**Work Order 46**

# Technical assistance to the Ghana Energy Commission to develop a dedicated programme to establish institutional biogas systems in 200 boarding schools, hospitals and prisons, and to prepare for CDM application

**Feasibility Study**

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## Acknowledgements

This report was researched and written by Emiel Hanekamp from Partners for Innovation and Julius Cudjoe Ahiekpor from the Centre for Energy, Environment and Sustainable Development.

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The authors welcome any feedback or suggestions for improvement. The corresponding author is Emiel Hanekamp (e.hanekamp@partnersforinnovation.com).

Cover photos, top row: ‘Construction of brick biogas domes’; left photo SNV, middle and right photos projects from Biogas Technologies Africa Limited
Cover photos, bottom row: Gas holder at KITA (Kumasi), programme against using wood fuel (Anglican School, Kumasi) and biogas installation at Wisconsin University (photos E. Hanekamp)

## Definitions and abbreviations

| | |
|---|---|
| ABPP | Africa Biogas Partnership Programme |
| ACP | African, Caribbean and Pacific countries |
| BCEL | Beta Construction Engineers Ltd |
| BEL | Biogas Engineering Limited |
| BTAL | Biogas Technologies Africa Ltd |
| CAP | Country Action Plan |
| CEESD | Centre for Energy, Environment and Sustainable Development |
| CSF | Climate Support Facility |
| $CO_2$ | Carbon dioxide ( a greenhouse gas) |
| CSIR | Council for Scientific and Industrial Research |
| EC | Energy Commission of Ghana |
| EPA | Environmental Protection Agency |
| EU | European Union |
| GEF | Global Environment Facility |
| GES | Ghana Education Service |
| GHS | Ghana Health Service |
| GPS | Ghana Prisons Service |
| GHC | Ghana Cedis |
| GHG | Greenhouse Gas |
| GIZ | German Development Organization |
| GSGDA | Ghana Shared Growth Development Agenda |
| IIR | Institute of Industrial Research |
| KIST | Kigali Institute of Science and Technology |
| KITA | Kumasi Institute of Tropical Agriculture |
| KITE | Kumasi Institute of Technology, Energy and Environment |
| KNUST | Kwame Nkrumah University of Science and Technology |
| kt | 1,000 kilograms |

| | |
|---|---|
| KVIP | Kumasi Ventilated Improved Pit |
| LPG | Liquefied Petroleum Gas |
| MESTI | Ministry of Environment, Science, Technology and Innovation |
| MoP | Ministry of Power |
| NAMA | Nationally Appropriate Mitigation Action |
| NGOs | Non-Governmental Organizations |
| NIBP | National Institutional Biogas Programme |
| SE4ALL | Sustainable Energy for All |
| SGP | Small Grant Project |
| SMEs | Small and Medium Scale Enterprises |
| SNV | Netherland Development Organization |
| UNDP | United Nations Development Programme |
| UNEP | United Nations  Environment Programme |
| USD | US Dollars |

## Summary

The promotion of small and medium-scale enterprise (SMEs) participation in institutional biogas technology penetration has been identified as one of the five key priority energy related Nationally Appropriate Mitigation Actions (NAMAs) in Ghana. This is in line with the country's pursuit for low carbon development options which is identified in the national climate change policy (2014) as well as the sustainable development objectives articulated in the Ghana Shared Growth Development Agenda (GSGDA).

To bring biogas as a low carbon energy source to a significant higher level in Ghana, the Sustainable Energy for All (SE4ALL) action plan intends to promote the establishment of institutional biogas systems for up to 200 boarding schools, hospitals and prisons.

This report presents the feasibility of institutional biogas systems in Ghana and provides input for the set-up of a national biogas programme for institutional biogas.

**Biogas systems are technically feasible in Ghana**

At least 400 biogas systems have been built in Ghana, pre-dominantly using the fixed-dome, floating drum and Puxin technologies. The main reason to build a biogas systems is to improve the sanitation situation. Although there are several issues with existing biogas systems, many of these systems are functioning well. To ensure long term sustainability, specific attention needs to be paid to:

> *Development and enforcement of standards for biogas digesters and quality control of system design, construction and maintenance;*
> *Financial commitment from buyers / beneficiaries throughout the system lifetime, ensuring both maintenance and proper operation.*

**Biogas-sanitation systems provide many social and environmental benefits**

Implementing biogas systems for sanitation purposes and in addition use the produced biogas for cooking and the effluent for irrigation and fertilising creates a range of social and environmental benefits for institutions and the society as a whole. The challenges and risks that need to be addressed when implementing institutional biogas on a large scale are:

> *Education of users (use of biogas and use of the system)*
> *Ensuring no harmful pathogens are in the effluent*
> *Ensuring the biogas is used and not emitted without flaring*

**Biogas systems seem economically viable**

There seems to be a business case for biogas digester systems as an alternative for the currently used septic tank systems for prisons, hospitals and boarding schools. This is especially the case if a new system has to be built ("Green Field"). The payback period for such systems is less than 2 years. For institutions that wish to substitute their septic tank with a biogas system, the payback period ranges from 1-6 years for the best case scenarios.

The following table summarises the current price ranges (based on private sector quotations) and estimated cost savings for institutional biogas systems for boarding schools and prisons. For hospitals the researchers have not been able to collect this data.

**Table 1 Summary of data used for cost-benefit calculations**

| | 1000 people | 4000 people |
|---|---|---|
| Investment (GHC) | 100,000 - 315,000 | 350,000 - 1,000,000 |
| Annual maintenance costs (GHC)* | 10,000 - 15,000 | 30,000 - 40,000 |
| Annual savings (GHC) | 25,000 - 35,000 | 130,000 - 200,000 |

* After three years of operation

To improve the reliability of the cost-benefit analysis, additional data gathering is needed.

**The biogas private sector is ready to implement biogas**

About 10 companies and organisations in Ghana have experience with the design, construction and maintenance and operation of biogas systems. At least six private companies have a good or very good knowledge base and technical experience, having built 10-100 systems each in recent years. These six have expressed their interest in cooperating / participating in a national institutional biogas programme and were present at both stakeholder workshops.

**A National Institutional Biogas Programme (NIBP) is desirable**

There is an urge felt by all relevant stakeholders in Ghana to take institutional biogas for sanitation a step forward. An inter-departmental approach targeting sanitation, renewable energy, private sector development and securing agriculture benefits is most likely to succeed. The Energy Commission is committed to lead this process in close collaboration with MoP, MESTI, EPA and other relevant stakeholders.

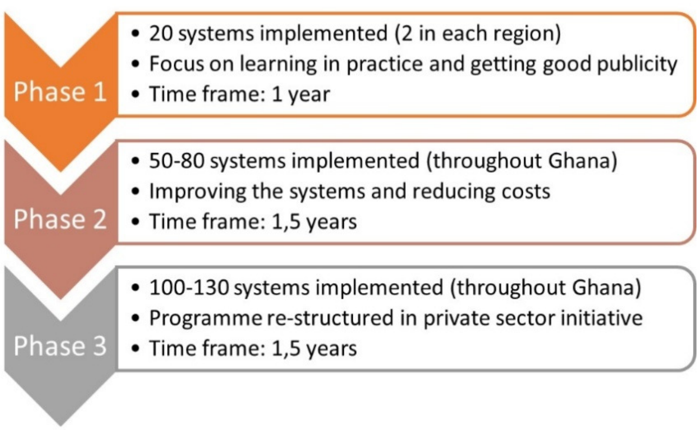



**Figure 1 The proposed three phases of NIBP**

A phased National Institutional Biogas Programme is advised, with the objectives to

> *Implement 200 biogas digester systems in public boarding schools, hospitals and prisons*
> *Kick-start the further development of a biogas market in Ghana.*

**Activities structured under 6 activity lines**

Based on other National Biogas Programmes in both Asia and Africa and the barriers to be tackled in Ghana to further the development of a well-functioning biogas market in Ghana, six activity lines are proposed for the NIBP. The following figure presents these activity lines and their interrelations with the three phases.

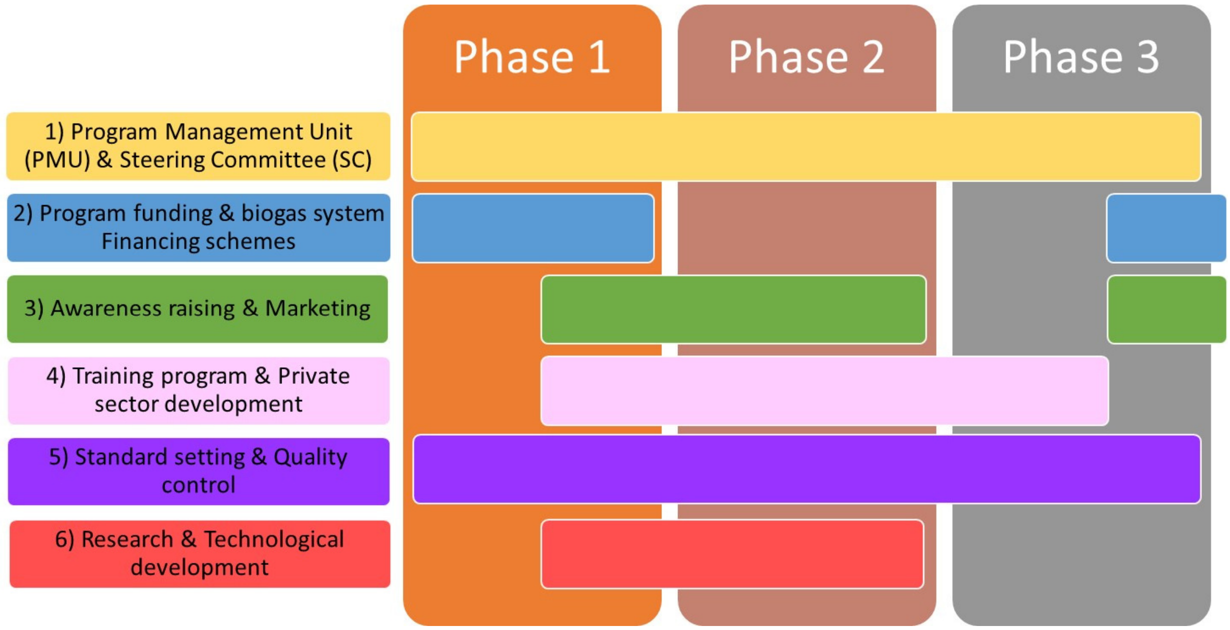



**Figure 2 Structure and timing of major activities for the Ghanaian NIBP**

**Table 2 First-mover institutions for phase 1 of the NIBP**

| **Programme activity** | **First-mover institutions** |
|---|---|
| 1) Program Management Unit & Steering Committee (including policy development and enforcement) | Energy Commission (lead organisation), MESTI, MoP, EPA, Ministry of Health, Ministry of Education and Ministry of Interior |
| 2) Program funding & biogas financing schemes | Financing organisations, donor and international development organisations (AfDB, WB / GEF, Danida, USAid, SNV, GIZ and UNDP) |
| 3) Awareness raising & Marketing | Energy Commission, GPS, GHS, GES (and related Ministries) |
| 4) Training program & Private sector development | Donor and international development organisations (see above), national Research Institutes (CSIR-IIR, KNUST, Kumasi Polytechnic, Valley View University) and private biogas companies |
| 5) Standard setting & Quality control | Research Institutes (see above), MESTI, MoP and EPA |
| 6) Research & Technological development (including impact monitoring) | Research Institutes (see above) and local NGOs (KITE, ABANTU, CEESD, Friends of the Earth Ghana, and NCRC West Africa) |

To be able to set-up and implement such a National Institutional Biogas Programme (NIBP) the following activities need to be carried out:

1. *A more detailed inventory of user needs and a cost-benefit analysis*
2. *Financial analysis and structuring of the NIBP in parallel with institutional structuring*
3. *Draft a detailed programme plan and secure funding*
4. *Secure potential funding and support for biogas from organizations such as UNDP and GEF*

All the above recommendations have been confirmed by the relevant stakeholders during the stakeholder meeting of 8th October 2014, as organised by the Energy Commission.

## Content

## Introduction

This report describes the feasibility of institutional biogas systems in Ghana and provides input for the set-up of a national biogas programme with a focus on institutional biogas. It is a result of a study for the Energy Commission in Ghana, executed between June and October 2014 by the biogas and bioenergy policy experts Emiel Hanekamp (Partners for Innovation, Netherlands) and Julius Cudjoe Ahiekpor (Kumasi Polytechnic and CEESD, Ghana).

The study is funded by the EU Climate Support Facility (www.gcca.eu/intra-acp/climate-support-facility), an European facility offering short-term customised technical assistance and training to public and private entities from ACP member states.

### Background

Biogas technology is a proven technology noted for improving sanitation, reducing greenhouse gas emissions, helping to prevent deforestation and forest degradation, producing fertilizer and providing clean decentralised energy.

In Asia, household and institutional biogas installations have gained widespread acceptance with hundreds of thousands of biogas installations being built annually. In Africa, biogas programmes have started in recent years but have not by far reached the level of success as in Asia. In Ghana, the total number of domestic and institutional biogas installations is estimated at less than 500.

The above benefits of biogas led to its selection by the Government of Ghana as a priority technology to be implemented as part of the Sustainable Energy for ALL (SE4ALL) Country action plan for Ghana, with the aim "to improve access to modern energy for productive uses".

### Ghana SE4ALL action plan

The Energy Commission (EC) is a technical regulator of Ghana's electricity, natural gas and renewable energy industries, advisor to the Government on energy matters and responsible for facilitating the implementing of the SE4ALL Country Action Plan (CAP).

The specific activity formulated within the SE4ALL CAP is "*to conduct a feasibility study to establish institutional biogas systems for 200 boarding schools, hospitals and prisons*" with 2012-2015 as implementation timeline. The purpose of this activity is to bring the use of biogas as a low carbon energy source to a significant higher level in Ghana.

The 200 systems will be a start and should stimulate and accommodate further implementation of biogas for productive usage in the country, with the long-term objective to develop a self-sustaining biogas market in Ghana.

### Feasibility study and implementation plan

This study is to provide the EC with expert advice on the feasibility of institutional biogas in Ghana. The main questions that will be answered in this report are:

> *Are institutional biogas systems technically feasible in Ghana?*
> *Are biogas systems economically viable for the intended end-users?*

> *Is the biogas private sector ready to implement the intended 200 biogas systems?*
> *What are the social and environmental advantages and risks of biogas systems?*
> *What policies and institutional initiatives and arrangements support or can support the implementation of institutional biogas?*

In relation to the intended 'national biogas programme' -starting with 200 institutional systems- the report addresses:

> *The relevant stakeholders for such a programme and their potential role.*
> *The market potential for institutional biogas systems in Ghana.*
> *Building blocks for such a biogas programme.*

### Activities undertaken for the study

For this study the following activities have been executed:

> *desk research: an overview of the literature used is provided in Annex D;*
> *interviews with relevant stakeholders: an overview of interviews is provided in Annex A;*
> *two stakeholder workshops have been organised by the Energy Commission. The first on 27th August 2014 and the second on 8th October 2014; the lists of participants are in Annex B;*
> *site visits to existing institutional biogas installations and visits to institutions for a needs-assessment: an overview of visits is provided in Annex A;*
> *a cost-benefit analysis for institutions, based on financial data provided by the biogas private sector, individual boarding schools and the Ghana Prisons Service (see chapter 4).*

### Guidance for the reader

This report presents the results of the study that has been carried out between June and October 2014. In chapter 1 to 8 the feasibility of institutional biogas in Ghana is assessed. Chapter 9 discusses a National Biogas Programme for institutional biogas.

The report is reviewed and approved by the Energy Commission. The conclusions and recommendations will be used by the Energy Commission to take further actions for setting-up a National Biogas Programme to realise 200 institutional biogas systems.

# 1 The intended biogas system

## 1.1 Biogas for cooking; overview of a digester system

Biogas has been selected by the Government of Ghana as a priority technology to be implemented as part of the SE4ALL CAP, with the objective "To improve access to modern energy for productive uses".

The specific activity formulated within the SE4ALL CAP is "*to conduct a feasibility study to establish institutional biogas systems for 200 boarding schools, hospitals and prisons*".

The intended biogas systems (biogas digester) will decompose human faecal waste into biogas which will be used for cooking purposes.

The choice for the three types of institutions is steered by the following considerations:

> *These institutions all have toilets and a, more or less, fixed number of people regularly visiting them. This means a stable amount of feedstock will be periodically fed in the biogas digester. This is important for a steady amount of biogas being produced and also has advantages in quantifying the size of the system.*
> *These institutions all have the need for energy in the form of LPG, firewood, charcoal or a combination of these three for heating or cooking purposes. Biogas can replace (part of) this energy use.*
> *The three types of institutions all have a role in the community. Potential cost savings will therefore benefit either the community or the government - as (partial) funder of these institutions - which indirectly will benefit the community as well.*

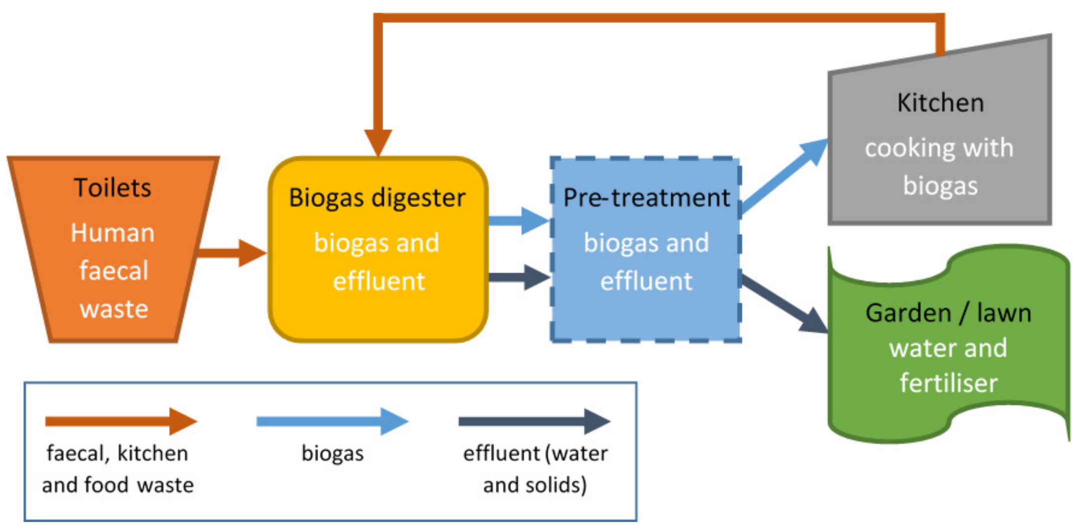



**Figure 3 Schematic overview of intended biogas system**

Figure 3 shows schematically the intended biogas system. In most cases the effluent needs to be pre-treated before being used for water and fertilizing purposes, to be sure the pathogens are sufficiently destroyed and the water quality meets EPA standards. The biogas needs to be dehydrated to be used in specific stoves, to prevent corrosion problems.

The retention time (the time the feedstock resides in the digester) of a biogas digester treating mainly faecal waste and with a lot of water and urine does not have to be much longer than 20 days. An oxidation tank will be needed to treat the effluent from the digester to be sure it will be free of pathogens and can be used as an organic fertiliser. The retention time and the amount of input into the digester will determine the size of the dome(s).

In addition to the faecal waste that can be used as a feedstock also other organic waste streams can be used. In the case of institutions, organic kitchen waste and food left-overs are the most relevant. When adding other organic waste streams, care has to be taken how and how much is added, but basically everything can go in the digester. Adding additional waste streams like kitchen and food waste is very interesting as the methane potential [1] of this waste is much higher than from faecal waste as shown in Table 3. An additional advantage is that this waste does not need to be disposed of anymore, which provides additional cost reductions.

**Table 3 Methane potential of different waste types**

| Type of waste | Methane potential ($m^3$ $CH_4$ / kg) | Reference |
|---|---|---|
| Faecal sludge | 0.14 | Gallagher, 2010 |
| Kitchen refuse (food waste) | 0.17 – 0.29 | Lim, 2011 |
| Maize (crop yield) | 0.29 – 0.34 | Weiland, 2010 |
| Food remains | 0.55 | Al Saedi, 2008 |
| Poultry slaughter | 0.6 – 0.7 | Salminen and Ritala, 2002 |

The intended biogas systems (can) have a number of advantages compared with currently used technologies and practices:

> *Biogas is produced, a renewable energy source, preventing $CO_2$ emissions but also reducing the amount of wood used for cooking.*
> *When fire wood is replaced, smoke and its health effects are diminished.*
> *The digester will take care of proper decomposing of the faecal waste, destroying (almost) all potentially harmful pathogens. This also has a positive health effect.*
> *The digester effluent can be separated into a liquid part and a solid part. The liquid effluent can be used for irrigation of gardens, lawns and food crops and the solid effluent can be used as fertiliser.*

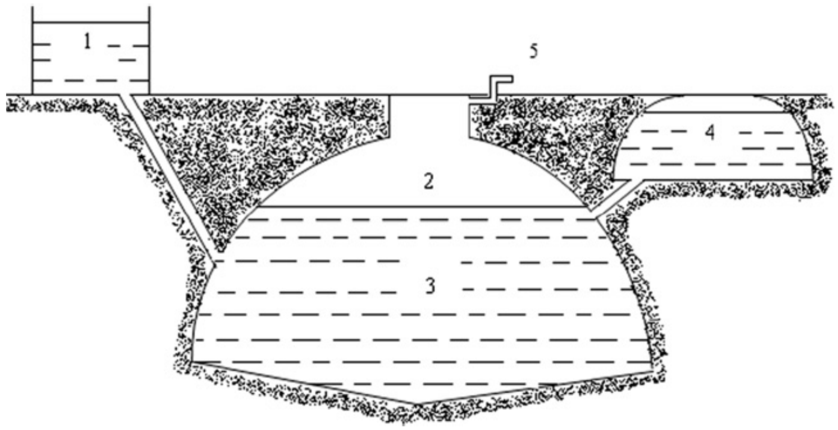
The above advantages have been shown to be valid - also in the Ghanaian context - by several studies (Osei-Safo, 2009; Bensah and Brew-Hammond, 2010; Arthur, 2010; Bensah *et al.,* 2010; Antwi and Arthur, 2010; Amankwah, 2011; Mulinda *et al.*, 2013), the majority done by respectable local research institutes.

