointly sponsored a workshop to address this challenge. Held May 21–22, 2012 at the ASME Washington, DC office, the Municipal Wastewater Reuse by Electric Utilities: Best Practices and Future Directions workshop brought together leading experts from municipal wastewater plants and electric utilities to identify best practices and potential paths forward for increasing the use of municipal wastewater in electric utilities across the nation. Through a series of highly interactive discussions led by professional facilitators, workshop participants defined the following:

- Characteristics of successful municipal wastewater reuse projects at electric utilities
- Common barriers to successful municipal wastewater reuse projects at electric utilities
- Potential steps needed to overcome the barriers and launch new projects

This report outlines the results above along with potential actions that merit further investigation and that could involve support from ASME and WEF (see Figure 1). It is intended to serve as a compilation of initial ideas regarding best practices and potential future initiatives to increase wastewater reuse at electric utilities and, ultimately, to help to reduce the power sector's freshwater consumption without sacrificing its ability to provide power to U.S. citizens.

Figure 1. Initial Best Practices and Future Directions for Launching Successful Projects

II. Municipal Wastewater Reuse at Electric Utilities

Energy and water have a well-known relationship that is interconnected and interdependent. While water production, processing, distribution, and end-use all require energy, electric utilities rely on a steady flow of water for essential functions, particularly cooling. In fact, the U.S. Geological Survey estimates that in 2005, thermoelectric power accounted for 49% of total water withdrawals, approximately 201 billion gallons per day. This portion is the highest of all U.S. water withdrawals, including irrigation, industrial use, and public supply.[1]

As the demand for power and water increases due to significant U.S. population increases in the coming decades due to organic growth and population shift, an increasing level of strain will be placed on the country's already dwindling freshwater supply. A new American Chemical Society report indicates that as a result of this increasing demand and the impacts of climate change, 7 in 10 U.S. counties could risk freshwater shortages by 2050, with 1 in 3 counties classified as having a high or extreme risk of water shortages in the same time period.[2]

The impending regional freshwater shortages and increasing electricity demand in the United States have encouraged the reuse of municipal wastewater in electric utilities. Treated by municipal wastewater plants, this reclaimed water can safely meet the water needs of the power producing process while conserving freshwater for other uses.

Successful projects incorporating municipal wastewater reuse into electric utilities have launched in areas that experience regular freshwater shortages or have regulations that favor such approaches, such as Florida, Arizona, California, and Texas. However, these projects typically take a long time to develop, and in some regions, are not even under consideration. Projects must offer a reliable supply of reclaimed water of consistent quality at a reasonable price, overcome public and political perceptions about the reuse of municipal wastewater, and be technically and logistically feasible. These requirements pose significant challenges to municipal wastewater treatment plants and electric utilities that make it difficult for them to launch new reclaimed water projects on their own.

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[1] Kenny, J. F., N.L Barber, and S.S. Hutsonm et al. "Estimated use of water in the United States in 2005," *U.S. Geological Survey Report*, Circular 1344, 2009. http://water.usgs.gov/watuse/ (accessed July 2012).

[2] Roy, Sujoy B., Limin Chen, and Evan H. Girvetz, et al. "Projecting Water Withdrawal and Supply for Future Decades in the U.S. under Climate Change Scenarios," *American Chemical Society Journal of Environmental Science and Technology*. Accessed at www.cleanwateramericaalliance.org/wp-content/uploads/2012/03/A9R71C0.pdf (July 2012).

The Role of ASME and WEF

The opportunity for greater municipal wastewater reuse by electric utilities prompted the American Society of Mechanical Engineers (ASME) and the Water Environment Federation (WEF) to jointly organize a workshop addressing this challenge. As member-driven organizations specializing in championing innovation and enabling collaboration and knowledge sharing in the areas of energy and water, ASME and WEF have a unique ability to convene the expertise of their membership to support municipal wastewater plants and electric utilities in the sharing of best practices and the development of new projects.

The Best Practices and Future Directions workshop, held May 21–22, 2012 at the ASME Washington, DC office, brought together leading experts from municipal wastewater plants and electric utilities to identify best practices and potential paths forward for increasing the use of municipal wastewater in electric utilities across the nation. Through a series of highly interactive discussions led by professional facilitators, workshop participants defined the key characteristics of successful municipal wastewater reuse projects at electric utilities, highlighted key barriers to such projects, and identified steps needed to overcome the barriers. Participants also identified potential actions that merit further investigation and that could involve support from ASME and WEF.

The following report outlines initial ideas regarding best practices and potential future initiatives to increase municipal wastewater reuse at electric utilities. It can serve as a starting point for developing and implementing initiatives that will ultimately help to reduce the power sector's freshwater consumption without sacrificing its ability to provide power to U.S. citizens and free up regional freshwater sources to promote growth and ultimately, an increase in power demand.

III. Case Studies

While new projects involving the use of reclaimed water at electric utilities have been slow to launch, several projects have successfully been established and continue to operate today. Examining these cases can help stakeholders identify best practices and lessons learned for use in developing new projects. The five case studies that follow are examples of successful, real-world partnerships between municipal wastewater plants and electric utilities.

San Antonio Water System

CPS Energy plant supplied by the San Antonio Water System

The San Antonio Water System (SAWS) in Texas is a prime example of a successful reclaimed water project. The city's perception of reclaimed water is historically positive, due in large part to the public's familiarity with reuse as part of their city's operations. Water reuse for municipal power generation cooling began in San Antonio in the 1960s. By 2000, SAWS was operating one of the largest reclaimed water systems in the United States, an expansion partly driven by federal court decisions restricting aquifer use to maintain several endangered species. These factors have enabled the use of reclaimed water in a number of projects. For example, CPS Energy uses 45,000 AFY (acre-feet per year) of reclaimed water from SAWS for its cooling lakes. SAWS conducted a pilot study of the use of its reclaimed water in cooling towers and found that no change in water volume was needed, acceptable corrosion rates were maintained, and that water treatment costs with recycled water were similar to existing treatment costs.

In addition to use at electric utilities, reclaimed water from SAWS is used at the San Antonio Water System's Downtown Central Chiller Plant, the Alamodome Chiller Plant, the Spurs AT&T Center, four military bases (including hospitals, barracks, and offices), multiple hospitals at San Antonio's Medical Center, and at the city's universities and data centers. By implementing this effective wastewater reuse system, the city of San Antonio runs on more than 20% reclaimed water, which has enabled the population to double in 20 years without increasing water demand.

Denver Water Recycling Plant

Located in a water-scarce, arid prairie region of the United States, Colorado's Denver Water is committed to wastewater reuse. The recycling plant treats up to 30 million gallons of effluent a day coming from the neighboring Metro Wastewater Reclamation District Plant, then pumps the water through 18 miles of pipeline to Xcel Energy, the Denver Zoo, Denver parks, golf courses, school systems, and other users. In addition to treating water for reuse, Denver Water has made it its mission to educate the public on water reuse and conservation, going as far as offering public tours of their recycling plant. Denver Water has also devised new ways of creating more of an incentive for its wastewater reuse partners. The plant provides a blend of raw and reclaimed water to Xcel Energy's coal-fired, steam-electric Cherokee Station plant to maximize the cost-effectiveness of the water. Cherokee Station uses it for washdown, and fire lines. By using this raw water blend, Denver Water has established a new and needed water supply with potential interest and value to customers. Keys to the success of this project include evaluating and monitoring the impact of fuel source changes on water requirements, addressing groundwater permitting issues, and understanding industrial pretreatment standards.

