ENERGY SAVINGS PERFORMANCE CONTRACT (ESPC)

BLACK & VEATCH

INTRODUCTION

The key to a successful Energy Savings Performance Contract (ESPC) is to quickly identify projects that will reduce operating costs, and provide overall financial benefit to the utility. In comparison to a traditional project, which may be driven by long-term capacity or concern, and will typically be performed within the framework of an overall facility plan, the ESPC project may be very narrowly focused around the least-efficient areas of the plant's current operations. That said, it is never in the utility's interest to perform work without an understanding of the potential impact on the overall plant process and long-term facility needs.

The following is an example of an initial evaluation of 20 million gallons per day (MGD) enhanced nutrient removal (ENR) wastewater treatment plant located in the Mid-Atlantic. This level of evaluation is typically conducted as a screening step to identify potential energy conservation measures (ECMs) and determine if an ESPC at the facility would likely be successful. This analysis is conducted after one or two site walk-throughs, and evaluation of available data.

PROJECT EXAMPLE

The example plant is a typical ENR process, including:

- Influent Screening
- Influent Pumping
- Grit Removal
- Primary Clarification
- Biological Reactors (including Anaerobic, Anoxoc, Oxic and Post-Anox zones) designed for biological phosphorus and nitrogen removal
- Secondary Clarification
- Intermediate Pumping
- Tertiary Filtration (sand filters)
- Chlorination/Dechlorination
- Sludge Thickening
- Primary Sludge Fermentation (to generate volatile fatty acids, or VFAs, to enhance biological phosphorus removal)
- Anaerobic Digestion
- Biosolids Dewatering (belt filter presses for ultimate land disposal)

INITIAL CONCEPT DEVELOPMENT

After an initial screening of all these processes, both for their impact on annual operating costs and their potential for improved operational efficiency, the following potential ECMs were identified:

DIGESTER GAS UTILIZATION FOR POWER GENERATION

Currently the WWTP operates two anaerobic digesters. The digesters receive fermented primary sludge, waste activated sludge (WAS) and industrial sludges (typically from food processing facilities). Digester gas is currently collected for use in boilers for direct heating of sludge. Excess gas can be burned in the plant's digester gas flare.

Digester operating data was evaluated to estimate digester gas production based on volatile solids reduction. The results indicate that the system may produce enough digester gas to produce an average of 300 kW of electricity through an internal combustion generator.

A potential project to install a cogeneration system would include:

- One 400 kW engine generator
- Gas cleaning system
- Membrane cover for one of the existing digesters (for gas storage)

The system would include heat recovery from the engine to be used for sludge heating. During the coldest months of the year, the heat available from the engine will generally meet the needs for sludge heating, though more detailed analysis would be required.

The capital cost for such a system would be in the range of $3.1 million. Estimated electrical savings would be on the order of $200,000 per year.

INFLUENT PUMP STATION

Preliminary evaluation of the main influent pump station indicates there are limited opportunities available for operating cost reductions. There is potential to raise the working level of the wetwell by 1 to 1.5 feet. This would reduce the required pumping power by 5 Hp at average day pumping rate of 22 MGD. While not a significant savings (less than $3,000 per year), there is also no cost to implement the change.

BIOLOGICAL REACTORS

Records regarding the actual power draw by the Biological Reactor aeration blowers were not available for this analysis. Based on the site visit and review of drawings, the current power demand for the BNR tanks is estimated at $570,000 per year with 6 tanks in service and two (2) blowers operating at maximum turndown (60% of rated capacity) for 3 months of the year, two (2) blowers operating at 80% of rated capacity for 6 months of the year, and two (2) blowers operating at 90% of rated capacity for 3 months of the year. Actual measured power draw would be recommended as a basis for further analysis.

Based on these power consumption assumptions, several options were identified related to the aeration system to reduce power costs associated with the 12 Biological Reactors. The options range from low-cost maintenance items to installation of new equipment.

