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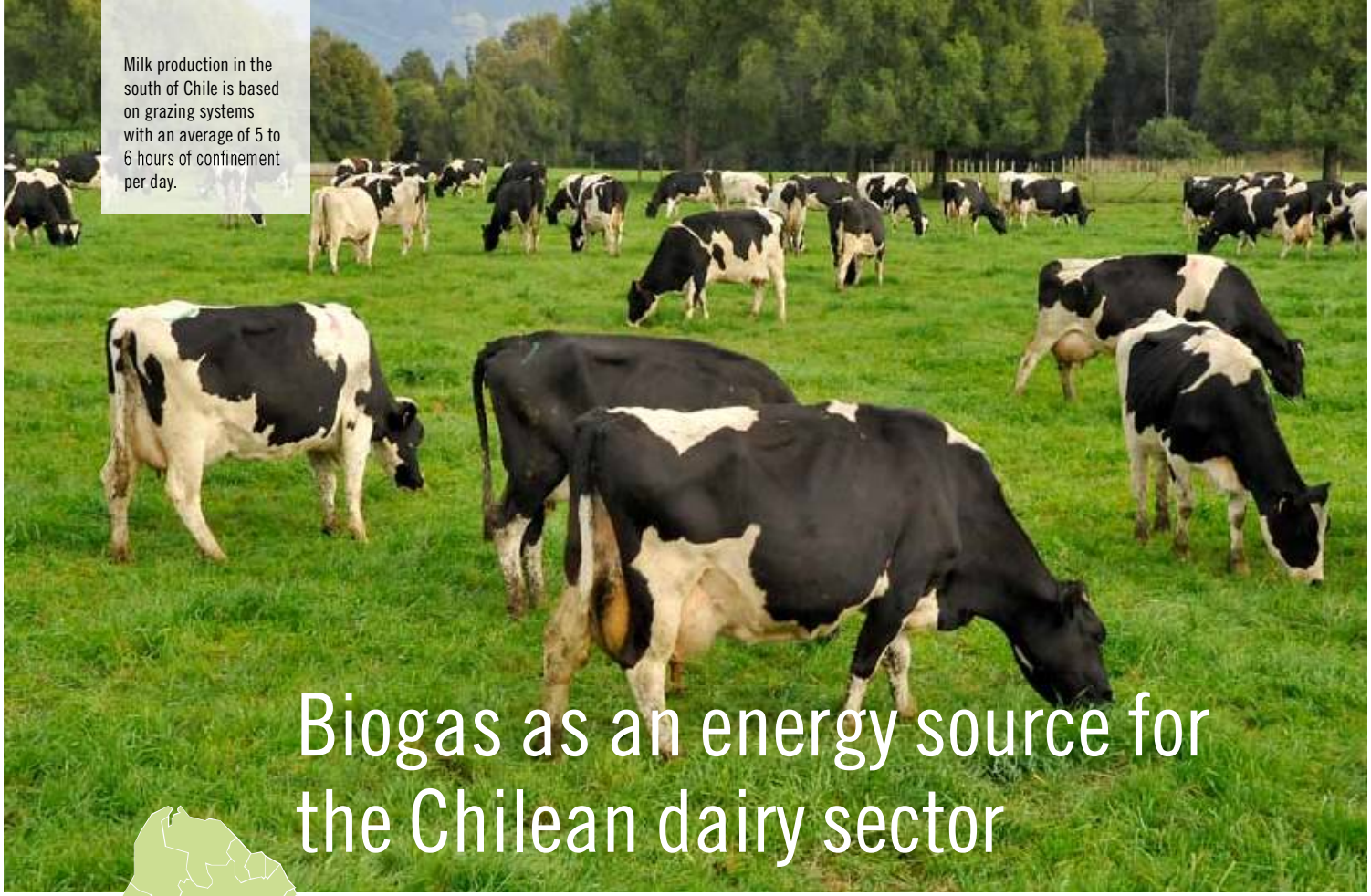

Milk production in the south of Chile is based on grazing systems with an average of 5 to 6 hours of confinement per day.

Biogas as an energy source for the Chilean dairy sector

Chile is probably the longest and narrowest country in the world. Its mainland is more than 4,000 km long with an average width of just 180 km. This provides the country with a great diversity of climates, soils and landscapes. Administratively, Chile is divided into 16 regions, but there are four large macro regions: Far North (Arica Parinacota to Atacama regions), predominantly a mining area in a country where this activity is the driving force of the economy; Near North and Central Chile (Coquimbo to El Maule regions), mainly agricultural areas with large production of wine, fruits and vegetables; the South (Biobio to Magallanes regions), largely dedicated to forestry with a significant presence of agriculture, livestock and fishing, which is also present in the rest of the country.

