C I T Y O F B O U L D E R
WATER RESOURCES ADVISORY BOARD
INFORMATION ITEM

MEETING DATE: December 14, 2015

AGENDA TITLE: Information Item: Update on Wastewater Treatment Facility Renewable Energy

PRESENTER/S:

Jeff Arthur, Director of Public Works for Utilities
Chris Douville, Wastewater Treatment Manager
Douglas Sullivan, Acting Principal Engineer - Utilities

EXECUTIVE SUMMARY:

The purpose of this memorandum is to provide an update to WRAB on renewable energy systems at the 75th Street Wastewater Treatment Facility (WWTF). Current status and future opportunities are covered. The annual operating costs for the WWTF are significantly affected by electricity demands and use. Annually, over $500,000 of grid electricity is purchased from Xcel (representing over 10% of the total annual O&M budget).

Next year, the Cogeneration (Cogen) System will be 30 years old. Overall the system has performed well and has provided alternative electric power generation as well as beneficial heat recovery since its inception. As all systems have a limited life cycle, the Cogen system is nearing the end of its useful life. The electrical and control systems for Cogen are of particular concern, and at some point will cause Cogen to become unreliable and unsafe. A key upcoming decision will be whether to re-invest in Cogen and continue to produce electricity, or whether to pursue a different pathway which utilizes the biogas as a fuel commodity.

The Solar Photovoltaic (PV) System reached the 5-year operational milestone in July 2015. Because of the third party ownership by SunEdison and associated O&M responsibility, the city has benefitted from purchasing affordable, clean, alternative source power with minimal burden or complications. In 2014, Utilities staff investigated the possibility of installing an additional Solar PV array adjacent to the SunEdison system, but ultimately declined due to several factors including cost and Utilities workplan priorities.

BACKGROUND:

The Cogen system was placed into operation in 1986 to generate electricity from digester biogas (60% methane) and to perform waste heat recovery for the digester process and the four oldest buildings on the WWTF campus. Cogen also served as the primary means of emergency power during a power outage, and still functions as a component of the emergency power system today. The Cogen system was funded by a significant grant from the U.S. EPA which covered 80% of the system cost. Cogen was one part of a larger $4,000,000 capital project (1985 dollars) that also included the flood protection levee and the septage receiving station. Initially, the Cogen system generated electricity that pushed on to the Xcel grid and the city earned revenue for the power generated through a Power Purchase Agreement (PPA). The PPA revenue exceeded the cost to purchase grid electricity, so this was a net revenue gain situation. Sometime in the mid-2000s, the cost of grid electricity exceeded the PPA revenue price, and in 2008, the system was reconfigured such that Cogen electricity fed directly to the WWTF to offset grid usage. The city owns, operates, and maintains the Cogen system.

In July 2010, the Solar PV System at the 75th St. WWTF went online. From the start, the system produced reliable, clean electricity and offset grid energy usage by approximately 15% during the first operational year. Fundamentally different from Cogen, the Solar PV system is owned, operated, and maintained by SunEdison. The city owns the land where the array is located, and has a 20-year land use agreement (ground lease) that dedicates the site for Solar PV. Since the electricity produced by the system is used directly by the WWTF (not pushed on to the Xcel grid), the city has a PPA with SunEdison and purchases all of the produced power. **Table 1** below includes a summary of the PPA cost terms over the 20-year agreement.

Table 1. 75th St. WWTF Solar PV System PPA Rates

Calendar Year	Operational Year	Rate ($ / kWh)	Calendar Year	Operational Year	Rate ($ / kWh)
2010	1	$0.0320	2020	11	$0.0420
2011	2	$0.0329	2021	12	$0.0420
2012	3	$0.0338	2022	13	$0.0420
2013	4	$0.0347	2023	14	$0.0420
2014	5	$0.0357	2024	15	$0.0420
2015	6	$0.0366	2025	16	$0.0420
2016	7	$0.0377	2026	17	$0.0420
2017	8	$0.0387	2027	18	$0.0420
2018	9	$0.0398	2028	19	$0.0420
2019	10	$0.0408	2029	20	$0.0420

Regarding source energy profiles, the combined Cogen and Solar PV systems constitute renewable energy sources that can supply up to 35% of the annual electric power needs for the WWTF. The power generation capability of the Cogen system is limited by how much biogas is available from the digesters. If more biogas was available, more electricity could be produced. The Solar PV system is producing all it can, based on weather conditions and known system degradation. **Table 2** summarizes the Solar PV system performance for the first five operational years, in comparison to projected performance.

