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Improving energetically operational procedures in wastewater treatment plants

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ABSTRACT

Water and wastewater systems are important energy consumers with an evaluated 3%-4% of total U.S. electricity consumption employed for the movement and treatment of water and wastewater. Water-energy problems are of increasing significance in the case of water shortages, more elevated energy and material costs, and a varying climate. In this economic context, it is vital for utilities to manage performances, both in water and energy utilization. Carrying out energy audits (EAs) at water and wastewater treatment facilities is one method community energy managers may recognize favorable occasions to save water, energy and money. In this review, the significance of energy utilization in wastewater facilities is shown by a case study of a process EA performed for Crested Butte, Colorado's wastewater treatment plant. The EA detected favorable occasions for crucial energy savings (ESs) by examining power intensive unit processes like influent pumping, aeration, ultraviolet disinfection, and solids handling. This case study shows best practices that may be easily applied by facility managers in their search for energy and financial savings in water and wastewater treatment. This article aims to ameliorate community energy managers' comprehension of the action that the water and wastewater sector performs in a community's total energy consumption. The energy efficiency roadmaps defined give information on ESs favorable occasions, which may be employed as a fundamental concept for treating energy management objectives with water and wastewater treatment facility managers.

1. Introduction

Water and wastewater systems are important energy consumers. An evaluated 3%-4% of U.S. electricity consumption is utilized for the movement and treatment of water and wastewater (EPRI, 2002; Galbraith, 2011; EPA, 2013). The correct cost of energy utilization may change largely from one utility to the next, with evaluations oscillating from 2%-60% of total operating costs (Carlson and Walburger, 2007; Elliot et al., 2003). Energy constitutes a crucial cost to wastewater utilities, as it is fundamentally needed for all steps in the treatment process, from the collection of raw sewage to the discharge of treated effluent. Knowing that water and wastewater treatment plants (WWTPs) are not firstly conceived and manipulated with energy efficiency as a main worry, these systems risk to be overlooked when communities fund energy improvement projects (Daw et al., 2012; Fishbein, 2014; Scanlon et al., 2013; Whited et al., 2013; Shrivastava et al., 2015; Sharma and Chopra, 2013; Stoddard et al., 2003).

Nevertheless, crucial energy and financial savings may be not recuperated upon operational modifications and capital ameliorations at water and wastewater utilities (Daw et al., 2012; Fishbein, 2014; Alexander et al., 2014; Russell, 2006). Operators and managers of water and wastewater facilities have a large interval of priorities, of which energy consumption is only a part. Some of their primary duties are listed in Table 1 (Daw et al., 2012).

Allotting time to perform an energy audit (EA) and conduct the required physical and operational modifications may generate crucial benefits. EAs give assistance to recognize the biggest energy-consumers at a facility, divulge chances for

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operational enhancements, and discover problems with aging and underperforming equipment. The outcomes of an audit may aid to ameliorate energy efficiency, which constitutes an occasion for municipalities to decrease operating costs and effects on both the nature and the surrounding community (Daw et al., 2012; Fishbein, 2014; Shrivastava et al., 2015; DOE, 2014).

Table 1: Primary duties of operators and managers of water/wastewater facilities (Daw et al., 2012)

Four essential priorities of operators of water/wastewater facilities	
Priority #1	Obeying regulatory requirements to satisfy customer, public health, and ecological requests.
Priority #2	Supplying dependable service at reasonable and predictable rates.
Priority #3	Stabilizing repair and replacement requirements with long-term debt, equipment condition, on-going operations and maintenance costs, and revenue.
Priority #4	Optimizing operations and maintenance to decrease costs and make sure longevity of assets.

