# How do I Begin to Implement an Energy Management Program for my Utility?

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Toho Water Authority (TWA) has begun implementing an energy management program to proactively look at current and future energy uses at its treatment and conveyance facilities. It is also identifying ways to conserve or offset costs through educational programs, procedural changes, technology improvements, and the cost-effective replacement of equipment.

As part of the strategic planning process, it was identified that energy costs make up a significant portion of the operations and maintenance budget and should be minimized as much as possible to keep rates stable for customers and continue to provide quality service far into the future. To effectively implement the program, TWA is using a combination of in-house staff and consulting support to maximize knowledge transfer and create efficiencies.

The process began with creating an energy management program vision statement with goals and objectives supporting the achievement of that vision so that staff at all levels could be brought into the process. Looking at where the larger energy spending was occurring indicated that the first logical step would be to evaluate energy use at the largest treatment plant, the South Bermuda Water Reclamation Facility (SBWRF), and use it as a learning process to go through the basic steps of implementing an energy management program, including:

1. Establish organizational commitment
2. Develop a baseline of energy use
3. Evaluate the system and collect data
4. Identify energy efficiency opportunities
5. Prioritize opportunities for implementation
6. Develop an implementation plan
7. Provide for progress tracking and reporting

This article will discuss the methodology for performing these basic steps at SBWRF, as well as the overall findings in terms of projects and operational changes recommended that can significantly reduce energy use. Any utility that is considering implementing an energy management program can benefit by learning the basic steps, understanding the issues and challenges in collecting and evaluating the data, and learning what is the typical energy profile for an advanced wastewater treatment plant, including key performance measures.

## Background

Energy savings come with a cost. For those not solely motivated by the social cause to become a "greener" utility, it is important that the costs to achieve the energy savings are adequately offset by measurable and reoccuring savings. For this reason, an energy management program is much more than a couple of energy audits and a few resulting capital projects; it involves understanding why an organization's energy needs are what they are. This understanding reaches far beyond the security fence of the facilities and involves understanding the following:

- Level of demand and rate of consumption for the water-related services provided.
- Process systems and equipment involved in extracting, treating, distributing, collecting, reclaiming and returning life's most precious resource.
- Standard operating procedures that dictate how and when actions are taken.
- Actual work practices that illustrate how water services are performed.
- Energy consumption, cost, and pricing models.
- Staff awareness, ability, and desire to affect changes in the consumption of energy.

Presented are the programmatic steps taken by TWA to define and implement its energy management program. By its very nature, TWA's program will continue to evolve as organizational knowledge grows.

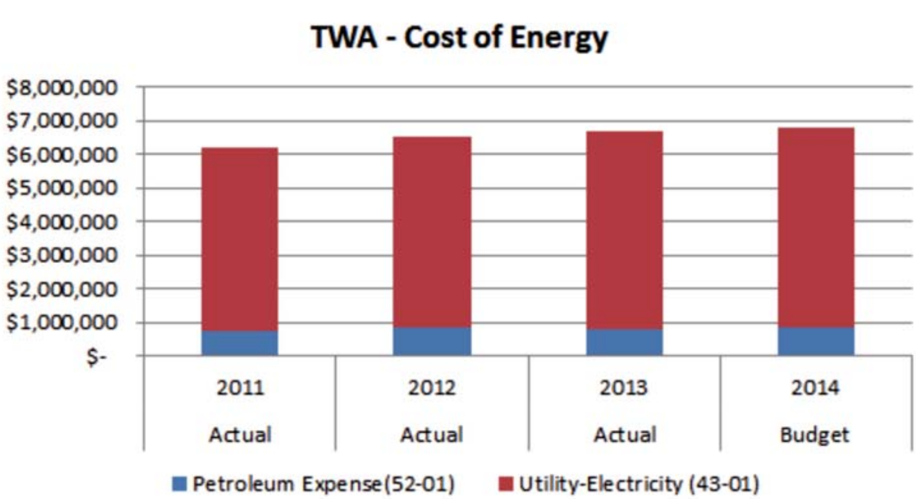


Figure 1.

## Roadmap to Implementation

**Establish Organizational Commitment**

Energy cost (combined petroleum and electricity) represents TWA's second largest operating expense, exceeded only by labor expenses. These costs have shown steady increases in the study years (2011 through 2014) and are shown in Figure 1.

