Wastewater: From Waste to Resource

The Case of Santiago, Chile

Generation and Sale of Biogas

Context

In 2005, only 3.6% of the wastewater of the city of Santiago was treated (United Nations Climate Change, n.d.) The remaining wastewater was discharged untreated into the Mapocho river, an important source of irrigation and potable water for the region. In order to treat more than 50% of the wastewater generated by the city, Aguas Andinas, the company managing water and sanitation for the Santiago metropolitan region,

View of La Farfana Wastewater Treatment Plant.
Source: Anna Delgado Martin / World Bank.

assigned SUEZ the construction of the largest wastewater treatment plant in Latin America at the time, with a capacity of 8.8 cubic meters of wastewater per second: La Farfana wastewater treatment plant.

The plant was implemented through a build-operate-transfer (BOT) arrangement between Aguas Andinas and Degrémont S.A (now SUEZ), the sole contractor for the design, supply, engineering, construction, testing, and commissioning of the treatment plant. Degrémont (Suez) still operates the plant under renewable five-year operation and maintenance (O&M) contracts.

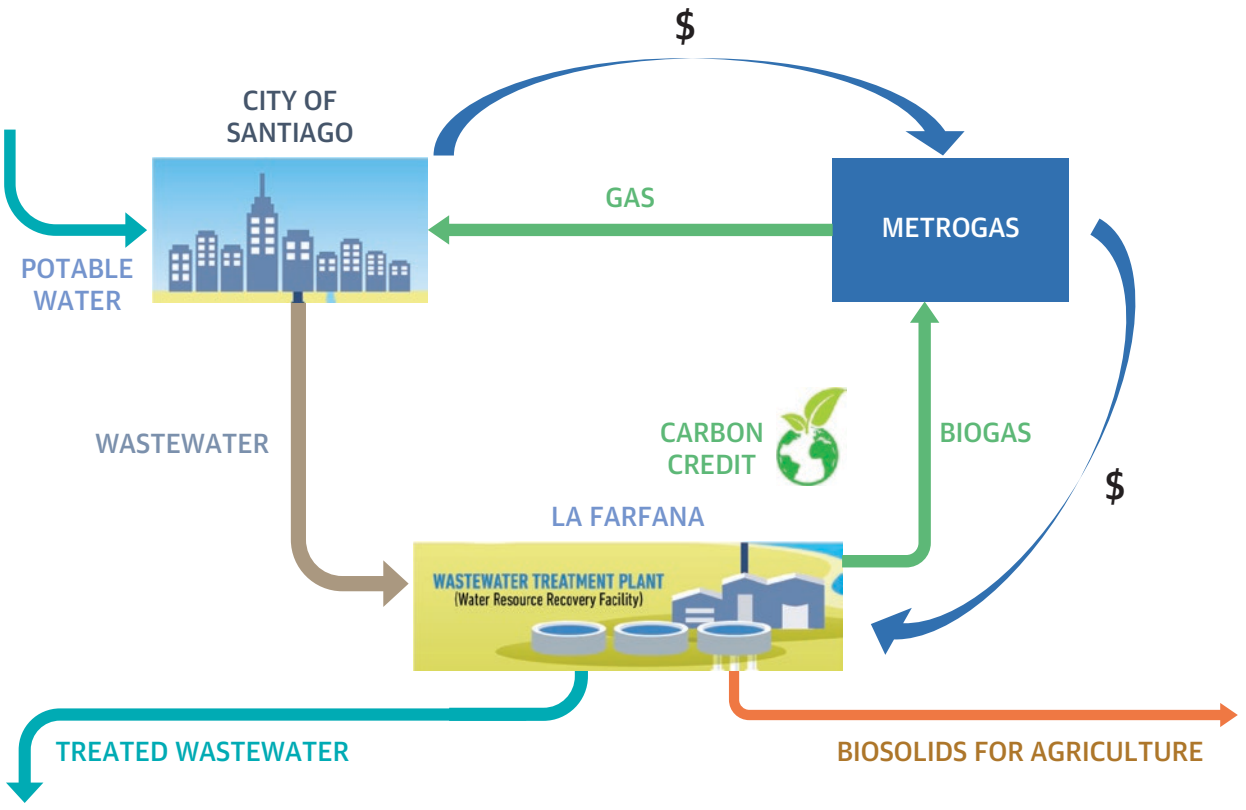
The plant treats 607,000-766,000 cubic meters a day of wastewater and produces an average of 11,752 cubic meters of sludge a month. The wastewater follows the traditional path of screening, then grit and grease removal, primary settling, biological treatment and clarification before finally being disinfected in chlorine prior to discharge (Suez n.d.).