West Basin Municipal Water District

The West Basin Municipal Water District in Los Angeles, California relies on imported water from the Metropolitan Water District of Southern California (MWDSC) to provide water to a population of approximately one million people. In the early 1990s, West Basin added recycled water to its portfolio to aid in conservation efforts and has since developed conservation and education programs to ensure that the public is well informed. To aid in overcoming perception issues and meeting the unique needs of their customers, and to diversify its revenue streams, the West Basin Municipal Water District in Los Angeles, California produces "designer water," or amended tertiary water for industrial and irrigation use. The types of designer water the district produces include the following:

- Tertiary Water: Filtered and disinfected for industrial and irrigation use
- Amended Tertiary Water: Conditioned tertiary for more effective soil penetration
- Nitrified Water: Tertiary water plus nitrified for cooling towers
- Softened RO Water: Secondary water, with either lime clarification or MF plus RO for groundwater recharge
- Pure RO Water: Secondary treated water plus MF and RO for low-pressure boiler feed water
- Ultra-Pure RO Water: Pure RO plus a second RO pass for high-pressure boiler feed water

The designer water strategy implemented by West Basin enables the use of recycled water far beyond the potential of a single treatment water product. In addition to more common irrigation applications for street medians, parks, and golf courses, West Basin can also service several local refineries and a power generation company with recycled water by matching the right quality of water with the right use. West Basin has been successful in providing water qualities ranging from sophisticated recycled water used for recharge of underground aquifers to basic recycled water for street sweeping operations and landscape irrigation applications.

Palo Verde Water Reclamation Facility

In Arizona's Palo Verde community, wastewater treatment and power are highly integrated. The Palo Verde Nuclear Generating Station, the largest nuclear generation plant in the United States, is the only nuclear power facility that uses 100% reclaimed water for cooling, due in large part to its desert location. Unlike other nuclear plants, Palo Verde maintains "Zero Discharge," which means that no water is discharged to rivers, streams, or oceans. The source of this water is the Palo Verde Water Reclamation Facility (WRF), which is located on site at the generating station. The 90 million gallons per day (MGD) tertiary treatment plant reclaims treated secondary effluent from the cities of Phoenix, Scottsdale, Tempe, Mesa, Glendale and Tolleson. After the water is treated and used for cooling, the WRF sends the cooling water make-up to the Redhawk Generating Station, which uses a thermal zero liquid discharge (ZLD) system to process and use it for their power-generating purposes.

Palo Verde Nuclear Generating Station Water Reclamation Facility

In addition to supplying the Palo Verde Water Reclamation Facility, the 91st Avenue Wastewater Treatment Plant in Phoenix which has a capacity of 204.5 MGD and treats 135 MGD per day, sends 30,000 AF to the nearby Buckeye Irrigation District, and 28,500 AF to the Tres Rios Flow Regulating Wetland Facilities. Palo Verde's success is a strong example of how wastewater is becoming a valuable resource that is being competed for in some areas of the country.

Tampa Electric Company and Orlando Utilities Commission

Many wastewater treatment plants are concerned about reclaimed water due to their need to handle effluent disposal and water conservation. In Florida, this type of water reuse is critical due to a major lack of effluent disposal options for discharge. The majority of surface water options have low or zero flow and little or no assimilative capacity which, when combined with extremely hot temperatures, creates algal blooms. Florida has the benefit of comprehensive regulations for different types of water reuse, which aids in a higher level of reuse. While most of this reuse goes to public access areas and landscape irrigation, a large amount also goes to cooling water for industry and power production.

The Tampa Electric Company (TECO) currently has a partnership agreement with the City of Lakeland to incorporate wastewater reuse into its 260MW integrated coal gasification combined cycle (IGCC) Polk Power Station through the Lakeland Wetland Treatment Area. Facilitated by the South West Florida Water Management District (SWFWMD) as part of its Reclaimed Water Initiative, SWFWMD provides 50% of the project funding to accomplish the following:

- Minimize the use of groundwater for cooling water make-up
- Maximize the beneficial use of reclaimed water from the Lakeland Treatment Area
- Provide a reliable, long-term source of reservoir make-up water
- Improve reservoir water quality—reduce total dissolved solids (TDS)
- Reduce reservoir loading through diversion of process waste streams to underground injection control (UIC) well

TECO Polk Power Station

TECO is employing an evaluation process to determine the effectiveness of the pilot system, which involves monitoring the wetlands effluent, testing conceptual-level screen treatment train alternatives, and modeling the selected treatment process. As this project progresses, it will serve as a case for how to retrofit such a system in other plants.

The Orlando Utilities Commission (OUC)'s Stanton Energy Center is another Florida utility using reclaimed water. The plant, which has been using reclaimed water as its primary source of cooling water make-up since the 1980s, has also implemented a crystallization system that enables them to treat their cooling water blow down on site and sell the treated water as a product stream. OUC recently conducted a study to determine how much demand could be put on a plant without devaluing the water, using water balance models to assess the future reliability of make-up water supplies in the face of increased flow and increased diversion to urban irrigation. The study found that there is more demand for the reclaimed water than they have supply, but that reliability is a critical part of the analysis and will mean more to customers than cost in the future.

IV. Characteristics of Successful Projects

Past municipal wastewater projects at electric utilities share common characteristics that can help formulate best practices for collaborative projects. In the broadest sense, successful projects offer a reliable supply of reclaimed water of consistent quality at a reasonable price. Appendix C provides a detailed list of characteristics shared by successful projects. The following are the most critical components to successful projects:

- Active collaboration and agreement between wastewater treatment plants and electric utilities
- Clearly defined water quality and flow rates
- Optimal and adaptable system design
- Compliance with all regulations
- Ongoing education and outreach efforts

Active collaboration and agreement between wastewater treatment plants and electric utilities

Incorporating reclaimed water into an existing power plant can be a complex endeavor. A physical system must be developed to transport water from the treatment plant to the electric utility; equipment that can accept, treat (if necessary), and integrate wastewater into the power plant may be design and retrofitted into current operations; water quality requirements and constituent limitations must be defined and monitored; and contingency plans for handling wastewater quality and quantity variations and unanticipated future operational problems must be determined. Finally, due to the size of the assets and the critical requirement to maintain electricity service, power plant managers and operators are highly sensitive to real or perceived risks. Because wastewater treatment plant and electric utility operators do not typically work together, successful projects require that these two groups make a concerted effort to collaborate from the earliest planning stages of any project. Although this point may seem obvious, the importance of effective collaboration between the two utility plants cannot be overstated.

Wastewater treatment plants and electrical utilities need to have a clear understanding of each other's needs, expectations, and capabilities. This involves the electric utility and the wastewater treatment plant making each other aware of the critical parameters of their respective plant and operations. In successful projects, the two parties also agree on respective responsibilities at a highly granular level and put in place an effective communication plan that remains active during operation of the system. Providing procedures for when and how to alert the other party, the plan ensures that both sides are proactive and communicative about all potential issues that arise before they adversely impact operations. Developing a formal, long-term (30+ years) contract between the wastewater treatment plant and the electric utility that outlines these parameters is a good practice that helps ensure this collaboration.

Clearly defined water quality and flow rates

Reclaimed water produced by a single treatment plant can vary in chemical composition and flow rates based on wastewater availability, composition, water treatment process fluctuations, and many other factors. At the same time, power plant operations are highly sensitive to water chemistries that vary outside of acceptable ranges, while inconsistent water supply can impact the plant's ability to supply power. As a result, successful projects require that water quality issues are thoroughly identified, planned for, and actively monitored to ensure success.

An important step in addressing this issue is for wastewater treatment plants to provide a sufficient history (ideally two years) of water quality data to the electric utility to provide confidence that the water will remain within acceptable tolerances for power plant operation. Establishing shared, definitive terms on water quality and developing communication protocols about possible variations in water quality helps to ensure that the electric utility's ability to supply power will not be compromised even if variations in quality arise. Taking these steps promotes a project in which the reclaimed water quality and delivery flow rates provided by the wastewater treatment plant matches the quality and volume required by the utility on an annual, seasonal, and hourly basis.

Optimal and adaptable system design

A truly successful project views the wastewater treatment plant and power plant as an integrated system, thereby anticipating, uncovering, and resolving many potential technical flaws. Unreliable water supply due to any system issue that exists or arises can threaten the electric utility's ability to provide uninterrupted power to their customers and, as a result, the success of the project.

In order to ensure reliability, a successful system is carefully designed to optimize the location of the plants, if possible, and the integration of their existing or planned operations. An effective system design also incorporates the ability to adapt to changing conditions in flow, quality, and other uncertainties. Implementing effective monitoring equipment that measures key parameters and having plans for outliers built into place are also essential for active system operation. Wastewater plant and electric utilities should also consider working closely with regulators, city and regional planners, and the general public throughout the design and implementation of the system to ensure optimal performance and adaptability.