2. Water and energy

The overlap between energy and water is known as the energy-water nexus. Water resources depend on energy, and vice versa (Pereira, 2014). Water and energy cannot be conceived individually if the target is the sustainability of the water cycle (Hofman et al., 2011; Sankaranarayanan et al., 2010). Energy can consider for 60-80% of water transportation and treatment costs and up to 14% of total water utility costs. Following the United Nations World Water Assessment Program (WWAP, 2009), the world will require almost 60% more energy in 2030 than in 2020 and renewable-energy resources alone are not enough to satisfy that need. Electricity is needed for potable water production and also for wastewater treatment (Oneby et al., 2010; Moreno et al., 2013; Tran et al., 2012; Liu et al., 2012; Wiesmann et al., 2006). Energy consumption is a main contributor to the operation cost of wastewater systems (Nelson, 2008). The costs for energy frequently quantify up to 10-30% of the total operation costs. Actually, electricity is the biggest non-staff operating cost item for companies involved in water management. In addition, water and wastewater treatment (Leentvaar et al., 1978; Ma et al., 2013; Sawa et al., 1980; Kalloum et al., 2011; Beltrán-Heredia and Sánchez-Martín, 2009; Brepols et al., 2008; Hutnan et al., 2006) can consider for more than half of the electricity bills of many municipalities (Elliott, 2005; Nemerow et al., 2014). Aeration is the main contributor and can account for approximately 60% of the energy used for wastewater treatment (Fig. 1).

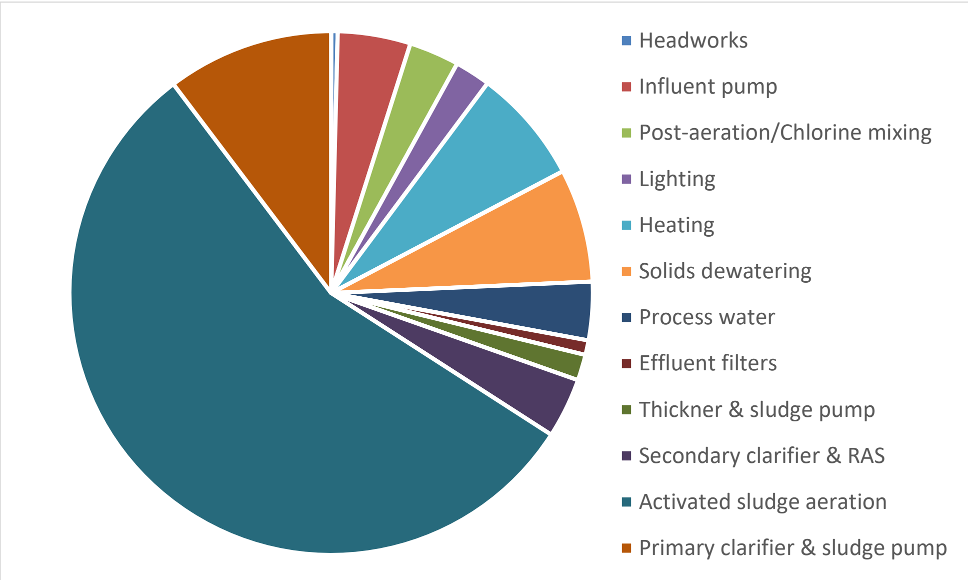

Fig. 1: Energy usage in biological treatment systems in WWTPs (Pereira, 2014)

3. Case study: Crested butte

The town of Crested Butte (U.S.A.) was asked to carry out a process EA of its WWTP. The EA concentrated on easily executable occasions for energy decrease upon process change and operational enhancements. The audit examined optimization of existing processes to attain ameliorated control, monitoring, and WWTP effluent quality. The audit also aided the town start tracking and benchmarking its WWTP energy utilization (Daw et al., 2012).

3.1. Crested butte's WWTP

Crested Butte is a small town located on the Western Slope of Colorado and is a major tourist destination for outdoor sports. The WWTP, constructed in 1997, serves the town, which has a permanent population of 1,500 people. The WWTP treats wastewater from residential and commercial customers, with no important industrial discharges to the plant. The plant also receives solids from the Mt. Crested Butte Water and Sanitation District (Daw et al., 2012).

