Rural Support Programmes Network

IEE for Pakistan Domestic Biogas Program

Final Report

March 2010

ES. Executive Summary

ES.1 Introduction

This report presents the findings of an Initial Environmental Examination (IEE) carried out by a team of consultants for the Pakistan Domestic Biogas Programme (PDBP) which is being implemented by Rural Support Programmes Network (RSPN) with technical support from SNV and Winrock International. This program envisions the creation of a commercially viable biogas sector in Pakistan in next 10 years. During the period, the vision is to set up 300,000 domestic biogas plants across Pakistan.

The project will involve the construction of five different digester units (4, 6, 8, 10 and 15 m^3 capacity) at different households throughout the country. These households will operate these units by using the animal waste at their disposal and the biogas produced as a result of anaerobic digestion will be used to fulfil their domestic household needs.

The IEE has been prepared to conform with the requirements of the Pakistan Environmental Protection Act 1997 (PEPA), the Pakistan Initial Environmental Examination and Environmental Impact Assessment Review Regulations 2000 and the guidelines provided in the Pakistan Environmental Assessment Procedures, 1997.

ES.2 The Proponent

RSPN was registered in 2001 under Pakistan's Companies Ordinance (1984) as a non-profit company by the Rural Support Programmes (RSPs) of Pakistan. RSPN is a network of ten RSPs. The RSPs involve poor communities (mainly but not exclusively rural) in improved management and delivery of basic services through a process of social mobilization. RSPN is a strategic platform for the RSPs, providing them with capacity building support and assisting them in policy research, advocacy and donor linkages. Currently the RSPs have a presence in 94 of the country's 138 districts and 2 Fata Agencies, stretching from the mountainous north to the central plains and down to the southern coastline. The RSPs have collectively worked with a rural membership of community organizations of 2.13 million rural households.

ES.3 The IEE Methodology

Various steps undertaken in the IEE preparation included understanding of the proposed operation; review of legislation and guidelines; collection of secondary data; field data collection; public consultation; impact identification and assessment; recommendations for mitigation measures; development of an Environmental Checklist and reporting.

The IEE team visited the project area in January 2010. During the site visits, primary information was collected regarding the biogas units along with feedback from the households presently using the pilot units as well as the communities living in the vicinity of these units.

ES.4 Impacts and Mitigation

The IEE covers potential impacts of the proposed project activities. Potential impacts on the physical, biological, socio-economic and cultural environment that may arise from the project activity have been assessed.

The proposed program will comprise of activities which shall be of a very limited extent, namely the installation of a small sized digester unit in the vicinity of a household.

The planned activities shall involve construction of the digester unit on site, requiring only minor masonry work utilizing readily available raw materials such as bricks and concrete and no machinery will be required which could possibly have resulted in impacts such as air emissions or noise disturbance. Also, the site selection of the biogas unit shall be conducted to ensure it is located at a minimum distance of 20 meters from any water source to prevent ground water contamination. In addition, only three to five persons shall be sufficient to complete the construction activity within a two to three week period and thus these minimal manpower requirements shall not result in any socioeconomic issues. Furthermore, no disturbance to the surrounding communities is expected since the construction activity shall be of a small scale and completely limited to the vicinity of the household installing the digester unit.

Once the digester unit is operational, no issues of noise or air emissions are expected since strict quality checks (using the environmental checklist which has been developed) shall be in place to ensure no leakage of the biogas produced takes place. Additionally, the biogas production is a biological process, requiring anaerobic digestion and does not consist of any activity which might produce disturbance due to noise pollution. Thus no disturbance or negative impact(s) to the surrounding communities is expected. Furthermore, the slurry/compost produced as a by-product of the biogas production process shall be used as fertilizer for the agricultural fields and thus shall not create any environmental issue(s) regarding its disposal.

Due to the reasons cited above, no significant environmental impacts are anticipated at any stage from the planned construction or operational activities of the proposed project. Even so, an environmental checklist has been developed which shall be used by the construction supervisor and RSPN for monitoring of the construction and operation activities of the biogas units to ensure compliance.

ES.5 Conclusion

The IEE concludes that the proposed project activities will not lead to adverse environmental impacts of any kind. Additionally, careful implementation of the environmental checklist will ensure that any potential environmental impacts are managed and minimized and the project proponent meets all statutory requirements.

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List of Acronyms

IEE	Initial Environmental Examination
PDBP	Pakistan Domestic Biogas Programme
RSPN	Rural Support Programmes Network
PEPA 97	Pakistan Environmental Protection Act, 1997
RSPs	Rural Support Programmes
NEP	National Environmental Policy
PEPC	Pakistan Environmental Protection Council
NCS	National Conservation Strategy
NEQS	National Environment Quality Standards
EPAs	Environmental Protection Agencies
EIA	Environmental impact assessment
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
TSS	Total Suspended Solids
TDS	Total Dissolved Solids
GI	Galvanized iron
QED	Quality Ensuring Discount
AEDB	Alternative Energy Development Board

List of Units

°C	Centrigrade
cm	Centimetre
cum	Cubic meter
db	Decibels

1 Introduction

1.1 The IEE

This report presents the findings of an Initial Environmental Examination (IEE) carried out by a team of consultants for the Pakistan Domestic Biogas Programme (PDBP) which is being implemented by Rural Support Programmes Network (RSPN) with technical support from SNV and Winrock International. This program envisions the creation of a commercially viable biogas sector in Pakistan in next 10 years. During the period, the vision is to set up 300,000 domestic biogas plants across Pakistan.

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1.3 The Project

The project will involve the construction of small digester units at different households throughout the country. These households will operate these units by using the animal waste at their disposal and the biogas produced as a result of anaerobic digestion will be used to fulfil their domestic household needs.

1.4 Contact Details

In case of further details or clarifications regarding this IEE, please do not hesitate to contact the proponent at the address provided below:

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2 Scope and Methodology

2.1 Scope of the IEE

This IEE investigates the impacts likely to arise from the construction and subsequent operation of the domestic biogas digester units (details of construction and operation are provided in **Chapter 4**).

It is the intention of the IEE to:

- Identify and investigate any impacts of the proposed construction and operation of the domestic biogas units on the physical and socio-economic environment;
- To propose any mitigation measures (if required) that would help RSPN in conducting the operation in an environmentally sustainable manner;
- To develop an Environmental Checklist that would assist RSPN in the effective implementation of the recommendations of the IEE.

2.2 IEE Methodology

The various steps undertaken in the IEE preparation are summarized below.

2.2.1 Understanding of the Proposed Operation

This involved collecting information from RSPN on the proposed project activities and understanding the activities to identify potential impacts resulting from them.

2.2.2 Review of Legislation and Guidelines

National legislation, international agreements, environmental guidelines, and best industry practices were reviewed to set environmental standards that RSPN will be required to adhere to during the project.

2.2.3 Secondary Data Collection

All available published and unpublished information pertaining to the various biogas projects installed in different countries worldwide along with the experiences of operating these household units were carefully reviewed and analysed.

2.2.4 Field Data Collection

The IEE team conducted two visits to Faisalabad to inspect the pilot biogas projects which have already been constructed in different households. The first visit took place from 8th to 10th January, 2010 while the second visit took place from 23rd to 24th January, 2010.

The data collection activity involved visiting two households for each digester size where the digester units had been installed as part of the pilot project activity. Only two households for each digester size were visited since after completion of the first visit and having closely observed the operation of digester units of different sizes, it was realized that the general operation of the units remains the same, independent of the digester size, with the amount of animal manure fed and slurry produced as the only variant. Thus it was concluded that visiting two households per digester size would prove more than sufficient.

Since five different digester sizes (4, 6, 8,10 and 15 m^3) are planned to be installed as per requirement of the different households, a total of eight different households were visited (digester units of $15m^3$ are yet to be installed) to gain an accurate idea regarding the working of the units and any potential issues/problems these households might have faced since the installation of these units.

As part of the data collection activity, a questionnaire was also developed (provided as **Appendix B**) to obtain any relevant data required to accurately assess any potential environmental issues/impacts resulting from the construction or operation of the digester units.

