



Alternative Energy Promotion Centre, Nepal

Ministry of Science, Technology and Environment, Government of Nepal

GUIDELINES FOR A MUNICIPAL SOLID WASTE BIOGAS PLANT FEASIBILITY STUDY



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1. INTRODUCTION

The following document establishes the guidelines for carrying out a feasibility study for a Municipal Solid Waste (MSW) biogas plant.

A MSW biogas plant is that plant intending to produce biogas or electricity from the organic waste fraction of MSW. The ultimate aim of the feasibility study must be to determine the feasibility or otherwise of a particular project, explaining the rationale behind the final decision following the structured approach detailed below.

1.1 Executive summary

Should inform the reader about all major findings and recommendations of the study

The executive summary shall include the main findings of the project, conclusion and recommendations. It should clearly state whether the project is feasible environmentally, socially, technically and financially and therefore whether its implementation is recommended or not.

The following sections should be included in the summary:

The nature of the project shall be described here, including for a brief overview of the type and amount of waste to be treated, the type of digester, volume, its application and the benefits from the implementation of the project.

The general setting of the project location shall also be included in the project summary, supported by a brief justification on why this is the most suitable.

A description of the ownership model of the scheme and the management structure should be included in this section, specifically how will the plant be operated and by whom and the level of training that will be provided.

An overview of the existing market shall be detailed here, identifying the end uses of the product streams from the biogas plant. The executive summary shall also contain the main findings from the financial analysis.

The executive summary shall also present a brief description of the resources, both material and human, required to make the project successful, and what the potential for employment creation will be.

The executive summary shall identify the main findings from the Environmental and Social Screening conducted as per ESMF (Environmental and Social Management Framework) and the main actions recommended.



The executive summary shall conclude on the feasibility or otherwise of the project. A final, clear statement determining whether the project is feasible from a technical, environmental, social and financial perspective, recommending the most suitable alternative if different options have been considered during the FS shall be included here.

1.2 Scope of the project

- **What is the goal of the project?**
- **Where is the project being carried out?**
- **What is the end use of biogas and slurry?**
- **What are the main limitations?**

This section should comprise mainly a description of the content of the project, including the main goals of the project, these being waste treatment, electricity production, thermal energy production or any other applicable, area of the project and main limitations.

This section should describe the technology and location proposed, including the potential uses that the project may give to the biogas or slurry, the type of digestion process or the type of digester to be installed.

1.3 Aims

- **What is the aim of the study?**
- **What are the specific objectives?**
- **Are there different aims and objectives for different stakeholders? Do they have to be considered separately?**

This section shall describe the aims of the study. It is important that these are not confused with the project aims.

1.3.1 Aim of the study and objectives:

The aim of the study is the general statement of intent describing what the FS aims to achieve.

The set of specific objectives are those that will be met by the FS in order to achieve the main goal.

It is important to consider the aims and objectives of the FS, not the project, as the purpose of the FS is to determine the viability of the project and this may be terminated if the result from the FS is negative.



1.3.2 Aims and objectives for different stakeholders

If there are different stakeholders their aims and objectives need to be considered separately.



2. INVENTORY OF CURRENT FRAMEWORK CONDITIONS

The inventory can be carried out stepwise, starting with coarse screening to more detailed data collection. For the selected options and sub-options, data with a high level of detail will be collected, which is required to assess the feasibility of each of these options and compare them among each other.

2.1 Data collection

It is very important for the success of the feasibility study and therefore of the project, that all the main data affecting the biogas and energy production is captured and analysed. The following table presents a non-extensive list of areas that need to be considered. The consultant may include more as applicable:

2.1.1 Climate:

- **What is the area climate?**
- **What are the maximum and minimum temperatures throughout the year?**

It will have an impact on the final design of the biogas system. A cold climate would require longer retention times in the digester to compensate for the lower temperatures. Equally, careful consideration should be given to methods for insulating the digester in order to withstand sharp temperature changes between day and night experienced in most areas in Nepal. The frequency and amount of rain may affect the dry solids content of the waste and thus require larger and more costly digesters, so its effect should also be considered.