The anticipated need for additional nutrient removal in wastewater treatment and the introduction of membrane filtration, as alternative water supplies are required, will continue to place upward pressures on this operating expense. These and other anticipated technology- or regulatory-driven energy demands represent the primary motivation for this program.

A visioning workshop was held in October 2011. Attendees at the workshop included the executive team and representatives from the engineering, operations, and field services divisions. The objectives of this workshop included:

- Gaining an understanding of what could be accomplished by an energy management program and what others were doing.
- Creating draft vision and mission statements to form the program policy.
- Looking at dependencies and overlaps with any existing programs.
- Developing a high-level road map of where to go.

Exercises to fully engage the workshop participants involved identifying:

- Internal and external drivers that could assist the development of an energy management program.
- Stakeholders and their perceived attitude, influence, viewpoints, and communication methods.
- Key outcomes of a successful program.

These exercises assisted in forming the shared realization that this was a program that would require leveraging the identified internal and external drivers (or competencies) to achieve the desired outcome. What resulted was also a clearer vision of who could affect or be affected by the program and that proper engagement of these stakeholders was necessary for program success. The program needed to have facets that not only involved getting the latest and most efficient equipment or control systems, but also introduced cost control and predictability through sound management practices, generation and process optimization through innovative solutions, and commonality in vision and mission through cultural change.

As a result of the visioning workshop, TWA's strategic plan was revised to include energy as a major component under the current infrastructure strategy. Integrating energy into the strategic plan helped to secure the commitment of the organization. Goals, objectives, and tactics were drafted to support the following energy strategy:

"Toho will achieve its mission through a results-driven energy program that incorporates staff expertise and the application of technology to operate at the lowest achievable level of energy consumption. Toho's ultimate goal is to become a net-zero electricity consumer across its treatment and pumping facilities."

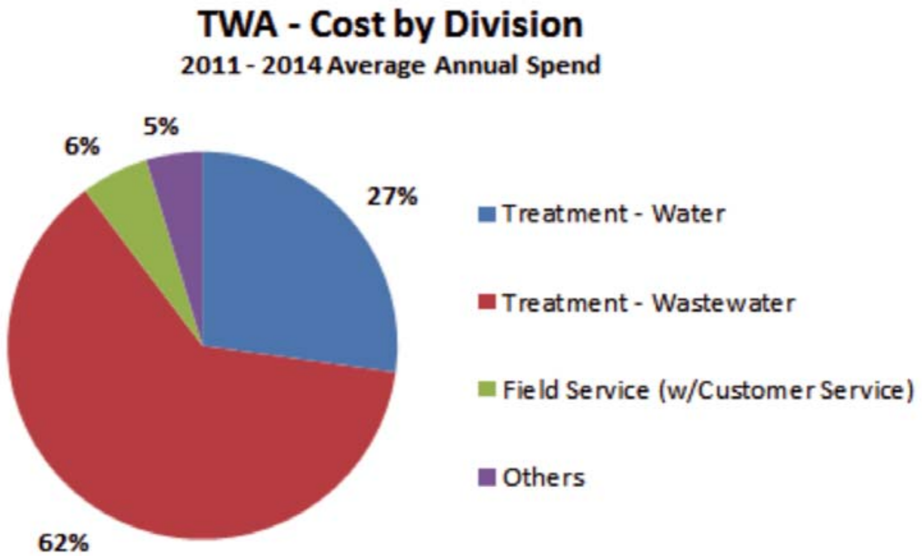

Figure 2

**Develop a Baseline of Energy Use**

It was revealing just how much data on energy use was available, yet how few people saw this information and how difficult it was to collect and represent this data in a meaningful manner. Pieces of energy-related information could be found in many systems, including accounts payable, financial, electric utility customer portal, and supervisory control and data acquisition (SCADA), but it was rarely accessed by those making the daily decisions that affect energy use.

To measure the effectiveness of actions taken to reduce energy consumption, it was critical that a baseline be established. This baseline would not only serve as a means to identify improvement opportunities, but would also measure the effectiveness of completed tasks, programs, and initiatives.

