

ACHIEVING WASTEWATER TREATMENT SUSTAINABILITY THROUGH MANAGEMENT OF BIOSOLIDS

A REVIEW OF TWO WASTEWATER TREATMENT PLANTS IN THE UNITED STATES

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ABSTRACT

Wastewater treatment represents significant energy consumption, and authorities are becoming increasingly aware of the need to provide sustainable services. Biosolids management at WWTPs offers the opportunity to achieve energy sustainability through anaerobic digestion. This paper looks at two agencies in the US largely achieving sustainability.

Blue Plains WWTP (1,400 ML/d) DC Water, Washington, encountered rapidly escalating costs in 2006 and new digestion facilities were placed on hold. After a strategic development investigation plant management proceeded with Thermal Hydrolysis and Mesophilic Anaerobic Digestion, dramatically reducing construction and O&M costs, and involving generation of 13 MW of power.

Hill Canyon Treatment Plant (50 ML/d) In 2006 the plant operations team began an aggressive energy conservation program to enable 50% of the plant's needs to be met by power production from biogas. Additional energy was provided by solar panels (150 kW) and upsized cogeneration (700 kW). To ensure adequate production of digester gas, HCTP treats a variety of high-strength waste streams, and now achieves 100% production of its energy usage.

Some Australian authorities are also looking at WWTP biosolids sustainability aspects and a summary of achievements is outlined.

Keywords: Anaerobic digestion, biosolids, co-digestion, cogeneration, energy efficiency, high-strength waste, sustainability.

INTRODUCTION

Wastewater treatment utilities around the world are increasingly aware of the urgent need to provide sustainable services. Sustainability is unique to each community, covering a broad range of aspects. Wastewater treatment facilities are typically the largest energy consumer for municipalities. Today, with a greater emphasis on energy efficiency and reducing resources, operators of wastewater treatment plants must consider their role as resource recovery centres, focusing on purifying water, beneficially using biosolids, and conserving/producing energy. There are significant social, economic and environmental benefits for such an approach.

Biosolids management at wastewater treatment plants offers the opportunity to achieve energy sustainability through anaerobic digestion, the production of digester gas with high methane content, and heat and energy production (CHP).

This potential can be further amplified if high-strength wastes are brought to the wastewater treatment plants for co-digestion with the collected sludge from the wastewater treatment process.

To illustrate how this potential can be realised, biosolids management at one large municipality and one small municipality are described in this paper. These agencies face similar but varying issues due to size, location, environmental and community circumstances. This paper presents how each agency is addressing its sustainability challenges by utilising biosolids management, and describes lessons learned and innovative approaches.

LARGE PLANT: DC WATER'S BLUE PLAINS ADVANCED WASTEWATER TREATMENT PLANT

DC Water's Blue Plains Advanced Wastewater Treatment Plant (BPAWTP) ranks as one of the five largest WWTPs in the US and is the largest advanced wastewater treatment plant.

In the 1990s, DC Water was facing seriously deteriorated biosolids facilities. Its comprehensive *Biosolids Management Plan* in 1999 recommended replacement of existing



Figure 1. Blue Plains Advanced Wastewater Treatment Plant (1,400 ML/d).

