4 Republic of Ghana

4.1 PESTLE or Macro Analysis

Introduction

Despite the abundant availability of feedstock for biogas generations in Ghana, the country is yet to develop a major programme that will promote the dissemination of biogas plants on a larger scale. The successful implementation of a biogas projects will depend on macro-environmental factors including financial and economic, policy and regulatory, socio-cultural, as well as technological and environmental challenges. Currently, there is no suitable financing mechanism available for renewable energy projects in Ghana, specifically biogas. Further, the lack of biogas specific technical, operational and management expertise hinders the implementation and demonstration of successful biogas plants on a large scale.

Interest in biogas technology in Ghana began in the late 1960s but it was not until the middle 1980s that biogas technology received the needed attention from government. Dissemination programmes before the mid-1980s focused on the provision of energy for domestic cooking. Most plants, however, collapsed shortly after the duration of projects due to immature technologies and poor dissemination strategies. Generally, biogas technology dissemination has faced several challenges, many of which may have discouraged the widespread dissemination of the technology. Some of these challenges among others include; poor level of construction, lack of skilled attendants, and poor maintenance (Bensah et al., 2015). These challenges cut across political, economic, social, technological, legal, and environmental spheres of our daily lives.

A PESTLE analysis is a framework or tool used to analyse and monitor the macro-environmental factors that may have a profound impact on an organisation's performance (see introduction section for more explanation). This framework is being used to analyze the political, economic, social, technological, legal, and environmental factors affecting the bioenergy industry in Ghana.

4.1.1 Political Aspects

National target and strategies

Generally, high political stability provides a stable and friendly business environment with predictable market growth trends. However, when there is political chaos, it deters investors and harms the stakeholders' trust in economic and consequent organizational performance. Ghana was the first in the Sub-Saharan African countries to gain political independence in 1957. The country has experienced the overthrown of government through high incidence of various military coup d'états. The 1992 election saw the first democratic government been elected to office and since then the country has seen a stable governance over the last two decades with successive elections. The country is ruled by two main political parties changing hands every two election cycles (eight years). Ghana has been touted as one of the best democratic countries in the African continent due to its strong adherence to democratic principles and respect

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for human rights[62]. This assertion is further collaborated in a global competitiveness report which indicated government instability as the least problematic in Ghana[63]. Despite these political gains the country is still plunged with high infrastructure deficit like roads and hospitals, as well as high inflation rate and unemployment (Fox, L., et al., 2011). The country is still battling with high levels of corruption with the country scoring 41% (80th country out of 180 countries) out of a possible clean score of 100 in 2019, according to Transparency International[64]. To deal with this, government has put certain mechanisms in place including the establishment of anti-corruption agencies such as the Commission on Human rights and Administrative Justice (CHRAJ), the Audit service, Economic and Organize crime Office (EOCO), Serious Fraud Office (SFO), the Special Prosecutors Office (SPO) and others.

Successive government has been able to put policies and programmes in place to mitigate measures to address political barriers in the energy and renewable energy sector. This is to avoid the disruption of projects in the case of government change over. Unfortunately, biofuels (biogas, biodiesel, and bioethanol) have not been adequately developed to play a major role in the energy mix of Ghana. For instance, in the Strategic National Energy Plan (SNEP) 2006-2020, the potential contribution of biogas technology towards the growth of the energy sector was not represented compared to other renewable energy options such as wind and solar. Renewable energy installations have seen a dramatic increase from about 3 MW in 2013 to about 43 MWp by end of 2017. In 2017, Installations by registered vendors totaled about 5 MW with over 85% in grid-connected areas[65]. In 2018, a 20 MWp solar PV plant was built, commissioned, and connected to the national grid. In order to realize a reduction in the share of wood fuel in the national energy mix from 60% in 2006 to 40% in 2020 as stipulated in SNEP, there is the need to promote research and development in other renewable energy options including biogas technology.

Energy: Ghana's power supply sources are from hydroelectricity, thermal fueled by crude oil, natural gas, and diesel, and solar. Ghana also exports power to Togo, Benin, and Burkina Faso. Ongoing grid expansions would allow further exports to other neighbouring countries in the sub region. Ghana has a vibrant power generation terrain with players from both the public and private sectors. Reforms in the Power Sector in the 1980's gradually removed barriers and created a level playing field for the participation of independent power producers (IPPs) in an area which hitherto had only public sector participants. The total installed capacity for existing power plants in Ghana is 4,132MW consisting of hydro 38%, thermal 61% and solar contributing less than 1% (Agyenim et al., 2020).

As at the end of 2017, the **installed electricity generation capacity** supplying the main grid of the country was about **4,310 Megawatt (MW)**. The installed capacity increases to **4,398.5**

[62] Kwesi Anning et al. (2012). Managing Election – Related Violence for Democratic Stability in Ghana. Friedrich-Ebert-Stiftung. ISBN: 9988-572-26-3

[63] http://www3.weforum.org/docs/GCR2017-2018/05FullReport/TheGlobalCompetitivenessReport2017–2018.pdf

[64] https://tikenya.org/wp-content/uploads/2019/01/2018-Corruption-Perception-Index.pdf

[65] Mohammed, Mutala; Agyenim, Francis; Dzamboe, Pax; Bawakyillenuo, Simon; Okrofu, Raymond; Decker, Edward; Agyemang, Victor; Nyarko, Eric. (2020). Powering communities using hybrid solar biogas in Ghana, a feasibility study. Environmental Technology & Innovation

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MW if primary embedded generation including the two major solar power plants at the sub-transmission (distribution grid) level is added. This was an expansion about 16% over the installed capacity in 2016. Total grid electricity generation in the country including the embedded generation was **14,069** Gigawatt-hours (GWh), comprising 39.9% hydro, 59.9% thermal and about 0.2% solar power (Energy Commission, 2018).

Table 16: Installed Grid Electricity Generation Capacity (Agyenim et al., 2020)

GENERATION PLANT		FUEL TYPE	CAPACITY (MW)				TOTAL GENERATION		
			Installed (name plate)	% Share	Average Dependable	Average Available	GWh	% Share (incl.embedd)	% Share (excl.embedd)
Hydro Power Plants	Akosombo	Hydro	1,020		900	505	4,282	*30.5*	*30.6*
	Bui	Hydro	400		340	205	582	*4.1*	*4.2*
	Kpong	Hydro	160		140	115	752	*5.3*	*5.4*
		Sub-Total	***1,580***	***35.9*[@] 36.7***	***1,380***	***825***	***5,616***	***39.9***	***40.2***
Thermal Power Plants[11]									
Takoradi Power Company (TAPCO)		Oil/NG	330		300	200	686	*4.9*	*4.9*
Takoradi Inter. Company (TICO)		Oil/NG	340		320	260	1,880	*13.4*	*13.4*
Sunon–Asogli Power (SAPP)		NG	560		520	180	1,417	*10.1*	*10.1*
Kpone Thermal Power Plant(KTPP)		Oil/DFO	220		200	20	124	*0.9*	*0.9*
Tema Thermal Plant1 (TT1P)		Oil/NG	110[12]		100	70	365	*2.6*	*2.6*
Tema Thermal Plant2 (TT2P)		Oil/NG	80		70	1	0.5	*0.0*	*0*
CENIT Energy Ltd (CEL)		Oil/NG	110[12]		100	30	59	*0.4*	*0.4*
AMERI		NG	250		230	200	1,229	*8.7*	*8.8*
Karpower		HFO	470		450	225	1,814	*12.9*	*13.0*
AKSA		HFO	260		220	100	799	*5.7*	*5.7*
		Sub – Total	***2,730***	***63.3***	**2,510**	**1,286**	**8,373.5**		
	Trojan*	Diesel/NG	44		40	30	52	*0.4*	-
	Genser*	Coal/LPG	22		18	0	0	*0*	-
Sub-total (including embedded generation)			***2,796***	***63.6***	***2,568***	***1,316***	***8,425.5***	***59.9***	
Renewables*	VRA Solar	Solar	2.5		1.5	1.5	3.0	0.02	
	BXC Solar	Solar	20		16	10	25	0.18	
		Sub – Total	*22.5*	*0.5*	11.5	11.5	***28.0***	***0.2***	
Total *(including embedded generation+ Solar)*			**4,398.5**		***3966***	**2,198**	**14,069**		
Total *(excluding embedded generation and solar)*			**4,310**		**3,890**	**2,156**	**13,989**		

*NG is Natural gas. * Sub-transmission (primary embedded) connection. [@]Including embedded generation and solar.*

Transmission of power is under the responsibility of the Ghana Grid Company (GRIDCo) which was established in 2006. GRIDCo operates in accordance with the Energy Commission Act, 1997 (Act 541) and the Volta River Development (Amendment) Act, 2005 (Act 692). These guarantee the establishment and exclusive operation of the National Interconnected Transmission System by an independent public utility and the separation of transmission functions of the Volta River Authority (VRA) from its other activities within the framework of the Power Sector Reforms. Government through the Ministry of Energy is embarking on major projects aimed at addressing transmission challenges through progressive replacement of outdated and obsolete equipment and reinforcement of others including the construction of 161KV and 330KV transmission lines, construction of new substations across the country, as well as the expansion of some existing substations and installation of capacity banks.

Lack of Prioritization of Biogas for Energy Generation: In 2018 the Energy Outlook of Ghana was published by the Energy Commission, but the document insufficiently referred to

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biogas. Biogas is largely seen as an intervention in the sanitation sector. In Ghana, the prevalent type of biogas plants is that of small to medium sized scale. An assessment of the Energy Commission in 2018 on the state of biogas installations in Ghana revealed that the vast majority is using it only for sanitation purposes. One of the main associated challenges identified was inadequate feedstock for the needed gas and poor maintenance. As a result, the vast majority of users only adopt for sanitation purposes.

Governance: Ghana's Energy Commission 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 implementation of the Sustainable Energy for All (SE4ALL) Country Action Plan (CAP). An activity was formulated within the SE4ALL CAP "*to conduct a feasibility study to establish institutional biogas systems for 200 boarding schools, hospitals and prisons*" with 2012-2015 as reference for the implementation timeline. The purpose of this activity was to bring the use of biogas as a low carbon energy source to a significant higher level in Ghana. The 200 systems were to act as a catalyst to stimulate and accommodate further implementation of biogas for productive usage in the country, with a long-term objective of developing a self-sustaining biogas market in Ghana. However, due to lack of government commitment and investment, the project is yet to be implemented. Notwithstanding, some institutions have initiated to install biogas projects to deal with their waste management such as the 200m^3 biogas facility at Mfantsipim Senior High School located in Cape Coast, the 70m^3 biogas plant at Tamale SOS Village Biogas Plant and the biogas plant at Ankaful Maximum Prison Centre in Cape Coast.