In addition, discussions were also held with members of the households where the biogas units are currently operational along with members of the community living in the vicinity of these biogas units to identify any potential environmental issues which might have been experienced by them during the construction or operation of these units.

2.2.5 Public Consultation

Members of the households where the biogas units are currently installed were consulted regarding their effectiveness and feasibility. In addition, communities living in the vicinity of these biogas units were consulted during the fieldwork to record any concerns and/or suggestions they might have.

2.2.6 Impact Identification and Assessment

Potential impacts arising from each phase of the proposed project activity were identified. Impacts were identified and assessed on the basis of field data, secondary data, expert opinion, and experiences of the pilot projects currently being implemented in Faisalabad district of Pakistan.

2.2.7 Recommendations for Mitigation Measures

Mitigation measures (if any) to minimise, eliminate, or compensate the potential environmental impacts were recommended. The mitigation measures were recommended on the basis of past experience, best industry practices, legislative requirements and professional knowledge.

2.2.8 Development of Environmental Checklist

An environmental checklist (providing key guidelines to be followed and implemented during both the construction and operation phases of the digester units) was developed to prevent any potential environmental impacts during the project activity.

During the construction of each biogas unit, the supervisor present on site would ensure compliance with the checklist, which upon completion would be provided to RSPN for monitoring.

Similarly, once the biogas units would become operational, the checklist would be used by RSPN to ensure compliance through monitoring of the biogas units on an annual basis.

2.2.9 Reporting

The IEE study was compiled in a report form. The format of the IEE report conforms to the guidelines provided in the Pakistan Environmental Assessment Procedures, 1997.

The IEE report is presented as one volume and describes the proposed project, relevant legislation and guidelines, assessment of the project impacts and recommendations for mitigation measures (if any).

3 Policy, Legislation and Guidelines

3.1 Introduction

This chapter provides a synopsis of environmental Policies, legislation, and guidelines that may have relevance to the proposed program. These include national environmental Policy, legislation and guidelines; and international conventions and guidelines. RSPN shall be required to adhere to the relevant requirements of the Policies and legislation during the construction and operation of the proposed program of activities; which shall also be incorporated in any mitigation measures which might be required and the environmental checklist which has been developed (**Appendix A**).

3.2 National Environmental Policy, Legislation and Guidelines

3.2.1 National Environmental Policy, 2005

The National Environmental Policy (NEP) was approved by the Pakistan Environmental Protection Council (PEPC) in its 10th meeting on 27th December, 2004 under the chairmanship of the Prime Minister of Pakistan and thereafter approved by the Cabinet on 29th June, 2005. NEP is the primary policy of Government of Pakistan that addresses the environmental issues of the country. The broad Goal of NEP is, "To protect, conserve and restore Pakistan's environment in order to improve the quality of life of the citizens through sustainable development". The NEP identifies the following set of sectoral and cross-sectoral guidelines to achieve its Goal of sustainable development.

a. Sectoral Guidelines:

Water and sanitation, Air quality and noise, Waste management, Forestry, Biodiversity and Protected areas, Climate change and Ozone depletion, Energy efficiency and renewable, agriculture and livestock, and Multilateral environmental agreements.

b. Cross Sectoral Guidelines:

Poverty, Population, Gender, Health, Trade and environment, Environment and local governance and Natural disaster management.

The NEP suggests the following policy instruments to overcome the environmental problems through out the country:

- Integration of environment into development planning,
- Legislation and regulatory framework,

- Capacity development,
- Economic and market based instrument,
- Public awareness and education, and
- Public private civil society partnership.

NEP is a policy document and does not apply to projects. However, RSPN will be required to ensure that the program should not add to the aggravation of the environmental issues identified in the NEP and mitigation measures should be adopted to minimise or avoid any contribution of the program in these areas.

3.2.2 National Conservation Strategy

Before the approval of National Environmental Policy (NEP), the National Conservation Strategy (NCS) was considered as the Government's primary policy document on national environmental issues. At the moment, this strategy just exists as a national conservation program. The NCS identifies 14 core areas including conservation of biodiversity; pollution prevention and abatement; soil and water conservation; and preservation of cultural heritage, and recommends immediate attention to these core areas in order to preserve the country's environment.

RSPN should ensure that the project should not add to the aggravation of the 14 core environmental issues identified in the NCS and mitigation measures should be adopted to minimise or avoid any contribution of the program activities in these areas.

3.2.3 National Environmental Legislation

a. Pakistan Environmental Protection Act 1997

The Pakistan Environmental Protection Act, 1997 (PEPA) is the basic legislative tool empowering the government to frame regulations for the protection of the environment. The PEPA is broadly applicable to air, water, soil, marine and noise pollution, as well as the handling of hazardous waste. Penalties have been prescribed for those contravening the provisions of the Act. The powers of the federal and provincial Environmental Protection Agencies (EPAs) were also considerably enhanced under this legislation and they have been given the power to conduct inquiries into possible breaches of environmental law either of their own accord, or upon the registration of a complaint.

Under section 12 of PEPA, no project involving construction activities or any change in the physical environment can be taken unless an IEE or EIA as required is conducted and a report submitted to the federal or provincial EPA.

b. Pakistan Environmental Protection Agency Review of IEE and EIA Regulations, 2000

The Pakistan Environmental Protection Agency Review of IEE and EIA Regulations, 2000 (the 'Regulations'), prepared by the Pak-EPA under the powers conferred upon it by the PEPA, provide the necessary details on the preparation, submission, and review of the initial environmental examination (IEE) and the environmental impact assessment (EIA).

The Regulation classifies projects on the basis of expected degree of adverse environmental impacts and lists them in two separate schedules. Schedule I lists projects that may not have significant environmental impacts and therefore require an IEE. Oil and gas exploration and production activities are included in Schedule I. Schedule II lists projects of potentially significant environmental impacts requiring preparation of an EIA. The Regulations also require that all projects located in environmentally sensitive areas require preparation of an EIA. As the proposed project activities will not be carried out in any environmentally sensitive area, an EIA study is therefore not required.

It is important to mention that the proposed program will comprise of activities which shall be of a very limited extent, namely the installation of a small sized digester unit in the vicinity of a household. The planned activities shall involve construction of the digester unit on site, requiring only minor masonry work utilizing readily available raw materials such as bricks and concrete. In addition, three to five persons shall be sufficient to complete the construction activity within a two to three week period and thus minimal manpower requirements are foreseen which shall not result in any socioeconomic issues. No disturbance to the surrounding communities is expected since the construction activity shall be of a small scale and completely limited to the vicinity of the household installing the digester unit.

Once the digester unit is operational, no issues of noise or air emissions are expected since strict quality checks shall be in place to ensure no leakage of the biogas produced takes place and the biogas production requires anaerobic digestion which is a biological process and does not consist of any activity which might produce noise. Thus no disturbance or negative impact to the surrounding communities is expected. Furthermore, the slurry/compost produced as a by-product of the biogas production process shall be used as fertilizer for the agricultural fields and thus shall not create any environmental issue.

Due to the reasons cited above, the proposed program of activities requires an IEE study since no significant environmental impacts are anticipated at any stage from the planned construction or operational activities.

c. The National Environmental Quality Standards

The NEQS promulgated under the PEPA 1997 specify standards for industrial and municipal effluents, gaseous emissions, vehicular emissions, and noise levels. The PEPA 1997 empowers the EPA's to impose pollution charges in case of non-compliance to the NEQS. Standards for disposal of solid waste have as yet not been promulgated.

During the project, NEQS will apply to all type of effluents, emissions and noise levels from the proposed program of activities.

NEQS for municipal and industrial effluents, selected gaseous pollutants from industrial sources and motor vehicle exhaust and noise are provided in **Table 2-1**, **Table 2-2** and **Table 2-3**.