The town possesses an oxidation ditch WWTP, with a permitted capacity of 0.6 million gallons per day (MGD) for a 30-day average daily flow. The plant consists of grit removal, influent pumping, aeration, clarification, ultraviolet (UV) disinfection, and solids handling processes. Treated effluent from the plant discharges to the Slate River. Sludge is thickened and dewatered on-site and hauled to a local landfill for disposal. A simplified process flow diagram for the plant is shown in Fig. 2 (Daw et al., 2012).

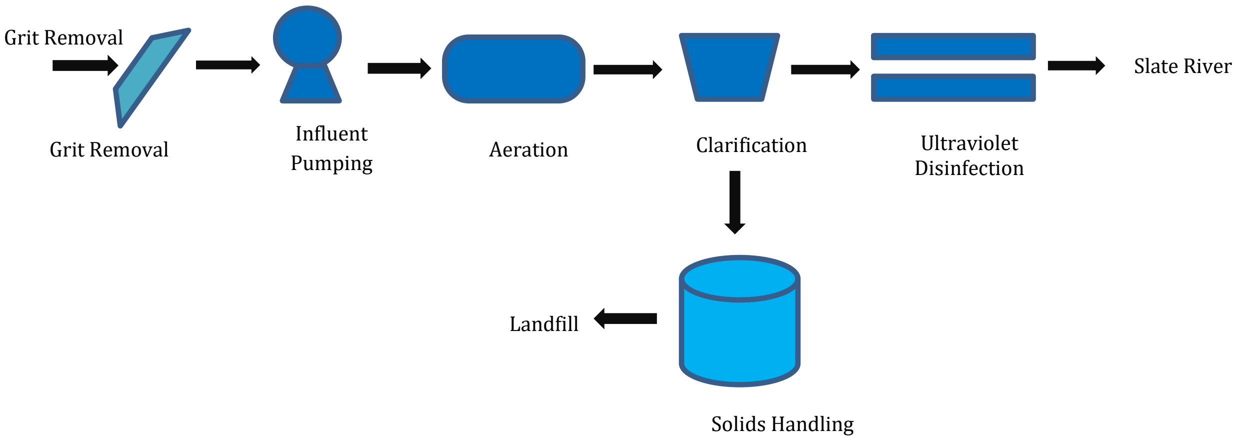

Fig. 2: Crested Butte's WWTP process flow diagram (Daw et al., 2012)

3.2. EA

An EA of the treatment process was needed. While not comprised in this study, building EAs, which assess lighting, heating, cooling, and ventilation systems, may as well generate crucial financial and energy savings (ESs) in treatment facilities (Daw et al., 2012).

There are three levels of EAs defined by the American Society for Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). These audit levels vary following level of complexity, depth of analyses, and the degree of detail the audit may supply. Audits, as shown in Table 2, range from Level #1 (a walkthrough) to Level #3 (computer modeling) (Daw et al., 2012).

Table 2: EA levels (ASHRAE, 2011)

EA levels	
Level #1	Walkthrough assessment
Level #2	Energy survey and analysis
Level #3	Detailed analysis/modeling

For Crested Butte, a Level #1 audit was carried out, which comprised a plant walkthrough concentrated on treatment process energy utilization. The Level #1 audit (Daw et al., 2012):

- Estimates energy consumption and efficiency upon an on-site investigation to recognize maintenance and/or operational requirements and deficient equipment,
- Employs energy consumption information to comprehend usage patterns and to establish an energy baseline,
- Evaluates energy and cost savings with a focus on low or no-cost measures.

