To
Erika Kociolek
Energy Trust of Oregon

Eric Braddock
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From
Jonathan Kleinman
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Re
Water-Energy Nexus Market Study

Executive Summary

To date, Energy Trust of Oregon (Energy Trust) has demonstrated considerable success in promoting energy efficiency in its water / wastewater sector. Energy savings from this sector have accrued to over 32.3 GWh since 2004 and completed projects include a wide mix of prescriptive and custom energy efficiency measures. Overall, custom process and pumping measures along with Strategic Energy Management have been the greatest sources of energy savings for Energy Trust's water and wastewater customers.

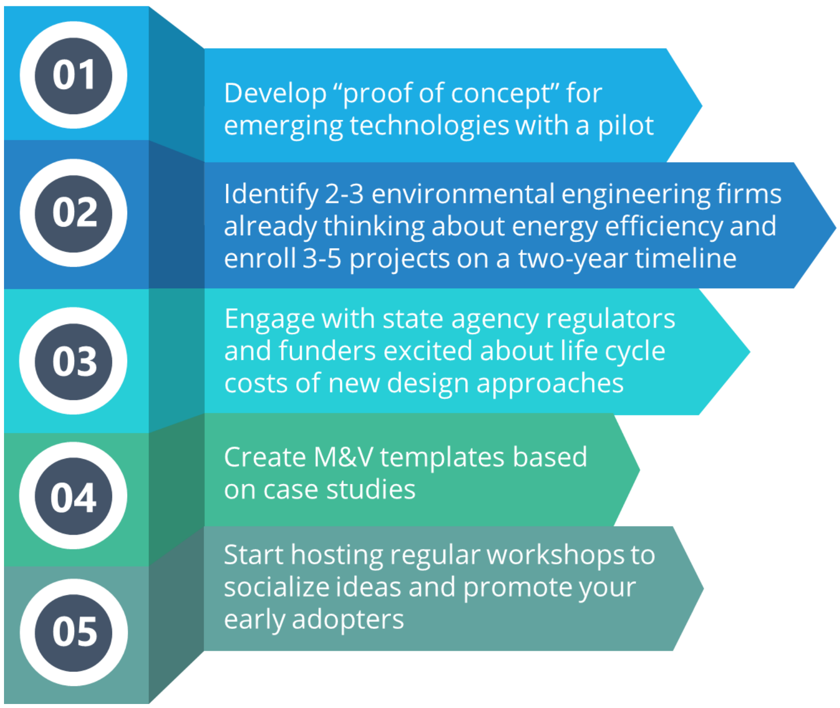
The full market potential of the water / wastewater sector, however, is not fully tapped. In order to capture deeper energy savings, Energy Trust must proactively target a wider range of emerging technologies and practices. Based upon AIQUEOUS' program implementation experience, our recommended approach to pursuing these measures is to focus on developing relationships with specific design professionals and funding organizations.

The reason for developing relationships with design professionals is two-fold. First, our experience suggests that it takes time and ongoing dialogue to encourage engineering firms to adopt changes to their standard design approaches. While our field experience shows that design engineers include certain measures – such as variable frequency drives and premium efficiency motors – on projects, fewer engineers adopt more sophisticated control sequences or alternate treatment technologies. We have seen energy efficiency program staff work in partnership with "early adopter" firms to adopt increasing levels of energy efficiency over time. Additionally, these firms can provide energy efficiency programs with a pipeline of project opportunities across all of their clients within Energy Trust's service territory.

Funding organizations play a different but no less important role. First, the vast majority of water and wastewater projects seek funds from the drinking water and clean water state revolving funds, and state agency staff can help utility programs identify new projects at early stages. State funders are also interested in the long-term financial viability of projects and minimizing life-cycle costs though energy efficiency will be of interest to these agencies. Finally, both design professionals and project developers worry about whether regulators will penalize projects that test new, energy efficient approaches. State funders could help broker discussions with state regulators to encourage test installations and provide flexibility, especially where significant

savings could be realized. Utility energy efficiency program participation in these discussions could be helpful.

Because these approaches are usually a departure for energy efficiency programs, AIQUEOUS recommends testing the proof of concept with a pilot over a one to two-year period, either as a separate effort or within the umbrella of the standard commercial and industrial programs. The five basic steps to follow are shown in the figure below:



1. The pilot would focus program staff efforts on the implementation of the strategy, and also create tracking and reporting requirements to ensure accountability to performance goals;

2. Starting with engineering firms is consistent with industry experience in this sector – these firms can both identify mid-term projects on which the energy efficiency program can influence design, and also short-term projects to capture immediate efficiency savings;

3. As stated above, engaging with state regulators and funders about the benefits of energy efficiency can leverage program investments, expanding program awareness and assisting in program recruitment;

4. Because the deeper efficiency measures require custom savings approaches, Energy Trust can streamline project development and implementation with standard measurement and verification (M&V) plans or templates; and

5. Utilities, notably American Electric Power Ohio, have seen regular workshops gathering water and wastewater professionals jump-start program participation and project enrollment.

The steps outlined above represent a tactical approach to promoting greater energy savings in the water / wastewater sector. In the report that follows, AIQUEOUS provides useful context for understanding the sector's energy usage profile, the cost-effective savings potential associated with emerging technologies, and various strategies for overcoming barriers to implementation. With this information, AIQUEOUS hopes to equip Energy Trust with strategic guidance on how to better serve its water and wastewater customers and strengthen its portfolio performance through greater participation in this sector.

Memo

EnergyTrust of Oregon

To: Board of Directors

From: Erika Kociolek, Evaluation Sr. Project Manager
Amanda Potter, Sector Lead – Industry and Agriculture
Eric Braddock, Sr. Technical Manager – Industry and Agriculture

Date: April 12, 2019

Re: Staff Response to Water-Energy Nexus Market Study

Energy Trust's Industrial sector has served water and wastewater customers since its inception. To identify opportunities to achieve deeper energy savings, Energy Trust contracted with AIQUEOUS to study energy efficiency in the water and wastewater sector.

The goals of the study were to:

- Analyze water and wastewater customers' participation in Energy Trust's Production Efficiency program.
- Define water and wastewater facilities' capital planning timelines and the life cycles of different components of the facilities' infrastructure
- Summarize emerging energy efficiency technologies and practices in this industry
- Identify market and technical barriers customers face when they implement energy efficiency technologies and practices
- Identify opportunities and strategies for achieving deeper energy savings in this industry

AIQUEOUS reviewed documents and data, surveyed market experts and performed a literature review. The final report contains a wealth of information about the water and wastewater sector, including detailed information about energy efficiency technologies and practices.

AIQUEOUS found that Energy Trust has been effective at serving water and wastewater customers, and recommended strategies and opportunities for achieving deeper energy savings, including:

- Working "upstream" with sector associations, design firms and state funding agencies to increase awareness of Energy Trust and of energy efficiency technologies and practices
- Working directly with water and wastewater utilities, particularly those with planned projects (identified by looking at capital improvement plans and funding programs) in the planning and pre-planning phases
- Providing technical assistance to water and wastewater utilities throughout all phases of projects

Energy Trust continues to work with market actors and provide technical assistance to water and wastewater utilities. Based on the study findings, the Industrial sector is now focusing on finding ways to get involved with projects earlier in the process. Examples include engaging directly with design firms, reaching out to Oregon's Department of Environmental Quality about their Clean Water State Revolving Fund, and directing the program delivery contractors to engage with water and wastewater customers much earlier than in prior years.

Project Overview / Objectives

Energy Trust commissioned AIQUEOUS to perform a Water-Energy Nexus Market Study focusing on emerging trends in the water / wastewater sector and effective strategies for promoting broader savings opportunities. The purpose of this study is to help Energy Trust better understand the market from the perspective of savings opportunities, capital life cycles, and key market channel. As part of its research efforts, AIQUEOUS analyzed Energy Trust's program history, explored emerging efficiency measures, and identified common market / technical barriers.

The project objectives included:

1. Evaluate historic program participation and equipment installation in Energy Trust of Oregon's service territory;
2. Ensure the completeness of prior research estimating the size and annual energy consumption of the water / wastewater segment and energy efficiency potential;
3. Define the capital life cycle of water and wastewater projects to inform future decisions on capital improvements and system expansion;
4. Evaluate emerging technologies and practices to drive energy efficiency improvements;
5. Identify market / technical barriers to implementing energy efficiency measures and appropriate mitigation strategies; and
6. Lay out a tactical plan for engaging with water / wastewater utilities, design professionals, state funding agencies, and state trade associations.

The following report is divided into 5 sections:

1. Understanding the water / wastewater market
2. Review of past program participation among Energy Trust's water / wastewater customers
3. Understanding capital project timelines and infrastructure lifespans
4. Energy efficiency measures and market barriers
5. Recommended strategies for achieving deeper savings

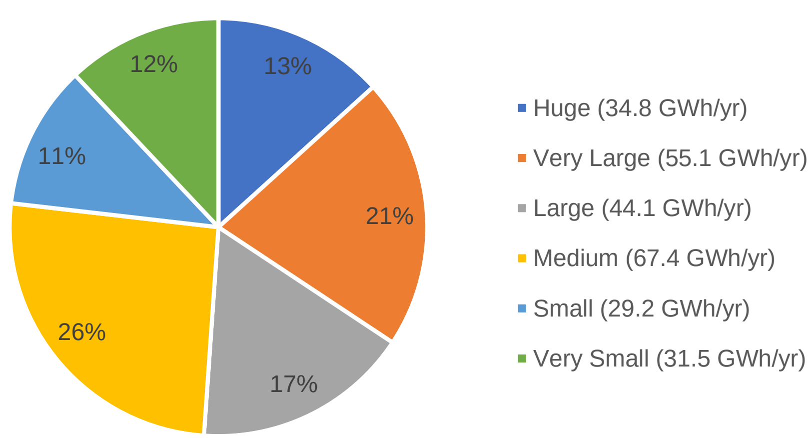
Understanding the Water / Wastewater Market

In 2016, Energy 350 prepared a report exploring the Northwest Power and Conservation Council's water and wastewater industrial segment[1]. This report set out to estimate annual energy use for the water and wastewater sector, highlight prevailing energy efficiency measures characterizing the market, and identify industry trends driving these efforts.

Based upon the findings of the report, there are 168 municipal wastewater treatment sites serving 2.96 million people in the state of Oregon. Although the majority of these sites are considered very small (1 million gallon per day, MGD, or less), medium- to large-sized facilities consume over 60% of total energy for the segment. These smaller facilities typically use lagoon systems for primary and secondary treatment, given their lower storage requirements. In contrast, medium to large facilities use standard secondary treatment with activated sludge.