By Marianela Rosas, Javier Obach and Christian Malebrán

Given the aforementioned, it is apparent that Chile is a country where economic activity is strongly connected with the exploitation of natural resources, producing a significant amount of waste. This fact, along with the agreements signed for climate change mitigation, the existence of an energy policy with sustainability as one of its pillars, and increasingly strict environmental legislation, inspire efforts to explore biogas technology as an alternative for treating waste and a way of developing a local energy source.

In this context, Chile's dairy sector is attractive for the implementation of biogas, since it constitutes a significant activity for the local economy, where biogas generation is not new. The sector comprises approximately 4,600 commercial producers with 10 to 5,000 cows each (information provided directly by *Consorcio Lechero*), with a large number of medium-sized producers (between 100 and 500 cows). Although the activity is carried out from the Valparaíso region (32° 02' S) in the southern tip of the country, 84% of the cows are concentrated in the regions of Los Rios and Los Lagos (*Consorcio Lechero*, 2016). However, these regions have a mild, wet climate with rainfall of around 1,200 mm/year and surface temperatures between 6 and 18° C. This means the cattle feed on grassland, which does not facilitate the collection of faeces and urine.

The high rainfall in the area, along with the scarce adoption of measures to channel or collect rainwater and the excessive volumes of water used for washing yards

PHOTOS: UNIDO

Well for slurry storage and biogas plant in Frutillar, Los Lagos Region.

and milking equipment, directly affects the volume and constitution of the effluents generated. It is estimated that 80% of the effluents or slurry volume is made up of water. In addition, faeces and urine collected during the livestock's confinement period represents barely 25% of the total volume generated. This means the average content of dry matter in slurries (mixture of faeces, urine and water) is around 2-3% (Salazar, 2012). Slurries are stored in wells built for this purpose, and from here they are pumped for application on grasslands as a source of nutrients. On average, a milking cow produces 105 litres of slurry a day, ranging from 34 to 260 L/cow/day. From the point of view of energy demand, the cost of energy in an average medium-sized dairy in Southern Chile is low, when compared to other production costs such as food and grassland fertilisation and represents about 5% of total production costs. Electricity consumption costs in this milk-producing area are currently around USD 0.13/kWh, with variations depending on the price contracted and the distributor.

On the other hand, there are significant variations in demand for electrical power depending on the size of the dairy and its automation. Electricity consumption of around 8,000 kWh/year has been reported for dairy farms with 200 cows or fewer (Agricultural Development Institute, INDAP, 2015) and around 100,000 kWh/year for dairy farms with 500 to 1,000 cows. Thermal consumption can also be significant: around 3,600 kWh/year for dairy farms with 200 cows or fewer (INDAP, 2015) and 280,000 kWh/year for dairy farms with 500 to 1,000 cows, with a significant consumption of firewood produced on the same property.

Status of biogas technology in Chile and in dairy systems in the south of the country

According to a biogas plant survey carried out by the Chilean Ministry of Energy, there are a little over 100 plants of all shapes and sizes. Around 60 of those are operating, producing biogas mainly from municipal waste, but with a large number of projects being carried out in the animal production and food industry.

Nearly half these projects are labelled as small (power rating from 0 to 180 kW) and allocate the generated biogas to self-consumption, while 13 plants are feeding electricity into the interconnected system that has an installed capacity of 59 MW, representing 2% of non-conventional renewable energy installed capacity ▶

Biogas plant in Osorno, Los Lagos.

in Chile (National Energy Commission, CNE, 2017). This shows that the technology is still relatively unknown in Chile, which explains why around 19 biogas projects were abandoned for various reasons. These reasons include the complexity of their operation, poor design, and lack of trained personnel for the operation and maintenance of the plants, which in the short term discourages users due to constant breakdowns.

The dairy sector of southern Chile is a reflection of what is happening at the national level. According to a survey conducted by the Centre for Innovation and Promotion of Sustainable Energy (CIFES), the Agricultural Research Institute (INIA) and UNIDO (2016), there are 14 biogas plants installed in dairy farms throughout Los Ríos and Los Lagos. They are all small but only six are in operation. The cattle farms surveyed have between 27 and 400 milking cows and treat from 0.26 to 8.92 m3/day of slurries as their only inflow.

