Saving energy and cutting water treatment costs on the US-Mexico border

The Border Environment Cooperation Commission has become a key promoter of efforts to reduce water utility energy costs in the US-Mexico border region. **ROBERT LONERGAN, ROBERTO MOLINA, RENATA MANNING-GBOGBO, FRANK BRACAMONTE** and **GEORGE HUNTER** look at how energy auditing of treatment facilities can help identify opportunities to make cost savings.

Aerial shot of the US-Mexico border with the Mexican city of Agua Prieta at the top and the US city of Douglas at the bottom. Douglas was chosen to receive technical assistance funding to support the development of its wastewater infrastructure. Credit: Frontpage / Shutterstock.

Water and wastewater treatment and distribution systems account for an estimated 75 billion kilowatt-hours (kWh) of overall US electricity demand (EPA, 2008). In addition, around 4% of the nation's electricity use goes into moving and treating water and wastewater, and electricity accounts for approximately 80% of municipal water processing and distribution costs (Goldstein and Smith, 2002).

Generating electricity requires the burning of fossil fuels: in the US, electricity generation accounts for 35% of all emissions of carbon dioxide (a major contributor to global warming and climatic change), 75% of sulphur dioxide (a respiratory irritant and a component of acid rain), and 38% of nitrogen oxides (a contributor to smog and component of acid rain) (Arora and LeChevallier, 1998).

Historically, energy efficiency was rarely considered to be an important metric when designing water and wastewater treatment plants. However, in recent years, federal, state and local governments have started taking steps to mandate, support, and / or incentivise efforts to increase energy efficiency and alternative energy production in such plants nationwide.

This is largely due to a range of factors. Wastewater treatment costs are expected to increase by 20% over the next 15 years (EPA, 2008), and budgets are tight due to the weakened state of the economy. Electricity costs continue to rise, and less energy use means a reduced impact on the environment.

Tetra Tech has taken a proactive position in facilitating energy conservation and promoting renewable energy production at water and wastewater treatment plants by performing energy audits, implementing energy conservation measures (ECMs), and installing renewable energy at municipal treatment facilities. The Tetra Tech team has completed more than 50 comprehensive energy audits for plants.

Border Environment Cooperation Commission

One vehicle that Tetra Tech is using to complete energy efficiency projects is a service contract with the Border

Environment Cooperation Commission (BECC). The BECC is a bi-national governmental organisation established in 1993 by the US and Mexico to preserve, protect and enhance the environment and human health in the region that lies between 100km north and 300km south of the US-Mexico border through project certification, technical assistance and capacity building.

The US EPA's US-Mexico border water infrastructure programme (BWIP) uses US EPA grant money together with funds from other sources to create affordable, high priority water infrastructure projects that otherwise could not be implemented. The BECC, in coordination with the US EPA, seeks to ensure the environmental and economic sustainability of BWIP projects in the region. To that end, the BECC and US EPA are incorporating energy and water audits into the development of projects being implemented on both sides of the US-Mexico border.

The BECC administers service contracts for energy and water audits for water and wastewater treatment plants, as well as value engineering (VE) reviews of plant design projects in the border region. To date, these efforts have been supported by funds administered by BECC from the US EPA (BWIP and Border, 2012), BECC's technical assistance programme, and funds from the US Agency for International Development (US AID), the World Bank and private sector partners.

As of June of 2014, BECC had certified 236 environmental infrastructure projects: 126 in Mexico and 110 in the US, with an estimated total cost of approximately $8205 billion. Figure 1 shows the locations and associated costs of these projects.

BECC has made an effort to perform a US border region needs assessment focused on defining the lack of access to centralised water and wastewater services, and to evaluate service needs in the solid waste and air quality sectors within the 100km border region. The needs assessment identified that providing adequate drinking water and wastewater services continues to be a need for residents in US border counties. While the primary gap in centralised service coverage largely exists in a rural setting, an investment would likely be required whether connecting to a centralised system or making improvements to address drinking water quality or adequate on-site wastewater disposal. Table 1 summarises the US needs and investment estimates for water and wastewater services in the border region throughout the states of California, Arizona, New Mexico and Texas.