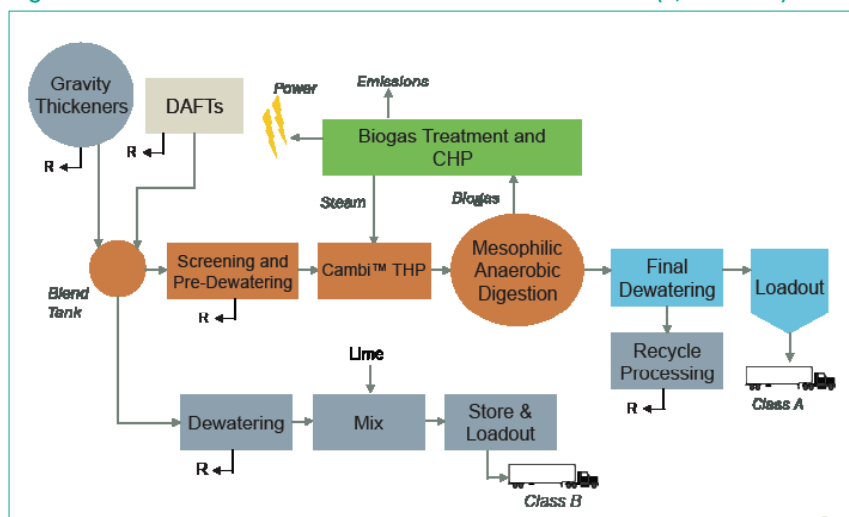


Figure 2. Process flow diagram of biosolids system (Cooper et al., 2010).

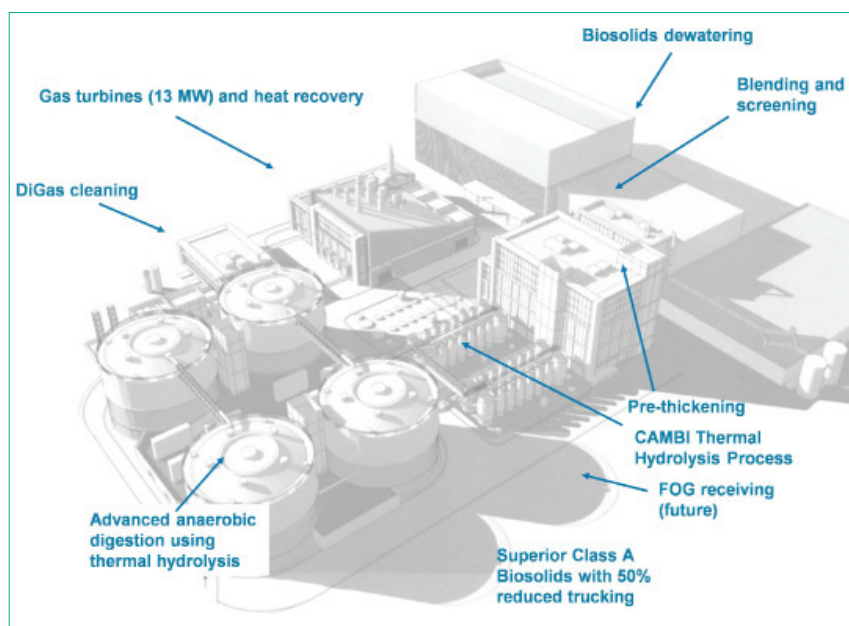


Figure 3. Schematic representation of new facilities at the WWTP.

facilities (EPMC IV, 2001). From 2000 to 2006 the program accomplished the following investments, totalling about \$250M:

- Lime stabilisation and storage facilities;
- Dewatering centrifuges (7 new, 7 existing);
- Dewatered sludge load-out facilities;
- Demolition of old anaerobic digestion facility;
- Upgrade gravity thickening;
- Upgrade and expand DAFTs;
- New gravity thickened solids screening and de-gritting.

In 2006, rapidly escalating costs for materials and construction meant DC Water could not proceed with its plans for new Thermally Phased Anaerobic Digestion (TPAD) and CHP facilities and stay within budget. DC Water's digestion facilities were placed on hold to wait for more appropriate costs. In 2008, a Blue Ribbon Panel of top biosolids consultants chosen by DC Water recommended proceeding with Thermal Hydrolysis + Mesophilic Anaerobic Digestion (TH+MAD) instead of TPAD as originally planned. This recommendation dramatically reduced the construction cost for new digesters and could, therefore, meet DC Water's remaining budget of \$450M. This also offered significant savings in O&M costs and the potential to generate energy (Schafer et al., 2010).

Since 2009, DC Water's Biosolids Management Program has implemented the following projects:

- Pre-dewatering (prior to Thermal Hydrolysis);
- Screening (prior to Thermal Hydrolysis);
- Thermal Hydrolysis (CAMBI™);
- Anaerobic digestion;
- BFP dewatering;
- Digester gas cleaning;
- Digester gas turbines/heat recovery generation.