Compliance with all regulations

Regulations for wastewater reuse projects at electric utilities can prove to be both the impetus for a project and one of the greater challenges it faces. Regions where strong regulatory drivers emerge provide motivation for reclaimed water projects; for example, municipal wastewater treatment plants in Florida cannot discharge water into the ocean after 2025. On the other hand, there is currently no regulatory framework specifically designed for wastewater reuse at electric utilities. As a result, today's projects have to comply with a range of regulations from different agencies, which can delay projects and even prevent them launching.

Successful wastewater reuse projects take all regulations with which they must comply into account during the planning process. This includes the wastewater treatment plant and the electric utility working together and with regulators to determine which regulations and standards the project must meet; apply for all required permits, such as permits for ground/surface water withdraw and cooling tower air permits that regulate impurities limits in reclaimed water; and reaching consensus on industrial discharge permit limits from electric power. A regulatory foundation with clear direction can also help ease this process. For example, California has a strong need to use reclaimed water or risk water scarcity issues, so its regulatory agencies are also focused on this goal.

Ongoing education and outreach efforts

A well educated public and political base helps to overcome negative perceptions about wastewater reuse and reduces opposition to launching new projects. Such as in the case of the San Antonio Water System, the perceptions of reclaimed water quality can greatly impact the buy-in and cooperation from the community and its decision makers that is so critical to success. Without clear communication about the reuse of wastewater, community organizations are likely to block projects and influence their politicians to do the same.

Successful wastewater reuse projects at electric utilities typically have an effective public relations campaign in place that actively works to educate and gain support from decision makers and the general public. Such campaigns focus on overcoming prevalent negative public perceptions of reclaimed water and target the voting population and politicians, ensuring that they are well educated about the project and what it entails. They also strongly demonstrate the need for and public benefit of the project, proactively communicate about health and safety concerns, and serve as a credible “face” for the project that the public trusts.

V. Common Project Barriers

Identifying common barriers to municipal wastewater projects at electric utilities can help those implementing similar projects proactively address potential issues. Appendix C provides a detailed list of common barriers to successful projects. The following are the most critical to overcome in order to launch successful wastewater reuse projects at electric utilities:

- Absence of a dedicated regulatory framework
- Lack of information sharing and best practices
- Risk aversion and resistance to change
- Inability of stakeholders to work cooperatively and establish long-term contracts

Absence of a dedicated regulatory framework

Wastewater projects at electric utilities are not currently governed by one set of regulations that are specific to the unique issues and conditions that are typically encountered. Instead, these projects are regulated by different regulatory agencies that can at times issue regulations that create conflicts when applied to wastewater use in electric utilities. For example, regulations limiting power plant air emissions can dictate specific limits on the quality of water used at the power plant. Such requirements can sometimes conflict with wastewater treatment regulations that also mandate specific water quality parameters. This absence of a supported regulatory framework for wastewater reuse in electric utilities makes it extremely complex and difficult for projects to get underway. In addition, the threat of having to answer to multiple regulatory agencies is often enough to prevent the involved parties from moving forward with such an undertaking in the first place.

Lack of information sharing and best practices

While there have been a number of successful wastewater reuse projects at electric utilities, no one authoritative best practices document has been developed to date. The ability to cross-compare in-depth case studies, best practices, and lessons learned in a real-world environment is critical to developing new projects that do not succumb to the same pitfalls and leverage knowledge gained. There is currently no ongoing forum or engagement platform for electric utilities, wastewater treatment plants, and related professionals to share this type of information or ask questions. In addition, there are no established best practices that can provide guidance to utilities on how to implement a reclaimed water project, which is critical to building a case for doing so.

Risk aversion and resistance to change

Power plants and wastewater treatment plants tend to be risk averse, as their success is imperative to a community's basic needs and to the financial stability of their operations. Because reclaimed water project implementation costs can be significant for an electric utility, a strong business case is needed to demonstrate a compelling driver for overcoming inherent risk aversion and proceeding with the project. Without a strong value proposition and clearly defined incentives for such a project, the conservative nature of electric utilities in particular often is a barrier to proceeding. Politicians' resistance to change combined with a lack of in-depth understanding of wastewater reuse can also prove to be a significant barrier to projects. In addition, the uncertainty surrounding wastewater availability now and in the future may be of concern to potential stakeholders.

Inability of stakeholders to work cooperatively and establish long-term contracts

Electric utilities and wastewater treatment facilities frequently have very different corporate cultures, driven in large part by the fact that many electric utilities are for-profit businesses while most wastewater treatment plants are owned by municipalities or state authorized utilities with controls on service rates. The nature of industry versus municipality cultures can create conflicts and misunderstandings that make reaching agreements difficult. A lack of agreement among stakeholders, including the wastewater plant, the power plant, and the city on the terms and conditions of a long-term contract will make a project extremely difficult to navigate in the future and can even prevent a project from taking off in the first place. Developing long-term contractual agreements for these projects is challenging in part because there exists no guidance on how to structure such agreement. Some key questions to be addressed in any agreement include who should pay if the city defaults, what happens if the power plant has an unusually high load and demand for water, and what the long-term cost of wastewater should be. Cultural and operational differences also mean that electric utilities and municipal wastewater treatment plants are frequently interested in different data, resulting in a lack of the data needed by both sides in order to design, implement, and operate an optimal system for both parties. More broadly, truly integrated regional water and economic resource planning is rare in most parts of the United States, creating greater uncertainty around a project's value proposition to all parties and its role in broader regional resource management.

VI. Potential Steps to Overcome Barriers and Launch New Projects

Each project that uses reclaimed water at electric utilities is unique. Differences in water chemistry requirements, wastewater availability and electricity production profiles, and local political and community support for projects demands a tailored approach for establishing a new project. However, such projects also share many aspects and can take advantage of successfully implemented projects to improve the likelihood of success. Using the common building blocks identified for these projects can help wastewater treatment plants, electric utilities, and other stakeholders work together to develop tailored approaches to wastewater reuse with high potential for success.

Appendix C provides a detailed list of steps that can be taken to facilitate new project launches overall. The actions that follow have the most potential to overcome barriers and launch new projects:

- Gather data to enable system optimization
- Compile best practices for water reuse
- Develop and implement technology guidelines
- Establish a collaborative forum
- Develop and disseminate public education resources

Gather data to enable system optimization

Designing, developing, and operating an optimal and adaptable system for wastewater reuse in an electric utility relies on having specific data from both the wastewater treatment plant and the power plant. While this data is essential to defining essential wastewater quality and quantity parameters needed for project success, data generally collected by wastewater plants and water chemistry data required by electric utilities for their operational purposes, are typically not the same data. As a result, both parties must expend extra effort to collect necessary data to accelerate project development and implementation.

Wastewater treatment plants typically request that electric utilities provide a sufficient history of incoming water quality data, as well specifications for critical water chemistry parameters and constituent limits. Electric utilities typically request that wastewater treatment plants gather data on scaling elements and other constituents of concern at various time scales, including long-term (two years) trends, 24-hour composite data, hourly averages, and instantaneous peaks. The list of compounds of interest is long and varied, including alkalinity, chlorine, calcium, magnesium, silica, and many other compounds, and can also include surrogate data metrics to monitor and view changes after the baseline for water quality is established. The two parties should work together to define specifically what water data and over what timeframe an electric utility needs to evaluate reclaimed water and ultimately define acceptable ranges for these parameters. ASME and WEF may be able to support such interactions at the industry level.

Defining, gathering, and assessing this type of data establishes effective communication between the parties that enables them to work together to evaluate the plant's ability to use reclaimed water and develop the overall system design in an informed and effective manner. Defining key data points also helps the wastewater treatment plant assign economic value to water treatment and provides guidance to them about the types of treatment options that electric utilities find valuable.

Compile best practices for water reuse

Best practices can be extremely useful to utilities considering whether to embark upon a new reclaimed water project at an electric utility. They provide stakeholders with a starting point from which to base their system design, tools to use in organizing and managing the project, and lessons learned in operational logistics. Providing this information is not only useful for the development of a project with higher potential for success, but in reducing potential risk to the point of motivating stakeholders who may not have otherwise considered launching new projects to do so.

