BIOGAS IN SOCIETY
A Case Story

DISTRIBUTED GENERATION USING BIOGAS IN A MICRO-GRID

IN THE WESTERN REGION OF PARANÁ, BRAZIL

IEA Bioenergy Task 37

IEA Bioenergy: Task 37: February 2019

MISSION AND VISION

Projections from the Food and Agriculture Organization of the United Nations suggest that Brazil will consolidate its position as the world's largest producer of animal protein, soy, corn and biofuels. The Western region of Paraná is one of the largest and most important producers of animal protein in Brazil. Animal husbandry uses the feedlot model. This leads to significant numbers of pigs, poultry and dairy cattle, which generate a large amount of organic wastes (such as animal manures and bedding material) in a concentrated space. This can be a limiting factor in expanding the scale of production if there is no suitable safe disposal or treatment route in place to address the organic waste produced. The feedlot model also requires electrical energy on site. Biogas systems offer a solution in that the organic wastes produced represent a significant resource of energy potential in the form of biogas, which can be used to produce electricity and digestate for biofertilizer, whilst reducing the environmental impact of the wastes and the associated feedlot model.

CONCEPT

One of the challenges faced when using organic wastes arising from animal husbandry for biogas production is the scatterd rural nature of the resource. Animal husbandry practices are usually spread throughout the territory and are remote from the national electricity distribution grid. The possibility of distributed generation (DG) in combination with the electricity grid does not increase existing demand on the national grid and can reduce losses in transmission and distribution lines. DG can improve the reliability of the electrical system and improve the quality of energy in congested areas and at the edges of the distribution grid.

If the electrical energy produced from biogas is not of the specified quality, particularly in regions with vulnerabilities in the electricity grid, the electrical utility may not allow connection. To overcome this, distributed generation must be supported by microgrids. A microgrid can be defined as a portion of the electrical grid, in which one or more generating units provide the electric power needed to supply the internal demand of the microgrid in case of contingency, such as in the event of a fault in the energy supply from the electrical utility (Figure 1). Under normal conditions of operation, i.e. when the electrical utility supplies electrical power, the energy is sent to the grid (DG), reducing the energy cost to the owner of the generating unit (Figure 2).

Rural microgrids have several benefits both for the rural producer/farmer and for the electrical utility. The rural producer will be able to invest in infrastructure to treat organic wastes associated with production of animal protein, whilst improving the environmental sustainability of meat production, and will have reliable electrical energy with overall reduced energy bills. The electrical utility will benefit from overall gains in stability of the grid, higher efficiency electricity with a decrease in transmission losses, and local controllability.

DISTRIBUTED GENERATION AND THE MICRO-GRID

In the decentralized model, the biogas is produced through basic biodigesters, such as covered lagoons, at the rural farms, where the manures are produced. The biogas is stored, then transported through gas pipelines to a central site, where electrical energy is generated.

In the centralized model, the manure is conveyed to a larger and more advanced anaerobic digester, such as a continuously stirred tank reactor (CSTR). These digesters are constantly monitored for variables that affect the biogas production, such as temperature and pH. Corrective action is taken when variables indicate stress on the digestion system, thus ensuring system stability. The biogas produced is stored in a gasholder and is transformed to electricity on site.

The combined heat and power (CHP) facility must have sufficient electrical capacity to supply the microgrid in cases of grid fault (Figure 1). The CHP facility must be commissioned for two operation modes: an islanded microgrid (Figure 1) and when connected to the grid (Figure 2).

Figure 1: Micro-grid without energy input from electrical utility (islanded microgrid)

Figure 2: Micro-grid with energy input from electrical utility

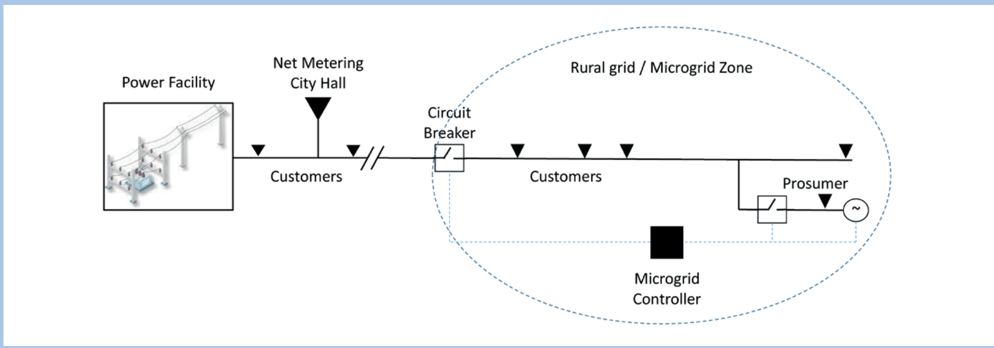

Figure 3: Basic arrangement for microgrid in Brazil

The microgrid controller is responsible for communication between the CHP facility and the electrical utility along with the circuit breakers that split up the distribution grid (thus forming the microgrid). The controller must be notified when there is a fault in the grid. The controller then actuates the circuit breakers creating the islanded microgrid. After the islanded microgrid is formed, the controller is responsible for electricity provision and must ensure constant voltage and frequency as well as adequate generation.

The Brazilian Electricity Regulatory Agency, allows captive consumers of the local distributor to reduce the costs of electricity bills through distributed generators certified by the Energy Compensation System. As shown in Figure 3, electrical energy injected to the distributed generation system is granted to the distributor who then “returns it” and recieves financial compensation monitored by net metering. This may be used to reduce the energy bills of the municipal government participating in the project (described below), which is responsible for the operation of the generating unit. This project financially rewards the owner of the CHP unit for services provided in energy security.