Figure 4. New thermal hydrolysis and mesophilic anaerobic digestion at Blue Plains AWTP.

BENEFITS FROM NEW BIOSOLIDS FACILITIES

From 2001 to 2014, DC Water was using lime stabilisation of undigested biosolids. At an average production of 1,100 wet tonnes/day of Class B, lime-stabilised biosolids, DC Water operated one of the largest land application and biosolids beneficial use programs in North America. The new facilities from 2015 onward offer these advantages:

1. Discontinued lime stabilisation saves 40 tonnes of lime per day;
2. TH + MAD decomposes previously undigested biosolids by nearly 50% (based on 65% VSS destruction, 78% VSS), dramatically reducing hauling and beneficial use costs;
3. Dewatered TH+MAD biosolids achieve 30+% solids versus 27% previously;
4. Combined impact of items 1–3 is a saving of 4,800 L/day of diesel fuel for hauling;
5. Class A biosolids are produced, thereby enhancing the value of the product and increasing beneficial uses, including some closer to the plant;
6. Digester gas production up to 145,000 MJ/day (60% methane);
7. Gas turbines generate 10–13 MW of electricity and steam from renewable energy; this avoids current energy usage from non-renewable sources with greater air emissions;

8. Power from the gas turbines provides standby capacity for critical processes and safety needs, thereby eliminating commercial power supply for this need;
9. Heat recovered from the gas turbines supplies TH+MAD and other uses at the plant, saving natural gas.

Using the CAMBI™ Thermal Hydrolysis Process, the recommended option (TH + MAD) at 410 dry tonnes/day requires four process trains with six reactors per train and four large anaerobic digesters (14 ML /each).

The combined heat and power facility will burn digester gas in gas turbines (GTs) followed by heat recovery steam generators (HRSGs). The GTs selected are Mercury 50 models manufactured by solar turbine. Steam turbines (STs) may be added in the future if merited. A steam boiler is provided to ensure steam production. Steam will heat

the TH+MAD processes. All equipment can burn natural gas as well as digester gas, and the GTs have the ability to combust a blend of natural and digester gas. The Mercury 50 gas turbines utilise recuperative combustion, providing the lowest level of air emissions. They also provide over 38% efficiency for producing electricity with overall combined heat and power production efficiencies over 70%.

ENVIRONMENTAL BENEFITS

• **Clean, renewable, cost-effective electricity** Using digester gas for heat and power at the Blue Plains AWTP avoids fuel costs.

• **Heat for Thermal Hydrolysis and Anaerobic Digestion** Thermal Hydrolysis operates at temperatures between 150°C–170°C. The CHP can meet these process heat needs with steam remaining for other uses in the AWTP.

• **Greenhouse gas (GHG) reductions** When digester gas is used in the CHP, power and steam production have limited or no reportable GHG emissions (in contrast to current fossil-fuel derived power in the District of Columbia). A reduction in the AWTP's GHG inventory will have a significant positive impact on the District's overall GHG inventory. The digester gas-fuelled CHP results in a carbon reduction of about 48,000 tonnes of CO₂e per year.

Table 1 summarises the environmental benefits of DC Water's Biosolids Program.

(continued after Table 1)

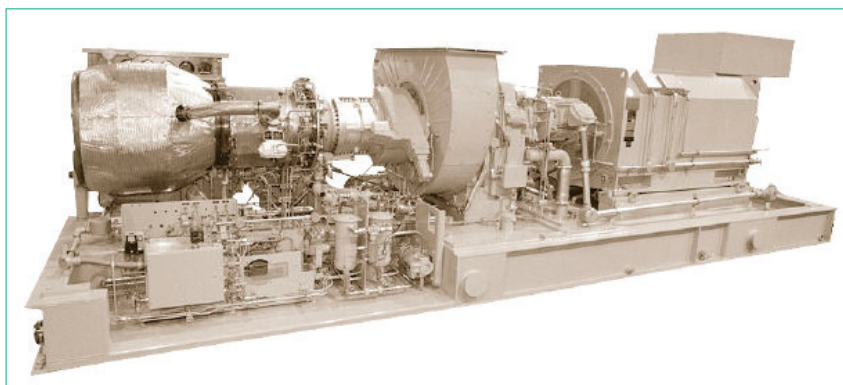


Figure 5. Solar turbine's mercury 50 gas turbine.