## 1.2 Biogas technologies used in Ghana

The three main types of biogas technologies that have been designed, tested and disseminated in Ghana are the fixed-domed, floating drum and Puxin digester [35]. The three do not differ very much as they all require construction of a digester made of concrete and or bricks. The Puxin digester uses moulds to build the digester and uses some prefabricated parts.

[1] The methane potential of organic material is the potential methane yield from anaerobic digestion.

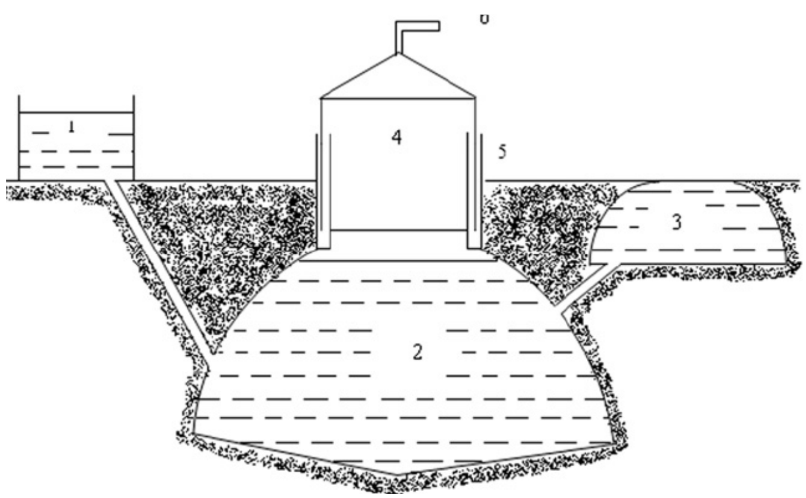
A fixed dome[2] plant comprises of a closed, dome-shaped digester with an immovable, rigid gasholder and a displacement pit, also named 'compensation tank'. The gas is stored in the upper part of the digester. When gas production commences, the slurry is displaced into the compensation tank as shown in Figure 4. Gas pressure increases with the volume of gas stored in the gasholder. If there is little gas in the gasholder, the gas pressure is low. When gas production starts, the slurry is displaced into the compensation tank.




1. Mixing tank with inlet pipe. 2. Gasholder. 3. Digester. 4. Compensation tank. 5. Gas pipe.

**Figure 4 Schematic picture of a fixed dome digester**

Floating-drum[3] plants consist of an underground digester and a moving gasholder as shown in Figure 3. The gasholder floats either directly on the fermentation slurry or in a water jacket of its own. The gas is collected in the gas drum, which rises or moves down, according to the amount of gas stored. The gas drum is prevented from tilting by a guiding frame. If the drum floats in a water jacket, it cannot get stuck, even in substrate with high solid content [12].




1. Mixing tank with inlet pipe. 2. Digester. 3. Compensation tank. 4. Gasholder. 5. Water jacket. 6. Gas pipe.

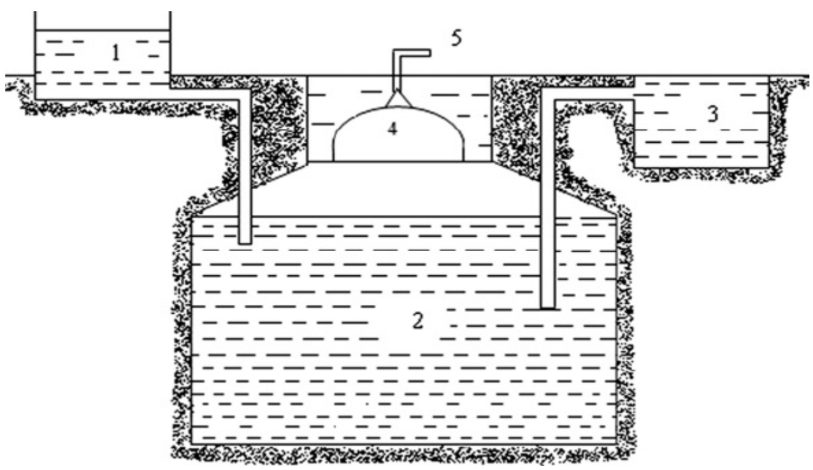
**Figure 5 Schematic picture of a floating-drum digester**

[2] The fixed dome digester is a Chinese technology.
[3] Floating drum digester is an Indian Technology.

The Puxin biogas[4] digester is a hydraulic pressure biogas digester, composed of a fermentation tank built with concrete, a gasholder made with glass fibre reinforced plastic and a digester outlet cover made with glass fibre reinforced plastic or concrete. The gasholder is installed within the digester neck, fixed by a component; the gasholder and digester are sealed up with water [2] as shown in 1. Mixing tank with inlet pipe. 2. Digester. 3. Compensation tank. 4. Gasholder. 5. Water jacket. 6. Gas pipe.

**Figure 5**.

The mesophilic[5] temperature range for biogas production is 20-40 °C [5] and with Ghana annual temperature of 25 °C, this implies that most biogas plants in Ghana operate well within mesophilic temperature conditions.




1. Mixing tank with inlet pipe. 2. Digester. 3. Compensation tank. 4. Gasholder. 5. Gas pipe.

**Figure 6 Schematic picture of a Puxin digester**

## 1.3 Other existing technologies for institutional biogas digester

For this study the researchers have only looked at the three technologies mentioned earlier. We are aware of many more interesting digester technologies, especially the prefabricated ones[6], bag digesters[7] and more advanced technologies, for example the Continues Stirred Tank Reactor. The first two technologies can be made of cheap materials like plastics or composite materials but these technologies are mainly targeting the domestic market and it is unclear if they also can be used for the institutions that are targeted. This study did not research if the prefabricated ones could also be used for example when connected in series. The latter technology is not common in Ghana.

## 1.4 Conclusions

Because the aim of the Ghana government is to implement 200 institutional systems in a short time span, we focussed on those technologies that have proven to be working in Ghana and for which a sufficient number of private companies can provide the technology and knowledge (e.g. the fixed dome, floating-drum and Puxin

[4] Puxin digester is a Chinese Technology.
[5] A mesophile is an organism that grows best in moderate temperature, typically between 20 and 45 °C
[6] African examples of existing technologies are SimGas (Tanzania) and Agama (South-Africa)
[7] For example Flexi Biogas (Kenya)

digester technologies). In time the appropriateness and economic viability of other technologies should be researched.

# 2 Technical feasibility of institutional biogas in Ghana

## 2.1 Biogas digesters in Africa

In Ghana, the total number of domestic and institutional biogas installations in 2010 was estimated at some 250 [28]. Based on the interviews (Annex A) with private biogas companies the current number of constructed biogas systems is estimated to be at least 400.

In Asia, household and institutional biogas installations have gained widespread acceptance with millions of installations being built annually. The success is a result of successful national biogas programmes. Sister nations such as Kenya and Tanzania, already in 2007, had over 2,000[8] and 5,000[9] plants constructed respectively. However these are mainly domestic biogas systems.

Recently also in Africa, biogas programmes have started being successful. The Africa Biogas Partnership Programme (ABPP)[10] reports that in 2012 in Burkina Faso, Ethiopia, Kenya, Senegal, Tanzania and Uganda a total of 27,275 digesters have been built resulting in amongst others: a growing number of biogas construction enterprises, reduced building costs, increased bio-slurry use, increased integration of the technology in agricultural systems, 136,375 people (women and children) are being protected from indoor air pollution, 256 kt reduction of GHG emissions annually and the substitution of 263 kt of biomass and nearly 2,000 litres of fossil fuel (kerosene and LPG). These biogas programmes are also focussed on domestic (in rural areas) biogas.

## 2.2 Biogas digester systems in Ghana; lessons learned

**Sanitation systems or biogas systems?**
The vast majority of the digesters in Ghana have been built or are being used for sanitation purposes only. The produced biogas is usually released into the air without flaring (burning), see **Figure 7**.

This situation is not entirely unexpected. Due to negative experiences in the past with biogas systems for energy use, e.g. the Appolonia Electrification project in 1992 (Bensah and Brew-Hammond, 2010) the market interest for biogas for productive use was almost non-existent. Following the low market interest for biogas as an energy source, private biogas companies have marketed the technology in recent years on purely business grounds. The focus of biogas technology shifted from provision of energy (use of biogas) to improvement in sanitation (treatment of waste). This development has created a situation where most plants have been constructed without adequate arrangements for the usage or proper handling of the biogas produced (Bensah and Brew-Hammond, 2010).

**Many systems are not working properly or not at all**
Several studies (Bensah and Brew-Hammond, 2008; Bensah and Brew-Hammond, 2010) have shown a huge portion of the biogas systems that have been built are either not working properly or are not working at all.

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[8] Marree F., Nijboer M., Kellner C. Report on the feasibility study for a biogas support programme in the northern zones of Tanzania. SNV publication, Nairobi, Kenya, 2007.

[9] Erosion, Technology and Concentration (ETC) Group. Promoting biogas systems in Kenya: a feasibility study in support of Biogas for Better Life – an African initiative. Commissioned by Shell Foundation. Nairobi, Kenya, 2007.

[10] ABPP website: http://africabiogas.org/

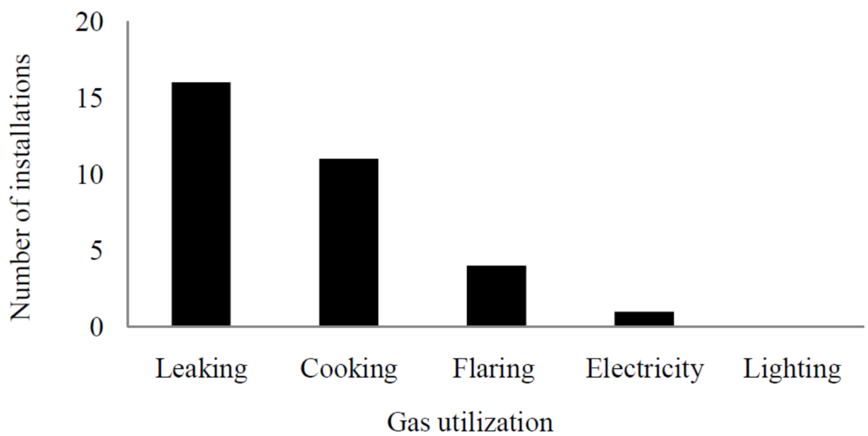


**Figure 7 Biogas usage (based on the number of surveyed plants, functioning fully or partially**

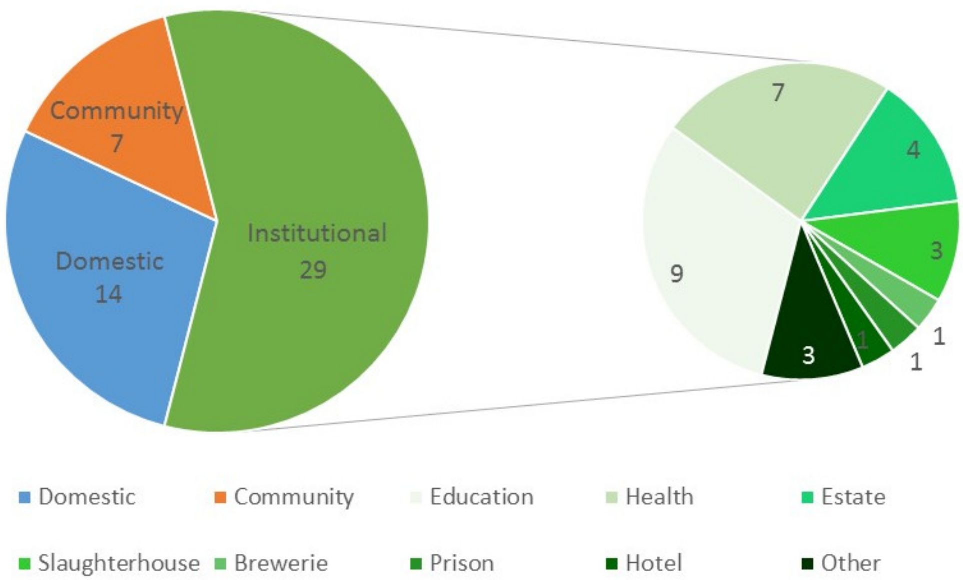


**Figure 8 Surveyed 50 installations grouped into institutional, community, and domestic plants [3]**

Between June 2008 and February 2009 researchers from KNUST and Kumasi Polytechnic conducted an assessment of 50 biogas plants, in order to ascertain the true state of biogas technology in Ghana. The sample size (50 plants) was determined from the population (100 known biogas plants) as captured in a survey by KITE (KITE, 2008) using stratified and convenience sampling techniques.

Out of the 50 plants, 22 (44 %) were functioning satisfactorily, 10 (20%) were functioning partially, 14 (28 %) were not functioning, 2 (4 %) were abandoned, and the remaining 2 (4 %) were under construction. Reasons for non-functioning included non-availability of dung, breakdown of balloon gasholders, absence of maintenance services, lack of operational knowledge, and gas leakages and bad odour in toilet chambers of bio latrines.

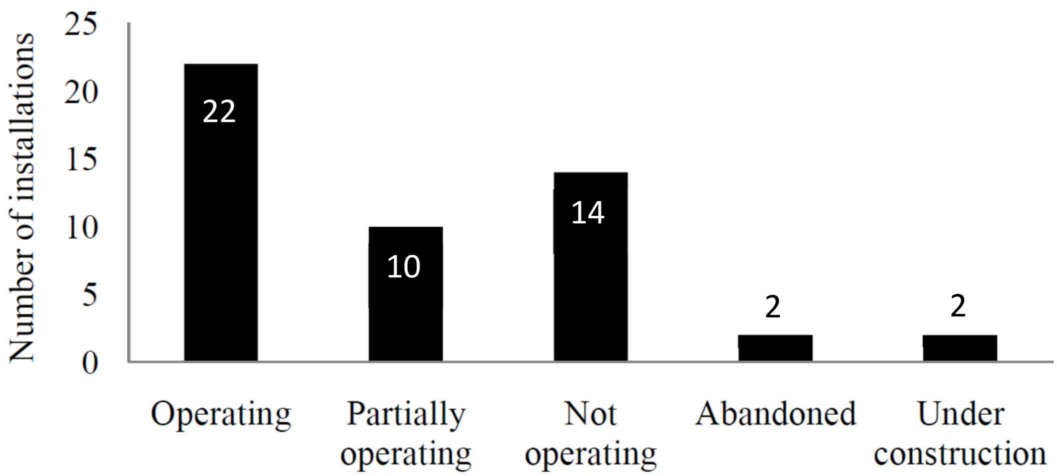


**Figure 9 Functional status of the 50 surveyed installations [3]**

The survey also revealed that the majority of plants (76%) had been constructed mainly in the cities for the treatment of human excrement from flushing toilets.

**Lack of technical expertise of private biogas construction companies**
About 20 Ghanaian private companies and research institutes have been active in building biogas digesters and sanitation systems able to produce biogas. A few are purely focussed on biogas or sanitation but most of them also have other business areas they are actively involved in. The latter is due to the slow market for biogas digesters.

Besides the organisations regularly building brick biogas domes it has been noticed that a number of systems have been built by individual masons. Although these may be good masons, they usually do not have the required knowledge and skills to build a biogas dome. This has resulted in poorly functioning, or failed systems.

In the course of this assignment (and other assignments), the researchers have visited 12-15 functioning and non-functioning biogas systems and were able to talk with users as well. Detailed technical and non-technical discussions were held with 7 biogas construction companies. These companies belong to the 10 companies in Ghana having installed the highest numbers of biogas systems (10-50 each). Based on these discussions and the site visits, the knowledge and expertise of these experienced companies can be said to range from good to very good.

**System size is not fit for its purpose**
A very common problem with biogas digesters is the under sizing of the biogas system (especially the dome). Sometimes this is a result of 'improper' design of the system due to lack of knowledge. More often the private sector tends to size the biogas digester dome as small as possible to make the system as cheap as possible for the client. The digester makes up more than 50 % of the total cost of the biogas system.
Another reason why biogas digester systems are not properly sized is that after commissioning, the number of users is increased or more toilets are connected to the system, e.g. schools expanding their number of students and building new dormitories with additional washrooms. In most cases this is caused by ignorance of the user.

As a result of the under sizing, the digester can have several problems:
> *Bad odour;*
> *Not producing sufficient biogas;*
> *Effluent with high pathogen levels (not meeting EPA standards).*

**Usage of low quality materials and bad construction**

In a few cases the use of low quality building materials or bad construction is the reason for biogas systems to collapse. In these cases the private company or mason did not have sufficient knowledge and experience with building biogas digesters. The construction of a digester dome requires specific knowledge and skills from masons and also the usage of good quality materials (e.g. bricks and mortar). When the dome is not constructed perfectly, the digester will not function properly and using low quality building materials can cause leakage and break down of the system after a few years of operation. When high quality materials are used a digester will have a lifespan of 15-20 years.

**Lack of maintenance**

Lack of maintenance is one of the major problems causing systems to fail after a few years of operation. A biogas digester does not require a lot of maintenance but sometimes some minor technical repairs are needed for instance, repairing small cracks in the dome, taking care of gas leakages (gas connections) and, replacing the gas balloon. In practice, users do not make arrangements with the biogas company to take care of such maintenance after commissioning. The study found that maintenance is not done because users are not familiar with the companies that provide such services. As a result many digesters are not functioning properly or not at all. However with some minor repairs (which can usually be done at low costs), many of these systems can operate fully. Another type of necessary maintenance is caused by improper usage of the system.

**Improper usage**

When non-biodegradable items are put in the system (often flushed), this does not only have a negative impact on the performance of the biogas system (production of biogas) but also can cause blockages, both in the inlet of the digester and the digester itself. These blockages need to be removed. Newly designed systems have simple but effective technical measures (e.g. sieves) to prevent non-biodegradable items from entering into the digester and also ease the cleaning of the inlet.

Another type of improper usage is when ‘feeding’ the digester with biodegradable material that is not properly pre-treated or has a negative impact on the microorganisms (bacteria) that take care of the breakdown of the biodegradable material in the biogas digester. In a worst case scenario ‘bad feeding’ can cause the bacteria culture in the system to perish fully. ‘Starting-up’ the system again can take a few months.

The above problems are caused by ignorance and inexperience of users caused by inadequate or missing instructions on how to use the system.

## 2.3 Conclusions

Biogas systems are technically feasible in Ghana. At least 400 systems have been built, many of them functioning well. In countries in Africa and Asia, similar to Ghana, hundreds of thousands of digester systems (based on the fixed dome technology or similar technologies) have been built and are also functioning well.

The anticipated problems, with systems that have been built in Ghana in recent years, can be overcome when properly addressed in a biogas programme. Issues to take care of are:

> *Development and enforcement of standards for biogas digesters and quality control of system design, construction and maintenance;*
> *Financial commitment from buyers / beneficiaries throughout the system lifetime, ensuring both maintenance and proper operation.*

These measures should secure long term sustainability of the biogas digester systems.

The majority of biogas (biogas-sanitation) systems that have been built in Ghana are waste treatment facilities, meant to improve the sanitation situation and lower sanitation costs. This has been the driving force for the biogas market in recent years.

## 3 Social and environmental benefits, risks and challenges

In recent years institutional biogas systems have been mainly built as waste treatment facilities for toilets. Institutions that opted for biogas digester technology instead of the commonly used sanitation systems as the (Kumasi) Ventilated Improved Pit (KVIP) and toilets with septic tanks, wanted to solve their practical challenges with odour and desludging of these systems. In addition the institutions saved the costs associated with desludging of the septic tanks. The produced biogas is seldom used but instead usually just released into the air without flaring (burning), with a severe impact on the $CO_2$ emissions of the installation. The use of biogas systems for sanitation partly has been stimulated by EPA as new institutional structures are obliged to use anaerobic digesters as standard technology.

This chapter describes the social and environmental benefits both for the institutions and the society as a whole, but also the social and environmental risks and the challenges when implementing institutional biogas.