Table 2. 75th St. WWTF Solar PV System Production

Calendar Year (ending)	Operational Year	Production (kWh)	Percent of 2009 Projection
2011	1	1,500,111	95
2012	2	1,576,071	100
2013	3	1,474,304	94
2014	4	1,451,745	92
2015	5	1,374,693	87

The WRAB memo items listed below can be referenced for additional background information on WWTF energy topics, as desired:

- December 2011 Meeting, Information Only Item – Energy Efficiency Work on City Facilities, and Wastewater Treatment Facility Energy Highlights
- January 2008 Meeting, Information Only Items –
    - Update on WWTP Electrical Usage and Energy Savings Measures
    - Photovoltaic Project at the WWTP

ANALYSIS:

The wastewater industry has seen impressive, recent results where some facilities are approaching and achieving net-zero energy usage (reference WERF Reports ENER 1C12b – *Demonstrated Energy Neutrality Leadership: A Study of Five Champions of Change* (2015) and ENER1C12 – *A Guide to Net-Zero Energy Solutions in Water Resource Recovery Facilities* (2015)). In Boulder, the commitment to diversifying source energy and moving away from grid electricity dependence began long ago and results are noteworthy. Cogen and Solar PV current provide approximately one-third (average of 33% since Solar PV came online) of the electricity needed at the WWTF, annually. This source electricity profile is encouraging and clearly aligns with overall city goals for greenhouse gas emissions reduction and climate action plan initiatives. **Table 3** below shows a summary of source power profiles from the past 10 years.

Table 3. Source Electricity Profile Summary for the 75th St. WWTF

Year	Total Electricity Used (kWh)	Percent Cogen	Percent Solar PV	Percent Renewables
2006	8,807,033	19.5%	n/a	19.5%
2007	9,230,673	18.2%	n/a	18.2%
2008	11,172,738	17.9%	n/a	17.9%
2009	11,021,096	18.4%	n/a	18.4%
2010	11,532,359	18.9%	5.4%	24.4%
2011	10,778,929	21.5%	14.2%	35.6%
2012	10,766,398	18.6%	14.1%	32.6%
2013	10,781,453	20.0%	13.8%	33.8%
2014	10,842,857	17.8%	13.1%	31.0%
2015 (thru Nov)	10,176,475	18.1%	13.0%	31.0%

Cogeneration Options

Utilities staff need to make an important decision in the next 2 to 4 years: either reinvest in cogeneration, or move away from cogeneration and utilize the biogas for a different purpose. Reinvesting in cogeneration could come in the form of modern, more efficient engine generators similar to the reciprocating, internal combustion engines currently in operation, or upgrading to microturbines. Most new facilities, or facilities that have embraced net zero initiatives, have installed microturbines due to the increased efficiency and ease of operation.

The "status quo" alternative includes implementing incremental repairs and minor upgrades to the various mechanical, electrical, and controls systems in order to keep the aging cogeneration system operational. This approach costs the city approximately $100,000 per year in staff labor, and an additional $50,000 to $150,000 per year in capital/maintenance expenses.

Colorado School of Mines Cogeneration Study (2013). In the 2013, the City worked with the Colorado School of Mines (CSM) with assistance from Brown & Caldwell Engineers, to develop a Wastewater Treatment Plant Biogas Cogeneration conceptual design report. This was an engineering student design project so the report's scope and findings should be taken in context with their relative expertise and experience. The purpose of the report was to evaluate various alternative energy options regarding the replacement of the existing cogeneration engines. The timing of the project was good because City staff was aware that impending cogen system changes were likely in the next 5-10 years.