4.1.2 Economic Aspects

The economic stability of a country indicates the country's financial system characterized by little fluctuations in the macro-economy (output growth) and fairly consistent low inflation (Business Dictionary 2012). Ghana was the second-fastest growing economy in Africa in 2017, with growth of 8.1%, driven by the mining and oil sectors (Macrotrends, n.d.). Ghana's economic stability can be attributed to factors such as inflation rates, taxes, interest rates, exchange rates, trading regulations and excise duties. The economy continued to expand in 2019, with real GDP growth estimated at 7.1%. High growth momentum since 2017 has consistently placed Ghana among Africa's 10 fastest-growing economies[66]. However, rebasing of the year (Ghana rebased its economic calculations from the base year of 2006 to 2013, determining GDP to be GHS257bn ($53bn) in 2017, a 26% increase from the GHS204bn ($42bn) the IMF calculated previously[67]) and effective macro-economic policies are the main economic factors with monetary policy considered as more powerful in promoting economic growth in Ghana. The current government has adopted several macro-economic policies such as the Public Financial Management Act, 2019 (L.I. 2378) to ensure prudent management of the economy. These measures have enhanced the economic growth of the country from 7.9% year-on-year in the fourth quarter of 2019 from that of the previous year's 5.6% (Macrotrends, n.d.). In the 2019 'Doing Business' Report published by the World Bank (2019)[68], Ghana has improved its worldwide ranking to 114 out of 190 economies up six places from being ranked 120th in the

[66] https://www.afdb.org/en/countries/west-africa/ghana/ghana-economic-outlook
[67] https://oxfordbusinessgroup.com/news/gdp-rebasing-improves-ghana's-economic-outlook
[68] https://www.doingbusiness.org/content/dam/doingBusiness/media/Annual-Reports/English/DB2019-report_web-version.pdf

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2018. The country's ease of doing business score formerly called distance to frontier has also increased by 2.06 to 59.22. The report indicates Ghana's progress reforms in three key areas. Firstly, government has made it easier to deal with construction permits by strengthening construction quality control by imposing stricter qualification requirements for professionals in charge of technical inspections. Secondly, the government has made it easier to pay taxes, by allowing financial losses to be fully carried forward during any of the following five years of assessment; and lastly, the government has made it easier to trade across borders, by implementing a paperless customs clearance processing system. Furthermore, investor confidence has increased due to the government's prudent fiscal and monetary measures which has resulted in a decrease in the interest rate with a corresponding increase in the banks' lending rate—which ultimately bolster investor confidence. Inflation and exchange rate of the local currency have also seen some fluctuation over the years. Inflation has seen a sharp decline of 7.31% from 2014 to 2018. It continues to fall from its peak of 19.2% in March 2016 to 9.4% in December 2018[69]. Additionally, the fluctuations in the exchange rate have had an impact on the economy. The Ghanaian cedi has come under considerable pressure over the last decade. At the end of 2018, the cedi had depreciated against the US dollar by 8.9%, cumulatively. Figure 20 below shows Ghana's GDP growth whereas Figure 21 indicates the inflation rate.

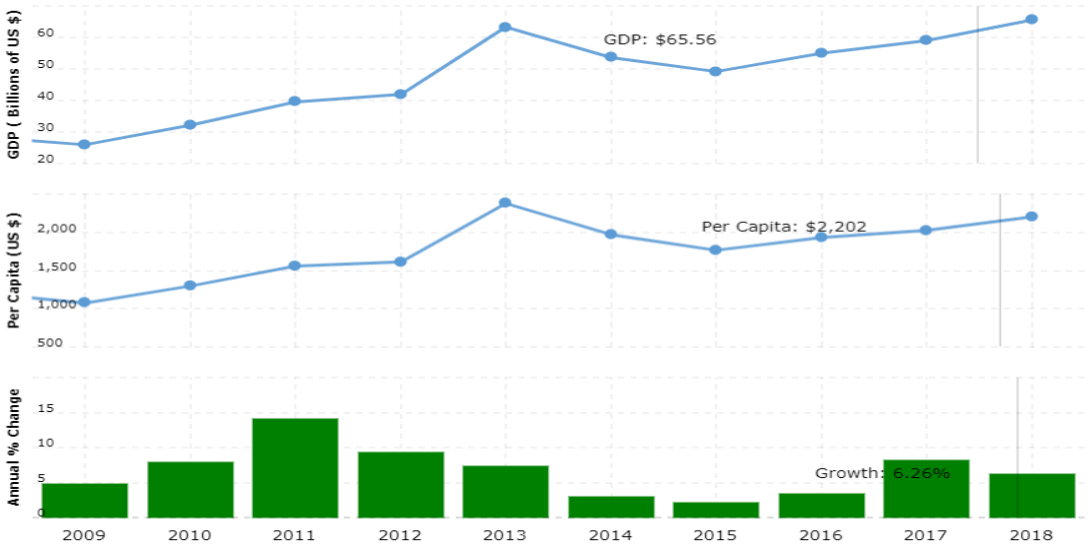

Figure 20: Ghana Real GDP Growth 2009 - 2018[70]

[69] Ghana's inflation rate can be accessed through: https://www.macrotrends.net/countries/GHA/ghana/inflation-rate-cpi

[70] Ghana's GDP (1960-2020) can be accessed through: https://www.macrotrends.net/countries/GHA/ghana/gdp-gross-domestic-produ ct'>Ghana GDP 1960-2020

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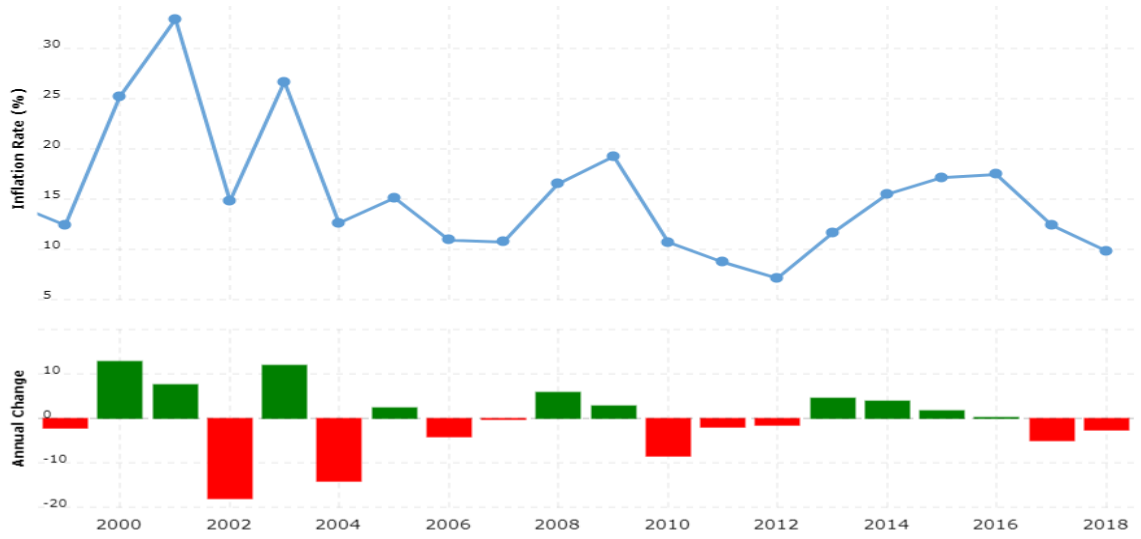

Figure 21: The rate of inflation 2000 - 2018[71]

In Ghana, investments for biogas development are mainly through the private sector, although there have been pockets of investments from the public sector. Private sector funding consists of a wide classification as it includes non-governmental source of financing, while public sector funding constitutes of grants derived from the national budget. One of the main barriers to sustained investment in the sector is change in government. In Ghana, governments are mainly run with a manifesto. So, if there is a change of the ruling government, investments made by the previous government are mostly redirected to new projects which align with their manifesto pledges. Additionally, the macroeconomic factors in Ghana such as inflation, high interest rates and foreign exchange volatility have largely hindered the ability of local banks to provide long-term financing beyond 3-5 years. Consequently, the support of the financial institutions to renewable energy projects has been very poor, and a wide gap exists between available local financing options and the special financing demands of renewable energy projects, such as non-recourse financing, longer tenors and lower interest rates (Ministry of Power, 2015).

4.1.3 Technological Aspect

Technology is considered one of the most critical areas of development in this modern era. The success of any business depends largely on how well it has positioned itself technologically with the rapid pace of technology development. Technologies also enable changes impacting the market to come from unexpected sources. Unfortunately, Ghana is suffering from an underdeveloped technological infrastructure (Energy Commission & UNDP, 2015). However, there are recent positive developments e.g., mobile telecommunications have seen a significant growth rate over the past decade. Ghana is presently among the top 10 countries projected to rule Africa ‘s Information and Communication Technology (ICT) sector in next five years and the telecommunication industry is estimated to be worth $1.1 trillion according to recent World Bank statistics. Ghana imports most of its technology products such as electrical and electronic equipment from abroad with the majority coming from China.

[71] Ghana’s inflation rate can be accessed through: https://www.macrotrends.net/countries/GHA/ghana/inflation-rate-cpi

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In spite of the promulgation of the Renewable Energy Act (832) of 2011, the technologies developed for some sectors related to renewable energy sources have not been fully developed yet—with the biogas sector being one of the specific examples. Renewable energy became a critical source of alternative energy during the persistent, irregular, and unscheduled power outages, popularly known as “dumsor” in 1983, 1998, 2006/7 and as recently as the past years (2013-2016). Government supports the development of the renewable energy sector through financing and other related support to research institutions including the Institute of Industrial Research of the Council for Scientific and Industrial Research (CSIR-IIR), Kumasi Institute of Technology and Environment (KITE), The Energy Centre as well as other private research institutions.

The development of biogas projects in Ghana is expected to remedy the waste management situation and increase the share of renewable energy mix in the country’s energy generation. The pre-dominant types of digesters installed in Ghana are the fixed-dome, floating drum and Puxin technologies (Osei-Marfo et al., 2018). The main reason of constructing biogas systems is to improve the sanitation situation. Although there are several issues with existing biogas systems, many of these systems are functioning well. Recent activities have sought to introduce technologies directly constructed by foreign companies or with a lot of foreign assistance. Examples include the concrete plant at Adeiso, owned by the fruit processing company HPW Fresh and Dry for the production of biogas for electricity generation. The plant was built by a foreign company but is wholly operated by local workers and maintained by Ghanaian biogas experts. The Ghana Oil Palm Development Corporation (GOPDC) also commissioned a biogas plant in 2014 at their mill for extraction of methane from palm oil mill effluent (POME). The system was built to increase renewable energy utilization through the capture and combustion of methane and to avoid the discharge of effluents that do not meet environmental standards into watercourses. The 2000 m^3 plant has an electricity generation capacity of 4 MW.

4.1.4 Environmental Aspects

According to the 1992 Constitution of the Republic of Ghana article 36(9): “*the State shall take appropriate measures needed to protect and safeguard the national environment for posterity; and shall seek co-operation with other states and bodies for purposes of protecting the wider international environment for mankind*”. Ghana is endowed with abundant natural resources including gold, timber, industrial diamonds, bauxite, manganese, fish, rubber, hydropower, petroleum, silver, salt, limestone, oil, etc. In the same vein, the country has abundant renewable energy resources which are yet to be fully exploited. These major potentials include biomass, hydropower, wind, along the coast and high solar irradiation. As of 2019, renewable energy contributes 1% to the energy mix. The main objective of the Renewable Energy Act of 2011 is to achieve 10% renewable in the energy mix by 2020. Rural households rely on land and other natural resources for their livelihoods; fisheries and wildlife provide important sources of protein in the Ghanaian diets. On the other hand, urban economic activities are highly depended on reliable hydroelectric power and fuel. Ghana has established a body known as the Environmental Protection Agency (EPA) under the laws of Ghana Act, 1994 (Act 490). The EPA is mandated by law to oversee all environmental issues and advice government accordingly.