Energy use at wastewater treatment plants is a function of size and treatment technology. Regardless of treatment process, however, larger facilities tend to have lower energy intensities than their smaller counterparts due to economies of scale. Total annual energy consumption by wastewater plants in Oregon is estimated to be 262.2 GWh per year. Figure 1 shows total usage by size category for wastewater facilities in Oregon. The Energy 350 Report did not provide definitions for these six size categories, except for very small facilities (1 MGD or less).

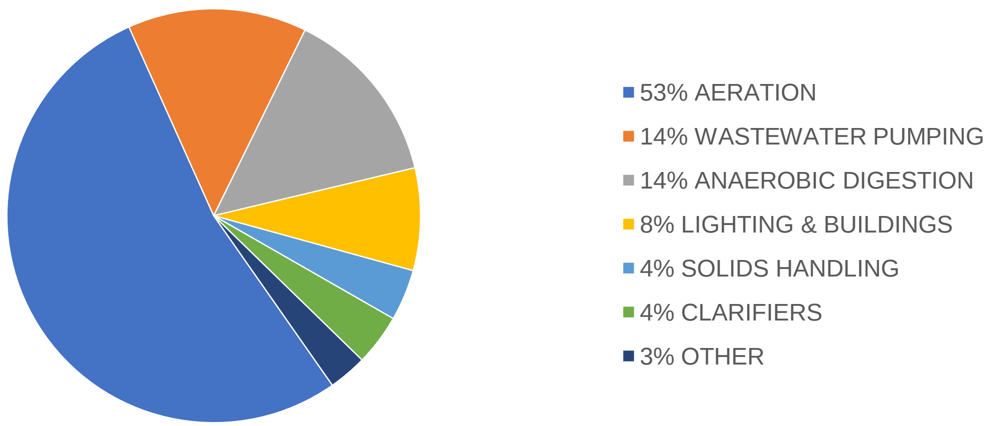
Figure 1. Total Energy Consumption by Size Category for Wastewater Facilities in Oregon



[1] Northwest Power & Conservation Council, *Water & Wastewater Treatment Industrial Segment Report*, 2016.

Although energy use at wastewater treatment sites depends largely on secondary and advanced treatment types, the energy end-use distribution at all sites is similar. Aeration is the primary energy end-use, accounting for more than half of the total energy consumption. Other major end uses include pumping and anaerobic digestion. Figure 2 provides the energy end-use breakout.

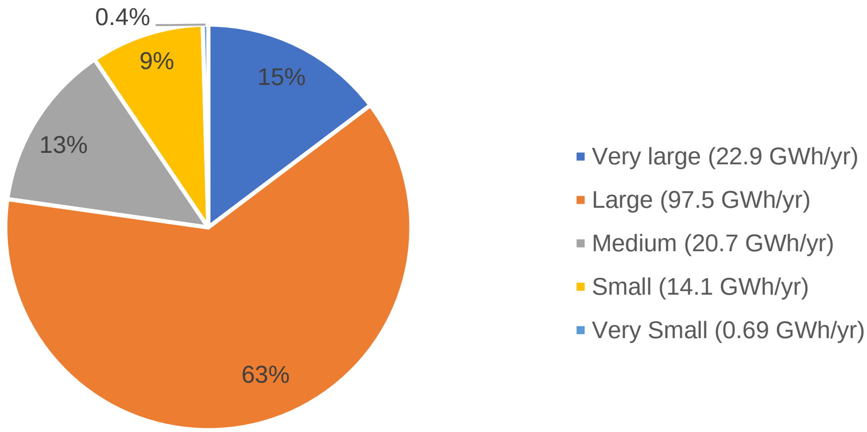
Figure 2. Wastewater Treatment Plant Energy Consumption by End Use



With respect to municipal water treatment sites, there are an estimated 302 facilities serving 3.65 million people in state of Oregon. The majority of these facilities are considered small (0.3 MGD or less). These smaller systems typically rely upon groundwater supplies, while medium to large systems are surface water-based. All in all, there is an equal distribution of surface water and groundwater sites. The distinction between surface water and groundwater systems is important to note because sourcing from groundwater is more energy intensive due to higher pumping requirements.

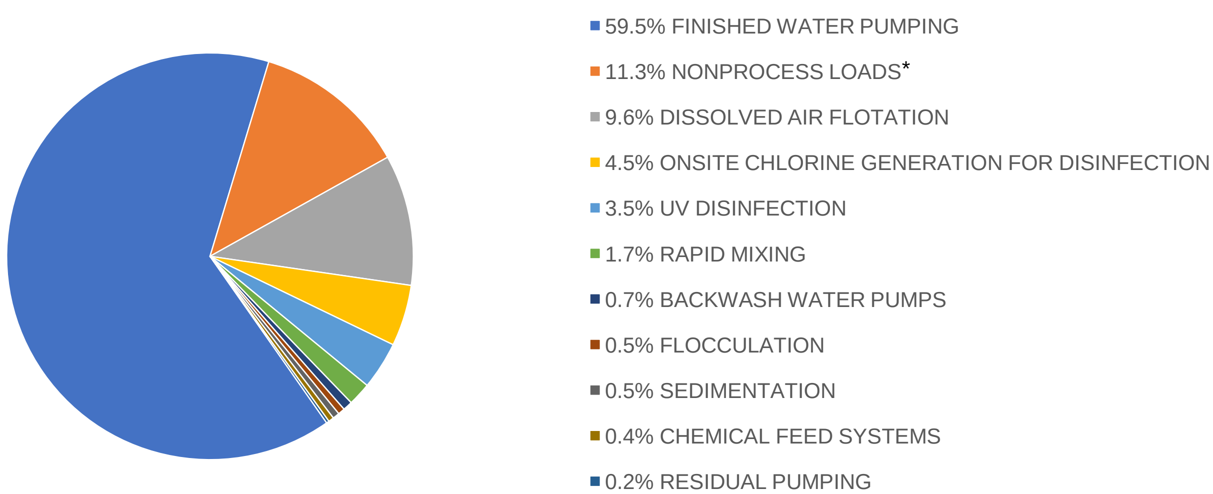
Oregon's water sector consumes an estimated 156.0 GWh per year. Figure 3 describes total energy use by size category for water facilities in Oregon. The Energy 350 report only defined two of these five size categories: small (0.3 MGD or less) and very small (0.05 MGD or less).

Figure 3. Total Energy Consumption by Size Category for Wastewater Facilities in Oregon



Typical end uses for a water treatment plant include raw water pumping, in-plant water pumping, water treatment, and finished water pumping (Figure 4). Pumping is by far the largest end-use, as it represents over 60 percent of the total consumption.

Figure 4. Water Treatment Plant Energy Consumption by End Use



* Nonprocess loads includes buildings, HVAC, lighting, computers, etc.

According to the Energy 350 report, aeration and optimized pumping systems have become common energy efficiency projects in the water and wastewater sector. As municipalities face increasingly stringent regulations requiring advanced levels of treatment, energy efficiency represents a cost-savings strategy to help reduce operating expenses. In the pursuit for net energy neutral operations, utilities often look at the following savings opportunities: reclaiming and reusing water, extracting and finding commercial uses for nutrients and other constituents, capturing waste heat and latent energy in biosolids and liquid streams, generating renewable energy using land and capturing methane gas, and other energy efficiency improvements.

Overall, the Energy 350 report provides a useful overview of the state of the water and wastewater market in the Pacific Northwest region. There are several areas of the analysis, however, that merit additional research and data to back up the report's findings. For instance, the report relied upon very small datasets (16 wastewater sites / 6 water sites) to extrapolate total energy usage across the sector. In addition to the limited amount of data points, electric use at many sites identified in the sample groups varied significantly from the national average, and without additional site-specific information, it is difficult to assess the accuracy of this data. A larger dataset would be ideal for improving the validity of the report's key findings. When gathering this data, it is critical to make sure total energy consumption reflects all components within the water and wastewater system, including plants, lift stations, pump stations, etc. Utilities often have separate accounts for each of these system components, making it difficult to gather complete data for each utility. A comprehensive energy use profile of each system in the dataset is ideal for understanding both total annual demand and the breakdown of energy use by system component.

In addition to using a limited dataset, the Energy 350 report did not provide a complete list of the water and wastewater facilities identified in the analysis. It would be helpful to have a list of the facilities located in the Energy Trust territory as well as site-specific information, such as total volume, baseload, population served, etc. The Energy 350 report was also missing key clarifying information such as the definitions of the size categories used to describe water and wastewater plants. This information would be useful for understanding the energy impacts at differently sized facilities.

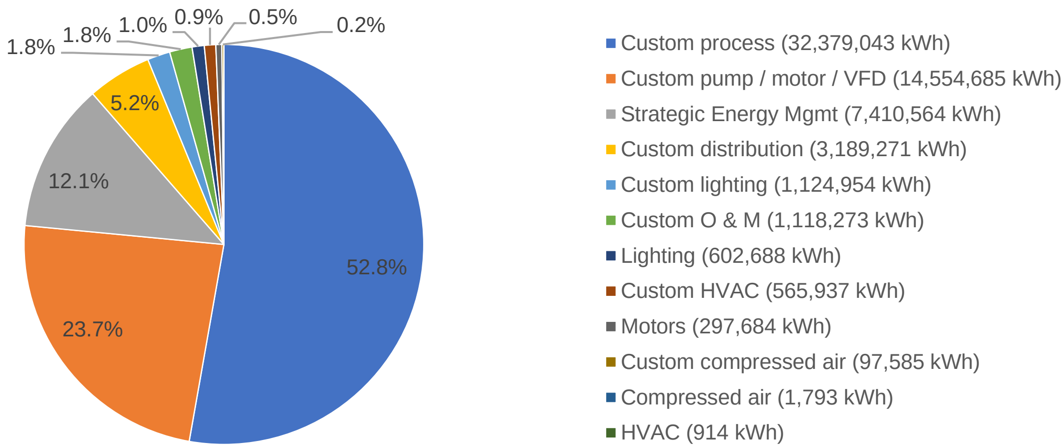
Aside from these data gaps, the Energy 350 report helps set the context for Oregon's water and wastewater sector. AIQUEOUS builds upon this research to provide Energy Trust with a better grasp on its past program achievements and the strategies necessary for better serving this customer segment.

Review of Past Program Participation Among Energy Trust's Water / Wastewater Customs

AIQUEOUS reviewed Energy Trust's past program participation (2004 to present) among water and wastewater customers. The dataset provided by Energy Trust offers insight into the types of efficiency projects implemented within this market segment, the estimated savings by measure type, and the observed changes in participation over the last decade[2].