Wastewater treatment plants, power plants, and supporting consultants should work together with stakeholders such as the Environmental Protection Agency (EPA), the North American Electric Reliability Corporation (NERC), and the U.S. Department of Energy (DOE) to develop a best practices document on the use of reclaimed water. ASME and WEF are ideal organizations to convene the two communities to conduct such an activity. This best practices document should serve as a guide that provides a checklist of all steps needed for a successful project, as well as guidance on which parties should take which steps. For example, guidance for wastewater treatment plants and electric utilities is needed regarding developing a formal project agreement, including who should pay if the city defaults, what happens if the power plant has an unusually high load, the municipality cannot supply the amount of contracted wastewater quantity and/or quality, or what the long-term cost of wastewater should be. These guidelines should also address the best use of water and wastewater surplus above common pool needs on a regional basis and in consideration of historical water rights.

Part of this effort to compile best practices also involves consolidating collective experience on municipal water use (e.g., case studies, technical papers) to identify successful projects and generate new case studies. Increasing the availability of detailed case studies with special attention to distinct technical and communication issues, such as how certain materials interact with constituents in the water (technical) and what strategies were used to get buy-in from all stakeholders (communication), will better inform future efforts, particularly if cases that failed are included. Ultimately, documenting best practices provides the groundwork for new efforts and could have the effect of bringing national and even international focus to the issue of wastewater reuse.

Develop and implement technology guidelines

Many electric utilities, even if they are interested in implementing a wastewater reuse project, do not know about the technology required and how it functions when integrated with their existing operations. Already generally averse to risk and resistant to change, this lack of familiarity with wastewater reuse and the potential costs can make electric utilities even more hesitant to buy in.

Developing a "manual of practice" provides electric utilities with all of the information they need to operate a wastewater reuse system at their power plant. Potentially developed by ASME and WEF, the manual should include a compilation of existing guidelines on cooling water treatments, power plant makeup water, wastewater reuse, and effluent, as well as measurement tools, such as an economic assessment template that electric utilities can use to determine whether implementing wastewater reuse would be economically beneficial to them. The manual should also include the best management practices and case studies outlined above in addition to instructions on public perception planning, definitions of elements of reliability for both industries, and cooling tower best practice monitoring and control (e.g., pH, cycles, free chlorine ions). In addition, the manual should identify optimum operating procedures and steps to take when operations drift outside of the optimum range. As a whole, the technology guidelines and information provided should give clear guidance to power plants on the reuse of municipal wastewater, making it easier for them to implement projects and encouraging an increasing number of power plants to adopt reuse.

Establish a collaborative forum

While much can be learned from examining past projects and developing best practices and guidelines, new projects are bound to encounter new issues that have not yet been addressed. Today, wastewater treatment plants and electric utilities who experience such issues or are unaware that their particular issue has been solved in the past have few published resources to turn to for outside help and advice from peers, which can increase time and costs required to address emerging issues and ultimately cause a project to fail. This lack of available support also increases risk for stakeholders, which could prevent them from wanting to participate in a reclaimed water use project at all.

An ongoing, web-based engagement platform should be developed, potentially with support from ASME and WEF, that provides a forum where interested electrical utilities and wastewater plants can go to share best practices, post questions, gain answers, and find mentors. Interacting directly with others developing similar projects will enable the community as a whole to gain a better understanding of the issues involved in reclaimed water projects at electric utilities and could even encourage the launch of new projects. This forum could potentially be developed with support from ASME and WEF at the national level, but could also be repeated at or segmented into local and regional levels for more detailed discussion of issues specific to regions. Ultimately, there may be benefit in also inviting international participation, focusing on regions where reclaimed water use in utilities is prevalent.

Develop and disseminate public education resources

Public acceptance can make or break wastewater projects at electric utilities. Discomfort with reusing treated wastewater and a lack of understanding about its true health and environmental impacts can create strong public opinion that makes it extremely difficult to launch new projects. Negative public opinions can also influence politicians and other decision makers, who often similarly lack a clear understanding of these types of efforts.

Wastewater treatment plants and power plants should work together to conduct public perception education and outreach as part of their respective projects. Developing and disseminating shared public education resources that strongly demonstrate the need for and public benefit of the project, clearly communicate about health and safety concerns, and focus on the concept that all water is recycled and reclaimed can effectively help overcome prevalent negative public perceptions of reclaimed water use. Such a strategy also provides a face for a particular project that is credible in communicating to the public. Ideally, these education and outreach materials should be developed and disseminated via a communications strategy that targets multiple education levels to ensure that messages resonate.

VII. Next Steps

The *Best Practices and Future Directions Report* outlines potential actions that electric utilities, municipal wastewater treatment plant, ASME, and WEF can take to support the launch of new wastewater reuse projects at electric utilities. By including input from leading electric utilities and wastewater treatment plant experts, this report is intended for use by the stakeholder community as a starting point for taking actions toward achieving the goal of increasing the reuse of wastewater for power production.

As the United States continues to experience freshwater shortages and increasing power demand, it is imperative that these stakeholders coordinate and collaborate their actions going forward. The tables that follow contain action plans for the priority steps to overcoming barriers to launch new projects. These include key tasks, milestones, outcomes and benefits, immediate next steps, and roles for ASME and WEF to help enable new collaborative projects to launch quickly and productively. ASME and WEF are committed to supporting these efforts and additional efforts to secure a sustainable supply of freshwater without compromising electric power supply.

PRIORITY ACTIVITY 1

Gather and disseminate best practices for reclaimed water use in electric utilites with EPA participation

KEY TASKS

- Identify key stakeholders (e.g., EPA, NERC, DOE, etc.) and invite them to participate
- Develop charter/forum/ leads
- Develop initial preliminary scope (e.g., guidelines for data needs)
- Develop case studies, successes/failures, and lessons learned
- Identify beneficiaries and funding sources
- Coordinate with other priority teams

OUTCOMES/BENEFITS

- Documents best practices, tools, data
- Provides groundwork/framework for ongoing effort
- Brings national (international?) focus to the issue

KEY MILESTONES

- Identify stakeholders
- Develop preliminary information and convene workgroup
- Produce the initial product(s)

IMMEDIATE NEXT STEPS

- Articulate the need for stakeholder involvement: Why should they care/ get involved?
- Identify key stakeholders (e.g., EPA, DOE, NRC, FERC)
- Schedule a workshop/meeting

ROLES OF ASME AND WEF

- Communicating and coordinating with ASME members, mostly utilities (ASME)
- Host workshop
- Publish report

PRIORITY ACTIVITY 2

Identify data of interest to electric utilities that municipal wastewater utilities should gather and encourage them to gather that data

KEY TASKS

- Identify all chemical constituents
- Identify the range and average of each constituent, the duration of the peak (5 minutes vs. 5 hours), and the range and average of flow (flow profile)
- Develop and share testing methodologies with municipal wastewater utilities for constituents that have not been monitored in the past
- Determine cost-sharing roles and responsibilities

OUTCOMES/BENEFITS

- Establishes a level of communication between municipal wastewater and power utilities to allow evaluation for use of reclaimed water and system design
- Assigns economic value to water treatment
- Provides guidance to municipality for treatment options

KEY MILESTONES

- Develop a specifications template for critical parameters (6 months)
- Begin sampling program (1–3 years)
- Continue to assess and update the sampling program (ongoing, 1 year+)

IMMEDIATE NEXT STEPS

- Provide a list of constituents to technical bodies and municipalities (ASME, WEF, WateReuse)
- Create a document to gather the information on the parameters and constituents

ROLES OF ASME AND WEF

- Help potential customers understand that there are alternate water sources (ASME)
- Help municipalities understand that there are potential customers and that their waste product is a commodity (WEF)
- Facilitate the data sharing/gathering
- Develop a guidance document and roadmap
- Update the template to state-of-the-art

ADDITIONAL COMMENTS

- Develop effective communication medium/strategy to reach out to the community and potential customers
- Three years of data is ideal, but assumptions can possibly be made from existing data