In Ghana, measures (in terms of local bylaws) have been put in place to ensure the environmental safety during biogas installations. Depending on the designs, operation and mainte-

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nance are mostly carried out with ease to prevent any negative environmental impacts. In recent years, biogas systems were built as waste treatment facilities for toilets. Institutions that opted for biogas digester technology instead of the commonly used digesters such as the Kumasi Ventilated Improved Pit (KVIP) and toilet facilities with septic tanks, wanted to address the issues of odor and desludging. The use of biogas systems for sanitation has been stimulated partly by the Environmental Protection Agency because newly built structures are instructed to use anaerobic digesters as a standard technology.

4.2 Competition Overview through the PORTER's Five Forces

Despite the promotion of biogas technology development by the Government, the technology is still at the adoption stage mainly adopted for bio-sanitation purpose with the produced biogas usually released into the air without flaring. The government has identified biogas technology as one of the five key energy-related priorities stipulated in the Nationally Appropriate Mitigation Actions (NAMAs). These priorities are in line with the country's pursuit for low carbon development options in the national climate change policy (2014) as well as the sustainable development objectives articulated in the Ghana Shared Growth Development Agenda (GSGDA). The GSGDA is a series of medium-term national development policy frameworks prepared under the 4th Republic containing specific strategies to be implemented to systematically position the country towards the attainment of the country's vision and goal under the CPESDP (Coordinated Programme of Economic and Social Development Policies)[72]. DiBiCoo is in line with Ghana's Sustainable Energy for All (SE4ALL) action plan intended to promote the establishment of large-scale biogas systems both at institutional and industrial level with the aim of improving access to modern energy for productive uses.

Ghana as a developing country gained interest in biogas technology in the late 1960s but it was not until the middle 1980s that the technology received the needed attention from government. The Ghana government's intervention in the dissemination programmes before the mid of 1980s focused on the provision of energy for domestic cooking. As a result, the first biogas project by government was the Appolonia Electrification project in 1992. The Apollonia Biogas Plant had a 12.5 kW generator to provide electric power for street and home lighting as well as cooking while the bio-slurry was used for agriculture with animal dung and human excreta as feedstocks. As part of a dissemination programme, the Ministry of Energy constructed a total of nineteen fixed-dome digesters comprising six 15 m^3 and two 30 m^3 Deenbandhu digesters, and eight 10 m^3 and three 25 m^3 Chinese dome digesters by engineers from the Ministry of Energy (MoE) and the Institute of Industrial Research (IIR). Since these events, the biogas sector has mainly been supported by donors with the Netherlands Development Organisation (SNV) and the United Nations Development Programme (UNDP) playing a key role in the sector. Subsequent to the low involvement of biogas projects by the Ghanaian government, a number of private biogas companies have been marketing the technology purely on business grounds, demonstrating the ability of biogas plants to improve sanitation. 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.

[72] For the complete document of Ghana's Shared Growth and Development Agenda, see: https://www.un-page.org/files/public/gsgda.pdf

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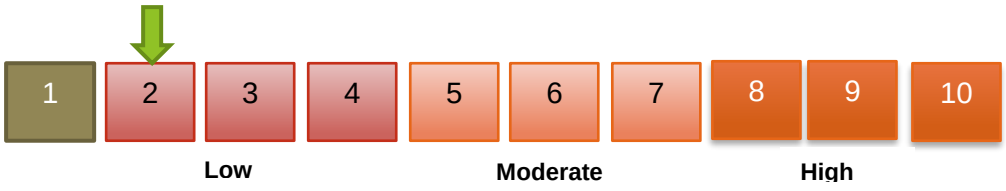
4.2.1 Economy

Ghana continues to be a beacon for democracy in Africa. Despite the political gains, the country is still plunged with several economic challenges with some significant economic gains over the last two decades. Peak economic growth was recorded in 2011, partially due to a competitive business environment, good government investment policies and a fast-growing private sector. The country's real GDP growth slowed down from the peak of 14% in 2011 to 9.3% in 2012, 7.3% in 2013, 2.9% in 2014, dropped further to 2.18% in 2015. Ghana's GDP is US$67.07 billion (2019) with inflation 9.16% year-on-year in January 2020. The current government has put a number of policies and programmes in place to stabilize the economy with the economy continued to expand in 2019 as the first quarter GDP growth was estimated at 6.7%, compared with 5.4% in the same period of last year.

Government has also put in place incentives and policies to attract more investments. Some of these include Tax holidays, Locational incentives, and Investment guarantees. The Ghana Investment Promotion Centre (GIPC) and Ghana Free Zones Board (GFZB) are also avenues where various degrees of assistance are provided to foreign investors. The GIPC ought to act as the first port of call for investors. The operation of the GIPC is governed by the 2013 Ghana Investment Promotion Centre Act 865 which was enacted as an instrument to show government's commitment to encouraging foreign investment in its economy, including the renewable energy sector.



1 absolute zero risk; 2 low risk; 3 straightforward operational solution; 4 require strategic adjustment; 5 moderate risk; 6 straightforward operational solution; 7 require strategic adjustment; 8 high risk; 9 straightforward operational solution; 10 require strategic adjustment

4.2.2 Existing Competition

Currently, there are about 20 private companies and research institutes who are actively involved in the design and construction of both domestic and institutional size biogas plants across the country. A few are purely focused 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. To date, Biogas Technologies Africa Limited (BTAL), now BTAL is one of the largely recognized biogas companies in the installation of fixed-dome digesters in Ghana. This company have been responsible for the construction of at least 400 biogas systems in institutions, hotels, government buildings and homes. Our market research revealed that most of the companies are engineering companies. Some of the companies also collaborate with foreigners in the installation of large-scale digesters. The Ghanaian biogas market will be well suited for biogas implementation due to rising electricity costs and need for alternative energy sources. The good news is that most of the companies do not have the capacity to construct large-scale digesters. Large scale digesters are usually installed by foreign companies. Additionally, most biogas companies are ready to improve their technical capacity and in search for technology that will suit the Ghanaian context. The only competition might come from BTAL who is well established in the African continent with several large-scale digesters installed in

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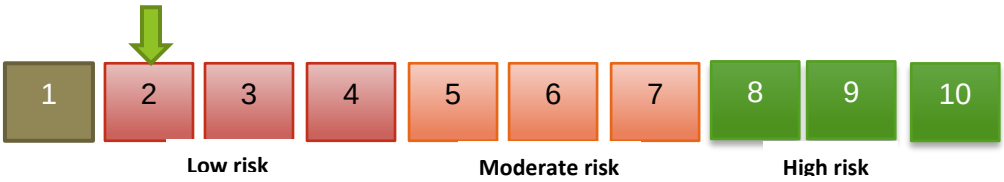
various African countries funded by UN organizations. Table 17 shown below lists several biogas companies affiliated with the Biogas Association of Ghana.

Table 17: List of organisations active in the design and construction of biogas sanitation systems in Ghana

Company	Year of entablement	Type of digester
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
CSIR-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



1 absolute zero risk; 2 low risk; 3 straightforward operational solution; 4 require strategic adjustment; 5 moderate risk; 6 straightforward operational solution; 7 require strategic adjustment; 8 high risk; 9 straightforward operational solution; 10 require strategic adjustment

4.2.3 Institutional and Market Factors

The successful implementation of biogas projects relies on a few factors with feedstock collection as one of the main identified factors that might hinder the implementation process in Ghana. Irregular amounts and irregular quality of feedstock is problematic. The collection of small volumes will create traffic movement and enormous costs. Other factors that are critical for biogas projects in Ghana include:

- ***Market size:*** The size of the market for a particular renewable energy technology is usually a driving force for the transfer of technology and hence could also become a barrier. The larger the market size, the more willing entrepreneurs are to exploit the possibility of acquiring the technology, adapting, and disseminating it. Likewise, the smaller the market size, the less likelihood that an entrepreneur will invest in technology

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transfer. In the case of Ghana, it is difficult to classify the size of the market as a potential barrier for some renewable energy technologies. Some renewable energy technologies with larger market size have not seen massive deployment, as is the case in other places. Domestic biogas for instance has a market potential of about 278,000 units for dung fed systems, however, less than 2004 units have been constructed nationwide so far (Bensah, 2015).

- ***High capital cost:*** Some potential clients such as food processors may have difficulties to finance the high initial investment that renewable energy projects i.e. biogas require as a result of challenging market situations and intermediate weak financial situations. The major waste management company in the country has shown concern with regards to the 1 MW electricity generation capacity.
- ***Access to finance and long-term capital:*** Financing biogas projects in Ghana becomes often uneconomical due to astronomically high interest rates and the lack of long-term loans. Even though financial mechanisms such as equity finance, venture capital fund, debt financing and crowd financing among others are available to entrepreneurs, some of them are not fully developed in Ghana. For instance, crowd financing is not fully developed in Ghana and hence inaccessible to entrepreneurs. Equity finance is also not very popular in Ghana thus the only financial mechanism available to Ghanaian entrepreneurs is perhaps debt finance. The current base rates of most banks are above 30% making the cost of borrowing very expensive in Ghana. In effect, access to long term financing has been identified as one of the major barriers to the successful implementation of biogas (Daniel et al., 2014).

  In 2019, the Agence Française De Développement (AFD) and Energy Commission (EC) of Ghana signed a Technical Assistance Facility (TAF) to support local banks and other key stakeholders towards the development of Energy Efficiency (EE) and Renewable Energy (RE) projects under the Sustainable Use of Natural Resources and Energy Finance programme (SUNREF) in Ghana. This has led to the establishment of unit/desk in some commercial banks such as Fidelity Bank, Cal Bank and Ecobank to specifically finance private sector investments in renewable energy project development in Ghana. The financial institutions will provide green credit loans to finance renewable energy and energy efficiency projects in Ghana (Energy Commission of Ghana, 2019).
- ***Unfamiliarity with biogas technology:*** Potential clients are generally unfamiliar with renewables and have institutional barriers to develop renewable energy concepts. Technical managers of food processors are focusing on their key competence – the production process itself. In terms of energy, managers are likely to concentrate on low-cost solutions and are not aware how renewable resources could fit into their systems. Only few environmental managers may consider pollution associated with their electricity demand.
- ***Lack of technical know-how:*** Workers must be trained to install, operate, and maintain renewable technologies. Biogas plants need special operating experience; the biological process needs to be controlled and monitored regularly to secure stable biogas generation. Education, training, and instructions to local managers, engineers and technicians are required and will also have a positive effect on the attitude to new technology in the long-term.

