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Household anaerobic digesters for biogas production in Latin America: A review



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ABSTRACT

This review aims to provide an overview of household biogas digester implementation in rural areas of Latin America. It considers the history of household digesters in Latin America, including technical, environmental, social and economic aspects. Several successful experiences have been promoted during the last decade, including the creation of the Network for Biodigesters in Latin America and the Caribbean (RedBioLAC) that provides a forum to coordinate implementation and research programmes throughout the continent. Although the potential of this technology is well demonstrated, some barriers are identified, such as the need for technical improvements, lack of social acceptance and high investment costs. Thus, further efforts should be undertaken to overcome these barriers and improve the technical performance, social acceptance, economic benefits and environmental impact in order to enhance its wide-spread dissemination in energy poor communities.

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Contents

1. Introduction	600
2. Household digester experiences in Latin America	600
3. Anaerobic digesters designs in Latin America	601
3.1. Fixed dome digesters	601
3.2. Floating drum digesters	604
3.3. Tubular digesters	605
4. Technical aspects of biogas production	605
5. Biogas production research in Latin America	606
5.1. Lab-scale research	606
5.2. Pilot and full-scale research	606
6. Digestate reuse in Latin American agriculture	609
6.1. Physical–chemical properties of digestate	609
6.2. The performance of digestate as fertilizer	609
7. Environmental aspects	610
8. Social aspects	611

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9. Economic aspects.....	611
10. Conclusions and recommendations.....	612
Acknowledgements.....	612
References.....	613

1. Introduction

Currently, 1.6 billion people in the world, mostly in rural areas, do not have access to electricity. Another 2.5 billion people still rely on traditional fuels, such as firewood and dried dung, to meet their daily heating and cooking needs. The use of traditional fuels is responsible for serious impacts on the environment and on people's health while limiting economic opportunity to overcome poverty [1]. Increasing access to modern and affordable energy is essential to improve basic services that require energy, such as water supply, sanitation, health care and education. Moreover, modern energy services contribute to poverty reduction by providing lighting, mechanical power, transport, and telecommunication services [1,2]. At the same time there is an urgent need to mitigate the climate change and reduce greenhouse gas (GHG) emissions, mainly generated by energy production and consumption [3,4]. Thus it is necessary to implement technologies that may contribute to both GHG emission reduction and poverty eradication.

Household digesters are considered a clean and environmentally friendly technology which can help rural communities to meet their energy needs for lighting, cooking and electricity, thus leading to improved living conditions [5–10]. Thanks to their technical, socio-economic and environmental benefits, household rural biogas plants have been spreading around the world since the 1970s [5,11]. However, the current situation of household digesters in developing nations differs from one to another.

The research and use of biogas has a long history in Asia. Since the 1970s, China and India were the two largest household biogas users in the world thanks to their extensive experience in anaerobic digestion, the availability of biomass and the strong support of national funds [12,13]. In these countries, several studies have shown and evaluated household digesters performance and biogas dissemination programmes [10,13–15].

In Latin America the implementation of household digesters was spurred after the energy crisis in the 1970s and several recent successful experiences have been reported [7,16,17]. Nevertheless, the number of biogas digesters installed in this region is far behind Asia, due to insufficient social acceptance, absence of long-term financial subsidies, and lack of institutional support and follow up [7,17–20].

This review aims to provide an overview of household biogas digester implementation in rural areas of Latin America. It considers the history of household digesters in Latin America, including the technical, environmental, social and economic aspects. Most importantly, it examines the barriers to overcome in order to improve the technology and its dissemination.

2. Household digester experiences in Latin America

It is estimated that 31 million people in Latin America lack access to electricity (87% in rural areas and 13% in urban areas) and that 85 million people rely on traditional biomass for cooking (70% in rural areas and 30% in urban areas) [2,21]. Access to basic modern energy is defined as the ability to satisfy basic energy needs (i.e. lighting, cooking, heating, education, healthcare and communication) through the use of reliable, efficient, affordable and environmentally friendly energy services [22].

Household digesters are simple and effective technologies available to deliver energy to poor communities, especially in remote rural areas. The first experiences of household digesters in Latin America date back to the end of the 1970s and beginning of the 1980s, when an interregional organization, the Latin American Energy Commission (OLADE), attempted to promote biogas in Bolivia, Guyana, Haiti, Honduras, Jamaica and Nicaragua. Ten digesters of various designs including batch, tubular and fixed dome were built in each country [12,23,24]. At the same time, the National University of Cajamarca (UNC) together with the Non-Governmental Organization (NGO) ITINTEC implemented almost 100 fixed dome digesters of 10–12 m³ in rural areas of the Peruvian Andes [25,26]. Likewise, the German Technical Cooperation (GTZ at that moment, now GIZ) supported the development and diffusion of the technology in the region. Most digesters were developed under a 100% subsidy model, but were not accompanied by specific training and follow up. For this reason, most of these experiences failed and household digesters were at some point abandoned by users. For instance, in the Bolivian Andes, the 65 fixed dome digesters installed from 1988 to 1992 were abandoned after a few years [17]. A survey carried out in 2007 showed that out of 100 fixed dome digesters installed at the Peruvian Andes during the 1980s, only one was still in operation [20].

At the end of the 1980s, the plastic tubular digester adapted from the PVC “red mud” model developed in Taiwan [27], was introduced in Colombia [28,29] by the Centre for Research on Sustainable Agricultural Production Systems (CIPAV). This model appeared to be easier to implement and less expensive than the fixed dome digester. Since then, tubular digesters have been spreading in rural areas of Latin American countries, especially Colombia, Costa Rica, Nicaragua, Ecuador, Honduras and Mexico [12,18,30,31]. Lately, this technology has been adapted to the harsh climate conditions of the Andean Plateau (2500–4500 m.a.s.l), in Bolivia (2003) [32] and Peru (2006) [33,34].

As a result of the renewed interest and efforts, the Network for Biodigesters in Latin America and the Caribbean (RedBioLAC) was created in 2009. RedBioLAC was formed and is administered by the NGO Green Empowerment, with support from the US Environmental Protection Agency and the Wuppertal Institute for Climate, Energy and Environment (WISIONS). The leadership board of RedBioLAC is comprised of representatives from NGOs, universities and businesses that promote digesters across Latin America. RedBioLAC's mission is to: (i) share information on innovations in the field; (ii) increase dialogue concerning biogas project promotion and management; (iii) identify and overcome technical, environmental, social and economic barriers for household, community and farm-scale digester dissemination in Latin America. This is achieved through an internet forum, an online library, webinars, international exchanges, coordinated research and annual conferences. So far, seven conferences have been carried out in different countries of Latin America (Peru 2009; Costa Rica 2010; Mexico 2011; Nicaragua 2012, Honduras 2013, Colombia 2014 and Chile 2015). Currently, it comprises 18 countries represented by 23 NGOs and Foundations, 15 Research and Development (R+D) centers and public institutions and 17 small companies, for a total of 55 organizations involved (RedBioLAC, 2014) (Fig. 1). As a result, the coordination of household digesters research and implementation has been significantly improving over the last years. Furthermore, training is promoted by means of internships of students and professors among institutions [35].

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