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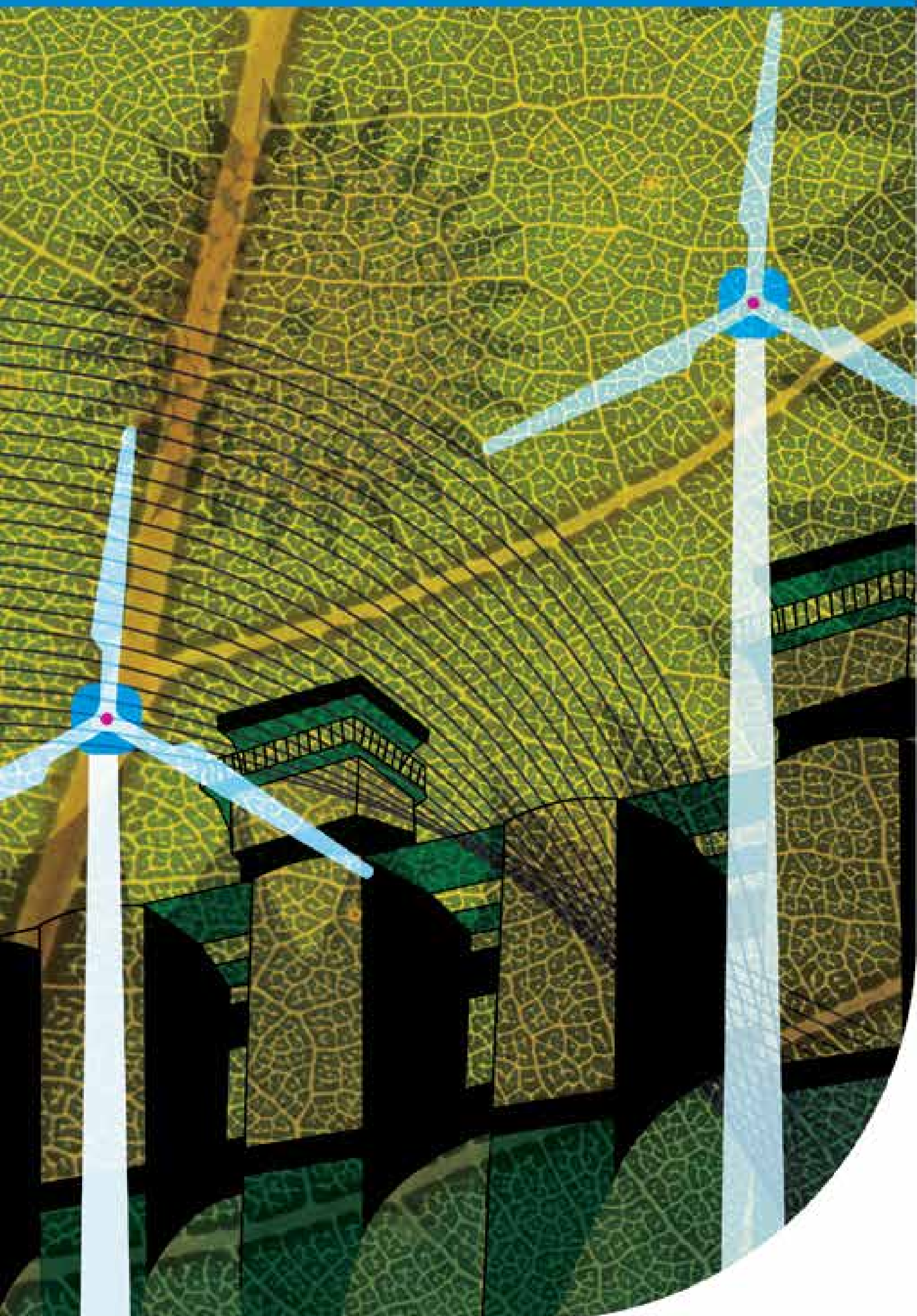
GHANA
RENEWABLES READINESS ASSESSMENT



November 2015

About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

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GHANA

RENEWABLES READINESS ASSESSMENT

FOREWORD

from the Minister of Power

Ghana is endowed with renewable energy resources that can be utilised to contribute to sustainable economic growth of the country. It has been recognised that these resources can contribute to achieving the Sustainable Energy for All agenda by ensuring access to modern energy services for the majority of rural communities. It has been established that small-scale renewable energy systems can provide affordable and cleaner energy for cooking and heating and for empowering enterprises for increased production, create employment and increase rural income and thereby reduce poverty.

In an effort to increase sustainable energy access to her population, particularly in the rural areas, the Government of the Ghana developed the Sustainable Energy for All Action Plan, which is anchored on the Renewable Energy Act passed by the Parliament of Ghana in 2011, whose objective is to provide for the development, management, utilisation, sustainability and adequate supply of renewable energy for generation of heat and power and for related matter.

