Potential of Biogas in Sub-Saharan Africa – An Overview

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Abstract. Biogas technology is a renewable energy with the potential to provide benefits to Sub Saharan Africa in several socioeconomic and environmental aspects, mainly considering all issues associated with the production of energy in this region nowadays. Despite many challenges related to developing the biogas industry locally, this technology has been considered a more sustainable energy source to fight energy poverty, mainly in rural areas. Therefore, this paper investigates the main benefits related to biogas dissemination in Sub-Saharan Africa. Considering the method, it was developed a textual search on ScienceDirect using the keywords "Sub-Saharan Africa", "Biogas", "biogas in Sub Saharan Africa", and "biodigesters in Sub Saharan Africa", between the years of 2000 to 2022. Afterwards, two main articles were selected to be used as base for the present literature review. Results show that biogas tends to develop the domestic industry, create jobs and technical trainings, reduce external dependence on energy, create quality of life, improve sanitation and food security, promote gender equality, improve farming conditions, reduce erosion, reduce poverty indicators, develop a waste management solution and improve air and water quality.

Keywords. Energy Poverty, Sub-Saharan Africa, Biogas.

1. Introduction

Environment issues have increased investments in renewable energy sources around the world, mainly because energy use is one of the most important socioeconomic indicators when measuring the development of any society today (Mikel González-Eguino, 2015). Considering Sub-Saharan Africa (SSA), those countries have produced energy burning wood for decades, mostly for cooking and heating homes. Since biogas technology is a renewable energy which also produces energy, but helps to manage waste, reducing greenhouse gas emissions and improves the local's everyday life as well, it has been considered as a growing and promising alternative solution nowadays (Gloria V. Rupf et al., 2015).

Basically, biogas is a renewable source of energy obtained at a low cost from various sources as sewage treatment plants, landfills and agricultural waste, such as animal manure and plant production waste. In view of how it works, waste is collected into a digester, a large airtight machine which processes the material with living microorganisms via anaerobic digestion, producing fertilizers and biogas--which can be burned as fuel. It is considered an affordable source of energy for farming, lighting and clean cooking fuel.

In low-income areas such as Sub-Saharan Africa, biogas production comes mainly from biodigesters of small-scale digester or small-scale biogas, by using feedstock--animal manure. Although Sub-Saharan Africa has abundance of resources, the energy condition is yet very underdeveloped considering the lack of production, distribution and accessibility. Therefore, most countries in this region fight to achieve their energy needs, sometimes importing costly fuels, or, relying on several kinds of biomass resources, such as wood, charcoal, cow dung and crop residue. (Gloria V. Rupf et al., 2015).

This technology addresses several matters at once, since it generates renewable energy and provides a method for waste management in rural areas without sanitation. Through the years, it has gained popularity considering its core socioeconomic and environmental benefit for these countries: A more sustainable energy source in rural areas to fights energy poverty (Tumwesige, Vianney et al., 2011).

Considering Reddy (2000), the lack or poor access to modern energy options deeply impacts on people's health, potential and development, mainly in rural regions from developing countries. On these remote places, polluting fuels--which are extremely time-consuming to produce, still are mostly in place, so communities can be able to meet the most basic needs. By producing and using it, people face several

difficulties to achieve day to day living requirements as discussed through the concept of energy poverty, or, energy dimension of poverty.

[Energy poverty] is "the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development". […] Increased access to such energy services will not, in itself, result in economic or social development. But lack of adequate energy inputs can be a severe constraint on development. Universally accessible energy services that are adequate, affordable, reliable, of good quality, safe, and environmentally benign are therefore a necessary but insufficient condition for development" (Reddy, 2000, p.44).

Considering the significance of this research, the time spent daily on producing energy to cook and warm homes, for example, impacts on the potential of communities' development in SSA, mainly considering the lack of time and resources left for them to invest and access education, information and health care, for example. After all, transportation, lighting, cooking, heating, cooling, going to work and access to communication technologies depends on energy. Although energy poverty and financial poverty are different concepts, those are strictly linked nowadays as observed (Reddy, 2000), which demands more research, investments and effort.

2. Research Methods

This review paper objective is to investigate and list the main opportunities related to Biogas dissemination in SSA through literature review. The current investigation involved a textual search on ScienceDirect using the keywords "Sub-Saharan Africa", "Biogas", "biogas in Sub Saharan Africa", and "biodigesters in Sub Saharan Africa", between the years of 2000 to 2022. These are the two main articles used as base: "Barriers and opportunities of biogas dissemination in Sub-Saharan Africa and lessons learned from Rwanda, Tanzania, China, India, and Nepal" (Gloria V. Rupf et al., 2015) and "Small-Scale Biogas Digester for Sustainable Energy Production in Sub-Saharan Africa" (Tumwesige, Vianney et al., 2011).

