National Biogas Implementation Strategy

Department of Renewable Energy

Ministry of Economic Affairs

Thimphu : Bhutan

May 2020

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This study on the National Biogas Implementation Strategy has been prepared by M/s. Norlha Engineering and Management consultancy through Department of Renewable Energy (DRE), Ministry of Economic Affairs (MoEA). The assignment has been carried out to study and assess roles and responsibilities of relevant stakeholders mainly the Executing agency, Implementation agency, decision makers, beneficiaries for enhancing collaboration in the promotion of the biogas technology in the country. The strategy is expected to serve as a useful tool for proper planning and implementation of biogas programmes.

The study outlines various strategies on project management, planning, construction, operation and maintenance and monitoring or evaluation through holistic, market-driven and participatory approaches in the implementation of the Biogas Programme. This report is the outcome of the literature review, consultation meetings and interviews conducted with various stakeholders at the national level as well as with the Dzongkhags, Gewogs and users of Biogas in Monggar, Trashigang, Samtse, Chukha, Wangdue, Paro and Haa.

We would like to acknowledge all the individuals and agencies involved in the preparation of this report. We would like to extend our sincere gratitude to DRE and the committee members for their critical input and assisting in developing the methodology and a comprehensive report. We would like to specifically thank Mr. Passang, Chief Engineer and Chhimi Dorji, Principal Engineer of DRE for guiding the field consultations and consistent efforts in shaping this report. We are also thankful to Mr. Dorji Gyeltshen, Project Director for providing us relevant documents and practical information about the biogas plants. We would also like to extend our gratitude to all Dzongkhag Livestock Officers for their valuable input and assistance in the field consultations with the users.

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ACRONYMS

ADB	Asian Development Bank
AREP	Alternative Renewable Energy Policy
BBP	Bhutan Biogas Project
BDBL	Bhutan Development Bank Limited
BSB	Bhutan Standards Bureau
BTN	Bhutanese Ngultrum
CO_2	Carbon dioxide
CNG	Compressed Natural Gas
CSO	Civil Society Organization
DoL	Department of Livestock
DRE	Department of Renewable Energy
EA	Executing Agency
FYM	Farm Yard Manure
FYP	Five Year Plan
GDP	Gross Domestic Product
GHG	Green House Gases
GNHC	Gross National Happiness Commission
kW	Kilowatt
LPG	Liquefied Petroleum Gas
M&E	Monitoring and Evaluation
m3	Meter cube
MoEA	Ministry of Economic Affairs
MU	Million Units
NA	Nodal Agency
NBIS	National Biogas Implementation Strategy
NGO	Non-Governmental Organization
O&M	Operation and Maintenance
RAA	Royal Audit Authority
SNV	Netherlands Development Organization
TOE	tonne of oil equivalent
TV	Television

1. INTRODUCTION

1.1 Background

The Bhutan Biogas Project (BBP) was initiated as a joint programme of the Asian Development Bank (ADB), Department of Renewable Energy (DRE), Department of Livestock (DoL), Netherlands Development Organization (SNV) and Bhutan Development Bank Limited (BDBL) since March 2011. The implementation of the first pilot of BBP was started in four southern districts of Tsirang, Sarpang, Chhukha and Samtse in March 2011. In May 2013, Dagana district was also included under the framework of the project. The first phase of the project came to an end on 28th February 2014 with the successful installation and operationalization of about 1,000 biogas plants[1]. The pilot project was intended to establish capacity to enable Bhutan to run a large-scale biogas program in the subsequent phases. Further, the project was extended from March 2011–December 2017, during which around 6,087 Biogas plants were constructed across all Dzongkhags in the country. In addition, more than 3,793 users, 629 masons and 308 supervisors were also trained and while awareness programs were held where about 3,926 people in the rural areas were educated on the benefits and technical aspects of the biogas as of December 2019[2].

The promotion of biogas in the country picked up and has been very successful in the 11th FYP. Similarly, in the 12th FYP, there are plans to roll out more number of biogas plants to meet the increasing demand from the public. Biogas has not only benefited the rural communities in meeting their cooking needs but has also helped to curtail people's reliance on firewood and import of LPG. By product from the biogas plants are also used as fertilizers which thereby minimize import of chemical fertilizers. Recognizing the success and its benefits, it is felt necessary to come up with a National Biogas Implementation Strategy to enhance the existing domestic biogas programme through standards, operation and maintenance protocols to ensure plants sustainability. The strategy is also aimed to serve as guidance for commercialization of the biogas program to combat the mounting waste problems in the country.

1.2 Energy Situation

Bhutan has aggressively pursued electrification through both off-grid and grid connected solutions, achieving an overall current electrification rate of 99% and 98.4% in rural areas. Electricity is also the most widely used sources of energy for cooking with 94.9 percent households reported using it for their cooking purposes. Electricity generation, though still relatively small in comparison with the rest of the world is growing in importance. In 2018, the total electricity generation was 6,940.58 Million Unit (MU). Domestic consumption of electricity has been also increasing as more people have access to modern facilities and electricity appliances. Firewood is still the main source of primary energy for the rural people of Bhutan, and it represents the largest slice of energy consumption. More than 60% of population lives in the rural areas where fuel wood is easily available from the nearby forests wherein, 70 % of country's land mass is covered with forests.

[1] Biogas User Survey 2015
[2] Progress report of Bhutan Biogas Project

Bhutan's energy demand is dominated by heat energy (72%), with only 28% of demand being serviced by electricity (Figure 1). Biomass in the form of fuel wood, biogas and briquettes is the largest source of heat energy, satisfying 36% of total energy demand. It is followed by diesel, coal and other petroleum products (petrol, kerosene and LPG), which satisfy 16%, 15% and 5% of demand, respectively[3].

The energy demand in industry and transport doubled in the period 2005–2014, making them the fastest growing sectors in terms of energy consumption. Over this period, per capita energy consumption increased from 0.6 TOE per capita in 2010 to 0.69 TOE per capita in 2017, which is indicative of rising industrialization and improving living conditions. While per capita energy consumption is increasing, the energy intensity of the economy as measured by energy consumption per unit of GDP has declined from 3.7 TOE/Bhutanese ngultrum (BTN) to 3.1 TOE/BTN[4].

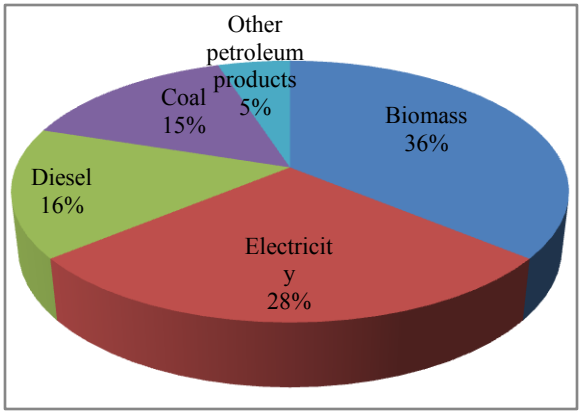

Fig 1: Fuel mix in the economy (TOE)

To assess the biogas market potential in Bhutan, SNV, Netherlands Development Organization, conducted technical feasibility studies, and ADB subsequently undertook the market assessment studies with SNV. These studies have concluded that there are at least 16,000 households that have the potential to use biogas plants cost-effectively.

1.3 Study Objective

The objective is to formulate a National Biogas Implementation Strategy (NBIS). The NBIS shall outline and streamline roles and responsibilities of all the relevant stakeholders involved in the biogas program for promotion of biogas technology in the country. In addition, it shall also provide a framework guidance to enhance the accessibility to biogas technologies along with the mechanism and options for promotion of the technology.

The NBIS shall incorporate all the practicable and relevant strategies suitable for Bhutan which must clearly define and outline the potential and scope of the program; planning and project implementation methodologies; promotional and marketing strategies; quality control measures; operation & maintenance protocols; monitoring & evaluation mechanisms.