2.1.2 Seasonality:

- **Does substrate availability vary depending on the season?**
- **Can seasonal variation be compensated?**
- **What is the population's projected growth? How will it affect substrate availability?**

The availability of substrate may depend on the time of the year, generally in case of MSW, rapid urbanization can increase the populations residing in the vicinity and thereby affecting substrate quantity.

The FS shall consider alternative scenarios by which the lack of one type of substrate could be balanced by using a different type of substrate or operating in a co-digestion mode in order to maintain a constant biogas production, when possible. If the reduction of substrate availability cannot be compensated, this should be accounted for in the design and economic analysis.



Variations in the municipality's projected population growth that may affect substrate availability shall be recorded here.

2.1.3 Natural resources:

- **How much water is there available? Where is the source?**
- **Who owns the water source? Is this an issue for the biogas application?**
- **Any past conflicts regarding water usage?**
- **Is there a sun-heated area for the biogas plant location?**

The biogas plant will most likely require water to dilute the substrate and facilitate the digestion process. It is therefore essential that availability of water is assessed in the FS, and that local water supplies are identified as potential sources.

The water needs for MSW biogas plant have to be evaluated to see how biogas application is affected. This may become a controversial issue its use should be agreed with all stakeholders involved and respect the hierarchy of water usage (i.e., human consumption is the main priority, domestic use, irrigation and commercial and industrial uses).

Water source ownership needs to be determined, whether public or private, and assess whether this may become an issue regarding its usage.

Availability of solar energy will also play a part. The digester should be located in an area in which direct solar radiation reaches it to optimise heating from natural sources and hence increase gas production. If solar systems are used for heating the digester then careful consideration should be given to the parameters affecting the performance of the solar system.

2.1.4 Geology and location:

- **Where is the proposed project location?**
- **Are there good transport links to main roads?**
- **How far is the project location from the nearest market? Distance to nearby farmers? Distance to nearby electricity or biogas potential consumers?**

Parameters such as the general geological conditions and location are keys for the success of the project.

Transport links to main roads and ease of access to the site should be described here.

Distance to closest market should be detailed here, as it may impact whether fertilizer can be easily sold in the market. If the project is planning to sell fertilizer to farmers, or biogas or electricity to potential consumers, distance from nearby potential customers should be included here.



Please also include the boundaries of the project area referenced to the biogas plant marked up in a map. GPS location shall also be noted.

2.1.5 Human background:

- **Who are the main authorities in the area? What is their interest in the biogas plant?**
- **Are there any religious, cultural or social barriers to the implementation of a biogas plant? If so, what are these and how can they be overcome?**

In this section the FS should evaluate the human context that may affect the project. It should identify local authorities, administration units and other relevant parties interested in the project.

A stakeholder matrix could be used as a tool to determine the interest and influence of each party in the project development.

Furthermore, any religious or cultural features of the local population that may affect the delivery of the project should also be noted here, identifying clear strategies to minimise any potential negative impacts.

2.2 Legislative framework

2.2.1 Legal framework and permit requirements

This section of the FS shall include a thorough assessment of the legal framework affecting the project delivery to ensure that there are no major obstacles in the implementation of the biogas plant.

- **Which legal bodies need to be asked for permission or should be involved in the development of the project?**
- **Is there a plan to support this type of projects?**
- **Are planning permissions required? Has the local authority been approached?**
- **Is there a land-lease agreement in place? How long for? Is land owned by the municipality itself?**

Current legislation, both national and local, should be reviewed to determine whether there are any showstoppers for the implementation of a biogas plant. The organisation implementing the project shall also list all relevant legislation applicable to the project, outlining a plan on how it is proposing to comply with such legislation. Any other permits, such as planning permission from local authorities and strategies to overcome potential challenges, registration certificate requirements, land-lease agreements or environmental licenses should be included here.



If there is a national support plan in place this should be noted here together with its influence on the project development.

2.2.2 Past examples, lessons learned.

- **Has there been any renewable energy projects in the past carried out in the same location?**
- **Did the previous projects succeed? If not, what are the lessons that could be learned?**

The consultant should also note the views of the organisation on previous projects to address their concerns during the FS, including their outcome and lessons learned. All relevant stakeholders should be part of the design and review process.