The sludge is thickened and stabilized through anaerobic digesters before being dewatered and sent to drying beds. Originally, about 24 percent of the biogas produced in the anaerobic digesters (6 million cubic meters) was used for self-consumption to heat the biodigesters; the remaining 76 percent (19 million cubic meters) was flared in situ and therefore wasted (Aguas Andinas 2010).

Proposed Solution

In 2002 Aguas Andinas and Metrogas, a gas company, signed a memorandum of understanding (MoU) to explore using the biogas for residential use. Aguas Andinas would export the residual biogas generated at the wastewater treatment plant to the Town Gas Factory (TGF) of Metrogas. In the TGF, the biogas would be used as feedstock to produce town gas and then distributed to around 30,000 customers in the

FIGURE 1. Summary Diagram of the Biogas Project



city of Santiago (see Figure 1). The joint venture agreement involved upgrading the biogas from the anaerobic digesters to town gas quality. Between 2003 and 2006, both parties carried out the necessary studies to implement the project. In 2007 they signed a contract and began construction of the additional infrastructure needed.

Town gas quality is achieved with different treatments to eliminate humidity, and remove hydrogen sulfide (H_2S), carbon dioxide (CO_2) and traces of oxygen and nitrogen in the gas. Installations at La Farfana included gas holders, open flares, gas purification equipment, compressors, a dehydration system, and automated systems to control the operation and ensure the safety of the process (United Nations 2006).

The biogas is dispatched from La Farfana through a 13.5-kilometer pipeline to the Metrogas Town Gas factory, where an additional purifying process (siloxane removal) is implemented before the gas is stored to be sent to residential users (United Nations 2006). In the event that Metrogas did not require more biogas, three open flares would burn the biogas. The biogas project began operation on May 13, 2009.

Business Model

The total cost of the project was about $6 million. The capital investment was divided equally between Grupo Agua Andinas, which invested in improved biogas catchment and treatment, and Metrogas, which invested in the 13.5-kilometer gas pipeline and the final treatment of the biogas (to remove siloxanes). In 2017 Aguas Andinas' profits from the sale of biogas were $1 million ($3 million in revenue and $2 million in O&M costs). Metrogas spent $3 million on the purchase of biogas, but saved an estimated $1.6 million (the difference between the price it would have paid to import the biogas and the price it paid Aguas Andinas).

Moreover, the project was registered as a Clean Development Mechanism (CDM)[1] on February 11, 2011, enabling Aguas Andinas to arrange the sale of renewable energy certificates (RECs). The project developer decided to apply a seven-year crediting period, which can be renewed twice, for a maximum of 21 years. The estimated amount of emission reductions to be claimed by the project activity in its first crediting period (2011–18) was 138,516 tonnes of CO_2 equivalent (19,788 tonnes a year),[2] a source of potential extra revenue.

The main construction risks were related to the transport system for the gas. In order to build the pipeline, Metrogas needed to obtain several permits and follow various regulations. Permitting for the pipeline project required clearance from the Ministerio de Vivienda y Urbanismo (SERVIU) and right-of-way permitting from the city.[3] Given these costs, it would have been ideal to ensure long-term supply of biogas. However, the agreement was made for just six years (renewable thereafter).