PRIORITY ACTIVITY 3

ASME/WEF create an ongoing engagement platform to bring electric and municipal wastewater utilities together

KEY TASKS

- Panel discussions at key ASME, WEF, and other conferences (e.g., WEFTEC; IMECE; WEF Water/Energy, Nashville; Water Reuse Association; WEFTEC 2013 Workshop, Chicago; ASME Power Conference, 2013)
- Cross communication to ASME/ WEF members about panel sessions
- Get member registration
- Put information on asme.org, link to other organizations
- Identify existing municipal wastewater/electric utility information that is available
- Identify gaps
- Create case studies
- Repeat efforts at the local and regional levels

OUTCOMES/BENEFITS

- Better understanding of issues involved in MWW/electric utility reclaimed water projects
- More collaborative reclaimed water projects being considered
- Collaborative funded projects developed in this area

KEY MILESTONES

- Mini-workshop or symposium at existing ASME and WEF conferences

IMMEDIATE NEXT STEPS

- Identify ASME, WEF conferences to get panels on municipal wastewater/electrical utility reclaimed projects

ROLES OF ASME AND WEF

- Identify respective conferences to do panel sessions on municipal wastewater/electrical utility reclaimed water projects

PRIORITY ACTIVITY 4

Develop technology guidelines on reclaimed water reuse at power plants for use by electric utilities

KEY TASKS

- Integrate existing guidelines (cooling water treatments, power plant makeup water, wastewater reuse, and effluent guidelines)
- Incorporate lessons learned, best practices, and case studies on existing water reuse facilities
- Identify optimum operating procedures
- Develop and incorporate an economic assessment template

OUTCOMES/BENEFITS

- Power plants have clear guidance on the reuse of municipal wastewater, making it easier for them to implement
- An increasing number of power plants will be encouraged to adopt reuse, if cost effective

KEY MILESTONES

- Identify stakeholders (e.g., ASME, WEF, EPRI, consultants, academia, regulatory, POTWs, utilities)
- Assign deliverables and determine funding
- Compile and publish a report

IMMEDIATE NEXT STEPS

- Identify lead organizations
- Initiate cooperation effort
- Define document outline

ROLES OF ASME AND WEF

- Bring parties together
- Determine funding and scope

PRIORITY ACTIVITY 5

Consolidate collective experience on municipal wastewater reuse by electric utilities

KEY TASKS

- Identify subject matter experts (e.g., WEF, ASME, EPRI, WateReuse, consultants, EPA, industry) and survey them for available, relevant information
- Obtain any additional available literature
- Develop an ASME/WEF electronic database that includes all papers, case studies, etc.

OUTCOMES/BENEFITS

- Centralized resource that creates the basis for guidelines
- Identifies gaps and research needs

KEY MILESTONES

- Identify key people to contact
- Identify keywords for research

IMMEDIATE NEXT STEPS

- Identify key contacts
- Identify keywords

ROLES OF ASME AND WEF

- Organize the list of potential electrical utility experts (ASME)
- Organize the list of potential water reuse experts (WEF)
- Identify a common liaison
- Maintain current information

ADDITIONAL COMMENTS

- ASME and WEF will work on details on the library; each will identify what information is available to each member

PRIORITY ACTIVITY 6

Establish best use guidelines of water and wastewater surplus

KEY TASKS

- Define use of water in power
- Educate power plants and water resource managers on technologies (e.g., dry vs. wet cooling) and water used (e.g., quality/source)
- Power plants take a proactive role in regional resource water management
- Identify water rights issues
- Create spaces for various stakeholders, power plants included, in regional water resource management

OUTCOMES/BENEFITS

- Broader acceptance of reclaimed water by power plants and other entities
- Securing a long-term, sustainable water source for power generation
- Economic benefit from building sustainable growth

KEY MILESTONES

- Increased reuse of wastewater in electric power industry
- More power plants included in regional water resource management boards/plans
- Publications that are used to educate in various areas related to water reuse by power plants

IMMEDIATE NEXT STEPS

- Review WEF/ASME curriculum and identify areas of opportunity
- Literature review of available information for best use guidelines (internal and external)
- Identify pathways (e.g., trade publications, target job titles and departments) to have power plants and water resource managers at the same table

ROLES OF ASME AND WEF

- Generate educational materials for the power side (ASME)
- Generate educational materials for wastewater resource managers (WEF)
- Dedicated sessions at conferences
- Conduct work/research to identify/do a literature review (maybe joint funding)

Appendix A. List of Participants

Iwan Alexander
Chair, Dept. of Mechanical and Aerospace Engineering
Case Western Reserve University

David Ammerman
AECOM National Practice Leader, Reuse
AECOM

Richard Breckenridge
Sr. Project Manager, Water Research Center
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Ross Brindle
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Commercial, Industrial and Institutional Water Efficiency Program Specialist
West Basin Municipal Water District

Robert Goldstein
Technical Executive, Water and Ecosystems
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Robert Holt
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Norma Johnston
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Managing Director, Technology and Personnel Certification
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Tom Mossinger
Associate Vice President and Chief Mechanical Engineer
Carollo Engineers

Lindsay Pack
Director of Communications
Nexight Group

Jimena Pinzon
Senior Research Manager
WateReuse Research Foundation

Denton Slovacek
Application Development Manager, Power
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Randy Turner
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Don Vandertulip
Principal, Water Reuse Leader
CDM Smith

Appendix B. Workshop Agenda

Municipal Wastewater Use by Electric Utilities:
Best Practices and Future Directions Workshop

Jointly organized by the American Society of Mechanical Engineers (ASME) and the Water Environment Federation (WEF)

May 21-22, 2012; ASME Washington DC Office

DAY 1 – May 21, 2012	
Time	**Activity**
7:30-7:45	**Arrive at ASME**
8:30 – 9:00	**Continental Breakfast**
9:00 – 10:00	**Opening Plenary Session** • Welcome Remarks and Workshop Purpose • Self Introductions and Drivers for Participation • Workshop Process and Logistics
10:00 – 10:15	**Break**
10:15 – 12:00	**Discussion Panel: Municipal Wastewater Reuse in the Electric Power Industry** • **Don Vandertulip,** Chair WEF & AWWA Water Reuse Committee, *Reclaimed Water Quality requirements (East vs. West, new vs. retrofit)* • **Dick Breckenridge**, EPRI, *Palo Verde Experience* • **David Ammerman,** *AECOM Orlando public utility and Tampa Electric reclaimed water usage projects*
12:00 – 1:00	**Lunch** – Participants will divide into two parallel breakout sessions after lunch
1:00 – 2:45	**Breakout Session #1: What are the keys to a successful municipal wastewater use project at an electric utility?** Participants will identify the conditions that lead to a successful municipal wastewater use project at an electric utility. Conditions may be technical, economic, financial, regulatory, political, logistical, or of another variety.

	Participants will prioritize keys to success near the end of this session.
2:45 – 3:00	**Break**
3:00 – 5:00	**Breakout Session #2: What are the most common barriers to new municipal wastewater/electric utility projects?** Participants will discuss the common barriers that must be overcome to establishing a new municipal wastewater/electric utility project. Barriers may include technical, economic, financial, regulatory, political, logistical, or of another variety. Participants will prioritize barriers near the end of this session.
5:00	**Networking Reception**
DAY 2 – May 22, 2012	
8:30 – 9:00	**Continental Breakfast**
9:00 – 9:30	**Breakout Session Report-Outs** Each breakout session will give a 5-minute presentation of the results of their Day 1 discussions. The entire group will discuss convergence or divergence of views.
9:30 – 9:45	**Break** – Participants will divide into two parallel breakout sessions after the break
9:45 – 12:00	**Breakout Session #3: What steps can municipal wastewater providers and electric utilities take, working as individuals and as a community, to overcome barriers and launch new projects?** Participants will discuss the best approaches for overcoming the largest barriers identified on Day 1. Participants will be encouraged to think both in terms of actions they can take as individuals and actions that the wastewater and electric utilities can take as a community, with ASME and WEF support.
12:00 – 1:00	**Lunch**
1:00 – 1:30	**Breakout Session Report-Outs** • Final reports from breakout sessions • Group discussion of results
1:30 – 2:30	**Large Group Discussion: What can ASME and WEF do to foster collaboration between the municipal wastewater and electric utility communities?** Participants will identify ways in which ASME and WEF can foster increased collaboration in hopes of better utilizing municipal wastewater in electric utilities to the benefit of both communities.
2:30 – 3:00	**Closing Session** – final remarks, next steps
3:00	**Adjourn**

Appendix C. Detailed Workshop Results

Characteristics of Successful Projects

The tables that follow include the detailed input provided by workshop participants as part of the discussion of successful project characteristics.

