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Biogas Initiative at Tezpur University
A Case Study

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ABSTRACT
This case study presents innovative approach taken by Tezpur University by developing biogas plants at the university and a nearby village in Assam towards establishing a circular economy at local level.

_VO**IS Planet** portal primarily focuses on environmental sustainability covering various aspects: **Low carbon, Renewable energy usage** and **E-waste management.**

It is aimed at aggregating and helping co-create knowledge and information on environmentally responsive behaviours and concurrently pursuing result-oriented social media campaigns to encourage people and specifically the youth, to take proactive actions in promoting sustainable lifestyle and creating a positive impact on the environmental ecosystem in their surroundings

By: _VO**IS Planet**

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BACKGROUND

1. THE CLIMATE EMERGENCY: DEPENDENCE ON FOSSIL FUELS

As of May 2022, 39 countries of the world have declared a climate emergency.[1] Climate change is regarded by the World Health Organization (WHO) as the biggest threat to world health in the twenty-first century.[2]

The average global temperature on Earth has risen by at least 1.1° Celsius (1.9° Fahrenheit) since 1880, according to an ongoing temperature analysis headed by researchers at NASA's Goddard Institute for Space Studies (GISS).[3]

Deserts are growing larger as a result of climate change, and heat waves and wildfires are becoming more frequent.[4] Storms, droughts, and other weather extremes are becoming more intense as a result of rising temperatures.[5] Numerous species are being forced to move or go extinct due to the rapid environmental change occurring in the Arctic, coral reefs, and mountains.[6] People are at risk from food and water shortages, greater flooding, high heat, an increase in disease, and economic loss due to climate change. Conflict and human migration are potential outcomes.[7]

The production of greenhouse gases like CO_2 is a major factor in climate change, and burning fossil fuels is the main source of these emissions.

In 2021, fossil fuels accounted for 82.28% of global primary energy consumption and 64% of total electricity.[8]

India, too, is heavily reliant on fossil fuel imports to meet its energy needs. India is dependent on fossil fuels for nearly 70% of its energy.[9]

Reduced fossil fuel consumption and a shift to renewable energy were major themes of the 2015 Paris Climate Agreement.

Energy obtained from natural resources that are renewed more quickly than they are used up is referred to as renewable energy. Some of the major renewable energies include solar energy, wind energy, geothermal energy, hydropower, ocean energy, and bioenergy.

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[1] https://www.cedamia.org/global/ CEDAMIA. Climate Emergency Declaration and Mobilisation in Action.
[2] IPCC AR5 SYR (2014). The Core Writing Team; Pachauri, R. K.; Meyer, L. A. (eds.).
[3] https://data.giss.nasa.gov/gistemp/
[4] IPCC SRCCL 2019
[5] IPCC AR6 WG1 Ch11 2021, p. 1517

2. INDIA'S COOKING FUEL PROBLEM

The Government of India's flagship scheme, 'Pradhan Mantri Ujjwala Yojana' has been claimed to be a huge success. It was reported that as on 1st April 2021, the LPG coverage in India has risen to 99.8%.

However, the National Family Health Survey (NFHS - 5), 2019–21 revealed that only 55.5% of households surveyed used LPG, while 33.4% used wood, 4.8% dung cakes, and a meagre 0.6% depended on electricity as a source of fuel for cooking. A large number of them cook in the same room where they live, exposing every member of the household to noxious smoke.[10]

Similarly, according to an independent study released in September 2021 by the Council on Energy, Environment, and Water (CEEW)[11], only 70% of households use LPG as their primary cooking fuel.

Up to 38% of homes still use traditional solid fuels, either solely or in combination with LPG. Such households are more exposed to indoor air pollution because they cook with traditional solid fuels such as firewood, dung cakes, agriculture waste, charcoal, and kerosene.

The study also highlighted that 84% of households that use traditional solid fuels along with LPG cite high cylinder costs as one of their reasons for stacking fuels. This finding is significant in the context of the ongoing surge in LPG prices, which have risen by INR 244 per cylinder (a 30% hike) over the past year.[12] Lower household incomes during the pandemic and the suspension of LPG subsidies in May 2020 have made LPG unaffordable for a section of the population. Other reasons for fuel stacking include the availability of free biomass (59% of households) and the limited availability of LPG refills (46% of households).