1.4 Benefits of Biogas

As per the best practice, an average biogas plant serving a household of 5 to 6 people generates the following main benefits:

a) Farmers with 2 cows can generate sufficient biogas to meet daily basic cooking and lighting needs of the small family in a house;

[3] Energy Status of MoEA, 2018
[4] National Statistics Bureau, Year Book 2019

b) Saving of traditional cooking fuel such as firewood (2000 to 3000kg/year) or kerosene (300 to 350liters/year);
c) Reduction of workload 1.5 to 3 hours per day per household;
d) Reduction of green house gasses up to 5 ton of CO_2 equivalent per year;
e) Reduction of indoor air pollution 3 persons per household less exposed;
f) Toilet attachment up to 65% of all biogas households have latrines connected to the biogas plants;
g) Potential increase of agricultural production or saving on the use of chemical fertilizer (biogas plants produce very high quality organic fertilizer-bio slurry up to 40%); and
h) Improved household and environmental sanitation and less pollution to ground water.

The direct benefits of the biogas are increased access to modern household cooking and heating, reduced greenhouse gas emissions, and reduced deforestation. The indirect benefits include: a reduction in adverse health effects from indoor air pollution resulting from firewood smokes, a reduction in time spent collecting firewood, and an improvement of crop yields through the use of organic by-product from the biogas plants.

1.5 Overall Strategic Objective

The overall strategic objectives are:

a) To develop, strengthen and facilitate access to suitable biogas plants;
b) To upscale the number of various sizes of biogas plants as per the potential in the country;
c) To increase the functionality of the biogas plants through proper operation and maintenance;
d) To provide technical assistance as well as to build the capacity through training and advocacy;
e) To make biogas plants sustainable by adopting strategic measures in place;
f) To assess and explore the potentials for commercial biogas to combat mounting waste issues;
g) To maximize the benefits of biogas plants in terms of products as well as usage.

2. POTENTIAL AND SCOPE

2.1 Biogas potential

The potential for biogas production in Bhutan can be based on numerous factors such as number of cattle or quantity of dung that could be available for biogas and the micro-climatic conditions in different parts of the country. The daily dung production from cattle or related animal alone is about 3,622 tons which has theoretically a potential to produce 130,398 m^3 of biogas. Practically, only 75 percent of the potential (i.e. 97,799 m^3) would be available since the number of animals also include households with only one cattle or related animal and hence do not have enough

dung volume to feed the smallest size biogas plant (4 m^3) which requires 20 kg of dung per day. These calculations do not take account of the dung available from poultry and other domestic animals such as pigs and goats (van Nes, 1991). The potential for biogas generation based on the number of cattle or related animals is presented in Table 1 below.

Animal	Number	Dung available per animal/day (kg)	Total dung available/day (kg)	Biogas yield /kg of dung (m^3)	Gas volume (m^3)
Cattle	298,601	10	2,986,010	0.036	107,496
Mithun/yak/buffalo	42,412	15	636,180	0.036	22,902
Total	**341,013**		**3,622,190**		**130,398**

Table 1: Biogas potential (Source NSB statistics 2018)

Accordingly, biogas market study in Bhutan was conducted through ADB[5] where the effective potential of biogas plants has been calculated based on the technical, economic, social and institutional factors. It was found that out of the 87,576 household across the country, 68,576 households (78%) possess at least one head of cattle, out of which 50,115 households (73%) produce enough cattle-dung to meet the requirement of a small family size biogas plant. In other words, 57% of the total households in Bhutan have enough feeding materials to install a biogas plant. Then out of the 50,115 households that have enough cattle dung to feed into the biogas plants, 24,606 households (49%) are technically feasible keeping in view of other technical factors such as temperature and water availability. In total, 28% of the households in Bhutan are technically feasible for installing biogas plant. Out of 24,606 households which are technically feasible, 16,879 households are expected to qualify as socioeconomically feasible to install biogas plants keeping in view of the farming practices, use and availability of conventional fuel sources and poverty level. Hence the effective potential of the country in terms of having favourable condition to install biogas plant is 16,879 households.

Further, Bhutan is also facing challenges in waste management which have multi-fold implications on environmental, economic and social dimensions. Like most developing countries, there has been rapid population growth and urbanization leading to growing waste generation. It was found that food waste on an average constitutes about 60% of the total waste. Further, when the food waste is segregated as per the source, it was found 45.9% comes from household, 36% from commercial like restaurants, 38% from institutions, 23% from industries, 33% from health and 73% from vegetable market[6].

The amount of biogas that can be extracted from organic waste depends on the organic waste itself and the design of the digester system. Some digesters can yield 20 m^3 of biogas per tonne of waste while others can yield as much as 800 m^3 per tonne. Similarly, there is also potential from the human waste to generate biogas. It was found that a person can produce 0.4-0.5kg/day and 1 kg of Human feces can produce about 0.4 m3 Biogas/day. It was also found that 1m3 of biogas can give light of about 60-100 Watt bulb for 6 hours, cook 3 meals for a family of 5-6 ,0.7 kg of petrol and generate about 1.25 kilowatt hours of electricity.

[5] Biogas market study in Bhutan, ADB, December 2009

[6] National Waste Inventory Survey, 2019, NECS and NSB

Accordingly, there are many sources of biogas generation potential, not only from the animal waste as practiced now in the country but also from other sources such as agricultural residues, waste water, forest and industrial waste, kitchen organic waste, municipal organic waste and other waste as indicated in the Fig 2 below.

Fig 2: Potential sources of feed to biogas plants

2.2 Scope

There are wider areas of scope of biogas in Bhutan besides the domestic level biogas plants and its utilization. Like any other fuel, biogas can be used for other household and industrial purposes as well as to upscale the biogas plants at a commercial level. Some of the scopes of biogas and its opportunities are as follows.

Gas: One of the main purposes of biogas plant is for cooking. If a family of 6 members owns a plant producing $2m^3$ of gas per day, usually two stoves (one with $0.22m^3$ and the other with $0.44m^3$ per hour capacity) can be used for one and half hours each in the morning and the evening to meet all cooking requirements of the family. Besides, the family size biogas plants, there is scope to established larger size plants mainly through organic waste, larger livestock farms and even at the urban areas due to availability of adequate quantity of organic waste from households, commercial areas and industries.

Lighting: Biogas can be used as an alternative source of lighting. Special types of gauze mantle lamps consuming 0.07 to $0.14m^3$ of gas per hour are used for household lighting.

Refrigeration: Biogas can be use for absorption type refrigerating machines operating on ammonia and water, and equipped with automatic thermo-syphon. Since biogas is only the refrigerator's external source of heat, the burner itself has to be modified. Refrigerators that run with kerosene flame could be adapted to run on biogas.

Biogas-Fueled Engines: Biogas can be use to operate four stroke diesel and spark ignition engines. Biogas engines are generally suitable for powering vehicles like tractors and light duty trucks, which has been successfully experimented in China. One of the wider applications in Nepal is to fuel engines to run irrigation pumps. A dual-fuel engine is available in India, which runs on a mixture of biogas and diesel (80% biogas and 20% diesel). In these engines, biogas is used as the main fuel while diesel is used for ignition. When gas runs out, the duel fuel engine can be switched back to run fully on diesel. Pre-converted dual engines are available in the market. Such engines could be used for pumping water both for drinking and irrigation purposes.

Electricity Generation: Electricity generation is one of the main uses of biogas in most of the South East Asian countries utilized at a larger scale. In the conventional energy, gas consumption is about 0.75 m^3 per kWh with which 25 to 40 W electric bulbs can be lighted for one hour, whereas the same volume of biogas can light about 7 biogas lamps for one hour. Small internal combustion engines with generator can be use to produce electricity in the rural areas with clustered dwellings. In the urban areas, municipal waste can be used to generate electricity.

