Wastewater: From Waste to Resource

The Case of Santa Cruz de la Sierra, Bolivia

Covered Anaerobic Ponds and Their Potential for Energy Generation in Wastewater Treatment Plants

Context

The city of Santa Cruz de la Sierra is a fast-growing and economically dynamic city with a population of approximately 2 million (2012). Commonly known as Santa Cruz, the city is one of the world's fastest growing, home to one-fourth of Bolivia's population, and responsible for 30 percent of Bolivia's GDP (Camara de Industria y Comercio Santa Cruz, 2016).

Population growth at an annual rate of 6 percent and a lack of infrastructure created challenges for the Santa Cruz sanitation sector. Up until 2007, sanitation services were provided by 10 cooperatives, the largest of which was Servicio de Agua Potable y Alcantarillado Sanitario (SAGUAPAC), serving 65 percent of the city's geographic area. However, SAGUAPAC's actual

PHOTO 1. SAGUAPAC WWTP's Anaerobic Lagoons Covered to Collect Biogas and Reduce Odors Generated During Anaerobic Metabolization

Source: SAGUAPAC.

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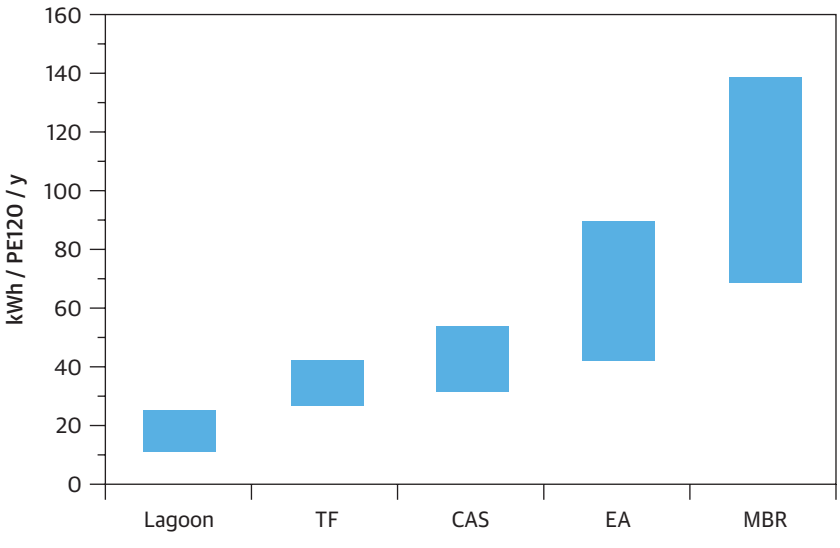
coverage in the service area hovered around 50 percent (World Bank 2007). The direct impact of the lack of infrastructure combined with continuous population growth was an infiltration of raw sewage into underground aquifers from housing unconnected to the sewage system. By installing covered anaerobic lagoons—an inexpensive solution to treat wastewater—SAGUAPAC is able to capture and burn biogas (methane). The biogas could potentially be used to generate electricity to cover part of SAGUAPAC's energy needs. Additionally, SAGUAPAC participated in the Urban Wastewater Methane Gas Capture project, which was developed to reduce greenhouse gas (GHG) emissions by burning the methane produced, generating carbon credits, and leveraging additional financing for sanitation infrastructure.

CHALLENGE
Rapid population growth and lack of infrastructure have led to increased wastewater flow, effluent aquifer infiltration, and high methane emissions
OBJECTIVE
• Increase wastewater treatment capacity cost-effectively
• Expand wastewater coverage and operational efficiency
• Generate cost savings through energy production
• Reduce GHG emissions from urban wastewater treatment facilities in Santa Cruz
• Use market-based instruments for financing

Project

As Santa Cruz struggled to increase its wastewater treatment capacity, covered anaerobic lagoons technology was identified as a possible solution. Not only are covered anaerobic lagoons cost-efficient and low-energy intensive but they also offer financial benefits such as energy generation and the ability to sell carbon credits for lowering GHG emissions. While lagoon wastewater treatment plants are demanding in terms of land requirements, they are considerably less capital intensive at US$50 per person compared with US$120 for conventional activated sludge. Similarly, operational expenditures (opex) are considerably less for lagoons than for other wastewater treatment technologies. Figure 1 shows the electricity requirements to operate different wastewater treatment technologies (electricity requirement is a good proxy for operations and maintenance [O&M] costs).

FIGURE 1. Electricity Consumption per Population Served per Year for Different Wastewater Treatment Technologies



Source: Crawford, Sandino, and CH2M Hill Canada Limited 2010.
Note: Based on assumption of 500 mg of Chemical Oxigen Demad/Liter, Lagoon data include anaerobic lagoons. PE120 is the population equivalent at 120 g COD/person-day (number of people served assuming that each person discharges 120 g of chemical oxygen demand per day). CAS = conventional activated sludge; EA = extended aeration activated sludge; MBR = membrane bioreactors; TF = trickling filters.