3.2.4 Antiquities Act 1975

The protection of cultural resources in Pakistan is ensured by the Antiquities Act of 1975. Antiquities have been defined in the Act as ancient products of human activity, historical sites, or sites of anthropological or cultural interest, national monuments etc. The act is designed to protect antiquities from destruction, theft, negligence, unlawful excavation, trade and export. The law prohibits new construction in the proximity of a protected antiquity and empowers the Government of Pakistan to prohibit excavation in any area, which may contain articles of archaeological significance.

No antiquity protected under this act was identified in the vicinity of the proposed project during fieldwork for the IEE. Furthermore, the project sites are unlikely to contain any buried antiquity. However, the project staff will be instructed before ground preparation and earthworks to report any archaeological artifact or what may appear to be an archaeological relic to the project management. In case of such a discovery, appropriate action will be taken.

Table 3-1: NEQS for municipal and industrial effluents[a]

Parameters	Into Inland Water	Into Sewage Treatment[b]
Temperature or temperature increase[c]	≤3°C	≤3°C
pH	6-9	6-9
Biochemical Oxygen Demand (BOD5) at 20^{o}C[d]	80	250
Chemical Oxygen Demand (COD)[d]	150	400
Total Suspended Solids (TSS)	200	400
Total Dissolved Solids (TDS)	3,500	3,500
Grease and oil	10	10
Phenolic compounds (as phenol)	0.1	0.3
Chloride (as Cl^-)	1,000	1,000
Fluoride (as F)	10	10
Total cyanide (as CN-)	1.0	1.0
An-ionic detergents (as MBAS)[e]	20	20
Sulphate (SO_4)	600	1000
Sulphide (S-)	1.0	1.0
Ammonia (NH_3)	40	40
Pesticides[f]	0.15	0.15
Cadmium[g]	0.1	0.1
Chromium (trivalent & hexavalent)[g]	1.0	1.0
Copper[g]	1.0	1.0
Lead[g]	0.5	0.5
Mercury[g]	0.01	0.01
Selenium[g]	0.5	0.5
Nickel[g]	1.0	1.0
Silver[g]	1.0	1.0
Total Toxic metals	2.0	2.0
Zinc	5.0	5.0
Arsenic[g]	1.0	1.0
Barium[g]	1.5	1.5

Parameters	Into Inland Water	Into Sewage Treatment[b]
Iron	8.0	8.0
Manganese	1.5	1.5
Boron[g]	6.0	6.0
Chlorine	1.0	1.0

Source: Pakistan's Environmental Laws and their Compliance, Dr. Shoaib Qadar, et.al (2003)

Notes

[a] All values are in mg/l, unless otherwise defined

[b] Applicable only when and where sewage treatment is operational and BOD5=80 mg/L is achieved by the sewage treatment system

[c] The effluent should not result in temperature increase of more than 3°C at the edge of zone where initial mixing and dilution take place in the receiving body. In case zone is defined, use 100 meters from the point of discharge

[d] Assuming minimum dilution 1:10 on discharge, lower ratio would attract progressively stringent standards to be determined by the Federal Environmental Protection Agency. By 1:10 dilution means, for example that for each one cubic meter of treated effluent, the recipient water body should have 10 cubic meter of water for dilution of this effluent

[e] Modified Benzene Alkyl Sulphate; assuming surfactant as biodegradable

[f] Pesticides include herbicide, fungicides and insecticides

[g] Subject to the total toxic metals discharge should not exceed level of total toxic metals

Table 3-2: NEQS for selected gaseous pollutants from industrial sources[a]

Parameter	Source of emission	Standard
Smoke	Any	40% or 2 Ringlemann scale or equivalent smoke number
Particulate matter[b]	Boilers and furnaces:	
	Oil fired	300
	Coal fired	500
	Cement kilns	300
	Grinding, crushing, clinker coolers and related processes, metallurgical processes, converter blast furnaces and cupolas	500
Hydrogen chloride	Any	400
Chlorine	Any	150
Hydrogen fluoride	Any	150
Hydrogen sulfide	Any	10
Sulfur oxides[c]	Sulfuric acid/Sulfonic acid plants	5,000
	Other plants except power plants operating on oil and coal	1,700
Carbon monoxide	Any	800
Lead	Any	50
Mercury	Any	10
Cadmium	Any	20
Arsenic	Any	20
Copper	Any	50
Antimony	Any	20
Zinc	Any	200
Oxides of nitrogen[d]	Nitric acid manufacturing unit	3,000

Parameter	Source of emission	Standard
	Other plants except power plants operating on oil or coal:	
	Oil Fired	400
	Coal fired	600
	Cement kilns	1,200

Source: Pakistan's Environmental Laws and their Compliance, Dr. Shoaib Qadar, et.al (2003)

Notes:

[a] All values are in mg/Nm^3, unless otherwise defined

[b] Based on the assumption that the size of the particulates is 10 micron or more

[c] Based on 1% sulphur content in fuel oil. Higher content of sulphur will cause standards to be pro-rated

[d] In respect of the emissions of the sulfur dioxide and nitrogen oxides, the power plants operating on oil or coal as fuel shall, in addition to NEQS specified above, comply with the following standards

Table 3-3: NEQS for motor vehicle exhaust and noise

Parameter	Standard	Measuring Method
Smoke	40% or 2 on the Ringlemann scale during engine acceleration mode	To be compared with Ringlemann Chart at a distance of 6 meters or more
Carbon Monoxide	New vehicles: 4.5% Used vehicles: 6%	Under idling conditions, non-dispersive infrared detection through gas analyzer
Noise	85 dB (A)	Sound-meter at 7.5 meters from the source

Source: Pakistan's Environmental Laws and their Compliance, Dr. Shoaib Qadar, et.al (2003)

Notes:

[a] 10 years or older

4 Project Description

RSPN is currently in the process of setting up 300,000 domestic biogas plants across Pakistan under the PDBP program. The long term objective of this Programme is to improve the livelihoods of 300,000 households through the provision of household biogas digesters promoted by a commercially viable biogas sector in the next ten years. The PDBP program shall promote biogas plants of sizes 4, 6, 8,10 and 15 m^3.

4.1 Biogas Technology

Biogas is generated when bacteria degrade biological material in the absence of oxygen, in a process known as anaerobic digestion. Since biogas is a mixture of methane (also known as marsh gas or natural gas, CH_4) and carbon dioxide, it is a renewable fuel produced from waste treatment. Anaerobic digestion is basically a simple process carried out in a number of steps that can use almost any organic material as a substrate - it occurs in digestive systems, marshes, rubbish dumps, septic tanks and the Arctic Tundra.

Conventional anaerobic digestion has been a "liquid" process, where waste is mixed with water to facilitate digestion, but a "solid" process is also possible, as occurs in landfill sites.

4.2 The Biogas Plant

Biogas plants are based on a uniform technical design and are manufactured and installed following established technical standards. The households feed cattle dung mixed with equal amount of water into the biogas plant, which through anaerobic digestion produces biogas. The biogas produced in the digester goes to the kitchen through a pipe. The biogas contains around 50-60% of methane and burns with a clear blue flame.

The biodigester model being promoted under the PDBP program is a structure constructed under the ground, made with cement, brick/stone, sand and pipes & appliances to decompose organic material and produce biogas- to supplement conventional fuel sources; and bioslurry- to apply as organic manure in the farms. By feeding the recommended amount of cattle dung and water every day in the digester, clean gas is produced. This fuel is used mainly for cooking and lighting purposes where as the digested slurry is used in vegetable gardens and agricultural fields.

There are 6 main parts of the biodigester, namely: inlet (mixing chamber) for cattle dung fed plant, digester (digestion chamber), gas holder (storage chamber), outlet (displacement chamber), gas conveyance system and slurry compost pit(s).

The specific role of each of the major components component is summarized below:

Inlet – The main purpose of the inlet is to mix organic material and water into a semi solid state. This mixture is fed into the digester via an inlet pipe. A hand operated mixer in the inlet helps mix the organic material and water thoroughly.

Digester – The digester holds the mixture of manure and water while microorganism activity produces biogas. It is cylindrical in shape and is made of brick masonry with a concave concrete cover, or the dome.