2.3 Economic framework

- **If intending to sell electricity, what is the average household income in the nearby community?**
- **How would the main economic activities present in the area affect or be affected by the project?**
- **What could be affordable and realistic rates for electricity, biogas, fertilizer, etc?**

This section should present an outline assessment of the main economic activities present and their potential impact on the project.

Current prices of fuel and electricity should be gathered. These will help to determine the price of electricity, fertilizer or biogas to affordable rates, hence favouring the project feasibility.

Following on from the general assessment, a more detailed look into the particular characteristics of the local economy should be carried out. This may comprise an assessment of the local agricultural sector, as its size and activity is likely to play a key role both from the supply aspect and as a destination for the fertilizer produced in the biogas plant. It should also include details of other commercial activities that may benefit from the implementation of a biogas plant, either from thermal or electrical consumption.

2.4 Energy

The organisation carrying out the FS shall perform a detailed assessment of the energy needs of the MSW plant, community or other industry benefiting from the plant.

- **What are the energy needs of the MSW plant?**
- **Is it planning to sell electricity and/or biogas to the local community? What are the community's needs?**



- **Is it planning on selling electricity to nearby industries/business? What are the industry/business' needs?**

2.4.1 Thermal energy consumption

If biogas is required to meet the thermal energy needs within the MSW, then these shall be established here.

If biogas is to be sold to the local community then this section shall contain an assessment on their energy needs.

If biogas is to be sold to nearby industries or business then this section shall contain an assessment on their energy needs.

The number of households that could be supplied to should be determined and their current consumption patterns established.

2.4.2 Electricity consumption:

In this section the FS shall describe the tentative electricity consumption within MSW plant. As per the section above, if electricity is to be sold to the nearby community or to surrounding industries, their electricity needs have to be assessed.

2.4.3 Grid line:

The project can decide to either export electricity to the NEA grid or supply nearby communities/business/industries using their own independent grid. If the project decides to provide their own grid, details of this will have to be included in the technical section.

If the project is considering exporting electricity to the grid, an assessment of the local grid shall be carried out. This will determine whether selling electricity to the grid is feasible. The local Nepal Electricity Authority (NEA) substations should be evaluated to determine whether they can accept the power that could potentially be uploaded from a large biogas plant. In addition, the NEA shall be consulted to find out any future plans to extend the network in the direction of the biogas plant.



2.5 Waste Management Sector

- **How is waste being managed currently? Who are the key operators/players?**
- **How is segregation carried out?**
- **Is there any pre-treatment or sorting required?**
- **What type of waste is being generated? What is the organic fraction?**
- **Is there an accurate waste characterisation?**
- **What is the frequency of waste collection? How is this carried out?**
- **What is the current waste disposal practice? Are there any temporary storage facilities/areas?**
- **Is the area rural or urban?**

In this section the organisation carrying out the FS should examine the waste management sector. This is a key part of the FS as the substrate availability, management and type will largely determine the viability or otherwise of the project.

It is important to identify any existing waste management operators in the area and what are their current practices and equipment used, in particular how effective the segregation at source is and their sorting practices on site.

The assessment should also evaluate the source of waste (household, restaurants, hotels, schools, hospitals, factories, etc) is available and what will be fed to the digester.

Where the solid waste is mixed, the components of the mixture should be described by percentage composition of the total (i.e., glass, metal, organic waste, wood, paper, etc).

The quantity of each substrate should also be estimated.

Current frequency and equipment for the collection of waste should also be established. Any existing facilities for temporary storage should be identified, as well as what the current practices for waste disposal are (open dump, landfill, etc.), and any pre-treatment being used prior to disposal.

The FS should also describe whether the area to be covered is urban or rural, as the density of the population will have an effect on the collection and transportation systems.

2.6 Financial and Investment Assessment

- **How will the project be financed?**
- **Can the developer/project afford to fund the gap between the government support and the total investment required?**
- **Is the developer/project willing to take a loan to finance the gap? How will this be repaid?**
- **Bill of Quantity and Estimates of Cost**



The organisation conducting the FS shall describe how the project will be financed:

It is important to determine whether the developer/project would be willing to take up a loan to fund the gap between the government support and the total investment required, or any other private investor contribution, CDM credits, NGO or other ODA (Official Development Aid) funding.