At the highest level, energy use is measured across TWA as the total dollars spent on energy (as illustrated in Figure 1). Stratifying this data across divisions, it was evident that the first area of concentration should be wastewater treatment, as it represents approximately 62 percent of the energy spent (Figure 2).

With wastewater treatment being the first area of focus, additional measures were adopted that were specific to this area. These measures provide a ratio of energy consumption to the flow and process effectiveness of each of the facilities:

- Unit electric use per water treated (kWh/MG) by process type
- Total water reclamation facility unit electric use per water treated (kWh/MG)
- Unit electric use per solids removed (kWh/lbVSSr)
- Unit electric use per biochemical oxygen demand (BOD) removed (kWh/lbBODr)

**Evaluate the System and Collect Data**

Adopting the premise that the greatest opportunity for savings exists where energy consumption is greatest; energy consumption across the wastewater treatment facilities and lift stations was evaluated. It was noted that 30 percent of the energy spent across these areas occurred at the SBWRF (Figure 3).

***South Bermuda Water Reclamation Facility Description***

The SBWRF is located in Kissimmee. It has a permitted capacity of 13 mil gal per day (mgd). The treatment processes consist of the following:

- Preliminary treatment, including mechanical bar screens.
- Primary clarification, which is the plant's vortex-type grit removal system.
- Secondary biological treatment through two anoxic/oxic/anoxic/oxic (AOAO) systems, followed by secondary clarification.
- Filtration with disk filters.
- Disinfection using chlorination.
- Effluent pumping for water reuse, irrigation, and aquifer recharge.
- Solids handling, consisting of mixed holding tanks, belt filter press dewatering, and sludge cake disposal to Florida N-Viro.

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The solids handling system also treats hauled sludge from the Parkway WRF and the Sandhill WRF, and the Harmony WRF, which is a smaller facility. The Cypress West WRF land-applied sludge until September 2012, after which time it started hauling sludge to the SBWRF. Sludge from the Camelot WRF is delivered by gravity to the head of the SBWRF for subsequent treatment and handling.

Treated effluent is pumped to two 3-mil-gal (MG) reclaimed water storage tanks. A portion of the effluent is then pumped by the reuse pumps to supply the Camelot WRF reuse system for irrigation of golf courses and subdivisions. The remaining portion (weather-related; on average, 50 percent on a yearly basis) of the effluent is pumped by the effluent pumps for use as irrigation, cooling water for power plants, supplement to the Camelot reclaimed system, and for the rapid infiltration basins (RIBs).

The site's major buildings consist of: operations, central control, laboratory, solids dewatering, chlorination, generation, and blowers (Building A). Other smaller buildings house the equipment motor control centers (Building B, Building C, MCC1/Compressor and MCC2). In addition to these buildings are the maintenance shop office building and the warehouse building, which are associated with different electrical meters than the main WRF system.

***The Audit Process***

The audit process consists of the following steps:

1. Initial data collection
2. Initial data review
3. Facility process walkthrough
4. Field data collection
5. Power consumption distribution
6. Follow-up field data verification
7. Document current situation/opportunities identification
8. Develop energy conservation measures (ECMs)

***Initial Data Collections***

Planning for an energy audit requires an understanding of current and historic electric cost, plant flows, influent/effluent properties, and equipment data.

Twenty-four months of power source billing were collected and reviewed. The specific information collected included the following attribute data for each billing cycle: start and end dates, days of service, electric billed usage (kWh), demand billed usage (kW), electric charge, demand charge, fuel adjustment, customer charge, total electrical charges, municipal utility tax and count utility tax, governmental transfers and taxes, and total charges.

Since multiple meters exist for this facility it was necessary to associate each of the meters with the supplied processes and equipment.

The solids processing performed by the facility must be identified so that it can be correlated to the power consumed. It is this correlation that will be used to measure the energy performance of the facility. The information collected should include the following: date, influent flow (mgd), effluent flow (mgd), reuse flow (mgd), influent BOD (mg/L), influent BOD (lb/d), effluent BOD (mg/L), effluent BOD (lb/d), BOD removed (lb/d), influent total suspended solid, or TSS (mg/L), influent TSS (lb/d), effluent TSS (mg/L), effluent TSS (lb/d),TSS removed (lb/L), influent total Kjehldahl nitrogen, orTKN (mg/L), influent TKN (lb/d) , effluent TKN (mg/L), effluent TKN (lb/d), and TKN removed (lb/d).