Group 1. Characteristics of a successful municipal wastewater project at an electric utility (● = one vote)

Outreach and Communication

- Wastewater treatment plants and electrical utilities understand each other's needs, expectations, and capabilities ●●●●●●●●●
  - Wastewater plants and utilities have an established, long-term relationship with a clear understanding of needs and expectations on both sides
  - For a particular project, the electric utility makes the wastewater treatment plant aware of the critical parameters of its plant and operations
  - Communication protocol about possible variations in water quality is developed
  - There is a better understanding between plants and utilities of mutual operating constraints

Regulatory

- Project complies easily with regulations (e.g., lack of permit for ground/surface water draw) ●●●●
- Consensus is reached on industrial discharge permit limits from electric power ●
  - Wastewater treatment plants often do not let electric utilities send water back to the treatment plant, so agreement on this issue needs to be reached by the start of the project
- Guidance and/or standards exist for the development of consistent health- and economic-based metrics
- Regions where strong regulatory drivers emerge provide motivation for reclaimed water project (e.g., municipal wastewater treatment plants in Florida cannot discharge water into the ocean by 2025; Title 22 in California)
- Cooling tower air permits are in place that regulate impurities limits in reclaimed water
- Environmental concerns regarding greenhouse gas emissions exist to help drive water reclamation and recycling

Financial

- Cost responsibilities are predetermined, especially for specific needs for a given project ●●
- Project parties can demonstrate a reliable, long-term water source, which is often required by lenders for financing ●
- Investors have examined water use/management/stewardship plan/metrics and assessed stock price/valuation ●
- Issues surrounding the different financial drivers of municipal wastewater treatment plants (typically non-profits) and power plants (for profit) are resolved ●
  - May be driven by the ability to raise capital

Group 1. Characteristics of a successful municipal wastewater project at an electric utility (● = one vote)

- Potential cost-sharing benefits to multiple entities are quantified
- Agreement is reached on capital cost payments based on drivers for municipal and electric utilities
- Impact on rate schedules with equity for both wastewater plants and electric utilities is determined

Economic

- Reclaimed water project helps wastewater treatment plants with discharge limits to simplify discharge ●●●
- Provides a lower-cost solution to water-quality needs at a project level and/or at a societal level ●●
- Price of reclaimed water is set just less than the price of potable water
  - Currently, reclaimed water is typically 70%–80% of the cost of potable water, but ranges up to 100%
- Rate of return is quantified and attractive for system modifications and required investments

Technical

- Reclaimed water quality and delivery flow rates provided by the wastewater treatment plant matches the quality needed by the utility and the water demand of the utility (annually, seasonally, hourly) ●●●●●●●
  - Includes hour flow profile of reclaimed water
- Sufficient water quality data for incoming water into electrical power plants is provided ●●●●●●
- Public health and safety is ensured through techniques and knowledge to assess health and economic risks of complex chemical mixtures and adequate monitoring data on constituents of emerging concern ●●●●
- Discharge water quality meets or exceeds requirements
- Water treatment plants have the ability to provide for the needs of multiple potential end users
- Design of delivery system is established (e.g., where water will be treated, system design, etc.)
- Cooling system materials are available, especially retrofit situations

Political and Public Awareness

- An effective public relations campaign is established to overcome prevalent negative public perceptions of reclaimed water ●●●●●●
  - Strongly demonstrates the need for and public benefit of the project
  - Provides a face for the project that is credible in communicating to the public
  - Communicates health and safety
- Project is beneficial to the community and the utility ●●
- A formal agreement from the city council that clearly supports water reuse is in place
- Education and outreach efforts to the public and policymakers is conducted

Logistical

- Systems design is integrated to optimize wastewater treatment plant and electric utility (co-location) ●●●●●
- Contracts and regulations are flexible to account for changes (e.g., changing energy prices, demographics, etc.) ●●
- Water source is uninterruptible with backup, potable supply just in case ●
- Short water transport distances are possible ●
- Simple legal agreements are in place (legal agreements are often complicated and produce long-term commitments)
- Legal responsibility for supply interruption is determined
- In some applications, decentralized wastewater treatment plants (e.g., scalping/satellite plants; 0.5-1 million gallons per day or larger) may make most sense
  - Reclaimed water from decentralized wastewater treatment plants can be a partial feed of the total water need
  - Smaller-sized electrical utility plants may be well suited
  - Decentralized plants are more energy efficient and resilient, but often cannot deliver the necessary water volume
- Flow supply and demand matches
- Long-term water demand changes are recognized

Group 2. Characteristics of a successful municipal wastewater project at an electric utility (● = one vote)

Technical

- Nature of wastewater for reuse (chemistry and variability) is understood ●●●●
- System has the ability to adapt to changing conditions (flow, quality, and unknowns), which includes having plans for outliers built in and in place ●●●●
- Effective monitoring equipment that measures key parameters is implemented ●●●
- A place exists to put blowdown and all residuals (stream, wastewater treatment plants, deep well) ●●
- Wastewater supply is reliable and backup supplies are in place ●●
- Design is linked to operating needs ●
- Operational guidelines are in place for successful treatment and water use ●
- Technical solution is proven and available in the marketplace
- Impact of wastewater demand and availability on the efficiency of process operation is addressed
- System is easy to operate and maintain; operator input is understood and implemented into design

Economic

- Economic benefit exists and is coupled with other benefits for parties involved, and a regulatory framework is in place to support public, private, and community partnerships ●●
- Cost/benefit risk sharing (is reconciled) ●
- Allows for a long-term solution to water supply issues
  - Long-term sustainability contracts are in place to assure continuous operation
- Industrial demand for wastewater exists; wastewater reuse is required for industries to survive
- Strong economic drivers exist
  - Incentive for wastewater plant (e.g., wastewater plants in Germany are paid to treat water, implementing wastewater into utilities provides lower-cost effluent management for the wastewater plants, etc.)
  - Incentive for utility (e.g., may cost less than upgrading a process)

Financial

- Financial arrangements empower project execution (public funding) ●●
- Funding mechanisms (may be external to either the wastewater facility or electric utility) exist and can be implemented (e.g., water management district) (i.e., public/private partnership) ●●
- Grants are available to help offset costs
- Sustainable funding is available
- Cooling water can be outsourced to help offset financial risk

Regulatory

- Wastewater plant and electric utility works closely with regulators, industry, planners, and the general public throughout the design and implementation of the system ●●●●
- A common definition of "water quality" is established
  - Differences are resolved between EPA National Pollutant Discharge Elimination System (NPDES) definition and the Electric Power Research Institute (EPRI) definition ●
- Regulatory foundation has clear direction (e.g., California needs to use reclaimed water or go dry)
- Technical and regulatory constraints and issues are identified and addressed

Political

- Voting population and politicians are well educated about the project ●●●
- No citizens group opposes the project, a good PR firm is in place to promote project, and there is strong political support for the project
- Zero liquid discharge (ZLD) provides a good environmental value that utilities can embrace (e.g., Russell City, CA)

Institutional

- A formal, long-term contract is in place between publically owned treatment works (POTW) and power plants (e.g., Palo Verde) ●●●●●●●●●

Group 2. Characteristics of a successful municipal wastewater project at an electric utility (● = one vote)

- Utility is focused on more than "we produce power"
- Wastewater plant has the mindset of "we produce a product"

Logistical

- From pipeline to power plant, there are no right-of-way issues and no technical flaws ●●●
  - Wetlands (no cross-basin transfer)
  - Stream crossing
  - Alliance for a Clean Environment (ACE) approves
- Working relationships are established with regulatory, municipal, community, and agricultural agencies
- Long-term conditions are forecast (e.g., population growth/decline, increased salinity, etc.)
- Publically owned treatment works (POTW) effluent is easily sourced
- System operation is as integrated as possible, perhaps at on-site at utility (e.g., in Mexico, the electric utility receives and treats sewage in house)

Stakeholder Communication

- Power plant and wastewater treatment plant agree on who is responsible and work together ●●●
- Municipal wastewater treatment plant is proactive and communicates all potential issues to the power plant
- Wastewater plants and electric utilities have shared, definitive terms on water quality
- An effective communication lifecycle with stakeholders is in place and functional

Other

- A good, solid consulting firm is involved ●●
- Realistic expectations of what is possible are in place
- A shared vision among all stakeholders exists
  - Power company, municipality, entire community (e.g., Las Vegas, Australia)
- Effective leadership is in place and active
- Electric utilities have a high demand for water

Common Project Barriers

The tables that follow include the detailed input provided by workshop participants as part of the discussion of common barriers to new projects.

