fully functioning biogas at one of the landusers house (Ongpo Lepcha)

Biogas plant (Bhutan)

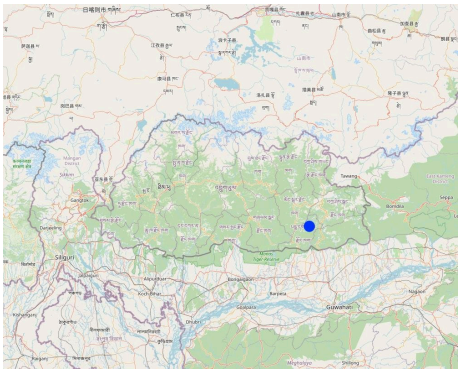
Kayden meylung (སྐྱེས་ལྡན་མེ་སྒྲུང་།)

DESCRIPTION

Biogas is a renewable fuel generated through the anaerobic digestion of organic matter like food or animal waste, typically within a biogas plant. The biogas plant is adapted to household conditions and animal waste production. While this technology benefits small-scale farmers, challenges include the cost of establishment and the need for consistent waste input. Adoption has significantly reduced costs for users, lowered greenhouse gas emissions, and provided organic fertilizer, enhancing crop productivity and livestock health.

Biogas is a renewable fuel produced through the anaerobic digestion of organic matter, such as food or animal waste. Typically, biogas is intentionally generated in an enclosed environment (a biogas plant) for household consumption. This plant is constructed near a livestock shed for easy collection of animal waste and in proximity to households, mainly used for cooking, heating, and as an alternative to commercial LPG gas.
The plant can be adjusted based on the amount of animal waste, making it viable for smallholder farmers with just a few cows. In most parts of the country, the technology is modified so that even a small amount of animal waste can produce some gas. The digestion chamber is made smaller in diameter and height to generate enough pressure for the gas to reach the stove through the pipe. Initially, the Biogas project started to promote clean and renewable energy for household cooking, reducing the consumption of firewood. Currently, there are more than 8000 biogas plants of different sizes - 4 m3, 6 m3, 8 m3, and 10 m3, and a few large-scale biogas greater than 50 m3 in large individual dairy farms and government livestock farms.
The major activities and inputs required to establish and maintain the technology include having ample space around the residential area for the plant's construction. Additionally, materials such as cement, sand, gravel, stone, iron rods, pipes, pressure gauges, and a stove are necessary. Human resources are needed for the construction of the plant, and land users should have livestock (cows, buffaloes, horses, etc.) that can provide dung/waste for gas generation.
There are numerous benefits and impacts of the technology, including its positive effects on rural communities, greenhouse gas emission reduction, maintaining carbon neutrality, and minimizing the use of imported LPG gas and chemical fertilizers. It also reduces electricity bills needed for operating electric heaters, saving time for land users who would otherwise collect firewood. The by-product (bio-slurry) from the digester is used as organic fertilizer, enhancing crop productivity and serving as a nutritious feed supplement for animals.
Land users both appreciate and have concerns about the technology. They acknowledge the cost reduction benefits, citing the significant savings compared to market-priced commercial LPG gas and reduced expenses on operating electric heaters. The technology has also provided them with additional time by eliminating the need to gather firewood. The bio-slurry, a by-product of the biodigester, serves as fertilizer to enhance crop production and contributes to livestock waste management, improving livestock health and production.
However, land users note that biogas plant establishment is expensive and may not be suitable for economically disadvantaged individuals. Some users experience challenges, such as the biodigester chamber failing to produce enough gas despite being constructed according to technical specifications. The daily requirement of adding animal waste to the input tank is perceived as tedious, and for land users with only one or two milking cows, supplying the required amount of animal waste for the biodigester chamber is often a problem.