Provide the bill of quantity and estimates of cost.



3. ASSESSMENT OF FEASIBILITY

3.1 Organisational capabilities:

The purpose of this section is to determine the capability of the organisation for managing and operating the biogas plant.

3.1.1 Staffing and Operations

- **Who and how will be operating the plant? Are there any existing structures that could be used?**
- **What is the management structure and who owns the plant once commissioned? Will it be formalised and transparent?**
- **If biogas or electricity is to be sold to the local community or nearby business, how will tariff collection be enforced?**
- **How will the income of the plant be utilised?**
- **What are the training requirements? When and how will these be done?**

The organisation carrying out the FS shall also specify the structure in place for operating the biogas plant, including a chart describing the roles and responsibilities of each member from managing, feeding, monitoring, managing the slurry, draining the water traps and any other routines that may be required. Any existing management structure that could incorporate the operation of the biogas plant shall be described here.

Any regular meetings from the organisation, procedures for dealing with complaints, defects, etc should be stated here.

Enforcement procedures for collecting tariffs should be detailed here.

Training to be provided to staff shall be detailed here.

3.2 Location:

- **Is the location easy to access for construction?**
- **Is the location easy to access for routine operation?**
- **Is there an easy biogas or electricity route to consumer points?**
- **Are ground conditions favourable for building a biogas plant?**
- **Is the plant far enough from water sources?**
- **Is there enough area to build the pre-treatment plant, biogas plant and composting plant?**
- **Is the plant in a sun-heated area?**
- **Have photographs been provided?**



- **Has a site plan schematics been provided?**
- **If intending to sell electricity, is the biogas plant close to the nearby community, industries, business, etc.? What is the potential transmission route?**
- **Is the plant close to an NEA substation?**

If there are different potential locations, the most appropriate shall be recommended here based on the criteria below.

The FS should analyse in detail the effect of location selected on the biogas plant.

The following should be considered when assessing the most suitable location for the biogas plant:

- Ease of access for construction, i.e., delivery of materials, man access, etc.
- Ease of access to feed chamber to facilitate substrate feeding to the plant. For instance, feed chamber located close to waste segregation area.
- Distance from consumer points: the biogas plant should be as close as possible to the consumer points to minimise pressure losses in the gas pipe, cost of gas pipe, minimise gas leakage as joints will be reduced, minimise transmission costs if electricity is generated, etc.
- Enough area for compost pits and ease of access to favour collection of bio-slurry fertilizer for sales.
- Ease of access to any equipment requiring regular maintenance and operation.
- Distance from nearby houses should be at least 2 m to avoid damages during construction.
- Distance from any water source should be at least 10 m to avoid water contamination.
- Assessment of the water table should be carried out to determine whether there is enough depth available for digging and constructing the biogas plant without reaching groundwater.
- Enough area should be available for building the biogas plant. Site measurements need to be carried out.
- Plant needs to be built away from trees or tree roots to avoid shading and future damage to the structure.
- Distance to an NEA substation, if electricity is to be sold to the national grid, shall be minimised.

Photographs and schematics for a site plan, including a services plan indicating water, electricity and biogas routes shall be provided in the report to back up the decision on the best location justifying it as per the items above.

The consultants carrying out the FS shall make a recommendation on what the best location would be based on the above considerations.



3.3 Technical

Main question to be answered:

- Is the project technically feasible?

3.3.1 Substrate supply chain:

- How will substrate be collected?
- How much substrate is available?
- Is the substrate going to increase or decrease with time? Will it be affected by any of the reasons? If so, how?
- Will toilet waste be fed to the digester? What is the toilet flushing system?
- Is the substrate source well known and have the main parameters been confirmed (biogas yield, volatile solids, substrate production yield, etc)?
- Is the waste characterisation appropriate?
- Have any lab tests required been carried out?
- Is there potential for inhibition?

It is essential to determine how the feedstock will be collected. It is also important to determine who will be the main actors involved in order to later devise strategies to develop a management structure to ensure the correct operation of the waste collection and feeding regimes.