PILOT PROJECT

A pilot project is underway on a rural property in the Western region of Paraná, Brazil. This is overseen by **Itaipu Binacional, Itaipu Technology Park Brazil (PTI-BR) and The International Center on Renewable Energy – Biogas (CIBiogás)**. This facility already has been generating electrical power through biogas from pig farming for over 10 years (Figure 4). Objectives of the pilot include: development of an understanding of the technical feasibility of implementation and operation of a microgrid; mapping the critical points to conduct a project of larger scale; and to assess the structure of a business model. Advanced negotiations have taken place with the local government of Marechal Cândido Rondon (Figure 5) to develop a large-scale rural microgrid. The municipality has a monthly spend on electricity (public buildings and public lighting) of c. R$ 350,000 (US$ 90,000); within the territory there is a herd of more than 520,000 pigs. There is sufficient organic waste to produce electricity from biogas to significantly reduce the cost of electricity to the municipality. Economic gains from reliable energy and environmental protection are added benefits of using organic waste to produce biogas. This pilot concept of a micro-grid could be rolled out to other municipalites in the West of Paraná, such as Toledo (with a herd of 1.18 million pigs).

Complimentary to this pilot project is The Living Lab of Microgrid (the main technical reference in the country), which will assess simulations of microgrid arrangements, several grid scenarios, different levels of system loading and the integration of other renewable sources of energy, such as solar, wind, hydroelectric plants and battery storage.

Figure 4: Pilot Biogas microgrid facility

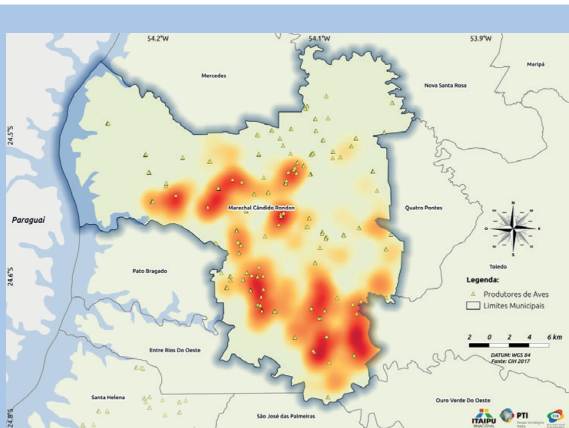

Figure 5: Marechal Cândido Rondon municipality

BIOGAS COMBINED WITH SOLAR

Biogas is the mainstay of the proposed micro-grid model. Energy from biogas is dispatchable and using simple storage mechanisms can be generated at anytime. Intermittent renewable electricity is not dispatchable. Solar electricity is available when the sun provides the energy source; photovoltaic systems can complement electric energy provision during the day, while stored biogas can be used for electricity when the sun's power is insufficient to match electricity demand. Itaipu is considering this combination of solar and biogas.

Socio-economic aspects:

- Reinforce the logistics of the food chain, using sustainable energy, improving health and sanitation, increasing productivity and ensuring greater competitiveness;
- Generate new income opportunities to the rural producer, aligned to policies to decarbonize and utilize renewable energy;
- Strengthen municipal initiatives in environmental education, including for renewable energy, and sustainable development.

DESIRABLE OUTPUTS

Energy:

- Promote innovation in energy generation and distribution, in a resilient, reliable and sustainable manner;
- Integrate and modernize existing energy infrastructure (electricity grids, equipment, distributed generation) using new technologies (automation, microgrid, smart grids);
- Modernize regulations to allow flexibility in grid operation.

Environment:

- Promote and strengthen sustainable development policies in the region, with emphasis on the Sustainable Development Goals;
- Value the energy resource of waste and prevent inappropriate disposal and environmental impairment of soil and water resources;
- Strengthen the efficient use and distribution of electrical power, reducing losses and thus mitigating emissions of GHG.

IEA Bioenergy task 37
"Energy from Biogas"
http://task 37.ieabioenergy.com

CONTACT

Paulo Afonso Schmidt, Marcelo Alves de Sousa, Rogério Meneghetti, Marcos Eduardo Eidi Kurata, João Carlos Christmann Zank, Felipe Souza Marques

Itaipu Binacional
E-mail: ergb@itaipu.gov.br
www.itaipu.gov.br

Itaipu Technology Park Brazil (PTI-BR)
E-mail: ri@pti.org.br
www.pti.org.br

The International Center on Renewable Energy – Biogas (CIBiogás)
E-mail: cibiogas@cibiogas.org
www.cibiogas.org

Further Information
IEA Bioenergy Website
www.ieabioenergy.com
Contact us:
www.ieabioenergy.com/contact-us/

IEA Bioenergy Task 37

IEA BIOENERGY

The IEA Bioenergy Technology Collaboration Programme (www.ieabioenergy.com) is a global government-to-government collaboration on research in bioenergy, which functions within a framework created by the International Energy Agency (IEA – www.iea.org). As of the 1st January 2016, 23 parties participated in IEA Bioenergy: Australia, Austria, Belgium, Brazil, Canada, Croatia, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Republic of Korea, the Netherlands, New Zealand, Norway, South Africa, Sweden, Switzerland, the United Kingdom, the USA, and the European Commission.

The mission of IEA Bioenergy is to increase knowledge and understanding of bioenergy systems in order to facilitate the commercialisation and market deployment of environmentally sound, socially acceptable, and cost-competitive bioenergy systems and technologies, and to advise policy and industrial decision makers accordingly. The Agreement provides platforms for international collaboration and information exchange in bioenergy research, technology development, demonstration, and policy analysis with a focus on overcoming the environmental, institutional, technological, social, and market barriers to the near- and long-term deployment of bioenergy technologies.