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- ***Lack of maintenance practice:*** Lack of knowledge and skills as well as awareness to maintain technology regularly and properly is considered to be a major risk in Ghana and will cause additional costs and funding for rehabilitation.
- ***Guaranteed price for energy services (feed-in-tariffs):*** The unavailability of feed-in-tariffs for electricity generation from renewable energy sources is a major obstacle for the adoption of large-scale biogas projects in Ghana. Safi Sana, who owns one of the largest biogas plants in Ghana has been struggling to meet their investment cost due to government inability to pay the approved feed-in-tariff to the company. The Public Utility Regulatory Commission in accordance with the provisions of the Renewable Energy Act 2011, Act 823 sets Renewable Energy Feed-in Tariffs (REFIT). The Guarantee period of the Power Purchase Agreement (PPA) has been a subject of concern for most project developers. Ghana's feed-in tariffs (FIT) guarantee period of 10 years is seen as a disincentive for project developers. The reason is the high risk of uncertainty after the 10-year period. Other countries using the FIT to drive the market have a guarantee period of 15 – 20 years. A shorter guarantee period scares banks away because of the high risk of uncertainty beyond the 10-year guarantee period.
- ***Lack of successful reference projects and failed experience:*** Successful reference projects serve to boost confidence in biogas technology leading to acceptability of the technology among end users. It also serves as a very powerful marketing tool for sceptics. Unfortunately, transfer technologies are perceived to be unreliable by end users even though that may not be the case. Failed demonstration projects re-enforce the perception of an immature technology that cannot be relied upon. This is evident in several renewable energy technologies solutions piloted in the past. For example, the failed Apolonia biogas project in 1986 with the support from the Chinese government due lack of operation and maintenance. Again, the absence of successful reference projects reinforces the perception of either an immature technology or a failed technology. Further, project financiers may consider renewable energy technologies too risky for the lack of visible projects. The interesting thing is that European companies and products will enjoy high reputation in Ghana due to their experience and innovation in the biogas field with evidence of most large-scale digesters installed by European companies.
- ***Controlled market in favour of conventional systems:*** The Government of Ghana used to subsidize transportation fuel leaving out market forces to determine the true price of the commodity even when the price of crude oil increased on the international market. However, in 2015, Government put in place a deregulation policy that allowed marketers and importers of petroleum products to set directly their own prices based on import parity costs, taxes and margins. Nonetheless, no subsidies have ever been announced for bioenergy products. Producers of electricity from renewable energy projects do not even have any means of selling their products to potential users since there are no dispensing mechanisms for fuel derived from renewable energy sources.

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Table 18: Feed-in Tariffs for utility-scale renewable energy technologies[73]

Electricity Generated from Renewable Energy Technologies/Sources	FIT (GHp/KWh)	Maximum Capacity (MW)
Wind with grid stability systems	55.7369	300 MW
Wind without grid stability systems	51.4334	
Solar PV with grid stability systems/storage systems	64.4109	150 MW
Solar PV without grid stability systems/storage system	58.3629	
Hydro ≤10MW	53.6223	No limit
Hydro (10 MW >≤100MW)	53.8884	No limit
Biomass	56.0075	No limit
Biomass (Enhanced Technology)	59.0330	No limit
Biomass (plantations as feedstock)	63.2891	No limit

4.2.4 Bargaining Power of Buyers/Customers

In Ghana, the technology is well known for its sanitation purpose. However, there is still lack of information with regards to the utilization of the technology for energy purpose. Additionally, there is limited information on the potential clients for investments into biogas systems in Ghana. The benefit of the technology to the customer is more of environmental solution than creating additional income for organisations. An example is the plant installed by Sewerage System Ghana Limited, where an anaerobic system is used to treat human waste without harnessing the gas for usage. The following are the most likely categories of potential clients for biogas installations in Ghana:

- Food processors that have a need to find cost-effective solutions to bio-degradable waste disposal. They may, or may not, take in other feedstock either to assist the biological processes or simply to increase income.
- Landowners/farmers who wish to treat their farm waste and add value to it. The waste coming from their farms can form a basic load for the plant. They may or may not take in material or waste products (e.g. source-segregated food waste) from other farmers or sources.

[73] Public Utilities Regulatory Commission of Ghana: PURC Gazetted Tariffs http://www.purc.com.gh/purc/node/178

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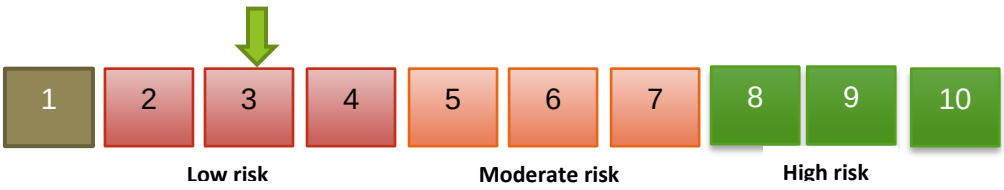
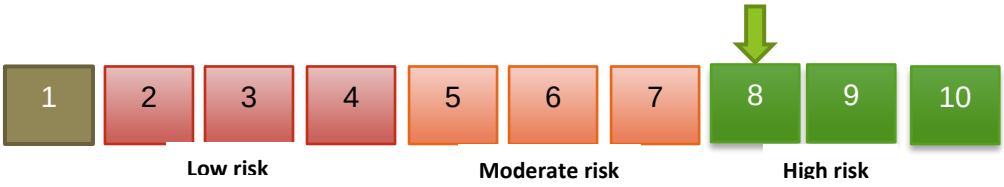
- Waste management companies that could install biogas plants close to landfill sites if the bio-degradable waste is separated and pre-treated before final disposal.



1 absolute zero risk; 2 low risk; 3 straightforward operational solution; 4 require strategic adjustment; 5 moderate risk; 6 straightforward operational solution; 7 require strategic adjustment; 8 high risk; 9 straightforward operational solution; 10 require strategic adjustment

4.2.5 Buyer cost

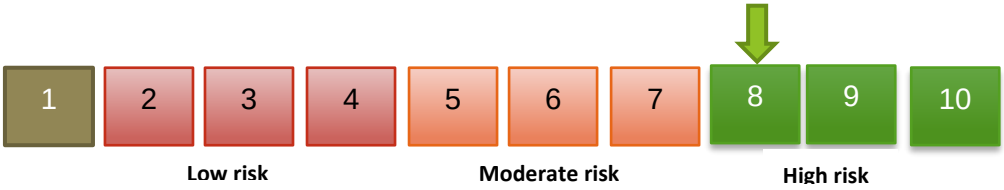
One of the major hindrances to adoption of biogas technology as identified by industries that need the technology is the high initial cost. A typical biogas projects with a capacity of 1.5 – 4 MW electricity generation ranges between 1.5 – 2.5 million Euros (Africa Business Communities, 2012). The lack of coordinated agency responsible for biogas projects in Ghana usually prolongs the project implementation period particularly in the acquisition of permit and licensing.



1 absolute zero risk; 2 low risk; 3 straightforward operational solution; 4 require strategic adjustment; 5 moderate risk; 6 straightforward operational solution; 7 require strategic adjustment; 8 high risk; 9 straightforward operational solution; 10 require strategic adjustment

4.2.6 Suppliers (Bargaining Power of Suppliers)

No biogas equipment can be sourced locally. They are usually contracted to foreign companies. A prominent company in the biogas sector indicated that they normally source their supplies from Germany including biogas storage facilities and CHP equipment. However, there might be competition of products from China due to pricing as most Ghanaian companies prefer to acquire their products from China. The biogas technology is dominated by local companies installing small-scale digesters with the large-scale digesters constructed by foreign companies, usually from Europe. The fluctuation of the local currency has cascading impact on supply of biogas products to the Ghanaian market with suppliers opting for Chinese products due to the high exchange rate with other foreign currencies like the USD dollar and Euro.



1 absolute zero risk; 2 low risk; 3 straightforward operational solution; 4 require strategic adjustment; 5 moderate risk; 6 straightforward operational solution; 7 require strategic adjustment; 8 high risk; 9 straightforward operational solution; 10 require strategic adjustment

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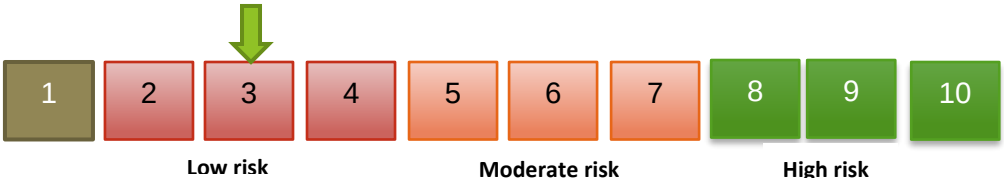
4.2.7 Threat of New Entrants/ Strategic Stakes

Government has put in place the necessary framework and policies to drive the renewable energy development in Ghana. An example is the Renewable energy Act 831 which was passed in 2011 with the aim of achieving 10% renewable energy penetration into the energy mix of the country by 2020. However, due to lack of investment in the sector, government has extended the current target to 2030. In Ghana, the government seems to be more focused on solar PV with little policy direction in the biogas sector as the current Bioenergy policy document is still in its draft stage since 2010. Most of the investment in the biogas sector has been driven by the private sector and donor funded projects specially to deal with waste management. The argument from the industries that are currently employing biogas technology to treat their waste is to comply with the standards sets by Environmental Protection Agency (EPA) in the discharge of waste into the environment. Government policy is to drive biogas technology as a solution to sanitation challenges at the household level in urban communities and for energy generation for off-grid communities in Ghana.



1 absolute zero risk; 2 low risk; 3 straightforward operational solution; 4 require strategic adjustment; 5 moderate risk; 6 straightforward operational solution; 7 require strategic adjustment; 8 high risk; 9 straightforward operational solution; 10 require strategic adjustment

4.3 Market Policies and Incentives

Biogas is a renewable energy technology that is starting to grow commercially in the Ghanaian market. Due to the country´s economic growth and development of the regulatory environment, the Ghanaian renewable energy sector is attractive for foreign companies. As a result of the present-day energy situation, characterized by grid instabilities and increasing power prices, commercial and industrial producers from the agricultural and other service industries look for alternative solutions to secure constant energy supply to avoid production loss and to reduce energy costs. The installation of biogas plants on production sites is one of the most attractive solutions. It enables producers to dispose of waste in an environmentally friendly manner, generate electricity for self-consumption, use residues as fertilizer and feed-in energetic surpluses to the grid at the same time.

The structure of this section will follow these basic guidelines:

a. Policies and Programs that provides incentives for biogas development in Ghana will be used in determining the levels of incentives for adoption of biogas in Ghana.
b. Mandates of the various ministries, department, and agencies whose activities provide incentives for biogas development will be analyzed.

The scope of incentives in Ghana is largely structured around governmental legislations and policies. The Government's objective is to create an enabling environment for private investments in renewable energy (RE) projects. As a result, the Ghanaian Government has outlined several policies that provide the incentives for renewable energy development in Ghana including the development of biogas.