3.3. Collecting data

The process EA was started by assembling data from drawings, operational records, utility bills, and equipment inventories to establish a comprehending of plant energy use patterns. The evaluation team consulted drawings to detect any operational or energy problems that may be linked to the physical layout of the plant. As an illustration, the drawings revealed that the present dissolved oxygen (DO) meter was placed in the anoxic zone of the oxidation ditch. This configuration does not detect an ideal feedback for oxygen control or oxidation ditch efficiency. It is usually more performing to place this measurement instrument where DO levels are bigger than zero, like near the effluent of the ditch (Daw et al., 2012).

Operational records and parameters, like Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS), were utilized to differentiate patterns in raw water quality and WWTP performance (Grady Jr et al., 1999; Sincero and Sincero, 2002). Plant operational data were employed to distinguish three "operating seasons" with different raw water situations. These seasons show variations in temporary population and infiltration observed in the collection system across the year. The conditions linked to the three seasons are listed in Table 3 (Daw et al., 2012).

Table 3: Distinguished three "operating seasons" with different raw water cases (Daw et al., 2012)

Three "operating seasons" with different raw water conditions	
Season #1 (October – March)	Low flow, low load (BOD, TSS on a pound per day basis), and low wastewater temperature.
Season #2 (April – June)	High flow, average load, and low wastewater temperature.
Season #3 (July – September)	Average flow, high load, and higher wastewater temperature.

Equipment inventories were examined to evaluate the age and horsepower of plant equipment and to define great energy consumers within the facility. A shortened list of important energy consumers in the town's WWTP, with their typical operations and controls, are given in Table 4. This information was employed to concentrate audit endeavours on important energy consuming processes inside the plant to maximize ESs occasions (Daw et al., 2012).

3.4. Existing process performance

Each process was discussed in detail with plant operations staff to understand performance trends and concerns. General observations on the WWTP's process performance and operational strategies are described as follows (Daw et al., 2012):

Influent pumping/Headworks

The influent system consists of three pumps: one 4.7 horsepower (HP) pump (Pump No. 1), two 17.5 HP pumps (Pumps No. 2 and No. 3). Pump No. 2 runs continuously based on level detection in the wet well. All pumps have Variable Frequency Drives (VFDs).

Aeration/oxidation ditch

The town's WWTP has one oxidation ditch that provides aerobic removal of BOD and ammonia. There is an anoxic portion of the ditch that provides DE nitrification, recovers alkalinity, and reduces oxygen demand. The ditch has one 75 HP aerator running on a VFD that is operated based on manual adjustment from a daily DO concentration reading. Typically, ESs from VFDs comes from adjustments that are made automatically to adapt to system conditions, not manual adjustments. The ditch also has two continuously operated mixers in the anoxic zone. The existing DO meter located in the anoxic zone is not operational.

Clarification

The WWTP has two clarifiers, one that operates continuously and a supplemental clarifier for high flow events.

Ultraviolet disinfection

The UV system was designed for a plant flow rate of 1.3 MGD (double the permitted capacity of the facility). The system currently operates with both banks on-line. The Plant staff changes UV system lamps once a year for preventative maintenance. Since 2008, the average effluent fecal coliform concentration has been 8.3 counts/100 millilitres (mL) with a 7-day average of 214.3 counts/100 mL. The permitted effluent Escherichia Coli (a part of the group fecal coliform) concentration is 1372 counts/100 mL (30-day average) and 2,744 counts/100 mL (7-day average). The current operational approach results in effluent fecal coliform levels that are significantly below permit requirements.

Solids handling

The WWTP has an Autothermal Thermophilic Aerobic Digestion (ATAD) system, which is not operational due to odor problems. Therefore, sludge is currently thickened in the raw sludge storage tank and transferred to the thickened sludge storage tank for holding. Due to existing plant piping configurations, sludge must be pumped from the thickened sludge storage tank to the ATAD holding tank to reach the centrifuge for dewatering. Although this allows for additional storage, and therefore potentially less frequent trips to the landfill, it also requires that the 15 HP blowers associated with the ATAD storage tank remain operational. The 40 HP centrifuge is controlled by VFD, but typically runs at a constant speed. The centrifuge fills a 20 cubic yard dumpster once a week. Centrate from the centrifuge is piped to the oxidation ditch, which may affect performance of the oxidation process.