Fertilizer: Biogas technology provides clean fuel as well as digested slurry, a by-product of biogas which can be used as manure in the agriculture field. Digested slurry contains plant nutrients in more concentrated form than the raw materials and is more nutritious compared to the traditional compost. The humus contained in digested slurry improves the physical properties of soil like water holding capacity, aeration, water stable aggregates and increases the crop production up to 20-30%. Accordingly, there is scope of using it as fertilizer in both solid and liquid forms as well as make compost and sell at the commercial level.

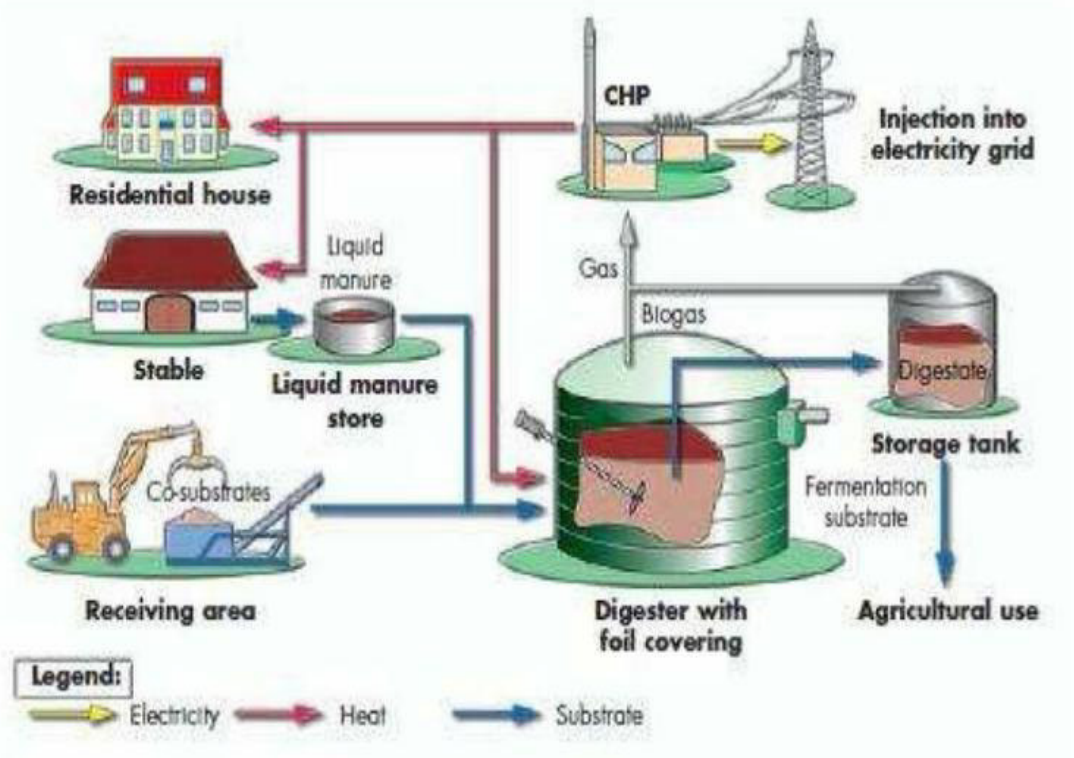

Fig 3: Scope of biogas and its application

3. PROJECT MANAGEMENT

The Biogas Programmes shall be managed and implemented by an implementing agency based on the approval by the Government or the Executing Agency through the Gross National Happiness Commission (GNHC) where the project may be supported by donor agencies besides the funding support from the Royal Government. In the present scenario, Department of Renewable Energy (DRE) under the Ministry of Economic Affairs is acting as the Executing Agency (EA) while Department of Livestock acts as the Implementing Agency (IA) for the domestic biogas projects. Then there is National Environment Commission (NEC) which is the designated agency for regulation of environment and waste in Bhutan which can provide support to the executing agency on biogas programmes.

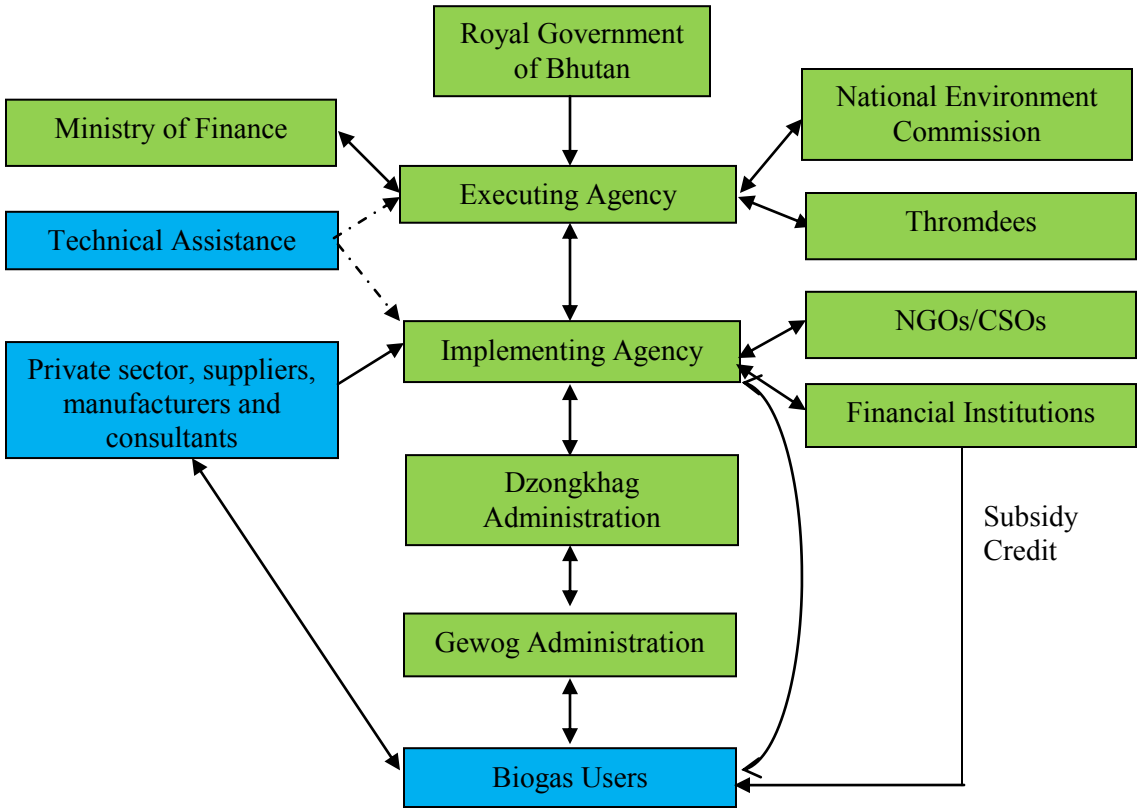

Fig 4: Project Management

3.1 Stakeholder roles & responsibilities

Following stakeholders have been identified for their role in promoting and implementing Biogas Project in Bhutan.

3.1.1 Royal Government of Bhutan

The Royal Government of Bhutan (RGoB) shall play vital role in the promotion, development and implementation of the biogas plants in the country through policy directives, plans and

funding. Since Gross National Happiness Commission (GNHC) is the central planning agency, all external funds, plans and policies shall be liaised through GNHC.

a) To provide government policy directives and plans to the executing and implementing agencies for implementation;
b) Efficiently manage Government Fund directed towards the development and implementation of the biogas plants;
c) Receive all external grants and loans towards the biogas programmes or projects on behalf of the government;
d) Mobilization of funds and liaise with donors;
e) Monitor progress of the plans and programmes including evaluation.