**Text block 1: Example of a success story of institutional biogas at Valley View University**

**Valley View University - Biogas Plant for Waste Water Treatment and Renewable Energy**

The biogas plant on campus was completed in January 2005. Its location is next to the new cafeteria and the sanitary block, which are the main “waste” providers and biogas users. Since the decentralized sanitary concept suggests a separation of different flow streams of waste water such as urine, grey and black water, the process was optimized which has led to a reduced size of the biogas digester.

*Biogas plant*

*sludge digester*

The simple and robust dome system is a continuous flow plant. Black water of the sanitary facilities is treated anaerobically in the biogas digester together with organic waste from kitchen and farms. The produced biogas is collected in a PE sack and used for cooking in the cafeteria. The sludge on the ground of the digester can be used as fertilizer in agricultural areas of the campus.

The outflow of the digesters discharge into three expansion chambers. From there the treated waste water goes into a septic tank where the wastewater is treated again. From the last filtration chamber purified water is pumped into an elevated tank and used under gravity for irrigation and as fertilizer on the farmland. The main purpose of the digesters is the treatment of black water. The production of biogas is just a secondary benefit.

In addition to the benefits mentioned above there are many more, both for the institutions and the society as a whole. This is especially the case if all three advantages of biogas systems are used to their full potential:

1. *Improve sanitation*
2. *Use the biogas as an energy source*
3. *Use the effluent for irrigation and as an organic fertiliser*

Many studies on biogas in Ghana have shown these potential advantages. References [1], [11], [12] and [14] are only a few of them.

**Text block 2: Example of a successful biogas plant at the African Regent Hotel in Accra**

**African Regent Hotel - Biogas Plant for sanitation and biogas for cooking**

The biogas plant at African Regent Hotel in Accra, Ghana, has been supplying gas to the kitchen of the hotel restaurant, with no failure, since the hotel was opened in 2007. The 2 digester domes are fed with the effluent from the hotel toilets and are positioned under the car park. The gas is stored in a storage balloon which is located in a corner of the car park. The biogas is led to the kitchen via a pipe and replaces part of the normally used cooking gas.

*Biogas storage balloon in the corner of the car park of the African Regent Hotel*

## 3.1 Socio-economic benefits of institutional biogas

Based on the literature studied it is evident institutional biogas has a wealth of socio-economic benefits. The following tables present an overview of these benefits.

**Table 4 Potential socio-economic benefits of institutional biogas**

| Benefits for institutions |
|---|
| Reduced / no odour |
| No desludging (and related costs) needed |
| Reduced nuisance from smoke and smoke borne diseases when substituting fire wood with biogas |
| Less water use (and costs) when using (watery) digester effluent for irrigation |
| Improved crop yield when using digester effluent as organic fertilizer (or cost reduction when replacing artificial fertilizer or income generation when selling fertilizer) |
| Cooking with biogas is easier than with firewood (or charcoal), saves time and is clean (no soot) |
| Savings in institution's health related expenditures |
| Health related productivity (reduction in unproductive time due to sickness) |

| Societal benefits |
| --- |
| Improved fertilizer availability which positively impacts cropland productivity and food security |
| Reduction in smoke borne diseases and infant mortality rates |
| Reduction of diseases caused by pathogens in human excreta (e.g. gastrointestinal diseases and cholera) |
| Health related productivity (reduction in unproductive time due to sickness) |
| Savings in health and illness related costs |
| Increased private sector development |
| Employment generation: skilled (e.g. masons, plumbers) and unskilled |
| Increased research activities and associated employment (e.g. civil engineers, agronomists) |

The most important driver for the implementation of institutional biogas is (and has been in recent years) the improvement of the sanitation situation (Bensah *et al*., 2010). The commonly used sanitation systems such as the (Kumasi) Ventilated Improved Pit (KVIP) latrine and toilets with septic tanks have many problems. Of course these problems are partly caused by the improper disposal of the faecal waste that is collected from these systems. The 12 institutions visited by the researchers all have toilets with septic tanks.

The recent outbreaks of cholera in Ghana have raised the emphasis on using improved sanitation technologies based on anaerobic digestion. Well-functioning anaerobic digesters produce an effluent (sludge consisting of water and solids with nutrients comparable with fertilizers) that is entirely free of harmful pathogens. When disposing the effluent into the environment or using it for irrigation and / or as a fertilizer, it will not have any health risks.

Another potential advantage of wide-scale implementation of digesters, instead of septic tanks, is the use of the produced biogas as an alternative for firewood or charcoal. When using firewood a lot of smoke is produced, with all kinds of irritations to the eyes, nose and lungs and eventually causing health problems. The institutions visited by the researchers primarily use firewood for cooking with some using both LPG and firewood.
According to the World Health Organization, 1.6 million people die annually from indoor air pollution caused from cooking, this is more than the fatality figure for malaria. The level of small particles in the air in a house with open fire is 3060 $\mu g/m^3$. The EU maximum level of small particles in the air is 40 $\mu g/m^3$.[11] In Ghana, about 13,400 of deaths recorded annually are estimated to be related to cookstoves and fuels used. [12]


**Figure 10 Photo's on indoor air pollution**

*Left: Poster from the Ghana Alliance for Clean Cookstoves, fighting indoor air pollution [photo: Emiel Hanekamp, Kumasi Anglican High School, 2014] Right: Woman cooking on an open fire [photo: practicalaction.org]*

[11] https://hivos.org/biogas/
[12] Global Alliance for Clean Cookstoves, http://www.cleancookstoves.org/countries/africa/ghana.html

A side effect of stimulating the implementation of institutional biogas is the development of a biogas private sector in Ghana, with the creation of jobs in this sector as a result. Compared with installing septic tanks, biogas digesters are more labour intensive (one of the reasons why they are more expensive). Also the design, construction and maintenance of biogas digesters require more skilled labourers, for example masons and gasfitters, compared with sceptic tanks. Also for maintaining and operating the biogas digester some skilled labourers are needed.

On a societal level illnesses like cholera, dysentery and other gastrointestinal diseases related to unhygienic situations will less often occur having a positive impact on the number of people getting ill annually. This will have a positive impact on the sickness absenteeism levels and other health and medical treatment related costs.

### 3.2 Environmental benefits associated with institutional biogas

There are a number of potential environmental advantages using anaerobic digesters. The biogas can be used as a substitute for (part of) currently used cooking fuels. For institutions this seems to be mainly firewood, with LPG and charcoal as additional energy sources. Substituting wood and charcoal will reduce deforestation and reduced $CO_2$-emissions.

**Table 5 Environmental benefits of institutional biogas**

| Environmental benefits |
|---|
| Decreased water use |
| Increased usage of organic fertilizer, decreased use of artificial fertilizer |
| Increased use of a renewable energy source, resulting in lower carbon dioxide emissions |
| Reduced deforestation and desertification as biogas is used instead of firewood |
| Improved soil fertility |

Also the effluent (bio-slurry) of the digester can be used for irrigation and as an organic fertilizer for lawns and flower and vegetable gardens, thereby reducing the amount of fresh water being used (sometimes also a cost saving) and increasing yields or reducing costs for fertilizers.

**Text block 3: Impacts of using the effluent (the bio-slurry) of a biogas digester**

Bio-slurry, an end product in a biogas digester is used in agriculture as organic fertilizer and in fish farming as fish feed. Bio-slurry use leads to improved agricultural produce, hence improved nutrition and food security. 72% of the surveyed biogas owners in Uganda reported that slurry has effectively fertilized their gardens. **84% reported improved farm productivity and income**. Most, 54 % applied it in its liquid form. Composting could further enhance the quality of the slurry but is not yet widely practiced. The majority of the respondents said they used this slurry in their own gardens as compared to only 9 % who said that they sold it for money. Selling bio-slurry is however an interesting business potential for farmers and deserves more attention from the programmes.

**Source: website Africa Biogas Partnership Programme (ABPP); http://africabiogas.org/**

### 3.3 Social-cultural challenges when implementing institutional biogas

Some of the literature studied (see for example the feasibility Study for a National Domestic Biogas Programme in Burkina Faso (GTZ, 2007, page 75), discusses the potential issues when using biogas and the effluent (water and fertilizer) as it is produced using human faecal waste. This has also been mentioned by a few people the researchers have been in contact with. Apparently there's a social perception that cooking from biogas is "unclean" or "dirty" because it is produced using faecal matter. The magnitude of this issue has not been researched but does not seem to be a real threat for the successful implementation of biogas systems and the full use of its 'products'. Proper education can probably change the perception.

There are a number of institutional biogas installations in Ghana where the biogas is primarily being used for cooking. Good examples are: The African Regent Hotel, Valley View University and the Kumasi Institute of Tropical Agriculture (KITA). The University and college also use the effluent.

Throughout Asia and in other African countries[13] this social barrier does not seem to be of great importance and might even be further diminished when providing stakeholders and users with factual information and showing them the advantages of using biogas.

Another issue is the flushing of non-biodegradable items like sanitary towels. These will either stay inside the digester, reducing the capacity of the system, or will 'contaminate' the effluent. Also they can cause blockages both in the inlet of the system and the dome itself, which increases the need for maintenance and increase maintenance costs. This issue can be managed by informing toilet users and taking some technical measures, preventing large non-biodegradable items to enter into the digester system.

A third issue is the use of the biogas. Currently the digesters are used for solving sanitation problems while the biogas is seldom used. Most institutes and the relevant people involved, are not aware what biogas is, how they can use it and what its potential risks are. As a consequence of this unintentional ignorance biogas is not commonly used and properly handled but released into the air without flaring (burning). This results in a negative environmental impact and a safety risk, as biogas contains 50-75% methane that will form a highly explosive gas as it is mixed with oxygen.

### 3.4 Environmental and health risks associated with institutional biogas

Biogas systems have many intrinsic social, economic and environmental advantages but there are also some risks.

A major risk, which unfortunately can be seen with many biogas systems in Ghana, is that the effluent from the system still contains potentially harmful pathogens; pathogens that originate from the faecal waste. This occurs when the faecal waste is not being treated long enough in the digester. This is a result of the digester size being insufficient for the amount of feedstock to be treated. There can be many reasons for this: improper system design, bad operation or incorrect feeding of the digester. As a consequence the amount of biogas produced is also less than what could be produced but more importantly the effluent is probably not pathogen free and the water that is being discharged will not meet EPA standards. When the effluent is being discharged into the environment or is used for irrigation purposes or as a fertilizer, people can get ill from the pathogens still active in the effluent.

Another environmental risk is the unnecessary emission of methane. Most digester systems in Ghana do not use the produced biogas and release it in the air without flaring. Biogas consists of 50-75% methane. With a comparative impact of methane ($CH_4$) on climate change being over 20 times higher than $CO_2$, over a 100-year period, not burning the biogas is much worse. This can be seen from the following graph.

[13] The Africa Biogas Partnership Programme (ABPP) has constructed in 2012 and 2013 almost 16.000 domestic biogas systems in five African countries; Ethiopia, Kenya, Tanzania, Uganda, and Burkina Faso.

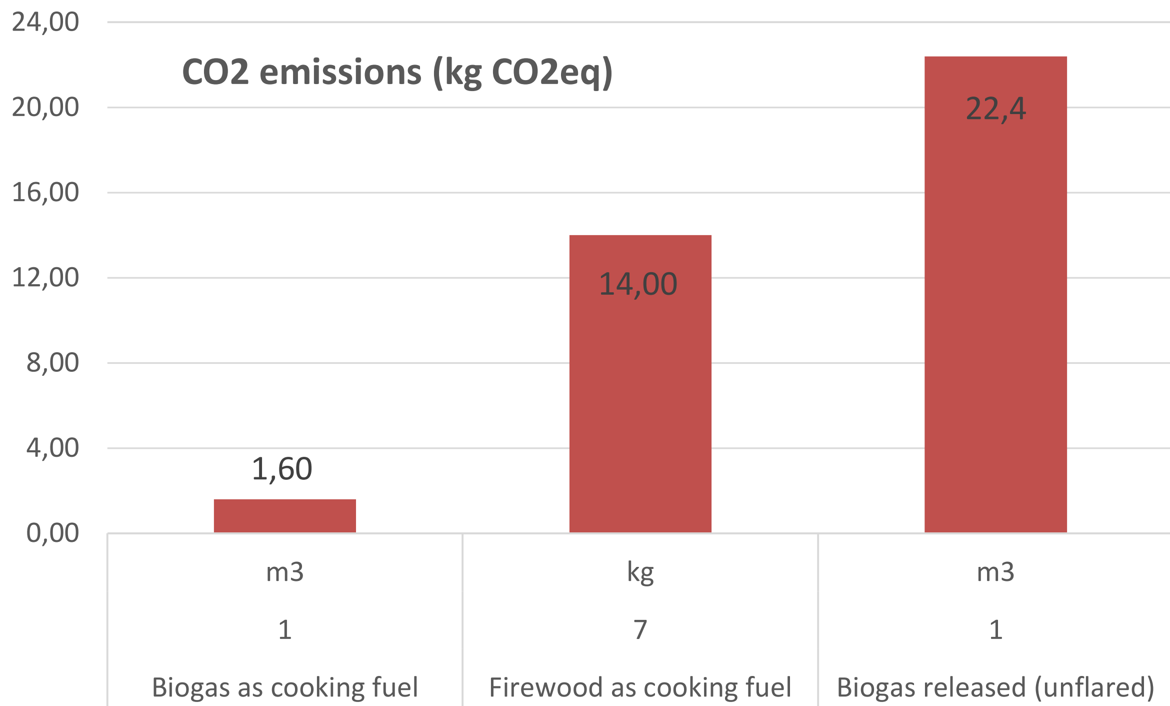


**Figure 11 Comparing the $CO_2$-emissions for three situations; 1) when using the biogas from the digester, 2) when using an equivalent amount of firewood 3) when biogas is released in the air.**

Both risks can be mitigated or entirely resolved using the following mix of measures:

> *Awareness and information campaigns;*
> *Setting-up standards for design, construction and operation of biogas systems and control mechanisms to check these standards;*
> *Regulatory measures and enforcement.*

### 3.5 Conclusions

Implementing biogas systems for sanitation purposes and in addition use the produced biogas for cooking (or other energy purposes) and the effluent for irrigation and fertilising creates a range of social and environmental benefits for institutions and the society as a whole. Institutions able to use all three benefits (e.g. agricultural boarding schools) are favourable for selection as pilot facilities. As there is no practical evidence available in Ghana about the social and economic benefits of using the biogas and the effluent, it is advised to include a monitoring system able to quantify these benefits, when a pilot phase is implemented.

There are also some issues and risks that have to be addressed when implementing institutional biogas on a large scale:

> *Education of users (use of biogas and use of the system)*
> *Ensuring good maintenance and operation practices*
> *Ensuring no harmful pathogens are in the effluent*
> *Ensuring the biogas is used and not emitted without flaring*

These risks can be mitigated or reduced when properly addressed in a National Programme. Other biogas programmes in Asia and Africa have proven that this is feasible.

## 4 Cost-benefit analysis of institutional biogas systems in Ghana

Part of this feasibility study is focussed on the costs and benefits of biogas systems for the beneficiaries (boarding schools, prisons and hospitals). The initial plan was to conduct this analysis based on desk research. However at the first stakeholder meeting, 27th August in Accra, the participants asked the researchers to make their own inventory of costs and benefits of institutional biogas systems. This was done between 28th August and end of September 2014.

The aim of the cost-benefit analysis is to answer the following questions:

> *Is there a viable business case for institutions to install biogas systems instead of the currently used septic tanks? If not,*

> *What is the amount of the additional funding (or funding mechanism) needed to make biogas an interesting alternative for institutions?*

### 4.1 Methodologies and approach used

When executing the cost-benefit analysis, the researchers used the following approach:

1. *Collect data from institutions on type of sanitation technology used, number of people using washrooms, cooking fuels used, sanitation costs and fuel costs.*
2. *Collect quotations from the biogas private sector for three standard systems/situations.*
3. *Estimate the costs for septic tanks for the three standard situations.*
4. *Calculations (based on standard figures) of the system size for the three standard situations and the amount of biogas produced.*
5. *Combining the above figures to calculate the payback time (based on a Discounted Cash-Flow-Analysis).*

The researchers visited from 17-29 August several schools, hospitals and prisons. In addition Ghana Prisons Service and Ghana Health Service where contacted to provide the data and information as described above.

In total, 7 private biogas companies have been contacted to provide quotations for the following standard biogas systems / situations, with a very brief textual description (see text block below):

1. BIOGAS SYSTEM 1: Boarding school with 800 students (1,000 in 2020)
2. BIOGAS SYSTEM 2: Boarding school with 3,500 students (4,000 in 2020)
3. BIOGAS SYSTEM 3: Prison with 4,000 inmates (4,000 in 2020)

**Text block 4: brief description of the anticipated standard biogas system / situation**

The systems include: new toilet facilities (not the building), a biogas digester, an oxidation tank, a water purification facility and all necessary facilities (piping, gas storage, etc.) for the biogas to be used for cooking in the kitchen. All three situations currently use 9 litre flush WC's.

Based on publically available data estimations have been made of costs for sceptic tanks as an alternative for a biogas systems.

Using conservative but generally used data, the system size has been calculated. Also very conservative data has been used when calculating the amount of biogas produced.

For the feedstock of the biogas system both human faecal waste and a limited amount of kitchen waste (kitchen leftovers and food leftovers) has been taken into account.

As interest and inflation rates in Ghana are high, a simple pay-back time calculation is very inaccurate, therefore a discounted cash-flow analysis has been used and payback times have been calculated using 0%, 15% and 25% discounting rates.

## 4.2 Limitations and assumptions

**Limitations of the used methodology**

Biogas systems can provide a number of benefits for both the beneficiaries (institutions) and the society at large. Some examples of these benefits are:

> *Institutions: solving poor sanitation situations, costs savings on desludging of septic tanks, costs savings on cooking fuels, providing water and organic fertilizer for gardens and lawns and less smoke in kitchens.*
> *Society: reducing health related risks and costs due to better treatment of human faecal waste and replacement of wood based cooking fuels.*

In chapter 3 the social and environmental benefits, challenges and risks have been discussed. In paragraph 4.6 the potential economic benefits are elaborated in more detail.

For this cost-benefit analysis only the cost savings related to the replacement of currently used wood fuels and the cost savings related to the desludging of septic tanks is taken into account. These are the direct costs for institutions that are easy to determine. The other costs and cost savings are much more difficult to quantify (e.g. higher yields due to use of organic fertilizer, costs as a result of smoke related diseases of employees).

The societal costs are not taken into account all together as they are out of the focus of this research. The overall (economic) benefits of institutional biogas systems are clearly much higher than calculated in this report.

**Limitations of the data gathered**

Due to a number of practical reasons, the researchers were able to collect relevant data only from a limited number of institutions. Usable information could be collected from five prisons (via the Ghana Prisons Service) and two schools (based on 12 field visits of the researchers). Unfortunately no data from hospitals could be gathered during the time frame of the assignment, despite three field visits to hospitals and several contacts with the Ghana Health Service.

The researchers have not been able to verify the data that was provided. Assessing the actual numbers, large variations can be seen (see paragraph 4.4).

Four of the seven private biogas companies provided quotations for the three standard systems. These quotations vary a lot in detail and total amount (see paragraph 4.4).

**Assumptions**

The researchers assumed the data provided by all stakeholders to be correct and did not verify any figures. All data from institutions and the quotations from the private sector have been normalised to represent one of the three standard biogas systems. This normalisation was done based on the number of students/inmates, respectively the system size (m3). It was assumed that this normalisation can be done without creating too much of an error in the figures.

A number of basic calculations were necessary to be able to make the cost-benefit analysis:

1. *System sizes for the three standard systems /situations;*
2. *Amount of biogas produced annually;*
3. *Amount of wood fuel replaced.*

For the above calculations, the following data was used (based on publically available reports). As the variations in this type of data often is large, conservative numbers, e.g. numbers that in the end will give a conservative financial benefit, have been used.

The following tables provide the numbers that have been used for the above calculations.

**Table 6: Numbers used calculating the system size**

| Variables (unit) | Number |
|---|---|
| Retention time (days) | 20 |
| Frequency of using toilet (per person per day) | 2 |
| Volume of WC cistern (litres) | 4.5 |
| Faecal waste generated per person per day (kg) | 0.5 |
| Kitchen/food waste generated per person per day (kg) | 0.2 |

**Table 7: Numbers used for calculating the amount of biogas produced and wood fuel replaced**

| Variables (unit) | Prisons | Schools |
|---|---|---|
| Percentage of people using washroom per day | 90% | 60% |
| Active days per year | 365 | 280 |
| Frequency of use of washroom per day | 1.5 | 1 |
| Specific gas production from faecal waste (L/kg) | 40 | 40 |
| Specific gas production from kitchen waste (L/kg) | 110 | 110 |
| Faecal waste generated per person per day (kg) | 0.3 | 0.4 |
| Kitchen/food waste generated per person per day (kg) | 0.05 | 0.1 |
| Per capita consumption of firewood per day (kg) | 0.69 | 0.69 |
| Biogas-firewood replacement ratio (kg fuel/$m^3$) | 7 | 7 |
| Percentage of firewood replaced by biogas generated | 22% | 43% |

The two tables show different numbers for the same variables (e.g. faecal and kitchen waste generated). This shows our conservative approach; not wanting to calculate a digester size that is too small and not wanting to overestimate the amount of biogas produced.