An interesting aspect of the business model is that production of upgraded biogas is not considered part of the duties of Aguas Andinas in the applicable water regulation. The cleaning of the biogas and its transport to Metrogas is performed by a nonregulated subsidiary company, Aguas de Maipu S.A., which is owned by the Aguas Andinas holding company. Therefore, the return on the investment made by Aguas de Maipu is recovered entirely by the holding company.

Other Businesses that Could Be Developed

Wastewater Reuse

Wastewater reuse is potentially the largest resource recovery market in terms of volume. La Farfana produces more than 600 million cubic meters of treated effuent a year that is suitable for irrigation. Currently, the effluents from the plant return to the river, and farmers are able to use the treated water downstream. Under Chile's water regulation, Aguas Andinas maintains ownership of the water rights until the water's

Biogas Holders at La Farfana Wastewater Treatment Plant.
Source: Anna Delgado Martin / World Bank.

final disposal, but the definition of final disposal is unclear. Moreover, the regulated business of water supply and sewerage services does not put any value on the treated effluent, as the treatment service is already charged to water users.

After further treatment, this treated water could be distributed through a distribution network to farmers using sprinklers or drip irrigation. However, the current water abstraction fee paid by the farmers ($0.012 per cubic meter) would be insufficient for Aguas Andinas to cover the extra treatment and distribution costs. The treated water could also be sold to industrial users at a higher price.

Biosolids

La Farfana produces about 800 tons of sludge a day. After the dewatering and drying process, the plant yields about 120 tons a day of dry biosolids. Depositing the biosolids in landfills costs about $40 a ton—an annual cost of $11.6 million.

Aguas Andinas has explored alternative uses for its biosolids. Currently, about 40 percent of the biosolids are used in agriculture, at no cost to the farmers. Aguas Andinas pays the transport cost, which averages $13 per ton. It does so because this cost is lower than the landfill cost; delivering biosolids to farmers saves Aguas Andinas about $27 per ton, reducing the company's costs by $3.2 million a year. Farmers benefit from free fertilizer, but many of them are reluctant to use it, because of lack of knowledge on its exact contents. In addition, regulations restrict the use of biosolids on some crops.

Aguas Andinas is evaluating the feasibility of entering the compost business, to increase the amount of sludge that could be used by farmers. The company created a nonregulated subsidiary, ECORILES, that is exploring this business. As with the sale of biogas,

the activities of Ecoriles, which is 99 percent owned by Aguas Andinas Holding, are not regulated under the concession agreement for water supply and sewerage.

Financial Structure, Financial Instruments, and Risk Mitigation

Financial Structure

The biogas project was established through a joint venture agreement based on a memorandum of understanding made in 2002, while La Farfana was under construction. The contract between Aguas Andinas and Metrogas was signed in mid-2007; the gas project was ready for operation in December 2008.