1. Ghana Energy Policy

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2. National Energy Policy
3. Sustainable Energy for All Action Plan (2012)
4. Renewable Energy Master Plan
5. Draft Bioenergy Policy (2010)
6. Scaling-Up Renewable Energy Program in Ghana (SREP) Investment Plan (2015)
7. Strategic National Energy Plan (2006-2020)
8. Energy Sector Strategy and Development plan
9. Ghana National Determined Contributions to Climate Change
10. Technology Transfer Regulations (L.I. 1547)
11. Environmental Sanitation Policy (2010)
12. Local Government Act, 462 (1993)
13. National Urban Policy (2012)
14. Ghana National Constitution (1992)

Table 19: Key Policy Framework for the energy sector in Ghana

Policy	Key issues related to RE, Environment and Industry
Constitution of Ghana, 1992	Parliament to pass all laws on the environment State to promote the development of agriculture and industry Citizens to protect and safeguard the environment
Local Government Act, 462, 1993	Places waste management under MMDA responsibility Encourages private sector involvement in waste management MMDAs to ensure drainage and sanitation in buildings
National Water Policy, 2007	Seeks to minimize the pollution of water sources from poor environmental sanitation services Ensures the provision of water and sanitation services
Environmental Sanitation Policy, 2010	Promote waste reduction, re-use, recycling, and recovery Ensure that sites for treatment and disposal of waste (landfills, composting facilities, waste stabilization ponds, trickling filters, septage treatment plants, etc.) are safe and hygienic and uses appropriate
National Urban Policy, 2012	Recognizes poor sanitation in poor neighborhoods Acknowledges that environmental deterioration which arises from unsatisfactory waste collection, disposal, and treatment
National Energy Policy	Encourages investments in renewable energy Bioenergy policy calls for recycling of waste to energy
RE Master Plan + SE4ALL Strategy	Prioritized investments in biogas, cookstoves and bioenergy solutions

Beside these, there are other relevant institutions whose mandate provides them with the responsibility to facilitate the development of renewable energy projects in Ghana. The roles, and policies of these institutions include:

- Ministry of Energy (MoE)

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- Energy Commission
- Ministry of Environment, Science, Technology, and Innovation (MESTI)
- Environmental Protection Agency (EPA)
- Ministry of Sanitation and Water Resources
- Ministry of Works and Housing
- Ministry of Local Government and Rural Development
- Ministry of Finance
- Ministry of Presidential Special Initiatives
- Ministry of Trade and Industry
- National Development Planning Commission
- Public Utility Regulatory Commission (PURC)

All these institutions have mandates and regulations that may serve as incentives or assistance to stakeholders in the biogas sector in Ghana. Besides the above-mentioned ministries/agencies, there are additional ministries and agencies whose activities and mandates also serve an important role for biogas development. However, specific ventures such as municipal waste-to-energy also require approval from the local Metropolitan, Municipal and District Assemblies (MMDAs).

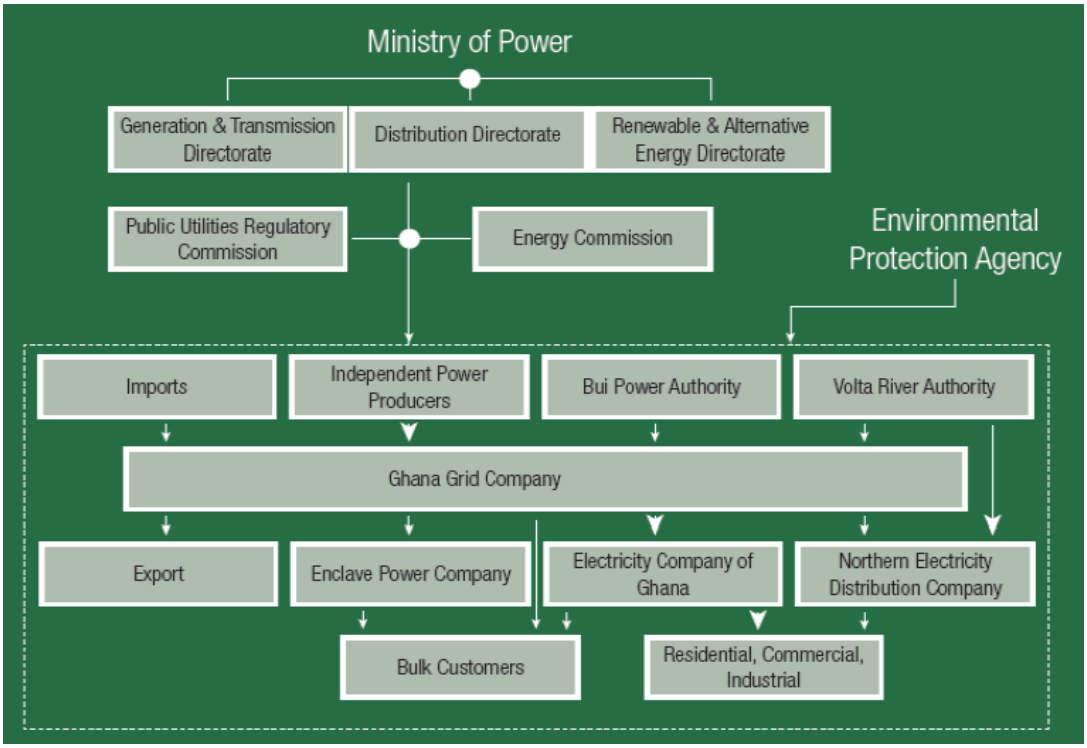

Figure 22: Key national institutions in Ghana's energy sector (Hagan, 2015).

4.3.1 Key Issues related to Renewable Energy, Environment and Industry within the National Regulations

There is no ongoing large-scale national biogas programme in Ghana yet. The Sustainable Energy for All (SE4ALL) Action Plan (2012) is the only national policy document that sets a target for the implementation of nationwide biogas system in Ghana. The target stipulated by

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SE4ALL focuses on conducting a feasibility study for the installation of 200 institutional biogas systems for selected boarding schools, hospitals, and prisons by 2019. However, government is yet to secure the necessary funds to see the realisation of this project.

Several policies and public initiatives are relevant for institutional biogas and its implementation. The Strategic National Energy Policy proposes to increase the use of renewable energy sources to 10% of the national energy mix by 2020. The plan recognizes the fact that establishment of a feed-in tariff regime that brings advantages for 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 that was reviewed in 2014. Also, the Ministry of Energy through the National Energy Policy 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) document also seeks to maximize 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, and;
- Reduce carbon dioxide (CO_2) emissions.

Within the Draft Bioenergy Policy, 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 renewable energy 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 the Ghana Shared Growth and Development Agenda (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 maximizing energy production from waste.

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Furthermore, sanitation and development policies in Ghana recognize the significance of improved sanitation and have thus outlined similar strategies in the GSGDA I, which are re-emphasized in GSGDA II. Strategies aimed at improving environmental sanitation include the following:

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

Though the various developmental interventions such as the Ghana Poverty Reduction Strategy II (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.

Other policies and initiatives

According to Environmental Protection Agency (EPA) officials, EPA has acts in place stating that new public buildings will not receive a building permit when utilizing septic tank sanitation systems. Also, the 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 a 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 United Nations Industrial Development Organization (UNIDO). This project was focused on industrial application of biogas systems, which in turn would also has an impact on large scale sanitation biogas systems by utilising a combination of industrial and/or agricultural feedstock.

In September 2014, the United Nations Development Programme (UNDP) and its partners 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 work on the ground.

4.3.2 Details of selected policies and regulations related to Biogas incentivization

NB: It is important to note that legislation and policy surrounding AD in Ghana is still under development

Renewable Energy Act, 2011 (Act 832)

The first legal framework condition for renewable energies has been established when the Parliament of Ghana enacted the Renewable Energy Act in December 2011. The goal is to increase the share of renewable energy technologies in the total energy mix and achieve 10% contribution in electricity generation by 2020. However, due to lack of investment in the sector, government has extended its target to 2030 with more strategic investment plans put in place.

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The objective of the Act is to support the participation of the private sector in the electricity sub-sector and to allow independent power producers (IPPs) access to the grid.

1.1. Key Provisions in Renewable Energy Act, 2011 (Act 832)

1. Renewable Energy Licensing

This regime gives the guidelines for the procurement of licenses for commercial service providers in the renewable energy industry. According to the Renewable Energy Act 832, 2011, any person or organization that wishes to engage in commercial activity in the renewable energy industry must obtain a license from the Energy Commission before doing so. For production and supply of electricity, Wholesale Electricity Supply License would be granted for 20 years. For installation and maintenance, Installation and Maintenance license would be granted for 10 years. Licenses are only granted to a citizen of Ghana or a body incorporated and registered under the company code 1963 (Act 179) or under any other law of Ghana or a partnership registered under the Incorporated Private Partnership Act, 1962 (Act 152). The acquisition of a License for the wholesale supply of Electricity undergoes three (3) main stages. First stage is the acquisition of provisional license, second is the acquisition of siting clearance and the acquisition of construction work permit, and the third stage is the acquisition of operational license.

To qualify for stage one, the applicant must submit feasibility reports and a financially sound business plan. Stage two requires an environmental assessment permit to be granted by Ghana's EPA and an approved Feed-in Tariff from PURC as well as a signed Power Purchase Agreement (PPA) with one of the electricity distribution utilities or a bulk customer (Ghana Energy Commission, 2012).

2. The Renewable Energy Feed-in-Tariff Scheme (RE FiT)

This scheme is to provide a guaranteed price for electricity generated from renewable energy sources. The Public Utility Regulatory Commission in accordance with the provisions of the Renewable Energy Act 2011, Act 823 sets Renewable Energy Feed-in Tariffs (REFIT).

3. Renewable Energy Purchase Obligation (RPO)

Under this provision, power distribution utilities and bulk electricity consumers are required to procure a specified percentage of their total purchase of electricity from renewable energy sources.

4. Net Metering (distributed generation)

Under this facility, renewable energy generation facility owners are credited for electricity the facility supplies to the grid, and this credit is set off against electricity purchased from the distribution utility. "Net metering is designed for applications where the renewable energy generation is not being used as a back-up to the main source of power supply. Instead, the excess energy is supplied to the distribution utility, on the assumption that the amount of energy supplied to the grid will not exceed the amount purchased over an annual tracking period".

5. Off-grid electrification for isolated communities

This provision promotes mini-grid and standalone off-grid renewable power systems for remote areas and islands.

6. Promotion of wood fuels and biofuels

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The Act provides for the efficient production and utilization of wood fuels and biofuels internally: and for exports where applicable

7. Research and Development (R&D)

This section elaborates the scientific, technological, and innovative research into renewable energy, as well as research into the establishment of standards for their utilization. The government has promised to increase funding for R&D to 2.5% of GDP from the current 0.25% in the long term to boost research programs including renewable energy projects. According to the Renewable Energy Master Plan, a Renewable Energy Demonstration Centre would be established to serve as a link between government and research institutions to promote and drive research that is targeted at national development priorities and bridge the gap between researchers, private sector and government. The Centre is expected to coordinate research dissemination, working closely with the existing universities and research centres. Government would also ensure to strengthen individual and institutional research capabilities, increase cost sharing in financing proposals, and upgrade equipment and instrumentation, and guides the Establishment of Renewable Energy Fund (RE Fund). Under this provision, a renewable energy fund has been established for the development, promotion, and utilization of renewable energy resources in Ghana such as financial incentives, feed-in-tariffs, capital subsidies, production-based subsidies, and equity participation. The Renewable Energy fund is sourced by funds approved from parliament, premiums payable by bulk consumers who fail to meet RPOs, donations, grants and gifts received for renewable energy activities, and funds approved by the board of the Energy Fund, and money generated by the Energy Commission from the provision of services for renewable energy activities. **Acquired money from the funds are to be used to promote activities such as:**

- innovative approaches, including new business models for developing and utilising sources of renewable energy.
- scientific, technological, and innovative research for renewable energy
- designing and implementing standards for the utilisation renewable energy
- manufacturing equipment for developing and utilising renewable energy
- programmes to adopt international best practices
- development of infrastructure for renewable energy
- capacity building for renewable energy development

8. Establishment of a Renewable Energy Authority (RE Authority)

The RE Authority oversees the implementation of renewable energy projects and activities in the country, execute projects initiated by the state and manage assets in the renewable energy sector on behalf of the state.