LOCATION



Location: Darchung under Shumar Chiwog (Community), Shumar Gewog (Block), Pemagatshel Dzongkhag (District), Bhutan

No. of Technology sites analysed: single site

Geo-reference of selected sites
- 91.38722, 27.05001

Spread of the Technology: applied at specific points/ concentrated on a small area

In a permanently protected area?: No

Date of implementation: 2021

Type of introduction
- ☐ through land users' innovation
- ☐ as part of a traditional system (> 50 years)
- ☐ during experiments/ research
- ☑ through projects/ external interventions

Officials from CNR interacting with land user on biogas plant (Ongpo Lepcha)

Mixer tank to mix cow dung and urine into slurry

Digester where decomposition and production of methane gas occurs

Valve to control amount of gas going to stove

Pressure valve to check pressure of incoming gas from digester

Stove

Slurry pit
slurry that comes out of digester

Different components of biogas plant (Chogyel Wangdi)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

- [x] improve production
- [ ] reduce, prevent, restore land degradation
- [ ] conserve ecosystem
- [ ] protect a watershed/ downstream areas – in combination with other Technologies
- [ ] preserve/ improve biodiversity
- [ ] reduce risk of disasters
- [ ] adapt to climate change/ extremes and its impacts
- [x] mitigate climate change and its impacts
- [x] create beneficial economic impact
- [ ] create beneficial social impact
- [x] The main purpose as discussed by the land user was to reduce the cost and effort invested in getting LPG. Getting LPG was difficult becuase of the distance.

Land use

Land use mixed within the same land unit: Yes - Agro-silvopastoralism

Cropland

- Annual cropping
- Perennial (non-woody) cropping
- Tree and shrub cropping

Number of growing seasons per year: 3
Is intercropping practiced? No
Is crop rotation practiced? Yes

Grazing land

- Land user allow six months of grazing in pasture land. Six months cattle are stall fed.

Is integrated crop-livestock management practiced? Yes
Products and services: economic security, investment prestige, manure as fertilizer/ energy production, milk

Species	Count
cattle - dairy	8

Water supply

- [ ] rainfed
- [x] mixed rainfed-irrigated
- [ ] full irrigation

Purpose related to land degradation

- [x] prevent land degradation
- [x] reduce land degradation
- [ ] restore/ rehabilitate severely degraded land
- [ ] adapt to land degradation
- [ ] not applicable

Degradation addressed

physical soil deterioration - Pu: loss of bio-productive function due to other activities

SLM group

- integrated crop-livestock management
- waste management/ waste water management
- energy efficiency technologies

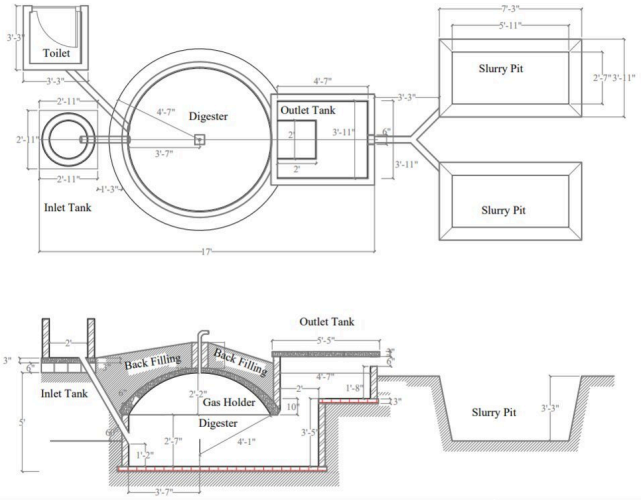
SLM measures

structural measures - S9: Shelters for plants and animals, S10: Energy saving measures

TECHNICAL DRAWING

Technical specifications

Technical design and specification of 4 cubic meter biogas plant capacity



Author: Bhutan Biogas Project, Department of Livestock, Ministry of Agriculture & Livestock

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology unit (unit: **inlet tank (mixing tank), inlet pipes, Digester, gas holder, manhole, outlet, main gas pipe turret, main gas valve, pipeline, water outlet, pressure gauge, gas tab, gas stove, gas lamp, slurry pit** volume, length: **Dimensions of unit is given in technical diagram.**)
- Currency used for cost calculation: **Bhutanese Ngultrum**
- Exchange rate (to USD): 1 USD = 82.73 Bhutanese Ngultrum
- Average wage cost of hired labour per day: Nu 350

Most important factors affecting the costs

Raw materials, transportation cost, labour charges.