3.5. Plant walkthrough

Employing this working vision, the evaluation team visited the WWTP to realize a Level #1 plant walkthrough. This determined attempt was composed of visual inspections to define working or maintenance problems and the gathering of energy data from main plant equipment. These data will be employed by the town to develop evaluated cost savings linked to operations and maintenance (O&M) and to prioritize capital enhancements to the facility (Daw et al., 2012).

During the audit, measuring actual power draw for main equipment, comprising sludge transfer pumps and blowers, which were rotated into operation for 15-minute increments to record real power usage, was performed (Fig. 3).

Table 4: Crested Butte WWTP: Important energy consumers (Daw et al., 2012)

Equipment	Quantity	Horsepower	Operations	Controls
Mechanical Aerator	1	75	Continuous	Variable Frequency Drive (VFD),manual adjustment
Centrifuge	1	40	10-20 hrs/week	VFD, fixed speed
Influent Pump (No. 1)	2	4.7	Continuous	VFD, speed based on flow
Influent Pumps (No. 2 and 3)	2	17.5	Pump No. 2 continuous Pump No. 3 back-up	VFD, speed based on flow VFD, speed based on flow
Blowers	3	15	Intermittent	Fixed speed
Mixers	3	4	Continuous	Fixed speed
UV System	2 banks	7.3 (kW)	Continuous	Fixed, 2 banks

Employing a consistent time range to measure power draw lets enough time for power consumption related to equipment start-up to level out. These data will be examined by the town to help make prioritizations for amelioration (Daw et al., 2012).

During the audit, DO concentrations were measured in the oxidation ditch to determine aeration effectiveness (Fig. 4). These concentrations created a DO profile that was used to better understand plant operations (Daw et al., 2012).

Fig. 3: Collecting UV system power draw data (Daw et al., 2012)

Fig. 4: Measuring DO profile (Daw et al., 2012)

A BioWin(TM) model was established for the plant utilizing influent characteristics, temperature, historical DO concentrations, typical aerator speeds, and the measured DO profile. Employing this process model, the evaluation team proved that the present aerator, which is 15 years old, had poorer transfer efficiency comparatively with newer aerators – implying more energy is utilized to drive the aerator than would be predicted for the resulting DO levels (Daw et al., 2012).

3.6. Primary opportunities for ESs

Following the plant working information and data gathered across the audit, the evaluation team established ESs recommendations for the WWTP (Daw et al., 2012).

3.6.1. Influent pumping/headworks

Flow data supplied for the WWTP shows that infiltration and inflow (I&I) is problematic during Season #2 (April – June). To alleviate these problems, it is useful to define grave I&I areas in the gathering system generated by leaks and breaks. This information will assist in prioritizing works to repair or replace system piping (Daw et al., 2012).

An additional best practice for Crested Butte's WWTP is to orient the working strategy for the headworks to satisfy the three different seasons mentioned above (Table 3). Utilizing smaller horsepower equipment, like Pump No. 1, to the extent possible, may decrease on-going energy consumption. Following typical daily flow patterns, Pump No. 1 can address nightly and mid-day low flow periods in Season #1 (October – March) and nightly low flow periods in Season #3 (July – September). Since Pump No. 1 age, the town must think about substituting it with a slightly higher capacity pump controlled by VFD to address wet well fluctuations. This augmented capacity and enhanced controls would expand the pump's works during lower flow periods and minimize utilization of the higher horsepower pumps (Daw et al., 2012).