In addition, based on Purchasing Power Parity (PPP), the LPG per litre price in India is the most expensive compared to any other country in the world.[13]

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[6] EPA (19 January 2017)
[7] Cattaneo et al. 2019; UN Environment, 25 October 2018.
[8] Ritchie, Hannah; Roser, Max (28 November 2020). "Energy". Our World in Data.
[9] https://www.thehindu.com/news/national/transition-from-fossil-fuels-to-renewable-energy-can-pose-fiscal-challenges-for-india-study/article65623618.ece
[10] International Institute for Population Sciences (IIPS) and ICF. 2021.National Family Health Survey (NFHS-5), 2019-21: India. Mumbai: IIPS.
[11] Mani, Sunil, Shalu Agrawal, Abhishek Jain and Karthik Ganesan. 2021. State of Clean Cooking Energy Access in India: Insights from the India Residential Energy Survey (IRES) 2020. New Delhi: Council on Energy, Environment and Water.

3. THE FRAGILE ENERGY SECURITY OF INDIA

Energy security refers to a country's capacity to provide enough, affordable, and reliable energy supply for its military, industrial, transportation, and household needs. It implies that, regardless of economic or political instability, current and future energy needs have a high possibility of being satisfied.

India's dependence on energy imports was 41.2% of the country's total energy consumption in 2020-21. If India wants to ensure its energy security, it has to find alternative ways to ensure more domestic production of energy.

Fossil fuels are unsustainable and hence not dependable as a reliable source of energy in the long term. A 2019 publication from the Millennium Alliance for Humanity and the Biosphere at Stanford University has predicted that the world's oil reserves will run out by 2052, natural gas by 2060, and coal by 2090. India is largely dependent on fossil fuel imports to meet its energy demands. About 70% of India's energy is sourced from fossil fuels.

In addition, while India is 85% dependent on imports to cover its oil demands, only around 50% of its domestic needs for natural gas are met by foreign sources.[14]

Although biomass, mainly fuelwood, is a reducing component of the energy mix, it is still commonly utilized as cooking fuel. Despite recent success in boosting LPG coverage in rural areas, 660 million Indians are yet to fully transition to contemporary, clean cooking fuels or technologies.[15]

THE POTENTIAL OF BIOGAS

Biogas is a type of biofuel that is naturally produced from the anaerobic decomposition of organic waste. When organic matter, such as food waste and animal waste, breaks down in an anaerobic environment (an environment absent of oxygen), they release a blend of gases, primarily methane and carbon dioxide. Due to the high content of methane in biogas (typically 50–65 %) biogas is flammable, and therefore produces a deep blue flame, and can be used as a fuel source. Biogas is a mixture of gases whose composition is as follows:

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[12] https://economictimes.indiatimes.com/news/india/smokeless-lpg-bringing-tears-to-eyes-as-prices-rise-30-in-one-year/articleshow/92766921.cms

[13] https://timesofindia.indiatimes.com/india/lpg-cost-in-india-highest-in-world-at-ppp-petrol-3rd/articleshow/90715416.cms

[14] https://economictimes.indiatimes.com/news/india/modi-sets-2047-target-for-becoming-energy-independent/articleshow/85343356.cms

Composition	Percentage
Methane (CH_4)	50–65%
Carbon dioxide (CO_2)	30–40%
Hydrogen (H_2)	1–5%
Nitrogen (N_2)	1%
Hydrogen Sulphide (H_2S)	0.1%
Oxygen (O_2)	0.1%
Water vapours (H_2O)	0.1%

Table: Composition of Biogas

Biogas is an environment-friendly, renewable energy source. It's produced when organic matter, such as food or animal waste, is broken down by microorganisms in the absence of oxygen, in a process called anaerobic digestion. For this to take place, the waste material needs to be enclosed in an environment where there is no oxygen.

Biogas can occur naturally or as part of an industrial process to intentionally create it as a fuel.

1. BIOGAS IN INDIA

The world's first biogas plant was built in 1859 in a leper colony in Mumbai (Bombay), India when scientists found that methane was generated in swamps and rotting organic matter.

Biogas in India often called gobar gas, has been traditionally based on dairy manure as feed stock and the biogas plants have been in operation for a long period, especially in rural India.

In the last 2–3 decades, research organizations with a focus on rural energy security have enhanced the design of the systems resulting in newer efficient low-cost designs.

It is estimated that India has a total of over five million biogas plants. The state of Maharashtra had the largest number of biogas plants in India, with over 931 thousand plants as of March 2021. Karnataka ranked second with nearly 513 thousand plants.[16]

2. BIOGAS AS COOKING FUEL: A FEASIBLE ALTERNATIVE TO LPG

With prices of LPG skyrocketing, Biogas can be a safe and affordable cooking fuel for a large mass of the country. In addition, LPG is a fossil fuel, which makes it less desirable, while biogas is renewable energy.

The source of LPG is a fossil fuel, which makes it non-renewable energy, whereas the source of biogas is organic waste, which makes it renewable energy.

The burning of LPG releases greenhouse gases such as CO_2 that contribute to global warming. While biogas too releases greenhouse gases, it absorbs an equivalent amount of them during its production process, thus, bringing its emissions to net zero.