Dome - The purpose of the dome is to collect the gas produced in the digester. This is plastered in several layers and painted with a special paint in order to minimize gas leakage. Gas accumulates under the dome creating pressure and pushing down the level of the slurry and increasing the slurry level in the connected slurry tank. It is the difference in slurry levels between the slurry tank and the inside of the dome that maintains the pressure to push the gas into the outlet pipe and into the kitchen.

Outlet - The outlet valve releases the collected gas under the dome to burners for cooking and gas lamps for lighting purposes. Gas is conveyed to the kitchen in galvanized iron (GI) pipes.

Water Drain – The water drain is put in at the lowest profile of the GI pipe, conveying gas to the kitchen. Its purpose is to release any condensed water from the pipeline. It needs to be opened and cleaned out periodically to make sure all the water in it is released.

Slurry Tank: The slurry tank holds the slurry that the gas pressure from under the dome displaces. This slurry overflows into a composting tank as more manure is fed into the digester. The slurry can either be used directly as a fertilizer in its liquid form or can be turned into a more solid fertilizer after it has been composted with other organic material.

The detailed components in any GGC Model Biogas Plant are as follows:

1. Inlet (Mixing Tank)
2. Inlet Pipe(s) separate for cattle dung and latrine
3. Digester
4. Gas Holder (dome)
5. Manhole
6. Outlet (Displacement Chamber) and overflow opening

7. Main Gas Pipe and Turret
8. Main Gas Valve
9. Pipeline
10. Water Outlet (Water Trap or Drain)
11. Pressure Gauge
12. Gas Tap
13. Gas Stove with rubber hose pipe
14. Gas Lamp (Optional)
15. Slurry pit(s)

The biogas plant for the proposed program will provide biogas to meet the thermal energy needs of households which have at least 2 heads of cattle (cows or buffaloes). The use of biogas digester plants will displace the domestic energy sources such as unsustainable biomass and fossil fuels (kerosene, liquefied petroleum gas) with biogas produced from the biogas plant using animal manure. The fixed dome design, called GGC 2047 model, which was initially designed and developed in Nepal, has been installed in the pilot projects with slight modifications. This model is considered to be reliable, well functioning, simple, durable and with low maintenance cost. A schematic of a GGC 2047 Model Biogas plant is provided in **Figure 4-1** below.

4.3 Construction and Operation of Biogas Plant

The various steps undertaken during the construction of the biogas unit as part of the pilot activity conducted in Faisalabad district are shown in **Photographs 4-1 to 4-16** below.

4.3.1 Responsibilities of a Mason

The mason's role is vital in successful installation of biodigesters. The following are some of the major responsibilities of a mason:

- Provide necessary information on benefits of biodigester to the users and motivate them for biodigester installation.
- Select proper size of bio-digester based upon the availability of feeding materials.
- Ensure that the quality standards of construction materials and appliances are properly complied with.

- Follow strictly the design and drawing as provided to them during construction of biodigesters.
- Comply with the Construction manuals while installing the biodigesters.
- Provide the users with minimum requirement of knowledge and skill to operate various components of bio-digester.
- Ensure timely completion of the work.
- Report progress and difficulties, if any, to supervisors regularly.
- Ensure the involvement of trained mason for the construction – do not allow untrained masons to take lead responsibly in constructing the biodigester.
- Work as extension worker and promoter of the technology in their areas of influence.
- Provide regular follow-up and after-sales services to the users to ensure trouble-free functioning of completed plants.

4.3.2 Steps in the Installation of a Biogas Plant

A mason has to carry out the following activities in sequential order while installing biogas plant in farmer's premises:

- Selection of correct size of biodigester
- Selection of construction site
- Collection of construction materials that meet the quality standards
- Lay-out of plant
- Digging of the pit (Excavation)
- Fixing the diameter and laying of collar (base layer for brick/stone work) for digester and manhole walls
- Construction of digester walls and manhole
- Installation of inlet pipes
- Backfilling the empty spaces outside the digester wall
- Construction of the top of manhole (usually called as beam)
- Construction of gas holder (preparation of mould, concreting, fixing of dome gas pipe)
- Constructing Inlet chamber
- Constructing outlet chamber and outlet covers

- Plastering of the inside of dome
- Construction of turret
- Installation of pipeline, fittings and appliances
- Testing for leakages
- Filling the plant with feeding
- Construction of slurry pit(s)
- Filling the top of dome and sides of outlet tank with earth
- Cleaning the site
- Orienting the users on simple operation and maintenance activities

The major steps mentioned above have been described in detail in the following sections.

Selection of correct size of Biogas Plant

The GGC biogas plant is fixed dome design plants. Only biodigesters of sizes 4, 6, 8, 10 and 15 m^3 of this model are eligible for obtaining the Quality Ensuring Discount (QED) from the Pakistan Domestic Biogas Programme (PDBP). No other sizes and designs will be eligible to receive the QED under the programme.

The size and dimensions of the biodigesters have been decided based upon 50 days retention time and 60% gas storage. This means that the fresh manure fed into the digester should remain inside it for at least 50 days before it comes out through the outlet. Likewise, the plant should be able to store 60% of the gas produced in 24 hours.

Therefore, the size of the biodigester has to be selected based upon the daily available quantity of feeding materials. Before deciding the size of biodigester to be installed, all the dung available from cattle has to be collected and weighed for at least a week to know how much feeding material is actually available every day. The **Table 4-1** below shows the capacity of biodigesters to be decided based upon the availability of feeding material (mainly cattle dung).

If the plant is not fed properly as per the requirement, gas production will be less than the theoretical expectation. If gas production is less, the gas collected in the gasholder will not have sufficient pressure to push the digested slurry to the outlet. In such case, the slurry level will continue to rise and reach the gas holder instead of flowing to the outlet. When the main gas valve is opened in this situation, the slurry may pass to the pipeline together with the gas. Therefore, if there is not enough quantity of feeding material available as per the prescribed rate, bigger size of the biodigester should not be installed. Underfed and bigger plants will only increase the cost of installation and also create problems in operation. The important points to be considered while deciding on the size of the biodigester should be the availability of dung, not the family size or gas demand. If the farmer has higher number cattle then only the size is determined by the gas demand which is usually taken to be 0.33-0.40 cum gas per person per day.

Selection of Construction site

Selection of construction sites are mainly governed by the following factors:

- The site should facilitate easy construction works.
- The selected site should be such that the construction cost is minimised.
- The selected site should ensure easy operation and maintenance activities like feeding of Plant, Use of main gas valve, Composing and use of slurry, Checking of gas leakage, Draining condensed water from pipeline etc.
- The site should guarantee plant safety

Based upon the above mentioned factors, it is recommended to select plant location based upon the following considerations. Please note that it will not be possible to meet all the requirements as stated below, however, it should be ensured that as many as possible points are considered:

- For effective functioning of biodigesters, right temperature (20-35°C) has to be maintained inside the digester. Therefore it is better to avoid damp and cool place – Sunny site is preferable.
- The area to construct the plant should have an even surface.
- The site should be at a slightly higher elevation than the surroundings. This helps in avoiding water logging while ensuring free flow of slurry from overflow outlet to the composting pit.
- To make the plant easier to operate and avoid wastage of raw materials, especially the dung, plant must be as close as possible to the cattle shed.
- To mix dung and water considerable quantity of water is required. If water source is far, the burden of fetching water becomes more. However, the well or ground water source should be at least 10 meter away from the biodigester especially the slurry pit to avoid the ground water pollution.
- If longer gas pipe is used the cost will be increased as the conveyance system becomes costly. Furthermore, longer pipeline increases the risk of gas leakage. The main gas valve which is fitted just above the gas holder should be opened and closed before and after the use of biogas. Therefore the plant should be as near to the point of application as possible.

- The edge of plant should be at least 2 meter away from the foundation of house or any structure.
- There should be enough space for compost-pit(s) as these are integral parts of the biodigester.
- The site should be at sufficient distance from trees to avoid damage of bio-digester from roots.
- Type of soil should have enough bearing capacity to avoid the possibility of sinking of structure.
- When space is a problem, the cattle shed can be constructed on top of the plant after proper backfilling.