The quantity of each substrate should also be established, both current and future predictions, accounting for projected population growth of the municipality/source location, as this will have an impact on the size of the digester.

When toilets are connected to the biogas plant, the consulting firm should assess the water currently used to flush the toilet, as this may lead to the need of a pre-treatment stage to separate solids to be fed to the digester in order to avoid oversizing of the plant or disregarding the treatment of toilet waste. The consultant shall recommend what alternative is more economically viable.

Each of the potential options shall be evaluated in this section regarding the substrate supply chain.

Inhibition potential:

Within the sources of waste section, the organisation carrying out the FS should also investigate whether there is potential for contamination of the substrate from inhibitory substances; this may be the case if antibiotics (for instance health care wastes), heavy metals or detergents are present in the feedstock. The potential for inhibition should be ultimately determined empirically in a certified laboratory.



Wastewater treatment practices:

This section should also describe current wastewater treatment practices and what changes are proposed, if any, as part of the implementation of the biogas plant. If any effluents arise from the plant, for instance leachates, they have to be treated as per the government guidelines (EMF and SMF assessment will trigger these).

3.3.2 Process design:

- **What are the design criteria?**
- **What are the main design outputs (digester volume, dimensions, electrical and thermal energy production, etc)?**
- **Enough detail for a biogas grid?**

This section shall include an outline description of the design proposed for each option evaluated. The type of biogas plant recommended shall be stated here. This could be the modified GGC 2047 or other biogas plant technology, particularly for larger digesters. Initial details of the description of the type of technology shall be provided here.

The following shall be provided:

- Type of biogas plant and justification for the selection of that technology.
- Technological option chosen: wet vs dry digestion, methane end use utilisation, multi-stage vs single stage digestion, operating temperature, continuous vs batch, etc) and reasons why.

Type of digestion		T	
Stage		Continuous/batch	

- Design and sizing criteria for all project processes. Biogas yield rate, electricity production rate, slurry production rates, thermal energy production rate. Operational parameters such as feed rate, pressure, temperature, biogas production- expected VS distributed, hydraulic retention time, water requirements for dilution, feed dry solids, pH, etc.
- Size and volume of the biogas plant (including biogas storage) and engine rating if used for electricity generation.
- Pre and post treatment equipment description
- Process flow diagram (this is a schematic diagram showing all the main streams and their composition– i.e., mass and volume flow rate and dry solids, quantity of different feeds, etc) and main process parameters such as temperature or pressure. This shall include main process units.



3.3.3 Construction aspects:

- **Is there enough area to build the plant?**
- **Are ground conditions favourable for a biogas plant?**

The consultants should evaluate the biogas plant from a constructability perspective. This analysis should include the land area required to build the plant, ground conditions and underground water evaluation.

3.3.4 By-product use:

Each option should be assessed on its potential for the production and distribution of fertilizer or any other by-products from the plant. Quantity produced shall be detailed here.

3.4 Financial, commercial assessment and market study

Main question to be answered:

- **Is the project financially feasible and is there an appropriate market for the products from a biogas plant?**

3.4.1 Financial and commercial analysis

In this section of the FS the consulting organisation shall carry out a financial analysis of the biogas plant project proposed and determine its financial feasibility.

- **Have all costs, capital and O&M costs been considered?**
- **Have all revenue streams and savings been identified?**
- **Has a biogas project specific initial financial viability assessment plan been produced?**
- **Do the main financial indicators favour the project?**

The proponent shall present a financial and commercial analysis comprising the requirements below:

Outline biogas project specific financial viability plan, this shall **not** include non-project related activities. The outline business plan must include the following:

For the above, the following must be considered for the biogas project specific requirements
Costs:

- Capital investment costs (biogas plant and ancillaries)
- Construction labour costs
- Leasing costs (if required)
- Operational and maintenance costs
 - Labour



- Water
- Maintenance and replacement parts (pressure meters, engine-generator maintenance, H₂S scrubbing unit maintenance, valves, etc)
- Land-lease (if required)
- Transport costs (feedstock and fertilizer)
- Other
- Revenue streams:
 - Connection tariff to biogas grid
 - Connection tariff to electricity grid
 - Biogas monthly fees
 - Electricity fees
 - Fertilizer sales
 - Sales of Recyclable materials
 - Other
- Cash flow analysis
- Loan repayment period and assumed interest rate
- Key financial indicators: NPV, payback period, IRR.
- Other legal requirements from the developer:
 - Photograph and citizenship of the developer
 - Certificate of registration (renewal) and PAN
 - Tax receipts
 - Audit report of previous fiscal year.