Figure 1: Certified projects (1995 to date) - 236 projects with an estimated total cost of $8.205 billion

Based on the extent of this existing need and the rising costs of energy burdening the operational costs of utilities, the energy audit efforts are expected to identify opportunities to relieve some of the demand on financial resources, which can then be reallocated to address new capital investment needs. These resources can be used to fund projects directly or leverage resources from other sources, e.g., loans and grants.

Willcox WWTP energy audit

The city of Willcox is about 99km north of the US-Mexico border and encompasses an incorporated area of approximately 15.8km^2. The city population is about 3757 residents according to the 2010 US census, and it is located in Cochise county, in the southeastern corner of Arizona.

As a task order under the service contract, Tetra Tech recently completed an energy audit of the existing Willcox wastewater treatment plant and collection system, as well as a VE review of the 60% design of the proposed upgrade to the plant. The city of Willcox, Arizona was selected by EPA Region 9's US-Mexico BWIP to receive project development assistance programme (PDAP) technical assistance funding, managed by BECC, to support project development tasks such as planning, environmental analysis and design for wastewater infrastructure projects.

The energy audit was divided into two separate tasks, the first of which was to establish an energy baseline. This included a review of energy usage, evaluation of rate structures, field testing of major equipment and considerations for operational changes during the evaluated time period. The team performed wire-to-water efficiency tests on all 11 of the pumps to determine how efficient they were at utilising grid power in pumping

Table 1: Access to centralised municipal services – US needs and investment estimates

State	Number of counties	Drinking water – unserved	Estimated investment – drinking water ($)	Wastewater – unserved	Estimated investment – wastewater ($)	Total estimated investment ($)
California	2	38,864	287.6M	70,803	849.6M	1.14B
Arizona	4	133,491	987.8M	138,359	1.67B	2.65B
New Mexico	5	11,826	87.5M	38,669	464M	551.5M
Texas	25	87,377	646.6M	289,609	3.48B	4.12B
Total US border region	36	271,558	2.01B	537,440	6.45B	8.46B

Table 2: Willcox WWTP Energy Conservation Measure (ECM) list

Energy Conservation Measure	Estimated Annual Savings
ECM 1: Replace inefficient influent lift station pumps	4600
ECM 2: Replace inefficient Magic Circle lift station pumps	150
ECM 3: Replace inefficient effluent lift station pumps	2800
ECM 4: Replace inefficient Wood Street lift station pumps	300
ECM 5: Replace inefficient Railroad lift station pumps	450
ECM 6: Install solar photovoltaic energy	N/A*
ECM 7: Install flowmeters on lift station discharge lines	TBD**
ECM 8: Develop an asset management plan	TBD**
ECM 9: Improve pre-treatment requirements	TBD**

* Not applicable ** To be determined

wastewater. The wire-to-water efficiency tests were performed on the existing pumps in an 'as is' scenario, and the resulting metric is a product of the motor efficiency and pump efficiency. This was achieved by measuring each pump's flow rate and electrical demand simultaneously to provide the data required for the efficiency calculations.

The second portion of the scope included a review and analysis of opportunities to reduce energy consumption and demand and / or generate renewable energy. The energy audit deliverable was a report identifying the baseline energy usage, as well as each ECM and its associated technical and economic feasibility.

As part of the energy audit, the team identified five ECMs related to pump station efficiency upgrades and evaluated the preliminary feasibility of installing solar photovoltaic renewable energy at the plant. The team also performed a detailed process evaluation in order to identify opportunities to reduce the aeration, mixing or pumping energy required for biological nutrient removal. Table 2 lists the ECMs identified along with the estimated annual savings associated with each.

Note that due to small pump sizes and limited run times, the team determined that ECMs 2, 4, and 5 were not economically viable for implementation based on energy savings alone.

Willcox wastewater treatment plant value engineering review

In 2011, the city initiated a plan to upgrade the plant treatment processes while maintaining a plant capacity of 2.27MLD. Based on the technical evaluation performed by Tetra Tech in 2012, the recommendation for upgrading the treatment plant was to install an activated sludge process incorporating oxidation ditches. Subsequently, a design consultant was retained to complete the detailed design for the upgrades to the existing Willcox wastewater treatment plant.