Figure 5 presents the program savings for water / wastewater customers by measure type, including a variety of prescription and custom measures. Since 2004, Energy Trust has completed approximately 399 projects in the water and wastewater segment[3]. Nearly a quarter of these projects involved custom process-related measures. These projects alone yielded nearly 53 percent of total program savings for water / wastewater customers. The second largest group of savings came from custom pump, motor, and VFD projects, which generated nearly 20 percent of total program savings for water / wastewater customers while accounting for only 12 percent of total projects. Alternatively, despite making up 20 percent of total projects, custom lighting projects represent just 2 percent of total program savings.

Figure 5. Energy Trust of Oregon's Program Savings for Water / Wastewater Customers (2004 – Present)



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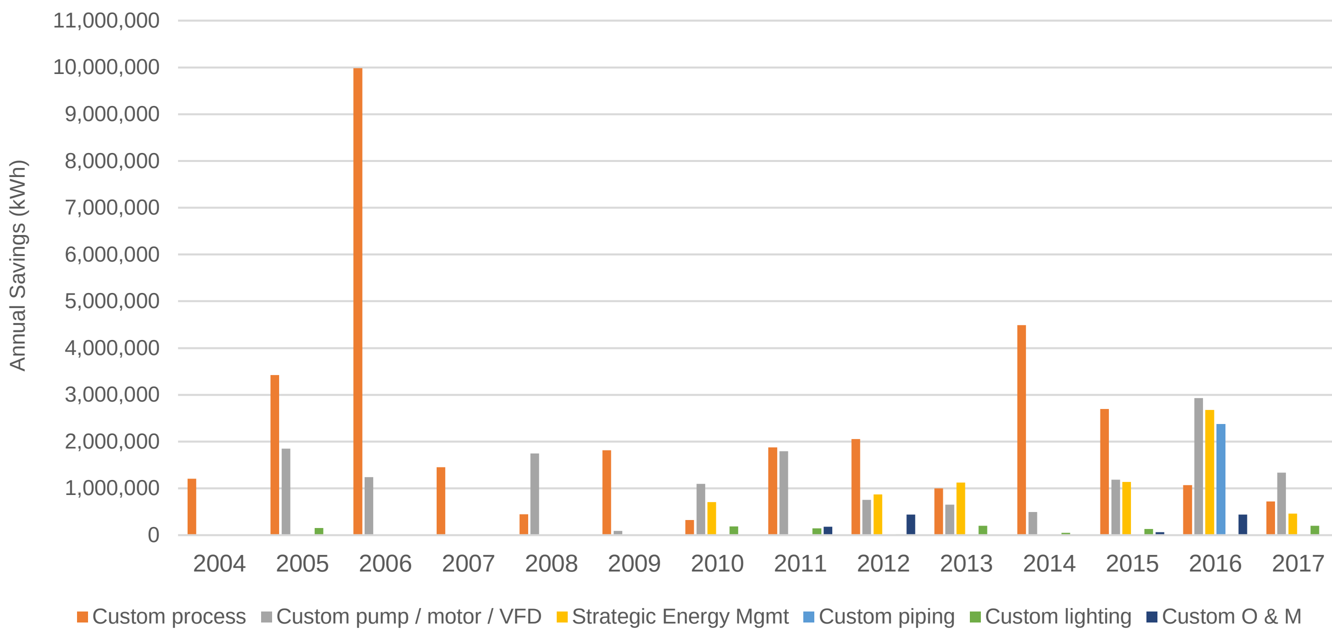
[2] The two primary fields AIQUEOUS used to identify projects in the dataset provided by Energy Trust were 'Evaluation Description' and 'Measure Notes'. In many instances, custom process-related projects (and in some cases, custom pump projects) were identified as "custom waste water' or 'custom fresh water'. AIQUEOUS used the 'Measure Notes' field to redefine these projects under the most appropriate project category. To help clarify the data, AIQUEOUS combined custom pump, motor, and VFD projects under one heading. AIQUEOUS also created a subcategory for custom process and custom pump / motor / VFD projects to provide a breakout of the different types of projects under each project category.

[3] This value represents projects that have associated savings. Projects not yielding direct savings were not considered in this analysis. For instance, Energy Trust conducted nearly 200 studies and technical-related services for this customer segment, but these projects are not reflected in the total project count.

Process- and pumping-related efficiency measures offer the greatest savings potential given the energy intensity of these end uses and their share of total energy usage systemwide. Lighting and HVAC, on the other hand, account for less than 8 percent of total energy usage[4].

Annual savings for water / wastewater customs captured by Energy Trust have fluctuated over the past fifteen years, as Figure 6 reveals. Custom process-related measures have led the way in nine of the past 15 years – peaking in 2006 with 9,980,777 kWh in annual energy savings. Since then, savings from custom process measures have dropped rather significantly, but in recent years, savings have remained relatively consistent year-over-year. It is also worth noting that Strategic Energy Management projects first appeared in 2010. Although these projects represent just 5 percent of the total number of projects, they have contributed 20 percent of total program savings over the past nine years. Figure 6 describes the top six measures contributing the greatest savings in the water / wastewater sector from 2004 to 2017.

Figure 6. Annual Savings for Water / Wastewater Customers by Measure Type (2004 – 2017)

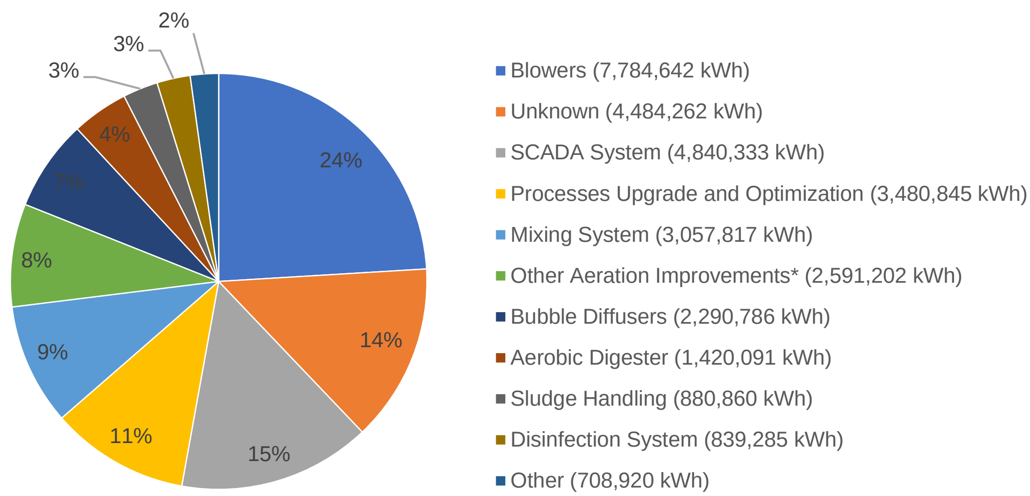


AIQUEOUS' prior work with and research on multiple electric utility energy efficiency programs indicates that energy savings in the water and wastewater sector typically come from prescriptive measures, such as lighting and motors. It can be difficult for water and wastewater utilities to participate in energy efficiency projects due to the emphasis on standard prescriptive measures.

[4] Energy Trust of Oregon, *Water and Wastewater Treatment Energy Savings Guide*.

However, Energy Trust has made significant strides in targeting broader participation and offering a greater mix of custom efficiency measures. These efforts have translated into much deeper energy savings than a portfolio focusing primarily on prescriptive measures. Altogether, 78 percent of Energy Trust's savings for water and wastewater customers come from custom efficiency projects geared toward treatment processing and pumping. To better understand the array of measures associated with these custom projects, Figures 7 and 8 provide measure breakouts for custom process and custom pumping (including motor and VFD) projects.

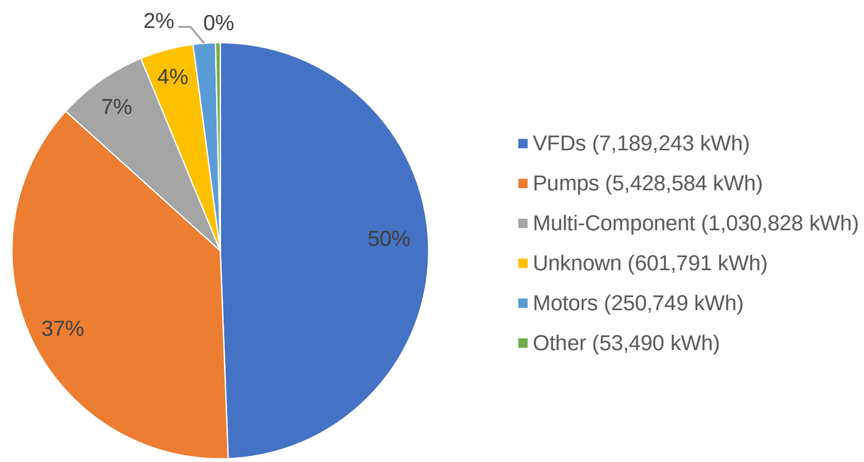
Figure 7. Breakout of Custom Process Projects[5]



*Other Aeration Improvements include dissolved oxygen control systems

[5] For projects identified as Unknown, the dataset provided by Energy Trust did not include sufficient information in the 'Measure Notes' field to determine the type of custom process measure associated with the project.

Figure 8. Breakout of Custom Pumping / Motor / VFD Projects



Blower technologies, advanced SCADA systems, general process upgrades, and enhanced mixing systems make up the majority of measures associated with custom process projects. The bulk of custom pump / motor / VFD projects involve VFD and high efficiency pump measures. Prevalence and applicability of these types of measures in the water / wastewater sector can vary. To demonstrate this, AIQUEOUS broke down these measures into three categories, as defined below.

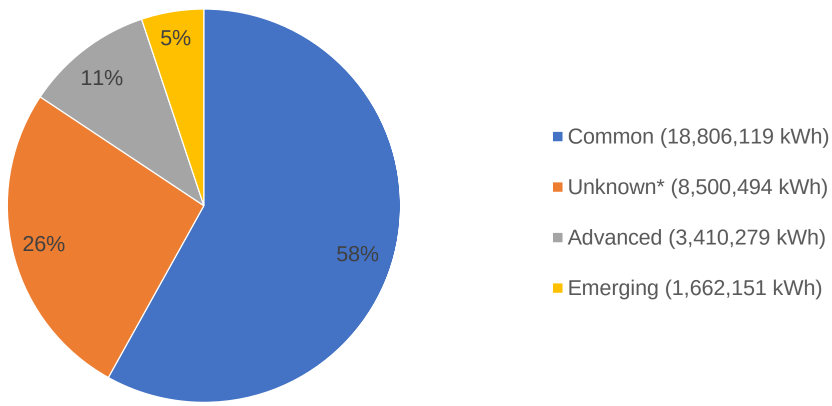
Table 1. Term & Definition of Measure Categories

Term	Definition
Common	Standard measures which can be used for most treatment plants regardless of their specificity
Advanced	Standard measures which can only be applied to a certain kind of treatment plant
Emerging	Measures which are not standard

Although Energy Trust has achieved significant energy savings via a diverse mix of efficiency measures, the categories defined above are helpful in gauging opportunities to drive these efforts even further. Common measures are considered standard practice and can be easily incorporated into project design. Advanced measures are also standard in practice—however, they must fulfil certain system characteristics and project needs in order to be implemented. Alternatively, emerging measures are the most difficult to implement. Since they are not widely commercialized, there is limited market awareness of the technology and few pilot studies demonstrating cost-savings potential.