Anaerobic lagoons have been effective for the pretreatment

of high strength organic wastewaters and provide advantages such as the rapid stabilization of strong organic wastes. However, anaerobic lagoons produce high quantities of methane, a GHG with a global warming potential much more powerful than carbon dioxide. (U.S. EPA 2014) In Santa Cruz, SAGUAPAC operates four WWTPs with anaerobic lagoons, all consisting of screening and covers, followed by open air facultative and maturation ponds. The methane gas collected from the covered anaerobic lagoons is sent to water traps, where water is removed. Following the water traps, the biogas is sent to a station where it is monitored, pumped, and burned under controlled conditions. Burning the biogas reduces GHG emissions by transforming methane into water and carbon dioxide (a less potent GHG).

PHOTO 2. Water Traps at Biogas Line at SAGUAPAC WWTP

Source: Nolasco 2014.

An Emissions Reductions Purchase Agreement was signed in 2007. According to the agreement, the first of its kind in low-income countries under the Clean Development Mechanism (CDM), the Community Development Carbon Fund would buy emission reductions from four SAGUAPAC wastewater treatment plants. Given that biogas (methane) is captured, the natural next stage in the project is to switch from burning the gas to using it for electricity generation. SAGUAPAC planned to produce electricity generated from the gas captured from the covered lagoons, creating an estimated savings of up to US$1 million per year and producing enough energy (1900 kilowatts) to supply over one-third of the electricity used by the whole utility (water and wastewater). Payback of the system for the utility was estimated at two years (Nolasco 2014).

Financial and Contractual Agreements

With an urgent need in Bolivia to mobilize investments for sanitation infrastructure, SAGUAPAC saw an opportunity to treat wastewater with the added benefit of financial gains through energy generation and the sale of carbon credits. Construction of the facilities was partially financed through the World Bank Bolivia Urban Infrastructure Project, which aimed at improving the access to basic services to the urban poor in Bolivia's major cities through targeted infrastructure investments. A subsequent Urban Wastewater Methane Gas Capture project, framed as a carbon finance operation and financed through the Community Development Carbon Fund (CDCF), provided a cost recovery mechanism for the gas collection system through the sale and purchase of Certified Emissions Reductions (CERs) and Verified Emissions Reductions (VERs). Moreover, the future potential to generate electricity from biogas would also lower operational costs.

SAGUAPAC planned to use the national electric network to transport the electricity generated from its wastewater treatment plants to the various points where SAGUAPAC needs energy. The electricity legislation in Bolivia (Ley de electricidad) establishes that electricity distribution agents must allow the use of their networks to self-generating ("autoproductores") and consuming entities within their concession area, provided that the self-generating entity pays for the use of the network (transportation fee). The law applies to SAGUAPAC, since it is both producing and consuming electricity within the distribution network in Santa Cruz de la Sierra. The legislation says that if the installed capacity is below 2000 kilowatts, producers have to register only with the electrical regulator, which is a quick, inexpensive, and easy procedure. For capacity above 2000 kilowatts, producers would have to obtain a license as generators and become a market agent, which from an administrative and institutional standpoint is more complicated, as well as more costly to SAGUAPAC. SAGUAPAC, as a regulated consumer, has requested the use of the network to transport the energy generated at its wastewater treatment plants to various points where SAGUAPAC needs that energy. Since there is no legal framework that directly regulates the electricity transmission fee, the service needs to be negotiated between SAGUAPAC and the Bolivia power utility (Cooperativa Rural de Electrificacion [CRE]). The lack of incentives for the electricity distribution utility to promote this type of use of its network and a lack of governmental policies that consider intersectoral partnerships (in this case between the water and electricity utility) is delaying negotiations, preventing the use of this valuable resource and unnecessarily increasing the operation costs for the utility.

Regarding the sale of emissions reduction credits, the Urban Wastewater Methane Gas Capture project facilitated the issuance of carbon credits to raise revenue for further infrastructure and sanitation improvements. At the time of the project appraisal by the World Bank, Bolivia had ratified the Kyoto Protocol and was in a position to participate in the CDM and receive revenues from the carbon market included in the treaty. Since Bolivia had the ability to develop projects through the CDM, the World Bank could finance the purchase of CERs under the CDCF project. As a result, the World Bank, as a trustee of the CDCF, entered into a CER purchase agreement with SAGUAPAC for the four anaerobic lagoons. The investment needed to cover the lagoons and build the system for gas flaring came from funds from the World Bank Bolivia Urban Infrastructure project for two WWTPs; SAGUAPAC used internal financing for the remaining two WWTPs. Finally, the Bolivian CDM Designated National Authority approved the gas capture development, which made the project viable, given that the project was consistent with the country's overall Sustainable Development Goals (SDGs).[1]