LPG needs to be purchased frequently whenever the cylinder gets empty. In addition, the prices of LPG are frequently hiked. In comparison, biogas is much more affordable. However, there are some operational and management costs to a biogas plant, but if the plant is established at a community level, those costs can be reduced substantially.

3. GOBARDHAN: SWACHH BHARAT MISSION (GRAMEEN)

As part of the Swachh Bharat Mission (Grameen) Phase II, the Government of India launched the GOBARDHAN scheme (Galvanizing Organic Bio-Agro Resources) in April 2018 with the goal of ensuring cleanliness in villages by converting bio-waste including animal waste, kitchen leftovers, crop residue, and market waste into biogas and bio-slurry to improve the lives of villagers.

Under SBM (G) financial assistance of Rs. 50 lakh per district is available for setting up model GOBARDHAN projects. Cluster and community-level biogas plants can be constructed at the village/ block/district level. But at least one model community-level biogas plant per district is mandatory under the program.

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[15] IEA (2021), India Energy Outlook 2021, IEA, Paris https://www.iea.org/reports/india-energy-outlook-2021

[16] https://www.statista.com/statistics/941298/india-number-of-biogas-plants-by-state a

[17] Tezpur University. (2021, July). Sustainable Campus Initiatives, Policy Document of Tezpur University (B.102/2021/3/1.3). http://www.tezu.ernet.in/sustainable/pdf/SCI-Document_Approved.pdf

CONTEXT: BIOGAS MANUFACTURING AT TEZPUR UNIVERSITY

1. ABOUT TEZPUR UNIVERSITY

Tezpur University is a Central University located in Tezpur in the North-eastern state of Assam, India, established by an act of Parliament, in 1994.

The university campus is located at Napaam village, about 15 km east of Tezpur town in the Sonitpur District of Assam. The university has a large campus spread across 262 acres (1.06 km2) of land, which plays host to a large number of accommodation buildings as well as many of the university's recreational facilities and dining areas, and dedicated health, horticulture, and computer centres. The university has a green campus with a wide variety of flora and fauna within it.

The university has five men's hostels, seven women's hostels, and one hostel for married scholars. Each hostel has a food mess of its own and both vegetarian and non-vegetarian food is provided in them.

At present approximately 4129 students are on the campus comprising males (58.5 %) and females (41.5 %).

The academic programs offered by the university have a distinct focus on science, technology, management, humanities, and social sciences, reflecting the objective of the university. At present, the university offers a number of programs on Undergraduate Degrees/Diplomas/Certificates, Integrated Programmes, Post-Graduate Degrees/Diplomas, and Doctor of Philosophy degrees in various disciplines.

Being a Central University, it receives funds from the Ministry of Education (MoE), Government of India, through the University Grants Commission (UGC). The University promotes an industry-academia alliance.

2. THE ENERGY INITIATIVE & BIOGAS

As part of its vision, Tezpur University aims to be a sustainable campus that contributes positive environmental, and social benefits and engages in sustainability-related activities.[17]

The annual food waste generation from all the hostels of the university is approximately 2,50,000 kg. This food waste is either drained or taken by the pig bearers of the locality.

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[18] Tezpur University. (2021, July). Sustainable Campus Initiatives, Policy Document of Tezpur University (B.102/2021/3/1.3). http://www.tezu.ernet.in/sustainable/pdf/SCI-Document_Approved.pdf

Figure: Description Board at the site of the Biogas Plant at the University

The university community was aware of this challenge and conscientious of the food wastage, hence it pondered over the matter to explore ways for utilizing this food waste in a better manner. This was discussed with the various professors of different departments of the university, and a possible pathway was figured out. The university arrived at a judicious and scientific approach to converting food waste into usable cooking gas (biogas) through anaerobic digestion.

Hence, as part of its initiative to utilize the bio-waste generated on the campus for energy, in 2014, Tezpur University commissioned a 50 cubic meter per day capacity community-sized bio-methanation plant in one of the student hostels (Patkai Men's Hostel). The biogas plant is a Shakti Surabhi-type biogas digester developed for kitchen waste-based biogas production by Vivekananda Kendra – Natural Resources Development Project (VK-NARDEP), Kanyakumari, India.

Utilization of a variety of bio-waste materials, generated on the campus of an academic institute, through a suitable energy conversion device has academic and entrepreneurial interests. Further, it is worth mentioning that the use of LPG in hostel messes has been partially replaced.

The university plans to demonstrate the facility as a business model of the circular economy taking the bio-waste stream. Therefore, the facility also supports R&D works and a learning platform for students.

Figure: The Biogas Plant at the University

The university also plans to install more food waste biogas systems in other hostels based on the performance of the system and user feedback in a phased manner.