## 4.3 Investment, exploitation and maintenance costs for institutional sanitation systems

**Biogas digester sanitation systems**

In total, four well-established biogas contractors (entrepreneurs) provided cost estimations for the three biogas systems / situations. These entrepreneurs have all built between 10-100 biogas systems in Ghana. The four quotations also specified the anticipated system size. All quotations have been normalised to the system sizes for the three standard systems / situations. The system sizes are 830 $m^3$, for the large systems (4,000 people) and 250 $m^3$ for the small system (1,000 people).

The following two tables show the anonymous (normalised) quotations from the entrepreneurs.

**Table 8: Normalised Biogas System costs for institutions with 4,000 people (Schools and Prisons)**

| Quotations large systems | Q1 | Q2 | Q3 | Q4 | Average |
|---|---|---|---|---|---|
| Cost Estimate (GHC) | 523,852 | 346,667 | 1,063,689 | 1,075,822 | 752,507 |

**Table 9: Normalised Biogas System costs for institutions with 1,000 people (Schools and Prisons)**

| Quotations small system | Q5 | Q6 | Q7 | Q8 | Average |
|---|---|---|---|---|---|
| Cost Estimate (GHC) | 179,385 | 97,167 | 315,286 | 244,860 | 209,174 |

| Lowest cost quotation | Highest cost quotation | Average cost quotation |
|---|---|---|

As can be seen from the tables above, the system costs vary widely, between 130 - 420 US$ [14] per $m^3$ biogas digester. This is more or less similar to the prices indicated in the 2008 KITE report [35] and the report "*Status and prospects for household biogas plants in Ghana – lessons, barriers, potential and way forward*" *(*Bensah *et al*., 2011*)*. In these two reports the prices for domestic (6-10 $m^3$) fixed-dome biogas digesters range from 200 - 447 US$ and 235 - 446 US$ per $m^3$, respectively. Of course institutional digesters are much larger and one should expect economies of scale. On the other hand, the prices for materials have increased significantly in recent years and with materials being 50-75% of the total cost of a digester dome this will have a significant impact.

The prices for similar (household) systems in other countries do vary a lot: US$ 574 in Kenya, US$ 960 in Uganda, US$ 417 in Nepal and US$ 245 in Vietnam per $m^3$ (ETC Group, 2007). The comparative high prices in Africa seem to be a result of too limited competition in the digester market (Amigun *et al., 2012)*; "*Higher capital cost is experienced in African biogas industry. This is due to the fact that the current market for biogas in Africa is slow. Contractors therefore tend to lump all of their costs into the unit they are constructing because they may not get another order for months (Biogas for better life, 2007).*"

The wide variation in the cost quotations can partly be attributed to the very general description of the systems / situations and the different ways entrepreneurs have interpreted them. The overall system costs are very much dependant on the actual situation (e.g. location of the digester in relation to the latrines and the kitchen, the compactness of the soil and undersoil). Some of the entrepreneurs provided quotations not taking into account all these variables and presented us the minimum costs, others included costs to cover for the unexpected situations. Also some entrepreneurs are probably more expensive than others.

None of the quotations covered exploitation and maintenance costs. As exploitation and maintenance have been identified as crucial elements for the sustainability of biogas digesters, exploitation and maintenance costs have therefore been included in the cost-benefit analysis. A fixed percentage of 5% from the average system costs was used, starting after three years of operation.

[14] Exchange rate: 1 GHC = 0.310549 USD

**Septic tank sanitation systems**

Based on discussions with the biogas private sector and institutions (users) the initial investment costs for a septic tank based sanitation system are about 1/2 of a biogas digester based system. The exploitation and maintenance costs are estimated to be 1/5 of the exploitation and maintenance costs for biogas digesters.

**Table 10: Estimates of investment, exploitation and maintenance costs for septic tank sanitation systems**

| Cost Estimates for septic tank sanitation systems | Large system | Small system |
|---|---|---|
| Initial investment costs as ratio of biogas digester costs | 1/2 | 1/2 |
| Annual exploitation and maintenance costs as ratio of biogas digester exploitation and maintenance costs (>three years) | 1/5 | 1/5 |

## 4.4 Costs savings gained by institutions with biogas systems

As explained above we have only taken into account two types of direct cost benefits:

1. *Savings on emptying septic tank (desludging)*
2. *Savings on cooking fuels*

The costs for cooking fuels and desludging and the average population have been gathered from a number of institutions. The data collected has been normalised to represent the proposed biogas systems, with 1,000 and 4,000 people respectively. The average, low and high expenses on fuel and desludging were determined for each category of institution as shown in the tables below. Unfortunately the researchers have not been able to collect data from small schools.

**Table 11: Normalized annual expenditure on firewood and emptying septic tanks for small prisons (1,000 inmates)**

| Expenses small prisons | High | Low | Average | Unit |
|---|---|---|---|---|
| Sanitation expenses | 51,200 | 2,743 | 22,431 | GHC |
| Fuel expenses | 25,200 | 20,022 | 23,305 | GHC |

**Table 12: Normalized annual expenditure on firewood and emptying septic tanks for large prisons (4,000 inmates)**

| Expenses large prisons | High | Low | Average | Unit |
|---|---|---|---|---|
| Sanitation expenses | 280,922 | 46,080 | 163,501 | GHC |
| Fuel expenses | 211,321 | 74,400 | 142,860 | GHC |

**Table 13: Normalized annual expenditure on fuel and emptying septic tanks for large schools (4,000 students)**

| Expenses large schools | High | Low | Average | Unit |
|---|---|---|---|---|
| Sanitation expenses | 102,099 | 70,892 | 86,496 | GHC |
| Fuel expenses | 63,301 | 123,077 | 93,189 | GHC |

**Sanitation cost savings**
The major financial impact (on cost savings) of a biogas plant is the reduction in expenditure for emptying conventional septic tanks. Since a properly designed and maintained biogas system would not require desludging, the savings on desludging are assumed to be the same as the current expenditure on desludging in the institution. As can be seen in the tables above, the amounts spent on desludging vary widely. We have not been able to find out the reason(s) for this wide variation.

**Fuel cost savings**
Financial benefits for the institutions furthermore result from actual cash savings due to reduced purchases of cooking fuel. The value of the fuel expenditure savings is dependent on the amount of biogas generated, the amount of fuel being used by the institutions and the cost of purchased fuel. The fuel cost saving is estimated based on the assumptions as shown in Table 7.

### 4.5 Payback period

**Substitution of a septic tank system by a biogas digester system**

When replacing their current septic tank based system, the payback period for institutions was estimated using average, best and worst case scenarios. The average case is using the calculated average cost of the systems and also the average expenditure on sanitation and fuel for each category of institution. The best case (optimistic) considers the lowest cost of the system and the highest expenditure while the worst case considers the highest cost of the biogas plant against the lowest expenditure on sanitation and fuel. Table 14 shows the results of the analysis for each category of institution. No depreciation costs for the currently used septic tank system have been taken into account in this calculation.

The payback period for the institutions ranges from 1 – 5.7 years for the best case scenarios. For the average scenario the payback period ranges between 4.2 and more than 25 years and for the worst case scenario all payback periods are more than 15 years.

**Table 14: Payback period for institutions when substituting septic tank sanitation systems**

| **Prisons with 4,000 inmates** | **Payback time (years)** | | |
|---|---|---|---|
| *Discounting rates* | *Average case* | *Best case* | *Worst case* |
| ***0%*** | **4.2** | **1** | **30.5** |
| ***15%*** | **7.5** | **1.1** | **54.7** |
| ***25%*** | **10.0** | **1.3** | **74.2** |
| **Prisons with 1,000 inmates** | **Payback time (years)** | | |
| *Discounting rates* | *Average case* | *Best case* | *Worst case* |
| ***0%*** | **10** | **1.7** | **> 100** |
| ***15%*** | **18.5** | **2.5** | **> 100** |
| ***25%*** | **25.9** | **3.7** | **> 100** |
| **Boarding Schools with 4,000 students** | **Payback time (years)** | | |
| *Discounting rates* | *Average case* | *Best case* | *Worst case* |
| ***0%*** | **7.2** | **2.5** | **14.8** |
| ***15%*** | **13.2** | **4.1** | **27.9** |
| ***25%*** | **18.6** | **5.7** | **38.7** |

Green cells: payback < 5 years; Orange cells: payback 5-10 years; Red cells: payback > 10 years

**"Green field" situation**

In a "Green field" situation a biogas system is installed instead of a septic tank based system. When calculating the payback period only the additional investment and maintenance and operation costs of a biogas digester, compared with a septic tank system, will have to be used.

**Table 15: Payback period for institutions in a "Green Field" situation – a newly built sanitation system**

| **Prisons with 4,000 inmates** | **Payback time (years)** | | |
|---|---|---|---|
| *Discounting rates* | *Average case* | *Best case* | *Worst case* |
| *0%* | **2.0** | **0.4** | **12.7** |
| *15%* | **2.9** | **0** | **23** |
| *25%* | **4.0** | **0** | **32** |
| **Prisons with 1,000 inmates** | **Payback time (years)** | | |
| *Discounting rates* | *Average case* | *Best case* | *Worst case* |
| *0%* | **4.4** | **0.8** | **> 100** |
| *15%* | **7.8** | **0.5** | **> 100** |
| *25%* | **11.0** | **0.6** | **> 100** |
| **Boarding Schools with 4,000 students** | **Payback time (years)** | | |
| *Discounting rates* | *Average case* | *Best case* | *Worst case* |
| *0%* | **3.3** | **1.2** | **6.6** |
| *15%* | **5.5** | **1.5** | **12.1** |
| *25%* | **7.8** | **2.0** | **17.0** |

Green cells: payback < 5 years; Orange cells: payback 5-10 years; Red cells: payback > 10 years

The payback periods for all institutions are less than 2 years for the best case scenarios for all discounting rates. For the average case they range between 2 and 11 years. For the worst case scenario only the boarding schools with 4,000 students seem to have a reasonable business case with a payback period of 6.6 years.

## 4.6 Other financial and economic benefits

**Financial benefits for institutions**

For the cost-benefit analysis only the cost saving for the reduced use of fire wood (a very conservative estimate of the savings has been used) and the absence of desludging the septic tanks are taken into account for the institutions. However the institutions might have additional costs savings or higher costs savings in the near future. These are:

> *The costs for desludging and cooking fuels are likely to increase.*
> *Costs for water use. The digester provides water for irrigation of gardens and / or lawns.*
> *Costs for fertilizer or increased yield from vegetable and fruit gardens. The digester provides organic fertilizer, replacing artificial fertilizer or increasing yield.*

**Economic benefits for the community / society**

For the community or society as a whole, there are a number of economic benefits:

> *Reduced medical and health (also absence from work) related costs: The preparation of food requires less or no fire wood anymore, reducing the problems caused by the smoke. Also the effluent of the digester is free of any harmful pathogens reducing the number of people getting sick (as the waste is often not properly being disposed of).*

> *The reduction in use of firewood reduces forest degradation. Forest can be used for other purposes with a financial benefit.*
> *Building biogas digesters is labour intensive and requires enhanced skills of labourers, thereby qualitatively and quantitatively increasing employment and economic activities in general.*
> *There is a significant reduction in carbon dioxide emissions.*

As stated before these societal benefits have not been taken into account in the above cost-benefit analysis.

### 4.7 Conclusions

Although the used data have rather wide ranges, it seems there is a business case for biogas digester systems as an alternative for the currently used septic tank systems. This is especially the case if a new system has to be built ("Green Field"). For institutions wanting to replace a septic tank with a digester system, the payback periods are less optimistic. However no depreciation costs for the currently used septic tank system has been taken into account in these calculations. The typical technical lifetime of a septic tank is 30 years. The actual payback periods for currently used systems will range between the 'substitution situation' and the 'green field situation', depending on the age of the system currently in use.

The researchers used a very conservative approach to calculate the financial benefits of a biogas digester. Only two benefits, wood fuel replacement and reduction of desludging costs, have been taken into account and the amount of biogas produced can be considered as a very conservative estimation.

What is clear from the cost-benefit analysis is:

> *Discounting rates have a huge influence on the economic viability of biogas digester systems.*
> *The reduction of the desludging costs are the most important cost savings for institutions.*
> *The cost of a digester system in Africa is much higher than compared with South-East Asia, which has a negative impact on payback period.*
> *Additional data gathering, providing data with less wide ranges, will improve the reliability of the cost-benefit analysis. Data should be gathered on:*
  - *Quotations of biogas digester systems;*
  - *Estimates of comparable septic tank systems;*
  - *Desludging costs savings and energy costs savings for institutions.*

  *Additional data gathering on the benefits of using the effluent for irrigation and fertilising will give a more realistic (and also better) picture of the benefits of biogas systems.*
> *Biogas digesters have many more financial and non-financial benefits but these have not been taken into account in this cost benefit analysis.*
> *Large prisons seem to have the best business case.*

## 5 Readiness of the biogas private sector in Ghana

The design and construction of a biogas system takes time and requires knowledgeable and skilled people. As an example, it takes about 30 days to build a 40 $m^3$ biogas digester (fixed dome) for a school of 140 students. The following table presents a breakdown of the work to be done. About 2/3 of the labour needed is unskilled and 1/3 skilled.

**Table 16: Amount of work to be done constructing a 40 $m^3$ fixed dome biogas digester**

| Activity | Number of days | Number of workers |
|---|---|---|
| Digging of earth (dome and expansion chamber) | 4 days | 2 (Unskilled) |
| Laying of bricks and plastering of dome | 15 days | 5 (3 unskilled) |
| Closing of dome | 5 days | 3 (2 unskilled) |

The anticipated 200 systems to be implemented, requires a sufficient number of private sector companies and skilled masons. Is the Ghana biogas private sector ready to implement these 200 systems in a 5 year period?

### 5.1 Previous experiences with readiness of the biogas private sector

In 2007 the Ghana government initiated some studies on the set-up, planning and development of a nationwide biogas programme. A pre-feasibility study conducted by the Kumasi Institute of Technology and Environment (KITE), revealed the highest potential for domestic biogas systems to be in the three Northern regions and the Ashanti Region. A follow-up study [35] by KITE assessed the feasibility of pursuing a market based, enterprise-centred approach to the large scale deployment of domestic biogas plants in rural Ghana with emphasis on the three northern regions and the Ashanti Region. The main conclusions, related to the readiness of the Ghanaian biogas private sector were:

- *There is very little in-country experience with regards to domestic biogas plants as the majority of existing biogas plants are bio-sanitation projects located in urban centres.*
- *The current supply chain for biogas digesters is weak and characterised by few entrepreneurs located in two major cities. The manpower base (the number of trained technicians/artisans) is also weak and appears inadequate to handle huge volumes of demand for the digesters.*

Based on the KITE report it was concluded that commercialisation of domestic biogas systems in the survey area in particular and Ghana in general, was not feasible at that time. The question is if this situation has changed in recent years:

1. *Is there sufficient in-country experience with regards to institutional (or similar sized systems) biogas-sanitation systems?*
2. *Is there a good supply chain for biogas digesters?*

### 5.2 Ghanaian private companies active in biogas digestion and sanitation

Several Ghanaian private companies and institutions have been involved in the design, construction, maintenance and operation of biogas sanitation systems in Ghana in the last 10-15 years. They are responsible for the construction of at least 400 biogas systems in institutions, hotels, government buildings and homes[15]. Based on desk research and discussion with biogas stakeholders, the following organisations have been identified (see table below). For some it is unclear if they are still active and / or involved in biogas systems. The level of expertise and experience differs widely among the organisations mentioned.

**Table 17: List (incomplete) of organisations that have been involved in the design and construction of biogas sanitation systems in Ghana in the last 15 years**

| Organisation | Year founded | Type of biogas technology |
|---|---|---|
| Abu Biogas Construction Limited (ABCL), Obuasi | 1998 | Fixed Dome + Floating Drum |
| Apana solutions ltd, Accra | 2012 | Fixed dome |
| Beta Construction Engineers Ltd (BCEL), Accra | 2006 * | Puxin |
| Biogas Engineering Limited (BEL), Kumasi | 2002 | Fixed dome |
| Biogas Technologies Ltd (BTAL) previously Biogas Technology West Africa Ltd, Accra | 1994 | Fixed dome |
| Biosanitation Company Ltd (BCL), Obuasi | 1998 | Fixed Dome + Floating Drum |
| Centre for Energy, Environment and Sustainable Development (CEESD), Kumasi | 2013 | Fixed Dome + Floating Drum |
| Environmental Impact Ltd, Obuasi | 2005 | Fixed dome |
| Environmental Impact Technology Ltd, Obuasi | 2002 | Fixed Dome |
| Global Renewable Energy Services | 1996 | Fixed dome |
| Institute for Industrial Research (IIR), Accra | 1986 | Fixed dome |
| Koajay Company Limited, Accra | 2010 | Fixed dome |
| Renewable Energy and Environmental Systems | 2002 | Fixed dome |
| RESDEM | 1996 | Bio-latrine |
| Unireco | 2001 | Fixed dome |

* Started biogas plant construction in that year, the company is older.

## 5.3 Discussions and meetings with the biogas private sector

As part of the study the researchers met with seven private biogas companies for individual interviews (see Annex A). During these interviews the following topics have been discussed:

- *Company profile: products and services, year of operation and experience with (institutional biogas) in Ghana and abroad.*
- *Technical details of institutional biogas systems; design, construction, maintenance and operation.*
- *Costs of institutional biogas systems.*
- *Providing services (e.g. maintenance and operation) and contractual arrangements.*
- *Capacity for implementing many biogas systems.*
- *How to implement a national biogas programme; timing, selection criteria for institutions and geographical focus.*
- *Interest in cooperating / participating in a national institutional biogas programme.*

[15] Several studies show lists of biogas plants that have been constructed in Ghana. See for example the following references [2], [3], [14],

All seven expressed their interest in cooperating / participating in a national institutional biogas programme. Six of the seven private companies also were present at both stakeholder workshops (see annex B), all having an important contribution in the discussions.

The six companies present in both stakeholder workshops seem very motivated, have a good knowledge base and are very experienced. They have constructed between 10-100 biogas systems each.

During both workshops the need for a biogas industry organisation was expressed (and supported by all private company participants) to strengthen the sector. During the second stakeholder workshop a first initiative has been launched to start discussions amongst the private sector organisations. The Energy Commission expressed its intention to facilitate these meetings.

### 5.4 Conclusions

The biogas private sector in Ghana seems ready to design, construct, operate and maintain 200 biogas systems in a few years' time.

> *There are about 10 companies and organisations in Ghana having a great deal of experience with the design, construction, operation and maintenance of biogas systems.*
> *At least 6 companies have built between 10-100 systems each.*
> *The knowledge base and technical experience of these 6 is good to very good, based on:*
    - *Detailed technical discussions with each of them*
    - *Field visits to some of their projects*
    - *Talking to actual clients / users*
> *The 6 companies seem very motivated to be engaged in a national programme for institutional biogas*

## 6 Policies and public initiatives relevant for institutional biogas

Ghana has not yet instituted a national biogas programme. The only document which specifically mentions a national target for the implementation of biogas systems is the Sustainable Energy for All (SE4ALL) Action Plan (2012) which seeks to conduct a feasibility study and establish institutional biogas systems for 200 boarding schools, hospitals and prisons by 2019.

A number of policies and public initiatives are relevant for institutional biogas and its implementation.

### 6.1 Renewable Energy and Climate Change policies

The Strategic National Energy Policy (2009) proposes to increase the use of renewable energy sources to 10 percent of the national energy mix by 2020. The plan recognises the fact that establishment of a feed-in tariff regime that is friendly to renewable energy and backed by regulatory framework is necessary to accelerate the development of renewable energy for electricity generation. The Public Utility Regulatory Commission (PURC) in 2013 published the feed-in tariffs for renewable energy sources and this was reviewed in 2014.

Also, the Ministry of Energy and Petroleum (now the ministry of Power) in its National Energy Policy (2009) provides direction on how to reverse the decline in the fuel wood resource base of the country and further sustain its production and use by improving the efficiency of production and use. The Plan suggests that, government should "*Promote the production and use of improved and more efficient biomass utilization technologies and the use of modern biomass energy resources through creation of favourable regulatory and fiscal regimes and attractive pricing incentives*".

The draft bioenergy policy (2010) also seeks to maximise the benefits of bioenergy on a sustainable basis. The policy targets, objectives and strategies which the development of institutional biogas could facilitate include:

- *Use of municipal wastes for energy purposes;*
- *Promotion of private sector participation in the bioenergy industry;*
- *Provision of an avenue to reduce poverty and wealth creation through employment generation;*
- *Reduce carbon dioxide emissions.*

Biogas is mentioned specifically, targeting the sanitation problems in the country.

In promoting renewable energy in general, the government of Ghana has demonstrated its commitment in meeting these targets by passing the Renewable Energy Law (ACT 832) in 2011 which is expected to create a favourable platform for development of green energy and low carbon options. The RE Act 832 also provides the legal backing to establish a renewable energy fund which could be utilized to promote the development of biogas in Ghana.