In implementing the SE4ALL Action Plan and the Renewable Energy Act, Ghana received the support of the International Renewable Energy Agency (IRENA) and the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) to increase the uptake of renewables through the Renewables Energy Readiness Assessment (RRA). The RRA is a process that assesses the potentials and opportunities for renewable energy development and identifies barriers and constraints that hinders its development and therefore identifies possible solutions and concrete actions over a short-term to increase the uptake of renewable energy to contribute to sustainable energy access. The RRA process therefore identifies components in the renewable energy sector agenda that impedes its development and identify potential opportunities in the form of investment potentials in the sector. Realising our national development plans will depend on the continuation of this support and the identification of increased resources for investment, Ghana is actively looking at opportunities in the renewable energy sector and ways of maximising investment.

Ghana is therefore grateful to the International Renewable Energy Agency (IRENA) and the ECREEE for being selected as a participating country for the Renewable Readiness Assessment (RRA) Process. The actions identified in the RRA process will help strengthen our investment framework, create a renewable energy friendly institutional and regulatory framework, support techno-economic assessments of renewable energy systems, and develop a biofuel framework, all of which will go a long way in assisting in the implementation of the Draft Renewable Energy Strategy for Ghana.

As a founding member, Ghana fully supports the mandate of IRENA to promote the deployment of renewable energy worldwide. We also fully endorse the RRA process, which creates a solid foundation for enhancing the contribution of renewable energy to social and economic development in Ghana and Africa.

It is my ardent hope that the RRA Report for Ghana will receive a wider international reception and consequently provide a medium for increasing investment in renewable energy development in the country with the support of all our development partners.

Hon. Dr. Kwabena Donkor
Minister of Power

FOREWORD

from the IRENA Director-General

The Africa High-level Consultative Forum held by the International Renewable Energy Agency (IRENA) in July 2011 highlighted the opportunity presented to African Countries by renewable energy and the need for technical support to countries and regions to identify their readiness to scale up. IRENA's Renewables Readiness Assessment (RRA) process, initiated as part of the forum's outcome, involves a holistic evaluation of a country's social, economic and environmental conditions, in order to identify the actions needed to overcome barriers to deployment of renewables. This is a country-led process, with IRENA primarily providing technical support and expertise to facilitate consultations among different national stakeholders.

Since 2011, more than 20 countries in Africa, the Middle East, Latin America and the Caribbean, Asia and the Pacific have undertaken the RRA process, which generates knowledge of best practices and supports international co-operation around the accelerated deployment of renewable energy technologies. Ghana, a strong and consistent supporter of IRENA's mission, is one of those countries.

The country has one of West Africa's highest rates of access to electricity, estimated at around 72% — with over 87% in urban areas and a little under 50% in rural areas — and also exports power to neighbours. However, local demand is growing at about 10% annually, necessitating further growth in energy generation.

Ghana is well endowed with renewable energy resource potential, particularly biomass, solar and wind, and to a lesser extent small and mini-hydropower. In combination with energy efficiency measures, renewable energy development would greatly bolster Ghana's energy security as well as filling the remaining gaps in electricity access.

The Renewable Energy Law adopted in 2011 provides for the establishment of two crucial policy instruments: the feed-in-tariff (FiT), which creates pricing incentives for renewable power generation; and the Renewable Energy Purchase Obligation (RPO), incumbent on every electrical distribution utility or bulk customer. The law prompted the establishment of a national renewable energy development fund, while the government has channelled levies on energy consumption to finance power sector upgrades. To attract private investment in Ghana's energy transition, renewable energy technologies have been made exempt from import duty.

IRENA wishes to thank Minister Kwabena Donkor and his team at the Ministry of Power for their commitment to this study. We are grateful for their positive engagement and valuable input, which has given us additional insights for further RRAs in Africa and beyond.

I sincerely hope that the findings and recommendations from the RRA consultations will enhance Ghana's pursuit of accelerated renewable energy deployment. IRENA stands ready to provide continuing support for the country to implement the actions identified and further the pursuit of a cleaner and more prosperous energy future.

Adnan Z. Amin
Director-General, IRENA

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ABBREVIATIONS

ECG	Electricity Company of Ghana
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EREP	ECOWAS Renewable Energy Policy
FiT	Feed-in Tariff
GDP	gross domestic product
GEDAP	Ghana Energy Access and Development Project
GHS	Ghana cedi
GRIDCo	Ghana Grid Company
GW	gigawatt
GWh	gigawatt-hours
ha	hectares
IPP	independent power producer
IRENA	International Renewable Energy Agency
km	kilometre
KNUST	Kwame Nkrumah University of Science and Technology
kV	kilovolt
kWh	kilowatt-hour
kWp	kilowatt-peak
LPG	Liquefied Petroleum Gas
m/s	metres per second
m^3	cubic metres
MoEP	Ministry of Energy and Petroleum
MoP	Ministry of Power
MW	megawatts
NEDCo	Northern Electricity Distribution Company
NGOs	Non-governmental organisations
PPA	power purchase agreement
PURC	Public Utilities Regulatory Commission
PV	photovoltaic
RPO	Renewable Energy Purchase Obligation
RRA	Renewables Readiness Assessment
SNEP	Strategic National Energy Plan
USD	United States Dollar
VRA	Volta River Authority
WAGP	West Africa Gas Pipeline
W	Watt