An inventory of all mechanical assets that are rated at 5 or more horsepower (HP) should be assembled from the Asset Registry. This inventory should identify the equipment and the operating configuration, including:

- Process – plant process that the equipment supports (i.e., pretreatment, activated sludge, clarifier, biosolids, effluent storage and pumping, reuse augmentation, and support)
- Description – asset description from Infor EAM
- Size (HP) – from Infor EAM or equipment name plate
- Variable Frequency Drive – installed?
- Usually Run (Yes/No) – in service?
- Typical Run Time/Day (hrs/d) – estimate
- Typical Run Day /Week – estimate
- Notes – any notes that explain how and when the equipment is sequenced or run

***Initial Data Review***

A review of the collected billing data was performed. This activity included a review of the energy provider's rate schedule options and confirmation that the correct rate schedule was being used for the facility. The potential applicability of alternative rate schedules was assessed based on the facilities historic demand (kW) and usage (kWh) data.

The Energy Use Assessment Tool (EUAT) was developed by the U.S. Environmental Protection Agency (EPA) to assist in associating the energy consumed by each asset at a facility and rolling up energy consumption levels with each of the plant processes. Trending graphs showing energy usage versus water treated and the breakout of energy usage by equipment are provided from this tool.

***Data Validation***

A "facility process walkthrough" is a tabletop exercise conducted by the members of the audit team to review the facility treatment processes and to verify that the equipment information provided during data collection is complete. A verbal walkthrough of each treatment process should be led by the operations

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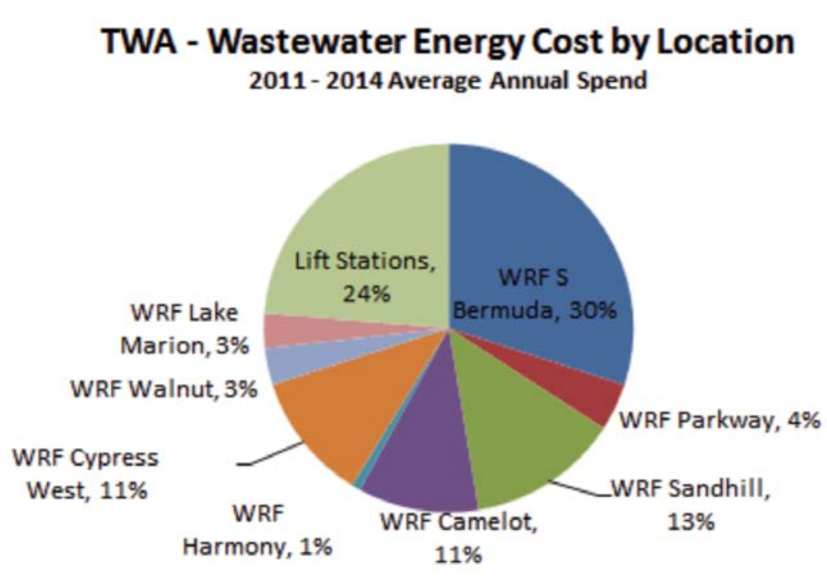


Figure 3

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supervisor. As a minimum, this discussion should cover the following areas:

- Any known deficiencies or inefficiencies with the process should be identified. These may include reliability, capacity, control, or obsolescence factors that dictate the effectiveness and/or efficiency of the process.
- Factors outside the control of TWA that impact how the facility must operate (such as influent quality or large variations in flow) should be identified. This conversation could provide insight into the facility's baseline energy usage.
- The major equipment that supports the process should be discussed. Any implemented prioritization, sequencing, or interlocking schemes should be identified. Equipment runtime should also be confirmed, particularly in process areas that represent a significant percentage of the total energy consumed at the facility (> 10 percent).

All remaining information necessary to conduct the energy audit is collected during a physical walkthrough of the facility:

- Building information, including size; hours of occupancy; lighting; and heating, ventilation, and air conditioning (HVAC) equipment is collected.
- Data on the outdoor lighting (not connected to a building) for the facility is collected. Quantity, wattage, and hours of operation should be collected.
- The list of major equipment is reconciled with what is actually in the field during this task. A multimeter should also be used to record the current draw for each piece of equipment, which may require that the equipment is cycled to collect the required data. When possible, current draw should be measured on each phase.
- The EUAT should be updated with the collected information from the field walkthrough. It will indicate the percentage of site electrical energy identified by the tool. Follow-up field verification is performed if the EUAT fails to account for at least 95 percent of the billed electricity. The output from this tool would be a stratification of the energy consumed by process (Figure 4).