Pumps, motors, and VFDs are largely considered standard practice and can be incorporated into project design with few obstacles. Process-related measures, however, differ more broadly in terms of prevalence, applicability, and specificity. For instance, process-related measures considered emerging include advanced reverse osmosis and advanced ozonation in water treatment processing and optical dissolved oxygen probe and hyperbolic mixers in wastewater treatment processing. Figure 9 summarizes the savings from custom process measures identified in the Energy Trust dataset, which have been categorized by AIQUEOUS as common, advanced, or emerging. A complete list of energy efficiency measures by categorization can be found in Tables 4 and 5 in the Energy Efficiency Measures & Market Barriers section of this report.

Figure 9. Savings from Custom Process Measures by Categorization[6]



Energy Trust's portfolio of process-related measures is dominated by common measure types. This makes sense considering the relative ease of implementing these types of measures. Advanced and emerging measure types, on the other hand, do not a have a strong presence in Energy Trust's portfolio.

Review of Energy Trust's program participation reveals overall success in promoting energy efficiency in the water and wastewater sector. The sector's energy efficiency potential, however, has not been eclipsed and deeper savings opportunities still exist. Advanced and emerging measures will be key to capturing these savings and strengthening Energy Trust's efficiency portfolio over the long-term. Implementing advanced and emerging measures can be more difficult because these projects have higher costs and require additional lead time. Better alignment between program outreach strategies and project timelines, however, will help Energy Trust overcome these barriers.

[6] For projects identified as Unknown, the dataset provided by Energy Trust did not include sufficient information in the 'Measure Notes' field to determine the type of custom process measure associated with the project.

Understanding Capital Project Timelines and Infrastructure Lifespans

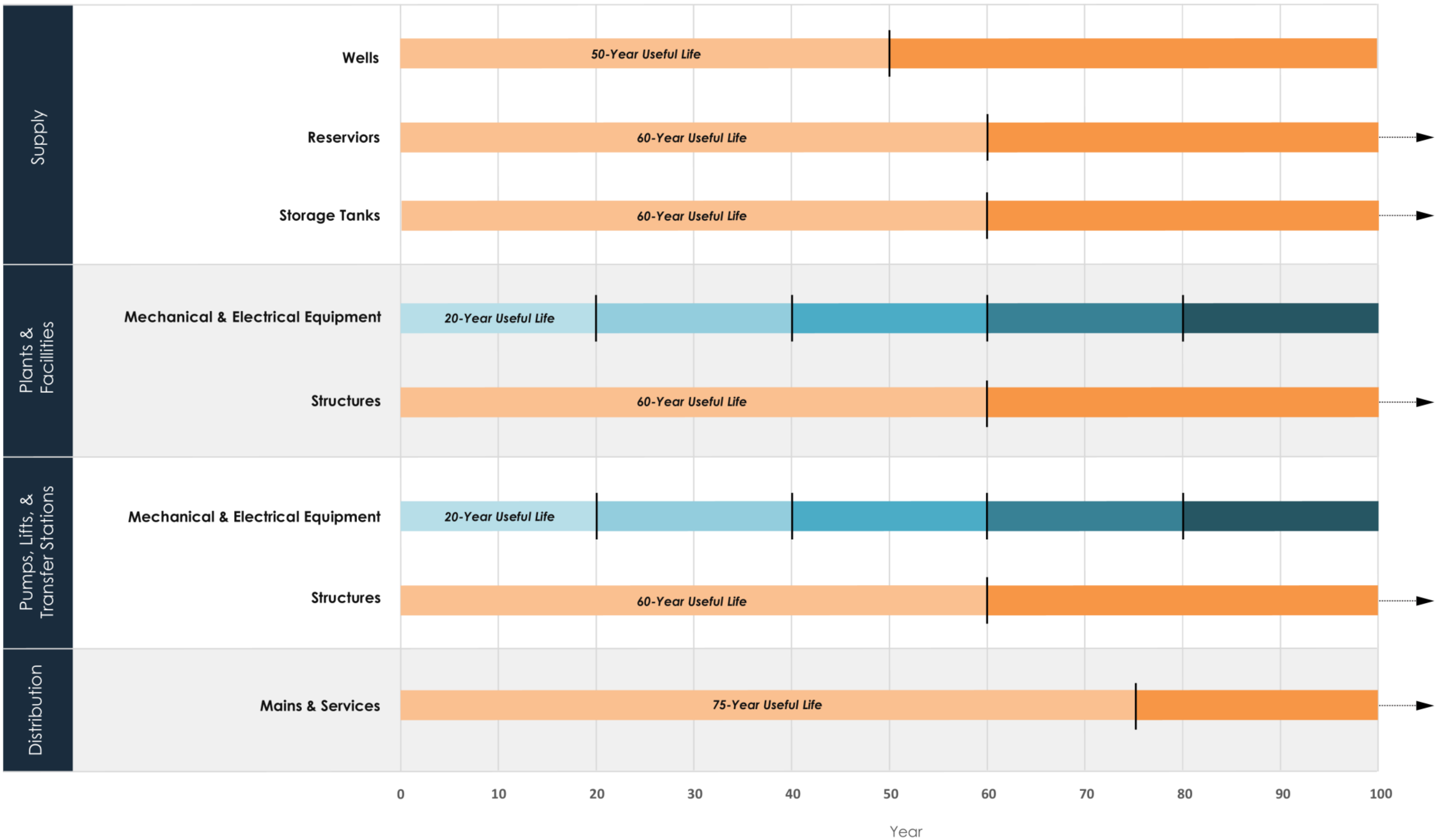
Before delving into specific efficiency measures, market barriers, and mitigation strategies, it is helpful to discuss the capital life cycles of water and wastewater treatment plants. Information on planned useful lives of these systems and the process by which water and wastewater utilities pursue and implement projects serves as guidance for determining the opportune time for introducing energy efficiency measures. Energy Trust can utilize this information to develop a framework for its outreach efforts.

Planned Useful Life

Water System Infrastructure

The primary components of water infrastructure systems include water supply, water treatment plants, pump/lift stations, and the distribution network. Figure 10 highlights each of these components and their associated equipment / assets, while each black bar indicates when the equipment must typically be replaced.

Figure 10. Lifespan of Water System Infrastructure (over a 100-year period)



Any component of the water system that is not inert (including pumps, motors, etc.) receives a 20 to 25-year lifespan (shown in blue). Everything else, including reinforced concrete structures, structural steel, and pipelines have an expected useful life of 50 to 70 years (shown in orange)[7]. Each of these components require ongoing maintenance to ensure longevity of the equipment.

Throughout a plant's lifetime, pumping equipment will have to be replaced on average three times. This type of improvement does not require significant change to the system and can be easily implemented. Because pumping represents a bulk of the plant's energy load, high efficiency pumps, motors, and VFDs, are cost-effective solutions for utility operators. Although it is unlikely utility management will replace pumping equipment before the end of its useful life, there are greater windows of opportunity to introduce higher efficiency alternatives given the shorter lifespan.

When it comes to facility-wide retrofits and new construction, project needs are typically driven by additional capacity requirements, deteriorating system conditions, or increasing water quality standards. Although these projects occur over a much longer time horizon, they are identified in the utility's capital improvement plan as many as 20 years out.

The Oregon Health Authority requires all public water systems serving more than 300 customers to have a current Water System Master Plan[8]. These plans serve as an asset management tool to assist utilities in prioritizing infrastructure needs over a 20-year planning horizon. In their evaluation of a given infrastructure need, utilities provide alternatives for meeting water quality and service objectives, identify a recommended alternative, summarize cost estimates, outline an implementation schedule, and consider available financing options. For utilities seeking to fund their capital projects through a state or federally-sponsored funding program, the Water Master Plan is a key requirement in the application process.

Wastewater System Infrastructure

The primary components of wastewater systems include collections, wastewater treatment plants, lagoons, and pump/lift stations. Figure 11 highlights each of these components and their associated equipment / assets, while each black bar indicates when the equipment must typically be replaced.