3. PROFESSOR DEBENDRA CHANDRA BARUAH

Professor Debendra Chandra Baruah is a Professor and the Head of the Department of Energy at Tezpur University, Assam. He has an M. Tech. from IIT Kharagpur and a PhD from Punjab Agricultural University, Ludhiana. His area of specialization in research are bioenergy and rural and agriculture energy management. He has several research publications in various national and international journals.

Figure: Professor Debendra Chandra Baruah

He has been instrumental in the establishment of the Biogas Plant at Tezpur University as well as a community-scale Biogas Plant at a nearby village Jhawani. He was among the first ones to come up with the idea of the biogas plant in the university as a solution to the management of kitchen waste and as a way to generate cheap cooking gas for the messes in the hostels. He helped convince the university about the potential of a biogas plant and subsequently oversaw the development of the plant. After the establishment of the plant, he has been experimenting with different sources to increase the efficiency of the plant. He has also conducted research regarding various aspects related to the plant and published papers in journals.

PROJECT DESIGN

1. THE STAKEHOLDERS

Besides its use in hostels' kitchens, the biogas is also used in the canteen and eatery using a biogas storage balloon. Organic fertilizer generated by the system is utilized in a vegetable garden in the vicinity of the biogas plant besides being sold to customers.

The major stakeholders in this project are as follows:

- **University Administration –** The university administration is responsible for managing food waste on the campus. It also provides necessary funds for the LPG gas used in the messes in hostels. It also takes care of the flora of the campus ensuring the right soil, fertilizers, pesticides, and water for trees and plants. With this project, the university gets the opportunity to save funds by switching partially from LGP to biogas and is also able to better manage waste. In addition, the plant generates organic fertilizer which saves the university from buying a lot of fertilizer from the market. Hence, the university administration is the biggest stakeholder in this project and also the biggest beneficiary.

- **University Faculty –** The plant has been designed, constructed, and operated with great coordination from the university faculty, especially from the energy department. The biogas plant also serves as a medium for various kinds of biogas-related research for the faculty, and they have even published some research papers based on the biogas plant. The faculties have also experimented with food waste and manure sources to make the biogas plant more efficient.

- **Research Students –**The students who have to do research as part of their course get opportunities to conduct research related to biogas through the plant.

- **Canteen Owner & Chai Thela –** Since the biogas is filled in a balloon and then transported to the canteen and chai thela, the owners and workers of these stalls get the benefit of cheaper cooking gas bringing down their costs.

- **Village Households –** With the establishment of the community-scale biogas plant in the Jhawani village, the village households have access to a cheap and labour-effortless source of cooking fuel, although they have to contribute to the running and maintenance of the plant which requires some labour. This in turn brings down the expenditure of the household and also saves them the time and labour spent in collecting biomass such as firewood.

- **Village Women –** Women are the ones primarily responsible for cooking in the village. Cooking with biomass such as firewood meant that there would be a huge amount of smoke pollution in small enclosed kitchens. This was a major health hazard for these women in the long term. With the availability of piped biogas in their kitchen, they have access to a clean source of cooking fuel saving them from exposure to polluting smoke.

- **Village Farmers –** Since the by-product of the biogas plant is the manure which is then sent for vermicomposting, the farmers have access to a cheap source of fertilizer for their farms and crops, bringing down their costs and increasing their harvest.

2. BACKGROUND DATA COLLECTION

Prior to the construction of the biogas plant in the university, an assessment was done to determine the daily waste generated, and the cooking energy consumption in the hostels of Tezpur University. A questionnaire survey was carried out comprising questions on LPG usage, food wastage, etc.

As shown in the table below, daily about 804 kg of food waste is accumulated cumulatively from all the hostels. The minimum monthly requirement in the case of men's hostel is 1 cylinder/day, whereas that of women's hostel is 0.7 cylinders/day.[19]

S.No	Hostel	No. of boarders	No. of cylinders required per day	MJ equivalent of LPG	Energy density (MJ/capita)	Food waste available (kg/day)
1	Saraighat CV Raman Men's Hostel	350	1	693.9	4.96	95
2	Patkai Men's Hostel	386	2	1413.98	3.66	92
3	Charaideo Men's Hostel	270	1.5	1014.66	3.76	112
4	Nilachal Men's Hostel	411	2	1413.98	3.44	74
5	Kanchenjunga Men's Hostel	390	2	1413.98	3.63	139
6	Dhansiri Women's Hostel	139	1	595.7	4.29	32
7	Pragjyotika Women's Hostel	136	1	654.62	4.81	30
8	Bordoichila Women's Hostel	104	1	458.23	4.41	24
9	Suwansiri Women's Hostel	183	1	654.62	3.58	49
10	Kopili Women's Hostel	186	1	654.62	3.52	44
11	Pobitora Madam Curie Women's Hostel	316	1	654.62	3.03	88
12	New Women's Hostel	126	1	510.6	4.05	25
Total		**2997**	**15.5**	**10133.51**	**47.14**	**804**

Table: Daily food waste generation & LPG consumption pattern in different hostels of Tezpur University

Based on the site suitability and ease of logistics, it was decided to construct a 50 m3 food waste biogas plant in the Patkai Men's Hostel of the university.