In accordance with funding programme requirements, BECC procured and contracted a value engineering task with Tetra Tech for the Willcox plant design. Tetra Tech's four-day VE review was conducted following the 60% design phase, with final design scheduled for completion in the third quarter of 2014. Information provided during the VE review indicated that the project was scheduled for completion of construction and start-up in the second quarter of 2016. The VE team included an electrical engineer, a process engineer, a civil / structural engineer, an energy/biosolids engineer, and a Certified Value Specialist (CVS). A subconsultant, Value Management Strategies, provided the CVS team member.

The objectives of the VE study were to:

- Improve the overall plant process control
- Investigate ways to reduce O&M costs incurred by the city of Willcox
- Review alternative biosolids disposal processes
- Increase value by optimising the relationship between project scope, cost, and schedule

During the course of the VE review, a number of analytical tools and techniques were applied to develop a better understanding of the baseline concept. A major component of this analysis was Value Metrics, which seeks to assess the elements of cost, performance, time, and risk as they relate to project value. The key performance attributes identified for the project were operating costs, regulatory compliance, plant operations, constructability and expandability.

Below is a summary of the major observations and conclusions identified during the evaluation of the baseline concept, which led the VE team to develop the alternatives and recommendations presented in the final report. The key cost drivers for this project were the oxidation ditch, residuals holding tank / solids dewatering / residuals storage, clarifiers and the O&M building.

From a performance perspective, the key drivers were operational costs, regulatory compliance and plant operations. The VE team was interested in maximising the quality of the effluent to benefit the city. A key focus of the VE review was to investigate ways to reduce O&M costs, in particular for transporting biosolids and the costs of the plant's electricity consumption.

The VE review generated 24 VE alternatives, each of which would result in increased value and a reduction in capital costs and / or operating costs if implemented. Several of the VE alternatives would result in a significant reduction in annual electricity and / or fuel consumption if implemented.

The VE alternatives included solids drying onsite followed by land application in lieu of landfill disposal, adding anaero-

Figure 2: Comparison of value – baseline concept and VE strategies

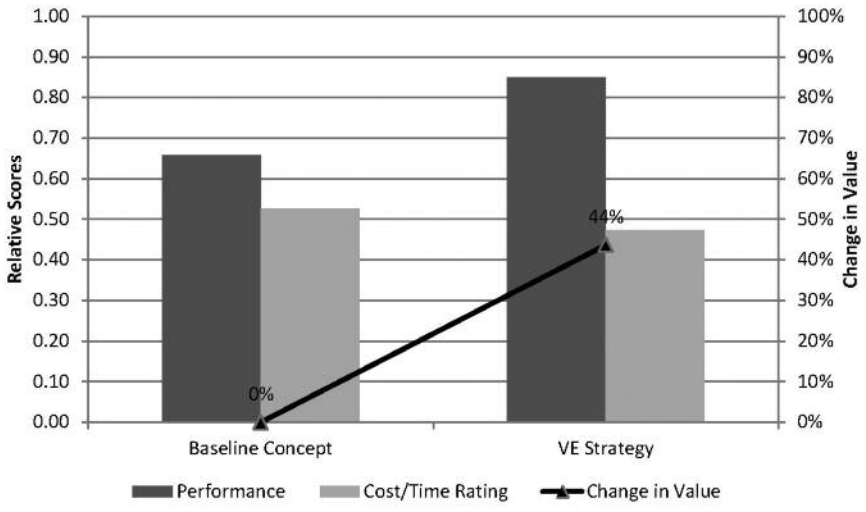

Table 3: Summary of VE strategies

Strategy description	Initial cost savings	LLC savings*	Change in schedule	Performance change	Value change
VE strategy: VE alternatives 1,3; 2,0; 3,0; 4,0; 5,0; 6,0; 7,0; 8,0; 9,0; 10,0; 11,.0; 12,0; 13,0; 14,0; 15,0; 16,0; 17,0; 18,0; 19,0; 21,0.	$1.072.600	$4.061.000	-2 months	+29%	+44%

* Life Cycle Cost (LCC) savings are based on the sum of the Capital Costs + Net Present Value (NPV) of the O&M costs. The baseline concept has a capital cost of $9,553,000 (using a blended rate of 11 cents/kWh for the electrical utility rate). The baseline concept has NPV for a 20-year term of the O&M costs = $9,413,000.

bic selector tanks and eliminating the effluent filters, installation of oxidation reduction potential (ORP) probes in the oxidation ditches to improve process control and avoid excessive aeration, eliminating the waste activated sludge (WAS) pump, eliminating the cover over the WAS storage tank, installing aeration control for the WAS storage tank, installing two electrical feeds into the plant instead of one, and using driven piles in lieu of drilled piers, among others.