Quality Standards of Construction Materials and Appliances

If the construction materials to be used for the construction of biodigester are not of good quality, the biodigester will not function properly even if the design is correct and workmanship involved in construction is excellent. The plant will never be of high quality if inferior quality of construction materials is used. In order to select these materials of best quality, RSPN will ensure that the required quality standards and specifications of these materials are as follows:

a) Cement

Cement should be high quality Portland cement from a brand with a good reputation. It must be fresh, free from lumps and stored in dry place. Cement with lumps should be used for construction. Bags of cement should not be stacked directly on the floor or against the walls. Wooden planks have to be placed on the floor to protect cement from dampness. Cement bags should be stalked at least 20 cm away from any walls.

b) Sand

Sand should be clean and should not contain soil or other materials. Dirty sand will have very negative effect on the strength of the structure. If sand contains more than 3% impurities, it must be washed.

c) Gravel

Size of gravel should not be very big neither very small. It should not be bigger than 25% of the thickness of the concrete product where it is used. The thickness of concrete layer in the foundation and that of outlet slabs is not more than 7.5 cm (3”), therefore the maximum size of gravels should be 2 cm or ¼ size of the size of thickness of concrete layer. Gravel should be clean, hard and of angular shape. If it is dirty, it has to be washed properly before use.

d) Water

Water is mainly required for making the cement mortar for masonry works, concreting works and plastering. It is also used to soak bricks before using. Besides, it is required for cleaning or washing construction materials if they are dirty. The water from ponds or canal may be dirty so it is better not to use it. Dirty water will have an adverse effect on the strength of structure.

Water from water tap or well or any other sources that supply clean water has to be used.

e) Bricks/Stones

Brick plays a very important role in construction especially for GGC model of biodigesters. Bricks should be of high quality (no.1), usually the best quality available in the local market. The bricks should be well burnt, straight, regular in shape and sizes and should not have cracks or broken parts. High quality bricks make a clear metallic sound when hitting them to each other. Such bricks should be able to bear a pressure of 120 kg per square centimetre. Before use, bricks must be soaked for few minutes in clean water. Wet bricks will not absorb water from the mortar which is needed for setting properly.

In areas where bricks are expensive and not available, stones can be used for construction of the GGC model biogas plants. Stones to be used in the construction should be best locally available. When hitting one stone with another, stones should not break. When the stone is scratched with a pointed object like iron nails, there mark should not be more than 1mm. If the stones are dirty it should be washed. Before use, stones must be soaked for few minutes in clean water.

f) Acrylic Emulsion Paint

It is used to make the gas holder (dome) of biodigester air-tight. Paint of this type should meet quality standard and they must be approved from concerned quality control authority.

g) Mild Steel Bars

MS bars are used to construct the covers of outlet tank and water drain chamber. It should meet the engineering standard generally adopted. For plants of 4, 6 and 8 cum, MS rods of 8 mm diameter and for plant of 10 cum capacity 10 mm diameter is recommended. MS bar should be free from heavy rust.

h) Main Gas Pipe

Gas stored in the gas holder is conveyed to the pipeline through this pipe which is placed in the topmost portion of the dome. The joint of reduction elbow with this pipe should be perfect and gas tight otherwise gas leakage from this joint cannot be stopped easily. Therefore it is recommended that the reduction elbow has to be fitted in a workshop to ensure perfect air-tightness of the joint. The gas pipe should be properly galvanised and approved by concerned quality control authority. This pipe should be made up of light quality iron and MS rod has to be welded at one end to embed it with the concrete during installation. The length of this pipe should be at least 60 cm.

i) Main gas valve

It controls the flow of biogas in the pipeline from the gas holder. It is opened when gas is to be used and closed after each use. If substandard quality of main gas valve is used, there is always risk of gas leakage. This valve should be of high quality and approved by the concerned quality control authorities.

j) Pipes and fittings

The pipe to be used to convey gas from gas holder to the point of application should conform to quality specification as per the standard of Pakistan. Light quality Galvanised Iron pipe is best suited for this purpose; however, high quality PVC pipe could also be used. The pipe should be of at least half inch diameter. For length of more than 60 m (30 m if two burners are to be used at a time), ¾" diameter pipe has to be used. If GI pipe is to be used, a six meter pipe should weigh at least 6 kg. The fittings used in the pipeline of a biogas plants are socket, elbow, tee and nipples. These fitting should meet the required quality standards.

k) Water Outlet

It drains the water condensed inside the pipeline when biogas comes in contact with the cool pipe. This is an important component of biogas plant and therefore, its quality should carefully be controlled. It should be easy to operate and threads in it should be perfect. It should be ensured that the hole in the screw nut is bored properly and is located at the right place. The thickness of the nylon washer has to be 4mm and either a 4 cm long handle pin or a properly knurled opener should be used. This appliance should be approved by the concerned authorities.

l) Gas Tap

Gas tap is used for regulating flow of gas to the gas stove. Care should be taken to install gas tap of high quality. It has been often complained by the users that this taps are becoming problematic with gas leakage through them. It is important that the 'o' ring is placed properly and is greased thoroughly and regularly. The gas tap should not be too tight or loose to operate. The taps to be used in biodigesters should be approved by concerned quality control authority.

m) Rubber Hose Pipe

It is used to convey gas from the gas tap to the stove. This pipe should be made up of high quality neoprene rubber and should not develop cracks when folded. It should have 15 mm outer and 9 mm inner diameters. The minimum wall thickness of the pipe should be 2.5 mm.

n) Gas Stove

Gas stoves can be found with single and double burners. In general a single burner gas stove used for household purpose consumes 350 to 400 litre of gas per hour. The efficiency of gas stove is very important for the successful functioning of the biodigester. The stove should be of good quality and strong enough to firmly rest in ground. The primary air intake should be easily adjustable and the holes should be properly placed. The jet and pipe leading to the burner should be straight and aligned properly. The holes in the burner cap should be evenly spread across it.

o) Gas Lamp

Gas lamp is another important appliances used in biodigesters. Often users complain about the malfunctioning of these lamps. These lamps should be of high quality with efficiency more than 60%. Usually, a biogas lamp consumes 150 to 175 litres of biogas per hour. Lamps to be used in biodigesters have to be approved by the concerned quality control authority.

p) Gas Pressure Gauge

U-shaped pressure gauge (manometer) made up-of a transparent plastic or glass tube and filled with coloured water or a clock-type digital or analogue pressure meter has to be installed in the conveyance system to monitor the pressure of gas. Whatever may be the type this device should best among those available in the local market and should meet set quality standards, if any.

q) Mixing Device

This device is used to prepare good quality water-dung solution in the inlet tank when cattle dung is used as feeding material. Usually for household biogas digesters, vertical mixing devices are installed. The device should be of good quality, as per the design, and the mixing blades have to be well galvanised. The blade should be properly aligned for the effective mixing.

Plant Layout

Construction works of biodigester starts with the process of layout works. This is the activity carried out to mark the dimensions of plant on the ground to start the digging work. For this purpose, first a small peg has to be stuck in the ground at the centre spot of the digester. Then the ground is leveled and the locations of the digester, outlet tank and inlet pit are determined.

After completion of lay-out work, the work for digging of pit has to be started. Tools like, crowbar, picks, spade, shovel and basket are usually available at the site. Gas-tightness of the gas-holder is very important for the effective functioning of any biodigester. If the gas stored in the gas-holder escapes through the minute pores, the users will not be able to get gas at the point of application. The whole investment will therefore be wasted if gas holder is not made perfectly gas-tight.

After approximately one week, depending on the temperature the earth of the mould can be removed through the manhole. When all earth is removed, the surface of the gas holder has to be cleaned with scrubbing with water and iron brush. The entire surface of the concrete dome has to be cleaned before starting the plastering. After cleaning, the following layers of plastering works have to be applied to make the gas holder perfectly gas-tight.