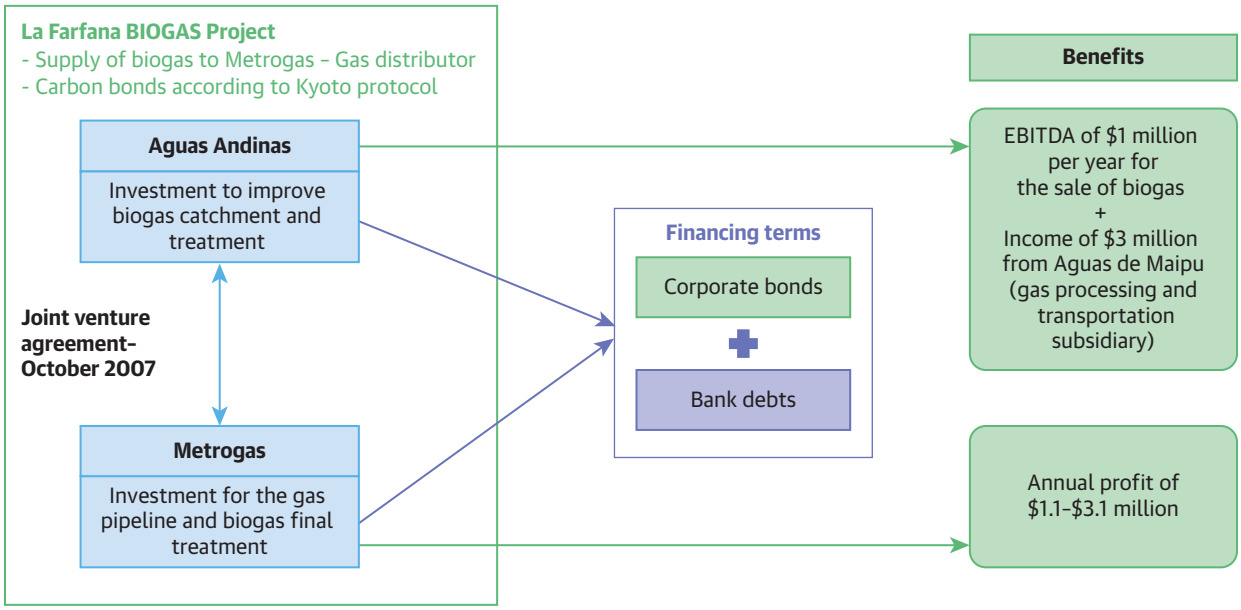
The joint venture consisted of a purchase/sale agreement between Aguas Andinas and Metrogas. The conditions of the agreement were as follows (figure 2):

- The price of biogas is fixed and indexed to the price of oil.
- The energy value of the biogas is measured in situ, to ensure its quality.
- A minimum volume of biogas is guaranteed per trimester.
- The agreement is for six years, renewable thereafter.
- Aguas Andinas and Metrogas finance their respective parts of the project with corporate bonds and bank debt.

Financial Instruments

Aguas Andinas used both corporate bonds and green bonds to finance the project. Every year the company issues corporate bonds to finance its investments (and refinance part of its existing debt if it makes sense to do so). Bonds are issued in local currency and sold in the domestic financial market. The good market return and long tenure (5-25 years) make the bonds of this AA+ rated company very attractive for institutional investors and insurance companies.

FIGURE 2. Terms of 2007 joint venture agreement between Aguas Andinas and Metrogas and benefits of deal to each party



Source: ITAC.
Note: EBITDA = earnings before interest, tax, depreciation, and amortization.

Using green bonds to finance green infrastructure projects like the biogas project was a logical step in Aguas Andinas' corporate strategy. The company launched its offer, of about $65 million, in April 2018. The term was seven years with a three-year grace period and a return of 1.8 percent. The issuance was sold in a record time of eight seconds, with demand exceeding the offer by a factor of 3.6 (ITAC 2019).

Risks and Mitigation

Demand risk for biogas was covered by the supply agreement with Metrogas. The initial six-year agreement allowed Aguas Andinas to pay back its investment on the project while giving it some freedom to renegotiate a new agreement with Metrogas, keep the gas for self-use, or sell it to other users, depending upon market conditions. Regulation risk is low, given the stable regulatory framework in Chile.

Benefits

The deal provides economic, environmental, and social benefits.

Economic

- It increases Aguas Andinas' energy efficiency, provides additional revenue from biogas and carbon credits, and allows it to access the green bond market.
- It reduces Metrogas' dependency on imports and the price it pays for gas and allows Metrogas to distribute a product that is more sustainable than natural gas.
- It allows farmers using the conditioned sludge (biosolids) to reduce the use of fertilizers by 50 percent, reducing fertilizer costs.

Environmental and Social

- It reduces local air pollutants and global greenhouse gas emissions (by replacing natural gas with biogas).
- It increases energy sustainability.
- It harnesses local resources and creates know-how

Lessons Learned

The Biogas Business Model Can Be Profitable for All Parties If Designed Correctly

The biogas business model has been profitable for both Aguas Andinas and Metrogas. Aguas Andinas reported a $1 million profit from its biogas selling activities in 2017 (Aguas Andinas 2017). Aguas Andinas also benefited from additional savings from the use of biogas for heating the biodigesters. The project also allowed the company to identify other waste to resource projects, such as potential power-generation activities in other plants or the beneficial use of biosolids, and it allowed Aguas Andinas to implement circular economy principles.