- **Chemical Cleaning of Ceramic Diffusers:** Ceramic diffusers accumulate debris, biofilm and other chemical contaminants that block the pores in the diffuser. This will result in lower oxygen transfer efficiency due to changes in bubble size, air flow restrictions and increased pressure drops. Numerous methods are available for cleaning of the system including acid cleaning and gaseous cleaning. The development of a periodic cleaning process and methodology will preserve the life of the diffusers and reduce overall aeration costs. A typical cleaning regime might be expected to cost $10,000 per year in labor and materials. It is estimated that this would improve aeration efficiency by 10% on the two (2) older tanks in service, or approximately $19,000 per year in savings.
- **Addition of a Trim Blower:** The current blowers are sized to meet maximum air flow demands at design flows. While necessary, the numerous safety factors and design conditions create blower sizing that is larger than actual peak day requirements when flows are below design flows and loading. At current average day dry weather loading, the biological reactors require approximately 1,800 scfm per process train (2 MGD/reactor) for complete nitrification and 2,200 scfm per process train at summer loadings. High-speed turbo blowers at a preliminary sizing of 100 hp per train would provide sufficient aeration capacity to handle the majority of flow and loading conditions at the plant. These blowers also have higher turn down capacity (between 45% and 50% of design air flow) and would be able to match dissolved oxygen (DO) to lower loadings during low flow conditions. A preliminary estimate of capital cost for the blowers is $250,000 per blower and four (4) blowers would be required to handle current dry weather flows. The existing multistate centrifugal blowers would be able to handle aeration loading during peak day conditions. The power consumption for this option is estimated at $250,000 per year. Based on a very conceptual review the plant could save as much as $320,000/year.
- **Replacement of Original Blowers:** Blower efficiency (both motor and compressor) have improved greatly in time, along with the internal blower control systems to match motor horsepower draw to desired airflow. The replacement of the older blowers with new blowers would provide opportunity to reducing power costs. Replacement of the two existing 450 hp blowers (installed in 1987), would cost an estimated $750,000 per blower for a project cost of $1,500,000. The estimated savings would be similar to the Trim Blower alternative. Although this option would not have as great a turn-down capability, it would cover the higher flow events more efficiently.
- **VFA Monitoring:** Several new instruments are available to measure and monitor VFA concentrations that have been developed for the chemical and food processing industry. These devices can be coupled to ortho-phosphate and nitrate analyzers to match the flow of fermentate to the biological reactors for biological phosphorus removal and denitrification. Excess VFA that enters the biological reactors must be removed through the aeration process with the associated oxygen demand and also deprives the anaerobic digesters of additional VFA that may be utilized for methane production. By matching the flow of fermentate to the reactors to the demand for VFA, the value of the VFA is optimized and the cost of removing the VFAs is reduced. VFA monitoring equipment (installed) and control programming would be on the order of $100,000. A rough estimate would be that the system could save 5% of aeration costs ($26,000 per year) and approximately $10,000 in chemical costs per year.

SECONDARY ANOXIC TANKS:

The secondary anoxic tanks have several opportunities to allow more efficient operation at current flows and loads. These options are associated with matching the aeration blower sizing with the current flows and loads. Based on the site visit and review of drawings the current power demand for the SAT tanks is estimated at $106,000 per year with 3 tanks in service and a single PD blower operating at maximum turndown (85% of rated capacity). As noted for the Biological Reactor blowers, power monitoring of these blowers should be conducted to confirm potential savings.

- **Addition of mixer in 1st zone and smaller blowers:** The aeration zone at the head of the Secondary Anoxic Tanks (SAT) is designed to provide sufficient aeration volume for the process at peak loadings during minimum temperature conditions. At current loads and during the majority of the year this aeration zone is not necessary as nitrification has been completed in the biological tanks. The addition of a submersible mixer to this zone would allow the current blowers to be removed from service during the majority of the year and only operated if peak loading and low influent temperatures require additional biomass in the system. A single (1) smaller blower sized only for the reaeration zone at 75 hp (301 scfm/tank) would be installed to provide nitrogen gas stripping and to aerate the mixed liquor prior to final clarification. A preliminary estimate of capital costs for six (6) submersible mixers and one 75 hp blower is $250,000. The estimated power consumption for this option is $52,000 per year. Based on a very conceptual review the plant could save as much as $54,000 a year.
- **Replacement of SAT blowers:** A slightly less capital-intensive alternative would be to improve blower turndown, without adding the submersible mixers. Because of the tanks' depth (28 feet SWD), limited options were available for blower selection. The newest models of high-speed turbo blowers provide greater turn down at higher discharge pressures. The replacement of one (1) of the 150 Hp positive displacement blowers with a 125 Hp high-speed turbo would allow blower turn down to 50% of rated flow and match the low aeration demand required at current flows and loads. The existing PD blowers would be utilized as flows and loads increased and during periods of warmer temperature when oxygen transfer efficiency declines. A preliminary estimate of capital costs for one (1) 125 Hp blower is $150,000. The estimated power consumption for this option is $74,000 per year. Based on a very conceptual review the plant could save as much as $32,000 a year.
- **On-line process modeling:** The use of on-line process modeling would allow the plant to match the number of SAT tanks in service to flow, loading and biomass concentrations. Based on preliminary evaluation of process performance, the facility can operate one (1) SAT tank at current loadings and influent temperatures of greater than 18C. Operational savings would include reduced air demand and reduction in mixing energy of more than 15 hp per tank removed from service. The excessive SAT volume under current operations may also result in secondary release of ortho-P and TN. Though it is not quantified here the reduction of the excess volume and secondary release would likely also reduce plant chemical demand for nutrient removal.