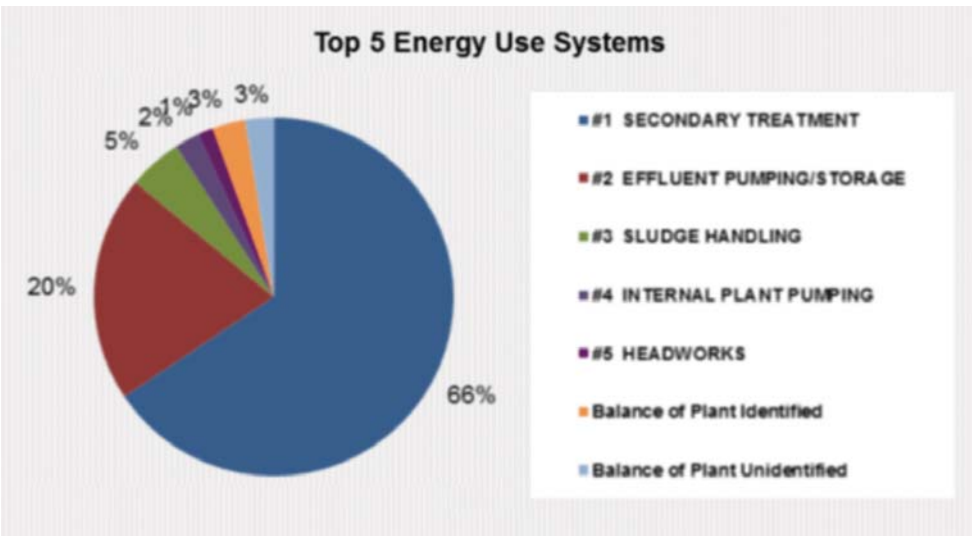


Figure 4


Figure 5

**Identify Energy Efficiency Opportunities**

At the completion of the physical facility walkthrough and the update of the EUAT, there should be an understanding of the current situation with respect to energy consumption at the audited facility. It is now possible to look deeper into each of the processes to obtain a better understanding of energy costs and the level of efficiency at the process level.

To identify the areas with the greatest opportunities for improvement, measurement against a standard or targeted performance is necessary. These ratios (kWh/MG) can be compared to the theoretical energy requirements by process, as published in the Water Environment Federation (WEF) Manual of Practice No. 32 (MOP 32). The manual presents estimates of electricity used in wastewater treatment for different types of wastewater treatment plants (WWTPs), including activated sludge WWTPs, advanced WWTPs without nitrification and advanced WWTPs with nitrification, and different treatment sizes in mgd: 1, 5, 10, 20, 50, and 100 mgd. Theoretical electricity requirements for a 10-mgd advanced WWTP with nitrification were used as the standard for the SBWRF assessment. A range of -10 percent to +25 percent should be included for comparison purposes to account for real conditions that might not be captured in the theoretical energy calculation included in MOP 32. The theoretical use of 10-mgd advanced WWTPs with nitrification is in the range of 1,791 to 2,239 kWh/MG (Figure 5).

The monthly variation in wire-to-water usage (kWh/MG) can be used to monitor the performance of the facility for a three-year period for internal benchmarking.

A different unit energy use indicator can be calculated to compare the energy use for solids treatment obtaining the same level of sludge stabilization. This is obtained by adding the total kWh use of the typical sludge process systems for the plant and dividing by the pounds of volatile solids removed (lbVSSr). Applying the same method as described, a typical secondary WWTP treating 10 mgd would be expected to use between 0.35 kWh/lbVSSr and 0.5 kWh/lbVSSr.