1.2. Progress since Implementing the Renewable Energy Act in 2011

1. Renewable Energy Licensing

The Energy Commission (EC) has developed the licensing framework, Grid Code, and manual for RE investment. It has also issued 66 provisional licenses; 17 sitting and 2 construction permits as at now. The provincial licenses categorised by technologies are as follows:

- Solar: 44
- Wind: 7

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- Biomass/Waste-to-Energy: 11
- Hydro: 3
- Tidal wave: 1

2. **The Public Utilities Regulatory Commission (PURC) in accordance with the RE Act has reviewed the RE Fit scheme on three occasions since 2013.** The first RE Fit scheme was set in September 2013. The second was reviewed and gazetted in October 2014, while the last review was gazetted in August 2016. The 2014 guideline introduced the integration of utility scale variable renewable energy technologies (i.e. solar PV and wind) with capacity limit indicated below. It was limited to an initial 10 years and made provision for grid stabilization and storage. The main principles of the 2014 guidelines are as follows:

    - The total nationwide capacity for solar PV and wind plants without grid stability/storage systems are limited to 150MW and 300MW respectively;
    - A maximum of 10MWp (Megawatts peak) per solar PV plant without grid stability/storage systems is allowed to be connected to the distribution system at any generation site;
    - A maximum of 20MWp per solar PV plant without grid stability/storage systems is allowed to be connected to the national transmission system (161 kV or 330kV) at any generation site (PURC, n.d.).

3. **Renewable Energy Purchasing Obligation (REPO)**

Under this scheme, the RE Act obliges all electricity distribution utilities and bulk consumers to purchase a percentage (%) of their electricity from renewable energy sources. Ghana currently has three distribution utilities 32 bulk consumers. The three distribution utilities include The Ghana Grid Company (GRIDCo), the Electricity Company of Ghana (ECG) and the Northern Electricity Distribution Company (NEDCo). On the percentage (%) required, the PURC is yet to establish the percentages of these consumers. However, German development partner, GIZ is offering technical support and capacity building for PURC to establish the required percentage and the mode of implementation.

There are also requests being considered by ECG from other renewable energy developers to sign PPAs. These developers are however seeking for government guarantees due to the troubling financials of ECG. These are presented in Table 20 and Table 21 below.

Table 20: Expressions of Interest (EOI) from Renewable Energy Developers (2015)

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RE Technology	No. of EOI	Proposed Capacity (MW)	Percentage Share
Solar	12	1,140	52%
Wind	4	175	8%
Hydropower	2	557	26%
Waste -to-energy	1	100	5%
Biomass	2	200	9%
Total	**21**	**2,172**	**100%**

Table 21: Wholesale Electricity Supply Licenses issued to Renewable Energy Developers (Energy Commission, 2015)

Category	No. of Wholesale Electricity Supply Licences Issued (as at 2015)			Total Proposed Capacity (MW)	Percentage Share
	Provisional Licenses	Siting Permits	Construction Permits		
Solar	55	16	1	2,742	58%
Wind	9	1	-	951	20%
Hydropower	4	-	-	201	4%
Biomass	2	1	-	68	1%
Waste -to-energy	10	1	-	764.61	16%
Wave	11	1	1	20	0.4%
Total	**81**	**20**	**2**	**4,746.61**	**100%**

4. Renewable Energy Net Metering Scheme

200,000 Solar Roof Top Programme has been initiated by the Energy Commission under this scheme. The government is giving a capital subsidy of 500W panel per installation.

5. Mini-grid Renewable Energy Electrification Programme

Five hybrid mini grids have been developed in island communities on the Volta Lake to cater for the electrical needs of more than 6,000 people

6. Off-grid Stand Alone Electrification Programme

Solar streetlights have been installed in remote off-grid communities, clinics, schools and security points. Energy centers have also been established in remote communities for charging mobile phones and batteries.

7. Kerosene Lantern Replacement Programme

70,000 solar lanterns with 70% subsidy have been deployed to replace kerosene lanterns. The target is 2 million solar lanterns by 2030.

8. Sustainable Energy for cooking and Productive Use

- Monitored cookstove initiatives (total improved woodstoves disseminated by private sector – 22,856 as June 30, 2016).

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- 32 Institutional Stoves constructed in 5 Districts for Gari Processors through a 50% grant facility from SNV/GIZ
- Rehabilitation works of Appolonia Renewable Energy Center has commenced - 30% work done to date.
- Completed market assessment for solar pumps for irrigation

9. Scaling-up Renewable Energy Program (SREP) in Ghana Investment Plan

In 2015, the Ministry of Energy (MoE) developed the Scaling-up Renewable Energy Program in Ghana Investment Plan (SREP-Ghana IP) to help facilitate and support Government's plan to access financial opportunities to develop a robust and sustainable renewable sub-energy sector. With targets for 2020, the program had four investment projects:

- Renewable energy mini-grids and stand-alone solar PV systems
- Solar PV based net metering with battery storage
- Utility-scale solar PV/wind power generation
- Technical assistance

Government has developed and obtained approval for $230m Ghana SREP Investment Plan. The 4 projects under SREP are:

- 55 Mini-Grid & 38,000 Solar Home Systems (SHS)
- 15,000 Net-metering
- 20-30MW utility scale solar/wind projects
- Technical Assistance
- Biomass waste to energy projects
- Sustainable energy for cooking.
- Medium-small hydro projects

The program will secure $40m financing from the Climate Investment Fund (CIF), of which $30m is granted to finance the above 4 projects. Additional $1.5m project preparation grant has been approved by CIF to develop the above projects. Table 22 presents the targets set by the Ministry of Energy on the renewable energy projects in 2020, under the Scaling-up Renewable Energy Program in Ghana Investment Plan.

Table 22: Targets on Renewable Energy Projects by 2020 – (Ministry of Energy, 2015)

Potential Renewable Energy Projects	Target	Required Investment US$ million
Development of utility type wind farms	50-150 MW	300-550
Development of grid-connected solar parks	N.A.	400-700
Solar lantern promotion	2 million units	150-200
Medium – small hydro	150-300 MW	450-900
Modern biomass /waste to energy	20-50 MW	60-150
Development of mini grid	30-42 units	21 - 38.5
Off-grid renewable energy project	30,000 units	10-25
Sustainable energy for cooking	2.0 million units	10-50
Total Investments		**1.4 - 2.6 billion**

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4.3.3 License Procedure under Energy Commission

By the provisions of the RE Act, any individual that wishes to engage in a commercial activity in the renewable energy industry must obtain a license from the Energy Commission before doing so. The Act defines the activities that require acquisition of a license, among others:

- The production and supply of electricity from renewable energy sources for supply to distribution utilities and bulk customers - Wholesale Electricity Supply License granted for 20 years
- The installation and maintenance of renewable energy systems – Installation and Maintenance License granted for 10 years.

A license may only be granted to a citizen of Ghana; or a body corporate registered under the Companies Code, 1963 (Act 179) or under any other law of Ghana; or a partnership registered under the Incorporated Private Partnership Act, 1962 (Act 152). The different manuals for licenses and application forms and license fees shall be available at the Energy Commission's website[74].

The acquisition of the Wholesale Electricity Supply License consists of three stages:

Table 23: Stages for the acquisition of the Wholesale Electricity Supply License

Stage 1:	Acquisition of Provisional License
Stage 2 A:	Acquisition of Siting Clearance (Siting Permit)
Stage 2 B:	Acquisition of Construction Work Permit (Authorisation to Construct)
Stage 3:	Acquisition of Operational License (Authorisation to Operate)

- At stage 1 the applicant has to submit the Feasibility Report and a Business Plan to demonstrate its financial capability as well as its operational experience and expertise.
- During Stage 2A an Environmental Assessment permit or certificate granted by EPA will have to be submitted.
- EPA has set guidelines for preparing of Environmental Impact Assessment for new energy investments as well as guidelines for preparing Environmental Management Plan for existing energy companies and general guidelines for monitoring environmental performance and indicators and de-commissioning of all energy investments.
- During Stage 2 B an approved FiT from PURC has to be provided as well as a signed Power Purchase Agreement (PPA) with an electricity distribution utility or a bulk consumer. ECG has developed a procedure for engaging IPPs. A template for a standardized form of a PPA is currently developed by EC and will soon be available.

4.3.4 Financing mechanisms and donor programs

A major barrier to rapid development of renewable energy projects is the lack of adequate financing mechanisms in Ghana. Although there is a strong interest by international and local financial institutions to promote RE projects, in Ghana, the financing becomes uneconomical

[74] Ghana Energy Commission website, can be accessed in: www.energycom.gov.gh

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due to astronomically high interest rates and a shortage of long-term loans. However, financing is one of the key elements in order to ensure project viability. Low interest long-term loans are the most suitable means for financing the renewable energy projects. This type of loan should meet the demands for long maturity, low interest, and low initial installments. Some local and international financial institutions have identified this lack and are in the process to develop instruments to make financing for renewable energy projects available under reasonable conditions.

- Establishment of Renewable Energy Desks by local banks to offer mainly micro to medium scale financing (i.e. by Fidelity Bank).
- Raising of Renewable Investment funds (i.e. by JCS Investment) to provide small to medium scale financing (GHS 500,000 to 3 million). The limited access to financing is also derived from lack of knowledge about suitable national and international available financing mechanisms and programs. Here just to name two special funds that could be suitable for certain biogas projects:
  (1) UNEP Renewable Energy Enterprise Development (REED) is providing seed capital to small and medium enterprises operating in the clean energy sector in certain developing countries, among others in Ghana.
  (2) Ghanaian Export Development and Investment Fund (EDIF): Under this scheme, companies with export programs can borrow up to $500,000 over a five-year period at a subsidized cedi interest rate of 15%.
- However, financing institutions or investors lack experience and knowledge in the sector. They are unfamiliar with the evaluation and calculation of biogas projects and only show interest in short payback period and high return on investment.