Also, promotion of small and medium-sized enterprise (SMEs) participation in institutional biogas technology penetration has been identified as one of the five key priority energy related Nationally Appropriate Mitigation Actions (NAMAs) in Ghana. This is in line with the country's pursuit for low carbon development options which is identified in the national climate change policy (2014) as well as the sustainable development objectives articulated in GSGDA. The waste-to-energy policy objective as stipulated in the GSGDA is to convert most of the wastes generated in municipal, urban, rural, industrial and agricultural activities to energy with the strategy of maximising energy production from waste.

## 6.2 Sanitation and development policies

Ghana recognizes the significance of improved sanitation and has thus outlined strategies for same in the GSGDA I which are re-emphasized in GSGDA II. Strategies aimed at improving environmental sanitation include the following:

1. *Promoting the construction and use of appropriate and affordable domestic latrines;*
2. *Support public-private partnership in solid and liquid waste management;*
3. *Promote cost-effective and innovative technologies for waste management; and*
4. *Develop disability-friendly sanitation facilities.*

Though the various developmental interventions (GPRS II, GSGDA I and GSGDA II) do not directly mention biogas as a means of enhancing sanitation, some of the policy strategies provide a platform for the development of sanitary biogas systems to promote good sanitation. For instance, biogas systems can be used to improve household and **institutional sanitation** as outlined in the strategy and can also be used to replace the improved pit-latrine technologies such as the Ventilated Improved Pit (VIP) and the Kumasi Ventilated Improved Pit (KVIP) which have been used as main technologies for public toilets in Ghana [Bensah *et al.,* 2010].

## 6.3 Other policies and initiatives

According to EPA officials, EPA has Acts in place stating that new public buildings will not receive a building permit when utilising septic tank sanitation systems.

Also EPA has a role in monitoring the efficiency of biogas systems and the quality of the effluent of biogas systems. The costs associated with this monitoring and the unavailability of sufficient budget obstructs a proper execution of these tasks by EPA.

In 2012 the governments of Korea and Ghana started a cooperation project “Supporting green industrial development in Ghana: biogas technology and business for sustainable growth”, supported by UNIDO. This project is focussed on industrial application of biogas systems but can have an impact on large scale sanitation biogas systems, maybe in combination with other industrial and/or agricultural feedstock.

In September 2014 the United Nations Development Programme (UNDP) and partners have launched an initiative to consolidate the partnership between the Government of Ghana, UNDP and Governments of China and Denmark on Renewable Energy Technology Transfer. The initiative aims to facilitate the development and transfer of renewable energy technologies from China to Ghana along with the support required to make the technologies actually work on the ground.

The project is expected to have a tremendous impact on increasing access to energy for the rural poor in Ghana. It focuses on technologies such as solar and wind for irrigation, biogas, mini hydro and improved cook stoves and will have private sector development as its centrepiece. The four-year project is a key component of UNDP’s support to the implementation of Ghana’s SE4All action plan.

## 6.4 Conclusions

A number of different Ghanaian policies are supportive to the implementation of biogas sanitations systems but without being very concrete. The SE4ALL action plan is the only policy plan specifying objectives and activities targeting (institutional) biogas.

The SE4ALL action plan will end its activities latest in 2019.

Development, implementation and enforcement of new policies / legislation is necessary to address:

> *Stimulating the implementation of biogas systems instead of septic tanks for new buildings and institutions.*
> *The risks of implementing biogas systems on a large scale:*

- *Ensuring the effluent meets the standard for pathogenic level;*
- *Ensuring the biogas is used and not emitted without flaring.*

## 7 Stakeholders for institutional biogas in Ghana

In the course of the research done, several stakeholders have been identified that can have an important role in furthering the stimulation and implementation of institutional biogas in Ghana. Based on discussions with the stakeholders (see Annex A), this chapter describes the potential role(s), for each group of stakeholders, to further stimulate institutional biogas in general. In chapter 9, specific roles per stakeholder are described for setting-up and implementing a National Programme for Institutional Biogas.

### 7.1 Governmental institutions

As institutional biogas is targeting a number of objectives and sectors, a number of government organisations need to be involved in activities aimed at furthering the stimulation of institutional biogas in the country. The identified government institutions are provided in the following table.

**Table 18: Governmental stakeholders relevant for Institutional Biogas in Ghana**

| **Governmental institutions** | |
|---|---|
| Ministry of Power (MoP) * | Ministry of Education (MoE) |
| Energy Commission (EC) * | Ghana Education Service (GES) |
| Ministry of Local Governments and Rural Development (MLGRD) | Ministry of the Interior (MINT) |
| Ministry of Environment, Science, Technology and Innovation (MESTI) * | Ghana Prisons Service (GPS) * |
| Environmental Protection Agency (EPA) * | Ministry of Health (MOH) |
| Ministry of Trade and Industry (MOTI) * | Ghana Health Service (GHS) * |

* Already involved in the course of this project

The Ministries have an important role in the development of supportive policies, the related enforcement mechanisms and assigned budgets. GPS, GHS and GES have a role in the practical organisation of activities, when their respective institutions are being targeted.

GPS has indicated, in the discussions with the researchers, to be very interested to take the biogas initiative further. GPS does have both skilled staff and unskilled labourers available that can be used for the construction of the biogas digester, thereby reducing the investment costs. Also there might be an opportunity to get the necessary funding, for the investment costs, from the Ministry of Interior.

The Energy Commission has taken the initiative for this project and is willing to be the lead organisation, to further the implementation of institutional biogas in Ghana, in close cooperation with other main stakeholders like MESTI, MoP and EPA.

### 7.2 Biogas construction organisations and private sector associations

Chapter 5 discusses the biogas companies (including the Institute for Industrial Research), active in Ghana. They have a role in the design and construction of biogas installations and also in maintenance and possibly in operation of these systems. In addition the private sector association ‘Ghana Alliance for clean cookstoves’ should play a role, especially in the organisation of the sector, focussing on setting standards and quality control.

**Text block 5: The Ghana Alliance for clean cookstoves (www.cleancookstovesghana.org)**

The Ghana Alliance for clean cookstoves has been established as a strong stakeholder platform to lead the front to catalyse a revolution in the cookstoves sector and mobilize high level national and donor commitments towards the goal of universal adoption of clean cookstoves and fuels in Ghana. Our ambitious target to foster the adoption of clean cookstoves and fuels by 4 million households in Ghana and distributing 5 million cookstoves by 2020 has generated interest from a wide range of private, public and non-profit stakeholders. The unprecedented consultative process with the global cook stoves sector has led to the development of the sector strategy for achieving its goal. By providing a roadmap for concerted action and measurable results that can quite literally change the lives of nearly 25 million Ghanaians in the country and become a beacon of example for the west African sub-region, the strategy will foster a unified vision for the sector while building a common sense of engagement by all stakeholders on the most critical actions required for universal adoption of clean cook stoves and fuels.

The Ghana Alliance aims to strengthen local actors working in the cookstoves sector, support government to achieve its renewable energy policy and climate change program goals and increase consumer awareness on the importance of fuel efficient and clean cookstoves. The Alliance could potentially act as the central coordinating body to provide support and ensure effective implementation of cookstoves programs in Ghana.

## 7.3 Local NGOs

A number of local NGOs focus on sanitation and biogas. The following three have been involved in the course of this project:

- *Kumasi Institute of Technology, Energy and Environment (KITE)*
- *ABANTU for development*
- *Centre for Energy, Environment and Sustainable Development (CEESD)*

Other NGOs potentially interested in biogas sanitation systems are:

- *Friends of the Earth Ghana*
- *Nature Conservation Research Centre West Africa*

The role of participating local NGOs is to ensure local development impacts are sufficiently addressed in plans and activities. They also can play a role in the effective communication with user groups and monitoring of local impacts.

## 7.4 Donor and international development organisations

Efficient biomass use for energy purposes is getting more and more attention worldwide but specifically in West Africa, as traditional biomass use is still very high with all negative impacts associated with it. In addition sanitation is a major topic in West Africa in general and in Ghana specifically, with the recent outbreak of cholera in the Accra region.

A large number of donor and development organisations focus on these two topics, either separately or in combination. Often private sector development is a crucial element of the implementation strategy of the development objectives. The following donor and international development organisations have been identified to potentially play a role in institutional biogas sanitation systems in Ghana.

**Table 19: Donor and international development organisations relevant for Institutional Biogas in Ghana**

| **Organisations** | |
|---|---|
| DANIDA * | Embassy of the Kingdom of the Netherlands to Ghana * |
| USAID * | Embassy of France in Ghana |
| SNV * | Embassy of Japan in Ghana |
| GIZ * | EU delegation in Ghana * |
| UNDP * | |

* Already involved in the course of this project

The role of these development organisations can vary, depending on their development objectives, strategies and activities. Based on discussions with a number of the organisations they can contribute, either actively or as a funding organisation, to:

> *Private sector development through training and capacity building*
> *Awareness raising amongst institutions and general public*
> *Research and knowledge transfer*
> *Monitoring of results and impacts*
> *The creation of funding mechanisms*

### 7.5 Research institutes

A number of research institutions are involved in biogas. Institute for Industrial Research (IIR) is probably the organisation with the longest track record in biogas, not only focusing on research but also having a lot of practical experience designing and constructing biogas systems. The following institutes seem to be the most relevant. The role of these institutes is of course predominantly in research, focussing on:

> *More (cost) efficient and cheaper biogas systems*
> *Developing design, construction, maintenance and operation guidelines and standards*
> *Monitoring of all social and economic benefits*
> *Assess the performance and usability for Ghana of new (for Ghana) biogas technologies as an alternative for the currently used ones*

**Table 20: Research institutes relevant for Institutional Biogas in Ghana**

| **Research institutes** |
|---|
| Institute for Industrial Research (IIR) * |
| Kumasi Renewable Energy Centre / Kumasi Polytechnic * |
| The Energy Centre / Kwame Nkrumah University of Science and Technology (KNUST) * |
| Valley View University |
| Council for Scientific and Industrial Research (CSIR) |

* Already involved in the course of this project

### 7.6 Institutions: boarding schools, prisons and hospitals

As public boarding schools, prisons and hospitals are the targeted institutions, they will of course have a role when biogas systems are being implemented. In the development of a programme their role is limited.

When discussing with institutions (see Annex A) the pros and cons of biogas compared with their current sanitation and cooking situation it became clear they are very much in favour of a biogas system, provided they can afford it. In chapter 8, indicative figures are provided on the number of institutions present in Ghana.

### 7.7 Private banks and funds and International Financing Institutes

A large number of institutions and funds are actively involved in renewable energy in Africa. The table below presents some of them, based on the researchers´ own experience and contacts and the report from Connect, "funding institutions for energy investment in Africa" [42]. Annex C provides a full list of potential sources of funding for institutional biogas in Ghana.

**Table 21: Financing organisations relevant for Institutional Biogas in Ghana**

| **Financing organisations** | |
|---|---|
| World Bank * | African Renewable Energy Access Program (AREAP) |
| African Development Bank * | Sustainable Energy Fund for Africa (SEFA) |
| UNDP-GEF * | Swiss International Finance Group AG (SIFG) |
| EcoBank * | ECOWAS Bank for Investment and Development (EBID) |
| SOVEC * | African Biofuels and Renewable Energy Fund (ABREF) |
| Dutch Development Bank (FMO) | The Africa Enterprise Challenge Fund (AECF) |
| Ventures Africa (Standard Bank) | KfW Green for Growth Fund |
| African Renewable Energy Fund (AREF) | Angel Investment Network for Green Energy |

* Already involved in the course of this project

The organisations that have been contacted by the researchers have stated to be potentially interested in participating in further activities. Each and every organisation has its own focus areas, financing conditions and type of financing. A blended financing mechanism seems most logical for any further activities in the area of institutional biogas.

### 7.8 Conclusions

Based on the individual discussions with stakeholders and the two well attended stakeholder consultation workshops, it seems there is an urge felt by all stakeholders to take institutional biogas for sanitation a step forward. The participants recommended an interdepartmental approach targeting sanitation, renewable energy, private sector development and agriculture.

The Energy Commission will help drive this process in close collaboration with MoP, MESTI, EPA and other relevant stakeholders.

When starting a National Institutional Biogas Programme, prisons seem to be the institutions of choice when starting a pilot. Ghana Prisons Service is very interested to take the biogas initiative further and they seem to have the willpower and manpower available to make biogas work in practice, both in the short and long run. Also there might be an opportunity to get the necessary funding, for the investment costs, from the Ministry of Interior.

A blended financing mechanism seems most logical for any further activities in the area of institutional biogas.

## 8 Market potential for institutional biogas systems in Ghana.

The SE4ALL action plan is focussed on implementing 200 institutional biogas systems. However the overarching aim is to develop a sector that is able to flourish by itself bringing the potential benefits to the Ghanaian community. In this chapter we present figures for the three types of institutions - public hospitals, boarding schools and prisons – giving an idea of the overall market for institutional biogas.

### 8.1 Biogas market for public boarding schools, prisons and hospitals

The market potential for institutional biogas systems in public institutions is estimated based on the number of public institutions in Ghana that satisfy one basic requirement, which is the ability to use the biogas for cooking. This requires that the institutions being targeted must have an in-house kitchen, where cooking is done on a daily basis. Or for example the biogas is used for heating water.

Government institutions that satisfy these conditions are:
> *Senior high schools (boarding);*
> *Senior technical and vocational institutions (boarding);*
> *Colleges of education (Teacher training);*
> *Nursing training schools;*
> *Prisons;*
> *Hospitals;*

**Table 22 Number of public institutions and their population [33]. Updated by authors.**

| Public institutions | Number of institutions | Population | Biogas potential (1,000 $m^3$ / year) |
|---|---|---|---|
| Educational centres: [16] | | | |
| Colleges of education | 38 | 28,000 | 100 - 840 |
| Polytechnics | 10 | 48,000 | 170 – 1400 |
| Senior high schools | 556 | 685,000 | 2450 - 22,000 |
| Technical and vocational schools | 118 | 35,000 | 140 – 1,150 |
| Universities | 6 | 110,000 | 550 - 5,300 |
| Prisons [17] | 45 | 14,800 | 120 – 640 |
| Hospitals [18] | 133 | 14,600 | 70 – 570 |
| **TOTAL** | **906** | **935,400** | **3,600 – 32,000** |

### 8.2 Biogas market for other institutions and companies in Ghana

Apart from the public institutions mentioned in the previously, there are many other privately owned institutions which meet the requirements. Also hotels and restaurants generate substantial amounts of kitchen and food

[16] Ministry of Education, 2014 (http://www.moe.gov.gh/site/emis/html/Technical-Vocational.htm) Accessed 07/04/2015
[17] Ghana Prisons, 2012 (http://www.ghanaprisons.gov.gh/) Accessed 07/04/2015
[18] Ghana Health Service, 2010 (http://www.moh-ghana.org/UploadFiles/Publications/GHS%20Facts%20and%20Figures%202010_22APR2012.pdf) Accessed 20/03/2015

waste and human waste that can be converted to biogas for cooking or heating water. The African Regent Hotel is a good example where they use the biogas sanitation system to produce biogas for cooking.

**Table 23 Number of private institutions and their population [33]**

| Other institutions | Number of institutions | Population | Biogas potential (1,000 $m^3$ / year) |
|---|---|---|---|
| Private school [19] | | | |
| Senior High school | 284 | 66, 400 | 240-2200 |
| Universities | 51 | 66,800 | 330-3,200 |
| Technical and vocational | 68 | 6,000 | 20-200 |
| Colleges of education | 1 | 550 | 2-20 |
| Private hospitals [20] | 225 | 7,500 | 35 – 290 |
| Hotels and restaurants [21] | 1869 | 56,000* | 440-2400 |
| **TOTAL** | **2,498** | **203,250** | **1100-8,250** |

* Rough estimate based on an average of 30 occupants per day.

## 8.3 Conclusions

In addition to the foreseen 200 public biogas sanitation systems there is still a huge market for both institutional biogas systems and systems for other user groups like hotels and restaurants. Also other sectors could be targeted, like apartment buildings, offices, gated communities and many others.

In a later stage also sectors can be targeted that require other types of biogas digesters, like households and industrial systems for slaughterhouses and in the food (processing) industry.

[19] Ministry of Education, 2014
[20] Ghana Health Service, 2010
[21] Ghana Tourism Authority, 2015. (http://www.ghana.travel/hotels/). Accessed 08/04/2015

# 9 A National biogas-sanitation program for public institutions

Based on the feasibility study and the responses (and recommendations) of the stakeholders it is recommended to set-up a National Institutional Biogas Programme with the following objectives:

> *Implement 200 biogas digester systems in public boarding schools, hospitals and prisons and*
> *Kick-start the further development of a biogas market in Ghana.*

## 9.1 Why a National biogas programme for institutions in Ghana?

Many studies addressing domestic and institutional biogas in Ghana[22] call for a National Biogas Programme, to capture the socio-economic and environmental benefits and overcome the technical, operational, financial and promotional barriers. Such a National Biogas Programme should have a three-pronged focus:

1. *Improve the sanitation situation*
2. *Use biogas for energy purposes*
3. *Use bio-slurry for irrigation and as organic fertilizer*

**Benefits of a National Biogas Programme**

In chapter 4 the costs and benefits for institutions are presented and although the figures are not fully conclusive it seems there is a decent business case for the involved institutions. This is in line with figures from other studies, although it should be noted that these have focussed on domestic biogas systems (Buysman and Mol, 2013). Examples of estimated benefit-cost ratios are presented in the following table.

**Table 24 Benefit-cost ratios of National Biogas Programmes for Households and Society (Winrock Int., 2007)**

| | Benefit-cost ratio for households * | Benefits-cost ratio for society |
|---|---|---|
| Sub-Saharan Africa | 1.22 | 6.38 |
| Uganda | 1.25 | 6.84 |
| Rwanda | 1.32 | 5.57 |
| Ethiopia | 1.35 | 4.52 |

* Including subsidy

The number 1.22 in the above table, for Sub-Saharan Africa, means that every dollar (or any other unit of money) invested by a household in a biogas system, results in 1.22 dollar of economic benefit (over the period of the programme; in this case 15 years).

In chapter 3 of this report, all the socio-economic and environmental benefits are presented, both for institutions and the society as a whole. The socio-economic benefits for institutions are much higher than presented in the cost-benefit analysis in chapter 4, as many benefits have not been monetised.

The benefit-cost ratios in Table 24 are somewhat better, taking into account:

> *Cooking and lighting fuel savings*
> *Time saving due to biogas*
> *Saving in household's health related expenditures*
> *Income effects of improved health*

[22] e.g. literature [3], [26], [28] and [35]

The social and environmental benefits of institutional biogas for society as a whole are also described in chapter 3 (see Table 4 and **Fout! Verwijzingsbron niet gevonden.**). Table 24 presents the economic value of these benefits. In the case of an integrated National Biogas-Sanitation Programme in Sub-Saharan Africa **every dollar invested in such a programme results in 6.38 dollar of economic benefit** (over the period of the programme; in this case 15 years).

The benefits that have been monetised are:

> *Cooking and lighting fuel savings*
> *Chemical fertilizer saving*
> *Time saving due to biogas and latrine (fuel collection, cleaning and cooking, latrine access)*
> *Savings in health-related expenditures*
> *Time savings due to improved health*
> *GHG reduction*
> *Local environmental benefits*

Biogas programmes running in Cambodia, Bangladesh and Nepal have shown similar results.

**Previous feasibility assessments of a National Institutional Biogas Programme?**

A study performed by KITE in 2008 [35] assessed the feasibility of pursuing a market based, enterprise-centred approach for the large scale deployment of domestic biogas plants in rural Ghana with emphasis on the three northern regions and the Ashanti Region. The main conclusions of this study are included in the text box below.

**Text block 6: Summary of the main conclusions of the KITE feasibility assessment report (KITE, 2008).**

- *The anticipated market potential does not yet exist and will have to be developed.*
- *Technically it's possible to install in about 80,000 households, at least one 6m3 fixed dome digester, to take care of their daily cooking energy needs.*
- *The investment costs for a fixed dome digester in Ghana is several times higher than in several Asian and Eastern African countries where the technology has been commercialised.*
- *These high costs result in a negative payback time over the 15 years lifespan of the digester (assuming an interest of 10% compared).*
- *There is very little in-country experience with regards to domestic biogas plants as the majority of existing biogas plants are bio-sanitation projects located in urban centres.*
- *The current supply chain for biogas digesters is weak and characterised by few entrepreneurs located in two major cities. The manpower base (the number of trained technicians/artisans) is also weak and appears inadequate to handle huge volumes of demand for the digesters.*

Based on this study it was concluded that commercialisation of domestic biogas systems in the survey area in particular and Ghana in general was not feasible at that moment.

The KITE report also concluded that the decision to invest in biogas technology should not only be based on the profitability or otherwise of the investment since the non-direct financial benefit to the household. The overall benefits to society at large provide the economic justification for public intervention that will create the necessary enabling environment to kick-start the development of the domestic biogas market. Therefore it was recommended to initiate a social business model focusing on technical training, business development, financing and market facilitation as its main components and based on the concept of private-public partnership (PPP) as the way forward for Ghana towards harnessing and commercialising its biogas potential.

