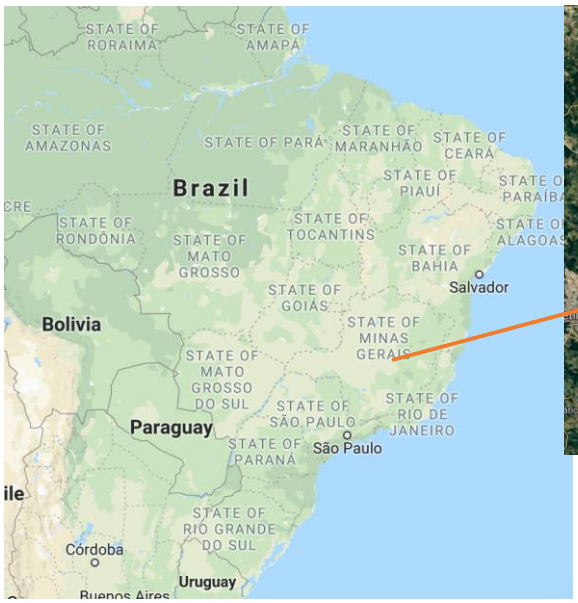
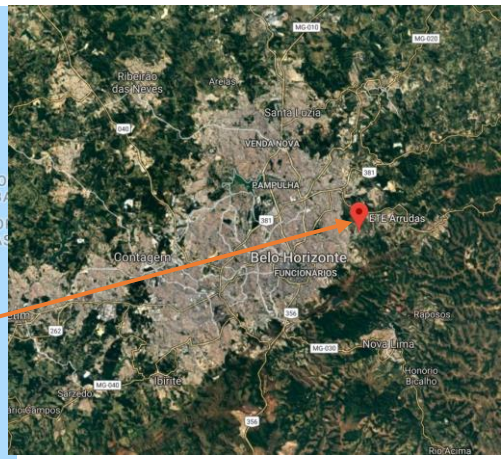
Case study: Arrudas Waste Water Treatment Plant Biogas Recovery

Conventional Activated Sludge with Anaerobic Digestion

By Christopher Godlove (2018)



Brazil



Location of Arrudas WWTP

Utility	Cia de Saneamento de Minas Gerais (COPASA)
Project Name	Arrudas WWTP Biogas Recovery
Location	Belo Horizonte, Mina Gerais State - Brazil
Population Served	1.5 million
WW treatment capacity	2.45 m3/second
Biogas produced	12,400 Nm3 / day
Energy generation capacity	2.4 MW
GHGs avoided (direct emissions)	880 tons CO2e / year
Technology overview	Activated sludge / 3 x 800 kW microturbines / Combined Heat and Power (CHP)
Point of contact	Ricardo Negri / Email: ricardo.negri@copasa.com.br http://www.copasa.com.br

The utility - COPASA

The **Companhia de Saneamento de Minas Gerais (COPASA)** provides water and wastewater services across the southeastern Brazilian state of Minas Gerais. Its water distribution network covers 48,000km with sewerage collection totaling 24,000km. In operation since 1963, the utility today provides water to 98% of the population living within its area of operations, and wastewater services to 83% of that population. One of Brazil's largest state run water and wastewater utilities, COPASA provides these services to over 800 municipalities across Minas Gerais, translating into water services provided to 13 million residential and 8.5 million wastewater users.

Photo credit: Instagram @vejadecima

Low-carbon connection:

Biogas recovery from sludge digestion offers an optimal strategy to reduce a facility's carbon footprint while building system resilience. Biogas recovery offers an independent energy resource close to the point of use. Digester biogas averages 60-70% methane and offers good energy recovery opportunities. Additionally, methane has a Global Warming Potential (GWP) 25 times* more than that of CO_2, meaning that reducing one ton of methane is 25 times more effective at reducing warming than the mitigation of one tone of CO_2.

** IPCC Fourth Assessment Report 2007.*

Arrudas – digesters, gasometers and microturbine housing

Plant overview - Arrudas Wastewater Treatment Plant (WWTP)

The plant receives municipal wastewater, treating it via a conventional activated sludge process, serving 1.5 million residents of the state's capital, Belo Horizonte. The Arrudas Wastewater Treatment Plant (ETE Arrudas) has a capacity of 2,25 m3/second with an average operational flow of 2,45 m3/s (2012). In the liquid phase (primary treatment), primary decanters remove suspended solids, fats and a portion of the organic material. Biological reactors then remove additional organic material via aerobic microorganisms acting upon the material, supported in the process by forced aeration. In the secondary treatment stage, secondary decanters separate the solids and liquid coming from the biological reactors, facilitating sedimentation and the formation of biosolids that settle at the bottom of tanks. In the solid treatment phase, anaerobic digestors receive biosolids from the secondary decanters and the process of stabilizing the organic material begins. Gas production kicks-off in this phase as digester temperatures reach the 30°C mark, at which point mesophilic processes activate, resulting in the production of methane.

Energy production and use

The Arrudas facility captures biogas from the plants' three anaerobic digesters. The biogas moves to transitional storage in a gasometer before receiving pre-treatment in a series of treatment skids – moisture, H_2S and siloxane removal. This pretreatment facilitates fuel combustion, preventing fouling of the turbines and maximizing their operational life.