The Spill-Over Effect: The Biofactory Concept

The biogas project in La Farfana was a starting point for the transformation of the management of wastewater treatment plants operated by Aguas Andinas into "biofactories"—which Aguas Andinas' CEO defines as "business units that do not generate waste, have no environmental impacts, and that do not consume fossil energy but produce their own energy to operate."[4]

The bio-factory project was launched in 2017 to pioneer innovative circular wastewater treatment solutions in Santiago and in the sector. With this new concept, Aguas Andinas wants to promote a paradigm change, moving from the treatment to the management of resources, from a linear to a circular approach in which biofactories extract and supply new valuable resources, such as electricity, natural gas, agricultural fertilizer, or clean water from what it used to be considered waste. The goal of Aguas Andinas is to be zero waste, energy self-sufficient, and carbon neutral in its three wastewater treatment plants in Santiago by 2022.

Encouraging utilities to implement waste to resource projects could lead to a profound change of their corporate culture, toward circular economy principles and could trigger the development of more waste to resource projects.

The Need for Appropriate Regulation

Before 1991 agricultural produce for the Santiago metropolitan area was supplied from 130,000 hectares of agricultural land, irrigated with untreated wastewater pumped by farmers from the river (World Bank 2010). In 1991 the area was struck by a severe cholera epidemic. The use of untreated wastewater for irrigation of food products was found to be a critical vector of the epidemic. In response, the government implemented new regulations, which included banning irrigation from contaminated surface waters and food products that come from these irrigated lands. The new regulation triggered the construction of wastewater treatment plants throughout Chile, with the target of treating 100 percent of wastewater. Despite Chile's success in treating wastewater, the strictness of the public health regulation made the sale of treated wastewater very difficult and costly. More appropriate regulation on the use of treated water for irrigation should be introduced to reduce costs and encourage direct reuse.

Enabling Factors

Financially sound partners. Both Aguas Andinas and Metrogas have sufficient creditworthiness to finance their investment with corporate debt or equity and to provide sufficient guarantees to each other. For other business lines, such as treated water or biosolids, where Aguas Andinas' counterpart is not a single entity, the counterpart is not creditworthy, or the market is not attractive, other incentives are needed. The government could provide clearer regulations, standards or subsidies to promote resource recovery projects beyond biogas generation.

Water sector regulation that fosters innovation. Chile has one of the oldest and more stable water service regulators in Latin America. The sector also prides itself on having a modern and effective regulatory framework. The World Health Organization considers Chile's water and sanitation regulatory system to be a model not only for Latin America but also for Europe. The tariff model of the Chilean regulator, Superintendencia de Servicios Sanitarios, fosters innovation and efficiency improvements by utilities. It provides a grace period of five years during which utilities can keep the profits obtained from an innovation before they are obliged to pass them through to consumers via tariff reductions. This feature provides sufficient incentive for private operators to keep innovating. The regulator has also embraced the goal of converting waste into resources. Tariff estimation methodologies specifically allow to include the capital and operational costs for potential waste to resource projects.

Long-term agreement among stakeholders. Success also depended on the long-term agreement between Aguas Andinas and Metrogas, which ensured demand for biogas, thereby giving Aguas Andinas the confidence it required to make the needed investments.

Notes

1. Under the Clean Development Mechanism, emission-reduction projects in developing countries can earn certified emission reduction credits. These saleable credits can be used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol. See https://cdm.unfccc.int/
2. Clean Development Mechanism Project Design Document Form (CDM-PDD) Version 03, in effect as of July 28, 2006.
3. The pipeline design was made according to ANSI B31.8; construction was performed in accordance with regulation DS 254/98. Pipeline operations and maintenance are performed under regulation DS 254/98 and DOT191 and 192.
4. Narciso Berberana, CEO, quoted in Aguas Andinas' 2017 annual report.

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