Kitchen to Kitchen - Circularity of kitchen waste

Shajimon Kaitheri, Angel Vinod

Image 1: 'Bio Urja 300' at ECO Kitchen, Chennai.

1. Introduction

Biogas is a locally accessible and renewable energy source that can be generated from organic feedstocks under anaerobic conditions[1]. As India strives for net zero emissions by 2070, the biogas sector can contribute significantly to achieving this target by adopting anaerobic decomposition of organic fractions from agricultural residue, municipal solid waste and sewage treatment plants. Decentralised, small scale biogas plants provide additional benefits like reduced emissions from waste transportation and localised gas consumption. The Government of India has been promoting biogas for several decades in rural India, primarily for cattle dung and agriculture residue treatment. In recent years, GoI has expanded the biogas's ambit to include urban areas as well, driven primarily with the objective of increasing the contribution of natural gas in the country's energy mix[2]. One of the aims of schemes like Sustainable Alternative Towards Affordable Transportation (SATAT) is to set up 5000 CBG plants by 2024-25 through financial incentives to entrepreneurs, investors and NGOs. Despite these aggressive targets, so far only 46 small scale biogas plants have been set up under SATAT[3]. The Indian Biogas Association (IBA) also estimates that India currently has 50 lakh small biogas plants, although most of them

[1] Shivika Mittal, Erik O. Ahlgren, P.R. Shukla, Barriers to biogas dissemination in India: A review, Energy Policy, Volume 112, 2018, https://doi.org/10.1016/j.enpol.2017.10.027

[2] PIB (2023): Government has set target to increase share of gas in energy mix up to 15 per cent by 2030

[3] Chugh & Goel (2023): SATAT scheme for biogas sector - A reality check and the way forward

are non-operational due to lack of social and technical support, especially the ones operating on municipal solid waste, where the feed is heterogenous and often mixed with inorganic fractions[4]. Suitable technology selection and maintenance is a key for running these plants successfully through their lifetime. New technology advancement has been slow in this sector probably due to the operational issues related to waste segregation, variations in waste composition and lack of regular supply.

This case study documents the success story of a small scale digester, by collating the steps taken to operationalize biogas generation using kitchen waste and its utilisation on-site, along with its challenges and strategies. It provides summaries of the objectives, partnerships, implementation, challenges and viability of the ECO Kitchen biogas plant.

2. Project Background

ECO (Enhancing Community Opportunities) Kitchen is a not-for-profit community kitchen managed by YRG Care, who were interested in circular solutions for responsibly managing their organic waste. They onboarded GPS Renewables as the technology partner for this initiative, who in turn brought Saahas, a non profit organisation, on board to implement, operationalise and monitor the biogas plant at the ECO Kitchen's Padappai site. Saahas was able to bring in corporate social responsibility (CSR) funding from CGI to cover the cost of plant installation as well as initial operations and monitoring cost. ECO Kitchen was an ideal set-up for installing a small, decentralised biogas plant as feedstock was readily available from the community kitchen and the gas output could be utilised in the kitchen itself.

A unit called 'Bio Urja 300' with an installed capacity of processing 300 kg of organic kitchen waste per day was installed in June 2022. At present, 200-300 kg of wet waste is being processed per day - the biogas produced by the unit replaces approximately 20% of traditional fossil fuel (liquefied petroleum gas cylinders) consumed, resulting in financial savings of Rs.5,36,000/- and the fermented organic manure (FOM) generated as a byproduct of this process is being used by nearby farms.

3. Project Implementation

The key steps involved in successful implementation of the project are detailed below:

(i) Land and CapEx funding: Often the two biggest challenges in biogas projects, the capital expenditure is prohibitively high compared to other waste management technologies and land allocation/availability is scarce. To address this, Saahas was

[4] Gupta (2023): Why the biogas sector presents a compelling case for growth of clean energy and startups

able to facilitate a CSR partnership with CGI[5], who provided the Rs. 30 lakhs required to cover the capital expenditure for commissioning the project. Land was identified close to the kitchen on the ECO Kitchen campus itself, to optimise the usage of the funding.

(ii) Technical specifications and support: GPS Renewables' expertise[6] in small scale biogas plants ensured that technical specifications - design, size of the digester, temperature controls and distance from the feedstock source to the digester unit were correctly assessed and planned. Additionally, their technical support throughout installation and streamlining of operations proved effective. The staff at ECO Kitchen also received training from GPS on the operations and maintenance of the biogas unit.

(iii) Phased implementation: Saahas formulated detailed plans, secured permissions and approvals, ensured seamless day-to-day operations and scheduled regular review meetings with the funders, beneficiaries and other partners. A well-defined, detailed roadmap for each project phase that was closely tracked by the Saahas team resulted in the attainment of full operational capacity within the defined time frame of 6-8 months.