A summary of the recommended VE strategies (combinations of VE alternatives) is provided in Figure 2 and Table 3. The chart illustrates the relative trade-offs between performance versus cost and schedule. The line indicates the net percentage change in total value relative to the baseline concept.

The implementation of the VE strategy could result in an 11% reduction in the initial (capital) cost, a 43% reduction in operating costs (LCC), and could reduce the construction schedule by two months while providing significant improvements in regulatory compliance, plant operations, constructability and expandability.

At the end of the project, the results of the energy audit and the VE review were presented to the city of Willcox. The stakeholders in attendance either in person or via conference call were BECC, the US EPA, the North American Development Bank (NADB), the Arizona Department of Environmental Quality (ADEQ) and the city of Willcox.

Douglas energy and water audits

The city of Douglas, Arizona is in the southeastern corner of the state in Cochise county. Douglas is on the US-Mexico international border, adjacent to the city of Agua Prieta, México, and is approximately 190km southeast of Tucson, Arizona.

Douglas was chosen by EPA Region 9's US-Mexico BWIP to receive PDAP technical assistance funding managed by BECC to support project development tasks for planning, environmental analysis and design of wastewater infrastructure projects, including the expansion and upgrade to the wastewater collection system in the Bay Acres Colonia and improvements to the Douglas wastewater treatment plant. The preliminary engineering reports and the environmental information document have been completed, and the National Environmental Policy Act (NEPA) authorisation process is underway. A scope of work is currently being developed for the final design of the project.

To support identification of additional improvements to increase the sustainability of the project and the utility, the BECC retained Tetra Tech to perform an energy audit of the existing wastewater collection system, as well as water and energy audits of the drinking water system. The recommendations of the water and energy audits may be integrated into the proposed project final design or implemented independently by the community.

Conclusions

These projects are just two examples of the numerous water and wastewater energy projects in both Tetra Tech's and the BECC's portfolios, but this is just a drop in the bucket. The industry is saturated with similar, untapped opportunities.

It is going to require a significant departure from current practices for the wastewater treatment industry and the general public to view wastewater as a valuable energy resource, instead of a nuisance that must be disposed of. It is essential that governments promote and provide incentives for energy efficiency and generation in order to reduce our carbon footprint and negative impact on the environment. Energy audits complemented by value engineering offer a good way to achieve these efficiencies. The US and Mexico have set an important precedent that other nations should follow. ●

References

Arora, H and LeChevallier, M (1998), Energy management opportunities. Journal – American Water Works Association, 90:2:40.

Ensuring a sustainable future: an energy management guide for wastewater and water utilities (2008), Environmental Protection Agency / Global Environment & Technology Foundation, Washington DC, US.

Goldstein, G and Smith, W (2002), US electricity consumption for water supply & treatment – the next half century. Water & Sustainability (Vol 4), Palo Alto, California, US.

The original version of this paper was presented at the IWA Water, Energy and Climate Conference 2014, held in Mexico City, Mexico, 21-23 May 2014.

Bob Lonergan

About the authors:

Robert Lonergan is Program Manager for Water and Wastewater Energy Projects at Tetra Tech, Inc., Denver, Colorado, US. Email: Bob.Lonergan@tetratech.com

Roberto Molina is a Program Manager and Renata Manning-Gbogbo is Director of Projects at the Border Environment Cooperation Commission, Ciudad Juárez, Chihuahua, Mexico.

Frank Bracamonte is Utilities Supervisor at the City of Willcox, Arizona, US.

George Hunter is Vice President of Value Management Strategies, Sacramento, California, US.