3.6.2. Aeration/oxidation ditch

The DO levels determined in the oxidation ditch, in concert with other operational data, mentioned that the aerator was not working efficiently (Fig. 5). Knowing that this is the biggest horsepower motor at the WWTP, and that the aerator is nearing the end of its useful life, the evaluation team recommends substituting it with a more energy-efficient model. The WWTP may also examine installing a new DO meter and/or ammonia sensor near the ditch outfall to give more helpful feedback on ditch performance. Connecting this meter to the plant supervisory control and data acquisition (SCADA) system will allow for continuous monitoring and control of DO levels. Additional ESs can be attained if these DO readings are employed to automatically control the speed of the aerator. As a best practice, the mixers are recommended to only be utilized when the aerator is not functioning, which will further decrease the energy usage of this process (Daw et al., 2012).

3.6.3. Ultraviolet disinfection

Actual operations of the UV system are consistent with the ultimate design flow rate, 1.3 MGD. With a current maximum working flow rate of 0.6 MGD (less than half of the design flow rate of the UV system); the WWTP is surpassing permit requirements. Consequently, the evaluation team recommends that the WWTP work only one bank of the UV system instead of both banks. As the system was conceived to treat importantly more wastewater than the WWTP actually receives, the facility may as well function with the manufacturer to significantly change the system to save energy by eliminating bulbs and retrofitting or de-energizing some of the ballasts. Connecting the UV system to SCADA would also enhance the control of performance (Daw et al., 2012).

Fig. 5: Mechanical aerator in oxidation ditch (Daw et al., 2012)

The WWTP can as well think about substituting UV system lamps less usually – the manufacturer recommends that bulbs be substituted after 13,500 hours of function or every 1.5 years. Actual working practices are to substitute bulbs as part of scheduled annual maintenance, regardless of running hours. Augmenting the bulb substitution range will save material costs and waste related to functioning of the plant (Daw et al., 2012).

3.6.4. Solids handling

The actual solids treating process is functioning inefficiently because of the usage of present ATAD system piping to attain the centrifuge for dewatering. When the ATAD system becomes working, once more, this inefficiency will ameliorate. Nevertheless, the WWTP may also think about making piping retrofits to let sludge to move directly from the thickened sludge tank to the centrifuge, bypassing the ATAD system. This modification would remove transfer pumping within the solids treating system (Daw et al., 2012).

One of the main products of a WWTP is sewage sludge or biosolids (EPA, 2009). Until two or three decades ago, the typical procedure for WWTPs in Region 8 was to dispose of biosolids via landfill or incineration. These days, nevertheless, more facilities put biosolids to beneficial reuse and 85% of the biosolids formed in Region 8 are now recycled (EPA, 2011). Most usually, biosolids are employed as a soil amendment to fertilize agricultural land or to restore soils on reclaimed land (Daw et al., 2012; Spellman, 2014; 2013).

Crested Butte's WWTP may also want to think about examining the energy needs that are required to treat its biosolids in order to divert them from the landfill for beneficial uses such as fertilizer for agriculture. During the time that more energy is needed to treat solids to a Class A or B standard (EPA, 2011), it could also decrease vehicle miles to haul the material to the landfill, alleviate some of the long-term environmental burden of landfill disposal, and decrease greenhouse gas emissions linked to landfilled sludge (Daw et al., 2012).

3.6.5. Reducing influent flow

Pinpointing areas in the collection system with I&I issues may assist the WWTP in concentrating on repair and replacement actions. Infiltration of groundwater may be a main contributor to the WWTP influent flow. Regular cleaning, inspection, and slip lining of collection system piping may importantly mitigate infiltration and decrease the quantity of wastewater being handled (Daw et al., 2012).

3.6.6. Community support

An effective community-wide conservation program is an additional important element in decreasing WWTP plant inflow. Cooperating with the community to enhance conservation awareness and to take actions such as installing water efficient fixtures, may greatly decrease flows at the WWTP and save energy (Daw et al., 2012).