Checking for Gas and Water Tightness

After the completion of the construction of structural components and installation of pipes and appliances, and before feeding with mix of dung and water, biogas plants should be checked for water-tightness (the digester) as well as gas-tightness (the gas holder – dome and conveyance system – pipe and appliances). If the plant is not water tight, there will be the risk of leaking of nutrients from the slurry as well as alteration of water-dung ratio which affects the Hydraulic Retention Time adversely. A leaking biogas plant hence produces inferior quality bio-fertilizer.

Likewise, if the gas holder, pipes and appliances are not air-tight, the produced gas will escape into the atmosphere resulting in less gas available for application (at the micro level) and detrimental consequences to environment (at the macro level). In other words, the efficiency and effectiveness of biogas plant highly depends on gas tightness of the gas-storage tank as well as pipes and appliances, and water tightness of the digester.

4.3.3 Solid and Liquid Waste Generation and disposal

During the construction phase of the household biogas unit(s), the activity involved shall primarily consist of masonry work as described in detail above. As a result, no significant solid or liquid waste will be generated since any bricks or material not used will be returned to the supplier. Furthermore, considering the scale of the construction activity which will be at a household level, the amount of raw material used will be quite insignificant. During the pilot projects conducted so far in Faisalabad district of Punjab, it was observed that no significant solid or liquid waste was produced as a result of the construction activity undertaken for the biogas unit.

Similarly, during the operational phase of the biogas unit(s),as described above, animal dung will be used to feed the biodigester unit to enable the anaerobic digestion process to take place. The slurry resulting as a by-product of the biogas production process shall itself flow due to hydraulic pressure and collect in the slurry and compost pits. As per requirement of the household where the biogas unit would be installed, the slurry would be applied to the agricultural fields as fertilizer or allowed to remain in the composting pits where valuable compost would be produced on completion of the composting process. Consequently, the slurry produced would prove extremely beneficial in increasing the fertility of the agricultural crops while remaining environmentally friendly.

During the pilot projects in Faisalabad district mentioned above, the various households were implementing these very practices and maximizing the use of the slurry by product. While doing so, they were ensuring that any solid or liquid waste generated as a result of the project activity was used in an environmentally friendly and beneficial manner.

4.4 Benefits of biogas technology

Domestic biogas production is an attractive option since it can provide solutions to a variety of problems simultaneously: In general it has been proven that the energy aspect alone does not justify the cost for biogas technology. But the essential benefits of biogas plants are not manifested in individual cost-efficiency calculation. The overall objective, to which biogas technology contributes, is environmental protection which includes energy-related objectives (decrease of greenhouse gas emissions as well as deforestation) and the improvement of livelihoods of biogas users.

Table 4-2 shows the savings of fuel wood resulting from installation and subsequent use of the different proposed sizes of the biogas units. Well-functioning biogas systems can yield a whole range of benefits for their users, the society and the environment in general:

- production of energy (heat, light, electricity)
- transformation of organic waste into high quality fertilizer
- improvement of hygienic conditions through reduction of pathogens, worm eggs and flies
- reduction of unpleasant odors
- reduction of workload, mainly for women, in firewood collection and cooking
- environmental advantages through protection of soil, water, air and woody vegetation
- micro-economical benefits through energy and fertilizer substitution, additional income sources and increasing yields of animal husbandry and agriculture

- macro-economical benefits through decentralized energy generation, import substitution and environmental protection
- Biogas technology can substantially contribute to conservation and development, if the concrete conditions are favorable

Construction of a Household Biogas Unit (Pilot project in Faisalabad district)

Photograph 4-1: Livestock rearing in Faisalabad district of Punjab

Photograph 4-2: Marking of dimensions for biodigester unit prior to start of excavation work

Photograph 4-3: Measurements of biogas unit and dimensions being calculated

Photograph 4-4: Brick lining being conducted by the mason at the base of the biodigester unit

Photograph 4-5: Wall of biodigester being constructed from bricks

Photograph 4-6: Inlet pipes for feeding of the animal manure into the biodigester unit being inserted

Photograph 4-7: Brick wall of the biodigester unit completed

Photograph 4-8: Dome of the biodigester unit constructed

Photograph 4-9: Inlet pipe for feeding of the animal manure into the biodigester unit

Photograph 4-10: Concrete being laid on the biodigester dome to ensure no leakage of gas takes place during operation

Photograph 4-11: Masonry work continuing to construct compartment to be used for feeding of animal manure into the biodigester unit

Photograph 4-12: Compartment for feeding of animal manure being completed

Photograph 4-13: Biodigester unit completed with concrete dome

Photograph 4-14: Outlet pipe on top of biodigester to be used for piping of the gas produced to the household appliances

Photograph 4-15: Construction of Slurry pit in progress

Photograph 4-16: Feeding compartment, biodigester unit outlet and slurry pit (with lid) on completion of biogas unit

Table 4-1: Quantity of feeding required

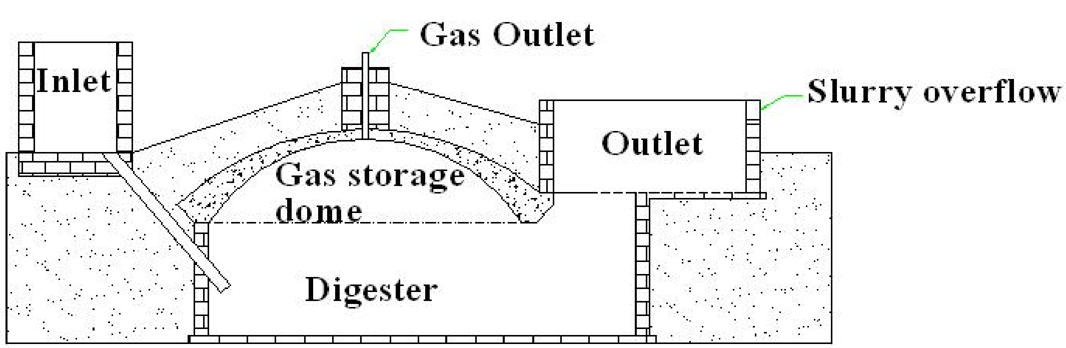
S.No.	Plant Capacity (m^3)	Daily Gas Production (m^3)	Fresh dung required each day (kg)	Water required everyday (liters)
1	4	0.8-1.6	20-40	20-40
2	6	1.6-2.4	40-60	40-60
3	8	2.4-3.2	60-80	60-80
4	10	3.2-4.0	80-100	80-100

* Capacity of plant means the volume of digester and gas storage dome
** Average retention time: 50 days

Table 4-2: Quantity of fuel wood saved daily

Quantity of feeding material available daily (kg)	Recommended Size of Plant (cum)	Quantity of Fuel wood saved per day (kg)
20-40	4	4 to 8
41-60	6	8 to 12
61-80	8	12 to 16
More than 80	10	16 to 20

Figure 4-1: **Design of the GGC 2047 Model Biogas Plant**



5 Project Need

5.1 Project Background

Pakistan is typical of many countries around the world where the biogas technology has been tried with some success in the past but has yet to be widely adopted. The Government of Pakistan started a comprehensive biogas scheme in 1974 and commissioned 4,137 biogas units by 1987 throughout the country. These were large plants with capacity varying from 5 to 15 m^3 gas production per day[1]. This programme was developed in three phases. During the first phase, 100 demonstration units were installed under a grant of the government. During the second phase, the cost of the biogas was shared between the beneficiaries and the government. In a subsequent third phase, the government withdrew financial support for the biogas plants, although technical support continued to be provided free of cost. Unfortunately, after the withdrawal of the government's financial support, the project did not progress any further (World Energy Council)[2].

Most of the biogas plants installed in recent years have been smaller household designs (3 and 5m^3 gas production per day) compared to the larger plants in the 1970s and '80s. Current dissemination programmes still largely have a piloting character; commercial promotion is not taking place. Most involved organizations seem to follow the current Government's promotion arrangements by providing a subsidy of 50% on the installation costs.