4.3.5 Investment conditions

The new Ghana Investment Promotions Centre (GIPC) Act 2013 (Act 865), which repeals the GIPC Act 1994 (Act 478), is introducing changes to the country's investment laws and institutions and contains provisions that may curtail foreign direct investment into Ghana. The Act requires Ghanaian citizens who partner with foreign investors to have at least 10% equity participation in the joint enterprise and capital requirements of the foreign investors of not less than US$50,000 in cash or goods relevant to the investment or a combination of both by way of equity capital. In the case of an enterprise that is fully controlled by a foreign investor, the capital requirement is not less thanUS$200,000. The Act also expands the investment activities reserved for Ghanaians and Ghanaian owned enterprises: Trading enterprise that is principally engaged in the purchase or sale of goods shall not be wholly owned by non-Ghanaian but shall operate by way of a joint venture with a Ghanaian partner. The capital requirement for the foreign investor is not less than US$1,000,000 and such joint ventures employ at least ten skilled Ghanaians.

4.3.6 Policy Gap and Barriers in the Renewable Sub-Sector

Regardless of the successes chalked since implementing the RE Act, there are still barriers that militate against the industry. Some of the barriers identified in this report are:

Challenges with license acquisition for RE projects and cumbersome licensing procedures:

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- Renewable energy developers experience difficulties in accessing license for projects because of the cumbersome processes involved. For a renewable energy IPP to enter the market, it has to interact with a host of regulators in the industry to facilitate license approvals, clearances and incentives where necessary.
- Some of these regulators and service providers include Energy Commission, Ghana Investment Promotion Centre (GIPC), Public Utilities Regulatory Commission (PURC), Environmental Protection Agency (EPA), Ministry of Energy, etc. The procedures involved here can be lengthy and complex with significant administrative and transaction costs. This can easily discourage potential investors and renewable energy project developers from conducting business in Ghana. Figure 23 below shows the licensing processes and procedures that IPPs must go through upon entering the RE industry.

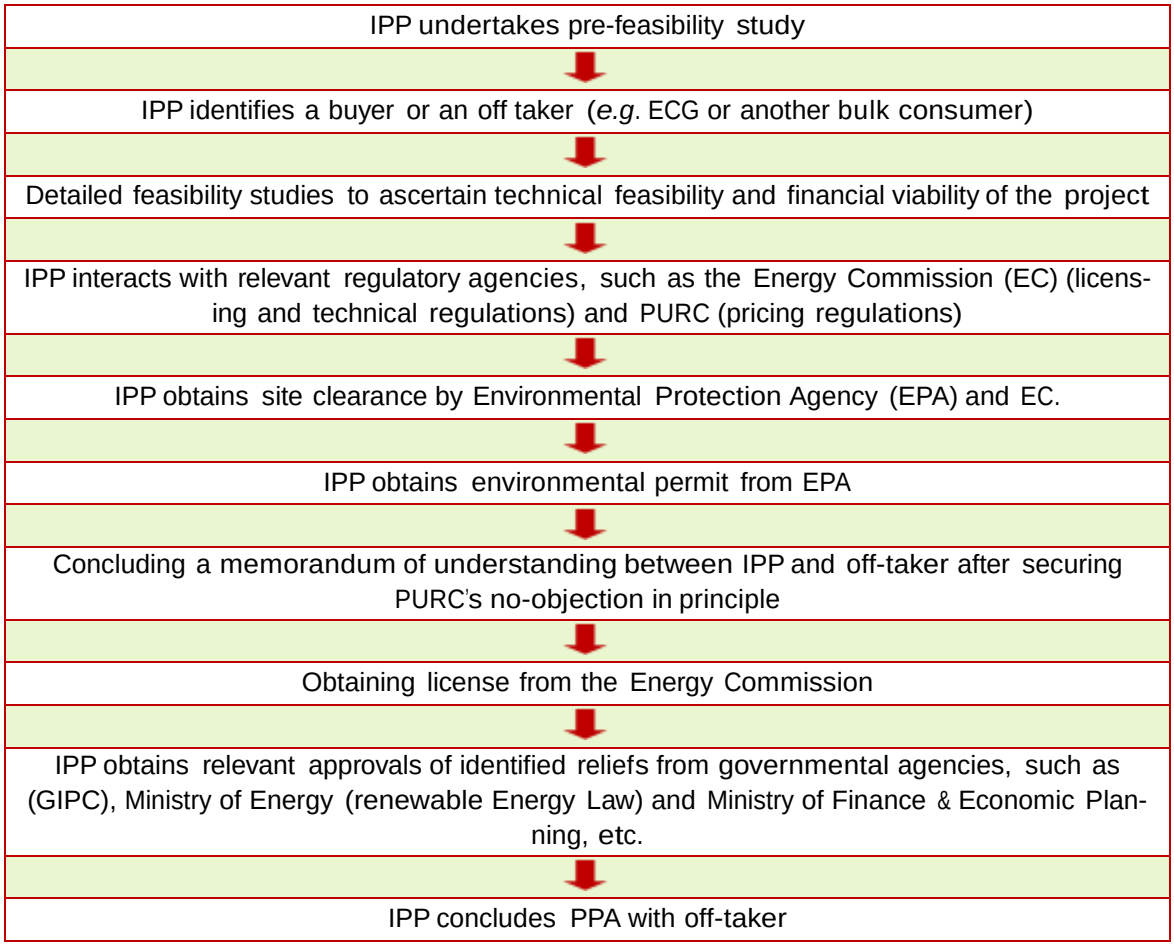

Figure 23: Procedures for Entry into the Electricity Market as Renewables (IRENA, 2015)

Poor financial investment mechanisms and lack of guarantees for IPPs

- Firstly, the Energy Commission has received a lot of applications for licenses from IPPs to develop RE projects. However, due to the financial state of ECG, the EC is cautious about granting these licenses. The utility provider is saddled with so much debt thus the question about whether it will be able to pay the RE project developers arises. Even if they turn to other financial service providers, financial closure for projects still becomes an issue because of the lack of government guarantees for payment, in the event of ECG defaulting in paying the RE companies.

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- Also, most RE developers are struggling to develop projects that are bankable to attract financial investment. There is also a general difficulty in accessing finance and long-term capital for RE projects in Ghana. This is because most financial mechanisms like crowd funding, venture capital funding, equity and debt financing are still underdeveloped in Ghana. Financial professionals from financial institutions also lack a good knowledge of the RE technology so they are unable to evaluate proposals for RE financing.

Lack of sufficient incentives in the RE industry

- One major challenge is the lack of adequate tax rebates and incentives in the industry. The high cost of RE technologies and its sheer market size means that incentives are important to ensure its full development and market development. In 2017, government put in place an import duty and a value added tax exemption for solar PV and wind generation systems.
- However, other RE technologies have not been catered for. Even though most of them are imported, they do not enjoy tax rebates and exemptions. These include some components of biogas systems such as de-sulphurisers, biogas storage balloons, pipes, and valves. Solar water heater components, large biogas systems, small hydro plants and improved cookstoves also do not enjoy these exemptions.

Lack of enforcement of key actions in the RE Act

- Firstly, the RE Act mentions the setting up of a renewable energy authority to oversee the implementation of renewable energy projects and activities in the country, execute projects initiated by the State and manage assets in the renewable energy sector on behalf of the State. However, this has not yet been established.
- Secondly, it also makes a provision for the establishment of a renewable energy fund to support the industry. This has also not been implemented. Thirdly, the Renewable Energy Purchase Obligation (RPO) in the provision obliges all electricity distribution utilities and bulk consumers to purchase a percentage (%) of their electricity from renewable energy sources. However, the PURC is yet to define and establish this percentage.
- Lastly, the Renewable Energy Master Plan that will set clear targets for the various RE technologies and the strategies to achieve the targets has also been fully developed and prepared.

Lack of adequate Research, Development, Demonstration and Deployment (R&DDD) into RE technologies

- R&DDD in Ghana to support the industry is either lacking or very low. One reason for this is the lack of a clear government policy direction for the process. Another is the lack of adequate funding to conduct R&DDD in the various RE technologies. Compounding these reasons is the lack of a clear strategic framework by the government on RE that will attract investors and funders to support R&DDD in Ghana. Universities and the industry can bridge this gap but lack of coordination and inadequate synergies; partnerships and weak linkage between them is also a problem.

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Lack of public awareness on Renewable Energy

- There is a general lack of awareness of RE technologies in Ghana. Though the solar technology (PV) has enjoyed considerable promotion in recent times, the public and consumers are generally lacking good understanding of the technologies to use them. Consumers believe RE technologies are overly expensive to acquire. They also lack access to information about the benefits of the RE technologies. therefore, creating a major barrier for renewable energy technology providers.

4.4 Resources

Agriculture continues to be the major contributor to Ghana's economy with 52% of the country's labour force engaged in agriculture. The five major subsectors of agriculture include food crops (59.9 %), livestock (7.1%), fisheries (7.6 %), cocoa (14.3 %) and forestry (11.1%). Despite the discovery of oil in commercial quantities in 2007, agriculture still contributes to 54% of the country's GDP, and accounts for 40% of export earnings[75]. The agrarian nature of the country is an indication of the nature of waste generated, with estimated 50-60% of the waste component being organic[76]. The availability of these feedstock particularly, agro-industrial residues, animal and agricultural residues presents a huge potential for biogas generation. Based on this, there are two main categories of feedstock for biogas production in Ghana. The first category includes farm-based products such as animal manure, agricultural by-products and farm-based wastes whereas the second category consists of a broad range of suitable organic wastes from the food and feed industries with municipal solid waste as the most dominant. The present report focuses on food processing waste, abattoirs and slaughterhouses and municipal solid and liquid waste. Despite the abundant availability of feedstock for biogas generations in Ghana, biogas as a sustainable renewable energy is at the introduction phase of market development in Ghana. With government effort to mitigate climate, biogas technology has been identified 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.

4.4.1 Food processing

Ghana's food processing industry includes the fruit processing, breweries, oil palm processing, cocoa, and cashew processing. However, the fruit processing and breweries industries are the focus of this study due to existing biogas plants in oil palm processing companies and the technical challenges in dealing with cocoa and cashew processing waste i.e. pre-treatment.

Ghana is a major producer of fruit and vegetables. Fruits such as mango, pineapple, papaya, and oranges are usually unprocessed and exported. Most of these agricultural products, fruit and vegetables are mainly cultivated by private small-scale farmers with the major commercial production areas located in the southern part of the country where close proximity to the ports enhances the export trade. At the coastal areas, commercial activities are concentrated in the

[75] http://agricinghana.com/wp-content/uploads/2017/07/AGRICULTURE-IN-GHANA-Facts-and-Figures-2015.pdf
[76] Agyenim et al. (2020) Powering communities using hybrid solar biogas in Ghana, a feasibility study. Environmental Technology & Innovation 19:100837

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Accra Plains and southern Central Region. Though most Ghanaian fruit is exported unprocessed, there are equally some companies that process mango, pineapple, papaya, or oranges locally. This sector is an important avenue for employment and private sector initiative.

The main different product groups are:

- Fresh fruit
- Fresh cut fruits
- Dried slices or fruit chips
- Fruit concentrates or juices

Even though most of the fruits and vegetables produced in Ghana are exported, there are few large fruit-processing companies that process the raw material for local consumption. These processing industries generate significant quantities of waste. The organic waste generated decomposes producing bad odour as one of the decomposition byproducts. Consequently, the decomposable material needs proper treatment with anaerobic digestion as an appropriate technology to generate energy and organic fertilizer as well. Table 24 below shows the capacity of the large fruit-processing companies in Ghana.