3.1.2 Department of Renewable Energy

The DRE under the Ministry of Economic Affairs is the Nodal Agency for all the renewable energy and energy efficiency & conservation related matters. Biogas is one of the renewable energy sources and therefore all planning, implementation and other policy aspects for the promotion and development of biogas is governed by the Alternative Renewable Energy Policy (AREP-2013). The NA shall administer all the policy directives including issuance of clearance for promotion and development of commercial scale biogas plants.

3.1.3 Executing Agency

At the moment, the DRE under the Ministry of Economic Affairs is functioning as the executing agency for promotion, development and implementation of the biogas plants in keeping with the provisions of the Alternate Renewable Energy Policy (AREP 2013). The functions of executing agency shall include:

a) Assess the overall biogas potentials from different sources and prepare promotional & developmental plans;
b) Support formulation of enabling policy and standards for the promotion and development of Biogas in Bhutan;
c) Act as a link between Royal Government represented by GNHC and the external agencies working towards biogas programmes;
d) Conduct research and introduce evolving nature of the biogas technologies in the country;
e) Seek external funds in coordination with GNHC for the biogas projects;
f) Coordination among the donor agencies, implementing agency and stakeholders;
g) Provide technical advice and guidance to the implementing agency as well as other stakeholders engaging in the development of the biogas plants;
h) Carryout regular monitoring of the biogas plants for ensuring sustainability through providing technical backstopping for timely maintenance;
i) Carry out planning and progress reporting to government agencies and others as and when required.

3.1.4 Department of Livestock

Since the Department of Livestock (DoL) is responsible for creating enabling environment for farmers/entrepreneurs to invest in livestock activities so as to enhance income generation through livestock production and other related activities, DoL has been functioning as implementing agency at the moment for the domestic biogas plants. As of now more than 6000 domestic biogas plants were installed across all the Dzongkhags through the Bhutan Biogas Project under the DoL and assistance from Dzongkhag and Gewog Livestock Offices.

3.1.5 Implementing Agency

In the present scenario, the Department of Livestock is functioning as implementing agency for the development and promotion of the domestic biogas projects in the country. The functions of the implementing agency shall include:

a) Carry out operation, management, implementation and coordination of all domestic biogas programmed activities;
b) Prepare report and submit to EA and to all relevant stakeholders;
c) Work closely with different sections of society including private and the public;
d) Develop annual plans and budget and submit to appropriate authority for approval;
e) Administration of subsidy and credit including follow up with financial institutions;
f) Quality control and monitoring of biogas plants in consultation with EA;
g) Conduct applied research on implementation of biogas plants and technologies;
h) Conduct training of trainers courses and other capacity building programmes;
i) Carry out promotion, advocacy and awareness programmes on biogas.

3.1.6 Ministry of Finance

Since the Ministry of Finance is a central agency for disbursement and approval of budgets, it can play crucial role in allocating national budgets for the implementation of biogas programmes. They can also oversee the programme implementation through proper monitoring of the accounts with a sound government accounting system.

3.1.7 National Environment Commission

The National Environment Commission (NEC) is a high level decision making and coordinating body on all the matters relating to the protection, conservation and improvement of the natural environment. So the NEC can provide environment clearance for projects, waste management guidance, information and other related services.

3.1.8 Thromdes

Waste management is a problem in most of the urban areas where Thromdes are responsible for the administration and management of waste. So if there is any biogas project from the organic waste as well as from waste water from the residents, commercial or industrial, then Thromdes shall play critical role in providing assistance to the biogas projects.

3.1.9 Financial Institutions

Financial institutions shall have a major role in biogas plants since there is need of credit and subsidy facility in order to upscale the biogas promotion and production due to availability of other sources of energy as well as high installation cost. In some cases, government may also collaborate with certain banks to specifically provide credit facility on biogas programmes. So the concerned financial institution may have to come up with own standards and mechanisms for providing such as facility on the biogas programmes.

3.1.10 Dzongkhag Administration

Since the domestic biogas plants are mostly installed in the Dzongkhags or Gewogs, all the proposals and procedures must be routed through concerned Dzongkhag Administration. Hence its role becomes critical for the biogas projects.

a) To coordinate with the gewog administration and the implementing agency for conducting awareness programmes, feasibility studies or potential of the biogas plants in the respective locations;
b) To facilitate implementing agency or the private entrepreneurs in taking up the construction of biogas plants in terms of regulatory procedures and according of approvals;
c) Coordinate with the project office for after services to the rural homes for the biogas plants;
d) Carry out any other activities that may be required at the Dzongkhag and Gewog level.

3.1.11 Gewog Administration

The Gewog Administration shall play its role in the success of biogas plants within the community as well as to provide after sales services. Thus their roles and responsibilities are as follows:

a) To coordinate with the implementing agency or the project office as and when required;
b) Facilitate in organizing sensitization activities, obtaining clearance as per the regulatory requirements and conducting feasibility studies;
c) To assist rural homes for the application of biogas plants as per the prescribed regulations as well as to apply for subsidy or credit facility;
d) To coordinate technical assistance and after services during plants operation through the concerned agencies.

3.1.12 Civil Society Organizations

The civil society organizations shall play critical role in sensitization of biogas plants as well as in providing assistance to rural homes in terms of funding and technical guidance. They can also provide small credits to the rural homes in order to improve standards of living and poverty.

3.1.13 Private service providers

There will be involvement of various levels of private service providers such as contractors, technicians, suppliers and companies. Accordingly, following are the general roles and responsibilities:

a) Supply of materials and spare parts to the project or to the users;
b) Involvement in construction, operation and maintenance of biogas plants;
c) Provide after sales and technical services to the biogas plants;
d) Own, operate and manage the biogas plants in some cases.

3.1.14 Beneficiaries

Since the biogas plant beneficiaries are the ones who should take care of their own plants. They have important task to manage and maintain proper functioning of the biogas plants. Accordingly, their responsibility lies in the following:

a) To put up application or business plan about the possibility of installing biogas plants in their own premises or in some feasible sites;
b) To obtain all necessary regulatory clearances for installation of biogas plants;
c) Mobilization of resources for the construction of the biogas plants;
d) To carry out regular operation, management and administration of the biogas plants.

4. PROJECT APPLICATION PROCESS

In the present scenario for the domestic biogas, it involved five stage application processes. The process involves expression of interest from the household for validation of construction of the biogas plant by the project representatives. Once the Dzongkhag or the Gewog Livestock Office make awareness to the people about the possible opportunities available for biogas plant, those interested will have to fill up the Form-02(a) which suffices for subsidy or credit application process. Then the application forms are submitted to the Dzongkhag and to the Biogas Project Office for verification and approval. Based on the approved budget availability, the potential sites are visited in order for technical suitability of the site and accordingly, actual implementation of the biogas project is undertaken. In general, following application process need to be undertaken for any type of biogas projects.

4.1 Application Process

Standard application process for adoption of biogas plant have to be instituted which will enable both applicant and the project office for proper management as well as to maintain quality standards.

a) Application for the biogas plant shall be applied through Gewog Office and to the Dzongkhag in the case of domestic biogas plants as per the prescribed format;
b) Gewog and the Dzongkhag shall verify the details of the applicant before submitting to the implementing or the concerned agency;
c) The proponent of the commercial plants shall obtain required policy clearance from the Nodal Agency wherein the terms and conditions for the project implementation and other necessary requirements may be specified in accordance with the extant policy, rules & regulation for guiding the development & promotion of the projects;
d) Once the policy clearance is obtained, then it can go to the executing agency for final approval. Such proposals should be accompanied by business plan detailing techno-economic analysis in the case of commercial plants;
e) The applications shall be verified in terms of technical feasibility and economic viability of the large scale plants;
f) In the case of domestic biogas plants, implementing agency shall verify the technical feasibility of the project sites;
g) After the approval of the applications, the implementation process can be initiated.