Electricity use for wastewater treatment processes, in addition to volume of treated water, is also dependent on the wastewater quality to be treated and the removal required by the effluent limits. This can be measured by the pounds of BOD5 removed (lb BODr) as the difference between the influent and effluent BOD5 loadings. The key performance indicator that normalizes the energy use to the process removal is the wire-to-process usage, or the daily kWh used per pounds of BOD5 removed (kWh/lbBODr). A typical 10-mgd secondary WWTP uses between 1.0 and 1.4 kWh/lbBODr.

It is important to note that when comparing to a theoretical facility, differences in the operating parameters assumed in the model and present at the physical plant need to be understood and quantified. Specific examples for the SBWRF include: additional biological loading received through the wet stream from TWA's Camelot WRF, effluent pumping to aquifer recharge and customer irrigation, and biosolids dewatering from multiple locations handled at this site. These three areas represent an estimated 862 kWh/MG, reducing the facility ratio by 25 percent.

The ECMs are developed for those areas where measured performance fails to meet the targeted level. An ECM decision tree was developed to provide a consistent methodology to determine whether ECMs should focus on equipment or process (Figure 6).

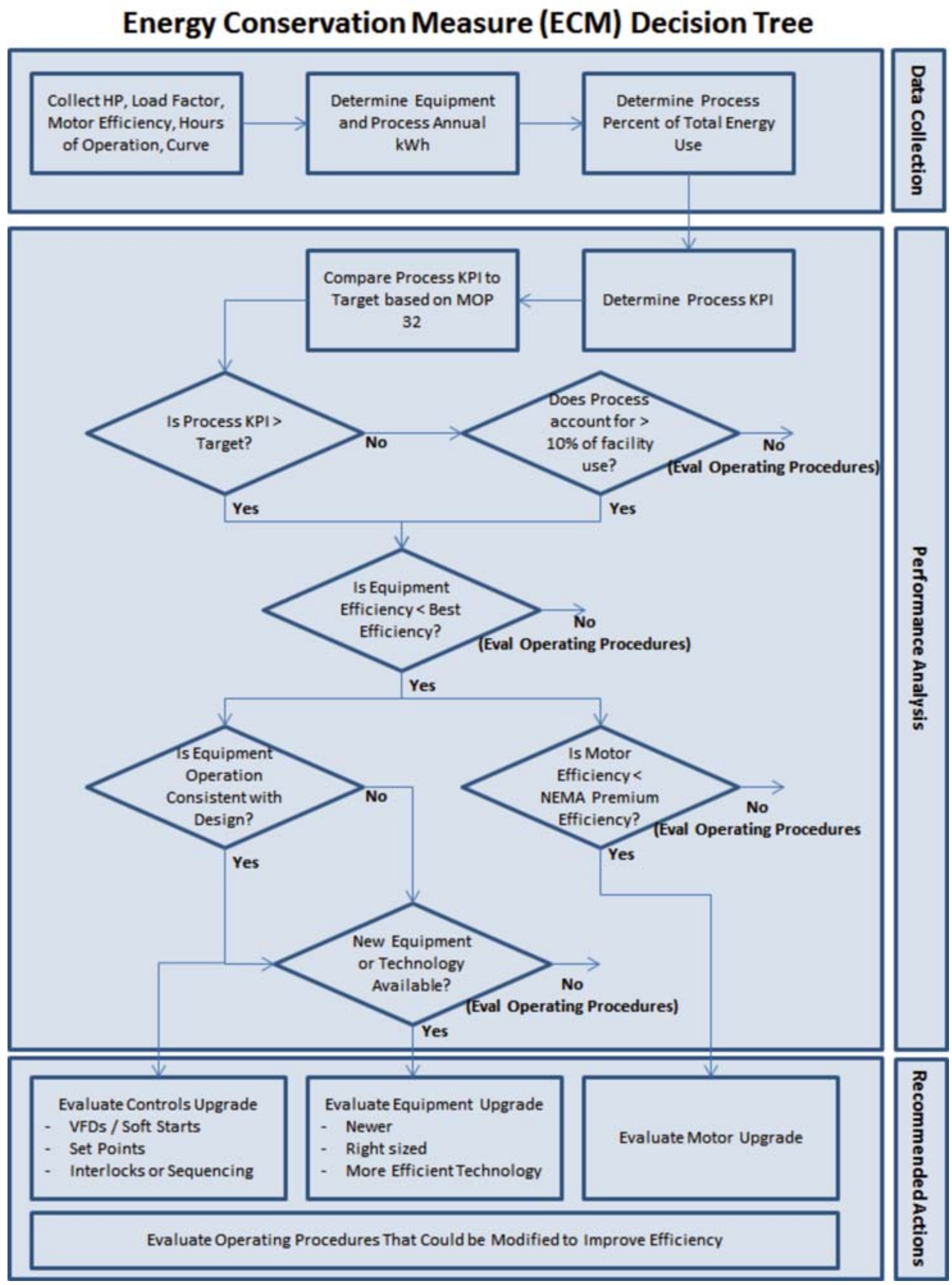

Figure 6

**Prioritize Opportunities for Implementation**

The ECMs are developed for those areas that represent the greatest opportunity for savings. Where available, the theoretical targets will be used to identify the importance or criticality associated with the ECM as follows:

- Tier 1 – equipment supporting processes performing less efficiently then the upper limit (theoretical + 25 percent)
- Tier 2 – equipment supporting processes performing less efficiently then the theoretical target but better than the upper limit (theoretical + 25 percent)
- Tier 3 – equipment supporting processes performing better than the theoretical target and staff feels that additional efficiency is possible

Tiers 1-3 represent an attempt to identify the magnitude of the potential savings. The go/no-go decisions for any ECM will be based on the merits of the business case developed to support it. The standard capital improvement program business case prioritization process will be used to compete for available funding. The prioritization process will rely on ranked scores, including condition, strategy alignment, financial, social, and environment, accompanied with an adequate description of the project, justification, funding requirements, alternatives, and a summary of the financial analysis.

**Develop an Implementation Plan and Provide for Progress Tracking and Reporting**

***Address People Issues (Knowledge and Motivation)***

Key issues here include communications, training, and providing useful data to staff. Progress has been made to develop an information portal on TWA's Intranet to communicate program detail, current initiatives (along with status), performance measures, and standard operating procedures.