The biogas produced by the digesters consist of 68% methane and 30% CO_2. The three, 800 Kw, Capstone microturbines are well matched to the characteristics of the biogas produced by the biosolids digestion. On average the plant produces 19.9 MWh a month, providing just over half of the plants' total energy requirements.

Focus on the Biogas Plant:

Capacity: 2.4 MW

Energy generation: 19,9 MWh/month
Energy consumed by plant: 37,4 MWh/month *(Jan 2013)*

Biogas production: 12,400 Nm^3/day
Methane content: 68%
Calorific heat value: 24.79 kJ/Nm3

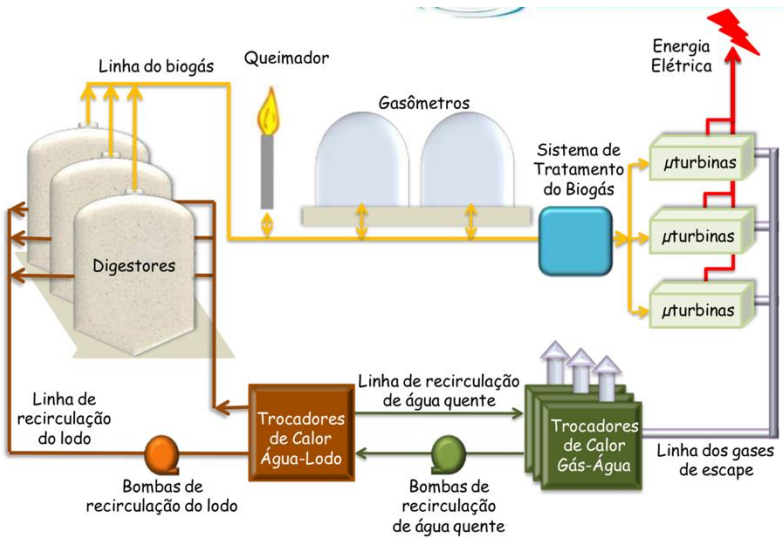
Control parameters for microturbines:

- Gas entry temperature control
- Pressure control
- Cooling water temperature
- Oil temperature

And for chiller (moisture removal):

- Pressure – suction and discharge

Energy produced is fed to the grid via interconnection and exhaust heat is captured by heat exchangers, providing a combined heat and power (CHP) loop that in-turn heats the digesters. The incorporation of CHP is an energy efficiency measure that permits the capture of waste heat which is then fed back into the digestion process, avoiding additional energy demand and associated GHG emissions.



Project drivers

While access to water supply is almost universal in Brazil, only about 39% of the country's wastewater is treated.[+] The barriers to expanding wastewater access are many, but energy inputs needed to power conventional systems have been one of the more significant barriers. Just under 9% of Copasa's total costs in 2012 were spent on energy, about 61 million Brazilian reais (14.5 million USD). By devising a means to generate on-site energy, and by incorporating a CHP element that offers additional efficiency gains, Copasa directly addressed the energy barrier to expanding wastewater services.

[+] *"Urban wastewater treatment in Brazil" Von Sperling, IDB, 2016.*

A second challenge that Copasa sought to address relates to biosolids handling. The biosolids produced by conventional activated sludge treatment pose treatment and disposal challenges for utilities globally. For the Arrudas plant, positioned at the edge of Brazil's sixth largest city, treatment and removal of biosolids represented significant costs both in terms of infrastructure and human resource investments. While biosolid digestion results in the production of significant quantities of biogas, it is perhaps best understood in the wastewater field as a means to stabilize waste and reduce volume, resulting in greater disposal options and reduced transport costs.

Project outcomes

The Arrudas biogas project offers a valuable example of a well-functioning energy recovery project that embraces the principals of low-carbon sustainability within municipal wastewater treatment operations. Since the project came on-line in 2011 it has avoided over 6,000 tons of CO_2e, emissions that would have otherwise been emitted directly to the atmosphere.[#]

Additionally the biogas energy plant provides sustainable green energy, powering a significant portion of the plants' total energy needs. The incorporation of CHP provides an additional sustainability measure by further boosting the efficiency of the project, directing waste heat back into the digestion process. Finally, the incorporation of microturbines as the primary mover, reduces overall environmental impacts, given their low-noise profile, low NOx emissions and minimal maintenance. The significant effort and investment made by Copasa in this project were rewarded in 2013 when the utility gained national recognition, receiving the Dimond Trophy, National Prize for Quality in Wastewater Treatment, given by the Brazilian Association of Sanitary Engineering (ABES).

Photo credit: Instagram @vejadecima

Future directions

Copasa has undertaken additional analysis, looking at opportunities to implement biogas recovery projects at other WWTPs in operation across their service area. They have begun this analysis by identifying those plants with a treatment capacity greater than 15 liters/second, which resulted in the identification of 40 plants. Of these 40 plants, Copasa determined that only the 5 plants treating over 300 l/second offer the necessary economies of scale to be viable both from economic and technical standpoints. The assessment of project feasibility of these plants is on-going.

[#] *GHG reduction estimates developed with Global Methane Initiative/World Bank "BioWATT" tool.*