Establishment activities

1. Selection of construction site and layout of the plant (Timing/ frequency: 1st March)
2. Digging of pits (Timing/ frequency: 15th April)
3. construction of digester (Timing/ frequency: May)
4. construction of gas holder (dome) (Timing/ frequency: May)
5. Plastering of Digester and gas holder (Timing/ frequency: May)
6. construction of turret, manhole and outlet tank (Timing/ frequency: May)
7. Construction of Inlet Tank (Timing/ frequency: June)
8. Fitting pipelines and appliances (Timing/ frequency: June)
9. Construction of compost pit (Timing/ frequency: June)
10. Finishing and instruction to users (Timing/ frequency: July)

Establishment inputs and costs (per inlet tank (mixing tank), inlet pipes, Digester, gas holder, manhole, outlet, main gas pipe turret, main gas valve, pipeline, water outlet, pressure gauge, gas tab, gas stove, gas lamp, slurry pit)

Specify input	Unit	Quantity	Costs per Unit (Bhutanese Ngultrum)	Total costs per input (Bhutanese Ngultrum)	% of costs borne by land users
Labour					
Labour	person-days	18.0	350.0	6300.0	
Masion	person-days	12.0	1000.0	12000.0	
Equipment					
Mixture machine	no	1.0	1740.0	1740.0	
GI nozzle	no	1.0	113.0	113.0	
Plant material					
water draining pipe	no	1.0	262.0	262.0	
Main gas valve	no	1.0	523.0	523.0	
Paint brush	no	1.0	85.0	85.0	
Iron brush	no	1.0	85.0	85.0	
CPVC glue (50gm)	Jar	1.0	390.0	390.0	
Teflon tape	roll	1.0	25.0	25.0	
PVC pipe 4"10' (inlet)	no	1.0	1050.0	1050.0	
Construction material					
Cement	Bag	18.0	380.0	6840.0	
Bricks	No	1000.0	11.0	11000.0	
Gravels	Truckload	0.5	5000.0	2500.0	
Sand	Truckload	0.25	6000.0	1500.0	

Arcrylic paint	litres	3.0	350.0	1050.0	
Iron rod	kg	10.0	70.0	700.0	
Dome pipe	No	1.0	1170.0	1170.0	
Other					
Stove	No	1.0	1399.0	1399.0	
CPVC Pipe (10')	No	10.0	350.0	3500.0	
Gas tap	No	1.0	465.0	465.0	
Pressure meter	No	1.0	320.0	320.0	
Elbow joint	No	4.0	350.0	1400.0	
T - union	No	2.0	150.0	300.0	
Total costs for establishment of the Technology				**54'717.0**	
Total costs for establishment of the Technology in USD				*661.39*	

Maintenance activities
n.a.

NATURAL ENVIRONMENT

Average annual rainfall
- ☐ < 250 mm
- ☐ 251-500 mm
- ☐ 501-750 mm
- ☐ 751-1,000 mm
- ☐ 1,001-1,500 mm
- ☑ 1,501-2,000 mm
- ☐ 2,001-3,000 mm
- ☐ 3,001-4,000 mm
- ☐ > 4,000 mm

Agro-climatic zone
- ☐ humid
- ☑ sub-humid
- ☐ semi-arid
- ☐ arid

Specifications on climate
The study area is located in sub humid area

Slope
- ☐ flat (0-2%)
- ☐ gentle (3-5%)
- ☑ moderate (6-10%)
- ☐ rolling (11-15%)
- ☐ hilly (16-30%)
- ☐ steep (31-60%)
- ☐ very steep (>60%)

Landforms
- ☐ plateau/plains
- ☐ ridges
- ☑ mountain slopes
- ☐ hill slopes
- ☐ footslopes
- ☐ valley floors

Altitude
- ☐ 0-100 m a.s.l.
- ☐ 101-500 m a.s.l.
- ☐ 501-1,000 m a.s.l.
- ☐ 1,001-1,500 m a.s.l.
- ☐ 1,501-2,000 m a.s.l.
- ☐ 2,001-2,500 m a.s.l.
- ☐ 2,501-3,000 m a.s.l.
- ☐ 3,001-4,000 m a.s.l.
- ☐ > 4,000 m a.s.l.

