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Brazilian case study for biogas energy: Production of electric power, heat and automotive energy in condominiums of agroenergy

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ABSTRACT

Brazilian projects on Condominiums of Agroenergy for Family Agriculture have demonstrated the feasibility of combining preservation of the environment to productivity and income generation through technologies accessible to small farmers gathered in a condominium energy. Such projects have also demonstrated the feasibility of transmuting the environmental liabilities of the Brazilian agricultural sector into electricity and fertilizer, working with the voluntary commitment to decrease the emission of greenhouse gases in Brazil by 2020. In this sense, this study presents examples as the Combined Heat and Power Generation Plant (CHP) fueled by biogas produced by Ajuricaba small farmers in the town of Marechal Rondon, Brazil. This work will provide an overview of the thermodynamical and chemical biogas energetic processes and also the technological components that constitute a CHP for the generation of thermal energy (grain dryer, use in household stoves and heating poultry houses), electricity (self-generation and sale of electricity to public company) and biogas future utilization in Brazilian farm vehicles.

Contents

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1. Introduction

In recent years important international agencies and institutions of the power sector have been evaluating how Brazil has highlighted the potential energy use of biogas obtained from the deposit of waste biomass [1–4]. It is the exploitation of a renewable energy resource and therefore is eligible to receive Certified Emission Reductions (CERs), which encourages the diversification of the energetic matrix and decentralized generation, besides the related obvious environmental benefit.

It fits in the classification of residual biomass the vegetable useless rests for consumption or planting, effluent solids and liquids from agribusiness in general or specifically from livestock or poultry that can be degraded as waste and manure [5,6]. In livestock, specifically, wastes have been dumped directly into the soil as fertilizer or have been disposed off in open-air lagoons, causing problems such as odor, water contamination and increased concentration of methane (CH_4) in the atmosphere, which can translate into dangerous contributions to the atmospheric greenhouse effect. It is well known that CH_4 has the potential to absorb infrared energy 24 times greater than that of carbon dioxide (CO_2) and the resulting greenhouse effect can lead to drastic climate changes in the next few decades [7,8].

The energy use of biogas comes basically from its mostly flammable component, methane. In order to mitigate the production of atmospheric methane, one can perform its energy recovery from the capture through the production of biogas. The main constituents of biogas are methane and carbon dioxide, with a composition of approximately 50–80% methane, with the remainder being primarily carbon dioxide. Other gases, such as hydrogen sulfide (H_2S), nitrogen (N_2), hydrogen (H_2) and carbon monoxide (CO), also compose biogas, but in lower concentrations [9–13]. Methane fermentation is a complex process, which can be divided into four phases of degradation: hydrolysis, acidogenesis, acetogenesis and methanation, according to the main process of decomposition in this phase. The individual phases are carried out by different groups of microorganisms, which partly stand in syntrophic interrelation and place different requirements on the environment [14]. In principle, methane formation follows an exponential equation dependent on time *t*. The most outstanding production of biogas is made by the process of anaerobic digestion of organic waste. The energy applications can be summed up to that applied to cases of obtaining thermal energy and use in electric vehicles. Fig. 1 illustrates the main features of the biogas energy route.

It is well known that, particularly for agricultural cases, the worldwide energy potential only with manure production is estimated at about 20 EJ (20×10^{18} J) [15]. The energy use of these wastes in Europe and Asia has created a benchmark in the industry standardizations, especially for the case of energy from biogas [16–18]. This success in recent years has also arrived in Brazil, as is the case in some urban projects such as the Basic Sanitation Company of the State of São Paulo (SABESP) that generates energy through biogas produced at Sewage Treatment Plant of Barueri [19]. Also in rural Brazil, the use of agroenergy from biogas is a reality that is growing at increasing rates. The main projects are located in southern Brazil [2,3,20,21].

Such advances in Brazilian bioenergy – in particular condo agroenergy biogas as an enabler of small rural properties – bring high strategic value to Brazil, creating a dimension, in the rural sector, of self-generation, which would result in the release of energy to meet other demands of society, not discarding the generation of surplus electricity, which can be commercialized in the national system. The potential of the Brazilian family agriculture for the production of energy should not be underestimated. In Brazil this sector covers about 13.8 million people, or 77% of the population employed in agriculture, according to the National Institute of Colonization and Agrarian Reform (INCRA) and the United Nations Food and Agriculture Organization (FAO) [22–26].

In this aspect, the experience of Agroenergy Condominium for Family Agriculture, developed since 2009 by the Itaipu Office of Renewable Energy in the Ajuricaba River watershed (Marechal Candido Rondon, Western Paraná, Brazil), has demonstrated the feasibility of combining the preservation of the environment to productivity and income generation through technologies

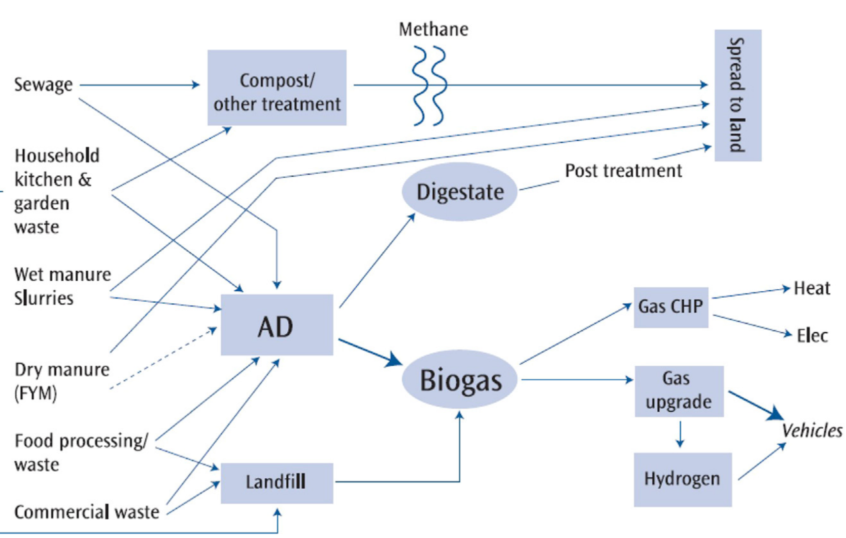

Fig. 1. Biogas energy route from anaerobic digestion (AD) for thermal utilization and electric vehicles. In this paper it will be used for the emphasis for power plants (CHPs) or direct automotive use. Adapted from [77].