FINANCIAL SCREENING

Once a suite of potential energy conservation measures (ECMs) has been developed, the ECMs can be screened against relatively simply financial metrics developed in collaboration with the Owner. For instance, the team may choose a simple financial payback period, such as 10 or 15 years. The team may also choose a cash flow goal, for instance that the project be cash flow positive in the first year, or within the first 5 years.

The following is a financial screening for the example described above.

ECM Number	EMC	Capital Cost	Annual Savings	Simple Paycheck	Cashflow Positive?
1	Influent Pumping Station		$2,500	<1 year	Yes
2	Chemical Cleaning of Ceramic Disks		$9,000 (net)	<1 year	Yes
3	Trim Blowers	$1,000,000	$320,000	3.1	Yes
4	Replace Original Blowers	$1,500,000	$300,000	5	Yes
5	VFA Monitoring	$100,000	$36,000	2.8	Yes
6	SAT Mixers and Smaller Blowers	$250,000	$54,000	4.6	Yes
7	Replacement of SAT Blowers	$150,000	$32,000	4.7	Yes
8	Digester Gas Utilization	$3,100,000	$200,000	15.5	No

At this point, the team (ESCO and Owner) will determine the best ECMs to carry forward. This can be based purely on economic criteria (for instance the Trim Blowers have a shorter simple payback than replacing the Original Blowers); can include the long term impact on the plant's other capital needs (for instance, if the plant was planning to replace the Original Blowers and had budgeted for that, in their CIP); or can include non-financial factors (for instance the Digester Gas Utilization may be consistent with a larger community GHG reduction goal).

For the purposes of this example ECM's 1, 2, 4, 5, 6 and 8 are carried forward for further analysis.

EXAMPLE PROJECT PROFORMA

Once the basic scope of the project has been preliminarily determined, a financial proforma is developed. The financial proforma will include a projected annual net cash flow for the project based on certain projections and assumptions, which are developed and confirmed in conjunction with the Owner. These include:

Parameter	Assumed for This Example
Interest Rate	3.0%
Annual Inflation Rate (General)	1.5%
Annual Inflation Rate (Energy)	2.0%
Electricity Rates	$0.08/kWh (Blended)
Natural Gas Rates	NA
Projected Plant Flows	1% Increase/Year
Projected Plant Loads	1% Increase/Year

For the example project, the plant's Year 1 operational costs are reduced by an estimated $638,000. Note that Year 1, is the first year of operations post-construction, and therefore includes two years of inflation and plant flow increase as compared to the initial project savings estimates. In subsequent years the estimated savings increase with inflation and increased load to the plant. Debt service is fixed.

For the example project the Year 1 net cash flow is $206,000. This represents a reduction in the overall utility budget that could be used to cover other expenses. Over the course of the 20-year project life, the annual savings increases to over $600,000 per year. The estimated total cumulative savings for the project is in excess of $8 million.

	Year 1	Year 2	Year 3	Year 4	Year 5
Savings	$639,000	$658,000	$677,520	$698,000	$719,000
Revenue					
Net Savings/ Revenue	**$639,000**	**$658,000**	**$677,520**	**$698,000**	**$719,000**
Debt Service	($333,000)	($333,000)	($333,000)	($333,000)	($333,000)
Additional O&M	($100,000)	($103,000)	($106,000)	($109,000)	($113,000)
Total Costs	**($433,000)**	**($436,000)**	**($439,000)**	**($442,000)**	**($446,000)**
Net Cash Flow	**$206,000**	**$222,000**	**$239,000**	**$256,000**	**$273,000**

PROJECT CASH FLOW