THE TECHNOLOGY

1. THE TECHNOLOGY DESIGN

The biogas plant's design is a Shakti Surabhi-type biogas digester developed for kitchen waste-based biogas production by Vivekananda Kendra – Natural Resources Development Project (VK-NARDEP), Kanyakumari, India.

The plant works on similar principles of a traditional floating drum-type biogas plant with a few modifications and comes in two designs: both portable and fixed.

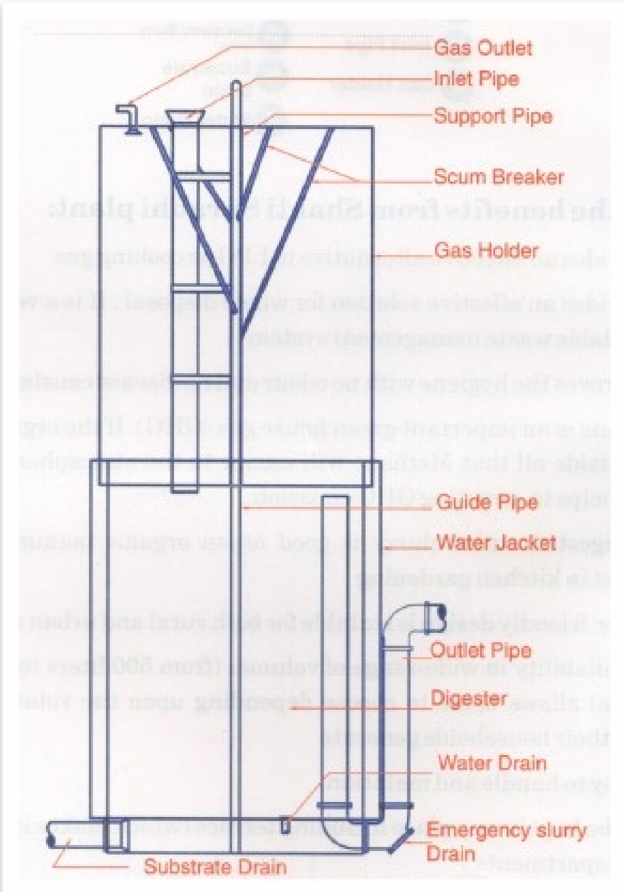

Figure: Model of a Shakti-Surabhi Biogas Plant_[21]

The main digester is initially fed with cattle dung as it is rich in methanogenic bacteria. It produces methane from starchy material. Subsequently, cattle dung is not required. Afterwards, one can start feeding the plant daily with kitchen/vegetable waste. The ratio of waste to water should be 1:1. This will facilitate the easy flow of waste through the inlet into the digester. The value of pH of the kitchen waste should be ideally kept in the range of 6.8 to 7.5 for the optimum production of biogas. About 5 kg. of kitchen waste is required for a 1 cubic meter plant. Gas coming out of the plant can be used in the kitchen with the help of a biogas stove while the slurry coming out from the outlet can be used as manure. The gas generated will have 60 to 70% methane, some amount of water vapour (moisture), and the balance will be mainly Carbon-di-oxide and very little amount of trace gases.[20]

2. LAB TO LAND

The university administration initially wasn't convinced about the usefulness of a large biogas plant. Hence, it was decided to first conduct a pilot project by constructing a small biogas plant with a capacity of 0.25 cubic meters per day to demonstrate the functionality to the university. Once, the university was convinced, the construction of the large plant was approved.

The construction of the plant started in September 2013 under the supervision of a technician from VK-NARDEP, Kanyakumari. The entire process took 2 months to complete.

From the date of construction to the date of commissioning, up-to-date details of the progress of work, material procurement, human resources engaged, etc. were properly recorded.

Figure: (a–d) Construction phases of the biogas plant

[19]Buragohain, S. et al. (2018). Feasibility Study on Implementing Kitchen Waste-Based Biogas Plant at Tezpur University, Assam. In: Ghosh, S. (eds) Utilization and Management of Bioresources. Springer, Singapore. https://doi.org/10.1007/978-981-10-5349-8_10

3. THE SOURCES

Food waste is considered potential anaerobic digestion (AD) feedstock because of its biodegradable nature and availability in the hostels of the university. The food waste mostly includes unconsumed food and food preparation leftovers.