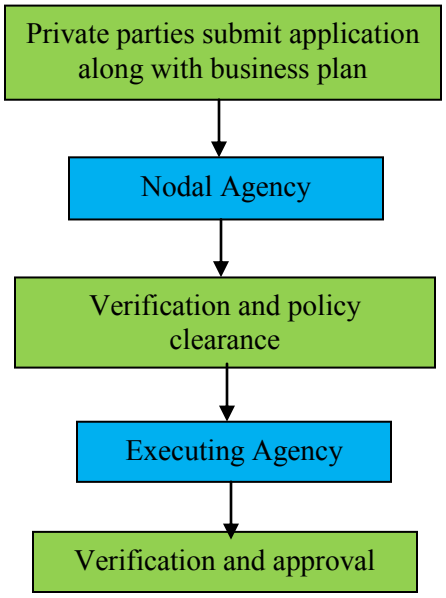

Fig 5: Application for large scale plants

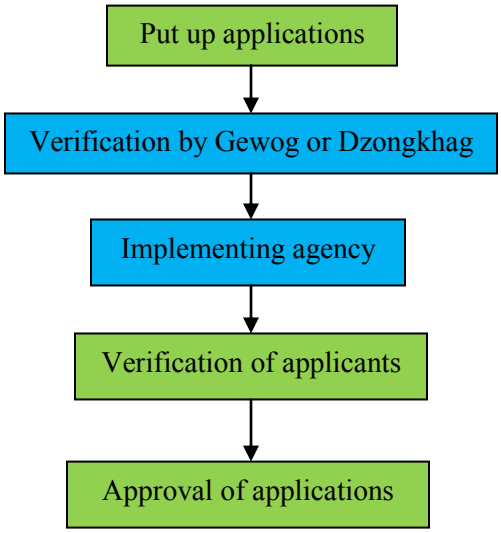

Fig 6: Application for domestic plants

5. PROJECT IMPLEMENTATION MECHANISMS

The overall implementation of the project shall be carried out through involvement of various central agencies such as the project office, Implementing Agency, Executing Agency, central agencies and other stakeholders along with well established systems in place. The implementation of the biogas project shall be also supported by the Dzongkhag or Gewog Administration, Thromdees and the private sector. Actual implementation of the project shall be carried out by the implementing agency by involving third parties or the concerned applicants themselves while the Project Office can coordinate, manage and provide technical support.

5.1 Strategies

Following are the project implementation mechanisms proposed for the biogas projects:

a) Operation of biogas project office or center

The operation of the project office or center shall be involved in budgeting and planning including technical assessment. It shall also carry out field visits to conduct technical feasibility studies, provide technical advisory services and also sanctioning of technical proposals. The office shall spearhead all administration and management of the biogas plants in the country. It shall also carry out liaison with government agencies and build partnerships with the relevant stakeholders such as private sectors including manufacturers, technical institutes and suppliers.

b) Committee meetings and consultations

There shall be frequent project committee meetings to discuss on the issues and policy directions for implementation of the projects followed by consultation meetings with relevant stakeholders both at the national level as well as in the Dzongkhag level.

c) Preparation of technical and management tools

During the implementation of the projects, there shall be requirements of several tools such as development of guidelines, templates and forms for various types of biogas plants. It can also include creation of awareness and marketing tools such as brochures, posters, booklets and pamphlets, construction manual, operation and maintenance guideline, formulation of technical standards and training manuals etc.

d) Training and capacity building

Various trainings and workshops shall be conducted for various levels of stakeholders such as private entrepreneurs, engineers, technicians and supervisors including project partners. The programmes shall also include on the job training and demonstrations through prototype biogas plants in operation.

e) Construction and quality monitoring

The actual construction of biogas plants shall be carried out after conducting feasibility studies by the concerned agencies including sanctioning of credit or subsidy. The actual constructions

shall be carried out by trained technicians in the case of domestic biogas plants while in the case of larger scale plants, concerned party should have own manpower arrangements. However, for any type of biogas plants, concerned agency shall monitor the quality aspects as per the standards, guidelines and in accordance with the relevant provisions of the AREP 2013.

f) Operation and maintenance

Once the plants are constructed, users shall be trained on the operation and maintenance of the plants based on the type of technology adopted. In the case of large scale plants, instructions along with operation and maintenance guidelines shall be provided.

g) Monitoring and evaluation

Monitoring and evaluation of all biogas plants shall be carried out by the concerned agency for compliance as per the standards. However in the case of projects which are implemented by the government, there will be regular field visits from the project office to check on quality as well as to see the impact of the programmes.

h) Biogas plant financing

The potential applicants shall be provided with estimated cost of construction of biogas plants including provision for subsidy and credit facilities. This provision shall be made mainly to promote biogas plants in the country as well as to upscale the projects.

i) **Progress reporting**

Progress reporting is essential for improving the project performance as well as to take fact based decisions. So quarterly or half yearly progress reports shall be prepared by the project office and submitted to relevant stakeholders.

6. TECHNICAL STANDARDS AND SPECIFICATIONS

A bio-digester is a structure constructed under the ground, made with cement, brick/stone, sand and pipes and appliances to decompose organic material and produce biogas to supplement conventional fuel sources. Bio-slurry is used to apply as organic manure in the farms. By feeding the recommended amount of cattle dung, organic waste and water every day in the digester, clean gas is produced which is used for cooking and lighting purposes.

There are different types and models of biogas digester such as fixed, floating and plastic tubular type of dome in various sizes. The selection of biogas plant model can be based on the availability of construction materials, degree of building complexity, durability and maintenance demand, ease of use, appropriateness for construction in both hilly and plain areas and cost. The size of the biogas plant can be selected on the basis of availability of certain quantity of daily feed, retention time and digester volume. As per the standard, the biogas plant should not be located further than 5 meters from the field. The digester chamber must be in an open area and should not be near any water source as animal excrement may seep into the underground water.

6.1 Strategies

Strategy 1: Adoption of appropriate technical standards and specifications suitable for Bhutan

Activity:

a) Appropriate biogas models shall be selected based on the selection criteria of availability of construction materials, degree of building complexity, durability and maintenance demand, ease of use, appropriateness for construction and the cost of installation;

b) Carry out studies on other types of biogas plants suitable to Bhutan such as small to medium scale (farm scale plant) and medium to large scale (centralized/joint co-digestion plants). Such types of plants will allow options based on affordability and feasibility of biogas plants for various other uses to substitute biomass energy;

c) Adopt various types of biogas plants such as biogas from organic waste, waste water and other waste or integrated biogas (waste water, solid waste, animal waste etc.) based on feasibility of different areas and regions;

d) Explore biogas technologies which are easier and cheaper to install and also climate resilient especially those in the colder regions;

e) Formulate appropriate national standards based on the experience and the lessons learnt from different technical standards being used.

Strategy 2: Implementation of technical standards and specifications for biogas plants

Activity:

a) The selection of size of the biogas plants shall be carried out as per the energy demand, availability of the feed stock and ability to pay. Biogas sizing shall be carried out during the feasibility study or in the business plan and should be guided by sizing guidelines;

b) Collaborate with the Bhutan Standards Bureau to standardize biogas technical specifications and get certified of some of the standard manufacturers for supply of quality materials;

c) Ensure strict monitoring and supervision of technical specifications and standards during the construction period to avoid substandard quality of the materials as well as construction norms;

d) Educate beneficiaries and technical people involved in the construction of the biogas plants on the importance of using reputed brands, application of technical standards and specifications for quality and durability of the plant.