Table 1. Environmental benefits of DC Water's Biosolids Program (Willis et al., 2010).

Emission Source	2007–2008 Average Annual Emissions Estimate, Tonnes CO ₂ e	Project Annual Emissions after CAMBI™ Digestion Upgrades ^A , Tonnes CO ₂ e	Overall Predicted Reduction, Tonnes CO ₂ e
Scope 1			
Natural gas	2,976	2,976	0
Vehicle (fuel usage)	2,788	2,788	0
Refrigerants	125	125	0
Nitrification/denitrification (process emissions) ^B	3,472	4,687	-1,215
Effluent discharge (process emissions)	1,736	1,736	0
Total of Scope 1	11,096	12,312	-1,215
Scope 2			
Electricity ^C			
DSS	10,237	10,237	0
DWS	10,178	10,178	0
DWT ^{D,E,F,*}	133,387	85,356	48,031
Total of Scope 2	153,802	105,771	48,031
Total of Scopes 1 and 2	164,898	118,083	46,816
Scope 3			
Biosolids hauling (fuel usage/ distance travelled) ^G	4,154	1,853	2,301
Lime production	14,547	727	13,819
Methanol production ^B	7,167	9,676	-2,509
N ₂ O emissions from land application ^H	50,437	35,306	15,131
Methane emissions for landfilling biosolids	290	149	142
Scope 3 GHG Emission Offsets			
Carbon sequestration land application ^K	-28,886	-28,886	0
Composting ^K	-12,837	-12,837	0
Carbon sequestration landfill ^K	-56	-56	0
N ₂ O offsets from avoided chemical fertilisers	-50,437	-35,306	-15,131
Fertiliser credits direct applied biosolids (N and P) ^H	-6,812	-4,768	-2,044
Fertiliser credits composted biosolids (N and P) ^H	-1,054	-738	-316
Total Scope 3 Emission Offsets	-23,847	-34,880	11,393
Grand Total (Scopes 1, 2, & 3 w/Offsets)	141,412	83,203	58,209
<p>Notes:</p> <p>Elements for proposed (non-accepted) methodologies are designated with an asterisk(*).</p> <p>^A Lime stabilisation will be used to process 5% of the sludge production.</p> <p>^B Nitrification/denitrification N₂O emissions and methanol consumption are estimated to increase by 35% to treat additional ammonia recycle from dewatering of digested biosolids.</p> <p>^C Based on 1.145 tonnes CO₂e/MWh consolidated carbon intensity of power.</p> <p>^D Effluent N₂O reductions or electricity and/or methanol increases from ENR are not included in comparison.</p> <p>^E Blue Plains electrical consumption averaged 29.26 MW in 2007 and 2008. Assumptions include addition of 2.2 MW of new load associated with the Cambi digestion upgrades; 1.5 MW of aeration energy for recycle nitrification; and 1.3 MW of load reduction associated with lime equipment that will no longer be in service. For the relatively small fraction of sludge processed using lime stabilisation, it is assumed that the lime processing electrical load is added to the digestion facility load.</p> <p>^F 13 MW will be produced from digester gas, having entirely biogenic CO₂ emissions.</p> <p>^G Outloading of biosolids will be reduced from 65 to 29 trucks per day.</p> <p>^H Assumes 30% reduction land-applied nitrogen and no reduction in phosphorus.</p> <p>^K Assumes no change in sequestered carbon on a mass basis.</p> <p>DSS – Department of Sewer Services. This grouping includes the sanitary sewer pumping stations not powered by BPAWTP. Only natural gas and electrical emissions are included.</p> <p>DWS – Department of Water Services. This grouping included potable water booster stations. Only natural gas and electrical emissions are included.</p> <p>DWT – Department of Wastewater Treatment. This grouping includes the BPAWTP. This total includes electrical power as well as methanol and natural gas. Process emissions of N₂O from nitrification and denitrification and from evolution of N₂O from nitrogen species discharged in the plant effluent are also included. Biosolids treatment loads within the plant boundary are also included in this group.</p>			