The university comprises a total of 12 hostels, which generate a substantially large amount of food waste per day. This food waste is used in the biogas plant in Patkai Men's Hostel and the rest of the waste is used as fodder for piggery of the locality.

The plant is fed with an amount of 150-200 kgs of food waste daily.

In addition to kitchen waste, leaves are also used as input for the digestor.

INNOVATION IN LAB

In addition to using kitchen waste as the source, the department has been experimenting with other types of materials to increase the efficiency of the biogas plant.

For instance, the leaves of mikania micrantha, locally known as Japani lota in Assam, a notoriously invasive weed, were used as a source in the digester. The results turned out to be very good and it generated a greater amount of gas in lesser time. Mikania micrantha was preferred because it is usually plucked and thrown away as a weed and hence is easily available.

Figure: (a–d) Construction phases of the biogas plant

1. USE OF IOT FOR MEASURING PARAMETERS IN DIGESTER

IoT-based management of the biogas plant has been devised and hence the operations team is able to monitor, showcase and change several parameters related to the digester. It is used for managing critical components that require immediate action.

The plant is embedded with ESP32, a system-on-a-chip microcontroller with integrated Wi-Fi and dual-mode Bluetooth. It is also implanted with a BME280 humidity sensor. This way it is possible to **measure, track and monitor parameters such as:**

[20] Er. V. Ramakrishnan. (2011). Handbook on Bio-Methanation - Shakti Surabhi (Waste to Energy). Kanyakumari, Tamil Nadu; Vivekananda Kendra - Nardep.

[21] Er. V. Ramakrishnan. (2011). Handbook on Bio-Methanation - Shakti Surabhi (Waste to Energy). Kanyakumari, Tamil Nadu; Vivekananda Kendra - Nardep.

- Relative humidity
- Barometric pressure
- Ambient temperature - It is ensured that the temperature inside the digester remains between 35 to 45 degrees which maintains the mesophilic condition, optimum for the growth of bacteria.
- Methane (CH_4)
- Carbon dioxide (CO_2)
- Hydrogen Sulphide (H_2S)
- Water vapour (H_2O)
- pH

These IoT devices are connected to the computer system and the parameters are measured periodically. It is instrumental in dealing with the adverse scenario.

2. INNOVATION IN DISTRIBUTION

The department didn't just want to use the plant for generating cooking gas, they also wanted to showcase the plant as a viable business opportunity. Hence, it was necessary to exhibit that it was portable.

Figure: Balloon used to fill biogas and transport at various locations through chai-thela rickshaw

Hence, a part of the biogas harvested from the biogas plant at the university is transported into a big biogas storage balloon with a volume of 25 cubic meters.

The biogas in the balloon remains in a gaseous state, unlike LPG which remains in a liquid state. The balloon is then mounted on a rickshaw that sells tea and snacks in front of the department, known as chai-thela. The gas from the balloon is used for making tea by the tea-seller. The chai-thela serves as a demonstration of the innovative possibilities of the biogas plant. The biogas is also sold to a canteen inside the university.

The vermicompost generated after treating the slurry from the plant is also sold by the university. The vermicompost has been found to be very nutritious and of good quality. The feedback received from the purchasers has also been very positive with customers returning again to make purchases.

3. OUTPUT GENERATED

The biogas plant is fed daily with 150-200 kg of kitchen waste per day and has been generating around 50 cubic meters of biogas every day which is equivalent to around 20 kg of LPG. However, the output at times varies depending on the ambient conditions, nature, and quantity of feed materials.

The plant can generate about 300 kg of solid organic fertilizer per month.