Group 1. Most common barriers to new municipal wastewater/electric utility projects (● = one vote)

Lack of Communication Between Wastewater Treatment Plants and Electric Utilities

- Clash between industry and municipality cultures can create misunderstandings and make communication difficult ●●●●●●●

Logistical

- Lack of an ongoing forum (engagement platform) to share information, share issues, ask questions, and share best practices ●●●●●●
- Wastewater is not always located where it is needed by utilities, which creates logistical issues

Political and Public Awareness

- Lack of public acceptance based on health concerns ●●●
- Resistance to change and a lack of understanding from politicians; reliance on the mindset that "we've always done it this way" (without reclamation) ●●●●
  - Fear of failure
- Inability for perceptions and politics to move past the "yuck" factor of reclaimed water (e.g., cooling tower drift) ●
- Lack of political will to implement needed regulations ●

Group 1. Most common barriers to new municipal wastewater/electric utility projects (● = one vote)

Regulatory

- Differing regulatory drivers from different regulatory agencies (e.g., water vs. air regulations) ●●●●●●●●
- State reuse guidelines or regulations that do not allow the use of wastewater in cooling towers (or not without a higher treatment cost)
  - In some regions, wastewater plants are regulated and cannot market reclaimed water because the water utility holds the market; water utilities and wastewater plants could partner to address this issue
- Conflicting regulatory requirements
- Reclaiming water can damage regional hydrology and downstream water rights, which can have ecological consequences

Financial

- Lack of budget for installation of equipment needed to treat wastewater

Economic

- Cost of delivered reclaimed water is higher than other options ●●●●
- Availability of alternative water sources ●●
- Lack of a "triple bottom-line" view (economic, ecological, and social) of reclaimed water, as well as a lack of a longer-term view (e.g., population growth) ●●
  - Determining whether the "lowest" bid is equal to the lowest capital expenditure, the lowest 10-year operating expenses, or something else
- Cost increases and required capital investment (including operation and maintenance) ●
- For wastewater plants, extending reclaimed water into uses that demand higher quality requires added capital and/or reduced water flow, which can limit or reduce production capacity
- Ability of water reclamation centers to meet specific water quality limits without new processes
- Lack of incentives for using reclaimed water

Technical

- Unavailability of best practices that can provide guidance to utilities on how to do a reclaimed water project ●●●●●●●
  - This information may be more available on the wastewater treatment plant side
- Electric utilities and municipal wastewater treatment plants are interested in different data, resulting in a lack of the data needed by utilities ●●●●●
  - Ideally should have several years of data
  - Pilot studies could be conducted to assess availability
- Lack of industry standards ●●
- Lack of data, tools, and scientific proof for assessing health and environmental risks ●
- Operational complexities involved with inconsistent water quality both to and from wastewater plants ●
  - Utility concern that supply is unreliable (unexpected and rapid changes in reclaimed water quality and quantity), which can greatly impact the power production process
  - Water quality changes are not well understood or accepted
- Use of false assumptions based on incomplete or otherwise partial water quality and quantity data when designing electric utility plants
- Lack of standard application of disinfection technologies to address public health concerns (varies by state regulations)
- Lack of data available for due diligence to commit to reclaimed water for new projects

Group 2. Most common barriers to municipal wastewater/electric utility projects (● = one vote)

Technical

- Risk-averse nature of corporations (mainly power plants, but also wastewater treatment plants) ●●●●●●
- Expense of cooling water blowdown and residuals (post treatment, disposal, etc.), such as zero liquid discharge ●●●●

Group 2. Most common barriers to municipal wastewater/electric utility projects (● = one vote)
– Determining who owns residuals risk and cost • Inadequate analysis of uncertainty in design to reflect potential changes that can impact a project ● • Lack of a proper understanding of materials of construction (concrete, metallurgy) and processes ● • Impacts of reclaimed water on power plant performance (incompatibilities) ● • Lack of understanding of the need for additional infrastructure when retrofitting municipal wastewater systems in existing power plants • Unavailability of a commercially viable, cost-effective water treatment technology
Economic
• High cost of projects does not make wastewater a competitive alternative for electric utilities ●●●●●● • Uncertainty surrounding wastewater availability; reuse supply may be insufficient now and in the future ●●● • Realization of costs (capital, operating, and maintenance) for utilities and wastewater treatment plants • Outdated supply-side public water/power infrastructure funding mechanisms (e.g., rate base recovery "incentives") – Water scarcity requires new funding mechanisms, as regulated and unregulated utilities are involved • Inability to secure public funding • Decreases in the demand for power can cancel or delay projects • Increases in natural gas use leads to more simple-cycle plants (a shift from coal to gas uses less water)
Financial
• Availability of free or subsidized water leads utilities to question why they should pay for reclaimed water • Lack of understanding of the true cost of water
Regulatory
• Absence of a supported regulatory framework for wastewater reuse in electric utilities ●●●●●●●●● • Lack of new, appropriate EPA regulatory permits • Conflicting regulations (drivers push parties apart) • Classification of all drift as fine particle designations ($PM_{2.5}$), which causes the application of unnecessary air permit rules in some cases • Lack of regulator knowledge about different wastewater reuse opportunities – Asking regulators to look at something they have not seen before and are not comfortable with • New and different regulatory permits for existing power plants that can make it difficult to implement wastewater • New guidelines for steam-electric generation effluent that make treatment for discharge more expensive • Wetland siting for a new plant can be prohibitive (storage volume site and plant site) • Inability to permit
Political
• Lack of truly integrated regional water and economic resource planning ●●●●● • Lawsuits from citizens groups against a project use regulatory processes to slow down progress • Separate water and wastewater purveyors/management can create conflicts • Protection for ecosystems, even though they are dependent on wastewater reuse (e.g., TECO reuses wetlands water) – Have to consider the environment as a customer
Logistical
• Absence of a route for a reuse pipeline from municipal plant to utility • Lack of understanding of the required operator skillset
Communication and Outreach
• Minimal effort from wastewater treatment plants to market their product to potential clients (e.g., electric utilities)●● • Weak benefits (financial, environmental, etc.) to the parties involved or a weak explanation or study of the benefits to parties involved ●

Group 2. Most common barriers to municipal wastewater/electric utility projects (● = one vote)
• Public health issues or public perception of public health issues (e.g., transferring problems to air, worker safety, public safety on resorts, etc.) – The public has not been presented with enough evidence to convince them it is safe
Institutional
• Inertia of existing power plants ●●●●●● – Why change what I'm already doing? – Insufficient incentive; no requirement to change • Lack of agreement among stakeholders (wastewater plant, power plant, city) on terms and conditions of long-term contract ●●●●● – No guidance on who should pay if the city defaults, what happens if the power plant has a high load, or what the long-term cost of wastewater should be • Conflict of interest between municipal parties and the private sector in defining priority • "No growth" initiatives inhibit new plants and wastewater transport infrastructure

Potential Steps to Overcome Barriers and Launch New Projects

The tables that follow include the detailed input provided by workshop participants as part of the discussion of steps to overcome barriers and launch new projects.