Most of the digestion technologies used in the dairy sector are covered lagoons with no heating or stirring system, with an average operating temperature of 13° C. This, added to the low content of organic matter in the slurry, results in a relatively low amount of biogas. Therefore, it is mainly used for heating water to be used in feeding the calves or cleaning milking equipment. To a lesser extent, there are new projects involving electricity generation and co-generation but with very low efficiency, mainly because of the lower efficiency of transforming biogas into electricity.

Programme to promote biogas in dairy farms across the country

Chile made a formal commitment to gradually increase the share of renewable energy in the energy mix some years ago. This is mainly due to the requirement for higher energy self-sufficiency at reasonable costs and compliance with the agreements on climate change. This objective has been met successfully in the large electric generation projects segment, mainly with large-scale photovoltaic and wind power systems. However, the same growth has not been apparent on a smaller scale with projects for energy self-consumption.

There are certain barriers in the self-consumption segment, which hinder the widespread use of renewable technologies and biogas in particular. These barriers relate to: a) lack of information and user distrust of this technology; b) high investment costs and limited access to traditional financing sources; c) absence or limited presence of local suppliers; and d) high dispersion of costs, among other things. In the case of biogas, the complexity of design and operation of the projects add to the previous barriers, which makes it necessary to have specially trained personnel for this purpose.

Therefore, the necessity of creating a programme to address these barriers and questions was clear, in order to promote this technology as an energy source for self-consumption and as a GHG mitigation tool. The dairy sector was considered an adequate starting point, since there are a good number of small and medium-sized producers concentrated in a relatively limited territory, where a substrate with potential to produce biogas is generated on a daily basis.

In September 2014, the project "Promoting the development of biogas energy amongst selected small- and medium-sized agro-industries" was launched with funding from the Global Environment Facility (GEF). This was implemented by the Ministry of Energy together with the United Nations Industrial Development Organization (UNIDO) as the implementing agency. The project focuses on small and medium-sized dairy farms (100 to 500 milking cows) from Los Rios and Los Lagos regions, and defines activities for achieving three main components. The first one is to produce valuable information and strengthen the regulatory framework for biogas; the second to create technical capacities in those in charge of operating and developing biogas projects; and a third component to develop a portfolio of operating projects that allows for the mitigation of greenhouse gases and to continue producing specialized knowledge in the field.

A relevant milestone to date is the technical preliminary feasibility studies conducted on 57 small and medium-sized dairy farms, which did not show very favourable results at first. Although it is estimated that these projects could mitigate an average of 80% of the CO_2eq emissions of dairy farms, none of the cases was proven profitable regarding energy saving or sales.

The main reasons for these results lie in the features of this sector, set out at the beginning of this article: mainly grazing systems with an average of 5 to 6 hours of confinement per day and excess water in the slurries (due to washing and rain). This means that the 0.2 m^3 CH_4/cow/day of biogas and methane (energy) obtained are insufficient to recover the investment within a reasonable period.

Another factor that contributes to this low profitability is that the thermal energy required by dairy farms is mainly supplied by firewood from the same property, obtained at a very low cost. On the other hand, bovine slurries in Chile do not have a large environmental impact as opposed to other waste, such as those from the pig industry where implementing biogas offers an alternative in order to avoid fines or even closure for non-compliance with the law.

Therefore, finding the key to encouraging the development of a biogas market for self-consumption in the Chilean dairy sector is still a challenge. That is why it is necessary to keep producing public technical and economic information, as well as moving forward in training professionals and technicians for the design and operation of biogas plants. These challenges will be addressed by the GEF Biogas programme during 2017 and 2018, but it will undoubtedly require a continuous effort that also includes other agricultural sectors, encouraging a more efficient use of water and understanding biogas technology mainly as an affordable and sustainable option for waste treatment.

In the particular case of Chile, which does not have a grant policy for developing renewable technologies, it is key to search for new business models that enable the farmer to finance these projects, such as the ESCO model or an associative model. It is also necessary to look for ways to transform all the non-energy benefits of a biogas project into financial benefits for the farmer, such as those derived from a cleaner production, using digestates for fertilising grasslands and more efficient use of water, etc. ◄

Authors

Marianela Rosas
Regional Coordinator of the GEF/UNIDO project

Javier Obach
National Coordinator of the GEF/UNIDO project

Christian Malebrán
Chilean Ministry of Energy, Division of renewable energies
Director of the GEF/UNIDO project