The current situation is entirely different:

> *Most importantly the anticipated National Biogas Programme (NBP) is focussed on institutional biogas instead of domestic biogas systems.*
> *The pay-back times of the installations seem much shorter than 15 years, whilst system cost reductions are very likely when a well-functioning market for biogas has been developed.*
> *More than 400 biogas systems have been built in Ghana.*
> *A sufficient number of knowledgeable and experienced entrepreneurs (with trained technicians) is already active in the biogas market.*

The justification for public intervention is still valid.

## 9.2 Objectives for a National Institutional Biogas Programme in Ghana

The initiative for the feasibility study on institutional biogas started from the SE4ALL action plan. The specific activity formulated within the SE4ALL action plan is "*to conduct a feasibility study to establish institutional biogas systems for 200 boarding schools, hospitals and prisons*" with 2012-2015 as implementation timeline. The purpose of this activity is to bring the use of biogas as a low carbon energy source to a significantly higher level in Ghana. The 200 systems therefore should kick-start the development of the biogas market and should stimulate and accommodate further implementation of biogas digesters in the country. Biogas digesters, not only for institutions but also for other market sectors and end-users, like hotels, restaurants, apartment buildings, offices, gated communities, households and industrial systems for slaughterhouses and in the food (processing) industry.

**Barriers to be tackled by a Ghanaian National Institutional Biogas Programme**

A number of barriers[23] obstruct the development of a well-functioning biogas market in Ghana, thereby depriving the entire country of all the socio-economic and environmental benefits associated with the use of biogas digester systems.

These barriers are:

> *Little market demand for digesters*
> *High construction cost of biogas digesters (compared to other countries)*
> *Limited private sector development*
> *Lack of maintenance and operation services for digester systems*
> *Lack of financing mechanisms for institutions (and other users) to pay high upfront costs*
> *Lack of appealing examples of biogas digesters which excellently show the benefits*
> *Lack of a national promotion programme*
> *Lack of quality standards for biogas digesters and control mechanisms to ensure quality and sustainability of the systems built*
> *Lack of a governmental focal point for biogas digestion ensuring the integration of biogas in energy, environmental, sanitation and agricultural policies*

**Multiple National Biogas Programmes**

The purpose of the SE4ALL biogas activity is to bring the use of biogas as a low carbon energy source to a significant higher level in Ghana. The 200 systems should kick-start the development of the biogas market and should stimulate and accommodate further implementation of biogas digesters in the country. The SE4ALL

[23] See for example literature [3], [34], [35] and [36]

activity, implemented in the first National Biogas Programme (NBP 1), is likely to be followed-up by programmes extending the successful implementation of biogas in the country. This can be visualised as presented in the following figure.

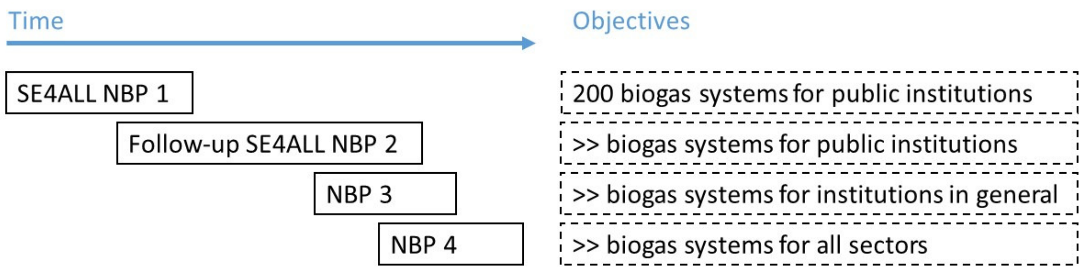


**Figure 12 Possible consecutive biogas programmes in Ghana**

### 9.3 Experiences from existing national biogas programmes

From the experience of biogas technology dissemination in developing countries, it is obvious that biogas promotion cannot be left in the hands of private companies alone. The direct involvement of government and state institutions in biogas promotion has been an important success factor in countries such as China[24], India[25], Cambodia and Nepal[26]. Cooperation between the state and the private sector has led to the development of favourable policies and regulatory frameworks that have ensured a sustained growth of the biogas sector.

The success story of the technology dissemination in the above countries can be partly attributed to the direct involvement of the State through special national or parastatal bodies empowered to lead the campaign in biogas dissemination.

**Text block 7: Experiences from the Cambodian National Bio digester Programme [39]**

Since the early 1990s international development organisations – often in cooperation with the national government – have attempted to introduce biogas technologies in many least developed countries, but most initiatives failed. In this landscape of failed biogas development programmes the National Bio digester Programme (NBP) Cambodia started in 2006, with the aim to establish a permanent market oriented and self-financed biogas sector. The results show the development of a sustainable domestic bio digester sector, a rapid diffusion of bio digesters among poor rural households, but still ambivalences on financial independency from external funding and carbon finance. The conclusion is that a pure market model for biogas development in the rural area of the least developed countries will not easily work. Governmental regulation and coordination will remain needed, and carbon finance will not easily fully replace ODA and governmental financial support.

[24] GTZ Biogas - country reports. Biogas Digest, Volume IV, Information on Advisory Service on Appropriate Technology (ISAT), Eschborn, Germany, 1999.

[25] Aggarwal D. Biogas plants based on nightsoil. TERI, New Delhi, India, 2003.

[26] Silwal B.B. A Review of the biogas programme in Nepal. Winrock International Research, Report series No. 42, BSP Lib Temp No. 72, p.52, Nepal, 1999.

## 9.4 Important elements of a Ghanaian National Biogas Programme for public institutions

Based on the feasibility study and the many discussions with all stakeholders, a number of important elements have been identified for a National Institutional Biogas Programme (NIBP), facilitating the implementation of the 200 institutional biogas systems. These elements are:

> *A long-term objective: a self-sustaining biogas market in Ghana (see Introduction)*
> *An interdepartmental approach targeting sanitation, renewable energy, private sector development and agriculture (see chapters 2, 3 and 7 and paragraph 9.1)*
> *A multi-year programme addressing the barriers as stated in paragraph 9.2*
> *Start with pilot institutions most likely to be successful (see chapters 3, 4 and 7)*
> *A well-balanced stakeholder involvement (see chapters 6 and 7)*
> *Blended programme funding (see chapter 7)*

**A long-term objective: a self-sustaining biogas market in Ghana**

The SE4ALL objective for the implementation of 200 biogas installations in public institutions is not a target in itself but merely a means of kick-starting the development of the biogas market in Ghana. This is expected to bring the use of biogas as a low carbon energy source to a significant higher level in Ghana and also provide all the previously described benefits to the country.

**An interdepartmental approach**

As indicated earlier in this report, it has become clear that only an approach targeting sanitation, renewable energy, private sector development and agriculture will be able to capture all benefits (social, economic and environmental) and simultaneously be able to successfully address all risks and challenges. To ensure a sound and coherent coordination, one public organisation should take the lead in this approach. The Energy Commission of Ghana has indicated to be willing to take on this role.

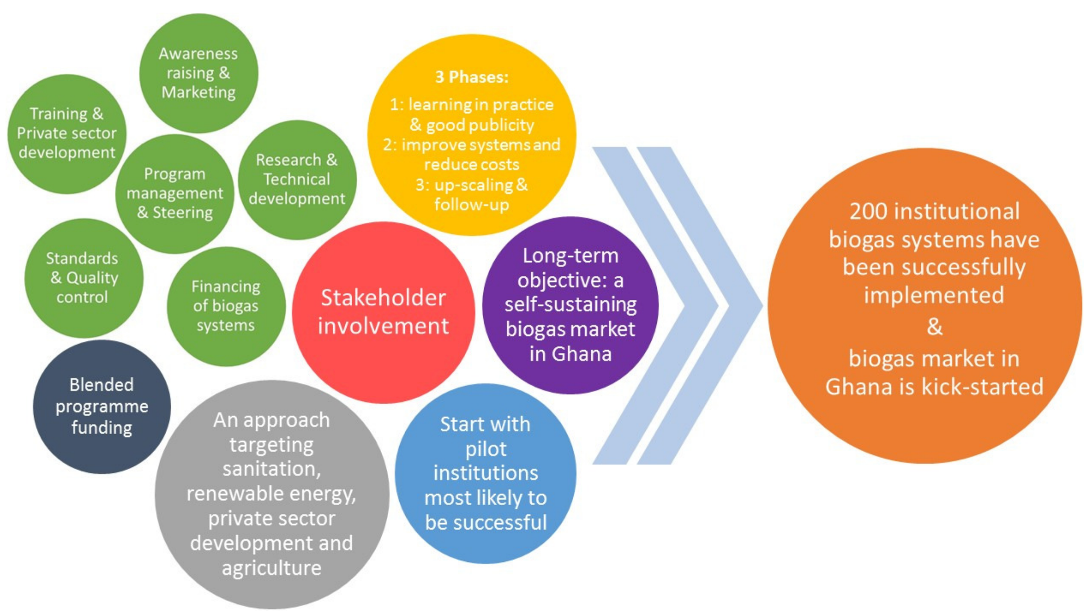


**Figure 13 Important elements for a National Institutional Biogas Programme (NIBP)**

**A multi-year programme addressing the different identified barriers**

Based on the feasibility study, the discussions with stakeholders and experiences from other National Biogas Programmes, a four year National Institutional Biogas Programme (NIBP) is foreseen with three distinct phases.

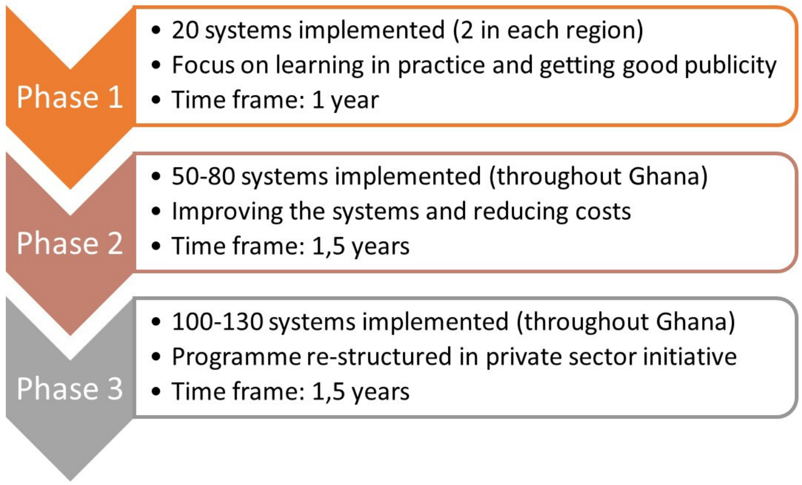


**Figure 14 The three proposed phases for the Ghanaian NIBP**

**Activities structured under 6 activity lines**

Based on other National Biogas Programmes in both Asia and Africa and the barriers to be tackled in Ghana to further the development of a well-functioning biogas market in Ghana, six activity lines are proposed for the NIBP. The following figure presents these activity lines and their interrelations with the three phases.

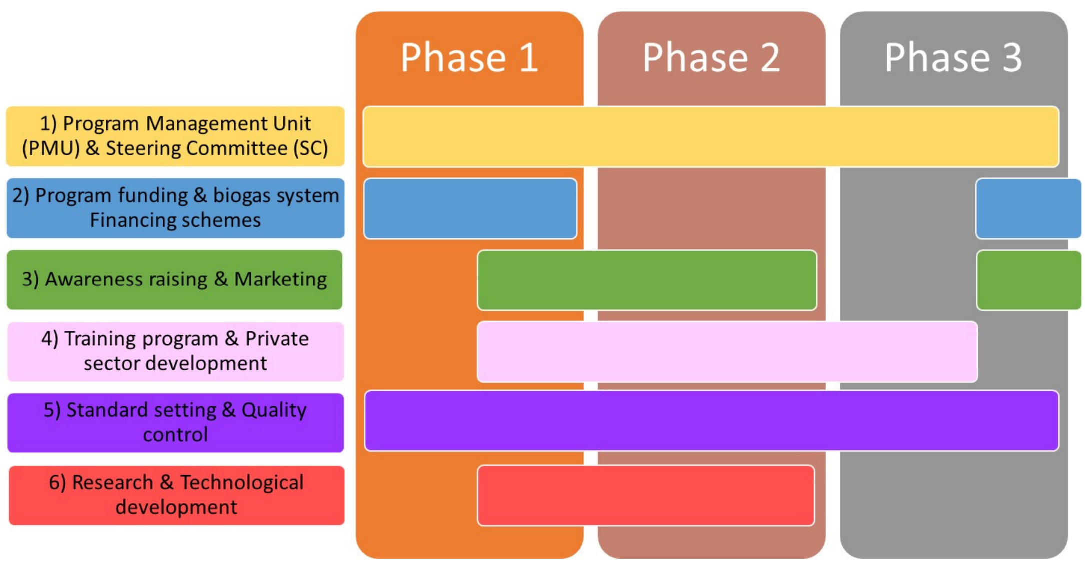


**Figure 15 Structure and timing of major activities for the Ghanaian NIBP**

In paragraph 9.6 the involvement of the different stakeholders per activity is presented.

**Start with pilot institutions most likely to be successful**

For a successful start of a National Institutional Biogas Programme it is advised to start the implementation of the first 20 biogas systems with pilot institutions most likely to be successful, which inter alia implies that they should be able to utilize all potential socio-economic, environmental and financial benefits. This is:

> *Good for publicity and marketing*
> *Good for all stakeholders involved*
> *Most cost-efficient and*
> *Will provide the necessary information to be able to assess the positive impacts.*

The selection criteria for the institutions in phase 1 are:

1. *Financial commitment from institutions throughout the technical lifetime of the system*
2. *Institutions willing and committing to use both biogas and effluent*
3. *Institutions willing and committing to operate the plant (after training) / or pay a service provider to do it.*

Large prisons and agri-schools seem the most promising at this stage.

## 9.5 Funding of a National Biogas Programme for public institutions

Based on the discussions with several stakeholders and experiences of existing National Biogas Programmes a blended funding mechanism is the most likely form of funding. What also has become clear from the discussions with the public sector, financial sector and private sector, the programme should not be donor driven but should have a large share of private sector involvement (including funding).

**Cost of a National Biogas Programme**

The costs of a National Biogas Programme for the implementation of 200 biogas systems are:

1. *Costs for financing / funding the 200 biogas systems.*
2. *Program costs related with the six identified activity lines.*

Using the quotations that have been provided by the biogas construction companies the overall costs for a National Institutional Biogas Programme for the implementation of 200 systems is estimated at 20 million USD. For this estimation the following numbers have been used:

> *the average construction costs for 20 systems for 4,000 people and 180 systems for 1,000 people*
> *Additionally, 20% overhead for all programme related activities.* [27]

The costs of the biogas-sanitation systems are too high for the majority of the beneficiaries to pay up-front (except maybe in the case of a new structure that is going to be built). Even if institutions are capable of paying the up-front cost it seems that not many are willing to do so. The cost-benefit analysis clearly shows that institutions will have significant cost savings, which they can use to pay for the biogas digester system in periodic instalments. The cost of installations can in that case partly be paid by institutions up-front and partly be subsidised or financed.

[27] Based on the report "A Cost-Benefit Analysis of National and Regional Integrated Biogas and Sanitation Programs in Sub-Saharan Africa" the overhead costs are seem to vary between 6-16% of the total costs.

The height of the subsidy or the length of the financing period, depends on the cost and benefits of a biogas digestion system. In chapter 4 these costs and benefits have been calculated, however the results are not very reliable due to poor data availability and quality – further research is required to ensure that the calculations are based on reliable data.

**Funding of a National Biogas Programme**

The funding of a National Biogas Programme can come from several sources:

> *Donor and international development organisations*
> *Private banks and International Financing Institutes*
> *Local and international funds*
> *The institutions (beneficiaries) themselves*
> *Local government*

Annex C presents a long list of potential sources of funding for the National Biogas Programme in Ghana.

The researchers have discussed with several potential funding organisations whether they would be interested in participating in the programme. All have expressed their interest in (part of) the programme but also expressed the need for a structured financial plan, including a cash-flow analysis.

**Carbon funding**

As has been shown in other National Biogas Programmes throughout Asia and Africa, carbon funding is not sufficient for setting-up a full-fledged national biogas programme. Carbon funding might be an additional funding component and might be sufficient to bear the costs of a fully developed and running national biogas programme (after 5-8 years) [34].

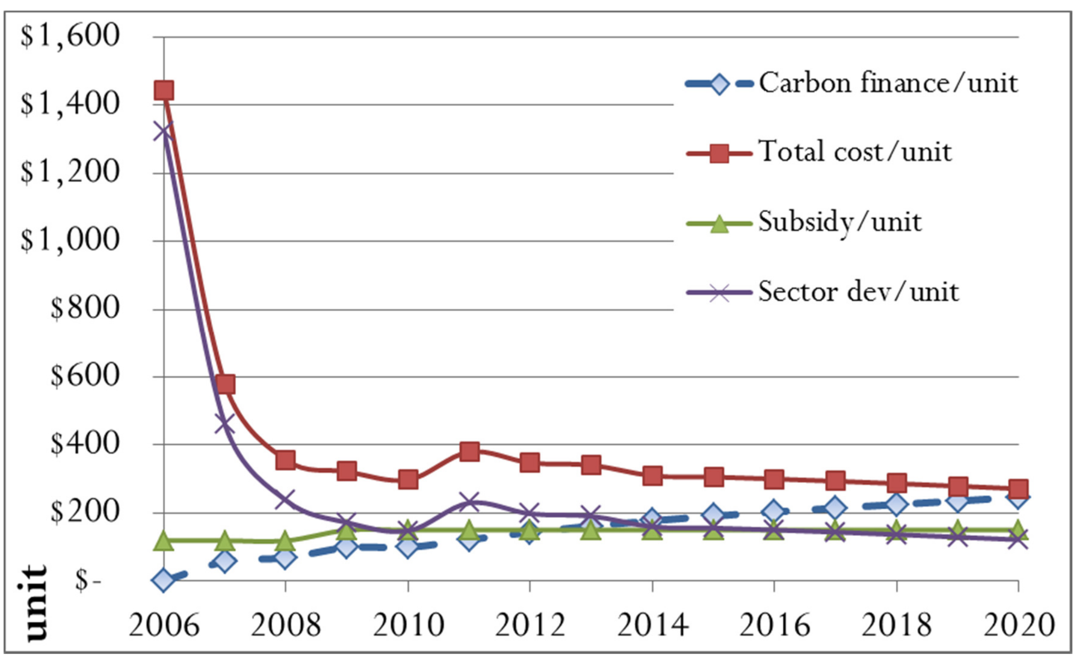


**Figure 16 Impact of carbon financing on the Cambodian Biogas Programme [Eric Buysman, 2014]**

Carbon funding can yield sustainable long term output based funding and it is the only alternative to ODA for programme financing. But carbon finance, due to high transaction costs, needs an economy of scale and it is also the most unreliable and challenging form of financing, due to:

> *The volatile market conditions and constantly changing methodologies*
> *Regulatory uncertainty on the carbon markets*
> *Monitoring and follow-up is very labour intensive and requires specific knowledge*
> *The need for significant upfront finance*
> *Prices on compliance market are very low and it is unsure if this will change in the near future.*

The UNFCCC focal point for Ghana advised the researchers not to investigate the possibilities for carbon financing for setting-up a National Biogas Programme, confirming that carbon financing is a possibility after a programme has been put in place and when long-term funding is needed for securing the sustainability of a programme.

The conclusion is that a pure market model for biogas development in the rural area of the least developed countries will not easily work. Governmental regulation and coordination will remain needed, and carbon finance will not easily fully replace ODA and governmental financial support. It is debateable whether this is problematic, as biogas markets also provide a lot of socio-economic benefits and many more markets (fossil energy) are stimulated (subsidised) by governments.

### 9.6 Stakeholders and their possible roles

The following table present the possible roles of the different stakeholders when carrying out a programme to implement 200 institutional biogas systems.

**Table 25: Possible roles for stakeholders in a National Institutional Biogas Programme**

| Programme activity | Stakeholders |
|---|---|
| 1) Program Management Unit & Steering Committee (including policy development and enforcement) | Energy Commission (lead organisation), MESTI, MoP, EPA, Ministry of Health, Ministry of Education and Ministry of Interior |
| 2) Program funding & biogas financing schemes | Financing organisations, donor and international development organisations |
| 3) Awareness raising & Marketing | Energy Commission, GPS, GHS, GES (and related Ministries) |
| 4) Training program & Private sector development | Donor and international development organisations and national Research Institutes |
| 5) Standard setting & Quality control | Research Institutes, MESTI, MoP and EPA |
| 6) Research & Technological development (including impact monitoring) | Research Institutes and local NGOs |
| 7) Biogas construction | Private sector, boarding schools, hospitals and prisons |

## 9.7 Conclusions

In summarising, the following conclusions can be drawn:

> *A number of barriers obstruct the development of a well-functioning biogas market in Ghana*
> *The socio-economic and environmental benefits of institutional biogas for the society at large outweigh the costs by far.*
> *A purely market driven approach for biogas development in Ghana will not work. The direct involvement of government and state institutions is an important success factor.*
> *The anticipated 200 systems should kick-start the development of the biogas market in Ghana.*
> *Blended funding is needed for a National Biogas Programme; carbon finance will not easily fully replace ODA and governmental financial support.*
> *Many relevant stakeholders are enthusiastic about a National Institutional Biogas Programme in Ghana and are potentially interested to participate / support the Programme but have expressed the need for a structured financial plan, including a cash-flow analysis.*

## 9.8 Recommendations

Based on the feasibility study and the recommendations from the stakeholders, the researchers formulated 5 main recommendations.