Table 24: Energy potential from biogas of selected fruit processing companies[77]

Companies	Products	Fruit residues (Mt/year)	Electric capacity (kW)
Peelco Ltd	45,000 Mt of tropical fruits	2,000 Mt of fresh cut residues	68
Fruittiland Ltd	Juice and concentrate for export from pineapples and oranges	45,000 Mt of fruit waste	1,249
Pinora Ltd	Juice concentrate for export from pineapples and oranges	40,000 Mt of fruit waste	1,110
HPW Fresh and Dry	Fresh, dried and fruit snacks for export from pineapple, mango, coconut, banana, and papaya	2,000 Mt	50
Blue Skies Ghana Ltd	Fresh cut-products for export and juice for the local market	8,000 Mt of fresh cut residues and fruit waste from juice production	298

4.4.2 Brewing

There are a number of companies in Ghana producing different alcoholic and non-alcoholic drinks. However, **Guinness Ghana Breweries Limited (GGBL) and Accra Brewery Limited are the largest breweries in Ghana.** The company has two branches. One in Kassi (Kumasi) and the other in Achimota (Accra). It is estimated that GGBL produces about 1.7 million hl beverages from the two breweries[78]. Accra Brewery Ltd (ABL) is the oldest brewing company in West Africa, a member of the Anheuser-Busch (AB) InBev family. ABL produces both alcoholic and non-alcoholic beverages with a total production capacity of 1,872 million hl.

Brewery wastes contain spent grains, yeast biomass but also liquid waste/ effluents. The company produces 6 hl of wastewater per every hectolitre of beer produced. Fortunately, GGBL

[77] https://energypedia.info/images/2/24/Biogas_in_Ghana_Sector_-_Analysis_of_Potential_and_Framework_Conditions_2014.pdf
[78] https://energypedia.info/images/2/24/Biogas_in_Ghana_Sector_-_Analysis_of_Potential_and_Framework_Conditions_2014.pdf

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has wastewater treatment facilities installed in Kumasi and Accra facilities and is generating biogas already producing biogas from its processes.

The following table gives an indication on the waste volume streams of a typical brewing process of one of the local breweries and their corresponding biogas potential:

Table 25: Energy potential from biogas of brewery in Ghana[79]

Type of residue	Volume [m³/year]	Electric capacity (kW)
Wastewater /effluent	300,000 m3	312
Sludge from wastewater treatment	4,000 m³	54
Spent grains	1,500 t	29
Spent yeast	120 t	Unknown

4.4.3 Abattoirs and slaughterhouses

The livestock sector is the third largest contributor to agricultural GDP of Ghana after crops and forestry. The major types of livestock production in Ghana include cattle, poultry, pigs, goats, and sheep. Among these, 50% of the livestock slaughtered in Ghana is cattle[80]. Each region in Ghana has a slaughterhouse. However, Accra and Kumasi abattoirs are the largest in Ghana and have been equipped with modern facilities. Both slaughterhouses are supposed to have a maximum capacity to slaughter 450-480 cattle per day, 450-480 sheep and goats per day and 200 pigs per day. Apart from these two large facilities in Kumasi and Accra, there are also small to medium scale slaughterhouses or slabs in Ghana with low number of animals slaughtered usually less than 200 large animals (cattle) per month or less than 1000 goats and sheep per month.

The livestock operations are prone to serious environmental impacts, such as GHG emissions, odour; water and land contamination; resulting from storage and disposal of animal waste. Slaughterhouses produce large quantities of solid waste such as rumens, darn, animal fats, bones, hooves, horn, meat scrap, animal dung and other kind of solid waste. These quantities of waste pose health and environmental hazards to the communities located near the slaughterhouses; largely affecting agricultural land. Unfortunately, majority of slaughterhouses in Ghana dispose of highly polluted wastewater and organic residues into the sewerage system and landfill without prior treatment resulting in environmental and ecological problems; and clogging wastewater drainage systems. One major environmental and health concern in most slaughterhouses in Ghana is the burning of rubber tyres for singeing the fur of the animals. However, by using biogas technology as an environmentally friendly alternative to generate energy from the organic component of the waste, we could also help discourage the use of car tyres which is considered unhealthy for meat consumers. Slaughtering of animals in various abattoirs is done daily in Ghana, indicating the consistent availability of biomass resource throughout the year with peaks on holidays.

Interestingly, slaughterhouse effluent has high Chemical Oxygen Demand (COD), high Biological Oxygen Demand (BOD) and high moisture content, which makes it well-suited to anaerobic

[79]https://energypedia.info/images/2/24/Biogas_in_Ghana_Sector_-_Analysis_of_Potential_and_Framework_Conditions_2014.pdf

[80] http://agricinghana.com/wp-content/uploads/2017/07/AGRICULTURE-IN-GHANA-Facts-and-Figures-2015.pdf

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digestion process. Slaughterhouse wastewater also contains high concentrations of suspended organic solids including pieces of fat, grease, hair, feathers, manure, grit, and undigested feed which will contribute to the slowing of the process of biodegrading organic matter. The biogas potential of slaughterhouse waste is higher than animal manure and reported to be in the range of 120–160 m^3 biogas per ton of wastes.

Table 26: Energy potential from biogas at abattoirs in Kumasi and Accra[81]

City	Type of live-stock	Average/month	Content per animal		Electric capacity (kW)
			Paunch (kg)	Blood (kg)	
Kumasi	Cattle	7,000	12	15.8	33
	Sheep	1,600	1.6	2.1	1
	Goat	1,900	1.6	2.1	1.2
	Pig	475	4.4	5.8	0.8
Accra	Cattle	1,900	12	15.8	8.8
	Sheep	275	2.1	2.1	0.2
	Goat	475	1.6	2.1	0.3

4.4.4 Municipal Solid and Liquid Waste

Solid waste management remains a major challenge for government and local authorities in Ghana, especially in the peri-urban and urban areas. The population of Ghana is currently estimated at about 30 million with a growth rate of about 2.5% p.a. (NPC, 2016). Each person is estimated to generate about 0.47 kg of solid waste daily. This translates to more than 12,000 tons daily of household solid waste generated in Ghana. Currently, apart from Kumasi, Tamale, and Takoradi, which have engineered landfill sites in place, the remaining towns, and cities, including the capital city Accra, do not have engineered landfills. As a result, more than 80% of the generated waste is either dumped in open fields or drains. Only about 10% (1200 tons/day) is collected and dumped. The remaining 10% is burnt or buried (Miezah, 2015). The uncollected waste and waste dumped in open fields and drains pose a huge environmental and health risk. Organic material forms the largest constituent of municipal solid waste streams in Ghana with household waste stream consisting of about 60-70% organic component. In rural areas, the percentage of the organic component increases to about 77-80%. Another major challenge confronting government and local authorities is the indiscriminate discharge of raw faecal and sewage sludge into oceans and landfills despite the advancement of anaerobic technology for the treatment of organic waste to generate energy. As shown in Table 27, there is huge potential for energy generation from municipal and solid waste generated in Ghana via anaerobic generation. However, most of the biogas plants installed in Ghana are usually for household which are used to produce cooking fuel or to power domestic lighting with few large-scale digesters installed by multinational companies operating in the food processing industry.

[81] https://energypedia.info/images/2/24/Biogas_in_Ghana_Sector_-_Analysis_of_Potential_and_Framework_Conditions_2014.pdf

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Table 27: Solid and liquid waste from various Metropolitan and Municipal capitals

Regional Capitals	Solid Waste/month (tons)	Liquid Waste per month (m^3)
Kumasi	45,000	6,500
Tema	41,600	3,281
Cape Coast	3,195	341
Accra	60,000	24,000
Sekondi-Takoradi	4,792	1,638
Sunyani	3,600	165
Wa	2,636	117
Koforidua	4,500	690
Bolgatanga	2,819	880
Ho	850	3,236
Tamale	5,600	5,504

4.4.5 Human Resource

Due to lack of legislative framework in the biogas sector in Ghana, there is no specific standard developed curriculum for training biogas practitioners in the country. However, there are several public and private institutions that carry out periodic training for practitioners, mainly brick layers. The lack of coordinated and formalized training has resulted in several unqualified experts who referred themselves as experts of biogas digester installers. Currently, the executives of the Biogas Association of Ghana (BAG) has been instructed by the Environmental Protection Agency (EPA) with funding from GIZ-Ghana to develop a standard curriculum for training of personnel in the value chain of the biogas sector. Many biogas projects have failed because of the lack of technical skills to operate and maintain the systems. This has been identified as the major obstacle to the development of the technology in Ghana.

Currently there are few training centres in the country mainly located in the two major cities in the country, Accra, and Kumasi. Unfortunately, most of these training centres are mainly focused on solar PV systems design, installation, and maintenance. However, the Institute of Industrial Research of the Council of Scientific and Industrial Research (CSIR) (public/research institution) and The Energy Centre (academic institution) have been involved in training of experts in biogas installation and maintenance in the past years.

4.4.6 Infrastructure and Support Industry

The supply of materials to construction sites depends to a large extent on the availability of infrastructure like roads and electricity. Manufactures of industrial biogas systems depend on power. Other technologies like domestic biogas plants may not require the availability of power but rather good roads to convey materials to site. The unavailability of good access roads to communities outside the urban centres thus has a negative effect on the manufacturing and dissemination of biogas technology. Additionally, the unavailability of spare parts like biogas storage system and other materials on the market are major impediment to mass production. The lack of supply of materials also affects the inability of biogas service producers to carry out periodic maintenance of biogas facilities which significantly affects the confidence end users have in the system.

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Conclusion

The passing into law of the Renewable Energy Act 832 in 2011 with the goal to scale-up Ghana's renewable energy capacity indicates the government of Ghana´s policy commitment towards renewable energy to support its development and deployment. In addition, some key regulatory and policy instruments including the Scaling-Up Renewable Energy Program (SREP) Investment Plan, Strategic National Energy Plan, and Renewable Energy Master Plan have also been established to facilitate the implementation of the Law. However, actual investments in the renewable energy sub-sector particularly in the biogas sector have been limited. Solar PV technology has seen some investment over the years with no specific investment earmarked in the bioenergy sector. Both private sector and government see biogas technology as a solution to waste management problems in the country rather than as an energy generation facility. Despite the abundance of biomass resources for biogas generation, most of the resources are either yet to be exploited or are not fully exploited. The analysis presented here identified food processing, municipal solid and liquid waste as well as brewery processing waste as the major feedstocks for DiBiCoo demo case projects in Ghana. The report presents a strong case for municipal solid and liquid waste in spite of the feedstock collection problem posed by this feedstock. The major impediment to the successful implementation of DiBiCoo lies on the project target of 1MW electricity generation capacity facility. Most of the potential companies/organizations approached and engaged during the compilation of this report were skeptical of the 1MW target due to unreliable availability of feedstock. Nonetheless, the good news is that there is a huge opportunity for large scale digester installers as the market is still untapped. The report further revealed less competition for large scale biogas installer companies as most of the local installers mainly focus on small scale/household digesters. Furthermore, the local companies may lack the capacity to operate in the commercial biogas installation sector.

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