Group 1. Steps that municipal wastewater providers and electric utilities can take to overcome barriers and launch new projects (● = one vote)
Technical
• Encourage municipal wastewater treatment plants to gather data on scaling elements and instantaneous peaks (vs. 24-hour composite) ●●●●●●●●●● – Identify and measure a few surrogate data metrics to monitor and view changes (after the baseline is established) including alkalinity, calcium hardness, total hardness, phosphate, chloride, sulfate, silica, conductivity, pH, iron, manganese, chlorine, TSS (organics), flow, nitrogen, discharge limits for utility, among others – Include data values for calcium, magnesium, alkalinity, ammonia, phosphate, nitrites, biochemical oxygen demand (BOD), and fecal, among others – Define what water data and in what timeframe (instant, hourly) an electric utility needs to evaluate reclaimed water for electrical utilities use; ASME/WEF should work together to get this information to their members – Electric utility should develop specifications for critical parameters and limits – Define hourly flow and chemistry range and average – Ultimately define acceptable ranges on these parameters (regionally dependent) – Provide data on "contaminants of emerging concern" so that power plants and regulators can conduct assessments • Develop best practices and related guidelines with participation from the Environmental Protection Agency (EPA); the Electric Power Research Institute (EPRI) did this for their UV treatment of drinking water ●●●●●●●●● – ASME/WEF should sponsor a best practices manual as a guideline for future projects – Develop data and tools for quantitatively assessing health and environmental risks • Develop a roadmap on the use of reclaimed water to guide best management practices ●●●●●● – Serves as a guidance document that provides a checklist of all steps needed for a successful project • Understand, document, and communicate benefits (and the extent of) wetland treatment of water to address water supply, nutrients, and filtration

Communication and Education

- ASME/WEF should create an ongoing forum/ engagement platform on their websites where interested electrical utilities/wastewater utilities can go to share best practices, post questions, gain answers, and find mentors ●●●●●●●
- Match wastewater availability and quality ranges to cooling water demand needs on a regional basis ●●●
  - Mapping what is available and what is needed regarding reclaimed water for electric utilities
- Increase the availability of case studies with special attention to distinct technical and communication issues, such as how certain materials interact with constituents in the water (technical) and what strategies were used to get buy in from all stakeholders (communication) ●●●
  - Focus particularly on those cases that did fail
- Encourage national agencies to hold forums on the issue of wastewater and include the issue in WEF and ASME/EPRI conferences, as discussion is the key to understanding ●
  - Get these forums to trickle down to local levels as well
- Promote approaches that consider wetland/ecological issues up front as a best practice (e.g., running reclaimed water through wetlands will establish good will with the community) ●
  - Economic benefit of naturally filtering water through the wetlands
- Build the wastewater treatment facilities' understanding of end user parameters and how they affect power plant operation
- Organize site visits for students or practicing engineers to "see the other side" (i.e., individuals from electrical utilities visit municipal waste water plants and vice versa)
- Develop educational curricula to train engineers/practitioners on water reuse/reclamation; include carbon footprint aspects
  - Include K–12 education that offers students an understanding of how we use water and explain opportunities for water recycling
  - Create a speakers bureau with site visits to high school students
- Develop a communication protocol/template based on constituents of greatest concern (quality) and availability of water (quantity) as a feedback loop

Political and Public Awareness

- Develop public education resources ●●●●●
- Educate the public and regulators on the concept that all water is recycled/reclaimed
- Develop a communication strategy for multiple levels of education (i.e., "boiler room to board room") that can also be used to help these different areas communicate
- Educate wastewater, electricity providers, and regulators on how to communicate health and environmental risk

Regulatory

- Create a regulatory roadmap (this may/will differ regionally) at the onset of a potential project to eliminate surprises ●●●
  - Be sure to answer the question of how often you update the roadmap
- Create a regional working group to address state-specific issues (e.g., military base); elevate national issues to ASME/WEF for EPA discussion ●●
- Develop a regulatory environment to facilitate reclaimed water use
- Develop a permitting guide

Economic and Marketing

- Develop economic incentives for reclaimed water use ●●●
- Encourage a change in the wastewater treatment plant mindset from viewing reclaimed water as a waste stream into viewing reclaimed water as a product stream that customers will want and buy ●●
  - Conduct market studies into major water users, etc.
  - Actively market the product
  - Provide continuous customer service to water users to ensure satisfaction, etc.

Group 2. Steps that municipal wastewater providers and electric utilities can take to overcome barriers and launch new projects (● = one vote)

Education and Outreach

- Establish a university graduate research program (e.g., National Science Foundation [NSF] Interactive Graduate Education and Research Traineeship [IGERT]) that supports research and training on water/wastewater utility/power utility partnerships at all scales (global, national, regional, local) ●●
- Conduct public relations efforts that discuss the benefits of established partnerships within a region to engage the public and decision makers ●
- Seek common ground for public perception marketing (wastewater and power plants)
- Develop energy/water/climate change optimization studies and facilitate discussions on more sustainable long-term options for water use at power plants

Definition and Communication of Needs (Electric Utilities)

- Provide the infrastructure requirements to utilize municipal wastewater for cooling through disposal ●●
- Conduct economic assessments and conduct long-term sustainability analysis ●
- Consider long-term water resource availability as part of the EPA's National Pollutant Discharge Elimination System (NPDES) permit renewal process ●
- Examine publically owned treatment works (POTW) effluent requirements and stream standards to establish blowdown treatment at power plants pre-discharge
- Define chemicals that are of concern to them
  - State what they are worried about and communicates it to wastewater treatment plants
- Prepare and/or update integrated water management plans to define and understand roles and the true value of water use and reuse

Analysis and Communication (Municipal Wastewater Plants)

- Encourage municipalities to consider reclaimed water in any upgrade project ●●
- Project cost, availability, and quality parameters ●●
- Develop reuse management procedures, fees, and structure in advance of requests for reuse water
- Actively market reclaimed water as a product

Guidelines

- Generate a clear "technology guide" for reuse at facilities that includes guidelines and best management practices for the electric utility and the wastewater treatment facility ●●●●●●●●●●●
  - Should be considered a "manual of practice"
  - Could potentially be developed by WEF
  - Should include instruction on public perception planning
- Define elements of reliability for both industries (determined by guidelines)
- Establish cooling tower best practice monitoring and control (e.g., pH, cycles, free chlorine ions)

Case Studies

- Consolidate collective experience on municipal water use to identify knowledge gaps and research needs (e.g., case studies, technical papers) ●●●●●
- With help from wastewater suppliers and consultants as well as power plants, identify successful projects and generate new case studies to demonstrate opportunities ●●●●
- Generate case studies on "contracts" between municipalities and utilities ●
- Start collecting relevant data for electric utilities (water quality and quantity); historical data is key
- Generate case studies on "cost/benefit" analysis of reuse option

Regional Planning

- Establish guidelines for best use of water and wastewater surplus above common pool needs and in consideration of historical water rights ●●●●●
- Involve regulators, planners, industry, and the general public in the development of best management practices ●●●●

- Establish communication early among all stakeholders, including regulators ●
  - Include stakeholders at multiple levels (national, regional, local)
  - Involve a body that can gather stakeholders (e.g., a consultant)
- EPA should host a regulatory workshop to discuss the issue of wastewater ruse in utilities ●
- Establish short courses/seminars sponsored by local universities that bring wastewater and electric utility decision makers together along with other local stakeholders
- Involve local politicians to "spearhead" a reuse project
- Power plants should dialogue with communities about preference for surplus water

Appendix D. Acronym List

AFY	acre-feet per year
ASME	American Society of Mechanical Engineers
DOE	U.S. Department of Energy
EPA	Environmental Protection Agency
IGCC	integrated coal gasification combined cycle
MGD	million gallons per day
MWDSC	Metropolitan Water District of Southern California
NERC	North American Electric Reliability Corporation
OUC	Orlando Utilities Commission
SAWS	San Antonio Water System
SWFWMD	South West Florida Water Management District
TDS	total dissolved solids
TECO	Tampa Electric Company
UIC	underground injection control
WEF	Water Environment Federation
WRF	Water Reclamation Facility
ZLD	zero liquid discharge

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