3. Potential to Development

3.1 Poverty, Economy and Employment opportunities

Even though the conventional understanding on the concept of poverty focuses on low income and low consumption, globalization and its challenges enlarged this perception. Not only income and consumption, as measured by the World Bank through the "international poverty line", is enough today to measure a country level of poverty or its economy, but several other aspects such as deprivation of common necessities. Measuring the relation between income and opportunity, capability to access education and health, food security, security, and the level of power and representation plays a big part when discussing measuring poverty nowadays. (Kathleen S. Short, 2016)

In a view of measuring poverty, two aspects are key to be considered: (1) Measuring the need of a country and (2) measuring the resources available so that people can be able to meet those needs, meaning that "families and individuals are poor if resources are not sufficient to meet needs" (Kathleen S. Short, 2016, p.46). Therefore, discussing biogas and its benefits gain relevance when analyzing poverty and economy in Sub-Saharan Africa, considering the availability of existing resources for its production in the area and the local need.

"The benefits of biogas to Sub-Saharan Africa are wide-reaching over the three main pillars of sustainability: economic, social, and environmental. The use of biogas systems that can be produced from locally available materials, including most fixed dome, some floating cover and tubular digester designs, assists in reducing the dependence on and need for aid, construction and spare parts, along with creating jobs and encouraging technical skills to be acquired locally. The implementation of biogas systems also helps to improve energy security and reduce reliance on expensive liquid fuel imports by providing a stable, decentralized energy supply from local, renewable sources (Gloria V. Rupf et al., 2015, p.473).

The tropical climate through the entire year supports the anaerobic digestion needed for the biogas production, fully. Additionally, livestock is commonly practiced, which provides a significant potential for using biodigesters of small-scale digester, considering the availability of feedstock (Gloria V. Rupf et al., 2015). Besides, the financial potential. By developing the local technical knowledge tents to increase employment opportunities in the area thought the creation of a domestic industry, which represents a relevant socioeconomic opportunity (Tumwesige, Vianney et al., 2011).

3.2 Health issues: Water and Air quality

In view of several health problems related to water and air quality in rural areas in Sub-Saharan Africa, sanitation and cooking are some of the key causes. Considering the air, by burning biomass fuels to produce energy, fine particulates matter and carbon monoxide is discharged indoors and outdoors, increasing the health risks linked to pollution. These are spread in the environment but also inside houses, by the practice of open fires and simple stoves normally used for cooking (Tumwesige, Vianney et al., 2011).

"The majority of households are poorly ventilated, yet use traditional open fire stoves, which propagates a build-up of smoke, particulates, carbon monoxide, sulphur, and nitrogen oxides in the home, thus posing serious health risks to its inhabitants […] Exposure to indoor pollution from the unimproved

stoves is strongly linked to a number of diseases, including pneumonia and acute infections of the lower respiratory tract for children under the age of five, and chronic obstructive pulmonary disease in women". (Gloria V. Rupf et al., 2015, p.469)

Since underprivileged households are more likely to use biomass fuels, air quality turns a matter of poverty when considering that only 14% of individuals in urban areas relied on indoor pollution comparing to 52% of the world rural population, as affirms the World Health Organization (WHO). Relevant to mention as well that 3.2 million people died because of household air pollution in 2020, which included 273,000 individuals under the age of 5. Since domestic tasks such as cooking and collecting firewood are predominantly assigned to women and children, they are mostly impacted (WHO, 2018).

Water quality is an issue as well, which demands discussing sanitation and hygiene. Improved sanitation is not predominant in Sub-Saharan Africa, which represents an enormous health risk. For example, diarrhea, a grave health issue for African children, is a threat associated to contaminated waters and lack of sanitation. Besides, health conditions linked to human wastes due to inadequate construction and use of pit toilets, normally too close to water sources, is also a problem. It contaminates not only water bodies but also the soil (Tumwesige, Vianney et al., 2011).

"Contamination of groundwater and reservoirs by running storm water and flash floods can result in significant sporadic pollution events. The type of contamination includes enterobacteria, enteroviruses and a range of fungal spores […] Many of these can be passed between animal and human populations. Access to an improved water source is not prevalent in Africa and contaminated or polluted water sources present a major health risk. Access to water is a precondition for sedentary agriculture and livestock husbandry, improved sanitation and the proper operation of a biogas plant. Many of these countries have the potential to improve their sanitation through use of domestic biogas digesters (Tumwesige, Vianney et al., 2011, p.6).