EXECUTIVE SUMMARY

Formerly known as the Gold Coast, Ghana is on the West Coast of Africa. In 2014, the population stood at 27 million, with a relatively high rate growth rate of 2.4% per annum. Its gross domestic product (GDP) has been increasing by about 5.5% per year on average, peaking at 15% in 2011 due to the start of crude oil production. Biomass, consisting mainly of wood fuel like firewood and charcoal and to a lesser extent crop residues, accounts for half the Total Primary Energy Supply. Oil is the second most widely used source of energy in Ghana, accounting for 40% of primary energy supply, followed by hydropower and natural gas accounting for 7% and 3% respectively. Large hydropower and oil-fired plants provide most of the electricity (64% and 36% respectively).

The Ghanaian power industry is unbundled and consists of state-owned utilities. The generation utilities are the Volta River Authority (VRA) and Bui Power Authority. The Ghana Grid Company (GRIDCo), the Electricity Company of Ghana (ECG) and the Northern Electricity Distribution Company (NEDCo) are responsible for transmission and distribution along with independent power producers (IPPs) like Sunon Asogli and CENIT Energy. Access to electricity is around 72% with over 87% for urban areas and just under 50% for rural areas. In 2012, total generated electricity in Ghana stood at 12,870 gigawatt-hours (GWh) with demand at 9,000 GWh. This means the country is a net power exporter to neighbouring countries Togo, Benin and Burkina Faso. However, domestic demand is growing annually by about 10% and is expected to reach around 24,000 GWh by 2020. This will require an increase in generation capacity to more than 3.5 gigawatts (GW) by 2020. Furthermore, recent constraints in the supply of natural gas caused by damage to the West Africa Gas Pipeline (WAGP) have severely curtailed the capacity of thermal power plants to meet peak demand. This amounts to around 1,745 megawatts (MW). This has forced the utilities to practise periodic load shedding since August 2012.

Ghana enjoys excellent renewable energy resources, particularly biomass, solar, wind and, to a limited extent, small (1 MW - 30 MW, according to Economic Community of West African States — ECOWAS) and mini (100 kilowatt (kW) - 1 MW) hydropower. When combined with aggressive measures to promote energy efficiency, renewable energy development can contribute substantially to expanding energy access while reducing the latent energy crises stalking the country.

Although, Ghana abounds in renewable energy resources, the bulk of this potential largely remained untapped. In 2011, a Renewable Energy Law (Act 882) was adopted to provide fiscal incentives and regulatory framework to encourage private sector investment. The provisions of the Renewable Energy Law includes: Feed-in Tariffs (FiT), Renewable Energy Purchase Obligations (RPO), Net Metering (distributed generation), Off-grid Electrification for Isolated Communities, Promotion of Clean Cookstoves, Research and Development, Renewable Energy Fund (RE Fund), and the establishment of a Renewable Energy Authority (REA).

This report presents the output of the Renewables Readiness Assessment (RRA) process in Ghana. It highlights a number of bottlenecks impeding the widespread deployment of renewable energy systems in Ghana, and identifies a range of critical actions in key areas, which when implemented, could have a significant impact on the scaling up of renewable energy in the short- to medium-term. The report also identifies stakeholders who are required or expected to play various roles towards the implementation of the recommended action and the period of time within which, the actions are realistically expected to be implemented.

The keys findings from the RRA process are as presented as follows:

Target setting

The National Energy Policy objective of using renewable energy for 10% of total energy production by 2020 was translated into the generation master plan as 10% of the electricity mix. This focused exclusively on grid-connected applications, essentially 6% dispatchable and 4% variable renewable energy power. Investor interest in developing variable renewable energy power has increased at a time when thermal power generation is expensive and backup capacity almost nil. The time has therefore come for the government to assess the grid conditions to accommodate variable renewable energy. This will further help establish technology-specific targets and related definite capacity additions, thereby increasing market confidence and competition. This should drive down costs.

Grid integration of variable renewable energy

Ghana has developed a comprehensive grid code, revised most recently in 2009. This establishes the requirements, procedures, practices and standards governing the development, operation, maintenance and use of the high voltage transmission system in Ghana. In its present form, this grid code lacks two prerequisites that would further enable the integration of utility-scale variable renewable energy in the grid. These are generation forecasting and priority dispatch. The grid code needs to be revised and include specific conditions accommodating renewable energy generators to provide accurate data. This also has some implications for the system operator, which would have to adapt by developing the necessary capacities and procedures in its daily operation. The grid code should, in addition, provide priority dispatch for renewable power.