The report evaluated five (5) alternatives including new cogeneration engines, microturbines, selling the biogas, as well the "do-nothing" alternative. The report concluded that new cogeneration engines similar to the existing engines were the most cost effective alternative at that time. This evaluation is merely one data point, and did not include an extensive alternative analysis of the various gas production or gas-to-energy alternatives available that would be typical if completed by a professional engineering consulting firm. City staff would complete a more comprehensive evaluation before proceeding with any future cogeneration system capital replacement project.

Controls Upgrades Bids (2015). During the past several years, the Cogen system has experienced an increased number of faults and shutdowns due to aging system components. This downtime negatively affects operations in two significant ways: 1) requiring more biogas to be flared and in turn purchasing more grid electricity, and 2) prevents staff from working on other facility priorities. While most of the known mechanical issues have been identified and repaired, the lingering problems are believed to be associated with electrical switchgear and controls. At the request of the city, some bids were obtained from a vendor familiar with the city's Cogen system for various options to upgrade the controls to achieve a modernized, more automated, and safer system. Proposals were as follows:

1. Upgrade the main switchgear controls and protective relays for both cogeneration engines, improving synchronization with the main bus and automatic engine start/stop functionality. $138,000

2. Upgrade the local engine controls and fuel system for both cogeneration engines, providing the ability to set a desired kW output and blend natural gas with biogas as needed. $215,000

Due to the significant costs involved, this potential upgrade work has not been accomplished. Preliminary discussions have occurred with one of the city's consultants to review the bids and possibly develop a set of bid documents to facilitate obtaining multiple bids for these upgrades, due to costs exceeding $50,000. Additionally, these upgrades are currently not funded within the CIP or operating budget.

Biogas Alternatives

The Utilities staff have received solicited input from consultants, academia, and peer communities regarding digester biogas and the tradeoffs of operating cogeneration vs. utilizing the fuel for other purposes. Unsolicited opinions from interested parties have also been obtained. The following information highlights a few noteworthy items with respect to biogas alternatives if the city decided to move away from cogeneration.

C2E Biogas Proposal (2014). The city was approached by a private development group named Carbon Cycle Energy (C2E) who submitted a proposal to implement a biogas-to-biofuel project. The essence of the project involved moving away from cogeneration, and installing gas treatment at the 75th St. WWTF to produce pipeline quality natural gas, and/or compressed natural gas (CNG) to fuel vehicles. A public-private partnership would be formed where C2E would own/operate the gas treatment and CNG station, and sell the fuel on the open market. It was estimated that approximately 300 gas gallon equivalents (GGEs) per day could be produced with current WWTF loadings. The presumed advantages for the city would be reduced O&M and capital burden (by no longer operating cogeneration), and access to BioCNG at a reduced price. While an appealing idea on some levels, the proposal heavily favored C2E economically, and the city declined the proposal.

Economic Evaluation (2015). One aspect missing from the cogeneration story is an economic comparison between the current situation of operating an aging system, and various future alternatives for biogas. Kennedy Jenks Engineers was hired to perform an economic evaluation for the city, to address the key question: What is the net economic benefit (or burden) of cogeneration today, and how do other options compare? The following scenarios were evaluated against the current Cogen system operation (baseline condition):

1. Heating and flare excess gas
2. New internal combustion engine (qty. 1)
3. New large microturbine engines (qty. 2)
4. New small microturbine engines (qty. 5)
5. BioCNG for fleet fuel (estimated to produce 500 GGE/day of fuel)

The work is being finalized. Preliminary findings suggest that when factoring in all appropriate O&M costs and savings for Cogen, the net result is a $30,000-$40,000 annual expense to operate the system. Alternatives to the existing Cogen system all have a capital investment, but show net annual savings when considering 20-year life cycle costs.