As observed, considering air and water quality, investments on domestic biogas digesters in SSA have the potential to improve sanitation by implementing a safer wastewater management, consequently reducing the risks of spreading related pathogens. Additionally, biodigesters may improve health conditions through the use of smokeless fuel.

3.3 Environment management, Farming and Food Security

Biogas technology has showed its potential to improve the energy situation in Sub-Saharan Africa considering the environment too (Gloria V. Rupf et al., 2015). "Aside from health impacts, the adverse effects from collection and use of these fuels on the environment and socioeconomic development include: deforestation, land degradation in dry lands, aggravated soil erosion, and, associated flooding" (p.469).

"At these smaller scales, the technology can be integrated into household, community, or commercial organic waste management systems for improved sanitation, as well asnutrient recycling. Consequently, biogas technology has the potential to play an important role in improving energy access in the development process in SSA, particularly in rural regions, [with] significant potential for biogas production from municipal organic solid and sewage waste, as well as agricultural residues. […] At the rural household scale, successful biogas technology adoption can reduce or eliminate the need to collect firewood for cooking, to provide a clean alternative, while improving sanitation, and providing the potential to increase soil fertility and crop productivity through accelerated processing of organic wastes" (Gloria V. Rupf et al., 2015, p.469)

As organic matter decomposes through aerobic conditions, carbon dioxide is released into the soil. Besides removing it from the atmosphere, this carbon sequestration increases the soil water holding capacity, which rises crop productivity. As a result, there is a decrease of erosion and loss of nutrients, which represents a substantial benefit, not only in a view of soil fertility and crop productivity, but regarding waste management, sanitation and nutrient recycling, such as fertilizers (Tumwesige, Vianney et al., 2011). By producing an odorless high protein organic fertilizer called slurry, nutrition though agricultural yield is improved, which adds more economic value to biogas technology (Tumwesige, Vianney et al., 2011). As productivity of vegetable gardens or food croplands is increased, food security and nutrition can also be enhanced (Gloria V. Rupf et al., 2015).

3.4 Woman and children

Besides the advantages of biogas technology to SSA described previously, which tends to benefit the entire community, women and children would be the most benefit groups once biogas technology is in place.

Fig. 2 – Firewood collection and cooking routine (AgriProFocus, 2019).

Firstly, there would be a considerable reduction on the workload on household activities which are extremely time-consuming for women and children, groups normally responsible for collecting firewood and cooking, as shows Figure 2.

Once biogas is in place, communities would stop fuel wood collection for cooking, allowing more time for developing other activities and attending school. However, this decision still is in men's hands, which represents a cultural barrier to be overcome (Gloria V. Rupf et al., 2015).

"Traditional gender roles in households can present a challenge to biogas adoption, as often the decision to invest in a biogas system rests on the man that is generally the head of the household, while the women and children would be the ones receiving the most benefit from it because they would use the technology for cooking" (Gloria V. Rupf et al., 2015, p.472).

Additionally, this complete game changing on the dynamic of household activities would allow women to dedicate their time to gaining technical knowledge and work with biogas too. Although it represents another cultural barrier related to gender inequality in the region, there are trainings for female technicians on biogas system construction already, so they can operate their domestic biodigesters properly as well as work in the sector domestically (Gloria V. Rupf et al., 2015).

Besides all opportunities to women and children, there are several other advantages of developing biogas technology in SSA as discussed previously. Those main opportunities can be seen in Table 1.

Tab. 1 – Main opportunities.

Sector	Description
Socioeconomic	Develop a domestic industry
	Low-cost energy
	Creating jobs
	Creating technical trainings and skills
	Reducing poverty indicators
	Reducing external dependence
	Improve farming through the use of fertilizers
	Improve health conditions
	Improve food production, food security and nutrition
	Time saving for women and children which can be used for studying
	More opportunities for women to study and work
Environment	Promoting sanitation
	Promoting waste management
	Promoting water quality
	Reducing erosion
	Promoting air quality
	Increased sequestration of carbon in soils

4. Conclusion

Biogas technology has the potential to contribute to SSA in several socioeconomic and environmental aspects. Considering its socioeconomic potential, through a low-cost energy source, small-scale biogas digesters can develop a domestic industry, create jobs and technical trainings--which reduces external dependence on energy and develops the region. The time saving from firewood collection would allow women and children to invest in education as well, allowing women to work with biogas, for example. Besides an extra source of income, it would contribute to gender equality issues in the area. Benefits regarding health, food security and improved farming conditions would also contribute, reducing several poverty indicators, tending to increase life expectancy and quality of life. In a view of environmental benefits, it is relevant to mention that biogas promotes sequestration of carbon in soils, reduction of erosion, a relevant waste management solution and sanitation and improves air and water quality.

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