Program Beneficiaries

This project will benefit the Washington, DC metropolitan area, i.e. residents of Prince Georges and Montgomery Counties in Maryland, Fairfax and Loudoun Counties in Virginia and the District of Columbia. In total, 2.2 million people are currently served by the BPAWTP. This is estimated to reach 2.7 million in the year 2030. The CHP will reduce air emissions in the entire DC metropolitan area with its population of 4.5 million people due to the highly efficient gas/steam turbines with low emissions. Energy costs will be reduced for DC Water customers.

Phased Approach To Achieve Cost Savings And Energy Reduction

Initial operation of the CHP uses natural gas for commissioning and then converts to digester gas from the Thermal Hydrolysis and Anaerobic Digestion facilities. Digester gas contains about 60% methane of biogenic origin, with no global warming impact when fully oxidised to CO₂ during combustion in turbines.

Economic Viability

DC Water's Biosolids Program has strong economic viability over current operations due to reduced land application costs, reduced use of lime and the economic production of electricity and heat using digester gas. Cost models developed for the Biosolids Program predict that annual O&M costs for the recommended program from 2015 onward can be about 40% of annual O&M costs for continued use and expansion of current lime stabilisation of biosolids. These dramatic savings provide the funding to pay for the required capital improvements (Figure 6.)

Meeting Air Emissions Requirements And Ensuring Adequate Steam Supply

The Biosolids Program must meet air quality and air permitting requirements, and the greatest potential for air permitting challenges is the CHP facility. The CHP must provide the steam requirements for the Thermal Hydrolysis process, and can produce electric power to offset

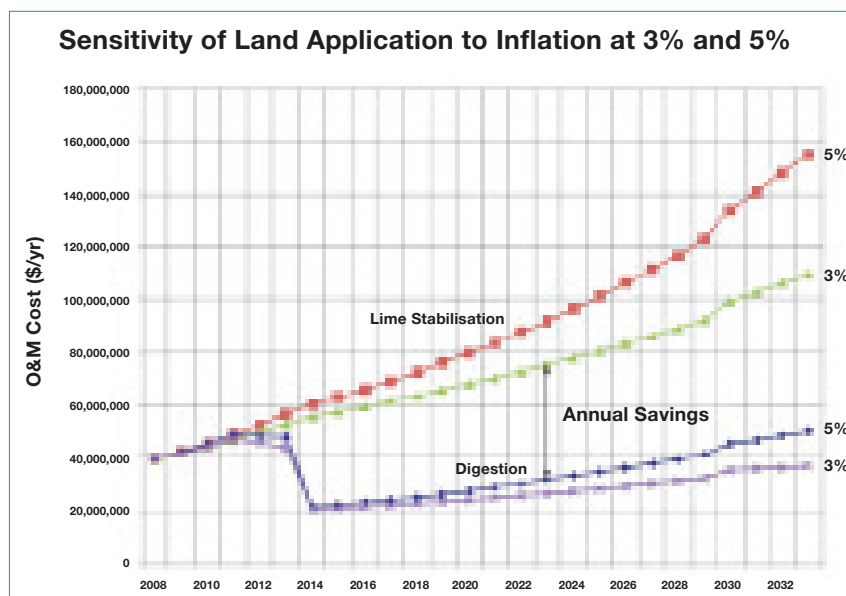


Figure 6. O&M cost comparison of digestion project (Biosolids Program) vs. lime stabilisation (continued and expanded) with 3% and 5% annual inflation.

major power purchases needed for the BPAWTP. NO_x production is perhaps the greatest permitting challenge for a project of this type located within the Washington DC Metro area, which is a non-attainment area for ozone.