Given the fact that the RPO imposed on distribution utilities in the Renewable Energy Law opens the door for consumers to sell renewable electricity to the grid, net metering solar photovoltaic (PV) electricity is an option that can be further explored. However, the government needs to engage in developing standards and codes for grid-connected rooftop solar PV as well as supporting capacity building efforts for local financial institutions.

Financial support mechanisms and payment guarantees to IPPs

The Renewable Energy Law provides the basis for developing grid-connected renewable energy. This is because it establishes supportive instruments like FiTs and RPOs for distribution utilities and bulk consumers, and requires all transmission or distribution operators to connect a renewable energy generator within their area. However the proportion of renewable energy in the electricity mix of bulk consumers has yet to be defined. It is important that this be developed in the context of the target for the entire renewable energy sector.

The Renewable Energy Law also provides for the establishment of a renewable energy fund to offer financial incentives, capital subsidies, production subsidies and equity participation for renewable energy power generation. However, the provision of payment guaranteed to IPPs, which will affect the commercial viability of renewable energy projects, remains a concern due to the fact that the distribution companies ECG and NEDCo are saddled with debt and are unable to meet their payment obligations to present suppliers, and cannot credibly form an offtake agreement for renewable energy investment. Therefore, it is important that appropriate structures are put in place to resolve such challenges, focusing on capacity building for relevant public, private and civil society organisations.

The local currency (Ghana cedi, GHS) fall could have implications for the development of renewable energy projects, as investments are most likely to be denominated in foreign currency, while revenues are expected in cedi. Designing effective currency risk mitigation instruments, would help increase investor confidence in financing renewable energy projects.

Streamlining the renewable energy IPPs procedure for entering the electricity market

To enter the electricity market, a renewable energy IPP has to interact with a number of regulatory agencies in the power sector, once detailed feasibility studies have been completed. These include the Energy Commission and Public Utilities Regulatory Commission (PURC), the Environmental Protection Agency, Ministry of Power (MoP), the Ministry of Finance and the Ghana Investment Promotion Agency. These provide various licences, approvals, clearances and incentives linked to the development of the renewable energy project (see figure 11). This complex and lengthy procedure can lead to significant administrative and transaction costs, and may discourage potential investors and project developers from entering the market. Thus there is a need to set up a one-stop shop, to reduce complexity and assist IPPs working through the bureaucracy.

Designing clear policy for off-grid mini-grids

The country's objective of increasing rural access to electricity would be facilitated by creating a level playing field for local private sector involvement.

The support announced through the renewable energy fund (REF) should be clearly defined, with reliable operating schemes designed for the small-scale decentralised renewable energy mini-grids. Competencies and responsibilities, as well as political direction and relationships between different stakeholders, should be clearly defined on the basis of local political frameworks and infrastructure. This would provide a sustainable, functional socio-economic background for mini-grids in Ghana.

Increasing political support for promoting sustainable use of biomass energy

The government should continue to create and support policy initiatives aimed at accelerating the development and promotion of sustainable biomass energy for households. This is needed alongside present policies and goals focused on tackling deforestation effects caused partly by traditional cookstove use.

High interest rates on loans have prevented supply-side investors from expanding their businesses and increasing production. There is a need to further encourage those entrepreneurs who are prepared to invest, by supporting them through building capacity, grants programmes and providing access to working capital. Matching government programmes are required to cultivate fast-growing energy wood plots, improve charcoal production technologies and skills, and improve cookstove production.

Supporting private sector involvement

The relatively small size of the off-grid market means it is not very attractive to foreign investors. Consequently the sector would probably be left to local private operators with the support of donors and development partners. Local private operators often face technical and financial constraints. These include lack of technical expertise to develop bankable proposals and insufficient working capital due to difficulties in accessing loans. Other constraints include high interest rates, attributable to the perception of high risk and a lack of financial institution expertise in evaluating off-grid renewable energy proposals. There is a need to build the capacity of local private operators and financial institutions to develop and appraise bankable decentralised renewable energy project proposals.

The development and operation of certain renewable energy technologies in mini-grids requires expertise to assess the local conditions, and when installing and maintaining systems. This is particularly the case for hybrid systems, because they use a greater range of generation technologies and more complex management systems. Utilities may also perceive the management of mini-grids as expensive, so these may be better run by small- and medium-sized enterprises and energy savings companies.

Facilitating end users access to technologies and improving cookstove awareness and acceptability

Reviewing electricity tariffs for off-grid systems would help to attract local private operators. This could be accompanied by end-user access facilitation options. It could include targeted subsidies and deferred payment schemes that could be pre-financed directly by the service providers or through a microfinance institution. A sound business model should be developed for both stand-alone systems and mini-grids, and needs to increase the viability and sustainability of decentralised renewable energy projects, as well as access to electricity services in rural Ghana.

Getting the REF up and running would help, as would other finance support mechanisms. These include group lending approaches and sustainable credit programmes for low-income operators and farmers. Additionally researchers should be supported in designing, *e.g.* solar dryers that could be manufactured locally.