Strategy 3: To undertake innovation, research and development on biogas technology

Activity:

a) Carry out study on biogas components development especially with regard to possible fabrication and assembly within the country by involving private entrepreneurs or groups;
b) Carry out study on appropriate newer technologies available in the global market and its application to Bhutanese context;
c) Carry out frequent studies on the market opportunities for different types of biogas plants and its potential to utilize organic waste, solid waste and other waste which are of major issue in the country;
d) Carry out studies on agriculture production, livestock production, waste management and environment conservation and how biogas can help to mitigate these issues.

7. QUALITY CONTROL

Quality control is important since even if the design is correct and the workmanship is excellent but if the construction materials used is not of good quality, then the digester will not function properly. Although there are adequate number of biogas plants already in operation across the country, still majority of the people are not aware of the technology. A well functioning plant with satisfied users is the only reliable means to develop and maintain people's confidence in the technology. Poorly installed biogas plants result in inefficiency and mal-functioning systems can lead to capital loss, frustration among owners, promoters and the donors as well. This will also damage the reputation of biogas technology causing negative impact on its adoption. The only precaution to take against such a possibility is to ensure that desired quality is maintained for each plant that is being constructed.

7.1 Strategies

Strategy 1: To develop systems and tools for quality control

Activity:

a) Adopt relevant quality control mechanisms/guidelines for effective quality assurance until the time when a standard quality control tools/mechanism is in place;
b) Develop quality control tools such as formal contract documents, biogas standards, training curriculum, biogas inspection guide, biogas user's guide, biogas trouble shooting guide, biogas operation and maintenance guide, list of acceptable brands for biogas materials and its appliances etc;
c) Develop biogas construction supervision framework to ensure close supervision of masonry work during the construction period including testing and commissioning;
d) Develop a system to monitor the quality starting from the feasibility study, selection of plant designs, construction, operation and maintenance through standard checklist.

Strategy 2: Implementation and enforcement of quality control measures

Activity:

a) Quality control monitoring and inspection shall be carried out to almost all the new plants as well as to revamp the old systems as per the clients demands;
b) Conduct frequent field visits during the construction period to ascertain compliance with as built design and drawings, technical specifications and standards;
c) Before the commissioning of the plants, quality inspection and testing shall be carried out especially on the bio-digester and its appliances;
d) The supplier or the contractor shall sign on the guarantee certificate granted to the beneficiaries prior to handing over of the site;
e) Carry out general inspection and testing of biogas system on regular basis to ensure proper operation of the plants;
f) Carry out training of the beneficiaries and technicians on quality assurance of the plants and its accessories.

8. OPERATION AND MAINTENANCE

Proper operation and maintenance of different components of the biogas plant is important for its efficient and long term functioning. Once the biogas plant starts operation, it is necessary to carry out maintenance on daily, monthly or yearly basis as necessary. Although, there are not many serious maintenance issues with the existing plants currently but as the number of plants increases with various types of plants in future, it is necessary to have a proper O&M system in place. Proper operation and maintenance is to ensure that all biogas plants remain operational in order to safeguard the investment and for maximization of benefit and return on investment. Therefore adopting a practical and well functioning operation and maintenance system is essential which must be done in timely manner.

8.1 Strategies

Strategy 1: Institute proper operation and maintenance system

Activity:

a) Develop operation and maintenance manual and user's guide and including its orientation to the relevant stakeholders;
b) Involve beneficiaries and relevant stakeholders during the construction of biogas plant to enable them to understand the functions of different components and its operation and maintenance requirements;
c) Conduct operation and maintenance trainings to relevant stakeholders;
d) Develop operation and maintenance checklist for site inspection.

Strategy 2: Set up framework for after sale service

Activity:

a) Establish a customer service help desk in the biogas office comprising of landline or mobile number so that the beneficiaries can lodge complaints or seek clarifications when there are operational or maintenance issues;
b) Make trained supervisors and technicians in various places as representatives of the project office to deal with operation and maintenance issues or problems;
c) During the post visit of biogas plant installation, the supervisors shall confirm that stipulated construction standards have been met, biogas plant is fully functional, beneficiaries are well trained and all necessary O&M information and reference guide has been provided;
d) Carry out proper handing over of the biogas plants to the beneficiaries along with the completion certificate to ascertain that the plant is operational.

Strategy 3: Operation and maintenance performance

Activity:

a) Establish network with suppliers, manufacturers and professional companies for operation and maintenance services as well as spare parts supply;
b) Routine field visits shall be made both in terms of on call as well as schedule visits to check on the physical status of the plant, and efficiency of the system in terms f operation and gas emission. If there are any observation on repair and defects, then provide advice on O&M deficiencies.
c) Carry out listing of critical items required for daily operation and maintenance of the biogas plants. Such list shall be provided to the suppliers so that as and when required, they can supply to the beneficiaries.

9. DEVELOPMENT AND PROMOTION

The development and promotion is required in order to raise awareness among the potential stakeholders on the benefits, economic feasibility and other characteristics influencing a positive decision to undertake biogas plants. At the moment, biogas technology, its benefits and requirements are not really known to the general public. As a result of this, a major challenge lies in motivating the potential households to invest in the technology. To generate a demand, there is need of creating more awareness and advocacy programmes.

It is found some rural homes are reluctant to construct the biogas plants due to availability of the alternative energy sources for cooking like subsidize LPG gas, cheap electricity and firewood. The other issues are in terms of high cost of installation, labour constraint, difficulty in transportation of material to areas where there is no motorable road access, and also uncertainty of feed stock.

9.1 Strategies

Strategy 1: To undertake promotion and development of market

Activity:

a) Establish promotion and marketing schedule of different regions in the country annually to conduct promotional activities on biogas plants;
b) Mobilize various community groups or cooperatives to attend awareness programmes where they can look for biogas as alternative towards income generation in terms of use of bio-slurry to boost agriculture production as well as selling of manure, use of biogas for cooking, electricity generation and waste management (organic waste and animal waste);
c) Develop appropriate tools for promotion of biogas such as print media like pamphlets, poster and banners; audio and visual advertisements like TV programmes, videos and documentaries. The promotion and awareness shall focus on the following aspects:
    i. Economic benefits of biogas technology-cost saving, time savings, income generation (bio-slurry and sludge use etc.), financial facilitation, clear demonstration on why biogas makes sense as an investment.
    ii. Social benefits and personal development benefits-health, sanitation, education, cleanliness and status.
    iii. Environmental benefits-air quality, forests linkage to river, water and agriculture including waste management.
    iv. Creation of definitive market linkages between complementary stakeholders like suppliers and financial institutions.
    v. Employment creation and entrepreneurship development through large scale biogas plants, manufacture of biogas plant spare parts etc.
    vi. Availing technical services for the installation and after sales service etc.

Strategy 2: Implement biogas demonstration areas

Activity:

a) Select appropriate locations for biogas demonstrations based on the availability of feed stock and proximity to target market;
b) Pilot one or two sites for installation and operation of integrated biogas system through integration of organic waste, waste water, agriculture production, electricity generation and production of manure through bio-slurry. It can serve as promotion to other stakeholders as well as for educational purposes and marketing;
c) Organize demonstration workshops to potential stakeholders who are willing to invest biogas plants.

Strategy 3: Development and promotion of biogas through other strategies

Activity:

a) Biogas promotion and development by involving other agencies such as CSOs, NGOs and private sectors working in the energy, agriculture and waste management sectors;
b) Promote and develop other modes of biogas plants such as use of solid waste, agriculture waste, poultry waste, kitchen waste and other waste besides cattle dung as alternatives;

c) Diversification of biogas usage such as refrigeration, fuel engines, electricity generation, fertilizer and other purposes.

Strategy 4: Development and promotion of biogas through funds from various sources

Activity:

a) Educate beneficiaries on the availability of biogas subsidy and credit from recommended financial institutes**;**
b) Seek funds from multi-level donors such as Green Climate Fund to enhance community livelihood and environment conservation by promoting biogas plants;
c) Promote biogas plants with tax incentives for the import of biogas items.