(iv) Efficient monitoring systems: Unlike cattle manure and other homogenous feed based biogas plants, waste composition varies daily in kitchen and food waste. This requires close monitoring of parameters in the digester such as pH level, temperature to ensure that conditions remain conducive for bacterial culture to grow and flourish. Decay in bacterial growth is often the key reason behind failure of the biogas plants. GPS provided an online monitoring system that was monitored by Saahas all through the year on a daily basis. An internal dashboard provided data on daily plant performance and production yield. Monthly reviews and reports by Saahas to all stakeholders on plant performance ensured engagement from all parties. Through a prompt escalation process and daily communication on Whatsapp, various operational issues were quickly addressed while building the capacity of the local staff.

[5] CGI
[6] GPS Renewables: Past projects

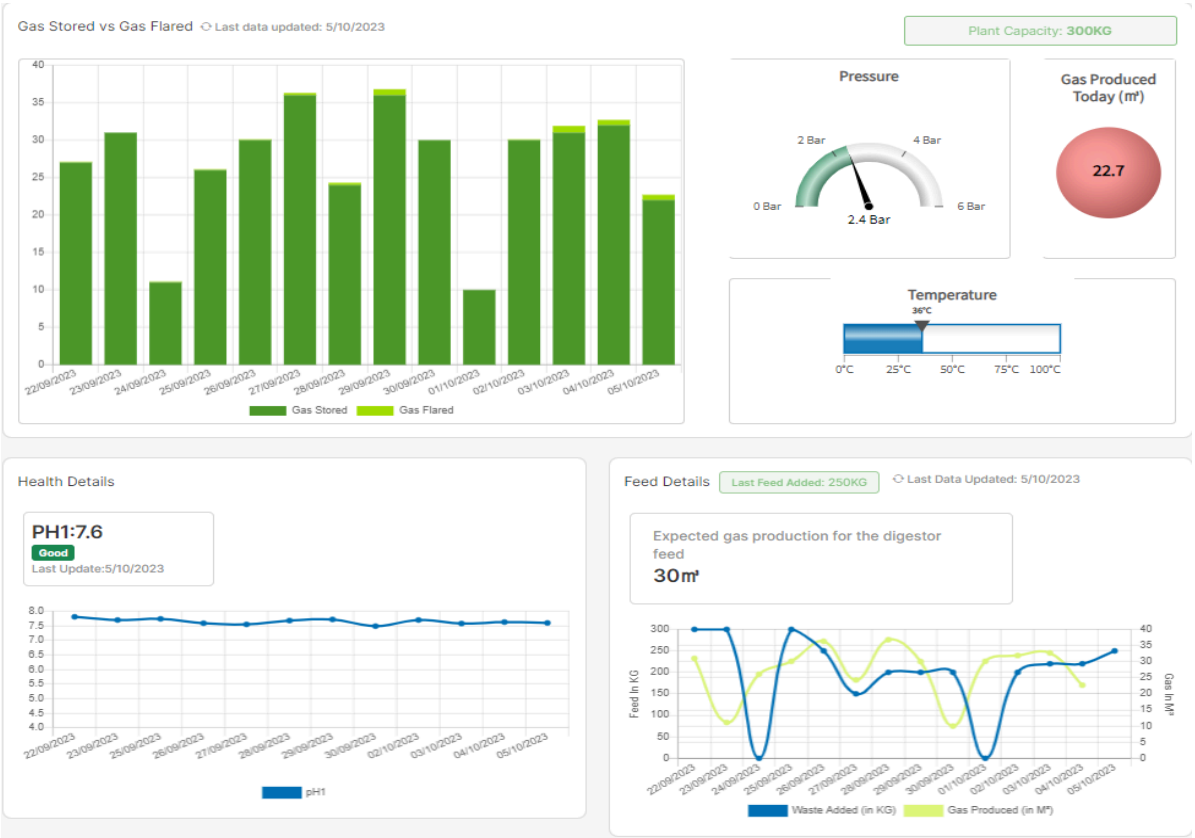

Image 2: Bio Urja online monitoring dashboard.

4. Challenges & Mitigation Strategies

Several challenges cropped up in the course of this project which are discussed below:

(i) Trained operator: Sudden resignation of a trained staff led to a crisis situation as the rest of the staff was not equipped to operate the biogas plant. This resulted in the plant being shut down for 4-5 days. This was a big lesson; Saahas then decided to get a larger team trained on operating the plant and entering data in the monitoring tool, so that there was shared ownership of roles and responsibilities. It is also recommended that at least 3-5 years of operational support and maintenance is provided to allow the team to arrive at a robust and sustainable operation model.