4. CAPEX

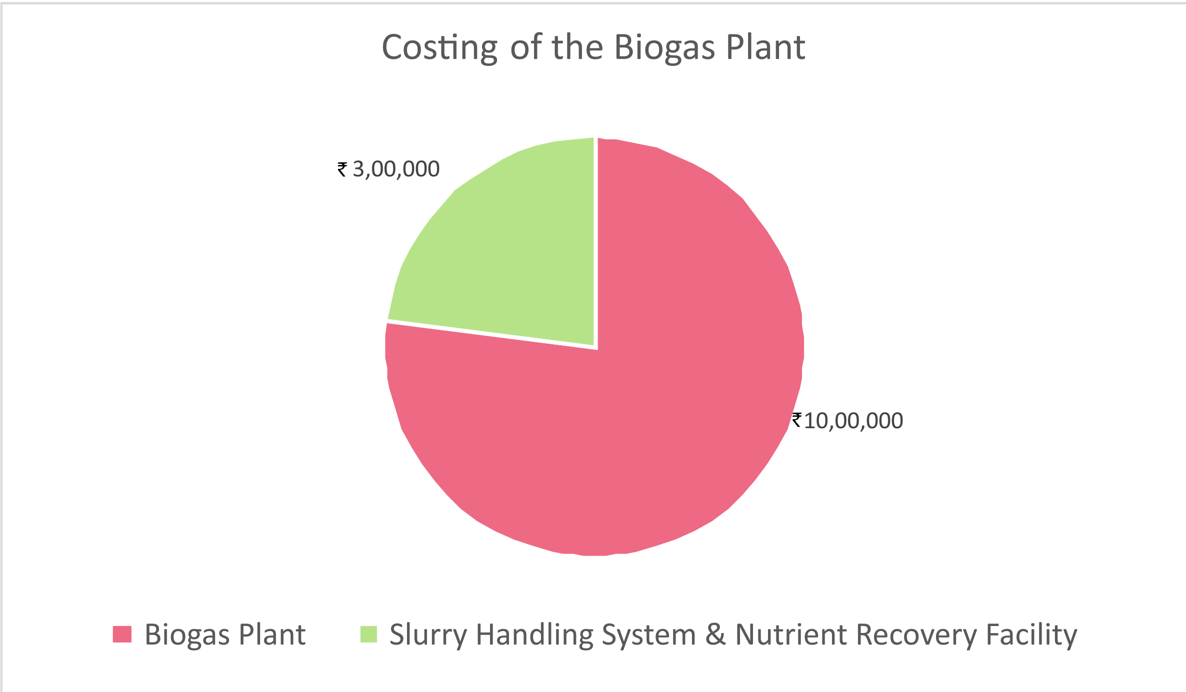

Figure: Balloon used to fill biogas and transport at various locations through chai-thela rickshaw

According to Professor D C Baruah, the cost of the university biogas plant with a capacity of 50 cubic meters was 10 lakh.

In addition, the slurry handling system and nutrient recovery facility cost another 3 lakh.

Hence, the total cost of the biogas system at the university came down to 13 lakh rupees.

5. FEASIBILITY

The average annual LPG cylinder consumption per boarder and annual waste generation per boarders are 2 cylinders and 87 kg respectively. The annual LPG cylinder consumption in the hostels of the University is approximately 6000 and annual food waste generation from the hostels is approximately 2,50,000 kg.

Professor Baruah along with other co-authors did a feasibility study on the biogas plant at the university.[22]

It was found during the experimentation stage that 14 LPG cylinders could be saved per month. This would amount to saving 168 cylinders per year. As of the 14th of October 2022, the price of a non-subsidized LPG cylinder in the Sonitpur district is 1,118.50. Multiplying it with the number of cylinders saved per year by using biogas leads to the university potentially saving 1,87,908 per year.

It was also found that the payback period of the biogas plant is 7.36 years.

With the ongoing growth in Tezpur University's population, cooking energy consumption is predicted to rise. In light of this, biogas, a cooking fuel based on renewable energy, might be a sensible choice in the future to meet daily energy needs.

All of the hostels rely on LPG or wood fuel (in times of need) to provide the necessary energy for cooking. The daily LPG use of a typical college hostel is between 1-2 cylinders. This illustrates the enormous expense incurred by the hostels all year round in purchasing LPG cylinders.

Furthermore, the creation of value-added products like vermicompost has proven to be very helpful in generating additional income.

The 50 m^3 bio-methanation plant's performance analysis and economic evaluation revealed that using it to create clean cooking fuel from the food waste produced at educational institutions can be a practical choice.[23]

6. LIMITATIONS

- Getting waste from each hostel to the biogas plant is labour-intensive. Furthermore, as a resolution to this, if it is attempted to mechanize the whole process, a big Capex and Opex would be required.
- Another major problem is that the biogas generated often contains water vapour, which creates problems. The department has been working on innovations to resolve it and instead of using a chemical process, they have been attempting to use a physical process to absorb it.

WHEN INNOVATION BLOSSOMS: COMMUNITY-LED BIOGAS PRODUCTION

1. ABOUT THE VILLAGE

Jhawani is a village located in the Bihaguri Development Block in the Sonitpur district in the state of Assam. It is located at a distance of 17 km from Tezpur town. The village has around 40 households and a population of around 100 people.

Figure: A road through Jhawani village

The total geographical area of the village is 329 acres. The cultivable land is 65 acres and the rest is a wasteland, grazing land, community land, etc.

Jhawani village is an agriculturally dominated village with 85% of households depending on agriculture. In addition, cattle rearing is also one of the major occupations in the village with most households having cows. About 2 tons of cow dung is available in the village daily.

Cow dung produced is generally used as a fertilizer for crops and the excess cow dung is sold in Jhawani village. Despite this, the handling of cow dung and disposal of agro wastes is a problem for households.