5.2 Existing Energy Situation

Pakistan is a net importer of energy. In 2006, it spent $7 billion, equivalent to over 40% of total imports, to import petroleum to meet its energy needs. Oil importation is a heavy burden on the country's foreign exchange. Recent high oil prices and their continuous fluctuation have further increased this burden. As per the forecast of the National Planning Commission, the reliance on imported primary energy will further increase over the next two decades, from 30% of the total demand in 2005 to 62% of the demand in 2025.

Most of the imported oil is for electricity generation and transportation purposes. Only 59% of Pakistan's population has access to electricity from the national grid. In rural areas, the percentage with electricity access falls to 37%. Even with all this

[1] The capacity of biogas installations is either stated in "volume of gas production per day" or "digester volume". A domestic installation with a digester volume of 8m^3 would produce about 2m^3 biogas per day.

[2] http://www.worldenergy.org/wecgeis/publications/reports/renewable/country_reports/chap_2_6_2.asp

imported energy, Pakistan currently faces a 20% power shortage, resulting in frequent load shedding.

Indigenous natural gas dominates the commercial energy sector of the country accounting for 48.5% of primary commercial energy used in the country. This is followed by oil (30.5%), hydro (12.6%), coal (7.3%), and nuclear 1%[3]. Roughly 30% of the country's total primary energy comes from traditional biomass fuels. The majority of the rural population uses firewood and other biomass fuels for cooking and heating and kerosene for lighting and some cooking.

Piped natural gas is available to 18% of the population for domestic use (Pakistan Economic Survey 2004-05) and is only available to users in urban and semi-urban areas. Towns that are not within the piped natural gas network have access to LPG (Liquefied Petroleum Gas) for cooking, although the high cost of this fuel limits its use to higher income families. Due to large costs involved in expanding the network, competing alternative uses such as fuel for power plants, input for fertilizer and other manufacturing sector factories, and vehicular transportation fuel, it is unlikely that the natural gas can be made available to a large number of the unconnected rural households any time soon. Furthermore, total availability of developed gas resources is not sufficient to meet the increasing demand for energy. This accounts for the increasing dependence on imported petroleum into the country. To meet the shortfall, the government has initiated discussions to import natural gas, both through pipelines and as LNG, from Iran and Turkmenistan.

The Government of Pakistan had set a goal of doing away with most natural gas tariff subsidies as well as subsidies on petroleum fuels by May 2005, but against the backdrop of rapidly rising world oil prices driven by lower production, the government had to reconsider and continue to subsidize natural gas as well as petroleum prices. To provide a buffer to people from the persistently high international oil prices, the government announced in the 2007-08 national budget that it will provide a subsidy of PKR 15 billion ($ 250 million) to keep diesel, kerosene, and LPG prices at affordable levels. This is an increase of 50% over the subsidy of PKR 10 billion provided in the 2006-07 budget. An additional subsidy of PKR 72 billion ($ 1.2 billion) is projected to be provided in 2007-08 to the power sector to keep electricity prices affordable[4].

It would thus be logical for the Government of Pakistan to strongly support and contribute to a future national biogas programme as investment in biogas will reduce the recurrent subsidies needed each year on fossil fuels.

[3] Pakistan Energy Yearbook 2007.
[4] http://www.dailytimes.com.pk/default.asp?page=2007\06\10\story_10-6-2007_pg7_9

Pakistan's renewable energy potential is substantial and the vast majority of it remains untapped. The Government of Pakistan has decided to put greater emphasis on renewable energy. In May 2003, it announced that it had set a target of 5% of the country's total power generation to be from renewable energy by 2030 (9,700 MW) and established the Alternative Energy Development Board (AEDB) as the apex organization to coordinate renewable energy promotion. AEDB has been tasked by the government under the Roshan Pakistan Programme to electrify the remaining villages in the country within the next three years using distributed renewable energy technologies. In terms of off-grid renewable energy systems, 140 micro wind turbines of 500 Watt capacity have been installed to meet the needs of rural households and institutions and 400 villages are being electrified using solar home systems through micro-finance.

5.3 Domestic energy

The average monthly expenditure on domestic energy amounts to PKR 713 (Pakistan Household Survey 2004-05) whereby urban households spend 45% more then rural households (PKR 904 and PKR 622 per month respectively).

Of this, the largest single expenditure item in both urban and rural areas is for electricity. The next largest expenditure in urban areas is on natural gas. In rural areas, as can be expected, the next largest energy expenditure is on fuel wood. However, it is clear that after adding the different fuel sources, rural areas spend most of their energy expenditure on cooking fuels: around 45% of their energy expenditure goes on solid biomass fuels; firewood, agricultural residues, and dung cakes. An additional 12% goes to LPG, kerosene, natural gas and candles, which are used for cooking and for lighting.

The available data from surveys depicts the commercial energy component only. From observation, however, it is evident that a significant share of the domestic energy requirement is not sourced from commercial markets. The Household Energy Survey 1992, quite outdated by now, provides insight in this by tracing the source of fuel wood. The figures show that on average, over 60% of the rural households and 12% of urban households collect fuel wood free of financial costs. Similar data on animal dung is not available, but the non-commercial share for this energy source –widely used in rural areas, is likely even larger. Kojima (WB-Household use of commercial energy, Feb 2006) argues that, induced by rising energy prices, the household energy price increase outstripped general inflation over the period 1994-2001, the uptake of "free" biomass has increased further since. This uptake increase is measured for both rural as well as urban households (but relatively more for urban households), and is valid in particular for poorer households.

Hence, domestic energy expenditure data only shows (a small) part of the total domestic energy use. Responses on the interviews of the Winrock / SNV technical assessment survey, based on a –very- small sample, indicate the energy consumption for cooking at a level of 62 GJ per year per household. The HESS 1992 measured a total annual household energy use of 130 GJ. This would indicate that approximately 50% of the domestic energy is used for cooking, a share which corresponds with the analysis of Pandey & Bajgain (Feasibility study of domestic biogas in Pakistan, 2007). Triangulating the above mentioned sources would indicate the gross domestic energy use for cooking in Pakistan at 19 and 64 GJ per year respectively for urban and rural households[5]. The triangulation further indicates that commercial cooking fuel provides about 60% of the total cooking fuel demand. For urban households the commercial share amounts to 80%. For poorer households, both rural and urban, the commercial share is likely significantly smaller.

Modern and clean domestic energy sources, except for SUI gas, are on average twice as expensive as traditional –biomass based- energy. The low tariff in natural gas, particularly to the lower slab lifeline user, makes this a very attractive domestic energy source for those households that are connected to the gas-grid (18% of the households, mostly urban). For the remaining part of the population, traditional biomass-based fuels remain their best option, despite their intrinsic risks regarding family health and environment.

[5] The large difference between gross domestic energy consumption for cooking can partly be explained by the larger size of rural households and, probably for a larger part, by the higher efficiency of the more modern energy sources used by urban households.

6 Potential Impacts and Mitigation

6.1 Introduction

This section discusses the potential positive and negative impacts that may arise from the project activities and the mitigation measures that will be adopted to reduce or minimise these impacts. The impacts and mitigation related to physical, biological and socio-economic environment have been discussed under three separate headings.

6.2 Physical Environment

6.2.1 Changes in Landscape and Soil Erosion

a. Impact Assessment

Soil erosion can be defined as the rate of soil loss from an area above that occurring under natural conditions. It is a two-phase process consisting of the detachment of individual particles from the soil mass and their transport by erosive agents such as wind and water (Morgan, 1988). In the context of soil erosion due to anthropogenic activities, the detachment part may occur due to various activities such as cropping, livestock grazing or similar activities due to which, soils or the landscape of an area is disturbed from its natural state. Construction of roads or other facilities has also been historically perceived and in some cases has actually led to soil erosion.

The proposed program will involve the construction of household level biogas units which shall require a minimal level of excavation to create pits for the biodigester and collection of the slurry. Since the quantity of soil excavated shall be insignificant, thus no possibility of soil erosion exists and almost all the soil will be reused on site for back filling and top filling.

b. Mitigation Measures

No mitigation measures are required.