A project to integrate power meter informa-

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tion for major equipment and an energy dashboard into SCADA for SBWRF has been initiated. This will deliver real-time data and alarms to the operators to assist with equipment actuation decisions.

An innovation rewards program has been implemented that will allow employees to actively participate in developing efficiency improvement recommendations and share in realized savings. This was viewed as an important component to securing buy-in from staff.

***Address Process (Change Work Practices or Plant Procedures) and Equipment (Inefficient or Miss-Sized Equipment) Issues***

Use of the ECM decision tree will assist in pointing out where work practices or standard procedures need to be evaluated for change. The SBWRF energy audit resulted in 26 ECMs; 13 of them were recommended for consideration by ARCADIS.

- The SBWRF is currently undergoing projects to replace the fine bubble diffusers in the AOAO tank and rehabilitate the secondary clarifier structures. The ECMs that tie to these process areas have been place on hold for more evaluation after these projects have been completed.
- A study was initiated by TWA to perform a biosolids treatment methods evaluation. All ECMs tied to biosolids handling, treatment, and disposal have been placed on hold pending reevaluation after this study is completed.

The remaining ECMs have been submitted for consideration as part of the capital improvement program process.

***Plan and Schedule***

The following list identifies the energy initiatives currently planned for TWA. This list includes initiatives that represent further development of the energy management program, as well as actions taken in response to the SBWRF energy audit.

- Publish energy management program information portal on TWA's Intranet – 2Q14
- Standard operating procedure (SOP) tracking energy use, SOP performing energy audits – 1Q14
- SBWRF rehabilitation projects underway – 2Q16 completion
- Biosolids treatment methods evaluation underway – 4Q14 (completion)
- SBWRF ECMs
  - Replace denitrification mixers – 4Q14
  - Install variable frequency drives (VFDs) on reclaim transfer pumps – 4Q14
  - Major equipment submetering and SCADA modification – 1Q15
- Interlock/sequence large equipment – 4Q15
- Perform additional WRF energy audits (Sandhill, Camelot, Cypress West) – 4Q14 (completion)
- Demand Reduction Initiatives
  - Distribution system leak detection – 3Q15 (pilot)
  - Gravity sewer inflow and infiltration reduction – ongoing program
  - Manifold force main head pressure analysis – 4Q15
  - Water treatment plant (WTP) and distribution system pressure optimization – 4Q16