Mostly the farmers are tempted to dispose of the excess cow dung into dumping areas and burn the surplus agro residues which become a source of soil and air pollution.

There is only one lower primary school in the village and the literacy rate is 85.5 percent.

2. COOKING ENERGY CONSUMPTION

LPG and firewood are the two energy sources that are most frequently utilized in cooking. Firewood is available within the village, mostly within the homestead. Sesbania javanica, a biomass grown in the community, is mostly utilized as firewood for cooking and space heating and is practically grown in every household. Few families use LPG, the reason being that collecting and carrying the cylinders from Bihaguri (approximately 5 kilometres from Jhawani village) is challenging.[24]

Figure: Community-scale Biogas Plant at Jhawani village

In addition to inefficient cooking using firewood, collection and preparation for fuel involves time and effort and most importantly indoor air pollution while cooking. The end result is a negative impact on the health of women and children. In order to tackle these issues, an effective solution was a necessity.

3. THE ENERGY HARVESTING MODEL

Since Jhawani is a village full of resources, it was thought that the abundant biomass may be used to replace current cooking practices in an environmentally benign way.

It was also considered that the utilization of cow dung for the production of biogas and enriched organic fertilizer would help with a number of important concerns relating to the rural economy, environment, and sustainable crop production. Additionally, it was believed that this would enable the rural community to operate a workable business model centred on the local biogas system.

Figure: Community-scale Biogas Plant at Jhawani village

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[22]Buragohain, S. et al. (2018). Feasibility Study on Implementing Kitchen Waste-Based Biogas Plant at Tezpur University, Assam. In: Ghosh, S. (eds) Utilization and Management of Bioresources. Springer, Singapore. https://doi.org/10.1007/978-981-10-5349-8_10

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[24] Patowary, D., Sarmah, T., Sarma, G.D., Terang, B., Patowary, R., Baruah, D.C. (2020). Economic Feasibility and Environmental Sustainability of a Community Scale Multi-component Bioenergy System. In: Ghosh, S. (eds) Energy Recovery Processes from Wastes. Springer, Singapore. https://doi.org/10.1007/978-981-32-9228-4_20

With this understanding, a community-scale biogas plant was established in the village by the Department of Energy, Tezpur University. The funding for the plant was secured from the Department of Science and Technology (DST), Science for Equity Empowerment and Development (SEED) division, Government of India to carry out research on a project 'Rural Hybrid Energy Enterprise System (RHEES)' under Indo-UK collaborative research initiative on 'Bridging the Urban-Rural Divide (BURD)'.

The land for the biogas plant was donated by one of the villagers.

4. MODEL OF THE COMMUNITY-SCALE BIOGAS PLANT

While the basic structure of the Jhawani village biogas plant remains the same, the input/raw material used is primarily cow dung, unlike the university plant in which the input mostly is kitchen waste.

Figure: Indev Team with Dr. Baruah visiting the community-scale plant at Jhawani village

The cow dung in the village biogas plant is mixed with various native wheat, plants, and agricultural waste. These ingredients then are put together in a container that has a mixing mechanism, where they are all mixed and diluted with water. Then, they are sent to the digestor.

There, the gas is synthesized and is taken to a compressor where it is put under high pressure and which has a valve through which it is transported to the village through a pipeline.

The cow dung is sent to the lower part of the digestor so the slurry that is removed later, is removed from the top of the container. The top slurry is taken and then dried through a machine. The liquid part is again sent to the digestor acting as a catalyst full of microbes. The solid part is sent for vermicomposting.

About 1000-1200 kgs of cow dung is collected every day from the homes of the villagers to be used as a source in the plant.

WAY FORWARD

The 50 cubic metres bio-methanation plant at Tezpur University provides several benefits to various stakeholders inside and outside the university. In addition, it was found that it saves a lot of cost for the university and even generates additional income.

With rising gas prices and the increasing population of the university every year, the cost of using LPG as cooking fuel will rise substantially. Considering this, the university could consider substituting LPG with biogas as the cooking fuel gradually through the establishment of more biogas plants. This also means that switching to biogas through the utilization of food waste could be **a feasible option for educational institutions.**

Similarly, interacting with the residents of Jhawani village revealed that the community-scale biogas plant in their village has provided them with several benefits and has increased their access to clean cooking fuel. It has also made cheap manure available to them.

With such advantages, and others such as being a cheap indigenous renewable energy resource that can provide local employment opportunities, enhance solid waste management, and establish a circular economy, biogas plants should be seriously considered as one of the optimum means to fulfil the energy requirements of both the local communities and the various institutions.

However, the role of government is key here as the establishment of biogas plants can be expensive. Regarding this, schemes such as GOBARDHAN by the government which provide financial assistance for setting up biogas plants would be really helpful.

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