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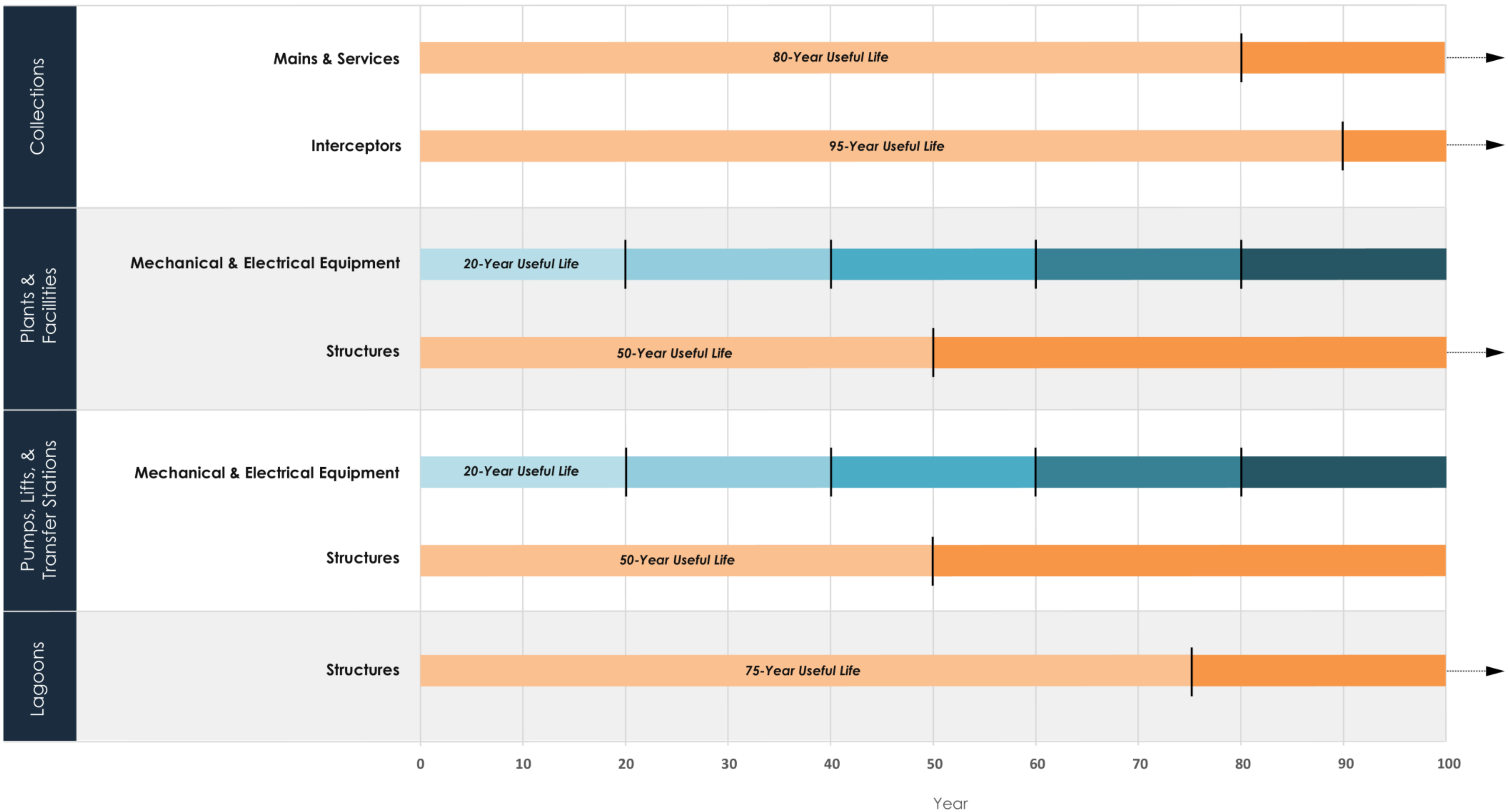
[7] Life cycle estimates are based on information obtained from a collection of sources: ASCE, *Failure to Act – The Economic Impact of Current Investment Trends in Water and Wastewater Treatment Infrastructure,* 2011; New Mexico Environmental Finance Center, *Asset Management: A Guide for Water and Wastewater Systems*, 2006; Government of Yukon, *Estimated Maximum Useful Life for Asset Management*; William Moriarty, phone interview, July 17 2018.
[8] Oregon Health Authority, *Plan Review requirements for Master Plans at Existing or New Public Water Systems*, 2018; *State of Oregon, Guidelines for the Preparation of Planning Documents for Developing Community Water System Projects*, 2001.

Figure 11. Lifespan of Wastewater System Infrastructure (over a 100-year period)



Again, any component of the wastewater system that is not inert (including pumps, blowers, motors, etc.) receives a 15 to 25-year lifespan (shown in blue)[9]. The expected useful life of wastewater equipment, however, is lower compared to the water sector because of the harsher environmental conditions found in wastewater facilities. This also factors into the useful life of wastewater treatment plants and pump/lift stations, which structurally speaking last around 50 years (shown in orange). The collection system, including services and mains, lasts longer – upwards of 70 to 100 years.

Like water systems, the window of opportunity to introduce high efficiency pumps, motors, and VFDs is more frequent than other system components. Although pumping accounts for a smaller proportion of total energy load since these wastewater systems are primarily gravity-fed, these types of measures represent a cost-effective savings opportunity. Aeration system upgrades for plant retrofits and new construction are another source of significant savings potential. As with water systems, these projects are typically identified in capital improvement plans well in advance of the projected need.

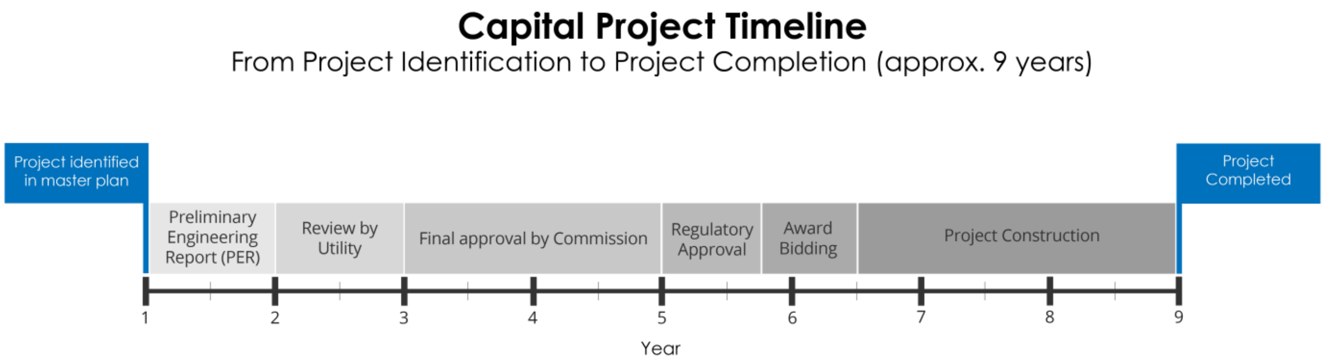
To assist in identifying and planning for system improvements and expansion, utilities prepare Wastewater Master Plans[10]. As with Water System Master Plans, these documents serve as a planning tool for inventorying assets, measuring system conditions, estimating capacity needs, and prioritizing future capital needs. Utilities are required to submit a Wastewater Master Plan to be eligible for state and federal funding.

Capital Project Timelines

The timeline for planning, designing, and constructing water and wastewater capital projects varies by size and scope. The length of time from start to finish can also vary depending on the method of project delivery. The most traditional method is the design-bid-build route which follows a more defined sequence of steps, as described in Figure 12.

[9] Life cycle estimates are based on information obtained from a collection of sources: ASCE, *Failure to Act – The Economic Impact of Current Investment Trends in Water and Wastewater Treatment Infrastructure*, 2011; New Mexico Environmental Finance Center, *Asset Management: A Guide for Water and Wastewater Systems*, 2006; Government of Yukon, *Estimated Maximum Useful Life for Asset Management*; William Moriarty, phone interview, July 17 2018.
[10] State of Oregon, *Preparing Wastewater Planning Documents and Environmental Reports for Public Utilities*, 2013.

Figure 12. Capital Project Timeline for Water & Wastewater Projects



The process begins with identifying the project in the Water or Wastewater Master Plan. Next, the utility hires an environmental engineering firm to prepare the preliminary engineering report (PER), a project-specific document demonstrating present and future need, potential alternatives, and preliminary cost estimates. For most types of projects, an environmental report (ER) must also be developed in parallel to the PER. These documents are typically completed within the first year, at which time they are presented to the utility for review and public commenting for another six months to a year. Project plans, designs, and specifications then go before the Utility Commission / Board for final approval, which can be a lengthy process especially for multi-phased projects (one to two years). Once approved, the utility seeks the go-ahead from regulatory agencies and begins soliciting bids for project construction. By this time, the project has already been in the works for four to six years and will take another two to three years until construction is complete. In total, the entire process from beginning to end can take anywhere from six to nine years to complete[11].

An alternative to the design-bid-build method is the design-build delivery method. The design-build method accelerates the project timeline by utilizing a combined engineering-construction consulting firm and shortening the design / award phases[12]. In addition to cutting down the project completion schedule, the design-build option allows for greater flexibility. This option is more advantageous for innovative efficiency projects because it ensures a fluid handoff between the engineer and the contractor, as well as clearer contractual agreements[13].

Aside from the design-bid-build and design-build methods, utilities may elect to proceed with designing and constructing the project in-house. Utilities are more likely to choose this route for projects with smaller scopes. Compared to the design-bid-build and design-build options, the in-house option is less common.

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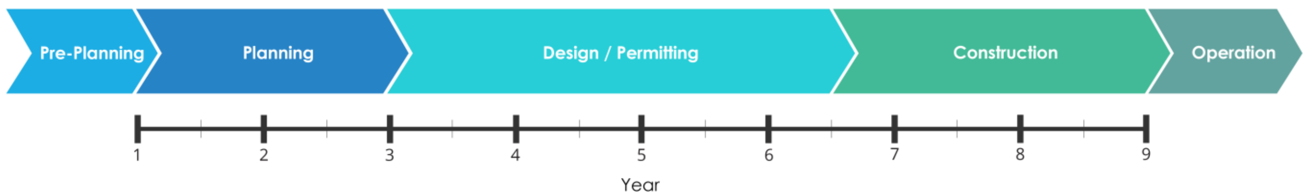
[11] William Moriarty, phone interview, July 17, 2018.
[12] William Moriarty, phone interview, July 17, 2018.
[13] NYSERDA, *Identification of Barriers to Energy Efficiency and Solutions to Promote these Practices*, 2015.

Building upon the capital project timeline information, Figure 13 highlights six defined project phases: pre-planning, planning, design/permitting, construction, and operation.

Figure 13. Water & Wastewater Project Phases



The project phases identified above fall in line with each capital project objective. For instance, the pre-planning phrase reflects the capital improvements planning process, while the design / permitting phase overlaps the final approval and bidding procedures. It is important to note the design / permitting phase also includes project funding. The following section uses these project time horizons to align energy efficiency measures and market barriers with appropriate market strategies.

Energy Efficiency Measures & Market Barriers

Water and wastewater utilities have historically been a hard to reach market. Their aversion to risk, combined with lengthy project schedules and complicated bidding process, have deterred greater participation in energy efficiency initiatives. However, Energy Trust has proven through its custom and Strategic Energy Management offerings that it can join forces with water and wastewater utilities to realize meaningful energy impacts. Despite this success, Energy Trust's past program participation has revealed that most of these savings come from common measure types. To help Energy Trust look beyond these standard practices and drive deeper energy savings, AIQUEUOS prepared a measure characterization of emerging trends, technologies, and best practices in the water and wastewater sector. In tandem with this list of measures, AIQUEOUS also identified major barriers to implementing these strategies and concludes with a detailed list of strategies for overcoming these challenges.

Measure Characterization

Starting with its existing database of technologies and practices, AIQUEOUS conducted an exhaustive literature review of efficiency measures and trends impacting the water and wastewater sector. AIQUEOUS used this data to develop a comprehensive list of measures, which can be found in a separate worksheet[14]. Measure details, as well as cost and savings information presented in this worksheet comes from a variety of data sources offering both nationwide and region-specific perspectives. For readability purposes, this report includes an abbreviated version of the measure list that omits savings and cost information.