10. CRITERIA FOR SELECTION OF BENEFICIARIES

The assessment for the selection of beneficiary shall be carried out on the basis of factors which have direct relationship with the biogas production as follows:

a) **Type of energy used**: In the rural homes, collection of firewood from the forest is a usual practice and is a tedious activity. Firewood need to be collected ahead of time and kept dried for burning. People will also be using electricity, kerosene or LPG for cooking. It is found that with the biogas in place, there is reduction on consumption of firewood, LPG and electricity consumption if used for cooking.

b) **Role of women:** The decision of women plays a vital role in the adoption of domestic biogas plants since they are the immediate beneficiaries of the technology in terms of cleaner and better ways of cooking than the conventional mode.

c) **Social and cultural issues:** In some of the surveys carried out in the past indicated that there are some social and cultural taboos associated with the use of biogas and bio-slurry as well as handling of cattle dung. Some people during informal discussions raised the issue of impurity of biogas produced through the waste from toilets which might rise to some resistance from the community.

d) **Health & Sanitation**: It was also found that majority of the people often encountered smoke-borne diseases due to smoke-filled cooking environment with poor ventilation in the kitchen. However, most of the households have proper toilets being constructed around the house although there is limited prospect for attachment of toilets to biogas plants.

e) **Farming Practices:** Farming is a common practice for majority of the Bhutanese farmers. The main source of fertilizer for agricultural lands is organic manure from cattle dung complimented with chemical fertilizers. Dung in the form of Farm Yard Manure (FYM) is widely used in most of the crops. Majority of the farmers use cattle dung in

farm as farm-yard-manure and they think that organic manure such as cattle dung is better than chemical fertilizers because of capacity of the former to preserve soil productivity for longer duration without imposing detrimental effect to soil texture.

f) **Dung Production:** The technical feasibility of biogas plant primarily depends upon the use of the required quantity of dung produced in the cattle shed. It depends upon the type of animals, grazing practices and condition of cattle sheds. It is found that 2 or 3 adult cattle would be sufficient to produce at least 20 kg of dung, which is minimum requirement for a household to qualify for installation of a biogas plant. However, the dung production alone may not be the true indicator for feasibility of biogas plant unless the structure of cattle shed, especially the stable floor, is constructed in a way that it facilitates easy collection of dung without much wastage on the ground.

g) **Educational status:** The implications of education and literacy for the biogas programme are that any outreach work that may be planned such as sensitization on biogas, construction, operation and maintenance of biogas components would have to consider the education level of the population and design the information and capacity building strategies accordingly not limited to more pictorial visual aids to supplement the didactic form of instruction.

h) **Landholdings:** Land is an important rural asset widely owned by farmers considering heavy dependence on agriculture and livelihoods derived from the land. Majority of the farmers own less than an acre of land while large parcels of land (exceeding 5 acres) are rare to find in the farmlands.

i) **Agricultural production**: Agriculture production is main activity for almost all the rural homes. They produce varieties of crops both for domestic consumption as well as for commercial scale to earn cash income.

j) **Income and expenditure**: The implication of limited income of families on the biogas programme is that the household may not be capable of sharing the costs of biogas plant installation. Therefore, low income families may not be able to participate in the biogas programme and derive benefits of biogas plant unless investment subsidy and other favourable financing mechanisms are put in place.

k) **Willingness and affordability:** In order to switch to renewable energy sources from conventional mode of cooking, there should be willingness of the people to invest for the new technology. Only if the household could decide on their willingness to adopt the technology and ready to spend, then only there are opportunities for biogas plants.

10.1 Beneficiary selection criteria for domestic plants

So based on the above assessment, following are the set of criteria that needs to be looked into while selecting the biogas plant beneficiaries.

Sl. No	Factors to consider	Criteria
1	Type of energy use: Firewood, electricity, kerosene and LPG	Main type of energy source used for cooking purposes
2	Role of women	Decision making in the family and their choice of energy for cooking
3	Social and culture	Look into the social and culture obligations in the community
4	Health and sanitation	Condition of health of the household family and sanitation of the surroundings
5	Standard farming practice	Type of manure or fertilizers used in farming
6	Rearing of domestic animals	Type of domestic animals reared
7	Production of dung	Quantity of cattle possessed and dung production per day
8	Level of education	Educational status of family member
9	Land holdings	Is there adequate land for biogas plant
10	Agriculture production	Assess type of agriculture activity such as vegetable production and other practices
11	Income and expenditure	Major source of income, average income and expenses
12	Willingness and affordability	Willingness and affordability of the households for biogas plant

It may not be possible to fulfill all the above factors under consideration by the household but if any of the households are able to meet at least 70% of the criteria, it may be considered as eligibility for biogas plant. Further, there may be exception for certain cases based on necessity as well as other factors under consideration for respective households. However, in the case of commercial scale biogas plants, this criterion may not apply since it would be decided through the business plan proposal.

10.2 Beneficiary selection criteria for large scale plants

In the case of large scale or commercial biogas plants, following set of criteria can be assessed during the screening of applications for the biogas plant beneficiaries.

The potential of the proposed biogas plant can be assessed based on the above criteria and will be approved if the proposed plan scores at least 70% or more during the screening process. However, in some cases it will also depend on other factors such as importance on environment management or waste management.

Sl. No	Factors to consider	Criteria
1	Type of waste to be used	Organic waste, animal waste, toilet waste or any other waste
2	Location of project site	Surrounding environment, social impacts and environmental situations
3	Social and culture	Look into the social and culture obligations nearby the site
4	Agriculture production	Type of production proposed
5	Type of waste management	Waste management methods/collection
6	Livestock production	Scale of livestock rearing proposed
7	Environment and social benefits	Benefits derive from the plants
8	Land holdings	Is there adequate land for biogas plant
9	Potential regulatory clearances	Possibility to obtain required clearances
10	Investment arrangement	Major source of investment
12	Product outcome from the biogas plant	What will be major products expected from the plant

11. SUSTAINABILITY AND COMMERCIALIZATION

Rise in fossil fuels demand, high import cost and unsecured future of energy provides signal to find alternative energy solutions. Biogas technology is a promising sustainable solution for village level households as well as to some extent to larger communities at the commercial level. Besides providing renewable energy, biogas also solves major environmental problems such as waste management, deforestation, CO_2 emission, and indoor air pollution and helps to resolve social issues associated with household chores in which women are mostly occupied.

The sustainability of the project depends on its cost and benefits compared to other alternative sources of energy. However, there is need to understand the uniqueness of the biogas plant in reducing the green house gas emission, boost agriculture production, improvement in health and sanitation and utilization of biogas for other purposes. The biogas plant is a onetime investment and all it needs is adequate number of cattle and production of enough cow dung, which will benefit the farmer not only for biogas but to increase dairy products and agriculture production.

11.1 Strategies

Strategy 1: To establish programme budget and plans

Activity:

a) In addition to RGoB funding, project shall explore other sources of funding for the biogas programme;
b) The project shall develop detailed annual budget and plans;
c) Establish collaboration with some potential funding institutions.

Strategy 2: To educate and initiate uses of bio-slurry for economical benefits

Activity:

a) Educate and initiate uses of bio-slurry for agriculture production, where manure can be used in conjunction with normal dose of chemical fertilizers. Such practice will help achieve better returns from fertilizers, minimize the loss of fertilizers from the soil and provide balanced nutrition to crops;
b) Carry out demonstrations for some of the well performing biogas plants in terms of proper methodology for using slurry in liquid or dried forms;
c) Adopt proper technology for making compost out of slurry. The compost manure can be manufactured from the slurry by mixing with other ingredients which can be easily sold in the market;
d) Encourage private sector to take up manufacturing of manure from the bio-slurry.

