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Low cost tubular digesters as appropriate technology for widespread application: Results and lessons learned from Bolivia

Jaime Martí-Herrero [a, *], Maria Chipana [b], Carlos Cuevas [b], Gabriel Paco [c], Victor Serrano [d], Bernhard Zymla [e], Klas Heising [e], Jaime Sologuren [b], Alba Gamarra [f]

[a] Centre Internacional de Mètodes Numèrics en Enginyeria (CIMNE), Building Energy and Environment Group, Edifici GAIA (TR14), C/Rambla Sant Nebridi 22, 08222 Terrassa, Barcelona, Spain
[b] Energising Development Bolivia (EnDev-Bolivia/GIZ), Bolivia
[c] Universidad Catolica Boliviana, Unidad Académica Campesina CarmenPampa, Bolivia
[d] Comunidad Collpapampa Tiquipaya, Bolivia
[e] Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Germany
[f] Centro de Información Nacional de Energías Renovables (CINER), Bolivia

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ABSTRACT

This paper presents the results and lessons learned from four and a half years of implementing low cost tubular digesters in Bolivia. The selection of this technology is justified in comparison with other popular technologies such as fixed dome or floating drum digesters. The highlighted weakness of the tubular model (its short life expectancy), is transformed into a strength, making the low cost tubular digester an appropriate technology for widespread application. The experiences in Bolivia show that the success of biogas programs depend more on socio-economic factors than on the validated technology selected, suggesting that local circumstances are a critical, and often underestimated, factor to be taken into consideration in the praxis. Finally, some testimonies of the use of biol (bio-slurry or effluent) are reported, identifying the high potential of this anaerobic digestion product that provides a food sovereignty approach, reduced expansion of the agricultural frontier, increased agricultural productivity and hence family income, that other household energizing systems do not have. A brief report of lessons learned is also included.

1. Introduction

One of the indicators for energy poverty at the household level is the reliance on traditional use of biomass for cooking. Another indicator is the lack of access to electricity. The International Energy Agency (IEA) reported in 2012, that 2.6 billion did not have access to clean cooking facilities and nearly 1.3 billion people continue without access to electricity in the world [1].

The IEA [2] has proposed a case for achieving universal modern energy access: by providing access to clean cooking facilities where these are lacking. The IEA proposal aims to achieve this goal by meeting the following targets within this proportion: 55% of improved cook stoves, 15% of biogas systems and 35% with access to Liquid Petroleum Gas (LPG) stoves.

In order to reduce the number of households suffering energy poverty, several initiatives have been developed in local, national and international consortiums. One of these initiatives is the Energising Development Program (EnDev) that promotes the supply of modern energy technologies and improved (more efficient) cooking stoves to household and small-scale businesses. EnDev started in 2005, as a partnership between the Netherlands, Germany, Norway, Australia, the United Kingdom and Switzerland, and cooperates with more than 20 countries in Africa, Latin America and Asia. The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) is acting as the lead agency for implementing this Program in Bolivia.

Biogas systems are considered as an appropriate technology by EnDev, with a relatively small implementation target when compared to the total number of the initiatives, in line with the IEA proposal proportions described above. A digester has several impacts on the daily routine of small farmers. These include the use of biogas for cooking instead of solid biomass (wood, charcoal, crop residues or dry dung) as combustible, resulting in a healthier,

* Corresponding author. Tel.: +34 937398575; fax: +34 937883110.
E-mail addresses: jaimemarti@cimne.upc.edu, tallerbiogas@hotmail.com (J. Martí-Herrero).

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smoke-free indoor ambient when cooking [3,4]; reducing the pressure on local biomass resources and also reducing the time dedicated (mainly by women and children) to collecting biomass fuel. In addition, the production of bio-slurry or effluent (known as Biol in Latin America and the Caribbean region) and its utilization as an organic fertilizer has shown a great potential to increase the crop production and therefore the farmers' income, as commented further on in this document.

The digesters offer advantages over other forms of waste treatment. These are summarized below from the benefits reported and referenced by Ward [5] and Yiridoe [6].

- Less biomass sludge is produced in comparison to aerobic treatment technologies, reducing the chemical oxygen demand by 60–90% and the biochemical oxygen demand by up to 80%.
- Significant removal (up to 98%) of coliforms and other pathogens. This is especially true for multi-stage digesters or if a pasteurization step is included in the process.
- Reduced water contamination, improved manure management and use and reduced eutrophication.
- Minimal odourous emissions as 99% of volatile compounds are oxidatively decomposed upon combustion, e.g. H_2S forms SO_2.
- The slurry produced (digestate, effluent, biol) is an improved fertilizer both in terms of its availability to plants and its rheology. It also reduces weed seed germination.
  •A source of carbon neutral energy is produced in the form of biogas.
- GHC emission reduction by a factor of 21 due to conversion of CH_4 to CO_2.