Different prime movers and steam generation systems were evaluated in the development of the biosolids program, and the decision to utilise combustion gas turbines was highly influenced by the low NO_x emissions that these units can achieve. The turbines utilise heat recovery steam generators (HRSGs) to produce the steam requirements. Recent advances in gas turbine designs utilising recuperative exhaust now offer very high energy conversion (38%) and reduced air pollutants emissions. Solar's Mercury 50 is one example. Steam at about 1,200 kPa is required for Thermal Hydrolysis, and about one tonne of steam is required per tonne of solids throughput. Gas turbines are highly reliable if proper digester gas quality and consistent supply are provided. Siloxane treatment of the digester gas will be needed.

A steam boiler is being included to ensure high reliability of steam supply. The boiler could be operated on either digester gas or natural gas. Therefore, the risks for air permitting problems have been kept to a minimum, and the overall energy output is maximised.

Additional Options

DC Water continues to explore opportunities for becoming energy-neutral. The following options are actively being considered:

- Solar panels over process tanks. This option is estimated to yield 14,600 MWh/yr;
- Solar panels over parking lots, building tops, etc. This option is estimated to yield 8,700 MWh/yr.
- Co-digestion of food waste of 15 dt/d (150 wt/d) is estimated to yield 1.5 to 4.0 MW.

Also, DC Water is actively looking at reducing energy usage and the following projects offer opportunities for savings as follows:

- Improving efficiency of secondary treatment blowers; changing to finer bubble air diffusion for secondary treatment to yield 2 MW;
- Changing to Anammox for BNR to yield 4 MW benefit.

DC WATER SUMMARY

Although the addition of new Thermal Hydrolysis and Mesophilic Anaerobic Digestion facilities requires significant capital expenditure (US\$450M), the annual costs savings in operations provide the savings needed to repay this debt and stabilise future



Figure 7. Hill Canyon Treatment Plant (50 ML/d).

increasing its capacity in 2005, the plant was facing major energy cost increases. After the completion of a multi-year three-phased upgrade of the treatment plant about 13 years ago (new aeration basins, thickening, dewatering, increased secondary clarification facilities, more tertiary filters and a new administration building), HCTP staff turned their attention to facility optimisation,

costs. Maximising the benefits from renewable energy is central to the savings for DC Water's Biosolids Program. When the production of 10–13 MW of power without purchasing fuel is considered, coupled with the production of enough heat for Thermal Hydrolysis and other plant uses, the near elimination of lime addition and approximately 50% reduction in biosolids quantities, the cost savings potential is obvious. The fact that these facilities will produce Class A biosolids and that reliable standby power for critical plant process is inherently available is a major bonus.

waste activated sludge, anaerobic digestion, dewatering, solar drying with some dewatered solids going to Toland Road Landfill. Current biosolids production is about 6.6 dry tonnes/day (2,400 dt/yr) with dewatered solids ranging from 15% to 75% (Rogers *et al.*, 2008).

Due to its permit requirements and environmental concerns, energy requirements are higher than for a typical wastewater treatment plant. After upgrading the facility and

energy conservation and onsite renewable energy generation. This included decreasing energy usage through conservation and best energy management practices.

Energy optimisation and energy conservation are often interchangeable concepts. Optimisation leads to conservation and vice versa. Conservation in its simplest form is shutting off equipment or processes that don't need to be used to achieve

SMALL PLANT: THOUSAND OAKS' HILL CANYON TREATMENT PLANT

The City of Thousand Oaks' HCTP is an advanced wastewater treatment facility producing an effluent with 0.3 NTU turbidity, less than 1 mg/L suspended solids, nitrates averaging 7 mg/L and a Biochemical Oxygen Demand of less than 2 mg/L. It has a capacity of 50 ML/d, with current flows averaging 34 ML/d. Biosolids treatment includes thickening of primary and



Figure 8. The 2,783 solar panels at Hill Canyon Treatment Plant.



Figure 9. The 700 kW cogeneration unit installed in 2013.

treatment goals. At HCTP, that meant shutting off one of the two head works most of the time to conserve energy and preserve equipment life. It also meant shutting off an HVAC unit to a building that is not used from Friday pm to Monday am. Other examples abound. A multi-disciplinary review of everything undertaken at the plant was considered, taking into account energy conservation, wastewater optimisation and renewable energy generation.