Previous experience in Ghana shows that communities often prefer grid connectivity as it has the potential for higher-wattage appliances. They may consider solar power to be inferior and even discontinue off-grid systems to put political pressure on governments. This is particularly true where the grid has been extended to neighbouring communities. Most farmers in Ghana have limited knowledge of labour-saving technologies or post-harvest management, especially for perishable produce. There is a need to run awareness-raising campaigns and create communications strategies to educate operators and farmers about the new business opportunities and off-grid renewable energy benefits.

Existing cookstove technologies also needs to be improved, with new and proven technologies introduced through innovations that not only increase efficiency, but also reduce emissions. This will decrease exposure to household air pollution and very likely to have an impact on health of such households, while continuing to support the local production of cookstoves. If consumers are to adopt improved cookstoves in the long term, the government should embark on critical mass education to increase product market penetration and acceptability.

Bui hydropower plant
Photo: Ministry of Power

I. INTRODUCTION

1.1 Country Overview

Previously known as the Gold Coast, Ghana is located on the West coast of Africa. It covers a total land area of 239,000 square kilometres (km^2) and is divided into ten administrative regions. Ghana's population in 2014 was 27 million (Ghana Statistical Service, n.d.), increasing each year at the relatively high rate of 2.4%. This compares to 1.6% for other lower-middle income countries, but is in line with the 2.5% average for sub-Saharan Africa (United Nations Development Programme, 2011). The country is endowed with diverse and rich natural resources, including gold, timber, cocoa, diamonds, bauxite and manganese.

In 2001-2009, Ghana's gross domestic product (GDP) growth averaged around 5.5%. This has risen to 8% since crude oil production began in 2010. It peaked in 2011 to 15%, as summarised in table 1.

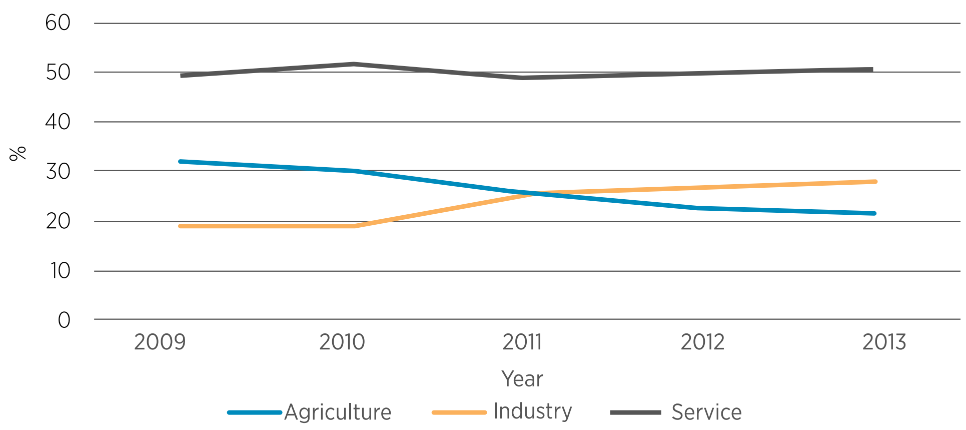
Table 1: GDP Growth Rates in Ghana

Economic aggregate	2009	2010	2011	2012	2013
GDP current (million USD)	25,773	32,816	39,517	40,436	44,154
Per capita GDP (USD)	1,100	1,328	1,606	1,563	1,688
Growth Rates			**%**		
GDP at current market prices	21.3	25.8	29.9	22.2	16.0
GDP at constant 2006 prices	4.0	8.0	15.0	7.9	7.4

Source: Ghana Statistical Service, 2013

The service sector is the backbone of the economy, accounting for about 51% of the country's GDP in 2013, followed by industry with 28% and agriculture with 21%. The evolution of GDP share for each economic sector in 2009–2013 is presented in figure 1.