Technology is applied in
- ☐ convex situations
- ☐ concave situations
- ☑ not relevant

Soil depth
- ☐ very shallow (0-20 cm)
- ☑ shallow (21-50 cm)
- ☐ moderately deep (51-80 cm)
- ☐ deep (81-120 cm)
- ☐ very deep (> 120 cm)

Soil texture (topsoil)
- ☑ coarse/ light (sandy)
- ☐ medium (loamy, silty)
- ☑ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- ☐ coarse/ light (sandy)
- ☑ medium (loamy, silty)
- ☐ fine/ heavy (clay)

Topsoil organic matter content
- ☑ high (>3%)
- ☐ medium (1-3%)
- ☐ low (<1%)

Groundwater table
- ☐ on surface
- ☐ < 5 m
- ☐ 5-50 m
- ☐ > 50 m

Availability of surface water
- ☐ excess
- ☐ good
- ☐ medium
- ☐ poor/ none

Water quality (untreated)
- ☑ good drinking water
- ☐ poor drinking water (treatment required)
- ☐ for agricultural use only (irrigation)
- ☐ unusable

Water quality refers to: surface water

Is salinity a problem?
- ☐ Yes
- ☑ No

Occurrence of flooding
- ☑ Yes
- ☐ No

Species diversity
- ☑ high
- ☐ medium
- ☐ low

Habitat diversity
- ☑ high
- ☐ medium
- ☐ low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- ☐ subsistence (self-supply)
- ☑ mixed (subsistence/ commercial)
- ☐ commercial/ market

Off-farm income
- ☑ less than 10% of all income
- ☐ 10-50% of all income
- ☐ > 50% of all income

Relative level of wealth
- ☐ very poor
- ☐ poor
- ☐ average
- ☑ rich
- ☐ very rich

Level of mechanization
- ☑ manual work
- ☐ animal traction
- ☐ mechanized/ motorized

Sedentary or nomadic
- ☑ Sedentary
- ☐ Semi-nomadic
- ☐ Nomadic

Individuals or groups
- ☑ individual/ household
- ☐ groups/ community
- ☐ cooperative

Gender
- ☐ women
- ☑ men

Age
- ☐ children
- ☐ youth
- ☑ middle-aged

- [ ] employee (company, government)
- [ ] elderly

Area used per household
- [ ] < 0.5 ha
- [ ] 0.5-1 ha
- [x] 1-2 ha
- [ ] 2-5 ha
- [ ] 5-15 ha
- [ ] 15-50 ha
- [ ] 50-100 ha
- [ ] 100-500 ha
- [ ] 500-1,000 ha
- [ ] 1,000-10,000 ha
- [ ] > 10,000 ha

Scale
- [ ] small-scale
- [x] medium-scale
- [ ] large-scale

Land ownership
- [ ] state
- [ ] company
- [ ] communal/ village
- [ ] group
- [ ] individual, not titled
- [x] individual, titled

Land use rights
- [ ] open access (unorganized)
- [ ] communal (organized)
- [ ] leased
- [x] individual

Water use rights
- [ ] open access (unorganized)
- [x] communal (organized)
- [ ] leased
- [ ] individual

Access to services and infrastructure

health	poor	good
education	poor	good
technical assistance	poor	good
employment (e.g. off-farm)	poor	good
markets	poor	good
energy	poor	good
roads and transport	poor	good
drinking water and sanitation	poor	good
financial services	poor	good

Comments

The hospital is located 10 km away from Land users' places. Which makes it a little difficult during emergencies. The school is 2 Km away which is very near. There are also Gypsum Mining which provides off-farm activities to many land user in the locality. The land user is trained in making Biogas plants, this also provides him the opportunity to work off-farm. When it comes to energy, apart from energy to light the house, energy is required for cooking purposes. This energy was previously derived from LPG, however, after the Biogas plant land user is not having any difficulties with energy shortage. Land users have their own water source and the same water is used to feed Jersey cows. Land users also said that they get financial assistance from Bhutan Development Bank Limited.