The measure list provided herein serves as a tool for better understanding the technologies and practices available to the water / wastewater market and the appropriate implementation strategy based on the project timeline. Each measure is assigned a type (common, advanced, emerging) and an associated time horizon (pre-planning, planning, design / permitting, construction, operation). The measure categorization refers to the measure's overall prevalence, specificity, and applicability. The time horizon refers to the most opportune time for introducing the measure. Definitions for these terms are provided below.

[14] Titled *Water and Wastewater Measure Characterization_final*

Table 2. Definition of Measure Categorizations

Term	Definition
Common	Standard measures which can be used for most treatment plants regardless of their specificity
Advanced	Standard measures which can only be applied to a certain kind of treatment plant
Emerging	Measures which are not standard

Table 3. Explanation of Time Horizon Categories

Time Horizon	Explanation
Pre-Planning Planning	This measure must be identified during pre-planning and planning to ensure integration in design / permitting and construction.
Pre-Planning Planning Design / Permitting	This measure should be identified as an objective during pre-planning and planning and integrated during design / permitting. It can be integrated during design / permitting if not identified earlier.
Design / Permitting	This measure should be implemented during design / permitting or identified earlier. It is unlikely that this measure could be implemented during construction or operation due to likely impacts on treatment performance.
Design / Permitting Construction* Operation*	This measure can be implemented after the design phase; however, the engineering firm needs to confirm that treatment performance will not be adversely affected. The full benefits of the measure can be captured during the design / permitting phase. (It is possible to identify the measure during pre-planning and planning.)
Operation	This measure is targeted to an existing facility in operation.
All	This measure can be incorporated at any stage of the capital life cycle.

*Indicates feasibility of introducing measure at the construction or operation phase is dependent upon decisions made at prior project stages

Tables 4 and 5 on the following pages provide a complete list of measures by segment and applicable end use. The time horizons associated with each measure vary by measure categorization. Emerging measures related to treatment processing and anaerobic digestion typically require early outreach during the pre-planning and planning phases. Conversely, emerging measures related to aeration systems do not require engagement until the design / permitting phases.

Table 4. Water Treatment Efficiency Measures

Market Segment	Applicable End Use	Measure name	Measure description	ECM categorization	Time Horizon
Water Treatment	Pump / motor	High efficiency pump/motor system	High efficiency pump/motor system	Common	All
		Pump modification	Replacing pumps operating far from their BEP, adjusting effluent pumping, inline flow meters in collection/distribution systems, and pump controls	Common	All
		Variable frequency drive	Varies the speed of a pump to match the flow conditions. Controls the speed of a motor by varying the frequency of the power delivered to the motor.	Common	All
	Distribution	Pipeline optimization	Reduce power required to overcome friction of a pumping system by selecting appropriate check valves, optimizing pipe diameter, optimizing flow rate	Common	Pre-Planning Planning Design / Permitting
		Advanced SCADA systems	This advanced control system can be applied to raw water pumping, treatment and distribution. Reduce pumping and treatment energy consumption. Increase quality and reliability. Decrease operation and maintenance costs.	Common	Design / Permitting Construction* Operation*
		Turbine in pipeline	These turbines are installed inside large-diameter (24" - 60") gravity-fed water transmission pipelines. The turbines spin as water passes through them, converting excess head pressure into electricity.	Emerging	Pre-Planning Planning
		Automatic meter reading (AMR) /Acoustic leak detection integration	Monitors consumption of water and detects leaks in pipeline	Common	All
	Treatment processes	Advanced membranes	Separate particulate matter with a size higher than the size of the membrane	Emerging	Pre-Planning Planning
		Advanced Ozonation	Reduce energy consumption of ozone generators by half. Decrease need for water transport pumping through use of local water sources. Reduce operation costs.	Emerging	Pre-Planning Planning
		Advanced UV (low-pressure high-output (LPHO))	The short UV wavelength radiation physically penetrates the cell wall of microorganisms and has a germicidal effect.	Advanced	Pre-Planning Planning
		Photo catalytic oxidation	Can utilize visible light as the driving force for the production of hydroxyl radicals (the disinfecting agent)	Emerging	Pre-Planning Planning
		Advanced reverse osmosis	Greatly reduce baseline energy consumption for desalination through optimizing components and energy recovery. Reduce operating costs.	Emerging	Pre-Planning Planning
		Capacitive deionization	Use about half the energy of the best-case RO system. Lower operating costs than RO. Develop new water sources.	Emerging	Pre-Planning Planning
		Membrane distillation	Capable of utilizing solar thermal energy and/or waste heat for water purification needs	Emerging	Pre-Planning Planning
	HVAC	Optimized and efficient system	Replace the existing system with a rightsized, more efficient system, replace the compressor, replace older, inefficient motors with high-efficiency motors, improve insulation, add electronic control systems and temperature sensors	Common	Operation
	Electric demand management	Electric demand management	Monitoring total energy use/demand with installation of electrical metering, maximizing off-peak operations	Common	All
	Lighting	Efficient lighting fixtures (LED) with sensors	Efficient lighting fixtures (LED) with sensors	Common	All
	Renewable Energy	Wind and solar	Wind and solar production	Advanced	All

Table 5. Wastewater Treatment Efficiency Measures

Market Segment	Applicable End Use	Measure name	Measure description	ECM categorization	Time Horizon
Wastewater Treatment	Design and control of aeration systems	Intermittent Aeration	Reduces number of hours that an aeration system operates or the aeration system capacity.	Common	Design / Permitting Construction* Operation*
		Dual Impeller Aerator (mechanical mixing)	Includes a lower impeller near the bottom of the basin floor to augment the surface impeller which provides additional mixing energy near the floor of the basin	Emerging	Design / Permitting Construction* Operation*
		Optical DO probe	Measures changes in light emitted by a luminescent or fluorescent chemical and relates the rates of change in the emission to the DO concentration in solution.	Emerging	Design / Permitting Construction* Operation*
		Most Open Valve (MOV) control	Ensures the control butterfly valve serving the zone with the highest oxygen demand is essentially full open.	Emerging	Design / Permitting Construction* Operation*
		Integrated air flow control	Eliminates the pressure control loop in automatic DO control systems which can cause instability in the operation of the blowers and control valves.	Emerging	Design / Permitting Construction* Operation*
		Automated SRT (standard residence time) / DO (dissolved oxygen) Control System	Optimize the DO and SRT levels with an algorithm based on activated sludge modeling, plant historical data, and statistical process control	Common	Design / Permitting Construction* Operation*
		Respirometry for aeration control	Measures oxygen uptake rate by a biological treatment culture. Direct measure of biomass needs can predict oxygen requirements for WW as it enters the basin.	Emerging	Design / Permitting Construction* Operation*
		Critical oxygen point control	Accurately knowing the critical oxygen point for the active biomass allows the optimal DO setpoint to be determined	Emerging	Design / Permitting Construction* Operation*
		Off-gas monitoring and control	Determines in-process oxygen transfer efficiency (OTE) based on a gas-phase mass balance	Emerging	Design / Permitting Construction* Operation*
		Online monitoring and control of nitrification using nicotinamide adenine dinucleotide (NADH) (Symbio® process)	Determine changes in biological demands. Based on the results, airflow to the basin is controlled to promote simultaneous nitrification-denitrification (SNdN) of wastewater	Emerging	Design / Permitting Construction* Operation*
		Bioprocess Intelligent Optimization System (BIOS)	On-line process simulation program optimizing the operation of a biological nitrogen removal process.	Emerging	Design / Permitting Construction* Operation*
	Blower and Diffuser Technology for Aeration Systems	Aeration control / improvements	Smaller blower installation, operation changes, better control with meter installation	Common	Design / Permitting Construction* Operation*
		High-speed gearless (Turbo) blowers. (Air bearing or magnetic bearing)	Design to operate at higher speed (upwards of 40,000 revolutions per minute [rpm]). Is friction free	Common	Design / Permitting Construction* Operation*
		Single-stage centrifugal blowers with inlet guide vanes and variable diffuser vanes	Pre-rotate the intake air before it enters the high-speed blower impellers. This reduces flow efficiently. Improves control of the output air volume	Common	Design / Permitting Construction* Operation*
		Ultra-fine bubble diffusers. (Traditional ceramic and elastomeric membrane)	Increased oxygen transfer rates afforded by the high surface area of the fine bubbles (0.2-1mm). More resistant to fouling	Common	Design / Permitting Construction* Operation*
		Ultra-fine bubble diffusers. (Strip homogeneous thermoplastic membrane)	Less prone to tearing. Also, the smaller strips allow tapering of the diffuser placement to match oxygen demand across the basin.	Emerging	Design / Permitting Construction* Operation*
		Polyurethane or silicone membrane materials	More resistant, less susceptible to biological fouling	Emerging	Design / Permitting Construction* Operation*
		In place gas cleaning: Sanitaire® by ITT Water and Wastewater	Clean ceramic fine bubble diffusers without interruption of process or tank dewatering. Injects anhydrous HCl gas into the process air stream. removes biological foulants by decreasing the pH	Emerging	Design / Permitting Construction* Operation*
		Monitoring device for diffuser cleaning	Predicts cleaning when diffused air systems require it. Measures oxygen transfer efficiency	Emerging	Design / Permitting Construction* Operation*
		Rotary screw compressor	Rotary screw compressor	Emerging	Design / Permitting Construction* Operation*

