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Assessing the Impact of Biogas on the Energy Sustainability of an Urban Restaurant in Mexico

Evaluación del impacto del biogás en la sustentabilidad energética de un restaurante urbano en México

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Abstract

Biogas technology represents an option to enhance sustainable energy use in developing nations particularly in the rural context. However, the production and use of biogas could also take place in urban settings in these countries with potential benefits for their sustainability. The present work introduces a set of nine indicators in the economic, social and environmental sustainability dimensions for assessing the impact of a small-scale biogas plant on the energy sustainability of a restaurant located in Mexico City. Indicators were evaluated before (base scenario) and after (biogas scenario) biogas plant installation and then they were linearly normalized using a scale between 0 and 1 corresponding to a growing level of energy sustainability. Economic dimension indicators averaged 0.67 in the base scenario and 0.68 in the biogas scenario; those of the social dimension, 0.52 and 0.54; and those of the environmental dimension, 0.17 and 0.49, respectively. Results indicate a positive impact of biogas plant on restaurant energy sustainability. These indicators provide objective elements to examine in detail biogas contributions in strengthening energy sustainability of cities in developing countries.

Keywords:

- biogas
- urban areas
- developing countries
- energy sustainability
- indicators

Resumen

La tecnología del biogás representa una opción para impulsar el uso sustentable de la energía en el mundo en desarrollo, particularmente en el contexto rural. Sin embargo, la producción y el uso del biogás también pueden acontecer en zonas urbanas de estos países con beneficios potenciales para su sustentabilidad. El presente trabajo ofrece un grupo de nueve indicadores en las dimensiones de sustentabilidad económica, social y ambiental para evaluar el impacto de una planta de biogás de pequeña escala sobre la sustentabilidad energética de un restaurante en la Ciudad de México. Los indicadores se evaluaron antes (escenario base) y después (escenario biogás) de la instalación de la planta y luego se normalizaron linealmente usando una escala entre 0 y 1 correspondiente a un nivel creciente de sustentabilidad energética. Los indicadores de la dimensión económica promediaron 0.67 en el escenario base y 0.68 en el escenario biogás, los de la dimensión social, 0.52 y 0.54; y los de la dimensión ambiental, 0.17 y 0.49, respectivamente. Los resultados muestran el impacto positivo de la planta de biogás en la sustentabilidad energética del restaurante. Estos indicadores proporcionan elementos objetivos para examinar a detalle las contribuciones del biogás en el fortalecimiento de la sustentabilidad energética de las ciudades en países en desarrollo.

Descriptores:

- *biogás*
- *zonas urbanas*
- *países en desarrollo*
- *sustentabilidad energética*
- *indicadores*

Introduction

In 1987 the Brundtland Report defined *sustainable development* (SD) as a development that can meet the needs of the present without endangering the ability of future generations to meet their own needs (WCED, 1987). This sort of development lies on a harmonious relationship between three main dimensions, namely: Economic, social and environmental.

From an energy point of view, SD demands the access to clean, safe, reliable and affordable energy sources (Vera *et al.*, 2005). *Renewable energy sources* (RES) can help achieve energy sustainability objectives as they offer benefits for energy security, *greenhouse gases* (GHG) mitigation, job creation, rural development and energy access (REN21, 2012). It is estimated that RES supplied 16.7% of global final energy consumption in 2010, most of which through some form of biomass energy (REN21, 2012). Biomass consists of different types of non-fossil organic matter that can be used directly for energy production (traditional biomass) or processed to solid, liquid or gaseous fuels (modern biomass). One of the latter is biogas, a byproduct of *anaerobic degradation* (AD) composed of methane (CH_4), carbon dioxide (CO_2) and traces of other gases.

In the developing world, deployment of biogas technology has taken place mainly in rural locations by means of small-scale units fed by animal manure and the biogas being used for domestic applications (Bond and Templeton, 2011). One of the major uses of biogas is as cooking fuel having the advantage of a cleaner and more efficient combustion than traditional biomass fuels (Smith *et al.*, 2000; Zhang *et al.*, 2000). Biogas also favors sustainable energy use in rural settlements by reducing the overexploitation of forest resources for fuel wood extraction, the incidence of health problems derived form the use of low quality fuels and the workload for fuel wood collection (Gosens *et al.*, 2013).

In Mexico in 2010 there were 721 biogas projects across the country, nearly half of which (354) were under construction, mainly for treating manure from large hog farms (FIRCO, 2011). To further boost biogas technology dissemination within the country, other locations, scales and feedstocks should be explored. The organic fraction of municipal solid waste (OFMSW) emerges as one of the most attractive alternative substrates for biogas production (Müller, 2007; Khalid *et al.*, 2011; Curry and Pillay, 2012). Mexico City alone generates approximately 12,500 t/day of municipal solid waste (MSW) of which 49.5% corresponds to organic materials (Duran-Moreno *et al.*, 2013).

Due to its amount and composition, the OFMSW requires an adequate management to avoid negative impacts on the environment and human health. Unfortunately, main cities in developing countries regularly manage their MSW in an unsuitable way. For instance, 32% (7,800 t/day) of the MSW transported to the 13 transfer stations in operation in Mexico City was directly sent to final deposition as well as more than 85% of the input waste of the three selection plants in the city (SEDEMA, 2012). As a result, final deposition capacity runs out rapidly (Curry and Pillay, 2012). The