The biogas EnDev-Bolivia program activities began in 2007 with small pilot projects and some workshops until mid 2012, when these activities stopped due financial resource depletion and the concentration of the remaining resources primarily on providing improved cooking stoves. Also, it was felt that both the technology development and the implementation strategies had been taken to sufficient maturity for other actors but EnDev to pick up the dissemination.

This paper documents the Endev experiences on the promotion of low cost digesters in Bolivia. The paper presents the context of Bolivia, the selection of the tubular low cost digester as the accurate technology to be promoted, the results of activities of four and a half years and the economical, technical and socio-cultural lessons learned.

2. Biogas in Bolivia context

2.1. First projects, first failures

Bolivia, like other Latin American countries, first introduced biogas systems in the 1980s. The technology selected was the fixed-dome (BORDA model) digester, which was very well known in Asian countries. 65 household digesters were implemented between 1986 and 1992. A few years later, none of the 65 digesters were working and no replication followed. The high level of subsidy, poor selection of users and lack of post-installation technical assistance are the most important contributory factors to this substantial project failure. A very similar, and equally unsuccessful, experience happened in Cajamarca (Peru) around the same time. Lessons learned from the Peruvian case can be extrapolated to Bolivia from the Spagnoletta report in 2007 [7].

Between 1992 and 2002, no new digester installations were reported. In 2002, 23 low cost tubular digesters where implemented in Mizque, at an altitude of 2400 m above sea level (m.a.s.l.). In 2003, the first digester working over 4000 m.a.s.l. was reported by Martí-Herrero [8]. Between 2002 and 2006 several small tubular digesters were installed, mainly in Cochabamba (valley, warm climate) and La Paz (altiplano, cold climate). The implementation scheme was similar to that employed in the 1980s with the fixed-dome digester, resulting in less than 25% technology appropriation by the users.

Bolivia is a country with a broad history of aid projects for rural development. In the time period from 1991 to 2005, Bolivia was the country that received most aid funds annually in Latin America. In terms of aid funding per habitant, Bolivia is still the country (excepting Guyana and Suriname) that receives the most aid: $67 US per habitant in 2010 [9]. These circumstances help explain the high subsidies given to the users to access a digester. Due to the welfare schemes of many of the projects and demands, users were used to receiving a certain amount of financial support. The other issue, low levels of technical assistance and follow up of the users, can also be explained by the particular characteristics of Bolivia. With an area of 1,050,000 Km^2 and roughly 11 million inhabitants, it is the country (excepting Guyana and Suriname) with the lowest population density in Latin America (9.5 hab/km^2). Also, the ecological diversity, with three distinct regions, is very significant. The three main regions are: the altiplano which is around 3500–4500 m.a.s.l and has mainly a cold climate; the valleys from 1500 to 3500 m.a.s.l. with warm climate, and the tropics from 300 to 1500 m.a.s.l. (tropical weather). This variety is compounded by cultural diversity: 67% of the total population is indigenous and is made up of 38 distinct and officially recognized indigenous nations. The combination of all these aspects make technical assistance particularly difficult and expensive due to the dispersion of users, the inadequacy of the road infrastructure in rural areas (notably during the rainy season), and also due to the cultural differences between users.

With this experience, very similar to those in other Latin American countries, it can be deduced, and it has been validated, that the failure of these initiatives has been a result of the strategy used in the projects, rather than because of the technology involved, (fixed dome or low cost tubular in the Bolivian case).

2.2. Situation before Endev-Bolivia

In Bolivia there was only one NGO implementing digesters for the whole country in 2007, with no technology transfer either to the users or to other institutions. The biogas technology was unknown to the great majority of the farmers, and in some high potential areas the technology had a very low credibility due to constant project failure. Since 1986, all the projects had focused on the benefit of biogas as a fuel for cooking, with the use of biol as a secondary or collateral product from the anaerobic digestion.

EnDev-Bolivia came in and focused on technology transfer to new institutions (NGOs, municipalities and farmers), consolidation of the technology (design methodology, design adaptation to different climatic regions, biogas reservoirs, etc.), low direct subsidies to the farmers, relatively high levels of investment in technical assistance and follow-up of users.

3. Biogas technology selection

The introduction of a biogas system in the rural area of Bolivia needs to consider the dispersion of the rural population, inadequate roads in the rainy season, long distances, high poverty and a continuous migration of rural labor to the cities. Under these circumstances, low-cost digesters offer significant advantages; characterized by the absence of active heat or mixing devices. This reduces the economic investment required and also minimizes the complexity of operation and maintenance. Fixed-dome, floating