Market Segment	Applicable End Use	Measure name	Measure description	ECM categorization	Time Horizon
Wastewater Treatment	Selected Treatment Processes	Clarifiers - Dissolved Air Flotation - Efficient nozzle	Reduced the absorbed power on the DAF recycle pumps due to more energy efficient nozzles.	Advanced	Design / Permitting
		Dewatering / Thickening - Belt Thickeners	Replacing decanters by belt thickeners which have a higher energy efficiency	Advanced	Design / Permitting
		Pretreatment	Removes suspended solids from wastewater and allows a plant to reach the same level of treatment at a lower UV dose	Advanced	Design / Permitting
		Low-pressure high-output lamps for UV disinfection	Used mercury amalgam so they can operate at higher internal lamp pressures. It reduces lamp requirements (quantity) and energy requirements	Advanced	Design / Permitting Construction* Operation*
		Mechanical and chemical cleaning (disinfection) of UV lamps	Prevent algal growth mineral deposits, and other materials that can foul the lamp sleeve and subsequently decrease UV intensity and disinfection efficiency	Advanced	Design / Permitting Construction* Operation*
		Membrane bioreactor (MBR) air scour alternatives. GE 10/30 Eco-aeration	Membrane is scoured for 10 seconds on, 30 second off during non-peak flow conditions.	Emerging	Design / Permitting Construction* Operation*
	Anaerobic Digestion	Hyperbolic mixers	The stirrer is equipped with transport ribs that cause acceleration of the wastewater in a radial direction to promote complete mixing	Emerging	Pre-Planning Planning Design / Permitting
		Pulsed Large Bubble Mixing (e.g., Biomx)	Reduces energy required for anoxic or anaerobic zone mixing by firing short bursts of compressed air into the zone. The large air bubbles minimize oxygen transfer and maintain anoxic or anaerobic conditions	Emerging	Pre-Planning Planning Design / Permitting
		Vertical linear motion mixer	Prevents solids deposition and minimizes scum and foam formation. Mixes digester contents by moving a thin steel disk in an up and down motion to create axial and lateral agitation.	Emerging	Pre-Planning Planning Design / Permitting
		Large feed pumps and macreator	Installation of larger feed pumps and macerator to ensure consistent digester feed. This enables increased sludge throughput by allowing additional imports of sludge to site, which reduces tankering costs, and increases biogas production.	Emerging	Pre-Planning Planning Design / Permitting
	Solids Processing	Thermal drying. Direct (convection) or indirect (conduction)	It is the use of heat to evaporate residual water from sludge. reduces the mass and volume of dewatered solids and results in a product with a high nutrient and organic content that can be used as a low-grade fertilizer. Energy provided by solar panels	Advanced	Pre-Planning Planning Design / Permitting
	Gas utilization	Flue Gas Recirculation systems with waste heat recovery	Takes the exhaust flow from the top hearth of the furnace and re-injects it into the one of the lower hearths. Allows the furnace to be run at a lower temperature (or without an exhaust gas afterburner), optimizing fuel consumption and eliminating ash slagging	Advanced	Pre-Planning Planning Design / Permitting
		Cogeneration or CHP (Combined Heat and Power)	Generate electricity and recoverable heat onsite using methane off-gas from anaerobic digesters.	Advanced	All
	Pump / motor	Optimized motor	Replace old inefficient motor with new more efficient ones	Common	Design / Permitting Construction* Operation*
		Optimized pumping system	Replace inefficient pumps with more efficient ones or optimize sizing or replace large capacities pumps with smaller capacities pumps	Common	Design / Permitting Construction* Operation*
		Variable Frequency Drive (VFD)	Varies the speed of a pump to match the flow conditions. Controls the speed of a motor by varying the frequency of the power delivered to the motor.	Common	Design / Permitting Construction* Operation*
	HVAC	Optimized and efficient system	Replace the existing system with a rightsized, more efficient system, replace the compressor, replace older, inefficient motors with high-efficiency motors, improve insulation, add electronic control systems and temperature sensors	Common	All
	Electric demand management	Electric demand management	Monitoring total energy use/demand with installation of electrical metering, maximizing off-peak operations	Common	All
	Lighting	Efficient lighting fixtures (LED) with sensors	Efficient lighting fixtures (LED) with sensors	Common	All
	Renewable Energy	Wind and solar	Wind and solar production	Advanced	All
		Hydroelectric turbines in the effluent stream	Depending on the head (ft) and flow (MGD), a hydropower turbine can be installed to create electricity	Advanced	Pre-Planning Planning

As part of the report's final recommendations, AIQUEOUS identifies specific market channels and tactics for promoting these measures. These recommendations are grouped by time horizon to offer parallels between each measure and its corresponding implementation strategy.

The next sub-section discusses common barriers to encouraging broader participation from water and wastewater utilities. As with the measure characterization, these barriers are tied back to the project time horizons.

Market Barriers

The concept of market barriers to energy efficiency has been studied for a number of years. The California Public Utility Commission commissioned a study on the topic in 1996, "A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs," to take a comprehensive look at the topic.

The authors of this study reviewed the literature and created a working definition of market barriers, identifying 14 distinct types of market barriers to energy efficiency technology implementation.

> ***Working Definition of Market Barriers:***
> Any characteristic of the market for an energy-related product, service, or practice that helps to explain the gap between the actual level of investment in or practice of energy efficiency and an increased level that would appear to be cost beneficial.

Of the 14 barriers identified in the 1996 study, the ones most relevant to energy efficiency implementation in the water / wastewater sector appear to be the following:

- ***Information or search costs*** **–** time and costs required to identify energy efficient products or services. For water and wastewater, this would apply not just to water and wastewater utilities, but to their design firms and funding sources as well.
- ***Performance uncertainties*** **–** here are the worries about whether the technologies will deliver the expected savings or, particularly in a regulated environment tied to public health, whether the systems will adequately perform with respect to water quality.
- ***Asymmetric information and opportunism*** – an issue related to performance uncertainties is whether the utility or design firm will trust performance claims made by third-party vendors or proponents of energy efficiency.
- ***Hassle or transaction costs*** – even after an energy efficient product is identified, there may be additional costs for design and installation, and possibly to getting project signoff by permitting entities.
- ***Hidden costs*** **–** there may be unexpected costs with energy efficient technologies, such as the possibility of increased maintenance costs with fine-bubble diffusers (if they are more susceptible to fouling).
- ***Organization practices*** **–** in a risk-averse sector such as water and wastewater, where both public and environmental health concerns are potential consequences, utilities and their design firms are more likely to stick with "what has worked."

- ***Irreversibility –*** the final barrier that seems relevant to the water and wastewater sectors is the difficulty of undoing a decision to install energy-efficient technologies should new information come to light about its performance.

To determine which market barriers are the most significant, AIQUEOUS conducted a literature review and surveyed design professionals in the sector. Table 6 summarizes the barriers identified in the literature review along each corresponding source.

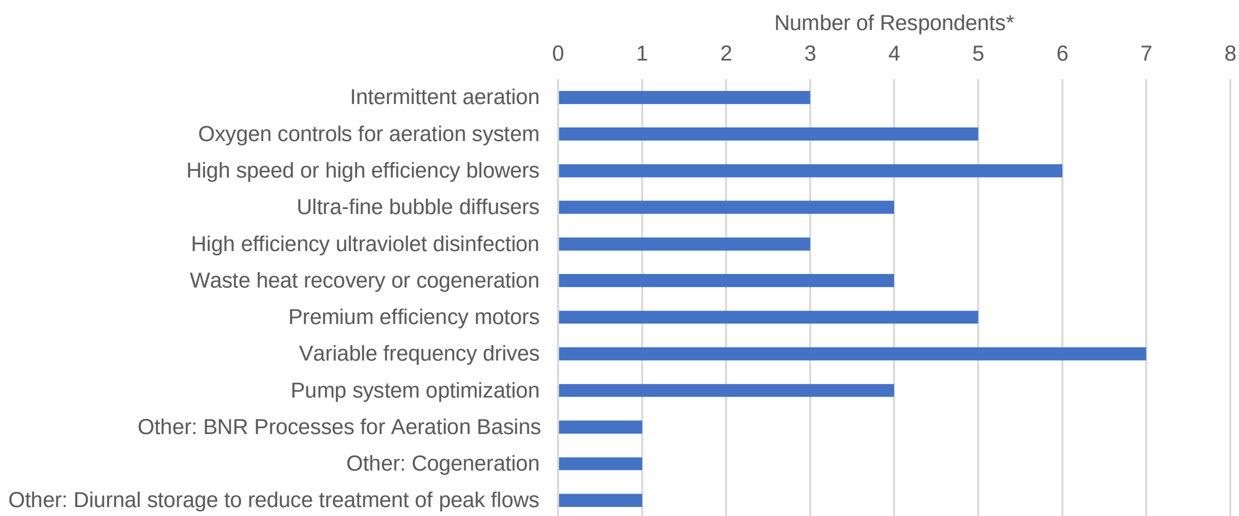
Table 6. Summary of Common Market Barriers

Barrier	Description	Source			
		NYSERDA[15]	NEEP[16]	ESMAP[17]	ACEEE[18]
Organization Structure	Organization-based silos disrupt facility-wide communications on energy usage, management, and procurement. For instance, operating staff typically do not see the plant's energy bill and have no responsibility for reducing energy costs.	X	X	X	X
Competing organizational priorities	Regulatory compliance is a top priority, so utilities are reluctant to try anything new that may negatively impact water quality permitting.	X	X	X	X
Financial constraints	Utilities are under pressure to minimize upfront costs and maintain low rates.	X	X	X	X
Oversizing of equipment	Plants are designed to handle much larger flows to accommodate future growth, leading to less-than-optimal energy performance.	X	X		X
Lack of awareness	Utility staff may lack a strong understanding of the facility's energy usage as well as the benefits associated with energy efficiency investments.	X	X	X	X
Low cost of energy	No internal incentive to encourage energy efficiency because of low energy costs. These low energy costs also impact the project payback period.	X		X	
Limited internal capacity of utility	Most utilities do not prepare energy management plans, and without an energy manager on staff, utilities lack the time and resources to focus on energy efficiency.		X	X	X

[15] NYSERDA, *Identification of Barriers to Energy Efficiency and Solutions to Promote these Practices*, 2015; NYSERDA, *Water & Wastewater Energy Management Best Practices Handbook*, 2010; NYSERDA, *Statewide Assessment of Energy Use by the Municipal Water & Wastewater Sector,* 2008.
[16] NEEP, *Opportunities for Strategic Energy Management in the Municipal Water Sector*, 2018.
[17] ESMAP, *A Primer on Energy Efficiency for Municipal Water & Wastewater Utilities*, 2012.
[18] ACEEE, Roadmap to Energy in the Water & Wastewater Industry, 2005.

In addition to the literature review, AIQUEOUS conducted a survey and requested input from industry professionals[19]. The purpose of this survey was to corroborate what AIQUEOUS believed were the biggest market barriers based upon its initial market research. Although the results of the survey are not fully representative of the entire market, they serve to supplement the literature review and provide deeper market insight. The figures below describe the results of the survey.

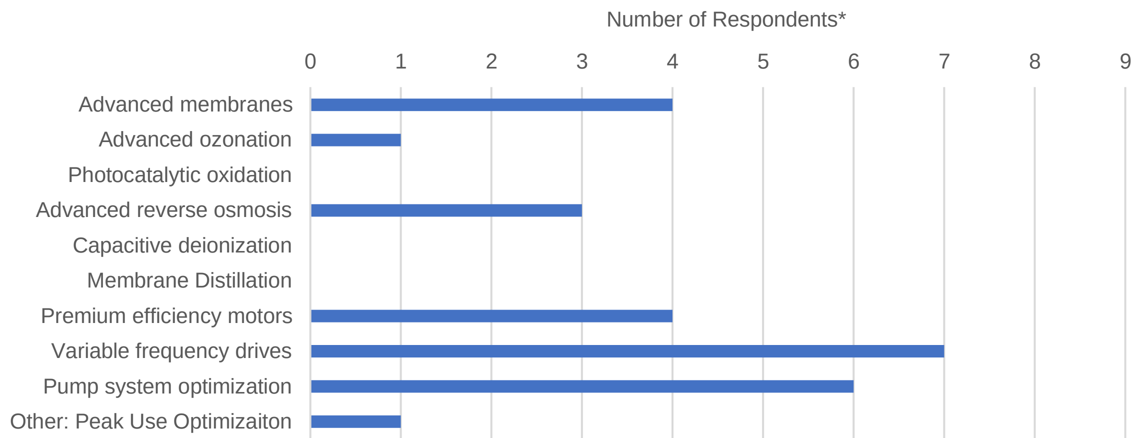
Figure 14. Aside from LED lighting, what energy efficiency technologies do you often see implemented at new or renovated wastewater treatment plants and facilities?