One effective measure was installing Turblex aeration blowers, reducing the overall electrical load at the facility by 0.2 megawatt average daily electrical usage. Southern California Edison provided a rebate to the City of \$75k. Other energy-saving ideas included the replacement of virtually all facility lighting with new efficient bulbs of various types, and the replacement of inefficient blowers, an oversized HVAC unit, pumping systems and pumping schemes. VFDs were utilised where practical. Filter backwashes could be reduced, utilising turbidity analysis. Inefficient heater blocks of emergency generators were changed. Seasonal and diurnal control of HVAC for buildings provided significant savings as well, as did replacement of an oversized chiller (Rogers *et al.*, 2008).

Through these energy optimisation efforts over the last seven years the plant's electrical usage reduced

by 29%. Two renewable energy projects were implemented in 2007 after evaluation of solar power and combustion of digester gas. The City secured California Public Utilities Commission grants for a 500 kW solar array and a 500 kW cogeneration system totaling \$2M in grants, which were turned over to eventual power providers (Rogers *et al.*, 2008).

Initially the solar array was rated at an additional 500 kW, however, accounting for climatic conditions and daytime operation, its overall contribution is about 125 kW per day when averaged over 24 hours. Therefore the combined value of the solar array (125 kW) plus the cogeneration (500 kW) could provide about 50% of the plant's optimised power requirements at that time. Without the energy optimisation efforts, this would have only provided 35% of the plant's power needs (Rogers *et al.*, 2008).

Because the solar panels have an expected life of over 30 years, at the end of the 20-year contract the City would theoretically have 10 years of added cost savings. The cogeneration engines are expected to be replaced every five to seven years throughout the life of the contract (Rogers *et al.*, 2008).

After selection of the cogeneration system the City began accepting

restaurant grease and general fats/oils/grease (FOG) trucked into HCTP to increase digester gas production. That worked well and provided a revenue stream to the City exceeding the costs of treating it. Then HCTP moved ahead to accept high-strength waste to further boost the production of digester gas. The plant first received dairy waste and has now expanded to include waste from coffee beverage, brewery, yogurt and salad dressing operations. The City is continuing to identify other potential sources, including locally generated food waste.

Coupled with the above increases in waste streams into digestion, HCTP

embarked on improvements to the digestion system itself to optimise digester performance, i.e. VS destruction and reducing or eliminating operational problems such as foaming. One simple solution was to reduce the number of digester turnovers to two or less. There have been no negative effects in more than two years of operation and, when the pumps were coupled with VFDs, the electrical savings were dramatic.

In 2013 the cogeneration system was rehabilitated, and a single 700 kW cogeneration unit, including biogas cleaning, was added.

Now, with the current HCTP energy requirements optimised at 700 kW after the efficiency improvements, the increased production of digester gas, the solar panels and new cogeneration rated at a combined capacity of 850 kW are more than adequate to produce all the power needed for HCTP. In September 2014, and during the six months following startup, HCTP has achieved its goal of 100% production of its energy usage.

LESSONS LEARNED AT THOUSAND OAKS

HCTP engaged three engineering firms to design its grease waste delivery station, but eventually



Figure 10. Oxley Creek CAMBI installation and digesters.

completed the design itself based on extensive firsthand experience with the materials. Software was developed with a local integrator to smooth out gas production through a closed loop at the three digesters, and ramp waste pumping up and down as needed to provide steady gas production. This allowed operators to log in set-points and allow the SCADA to control the process instead of constant manual adjustments.

Revenues to the facility are generated from reclaimed water sales, land rentals to farmers, receipt of high-strength wastes, film and photo location fees, and beehives. It is important to note that HCTP is not different from many mid-sized treatment plants with anaerobic digesters that have the potential to generate more energy than needed. Aeration basin optimisation efforts and new dewatering equipment installation are expected to shrink energy usage by an additional 10% over the next two years.