IMPACTS

Socio-economic impacts

Crop production	decreased / increased	Land users didn't keep a record of the production, however, it was reported that crop production has improved.
crop quality	decreased / increased	land users reported that crops are healthier and green when manure prepared from cow dung/ biogas plants is applied on the land.
fodder production	decreased / increased	Land user is also members of milk cooperatives. He maintains different fodder species to have feed for his cows throughout the years. He said fodder production has increased over the years.
fodder quality	decreased / increased	Different species of fodder species like Napier, Ruzi, Guatemala, Super Napier, Banana, Rice straw, maize, and fooder tree species like Ficus auriculata, Ficus simicordata, etc., were observed.
energy generation (e.g. hydro, bio)	decreased / increased	Quantity before SLM: 6 LPG cylinder per annum Quantity after SLM: 0 Each LPG cost around Nu. 1000. LPG is completely replaced by biogas technology.
drinking water quality	decreased / increased	Water was not a problem from the beginning. However, with an improved breed of cow (jersey), water sanitation is also given more importance. Because water can bring diseases to family members and livestock.
farm income	decreased / increased	Land user don't have to buy LPG cylinders. He saves around 7000 in a year.
workload	increased / decreased	Workload has increased since the biogas plant was constructed. Every day the land user have to collect cow dung and add it to the plant. He also has to collect slurry and add to the land to improve fertility.

Socio-cultural impacts

Ecological impacts

Off-site impacts
impact of greenhouse gases

increased ☐☐☐☐☐☐☑ reduced

Scope to conduct research to estimate GHG emission reduction from biogas technology

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative ☐☐☐☐☐☐☑	very positive
Long-term returns	very negative ☐☐☐☐☐☐☑	very positive

Benefits compared with maintenance costs

Short-term returns	very negative ☐☐☐☐☐☐☑	very positive
Long-term returns	very negative ☐☐☐☐☐☐☑	very positive

The investment cost is shared by the Government. Therefore, the land users felt the benefits are very positive.

CLIMATE CHANGE

Gradual climate change

annual temperature increase	not well at all ☐☐☐☑☐	very well	
seasonal temperature increase	not well at all ☐☐☐☑☐	very well	Season: summer
annual rainfall increase	not well at all ☐☐☐☑☐	very well	
seasonal rainfall increase	not well at all ☐☐☐☑☐	very well	Season: summer

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

- ☐ single cases/ experimental
- ☐ 1-10%
- ☑ 11-50%
- ☐ > 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

- ☑ 0-10%
- ☐ 11-50%
- ☐ 51-90%
- ☐ 91-100%

Number of households and/ or area covered

Only two households were interviewed, alothough, there are more than 300 households who have adopted biogas technology under study area (Shumar Gewog).

Has the Technology been modified recently to adapt to changing conditions?

- ☐ Yes
- ☑ No

To which changing conditions?

- ☐ climatic change/ extremes
- ☐ changing markets
- ☐ labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Land user need not buy LPG cylinders because the Biogas plant
- No need to go to collect firewood

Strengths: compiler's or other key resource person's view

- Efficient use of livestock (cow dung) for generation energy which is used for cooking.
- The technology is not easily damaged by pests, temperature, rainfall, etc.

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

- Cow dung has to be collected, and put into a mixing tank and mixing has to be done manually which is hectic.
- A huge amount of cow dung is required.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's viewhow to overcome

- Sometimes, despite good construction material, small calculations in biodigester and gas compartments can lead to a technical error, and this can inhibit gas production. In such cases, the biogas plant becomes nonfunctional. Being extra careful with the design and consulting the biogas focal person to monitor the construction work.
- Low temperature has a deleterious effect on methanogenesis and can cause decreased gas yields. So the technology may not work effectively in winter. Maintaining the temperature by covering the tank with warm material.

REFERENCES

Compiler
ONGPO LEPCHA

Editors
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Resource persons
Rangsem Tshojay - land user

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_6865/

Linked SLM data
n.a.

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Project
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