(ii) Consistency of feedstock: Since the feedstock for this plant comes from a kitchen, the quantity of feedstock and substrate composition varies depending on the quantity and type of food cooked each day. These variations in feedstock affect the performance of the biogas plant. It was suggested that while the kitchen has nearly 100% segregation levels, it should also attempt to arrive at a more consistent order quantity per day, so that consistent waste generations and feedstock loading is possible.

(iii) Breakdowns: Breakdowns are an issue with biogas plants and a reliable technology provider that provides an Annual Maintenance Contract (AMC) and

prompt service is a must. This is especially important as the plant gets old. ECO Kitchen was slated to have an AMC with GPS Renewables for periodic maintenance and upkeep of the plant. As this comes at a cost, we have seen challenges with getting this contract renewed in a timely manner. However, the cost is only a fraction of the direct savings in terms of the fuel bill and will be very beneficial in the long run.

(iv) Slurry management: Large quantities of nutrient rich slurry is generated as a by-product of any biogas plant, which when treated can be used as fermented organic manure (FOM) in agricultural farms. Currently, the plant generates about 6000-8000 litres of FOM per month. However, in the absence of a market for this important output of biogas plants, it is given free of cost to farmers, with transport costs covered by ECO Kitchen. Hence, there is need for government support to sustainably manage slurry - a viable market for the sale of these by-products needs to be created, some policy measures for which are already underway[7].

5. Project Outcomes

The ECO Kitchen biogas initiative, in spite of a few challenges, was a success. The project was initiated in January 2022, commissioned in June 2022 and reached full operational capacity by September 2022. The unit now efficiently converts organic kitchen waste into biogas which is used for cooking, significantly reducing the reliance on fossil fuels, especially LPG cylinders. Since its commissioning, the plant has processed 73,000 kg of biodegradable waste, yielding approximately 10000 m^3 of biogas, which replaced around 4300 Kg equivalent of LPG (equivalent to 268 commercial LPG cylinders). At an average cost of Rs.2000 per cylinder this resulted in a direct cost savings of approximately Rs.5,36,000/-. Furthermore, the plant's operational efficiency is underscored by its minimal manpower requirements, with just half a day of semi-skilled labour needed for daily operations and a low electricity consumption of approximately 21 units per day, thus making it one of the most economical operational systems for waste management.

[7] Deccan Herald (2023): Market Development Scheme (MDA) for FOM.

Image 3: Biogas facility at ECO Kitchen, Chennai.

Additionally, ECO Kitchen is able to redirect the slurry from the plant to support local agriculture in neighbouring farms, where the slurry is used as manure.

6. Potential for Replication

There are several factors such as climatic conditions, seasonal variations in feedstock availability and composition, moisture content, consistency of operations, availability of technical and maintenance support, skilled man power and onsite gas utilisation etc. that dictate the success of small scale biogas plants. But, despite so many variables, small-scale biogas plants are ideal for a wide range of urban bulk waste generators in India such as institutions, hotels, canteens and tech parks where biogas plants of 300 KGs - 2 MT can be installed, fuel generated with feedstock available onsite and consumed directly in their kitchens as cooking fuel. In cases across countries[8], biogas plants have all the environmental benefits that are

[8] EESI (2017): Fact Sheet | Biogas: Converting Waste to Energy

associated with any decentralised waste management facility and more, after careful design and considerations that ensure the desired outcome - a reduction in greenhouse gas emissions[9]. Decentralised units also minimise waste transportation costs and reduce reliance on fossil fuels.

Thus, small scale biogas plants have potential for replication, provided holistic solutions are designed, keeping technical, social, economic, environmental factors as well as localised, context-specific factors in mind. When more waste is managed in a decentralised manner, there is a reduced load on the city's overburdened waste collection and processing infrastructure.

It is imperative that all stakeholders are invested in the success of the project; collaboration of the investor, operator and the beneficiary is a must. In the absence of these collaborative efforts, there is a high likelihood of such small scale plants becoming defunct once an implementation & monitoring agency like Saahas exits the project.

The ECO Kitchen biogas plant is testament to the fact that creating circularity in local organic waste streams can be a game changer in India's effort to reduce waste and cut greenhouse gases.

[9] Valerio Paolini, Francesco Petracchini, Marco Segreto, Laura Tomassetti, Nour Naja & Angelo Cecinato (2018) Environmental impact of biogas: A short review of current knowledge, Journal of Environmental Science and Health, Part A, 53:10, 899-906, DOI: 10.1080/10934529.2018.1459076