*8 respondents total with multiple responses allowed and option to write in 'other'

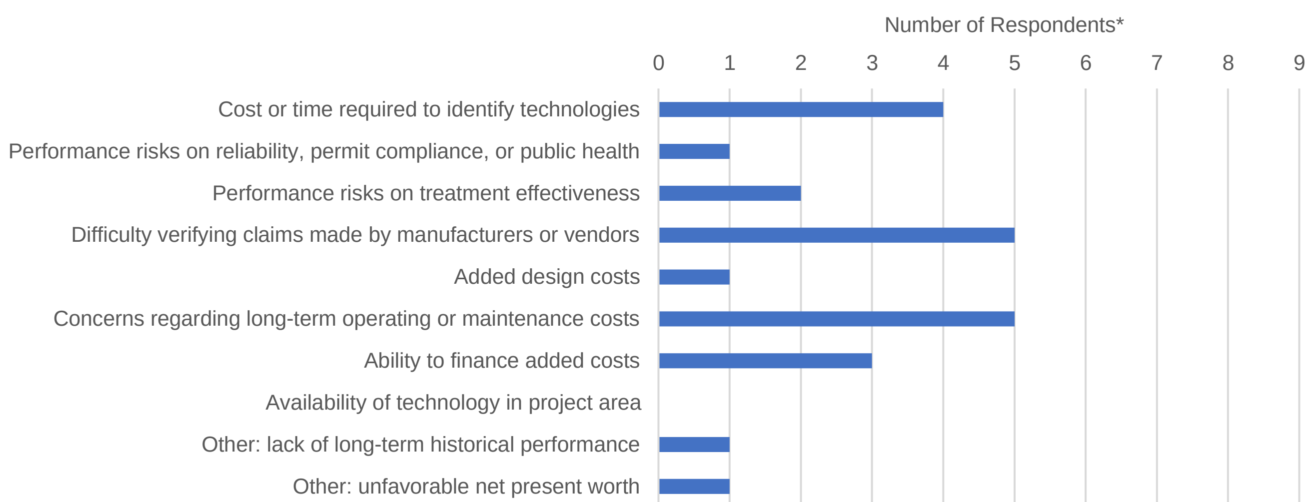
[19] AIQUEOUS used SurveyMonkey, an online tool, to field the survey. The survey contains seven questions covering two main topics: common energy efficiency technologies and the most significant barriers to implementing these measures. The complete set of survey questions can be found here: https://www.surveymonkey.com/r/DC6KXBB. AIQUEOUS reached out to 30 water and wastewater-related professionals representing public, private, and non-profit entities both local to the Pacific Northwest region and others statewide. AIQUEOUS sent an email to these individuals on August 13 and 14, 2018 asking them to participate in the survey. Of the 30 requests, 9 individuals provided responses. The complete set of survey responses can be found here: https://www.surveymonkey.com/results/SM-86V8TT7ML/.

Figure 15. Aside from LED lighting, what energy efficiency technologies do you often see implemented at new or renovated water treatment plants and facilities?



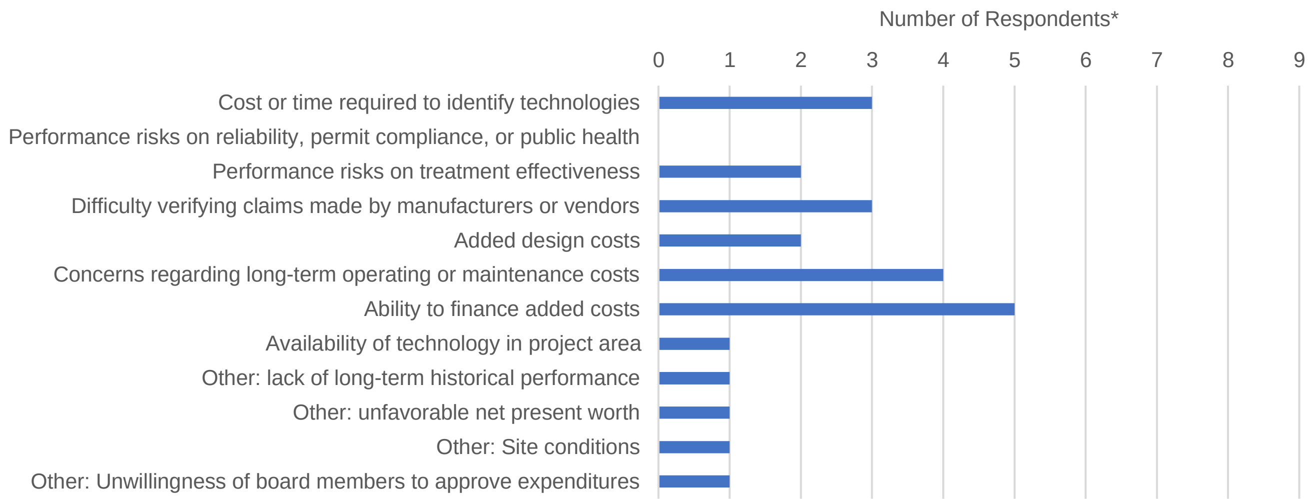
*7 respondents total with multiple responses allowed and option to write in 'other'

Figure 16. What are the three most significant barriers to the installation of energy efficient technologies in NEW water and wastewater treatment plants and facilities?



*7 respondents total with multiple responses allowed and option to write in 'other'

Figure 17. What are the three most significant barriers to the installation of energy efficient technologies in EXISTING water and wastewater treatment plants and facilities?



*8 respondents total with multiple responses allowed and option to write in 'other'

Based upon information gathered from the literature review and survey, Figure 18 summarizes the most significant barriers observed in each project phase.

Figure 18. Summary of Significant Barriers by Project Phase

Project Phase	Significant Barrier
Pre-Planning	• Resistance to change & innovation • Lack of facility-wide energy awareness • Insufficient information on energy efficiency opportunities & benefits
Planning	• Higher priority afforded to regulatory compliance • Limited internal capacity / resources to pursue & undertake projects • Pressure to minimize upfront costs & maintain low rates
Design / Permitting	• Difficulty obtaining approval when the project is not required by capacity or condition • Difficulty obtaining organizational buy-in without strong payback • Difficulty financing added costs
Construction	• Difficulty verifying claims made by manufacturers / vendors • Lack of onsite commissioning
Operation	• Concerns regarding long-term operating & maintenance costs

Energy efficiency programs have a long history at addressing these market barriers for similar types of risk-averse organizations (e.g., schools, hospitals, data centers). Among the more effective strategies to overcome these barriers are:

1. Partnerships with credible organizations within the sector that have relationships with customers and trade allies (e.g., AWWA, WEF);
2. Case studies, demonstration projects, and tours of completed facilities;
3. Third-party technical assistance, independent of manufacturers, vendors, or trade allies;
4. Financial rebates; and
5. Partnerships with funding agencies that provide access to capital for energy efficient technologies (e.g., state energy offices, water funding agencies).

Different measures require different implementation strategies and timelines. In the concluding section, AIQUEOUS provides a list of recommended strategies for each project phase.

Recommended Strategies to Achieve Deeper Savings

When developing and implementing strategies to drive deeper savings in the water and wastewater sector, it is important to keep the following in mind:

1. How successful has Energy Trust already been at promoting that measure in its programs;
2. Whether the measure is common, advanced, or emerging; and
3. At what time horizon the Energy Trust should engage to promote the measure.

Review of prior program participation indicates Energy Trust has been effective at promoting common and, to a lesser extent, advanced measures. Achieving deeper savings will require more focus on emerging measures. To effectively target these measures, Energy Trust should begin engaging with key market players as early as the pre-planning and planning project phases, based on the measure characterization.

Table 7 below outlines AIQUEOUS' recommended strategies for introducing efficiency measures at key stages of the project implementation timeline. For each time horizon, AIQUEOUS identifies the targeted measure type, the recommended promotion strategy, and the associated market channels and tactics. These recommended strategies tie directly back to the measure list via the time horizon and measure categorization fields.

Table 7. Recommended Strategies

Time Horizon	Targeted Measure Type	Recommended Strategy	Key Market Channels / Tactics
Pre-Planning Planning	Primarily Emerging	**Engage upstream.** Energy Trust should utilize upstream approaches to encourage awareness, generate drive, and demonstrate credible savings opportunities.	• **Education** – provide education & training opportunities to environmental engineers • **Outreach** – engage with state trade associations (e.g., AWWA, RWA, WEF), state funding agencies, & design professionals • **Case Studies** – develop case studies documenting energy efficiency solutions, costs, and benefits • **Conferences** – give presentations on energy efficiency opportunities in the sector & emerging trends • **Design Competitions** – recognize innovative practices in the design community at annual state conferences (e.g., AWWA Pacific Northwest Section, WEF) • **Pilot Projects** – conduct pilot projects to verify energy savings & process performance for emerging measures

Design / Permitting	Common Advanced Emerging	**Engage with utilities.** Energy Trust should reach out directly to utilities with planned projects, based on Capital Improvement Plants as well as the Drinking Water and Clean Water State Revolving Fund Programs.	• **Outreach** – engage with utilities that have projects in the pipeline • **Benchmark** – work with utilities to perform benchmarking evaluations for smaller projects / more standard technologies • **Financing** – assist utilities in exploring additional financing mechanisms (e.g., municipal leases) • **Case Studies** – develop case studies demonstrating high level of treatment performance
Construction Operation	Primarily Common	**Provide ongoing support.** Energy Trust should provide technical assistance throughout the construction and operation phases to ensure energy efficiency projects meet their performance objectives.	• **Testing** – provide technical assistance for verification checks, diagnostic monitoring, & factory / functional testing • **Training** – offer utility staff training on new equipment / technologies • **Equipment Review** – assist utility staff in conducting near warranty-end reviews of equipment / technologies