Figure 1: Sector Growth Rates in Ghana, 2009 - 2013



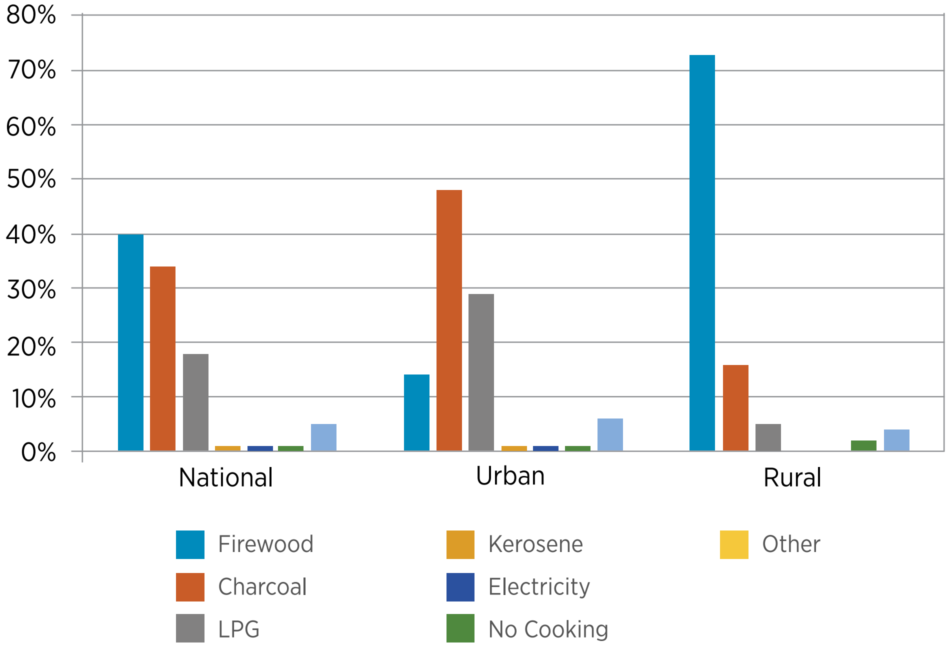
Source: Government of Ghana, 2013

1.2 Energy and Development Nexus in Ghana

Energy use is linked directly to economic growth and living standard and consequently energy is essential for development. Equally, energy supply can have an impact both environmentally and financially, with unrestrained energy consumption having an adverse effect. Although the benefits of increased energy to national development are not in doubt, Ghana and many of its neighbours in sub-Saharan Africa continue to lag behind in terms of energy access.

Authorities in Ghana use two different definitions when it comes to energy access. The Ghana Statistical Service measures access to electricity in terms of the total number of people living in homes connected to the distribution grid.[1] Using the Ghana Statistical Service definition, electricity accounted for 64.2% of household lighting fuels in 2010. Access to modern fuels has not kept up with electricity access. As illustrated in figure 2, household access to Liquefied Petroleum Gas (LPG) stood at 18.2% in 2010, while the rest of households relied mostly on firewood, charcoal and agricultural residues. The situation is far worse in rural communities where close to 90% of households depend on either firewood or charcoal for cooking.

Figure 2: Access to Fuels in 2010



Data from Ghana Statistical Service (2012)

Per capita consumption of electricity was 357 kilowatt-hour (kWh) in 2012. This is on the high side compared to about 180 kWh per capita in sub-Saharan Africa, excluding South Africa (Bazilian, *et al.*, 2012). However, it is far less than the world average of 2,500 kWh. In 2012, electricity and petroleum product consumption grew by 7.2% and around 17.2% respectively. GDP growth was at 7.9%. This suggests GDP growth was somehow correlated with electricity, but still lagged behind petroleum product consumption growth.

The service sector recorded a growth of 10.2% in 2012 led by transportation and storage. Public administration, trade and hospitality were other dominant sub-sectors. Energy demand in the service sector is in the form of electricity and petroleum fuels. Electricity consumed by the service sector increased by about 11%. This correlates with the sector's electricity consumption.

As shown in figure 1, industry overtook the agricultural sector in 2011 due to oil exploitation and grew by 9.1% in 2012. The mining and quarrying sector led the industrial growth, with manufacturing remaining low at 2.5%. Industrial electricity consumption outpaced industrial GDP growth. It rose by over 15%

[1] By contrast, the Ministry of Energy calculates access to electricity in terms of the total population of communities connected to the grid, regardless of whether homes in that community are connected or not. Going by this method, 72% of Ghana's population in 2010 were living in communities that had access to electricity. This report utilises the Ghana Statistical Service definition of energy access as this takes affordability into account, thereby providing a more accurate assessment of access than is possible using the Ministry of Energy's definition.

from 3,900 gigawatt-hours (GWh) in 2011 to 4,513 GWh in 2012.

Agriculture in Ghana is labour-intensive. Over 90% of agricultural output comes from subsistence farmers cultivating less than two hectares (ha) of land. Diesel for ploughing is the main form of energy used in agriculture, although, there are no records of exactly how much fuel is used.

In dry periods, water flow to hydroelectric dams is reduced. Combined with the low electricity generation reserve capacity and difficulties acquiring fuel for thermal generation, this often leads to power cuts or load shedding. Low rainfall in 2003 and 2007 and long-term maintenance on the West Africa Gas Pipeline (WAGP) in 2013 caused disruption to the power supply. This not only affected households, but commerce and industrial activity. The Volta Aluminium Company is the best known case in point. Once a flourishing bauxite processing company, it has had to shut down some of its production due to inadequate electricity supply and rising power costs. This has meant job and income losses for many families whose livelihood depends on the company and on related downstream industries. This illustrates the strong correlation between economic development and energy supply in Ghana, especially electricity. The country's GDP growth rate of 8% will only be sustained over the coming years if the energy supply is maintained. This warrants an examination of all forms of available and indigenous energy resources that could play a crucial role in meeting the country's energy needs.