AUSTRALIAN ASPECTS

Wastewater treatment is a significant energy user and water utilities are looking to minimise costs, so there are a number of WWTP studies on

energy efficiencies and sustainability happening in Australia. The recognised opportunities for reducing electrical usage through energy self-supply, and efficiency improvements within the treatment processes include:

- Appropriate pump selection and rationalising flow rates and operating pressure (duty points);
- Upgrading aeration systems – e.g. review type, blowers, tank depths and close control of DO;
- Anaerobic digestion, with biogas generation and on-site cogeneration (particularly for larger plants);
- Use of anaerobic co-digestion of biodegradable waste to promote biogas production;
- Improved monitoring and reporting of unit process energy efficiency;
- Improved training of operators to respond to changes in energy efficiency (de Haas *et al.*, 2015).

There are several examples of cogeneration being practised using biogas around Australia. In addition, the Oxley Creek STP (65 ML/d) in Brisbane was upgraded in 2006 with the CAMBI™ process (Solley,

2006; Barr *et al.*, 2008) and other biosolids enhancements have been implemented or planned at a number of WWTPs, including increasing temperature to improve gas output, and recuperative thickening or pre-thickening of sludges for digestion (Taylor and Batstone, 2015). The recuperative thickening process is regarded as a key strategy, since increasing the digester SRT has been shown to decrease biosolids wet mass, leading to lower out-loading costs, and increasing gas production by up to 20%. Hydrogen sulfide generation has also been found to reduce (Bharambe *et al.*, 2015).

Optimising the solids capture and carbon/energy balance in wastewater treatment plants with primary settling and anaerobic digestion also has good potential for increasing plant capacity and improving biogas and energy production though cogeneration, as well as reducing secondary process aeration demand for the plant. In one case study for Luggage Point STP (140 ML/d), the net result of the optimisation was a 30% increase in plant capacity, 40% increase in biogas production and significantly improved energy efficiency (Solley *et al.*, 2014).

CONCLUSIONS

It is considered that there are a number of opportunities to enhance energy efficiency at wastewater treatment plants, particularly around biosolids management.

Large WWTPs can produce significant flows of biogas, thereby allowing for the use of gas turbines with heat recovery steam generators (HRSGs). This combination of technologies offers the highest recovery of energy from combustion. It is considered difficult for large plants to find sufficient quantities of high-strength wastes for increased digestion and gas/energy production needed to achieve complete energy sustainability. In addition, large treatment plants are often constrained by available land and proximity to urban areas, so staging of biosolids facilities and operations can be problematic.

While the capital cost for energy sustainability facilities for large plants can be extensive, significant benefits can be achieved by adopting energy sustainability principles, even though maximum energy efficiency is not realised.

Smaller WWTPs generally should have less trouble finding high-strength wastes to supplement wastewater biosolids for digestion. Energy and heat production recovery are usually by combustion engines and low-grade heat recovery, due to their size, although these systems are not as efficient as gas turbines and HRSGs. Projects at small plants are typically less costly and less complex than for larger plants, and easier to implement. There are also significant opportunities for multiple sources of income, as demonstrated by Thousand Oaks.

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Chuck Rogers is the Wastewater Superintendent of Hill Canyon Treatment Plant, Thousand Oaks, California. Graduating from Eastern Michigan University in 1977, he is a national speaker in the US on issues of Renewable Energy and Wastewater Treatment Plant Optimisation.



David Solley is a Process Engineer with over 20 years' experience in the water industry, involving strategy development and planning, design, modelling, optimisation, operation and commissioning. He has led successful projects covering biosolids treatment, nutrient removal for municipal and high-strength wastewater and water recycling. David's biosolids experience includes concept development and detailed design of the Oxley Creek STP centralised biosolids treatment, including thermal hydrolysis pre-treatment for anaerobic digestion and sludge import facilities.



Mitch Laginestra is a Chemical Engineer and Master of Environmental Studies and is based in GHD's Adelaide office. He has over 30 years'

experience in the wastewater industry, involving operations, training, investigation and design of wastewater (municipal and industrial), biosolids and odour control facilities in Australia and internationally. Mitch is GHD's technical leader for Wastewater Treatment and Recycling for Australia, Asia Pacific, UK and Middle East.

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