6.2.2 Soil and Water Contamination

a. Impact Assessment

The construction activity to be undertaken as part of the proposed program of activities primarily consists of masonry work. No machinery shall be required which might result in fuel spillages or any toxic chemicals which might result in soil or water contamination.

Similarly, during the operation of the biogas units, the pits developed for the biodigester shall be concreted while the slurry pits will be made of bricks, either with or without plaster depending on the household requirement. In order to further ensure any ground water contamination from the slurry pits is prevented, the households shall be encouraged by RSPN to use large polyethene sheets. Lastly, the distance of the biogas plant shall be kept at a minimum distance of 20 meters from any water source.

b. Mitigation Measures

No mitigation measures are required.

6.2.3 Use of Water

a. Impact Assessment

The construction and operation of each household biogas unit shall require a minimal amount of water. During the construction phase, a small quantity of water shall be used only to soak the bricks prior to start of the masonry work to improve cohesion. Once the biogas unit becomes operational, water shall only be used to mix with the animal manure to create a slurry prior to feeding into the biodigester.

Each household has access to hand pumps in addition to tubewells and thus the minimal amount of water required for the biogas unit(s) construction shall be insignificant.

b. Mitigation Measures

No mitigation measures are required.

6.2.4 Ambient Air Quality

a. Impact Assessment

The construction of a household biogas unit shall primarily involve masonry work as described earlier and shall not require the use of any machinery, vehicles or construction equipment which might produce emissions. During the operation of the biogas unit, no emissions shall be produced. The biogas produced shall be contained within the biodigester unit which will be completely sealed off to ensure no leakages to the environment take place.

In addition, the biogas plant shall ensure harmful greenhouse gases (GHGs) released from the decomposing manure are prevented and instead the manure is used to provide biogas in an environmentally friendly manner.

b. Mitigation Measures

No mitigation measures are required.

6.2.5 Noise Pollution

a. Impact Assessment

The nature of the activities involved in the construction and operation of a household biogas unit ensure that noise pollution does not take place.

As mentioned and described earlier, the construction activities consist primarily of masonry work which does not require the use of any machinery or tools which might result in significant levels of noise. Similarly, the operation of the biogas is based on the feeding of the animal manure and anaerobic digestion taking place which is a biological process and does not produce noise.

As a result, insignificant noise levels are produced during both the construction and subsequent operation of a household biogas unit.

b. Mitigation Measures

No mitigation measures are required.

6.3 Impacts on Biological Environment

6.3.1 Vegetation

a. Impact Assessment

The proposed activities shall be of a very limited scope and carried out on a considerably small scale, typically in the yard or backyard of the household. Due to this reason and considering that the entire biogas plant shall only require a small amount of space, no significant vegetation cover will require removal.

b. Mitigation Measures

No mitigation measures are required.

6.4 Impact on the Socio-economic and Cultural Environment

6.4.1 Assessment of Potential Impacts

As part of the proposed program of activities, RSPN as a pro-poor organization, shall provide technical training and thus develop capacity of the local masons in the construction of household biogas units. In addition, the program shall also support the capacity building of the local level small scale workshop people to start their own business of appliance manufacturing.

This is expected to result in sustainable income generation of the local communities by providing greater avenues of employment, for both unskilled and skilled classes of labor. Lastly, the installation of biogas plants shall also provide more time to women for social as well as income generation activities.

Furthermore, the readily available gas for household use shall also allow tasks typically performed by women, such as cooking, to be made easier and thus result in an overall positive mindset.

7 Conclusions

Pakistan is an energy deficient country, a large part of the country's energy demands are met through imports. There is therefore an urgent need to develop and provide additional energy resources, particularly to communities whose basic energy needs are currently not being met. The proposed program to be implemented throughout the country at the household level will help towards achieving this objective and will not result in any potential environmental impacts.

The assessment of any potential environmental impacts resulting from the proposed program of activities has been addressed in this IEE, which has covered in detail the following:

- The proposed project activities;
- Legislative requirements related to the project;
- Potential environmental effects of the proposed project activities on physical, natural and socio-economic receptors;

The IEE concludes that the proposed project activities will not lead to adverse environmental impacts of any kind. Additionally, careful implementation of the environmental checklist will ensure that any potential environmental impacts are managed and minimized and the project proponent meets all statutory requirements.

8 References

1) Pakistan's Environmental Laws and their Compliance, Dr. Shoaib Qadar, et.al (2003)
2) http://www.worldenergy.org/wecgeis/publications/reports/renewable/country_reports/chap_2_6_2.asp
3) Pakistan Energy Yearbook 2007
4) http://www.dailytimes.com.pk/default.asp?page=2007\06\10\story_10-6-2007_pg7_9

Appendix A: Environmental Checklist

Environmental Checklist

Location: **Date:**

Inspected by	Organization/Individual	Signature
	RSPN	
	Construction Supervisor	

S/N	General	Y	N	Recommendations	Action by	Completion Date
	CONSTRUCTION					
1	Site selected for Biogas unit must be at least 20 meters away from any water body.					
2	Masons and labourers have been trained to sensitize them to various potential environmental issues during their construction activity.					
3	Trees/Bushes etc. are not being cut unnecessarily.					
4	Water is not being wasted unnecessarily.					
5	The pit for the biodigester tank has been constructed and concreted properly and will not allow seepage into the ground.					
6	Disturbance due to excessive noise is not being created by the masons/labourers which might appear as a menace to the surrounding receptors, particularly the local community.					
7	The pipe fittings do not have any loose connections resulting in possible leakage of gas to the environment.					
8	The plastic pipes used to feed the biodigester are not cracked and will not cause leakage of the slurry.					
9	Soil excavated for formation of the pits is utilized in an environmentally friendly and beneficial manner through. reuse for back filling and top filling of the dome.					

Environmental Checklist for biogas units

Environmental Checklist

S/N	General	Y	N	Recommendations	Action by	Completion Date
10	Site on which biogas unit has been constructed has been cleaned up and any excess construction materials have been removed after completion of construction activity.					
	OPERATION					
1	Wastage of water is not taking place during adding of water to animal manure to create slurry for feeding into the biodigester.					
2	Care is being taken while adding animal manure to the inlet compartment of the biogas unit to ensure no spills are taking place					
3	The connections of the gas piping do not have any leakage in them.					
4	All slurry and compost produced from the biogas unit operation is applied as fertilizer to the agricultural fields and is not disposed in the sewers. In cases where households do not possess agricultural lands, alternate arrangements must be made to ensure the slurry and/or compost is not disposed into the sewers.					
5	Ensure by observing to the extent possible that care is being taken to prevent or minimize any spillage of slurry or compost onto the ground on its way to the agricultural fields.					

- **OVERALL COMMENTS:**

Appendix B: Questionnaire for Households with Pilot Projects

Household Questionnaire (Biogas Units installed)

Name of Respondent: ____

District and Village name:____

Monthly Income (PKR): ____

Income Level: Low Medium High

Number of people in household: _____________________________________

Male: __________

Female: __________

Children: __________

Occupation: ____

Type of fuel used prior to biogas digesters: ___________________________

Fuel used for (purposes): ____

Quantity of fuel used on daily basis: ______________________________

Cost of fuel used on daily basis (PKR): ___________________________

Time period since biogas digester installed: ________________________

Capacity and Specifications of digester: ___________________________

Uses of biogas produced:____

Animal manure use/disposal mechanism prior to digester installation:________

____

Placement of digester (on own property or not):____________________________

Amount of manure consumed on daily basis:______________________________

Amount of water used daily:____

Source of water:____

Any potential leakage of either gas or slurry experienced? :___________

____

Any health hazard posed during either construction or operation of digester unit:

____

Any complaints due to odor or any other reasons from surrounding inhabitants as a result of operating the digester?:

____

How is solid waste/slurry disposed? Any efficient uses?:

____

Any income generation through sale/use of solid waste/slurry?:

____