1. ***Start a National Institutional Biogas Programme (NIBP) with the following objectives:***

> *Implement 200 biogas digester systems in public boarding schools, hospitals and prisons*
> *Kick-start the further development of a biogas market in Ghana.*

The NBP should contain the following elements:

> *A long-term objective: a self-sustaining biogas market in Ghana*
> *An interdepartmental approach targeting sanitation, renewable energy, private sector development and agriculture*
> *A four year programme with 3 phases*
> *Activities structured under 6 activity lines*
> *Start with pilot institutions most likely to be successful*
> *A well-balanced stakeholder involvement*
> *Blended programme funding*

To be able to set-up and implement such a National Institutional Biogas Programme (NIBP) the following four activities need to be carried out.

2. ***A more detailed inventory of user needs and cost-benefit analysis***

Unfortunately the inventory of user needs and the data for the cost-benefit analysis shows too much variation. Therefore the following activities are proposed:

> *Inventory of the user needs for a biogas system and the current costs for sanitation, cooking fuels and, if relevant, fertilisers (30-50 schools, 10 prisons and 20 hospitals throughout the country and preferably evenly spread over the 10 regions)*
   - *Meetings with Ghana Prisons Service, Ghana Health Service / Min. of Health and Ghana Education Service / Min. of Education, to select institutions and agreement on how to approach the institutions*
   - *Set-up and carry out user needs and costs inventory with institutions*

> *Set-up and collect more detailed cost estimates for biogas systems*
> *Verify collected data and analyse results*

The expected result is a solid cost-benefit analysis report.

***3. Financial analysis and structuring of the programme in parallel with institutional structuring***

The following activities are proposed:

> *Securing the regulatory framework, procedures/rules and mandates are in line with intended programme (several meetings with relevant governmental organisations), e.g. schools are allowed and able to invest in a biogas system*
> *Discussions with biogas private sector on the financial analysis and structuring of the programme and assessment of their ability and willingness to engage with the proposed structuring*
> *Prepare financial (cash-flow) and operational scenarios for the programme*

The expected result is a proposal how to financially structure the programme. The actual fundraising is not part of this work.

***4. Draft a detailed programme plan and secure funding***

The following activities are proposed:

> *Select the first most appropriate institutions.*
> *In close cooperation with the Energy Commission a first programme plan is drafted*
> *The plan and financial structuring is discussed with potential donors and supporters*
> *The programme is adapted to the needs of donors and supporters*
> *Funding and support is officially requested by the Energy Commission from the selected donors /supporters*

The expected result is a detailed programme including secured funding and support from international donors.

***5. Secure potential funding and support for biogas from UNDP and GEF***

Try to get biogas as a priority into strategic plans (and budgets):

> *UNDP / Energy Commission strategic plan for 2015-2016*
> *GEF / MESTI strategic plan for 2015-2020*

All the above recommendations and activities have been confirmed by the key stakeholders engaged as part of this study.

## Annex A. Meetings and Interviews

**The following table presents all the meetings and interviews from 18-29 August 2014.**

In total 41 visits and / or interviews have been held, of which 36 were successful (resulting in meaningful feedback and / or information). The experts met with 43 different people, relevant for this study, not taking into account the workshop organised on 27 August (with 30 participants) and the CREC stakeholder meeting (with over 30 participants).

**Table 26 List of Institutions visited during first mission**

| No. | Organisation | Name | Date and time |
|---|---|---|---|
| 1. | Energy Commission, SE4ALL Secretariat | Mrs. Paula Edze | 18 August, 09:00 |
| 2. | Energy Commission | Mr. Kwabena Ampadu Otu-Danquah | 18 August, 09:00 |
| 3. | Energy Commission | Dr. Nii-Darko K. Asante | 18 August, 11:00 |
| 4. | Ministry of Energy and Petroleum | Mr. Wisdom Ahiataku-Togobo | 18 August, 12:00 |
| 5. | Ministry of Energy and Petroleum | Mrs. Gifty Tettey | 18 August, 12:00 |
| 6. | Saint Thomas Acquinas SHS | | 18 August, 14:00 |
| 7. | EU delegation Ghana | Mr. Simon Rolland | 18 August, 15:00 |
| 8. | Kumasi Polytechnic | Mr. Edem Bensah | 19 August, 09:30 |
| 9. | Centre for Energy, Environment and Sustainable Development | Mr. Edward Antwi | 19 August, 10:30 |
| 10. | Biogas Engineering Limited (BEL), Kumasi | Dr. Elias Delali Aklaku | 19 August, 12:00 |
| 11. | KITA | Mr. Samuel Owusu-Takyi | 19 August, 15:00 |
| 12. | Kumasi Central Prison | Commander | 20 August, 10:00 |
| 13. | Kumasi Polytechnic | Attended a stakeholder meeting to establish Renewable Energy Centre at the Polytechnic | 20 August, 12:00 |
| 14. | Environmental Impact Limited | Mr. Daniel Osei-Bonsu | 20 August, 14:00 |
| 15. | Kumasi Anglican Senior High School | Head master and Administrator | 20 August, 15:00 |
| 16. | Kumasi central hospital | Administrator | 20 August, 16:00 |
| 17. | Accra Psychiatric Hospital | Administrator | 21 August, 10:00 |
| 18. | Achimota Senior High School | Headmistress | 21 August, 12:00<br>26 August, 9:00 |
| 19. | GIMPA | Mr. Lawrence K Avevor | 21 August, 15:00 |
| 20. | Tema International High School | Administrator | 22 August, 09:00 |
| 21. | SafiSana (Ashaiman) | Facility Manager on site (Seth) | 22 August, 10:30 |
| 22. | Central University College | Estate manager | 22 August, 11:30 |
| 23. | Ashaiman Senior High School | Mrs. Beatrice Mensah | 22 August, 13:00 |
| 24. | Tema Secondary High School | Assistant Headmaster | 22 August, 15:00 |
| 25. | Environmental Protection Agency (EPA) | Mr. Antwi-Boasiako Amoah | 25 August, 09:00 |
| 26. | Environmental Protection Agency (EPA) / UNFCCC Focal Point | Mr. Kyekyeku Yaw Oppong-Boadi | 25 August, 10:00 |
| 27. | Agykot Company Limited, www.agyakot.com | Mr. Samuel Agyapong | 25 August, 12:00 |
| 28. | Koajay Company Limited (Accra) | Mr. Charles Anan | 25 August, 15:00 |

| No. | Organisation | Name | Date and time |
|---|---|---|---|
| 29. | Achimota Senior High School | Headmistress | 26 August, 9:00 |
| 30. | Accra Girls Senior High School | Headmistress | 26 August, 10:30 |
| 31. | Accra High School | Administrator | 26 August, 11:30 |
| 32. | Embassy of the Kingdom of the Netherlands to Ghana | Mr. Fred Smiet | 26 August, 14:00 |
| 33. | Kumasi Institute of Technology, Energy and Environment (KITE) | Mr. Ishmael Edjekumhene | 26 August, 16:00 |
| 34. | Kumasi Institute of Technology, Energy and Environment (KITE) | Mr. Christopher Agyekumhene | 26 August, 16:00 |
| 35. | CSIR-IIR (Institute of Industrial Research) | Dr. Moses Duku | 27 August, 13:00 |
| 36. | Apana solutions ltd | Mr. Kwasi Twum | 27 August, 14:00 |
| 37. | Apana solutions ltd | Mrs. Obuafo Alnice | 27 August, 14:00 |
| 38. | Energy Commission, SE4ALL secretariat | Mrs Paula Edze | 27 August, 16:00 |
| 39. | SNV Ghana | Mr. Lovans Owusu-Takyi | 28 August, 08:30 |
| 40. | Beta Construction Engineers Ltd | Rev. Kofi Ahenkorah | 28 August, 11:00 |
| 41. | GIZ | Mr. Samuel Adoboe | 28 August, 14:00 |
| 42. | GIZ | Mr. Leslie M Aglanu | 28 August, 14:00 |
| 43. | Energy Commission | Mr. Kwabena Ampadu Otu-Danquah | 28 August, 16:00 |
| 44. | Biogas Technologies Limited | Dr. John Idan | 29 August, 09:30 |
| 45. | Ghana Prisons Service | Mr. E.Y. Adzator | 29 August, 12:00 |
| 46. | Ghana Prisons Service | Mr. Godwin Hoenyedzi | 29 August, 12:00 |
| 47. | EU delegation Ghana | Mr. Simon Rolland | 29 August, 14:30 |

**Table presenting all meetings and interviews from 30 September - 9 October 2014.**

In total 23 meetings were held resulting in meaningful feedback and / or information. The experts met with over 40 different people, relevant for this study, including the workshop organised on 8 October 2014 with 33 participants.

**Table 27 List of meetings held during second mission**

| No. | Organisation | Name | Date and time |
|---|---|---|---|
| 1. | Energy Commission | Mr. Kwabena Ampadu Otu-Danquah | 30 September, 13:00 |
| 2. | Energy Commission | Mr. Kwabena Ampadu Otu-Danquah | 1 October, 11:00 |
| 3. | Energy Commission | Mr. Kwabena Ampadu Otu-Danquah | 9 October, 13:00 |
| 4. | MESTI | Mr. Peter Dery | 1 October, 10:00 |
| 5. | Eco Bank | Mr. Mark Ofori Kwafo | 1 October, 13:00 |
| 6. | CTI Pfan / Power Africa | Mr. Albert Boateng | 1 October, 15:00 |
| 7. | USAID/West Africa | Kwabena Adom-Opare (Clean energy and Infrastrature) | 1 October, 16:00 |
| 8. | Danida | Mr. Lars Joker | 2 October, 11:00 |
| 9. | Danida | Mr Emmanuel Kodwo Sackey | 2 October, 11:00 |
| 10. | Kingdom of the Netherlands | Fred Smiet (First Secretary Water and Climate) | 2 October, 15:00 |
| 11. | UNDP Ghana | Mr. Paolo Dalla Stella | 2 October, 13:00 |

| **No.** | **Organisation** | **Name** | **Date and time** |
|---|---|---|---|
| 12. | Energy Commission, SE4ALL secretariat | Mrs. Paula Edze | 3 October, 09:00<br>7 October, 12:30 |
| 13. | UNEP GEF-SGP | Mr. George Ortsin | 7 October, 09:00 |
| 14. | World Bank | Mrs. Carol Litwin | 7 October, 11:00 |
| 15. | Energy Commission | Dr. Alfred K. Ofosu Ahenkorah | 7 October, 13:00 |
| 16. | Ghana Prisons Service | Mr. Godwin Hoenyedzi | 8 October, after WS |
| 17. | Ghana Health Service | Mr. Emmanuel K-Amoah | 8 October, after WS |
| 18. | Ghana Prisons Service | Mr. E.Y. Adzator | 8 October, after WS |
| 19. | EPA / UNFCCC Focal Point | Mr. Kyekyeku Yaw Oppong-Boadi | 8 October, 16:00 |
| 20. | EU delegation Ghana | Mr. Simon Rolland | 9 October, 11:00 |
| 21. | African Development Bank (AfDB) | Mr. Thierno Bah | 9 October, 14:00 |
| 22. | Biogas Technologies Limited | Dr. John Idan, Director | 9 October, 16:00 |
| 23. | SOVEC Investment company | Mr. Paul van Aalst | 10 October, 16:00 |

## Annex B. Stakeholder consultation Workshops

As part of the assignment, two stakeholder consultation workshops have been organised:

1. Workshop 1, 27 August 2014, 09:00-12:00, STEPRI, Accra
2. Workshop 2, 8 October 2014, 09:00-12:00, Best Western hotel, Accra

**Table 28 First biogas stakeholder consultation Workshop 27 August 2014**

| No. | Organisation | Name |
|---|---|---|
| | **Government Institutions** | |
| 1 | Energy Commission | Mr. Kwabena Ampadu Otu-Danquah |
| 2 | Energy Commission | Mr. Okai Emmanuel |
| 3 | Energy Commission, SE4ALL secretariat | Mrs. Paula Edze |
| 4 | Energy Commission | Mrs. Sandra Nyaaba |
| 5 | Environmental Protection Agency (EPA) | Mrs. Florence Agyei |
| 6 | Environmental Protection Agency (EPA) / UNFCCC Focal Point | Mr. Kyekyeku Yaw Oppong-Boadi |
| 7 | Ghana Health Service | Mr. Emmanuel K-Amoah |
| 8 | Ghana Prisons Service | Mr. E.Y. Adzator |
| 9 | Ghana Prisons Service | Mr. Godwin Hoenyedzi |
| 10 | CSIR-IIR (Institute of Industrial Research) | Dr. Moses Duku |
| 11 | Ministry of Energy and Petroleum | Mr. Wisdom Ahiataku-Togobo |
| 12 | Ministry of Energy and Petroleum | Mrs. Doris Duodu |
| 13 | Ministry of Environment, Science, Technology and Innovation | Mr. Peter Dery |
| 14 | Ministry of Trade and Industry (MOTI) | Mrs. Jane A Mensah-Onumah |
| 15 | Ministry of Trade and Industry (MOTI) | Mrs. Afia Gyambea Amouko |
| | **CSOs** | |
| 16 | ABANTU for Development | Mr. Kofi Karikari |
| 17 | Kumasi Institute of Technology, Energy and Environment (KITE) | Mr. Christopher Agyekumhene |
| | **Private Sector** | |
| 18 | Apana solutions ltd | Mr. Kwasi Twum |
| 19 | Apana solutions ltd | Mrs. Obuafo Alnice |
| 20 | Beta Contruction Engineers Ltd | Rev. Kofi Ahenkorah |
| 21 | Biogas Technologies Limited | Dr. John Idan |
| 22 | Biogas Engineering Limited (BEL), Kumasi | Dr. Aklaku |
| 23 | Consultant | Dr. Essel Ben Hagan |
| 24 | Environmental Impact Limited | Mr. Daniel Osei-Bonsu |
| 25 | Environmental Impact Limited | Mrs. Joyce Kwafo |
| | **Development Partners** | |
| 26 | GIZ | Mr. Samuel Adoboe |
| 27 | GIZ | Mr. Leslie M Aglanu |
| 28 | SNV Ghana | Mr. Lovans Owusu-Takyi |
| | **Financial Institutions and donor organisations** | |
| 29 | Eco Bank | Mr. Mark Ofori Kwafo |
| 30 | UNEP GEF-SGP | Mr. George Ortsin |
| | **Organisers** | |
| 31 | Partners for Innovation | Mr. E. Hanekamp |
| 32 | CEESD | Mr. Julius Cudjoe Ahiekpor |

**Table 29 Second biogas stakeholder consultation Workshop 8 October 2014**

| No. | Organisation | Name |
|---|---|---|
| | **Government Institutions** | |
| 1 | Energy Commission | Mr. Kwabena Ampadu Otu-Danquah |
| 2 | Energy Commission | Ms. Dorothy Adjei |
| 3 | Environmental Protection Agency (EPA) | Mrs. Florence Agyei |
| 4 | Ghana Health Service | Dr. Emmanuel K-Amoah |
| 5 | Ghana Prisons Service | Mr. Emmanuel Adzator |
| 6 | Ghana Prisons Service | Mr. Godwin Hoenyedzi |
| 7 | Institute of Industrial Research, Council for Scientific and Industrial Research (IIR-CSIR) / PSMD | Dr. Moses Duku |
| 8 | Ministry of Energy and Petroleum | Mrs. Gifty Tettey |
| 9 | Ministry of Environment, Science, Technology and Innovation | Mr. Peter Dery |
| | **CSOs** | |
| 10 | ABANTU for Development | Mr. Kofi Karikari |
| 11 | Kumasi Institute of Technology, Energy and Environment (KITE) | Mr. Christopher Agyekumhene |
| 12 | Global Alliance for Clean Cookstoves | Mrs. Sandra Nyaaba |
| | **Private Sector** | |
| 13 | Biogas Engineering Ltd. (BEL), Kumasi | Dr. E.D. Aklaku |
| 14 | Apana solutions Ltd. | Mrs. Obubuafo Allnice |
| 15 | Apana solutions Ltd. | Mr. Kwasi Twum |
| 16 | Beta Construction Engineers Ltd. | Rev. Nana Kofi Ahenkorah |
| 17 | Biogas Technologies Africa Ltd. (BTAL) | Dr. John Idan |
| 18 | Impact Environmental Ltd. | Mr. Daniel Osei-Bonsu |
| 19 | Impact Environmental Ltd. | Ms. Joyce Kwafo |
| 20 | Koajay Company Ltd. | Mr. Charles Annan |
| 21 | Koajay Company Ltd. | Mr. Paul Edward Kartey |
| 22 | CTI PFAN | Mr. Albert Boateng |
| 23 | ECOBANK | Mark O. Kwafo |
| | **Development Partners** | |
| 24 | Embassy of the Kingdom of the Netherlands to Ghana | Mr. Fred Smiet |
| 25 | Embassy of the Kingdom of the Netherlands to Ghana | Mrs. Mariska Lammers |
| 26 | GIZ | Mr. Leslie Mawuli Aglanu |
| 27 | SNV Ghana | Mr. Lovans Owusu-Takyi |
| 28 | UNDP Ghana | Mr. Paolo Dalla Stella |
| | **Organisers** | |
| 29 | Partners for Innovation | Mr. Emiel Hanekamp |
| 30 | CEESD | Mr. Julius Cudjoe Ahiekpor |
| 31 | Energy Commission | Mrs. Paula Edze |
| 32 | Energy Commission | Mr. Michael Abrokwa |

## Annex C. Potential sources of funding for institutional biogas in Ghana

**Commercial banks**

DBSA

Deutsche Bank

EcoBank

First Rand

MunichRe

Rand Merchant Bank

Standard Bank (Ventures Africa)

Standard Chartered Bank

Triodos

**DFIs**

ElectriFI

Dutch development bank (FMO)

KfW Green for Growth Fund

Norfund

**International Financing Institutes**

African Development Bank (AfDB)

GEEREF

InfraCo

UNEP

UNDP

World Bank

**Local and international private investors**

Acumen

Africa Enterprise Challenge Fund (AECF)

AlphaMundi Group Ltd

Angel Investment Network for Green Energy

CTI-PFAN

D-Capital

DOB

Global Villages Energy Partnership International (GVEP)

Grassroots Business Fund (GBF)

NOTS

Persistent Energy Partners

SOVEC

TriLinc Global

**Foundations and funds**

African Biofuels and Renewable Energy Company (ABREC)

African Renewable Energy Access Program (AREAP)

African Renewable Energy Fund (AREF)

Akuo Foundation

Ashden Awards - International Awards for Sustainable Energy

Ashden Trust – Climate Change

Carbon War Room

Charles Stewart Mott Foundation - International Finance for Sustainability

Ecowas bank for investment and development (EBID)

Energy Access Foundation (EAF)

energy4everyone

French Global Environment Facility (FFEM)

GDF SUEZ Foundation - Energy, Climate, and Biodiversity

Global Alliance for Clean Cookstoves

Good Energies Foundation

Hivos - Green Entrepreneurship

Livelihoods Fund - Funding for Agroforestry, Mangrove Restoration, and Rural Energy

Minor Foundation for Major Challenges - Public Awareness on Climate Change

Oak Foundation – Climate Change

OPEC Fund for International Development (OFID)

Rockefeller Brothers Fund – Climate Change and Clean Energy

Stiftung Mercator - Climate Change

SunFunder

Sustainable Energy Fund for Africa (SEFA)

Swiss International Finance Group AG (SIFG)

The Africa Enterprise Challenge Fund (AECF)

The Clinton Foundation

The Ghana Renewable Energy Fund

The Light Foundation

The Mary Robinson Foundation - Climate Justice (MRFCJ)

The Solarillion Foundation

The SunEdison Rural Energy Fund (SREF)

UNFCCC - Adaptation Fund

USAID - Development Innovation Ventures

Venture Capital for Africa (VC4A)

WB - GEF Projects for Global Environment

WB - GEF Small Grants Program

WB - Global Partnership on Output-Based Aid (GPOBA)

WB - Public-Private Infrastructure Advisory Facility (PPIAF)

Wuppertal Institute - Sustainable Energy Project Support (SEPS)

## Annex D. Literature


[01] Cost-Benefit Analysis of national and regional (integrated) biogas and sanitation programs in SSA.; April 2007; Winrock International; Financial and economic cost-benefit analysis of an integrated household-level biogas, latrine, and hygiene PROGRAM in Sub-Saharan Africa and other countries, to help inform investment decisions.