Strategy 3: To encourage private sector participation

Activity:

a) Establish framework for working modality and participation of private sector in biogas implementation programme;
b) Create awareness on the opportunities for private sector involvement in construction, operation and maintenance of biogas plants with credit support from the financial institutions;
c) Encourage people interested in supply of biogas materials as well as to provide services once the biogas plant is operational;
d) Encourage people or parties to invest in biogas plants in terms of LPG substitution and conservation of forest.

Strategy 4: Diversification of biogas production and its usage

Activity:

a) Conduct awareness programmes among various stakeholders on various biogas production schemes, opportunities and usage;
b) Develop feed-in tariff for generation of electricity from biogas and its integration to grid electricity supply so that private individuals or any parties can either sale the surplus power or get credit in their energy consumption;
c) Provide technical support for large dairy farms or private individuals for installation of biogas plants from animal waste, kitchen waste and other waste which are of concerned to the government;
d) Support establishment of biogas plants for bottling and bio-CNG for commercialization;
e) The fermentation of animal dung in domestic biogas digesters, and the subsequent application of biogas and slurry contribute to global reduction of GHG emissions. As such, the reduced amount of GHG can be sold to potential carbon market and can

generate a significant amount of funds that can be utilized for further development of the biogas project. Accordingly, need to apply for carbon credit from the biogas plant.

12. MONITORING AND EVAUATION

Monitoring and evaluation are two different concepts but for the general understanding, they are expressed together as M&E. Monitoring is a continuous or periodic review and surveillance by management at every level of the hierarchy of the implementation of a program activity. It is more of a feedback system for problem solving during programme or project implementation. While evaluation is an intermittent activity in the organizational process which takes a broader view for improving performance guided by the information obtained.

12.1 Strategies

Strategy 1: To adopt standard performance monitoring and evaluation procedure

Activity:

a) The project office shall develop and comply with a standard performance monitoring system such as performance monitoring matrix with details of progress, outreach and impacts;
b) The responsibility to monitor and evaluate the progress of the project as per the annual plans lies with the project office;
c) The monitoring and evaluation tools shall include i) templates to check and monitor on monthly basis as per the actual achievement against the plan; ii) conduct end user impact studies and iii) submit progress reports.

Strategy 2: To ensure transparency and accountability

Activity:

a) The project office shall maintain books of accounts and records in accordance with the government accounting procedure;
b) The accounts shall be audited by the Royal Audit Authority (RAA) or any other appointed registered auditors annually.

Strategy 3: To ensure proper project communication and documentation

Activity:

a) The project office shall develop and submit progress reports to all stakeholders;
b) The project office and the relevant stakeholders shall meet half yearly or quarterly to evaluate on the project progress, share experiences and lessons learnt.

13. REFERENCES

a) First Annual Progress Report, March, 2012, PIU
b) Biogas technology: a training manual for extension
c) Project Completion Report, December 2017
d) Biogas Market Study in Bhutan, December 2009
e) National Energy Efficiency & Conservation Policy, 2019
f) Alternative Renewable Energy Policy, 2013
g) Energy Efficiency Roadmap, 2019
h) Progress report on Biogas, BDBL, 2017
i) Evaluation of Bhutan Biogas Project, SNV
j) Construction manual, Bhutan Biogas Project
k) Operation and Maintenance guideline, Bhutan Biogas Project
l) Report on Macroeconomic Impacts of Sectoral Energy Efficiency Initiatives in Bhutan, DRE, 2016
m) Challenges and an Implementation Framework for Sustainable Municipal Organic Waste Management Using Biogas Technology in Emerging Asian Countries, September 2019
n) Biogas for rural communities, Center for Technology Alternatives for Rural Areas, Indian Institute of Technology Bombay, May 2011
o) Socio-Economic and Environmental Impact of Biogas Programmes, Kerala Research Programme on Local Level Development Centre for Development Studies, Thiruvananthapuram, Kerala, India, May 2004
p) Feasibility of a Biogas Programme in Bhutan, SNV, December 2008
q) Biogas as a Renewable Source of Energy in Nepal, Theory and Development, Alternate Energy Promotion Center, Ministry of Population and Environment, Government of Nepal, December 2015
r) Evaluation of Bhutan Biogas Project (BBP – 2011-2016), Niras
s) Bhutan Biogas Project Promotion Brochures
t) Implementation Plan, National Programme on Domestic Biogas in Rwanda, September 2006

14. APPENDIX

Appendix 1: Field visit Schedule

Dates	Field Visit
First group	
22/2/2020	Thimphu-Bumthang
23/2/2020	Bumthang – Monggar
24/2/2020	Interview and consultation with the Monggar Dzongkhag
25/2/2020-26/2/2020	Visit to Rural homes, interview and survey
27/2/2020	Monggar-Trashigang
28/2/2020	Interview and consultation with the T/gang Dzongkhag
29/2/2020-1/3/2020	Visit to Rural homes, interview and survey
2/3/2020	Trashigang-Monggar
3/3/2020	Monggar-Bumthang
4/3/2020	Interview and consultation with the Bumthang Dzongkhag
5/3/2020	Visit to Rural homes, interview and survey
6/3/2020	Bumthang-Wangdue
8/3/2020	Interview and consultation with the Wangdue Dzongkhag
9/3/2020	Visit to Rural homes, interview and survey
10/3/2020	Wangdue-Thimphu
Second group	
23/2/2020	Thimphu-Haa
24/2/2020	Interview and consultation with the Haa Dzongkhag, site visit, survey and consultation
25/2/2020	Haa-Thimphu
26/2/2020	Thimphu-Chukha
27/2/2020-28/2/2020	Interview and consultation with the Chukha Dzongkhag, site visit, survey and consultation
29/2/2020	Chukha-Samtse
2/3/2020	Interview and consultation with the Samtse Dzongkhag,
3/3/2020-5/3/2020	Site visit, survey and consultation
6/3/2020	Samtse-Pling
7/3/2020	P/ling-Thimphu

Appendix 2: List of Consultations

Sl.No	Name and Designation	Agency
	Central Level Agencies	
1	Mr. Ugyen Lhendup, Chief Program Officer	Bhutan Trust Fund for Environmental Conservation
2	Mr. Tshering Penjore	UNDP
3	Mr. Raj Kumar, WASH Officer	SNV, Bhutan
4	Mr. Tsheten Dorji, Chief, Conservation and Sustainable Livelihood Division	RSPN
5	Mr. Tenzin Khorlo, Chief	National Environment Commission
6	Mr. Thinley Dorji, Chief	Waste Management Division, NEC
7	Mrs. Ugyen Tshomo, Environment Officer	Waste Management Division, NEC
8	Mr. Jamyang Phuntsho, Asst. Program Officer	Tarayana Foundation
9	Mrs. Tshering Pem, Finance Officer	Bhutan Development Bnak Limited
	Dzongkhag and Gewog Level	
1	Mr. Sherab Tenzin, Dzongkhag Livestock Officer	Chukha Dzongkhag
2	Mr. Karma Dorji, Dzongkhag Livestock Officer	Samtse Dzongkhag
3	Mr. Sangay Phuntsho, Extension Supervisor	Darla Gewog, Chukha Dzongkhag
4	Mr. Dil Pardhan, Livestock Extension Officer	Samtse Gewog, Samte Dzongkhag
5	Mr. Ugyen, District Livestock Officer	Wangdue Dzongkhag
6	Mr. Tenzin Dorji, District Livestock Officer	Monggar Dzongkhag
7	Mr. Khamsum Wangdi, Livestock Supervisor	Monggar Gewog, Monggar Dzongkhag
8	Mr. Naina Singh Tamang, District Livestock Officer	Trashigang Dzongkhag
9	Mr. Loden Jimba, District Livestock Officer	Paro Dzongkhag
10	Mr. Jambay Dorji, District Livestock Officer	Bumthang Dzongkhag