1.3 The Renewables Readiness Assessment Process in Ghana

The Ministry of Energy and Petroleum (MoEP) and the Energy Commission led the Renewables Readiness Assessment (RRA) process in Ghana in partnership with the Economic Community of West African States (ECOWAS) Centre for Renewable Energy and Energy Efficiency (ECREEE) and the International Renewable Energy Agency (IRENA). The MoEP and Energy Commission invited experts from key governmental institutions, the private sector and civil society to be part of the Ghana RRA team. They were briefed on the RRA process. Several workshops were conducted throughout the RRA, involving identifying renewable energy service-resource pairs, selecting prioritisation criteria and filling in a set of templates for each service-resource pair. A final RRA workshop on 9 August 2013 completed the service-resource pairs and identified specific action needed to get the renewable energy sub-sectors going. The service-resource pairs are listed in table 2.

Table 2: Ghana RRA Service-Resource Pairs

1.	Mini-grid Electricity — Hybrid Sources (Solar Photovoltaic (PV) + Wind or Fossil)
2.	On-grid Electricity — Proven Renewable Energy Sources (Wind or Small Hydro or Solar PV)
3.	Crop-drying/Agro Process Heat — Solar Thermal
4.	Cooking/Heating — Modern Biomass
5.	Off-grid Electricity — Solar PV

This report is divided into four sections. The first section contains the introduction covering country background and the RRA process in Ghana. The second is an overview of the regional energy setting. It puts Ghana's national energy sector in context, as well as describing the challenges it faces, and provides an overview of renewable energy potential and use. It also provides a detailed discussion of the electricity sector. The third section identifies institutions playing a role in Ghana's energy sector. It also defines key energy policies and regulatory frameworks as well as finance and investment conditions in Ghana. The fourth section discusses the RRA findings on emerging concerns and enabling conditions for scaling up the service-resource pairs, presenting the recommended actions and details of the opportunities and constraints. The Annex contains the detailed recommended actions necessary to scale up renewable energy in Ghana.

Solar PV for a school in island community
Photo: Ministry of Power

II. ENERGY CONTEXT

2.1 Regional Context

Energy in Ghana mirrors its broader regional setting, defined here in terms of ECOWAS. As described in later sections of this report, regional trends in energy markets, as well as policy and regulatory developments, significantly affect prospects for renewable energy development in Ghana.

The ECOWAS region has very low energy consumption. This is explained by insufficient access to modernised forms of energy, including electricity and modern cooking fuels. These are key to building economic activity and reducing poverty. Electricity access in 2010 exceeded 20% in only 10 out of the 15 ECOWAS countries, namely Benin, Burkina Faso, Cabo Verde, Ivory Coast, the Gambia, Ghana, Mali, Nigeria, Senegal and Togo. Ghana's high electricity access rate was probably due to the successful implementation of its National Electricity Scheme. The average electricity access rate in the region was around 40% in 2011, but for many countries stood at less than 20% (ECOWAS, 2012).

The lack of electricity access is most apparent in rural areas, where it fails to reach over 95% of the population. Lower rural energy access in most ECOWAS countries is partly due to low incomes and the underdeveloped electricity supply infrastructure.

The majority of the ECOWAS member countries predominantly use biomass energy, which contributes more than 80% of the final energy consumption, as access to modern fuels, such as LPG and kerosene, is limited (ECOWAS, 2012). Most of the population is in rural and peri-urban areas, and are dependent on traditional biomass for cooking and heating, with its related health concerns and environmental consequences.

If sub-Saharan African countries, especially those in the ECOWAS region, are to reach the Millennium Development Goals by 2015, at least half the rural and peri-urban population must gain access to modernised energy services. This access plays a key role in economic and social development. To support such development, ECOWAS member countries have made some investments in the energy sector to improve their population's access to modernised energy services. However, these countries still face common problems and concerns such as: (i) a low rate of access to modern energy services; (ii) a difference between urban and rural access to modern energy services; (iii) an inadequate institutional and regulatory framework offering incentives for new energy service providers and investor protection; (iv) a substantial dependence on oil products for power generation and rural lighting (v) barriers to the development of local and renewable energy sources; (vi) a lack of strong political support and will to improve energy efficiency and a lack of national access targets for energy services.

ECOWAS has taken the initiative in promoting sustainable energy technologies and harmonising national energy legislation to increase energy supply autonomy and massively improve access to modern energy services. This is a policy response to rising energy security concerns, continued lack of energy access and the need to mitigate climate change. In order to achieve these goals, various policy initiatives and programmes have been developed in the ECOWAS region. They are outlined as follows:

In 2006 ECOWAS published a white paper concerning the regional policy on access to energy services for populations in rural and peri-urban areas. It expects an increased access to energy services and at least 20% of new investments in electricity generation originating from locally available renewable resources. The white paper calls for 100% access to electricity by 2015, to meet the basic needs in urban and peri-urban areas and 36% basic needs access for rural households. ECOWAS also hopes to achieve 100% access to modern fuel by 2015, with 50%-70% provided through LPG and the rest through improved wood fuel cookstoves.