3.4.2 Market study

Potential market for electricity, fertilizer or biogas sales shall be described here.

- **Is there a market for the biogas products? Please describe briefly.**

3.5 Environmental and Social Impact:

3.5.1 Social Impact

- **Has the SMF screening been completed?**
- **Have the main recommendations from the screening for further assessment been included?**

The developer will have to comply with the safeguard policies. The Social Management Framework ([SMF](#)) shall be taken as reference document for complying with social safeguards. These cover the following aspects:

- Impact on specific assets due to project intervention
 - Land
 - Structures
 - Community resources properties



- Natural resources
- Impact on livelihood
 - Loss of shelter or housing structure
 - Loss of income source
 - Loss of grazing field
 - Loss of agricultural land
 - Other
- Impact on trees and crops
 - Vegetation clearance
 - Agricultural crop/fruit bearing tree loss
- Vulnerable groups
 - Adibasi/Janajati/Dalit/Women headed households residing within or adjacent to project site
 - Displacement of the above
 - Threats to cultural traditions or ways of life of vulnerable groups
- Perception of community towards the project (positive or negative)

Please refer to the SMF guidelines for further details. The social screening process shall be completed at the feasibility stage and is included in the Report Format of these guidelines. The main recommendations from the SMF screening shall be included here.

3.5.2 Environmental Impact

- **Has the EMF screening been completed?**
- **Have the main recommendations from the screening for further assessment been included?**

The developer will have to comply with the safeguard policies as well as governmental requirements. The Environmental Management Framework (EMF) shall be taken as reference document for complying with environmental safeguards. These cover the following aspects:

- Impact to forests or vegetation due to the project location
- Water sources/bodies affected by the project
- Air pollution
- Land use
 - Loss of private land
 - Loss of agricultural product
 - Loss of private structures/community structures
 - Loss of forest and vegetation
 - Other
- Waste
- Technology description and outputs
- Odour
- Slurry use



- Health and safety

Please refer to the EMF document for further details. The Environmental screening process shall be completed at the feasibility stage.

The main recommendations from the EMF screening shall be included here.



4. RISK ASSESSMENT

Relevant questions:

- **What are the main risks for the implementation of the project?**
- **Consequences?**
- **Strategies or control measures in place to overcome these?**

Once the analysis above has been carried out, a risk assessment shall be conducted in order to identify the main hazards to the project success, their consequences, and control measures that will be put in place to mitigate them. The risk assessment should evaluate the risks from technical and financial to social, environmental or regulatory, explain and discuss the criteria for the assessment and whether it is a quantitative or qualitative evaluation.

The risk assessment should consist of three parts:

- Identify the hazard and its consequences
- Evaluate the chance of that particular hazard occurring
- Establish a control measure for each hazard

Hazard	Likelihood	Mitigation
...
...
...



5. RECOMMENDATIONS

Main questions to be answered:

- **Based on the overall Feasibility study, is the project feasible or not?**
- **What are the next steps?**

In this section the consultant performing the FS should recommend the best option, explaining the reasons why, based on the comparison carried out above.

This section shall clearly determine whether the project is feasible or not based on the overall study. The conclusion should account for all the criteria followed during the study.

Any further actions recommended for the project development should also be described here.



6. APPENDICES

This section is used to provide the detailed data on which the main text of the FS is based, and to provide extra information of interest to the readers of the FS. Items would normally include some of the following. This is a non-exhaustive list:

- Detailed Technical calculations (mandatory)
- Detailed financial and commercial calculations (mandatory)
- Market research findings (mandatory)
- Records of organisation meetings, surveys, feedback from interviews, etc. (mandatory)
- Other