Initially, the World Bank committed US$3 million for purchase of ERs (emission reductions) up to 2012. However, by 2010 the World Bank had disbursed only US$190,000 and subsequently canceled the CER purchase agreement due to a change in legislation. In 2010, Bolivia's legislative assembly passed the Law of the Rights of Mother Earth, granting rights to the natural world and life systems. Consequently, the concept of selling and purchasing natural resources, including carbon emissions, would no longer be consistent with the law. This resulted in a new government strategy for sustainable development: a strategy that did not include the Urban Wastewater Methane Gas Capture project and which thereby rendered the project ineligible for the CDM.[2] Although the CER purchase agreement was cancelled, SAGUAPAC implemented the methane gas capture systems at its lagoons in Santa Cruz and it continues to maintain operations at its wastewater treatment plants. Therefore, even if the project still has environmental benefits, it is not achieving its full economic potential.

Benefits

For SAGUAPAC

- Covered anaerobic lagoons have lower O&M costs than other wastewater treatment technologies
- Improved treatment capacity: heat from biogas combustion can be used to heat and mix the contents of the anaerobic lagoon, which improves its treatment performance, increasing the generation of biogas
- Investment secured through World Bank project and private funding meant financial risks were not directly associated with the carbon finance operation
- Future potential: by installing generators with total power of 1,900 kilowatts, SAGUAPAC could supply over one-third of the electricity used by all the utility, generating savings of US$1 million per year
- Potential (unrealized due to the change of legislation): the sale of ERs could have represented a total income of around US$ 2.79 million over 12 years.

Environmental

- Climate change mitigation: even if the sale of CER were not realized, the project stills reduces GHG emissions
- The project aimed at displacing over 44,000 tons of CO2e per year of operation

For the community of Santa Cruz

- Expansion of sanitary infrastructure and capacity
- Reduction of odors to nearby residential areas: by keeping the contents of the lagoon covered, undesirable odors are captured and burned, increasing the acceptance for wastewater treatment plants
- Community benefit plan was developed to connect up to 600 families in a low-income area of the city to a sewage treatment system financed through a premium added to the agreed ER price

Lessons Learned

Ambiguous legal and regulatory framework. The full potential of the project has not been realized due to ambiguous or lack of regulatory frameworks. Both the sale of carbon credits and the use of electricity generated have been stalled. At the time of project preparation, the CDM rules and Bolivia's definition of sustainable development were under development. Since the local regulation changed, the CDM was no longer the right mechanism to continue supporting this project. The lack of a regulatory framework to integrate water and energy utilities in Bolivia was a barrier to exploit the value added from biogas and convert it into electricity.

Benefits of methane gas capture facilities. By the end of the project, three functioning methane gas capture facilities were realized. SAGUAPAC benefited from the investment in terms of commitment to global environmental issues and improving wastewater treatment operational and safety measures even without the financial revenues of the CDM. In the future, with the right regulation framework in place, SAGUAPAC could generate electricity from biogas and decrease operational costs and could engage with the CDM if the legislation changes.

PROFILE

NAME

Santa Cruz Anaerobic Ponds and Methane Gas Capture

LOCATION

Santa Cruz de La Sierra, Bolivia

SIZE

118,000 m^3/day (capacity)

MAIN INNOVATION

Innovative contract agreement and finance

TECHNOLOGY

Covered anaerobic ponds

Methane gas capture and controlled burning

Potential for electricity generation

Strong and proven implementation capacity. The implementation success of the infrastructure part of the project can be attributed to the competence and interest of the SAGUAPAC to carry out the project. The choice of implementing agency was thus of key importance in the methane gas capture project design.

Integrated approach. The existing Bolivia Urban Infrastructure Project helped leverage funds and provide investment where it was needed. This allowed the Urban Wastewater Methane Gas Capture project to generate benefits through market instruments such as the CDM.

Conclusion

Integrating innovative financing mechanisms such as CDM and ER sales with concessional financing for infrastructure can add tremendous value and leverage further improvements where sanitation infrastructure is sorely needed. However, legal and regulatory changes—though unlikely to be as sweeping as the Law of the Rights of Mother Nature—can derail or delay successful project implementation. Furthermore, this case demonstrates that similar projects in the future should consider early in project preparation the potential for regulatory challenges, such as the lack of a legal framework establishing the cost to transmit self-produced electricity.

Notes

1. "A Designated National Authority (DNA) is the organization granted responsibility by a Party (Bolivia) to authorize and approve participation in CDM projects. Establishment of a DNA is one of the requirements for participation by a Party in the CDM" (UNFCCC 1997).
2. The rules for eligibility for the CDM incorporate a mechanism for country approval, which ensures the project contributes to local sustainable development.

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