One concern with the BioCNG option is that the city has currently embraced electric vehicles and hybrids, along with biodiesel compatible vehicles, and does not own any CNG vehicles.

Thus, for a BioCNG project to be viable, the city would need to acquire a fleet of CNG vehicles, convert some of the existing fleet, or perhaps consider selling the CNG. High mileage vehicles are the best candidates to use CNG (trash truck and busses are excellent examples). The City of Grand Junction, Colorado is the best local example of a WWTF producing BioCNG.

Solar PV Options

McKinstry Proposal (2014). The city continues to embrace Solar PV technology, and the city's Energy Performance Contracting (EPC) company McKinstry brought a proposal to the table for a new 500-kW array located adjacent to the existing WWTF array. The large, flat, open acreage east of the WWTF fence line is ideal for Solar PV. The proposal included several cost scenarios:

1. City Owned, Financed
2. City Owned, Lease Purchase
3. City Owned, Cash
4. Third-party owned with PPA – this option was desired, but excluded as it would void a $0.06 / kWh Renewable Energy Credit (REC) available to the city.

The project was drafted to be a change order to the larger city EPC program, which had certain advantages including turn-key construction. The complete cost of the Solar PV array was $1,465,000, with an associated simple payback of 17 years. The system was projected to produce approximately 800,000 kWh of electricity per year (~7% of the WWTF annual use). The Utilities staff closely evaluated this opportunity, and ultimately declined the proposal due to cost and other higher priority projects.

Other Considerations

Digester Cover. The floating cover on the secondary digester has tipped 4 times within 35 years. While fortunately none of the tipping events were catastrophic, a digester cover tip is a very concerning episode. Also, fugitive gas can escape from the sludge seal around the annular space of the cover perimeter. To mitigate fugitive gas emissions and risk of cover tipping, a fixed digester cover is desired. Costs for a fixed cover are estimated at $2,000,000 and budgeted in the 6-year CIP.

Gas Storage. The existing secondary digester floating cover does provide gas storage capability, which allows operations to use stored biogas during a power outage if needed, or send gas to storage temporarily if Cogen malfunctions. Gas storage is limited, however, and improved gas storage is desired in the future. Many facilities have embraced bladder systems to provide enhanced gas storage capability, which allow for greater flexibility to store or use gas, either proactively to manage digestion and biogas operations, or during emergency operations such as power outages. If the city moves away from cogeneration, however, a gas bladder system may not be warranted.

Supplemental Feedstock. Investment in any new system becomes financially more attractive with the prospect of generating more biogas. The most tangible way to generate more biogas is to introduce new or supplemental feedstock to the digestion process, such as food waste or fats, oils, and grease (FOG). Many WWTFs have made the leap to bring in supplemental feedstock and produce more biogas, which has resulted in significant jumps to achieve net-zero energy status. Work is required to identify local sources of potential feedstock, and explore transport and receiving options. A known issue for the 75th St. WWTF is the capacity of the digestion

process. Initial evaluation of the digester capacity indicated that a third digester would be required to successfully implement supplemental feedstock addition to the existing solids loading, so the cost of a third digester would need to be included.

Capital Improvements Program (CIP) Impacts

- Ongoing Major Rehabilitation of Cogeneration System – $185,000 @ year 2020
- New Digester Cover and Gas Storage - $2,000,000 @ year 2020
- New Cogeneration Engines (reciprocating engines or microturbines) – currently unfunded in CIP
- Biogas Treatment System or Alternative Use Project – currently unfunded in CIP

NEXT STEPS:

- Utilities staff will continue to evaluate options for upgrading the existing Cogen system, and make appropriate decisions on mechanical, electrical, and controls componentry that minimize stranded investments.
- Utilities staff will stay informed of industry trends with respect to biogas utilization.
- At some future date in late 2016 or early 2017, return to WRAB with a specific recommendation for a plan to study and make a determination for reinvesting in cogeneration, or proceeding with a biofuel project.
- Utilities staff will work with other city staff on how electric utility municipalization may affect the WWTF and associated electrical systems and goals.