[02] Biogas effluent and food production in Ghana; March 2008; E. C. Bensah and A. Brew-Hammond; institutional; Trend of biogas technology dissemination in Ghana, overview utilisation of effluent from biogas plants in Ghana and overview of 14 major biogas installations.

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[04] Ghana SE4ALL CAP; Energy Commission; The document provides a roadmap for the country to achieve the SEA4LL goals and targets; 2012.

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[08] Dissemination and Problems of African Biogas Technology 2013; July 2005; Mulinda et al; Present status of biogas technology in Africa, focusing on biogas market potential, stake-holders, investments and bottlenecks.

[09] 2013 Energy Outlook for Ghana; April 2013; Energy Commission; Energy outlook for all fuel and energy types for Ghana.

[10] Feasibility study: Constructing a biogas plant for a boarding school in Cape Coast; March 2011; RWTH Aachen Morgan State University; This report looks at the potential use of biogas to provide fuel and improve sanitation at the Mfantipim Boys Senior High School in Cape Coast, Ghana.

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[12] Biogas utilization and it's agricultural implications in Ghana; Ms. Christine Osei-Safo; The Ministry of Energy and Mines seeks to resolve the energy supply problems by introducing biogas technology. This paper presents the results of a study on using slurry.

[13] Biogas - Costs and Benefits and Biogas Programme Implementation; 1999; GIZ, ISAT; Biogas Costs and Benefits for households, country or the society and implementing a biogas programme.

[14] Edem Cudjoe Bensah, Edard Antwi and Julius Cudjoe Ahiekpor; Improving sanitation in Ghana - Role of Sanitary Biogas plants; Journal of Engineering and Applied Sciences 5 (2): 125-133; 2010.

[15] B. Amigun, W. Parawira, J. K. Musango, A. O. Aboyade and A. S. Badmos (2012). Anaerobic Biogas Generation for Rural Area Energy Provision in Africa, Biogas, Dr. Sunil Kumar (Ed.), ISBN: 978-953-51-0204-5, InTech, Available from:

http://www.intechopen.com/books/biogas/anaerobic-biogas-generation-for-rural-areaenergy-provision-in-africa

[16] Integration of Biogas Technology into Farming System of the three Northern Regions of Ghana; 2011; Emmanuel Amankwah.

[17] The private biogas sector in Tanzania: The companies are coming; Aug 2012; Alexander Dijkstra; Analysis of private sector development of Biogas Constructing Enterprises in Tanzania and way forward.

[18] Ghana Water Forum: Meeting Ghana's MDG Target on Sanitation through dissemination of biogas plants; Sep 2011; Richard Arthur, Edward Antwi.

[19] Physical Feasibility of Domestic Biogas in the Upper East region of Ghana; Jan 2008; Rajesh B. Shrestha, Ben Alenyorege.

[20] Operating and Financing a Family Biogas Plant; May 2012; Emmanuel Dioha, Joseph Dioha and Bruno Nfor; The paper studied the overview of activities of biogas operations in different parts of the world and the technology involved in the production of biogas from anaerobic digestion of organic wastes in a biogas plant. Different designs of biogas plants operating in different places in the globe were highlighted.

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[23] Case studies of Productive Biogas in Vietnam, Uganda, Honduras, Mali and Peru; April 2014; Fact foundation; Five case studies of productive biogas, none of them using human excreta.

[24] Renewable Energy export changes (for Dutch companies), via international organisations, with a focus on Africa [Dutch]; 2014; Netherlands Enterprise Agency (RVO); Opportunities for funding of projects, projects financing and assignments from international organisations.

[25] Biogas experience in Africa; the case of Ghana; Feb 2010; W. Ahiataku-Togobo.

[26] Biogas as a potential renewable energy source: A Ghanaian case study; May 2010; R. Arthur, M. Francisca Baidoo, E. Antwi; This paper presents the energy situation and the status of the biogas technology and utilization in Ghana. It also presents the potential benefits, prospects and challenges of the biogas technology.

[27] Draft bioenergy policy for Ghana; Aug 2010; Energy Commission.

[28] Status and prospects for household biogas plants in Ghana – lessons, barriers, potential, and way forward; May 2011; E. Cudjoe Bensah, M. Mensah, E. Antwi; Good overview off all important aspects for our study.

[29] Sonic Biogas training; Sonic Biogas Technology is an organization training individuals to become professional biogas technician within six months.

[30] RE tariff methodology for electricity generation; Sep 2009; PwC.

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[34] Feasibility Study for a National Domestic Biogas Programme in Burkina Faso; 2007; GTZ; Structure of Feasibility report and elements for national programme.

[35] Feasibility Study Report on domestic biogas in Ghana - revised draft; March 2008; KITE; Table 3-1: Profile of Selected Biogas Service Providers and Annexes with: Biogas Initiatives in Ghana and Cost Breakdown of Fixed Dome Digesters.

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[39] Market-based biogas sector development in least developed countries —The case of Cambodia; May 2013; Eric Buysman, Arthur P.J. Mol; Cambodia; After 7 years the National Biodigester Programme (NBP) in Cambodia shows: the development of a sustainable domestic biodigester sector and a rapid diffusion of biodigesters among poor rural households. But also that governmental regulation and coordination will remain needed, and carbon finance will not easily fully replace ODA and governmental financial support.

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[43] Business Opportunities for Renewable Energy in Ghana; May 2014; RVO.nl; short report describing the opportunities for Dutch companies in Ghana focussed on Renewable Energy.

[44] Country Monitor Ghana; May 2014; RVO.nl; Short report describing the opportunities for Dutch companies in Ghana focussed on biomass and bioenergy.

[45] Bioenergy for Rural Development in West Africa; The case of Ghana, Mali and Senegal; Sep 2010; ENDA; Case studies for bioenergy in the three countries.

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## Annex E. Draft National Institutional Biogas-Sanitation Program

This annex presents a draft National Institutional Biogas-Sanitation Program. It addresses the following topics:

> *Objectives*
> *Action plan and Log frame*
> *Key partners and stakeholders*
> *Finance plan (with CDM component)*
> *Selection process and criteria for the location of the 200 biogas systems*

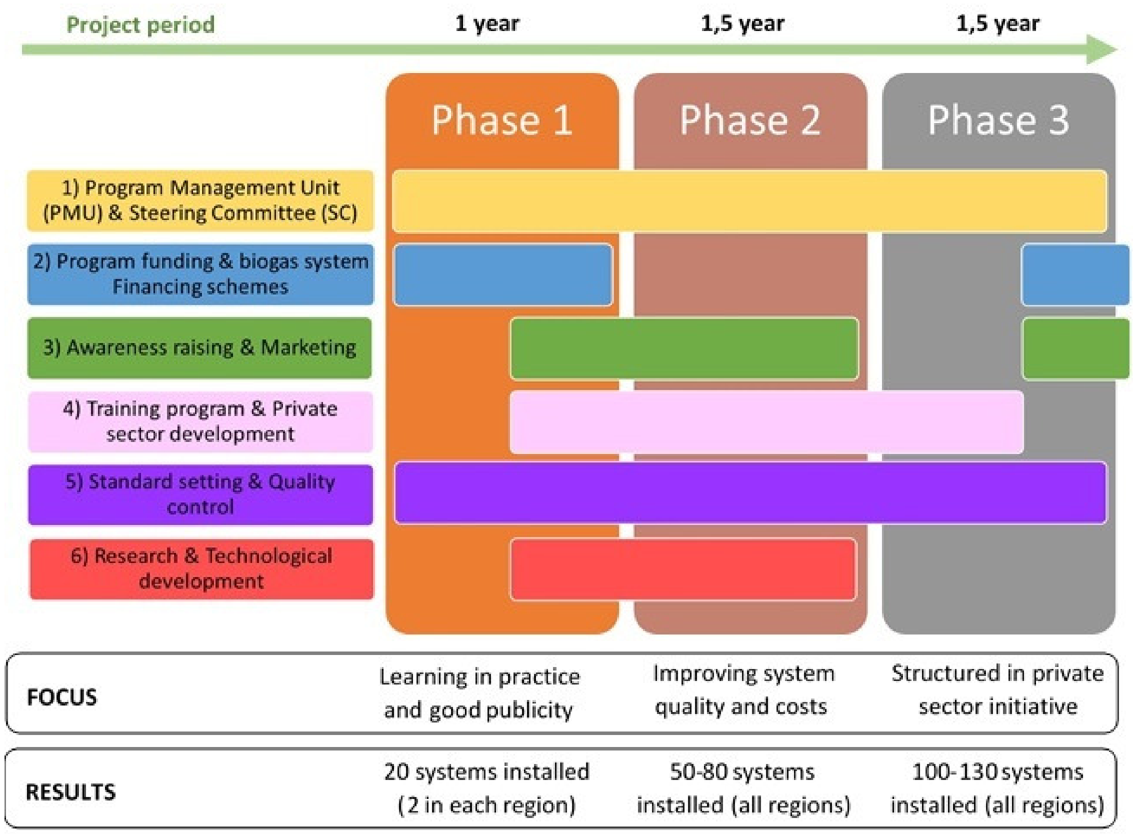
**Objectives**

The NIBP overall objective is: "**Kick-start the development of a biogas market and biogas private sector in Ghana**".

The project specific objective is: "**Implement 200 institutional biogas-sanitation systems in public hospitals, prisons and public boarding schools between 2015 and 2019**".

**Action plan and log frame**

Actions can be structured in 3 phases and 6 activity lines.




The following log frame details the activities inputs and (re)sources.

| A NATIONAL INSTITUTIONAL BIOGAS-SANITATION PROGRAM (NIBP) | | | |
|---|---|---|---|
| **OBJECTIVES** (What you want to achieve) | **INDICATORS** (How to measure change) | **MEANS OF VERIFICATION** (Where & how to get information) | **ASSUMPTIONS / RISKS** (What else to be aware of) |
| **Goal:**<br>Kick-start the development of a biogas market and biogas private sector in Ghana | G1 50-100 additional biogas-sanitation systems are operational annually<br>G2 majority of the systems are built and maintained by Ghanaian companies | G1 Energy Commission (EC) - Energy Outlook for Ghana, SE4ALL Ghana Newsletter and reports<br>G2 survey done by EC / Energy company records of EC | |
| **Outcome 1**<br>In 2018, 200 institutional biogas-sanitation systems are fully functioning and economically viable | 1a >90% of institutions (boarding school, prison or public hospital), are content with system<br>1b biogas is being used in >90% of the cases | 1a + 1b EC project records / or survey | Institutions do want the biogas systems and are willing to pay (partly) for it |
| **Outputs**<br>1.1 200 biogas-sanitation systems are built according to standards | 1.1 200 systems are quality checked and approved | 1.1 Project Quality Control unit | Quality Control is done well and objectively |
| 1.2 All installations are properly managed | 1.2 Each installation is managed by a knowledgeable person(s) / company | 1.2 Institutions survey + audit | Quality Control is done well and objectively |
| 1.3 All installations are properly serviced & maintained | 1.3 Each installation is serviced & maintained by a knowledgeable person(s) / company | 1.3 Institutions survey + audit | Sufficient # of good service & maintenance companies |
| 1.4 Program is well managed and aligned with societal developments | 1.4a Involved stakeholders are satisfied with the process and results of the program<br>1.4b Results are realised within time and budget | 1.4a Survey amongst involved stakeholders<br>1.45 Review of program results | |
| 1.5 Private sector has sufficient qualified staff available | 1.5 Installations are built on time and meet the standard(s) | 1.5 Project assessment by Quality control Unit | |
| 1.6 Standard biogas-sanitation system is cost-effective and efficient | 1.6 IRR for institutions is less than 6 years (substituting pit-latrines) and less than 3 years for new installations. | 1.6 Economic assessment by research institute or consultant | Material and labour costs will not increase too much |

| A NATIONAL INSTITUTIONAL BIOGAS-SANITATION PROGRAM (NIBP) | | | |
|---|---|---|---|
| **OBJECTIVES**<br>(What you want to achieve) | **INDICATORS**<br>(How to measure change) | **MEANS OF VERIFICATION**<br>(Where & how to get information) | **ASSUMPTIONS / RISKS**<br>(What else to be aware of) |
| 1.7 Program funding secured and biogas-sanitation system financing scheme is available | 1.7a Budget for NIBP is available<br>1.7b Financing scheme is available and being used by institutions | 1.7a SC agrees to start of program<br>1.7b Number of financing agreements with institutions | |
| **Activities (for output 1.1)**<br>1.1.1 Set-up Q-control Unit for standard setting & Q-control<br>1.1.2 Marketing and selection of appropriate institutions<br>1.1.3 Tender (groups of) the installations to be build<br>1.1.4 Perform Q-control of installation work | ***Input/ Resources***<br>1.1.1 Office space and office equipment (furniture, computers, phones, printers, and etc.) for Q-control Unit for four years<br>1.1.2 Marketing team, -campaign and -materials | ***Costs & sources***<br>2 full-time persons and 1 support staff (Q-control Unit) and 1 full-time person (Marketing). Offices and equipment are in kind contributions from Ministries and Research Institutes | All relevant Ministries and Research Institutes support NIBP<br>Program Funding is secured and program is supported by donor and international development organisations |
| **Activities (for output 1.2)**<br>1.2.1 Create institutional awareness: management of installations<br>1.2.2 Set-up installation management training for institutions<br>1.2.3 Regular check of management | ***Input/ Resources***<br>1.2.1 Information campaign including materials.<br>1.2.2 Training Unit, training programme and training materials<br>1.2.3 Q-control of decent management | ***Costs & sources***<br>In total 1/2 full-time person (part of Q-control team) for training and good management audits | Institutions are not able / willing to pay for good management |
| **Activities (for output 1.3)**<br>1.3.1 Arrange service & maintenance are integral part of installations<br>1.3.2 Regular check of decent service & maintenance | ***Input/ Resources***<br>1.3.1 –<br>1.3.2 Q-control of decent service & maintenance | ***Costs & sources***<br>In total 1/2 full-time person (part of Q-control team) for service & maintenance audits | Institutions are not able / willing to pay for good management |
| **Activities (for output 1.4)**<br>1.4.1 Set-up Program Management<br>1.4.2 Organise regular Steering Committee (SC) meetings | ***Input/ Resources***<br>1.4.1 Program Management Unit (PMU)<br>1.4.2 Meeting room, drinks and snacks | ***Costs & sources***<br>In total 2 full-time and 1 support staff. Office and equipment in kind contributions key stakeholders | All relevant Ministries and Research Institutes support the project |

| A NATIONAL INSTITUTIONAL BIOGAS-SANITATION PROGRAM (NIBP) | | | |
|---|---|---|---|
| **OBJECTIVES**<br>(What you want to achieve) | **INDICATORS**<br>(How to measure change) | **MEANS OF VERIFICATION**<br>(Where & how to get information) | **ASSUMPTIONS / RISKS**<br>(What else to be aware of) |
| **Activities (for output 1.5)**<br>1.5.1 Discuss with private sector the availability of qualified staff<br>1.5.2 Develop a sector wide training course for biogas masons | ***Input/ Resources***<br>1.5.1 Individual and group meetings with private sector<br>1.5.2 Regular biogas mason training (theory and practice) for 2 years | ***Costs & sources***<br>Biogas mason training (private training company or research institute) | Private sector involvement |
| **Activities (for output 1.6)**<br>1.6.1 Research & Technological development to improve cost-effectiveness and efficiency | ***Input/ Resources***<br>1.6.1 Research Institutes have several research projects aimed at cost reduction and efficiency improvement | ***Costs & sources***<br>Research Institutes staff and lab facilities. Partly in kind contribution from Research Institutes | Coordinated and aligned research of several research institutes |
| **Activities (for output 1.7)**<br>1.7.1 Present NIBP program to donor and financing institutes<br>1.7.2 Develop financing scheme | ***Input/ Resources***<br>EC and consultant prepare plan and financing scheme and present to international donor and financing institutes | ***Costs & sources***<br>EC in kind contribution. 50-100.000 euro for consultancy. | Interest from international donor organisations and financing institutes |

**Key partners and stakeholders**

Key partners for set-up of the program are listed in the table below.

| Programme activity | First-mover institutions for phase 1 of the NIBP |
| --- | --- |
| 1) Program Management Unit & Steering Committee (including policy development and enforcement) | Energy Commission (lead organisation), MESTI, MoP, EPA, Ministry of Health, Ministry of Education and Ministry of Interior |
| 2) Program funding & biogas financing schemes | Financing organisations, donor and international development organisations (AfDB, WB / GEF, Danida, USAid, SNV, GIZ and UNDP) |
| 3) Awareness raising & Marketing | Energy Commission, GPS, GHS, GES (and related Ministries) |
| 4) Training program & Private sector development | Donor and international development organisations (see above), national Research Institutes (IIR, KNUST, Kumasi Polytechnic, Valley View University, CSIR) and private biogas sector |
| 5) Standard setting & Quality control | Research Institutes (see above), MESTI, MoP and EPA |
| 6) Research & Technological development (including impact monitoring) | Research Institutes (see above) and local NGOs (KITE, ABANTU, CEESD, Friends of the Earth Ghana, and NCRC West Afrika) |

Other stakeholders and potential partners are listed in the tables in chapter 7.

**Finance plan**

The costs for the NIBP is estimated to be 20 million USD. The majority (>80%) being costs for the 200 biogas-sanitation installations (material, equipment and labour).

For the NIBP, the lead times are too long, costs for acquiring CDM funds too high and financial benefits too insecure. Funding from CDM is not an option for the NIBP but can fulfil part of the funding needed in purely private sector led initiative when long-term funding is needed.

Financing for the NIBP should come from mixed sources and will be both financial and in kind. The following table presents a first idea for the funding sources for NIBP.

**Table 30 Funding sources for NIBP**

| Funding need | Source of funding |
| --- | --- |
| Basic NIBP funding: financial | Energy Fund and WB/GEF |
| Biogas financing schemes: both financial and in kind | Danida, GIZ, USAid and local commercial bank |
| Private sector development: both financial and in kind | SNV, Danida, GIZ, USAid and private sector |
| Training program: both financial and in kind | SNV, Danida, GIZ, USAid, IIR, KNUST, Kumasi Polytechnic, Valley View University and CSIR |

| | |
|---|---|
| Standard setting: both financial and in kind | IIR, KNUST, Kumasi Polytechnic, Valley View University, CSIR, MESTI, MoP and EPA |
| Research & Technological development: both financial and in kind | IIR, KNUST, Kumasi Polytechnic, Valley View University and CSIR |

For a more elaborate finance plan for NIBP the following 3 activities need to be executed:

***A. A more detailed inventory of user needs and cost-benefit analysis***

Unfortunately the inventory of user needs and the data for the cost-benefit analysis shows too much variation. Therefore the following activities are proposed:

> *Inventory of the user needs for a biogas system and the current costs for sanitation, cooking fuels and, if relevant, fertilisers (30-50 schools, 10 prisons and 20 hospitals throughout the country and preferably evenly spread over the 10 regions)*
    - *Meetings with Ghana Prisons Service, Ghana Health Service / Min. of Health and Ghana Education Service / Min. of Education, to select institutions and agreement on how to approach the institutions*
    - *Set-up and carry out user needs and costs inventory with institutions*

> *Set-up and collect more detailed cost estimates for biogas systems*

> *Verify collected data and analyse results*

The expected result is a solid cost-benefit analysis report.

***B. Financial analysis and structuring of the programme in parallel with institutional structuring***

The following activities are proposed:

> *Securing the regulatory framework, procedures/rules and mandates are in line with intended programme (several meetings with relevant governmental organisations), e.g. schools are allowed and able to invest in a biogas system*

> *Discussions with biogas private sector on the financial analysis and structuring of the programme and assessment of their ability and willingness to engage with the proposed structuring*

> *Prepare financial (cash-flow) and operational scenarios for the programme*

The expected result is a proposal how to financially structure the programme. The actual fundraising is not part of this work.

***C. Draft a detailed programme plan and secure funding***

The following activities are proposed:

> *Select the first most appropriate institutions.*

> *In close cooperation with the Energy Commission a first programme plan is drafted*

> *The plan and financial structuring is discussed with potential donors and supporters*

> *The programme is adapted to the needs of donors and supporters*

> *Funding and support is officially requested by the Ghana Energy Commission from the selected donors /supporters*

The expected result is a detailed programme including secured funding and support from international donors.

**Selection process and criteria for the location of the 200 biogas systems**

For a successful National Institutional Biogas Programme it is advised to select institutions most likely to be successful, which inter alia implies that they should be able to utilize all potential socio-economic, environmental and financial benefits. This is:

> *Good for publicity and marketing*
> *Good for all stakeholders involved*
> *Most cost-efficient and*
> *Will provide the necessary information to be able to assess the positive impacts.*

For the first phase of NIBP, the most successful 20 institutions (2 in each region) should be selected in order to function as showcases in their respective regions. The selection criteria for the selection of institutions in phase 1 are:

1. *High financial commitment from institutions throughout the technical lifetime of the system*
2. *Institutions willing and committing to use both biogas and effluent*
3. *Institutions willing and committing to operate the plant (after training) / or pay a service provider to do it.*

Large prisons and boarding schools offering agricultural science seem the most promising at this stage.

For phases 2 and 3 the same selection criteria are valid.