Recommendations and evaluated energy and annual financial savings are illustrated in Table 5. These recommendations have been divided into: (1) short-term opportunities, which are lower cost and more easily implementable; and (2) long-term opportunities, which would need more planning and capital expenditure. As presented in Table 5, the aeration process offers the largest opportunities for energy and financial savings for the town of Crested Butte (Daw et al., 2012).

3.7. Next steps for crested butte

As a following move, the town will moreover evaluate ESs linked to the recommended enhancements and start work on their Energy

Management Plan. The Energy Management Plan will establish the objectives and targets to be utilized to quantify the town's progress in energy decrease and will guide the town's capital enhancement actions as well as plant O&M activities. More information on how this information will be utilized can be found in the EPA's Guidebook (EPA, 2008).

Crested Butte's WWTP will also employ its energy data to benchmark operational performance against other WWTPs, with the EPA Portfolio Manager. Portfolio Manager is a tool that may assist the town to identify more opportunities for performance improvement and prioritize investments (Daw et al., 2012).

Table 5: ESs recommendations (Daw et al., 2012)

Process	Recommendations	Savings (kWh - % energy - $/year)
Influent	Use Pump No. 1 during low flow (ST)*	4,300 – 10% - $150
Pumping/Headworks	Conduct IandI study (LT)**	14,000 – 35% - $550
Aeration/Oxidation	Replace Pump No. 1 (LT)	8,700 – 20% - $350
	Turn mixers off when aerator operates (ST)	45,900 – 90% - $1,750
Ditch	Replace DO meter (ST) Connect new DO meter to SCADA/ Replace aerator (LT)	19,800 – 10% - $750 123,000 – 40% - $4,700
UV Disinfection	Remove one UV bank from service/ Determine if bulbs can be removed	32,000 – 50% - $1,200
Solids Handling	Retrofit piping to feed sludge directly from thickened sludge tank to centrifuge (LT)	23,500 – 100% - $1,000

*ST = short-term; **LT = long-term

4. Future strategies

The Crested Butte instance survey is a good illustration of how performing an EA may enhance a facility or community energy manager comprehends of ESs occasions at water and wastewater facilities. The next sections give a brief overview of many general ESs strategies.

Facility and community energy managers alike may want to think about how these ESs strategies (Table 6) could be selected at their community's water and wastewater treatment facilities. Operators or managers who are apt to establish and apply a comprehensive energy management plan, and readers who are interested in step-by-step guidance, can get started with EPA's ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities (Sankaranarayanan et al., 2010; EPA, 2008).

Table 6: Energy efficiency strategies for municipal WWTPs (Daw et al., 2012)

Focus efforts for ESs	
Strategy #1 – Process energy	Focus on biggest energy consumers at WWTP.
Strategy #2 – Operational controls	Tailor operations to meet seasonal and diurnal changes.
Strategy #3 - Quality vs. energy	Balance water quality goals with energy needs.
Strategy #4 - Repair and replacement	Consider equipment life and energy usage to guide repair and replacement.
Strategy #5 – Biosolids	Consider tradeoffs between treatment energy and improved biosolids quality.
Strategy #6 - Infiltration/inflow	Address IandI to reduce treatment energy.
Strategy #7 - Leaks and breaks	Address leaks and breaks to reduce pumping energy.
Strategy #8 - On-site renewable energy	Consider opportunities for on-site generation to reduce energy purchases
Strategy #9 – Conservation	Educate the community: Less water reduces WWTP loads and energy needs.

Daw et al. (2012) concluded that the Crested Butte example survey illustrates the significance of EAs in supplying community energy managers with the capacity to identify and apply ES opportunities at their facilities. Working to ameliorate the comprehension of energy patterns and efficiency opportunities is a best practice that all communities can follow. By tracking energy usage, benchmarking, and making operational improvements, all communities can start their efforts to decrease energy usage and perform financial savings.

5. Energy or fuel generations from wastewaters

In the same orientation of this review paper, from wastewaters energy or fuel may be as well generated. This interesting technico-economical aspect of treating wastewater would attract municipalities to more focusing on wastewater treatment industry. Indeed, ethanol is nowadays being utilized in gasoline blends and fuel for specifically designed automobile engines. Ethanol can be generated from food and agricultural wastewaters as long as there are sufficient amounts of sugar or starch present (Liu, 2008). The fermentation-formed ethanol has a relatively low ethanol tenor, which must be enriched to 95% or higher for utilized as fuels for internal combustion engines. A combination of distillation and pervaporation will generate almost 100% pure ethanol (Peng et al., 2003).

Biogas from anaerobic processes, such as anaerobic sludge digesters or anaerobic reactors for decreasing high-strength wastewaters, has been popular and used to some degree on a small scale. Nevertheless, the enthusiasm for its energy production capacity has never lasted very long, as people soon realize the costs linked to enriching methane gas from biogas, and the collection and transportation of this gas in such small quantities (Liu, 2008).

On the other hand, landfills generate biogas naturally under anaerobic conditions; however, this gas has attracted little serious notice until recently, as groups interested in the biogas from landfills have shared little common ground with one another. Those anxious about global warming have been concerned about the fact that methane and CO_2 comprise of the majority of biogas from landfills, while entrepreneurs have seen the same biogas as "diamond in the rough" – part of a new "green revolution" that will usher in a green economy (Liu, 2008).

6. Evaluating overall costs of wastewater treatment processes

Overall costs of wastewater treatment processes with substance/energy recovery in a treatment facility are the sum of capital costs and operating costs, minus sale price or savings of recovered substances and/or energy. Nevertheless, forecasting cost savings as a consequence of recovered substances and/or energy is not easy. Whether a new product or energy from wastewater treatment facility will be accepted in the marketplace depends on several factors, comprising any extra costs of generating the product, properties of the product, environmental effect, public acceptance, and governmental subsidies (Liu, 2008).

A supplementary hurdle to forecasting the fate of a recovered product from food and agricultural wastewater treatment process is that price and/or availability of the competing alternative to the recycled product is as well varying constantly. This makes any meaningful long-term forecasting of economic benefits of energy/substance recovery from wastes contentious. Biofuel is a case in point; if the petroleum oil price in the world market goes through the roof, or there is a widespread shortage of petroleum products due to catastrophes or wars in oil-producing nations or regions, then biofuel will be very competitive in price (Liu, 2008).

7. Conclusion

The main points drawn from this review are listed as below:

1. Allotting time to perform an EA and conduct the required physical and operational modifications may generate crucial benefits. EAs give assistance to recognize the biggest energy-consumers at a facility, divulge chances for operational enhancements, and discover problems with aging and underperforming equipment. The outcomes of an audit may aid to ameliorate energy efficiency, which constitutes an occasion for municipalities to decrease operating costs and effects on both the nature and the surrounding community.
2. The significance of EAs in supplying community energy managers with the capacity to identify and apply ES opportunities at their facilities is established. Working to ameliorate the comprehension of energy patterns and efficiency opportunities is a best practice that all communities can follow. By tracking energy usage, benchmarking, and making operational improvements, all communities can start their efforts to decrease energy usage and perform financial savings.
3. From wastewaters, energy or fuel may be as well generated. Ethanol is nowadays being utilized in gasoline blends and fuel for specifically designed automobile engines. Ethanol can be generated from food and agricultural wastewaters as long as there are sufficient amounts of sugar or starch present. Biogas from anaerobic processes, such as anaerobic sludge digesters or anaerobic reactors for decreasing high-strength wastewaters, has been popular and used to some degree on a small scale. Nevertheless, the enthusiasm for its energy production capacity has never lasted very long, as people soon realize the costs linked to enriching methane gas from biogas, and the collection and transportation of this gas in such small quantities.

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