The West African Power Pool has issued a revised master plan aiming to create a regional electricity market by 2020-2025. ECOWAS countries have been classified in the plan as follows:

i. potential self-sufficiency due to large coal-fired thermal power plants, after 2020 — Senegal, Ivory Coast, Ghana, Nigeria, Togo/Benin and Niger;

ii. expected to remain dependent on power imports from neighbouring countries up until at least 2020 — the Gambia, Guinea-Bissau, Mali, Burkina Faso and Niger; and

iii. potential power exporters after 2018 usually by developing hydropower — Ivory Coast, Guinea, Sierra Leone and Liberia.

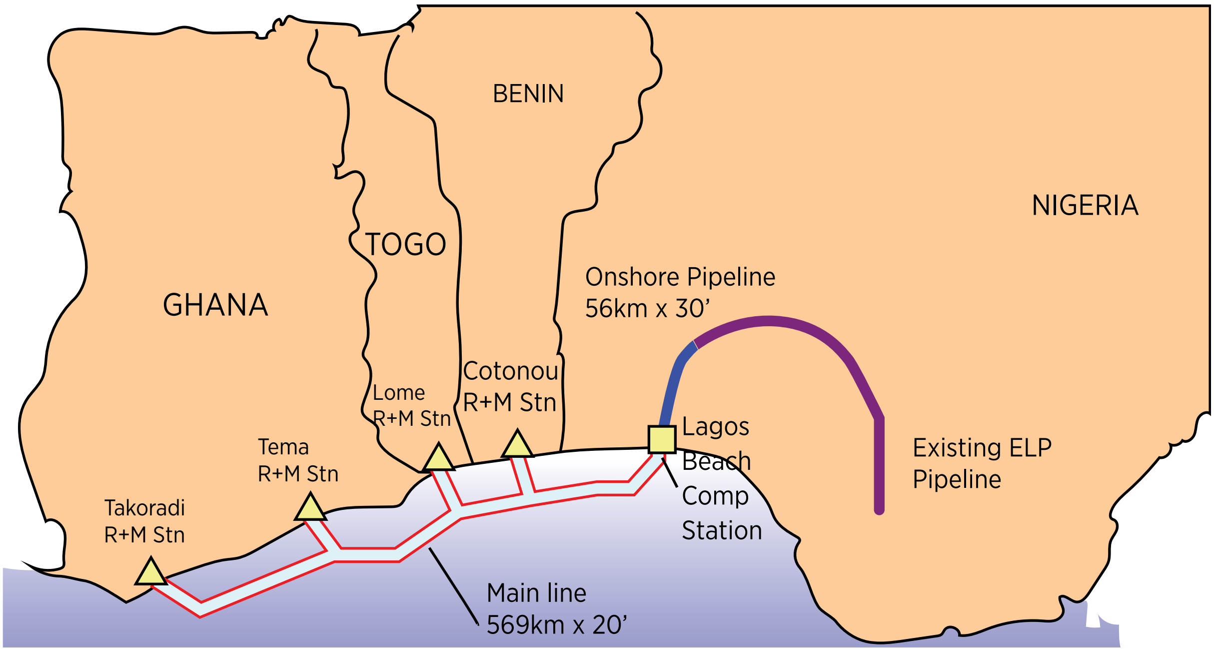
The bulk of electricity supply capacity additions are expected to come from large hydropower and natural gas. The master plan envisages adding 16,000 km of transmission lines and 10,000 megawatts (MW) of installed capacity. Of this, 7,000 MW will be derived from hydropower sources by 2025. The plan also adds 10% renewable energy (excluding large hydropower) into the regional electricity fuel mix. A 330 kilovolt (kV) Ghana-Togo interconnection project is expected to be commissioned in December 2014 (ECOWAS, 2013).

After ECOWAS proposed a natural gas pipeline across West Africa in 1982, Benin, Ghana, Nigeria and Togo heads of state signed the WAGP treaty in 2003. The pipeline was to transport natural gas for power plants and industries using heat, from Nigeria to Benin, Togo and Ghana. As illustrated in figure 3, the 678 km pipeline connects with the existing Escravos-Lagos pipeline at the Nigeria Gas Company's Itoki natural gas export terminal in Nigeria. It then continues offshore to Takoradi in Ghana via a beachhead in Lagos. Gas delivery laterals from the main Lagos — Takoradi line provide connections to Cotonou in Benin, Lome in Togo and Tema in Ghana. The WAGP was commissioned in 2008 and has a maximum capacity of 474 million standard cubic feet (MMscf) per day. The WAGP Company owns and operates the WAGP. This multinational is owned by Chevron West African Gas Pipeline (36.7%), Nigerian National Petroleum Corporation (25%), Shell Overseas Holdings (18%), Takoradi Power Company (16.3%), Société Togolaise de Gaz (2%) and Société BenGaz (2%). Nigeria, whose natural gas reserves are estimated at 180.5 trillion cubic feet, supplies gas to the WAGP (West African Gas Pipeline Authority 2011).

The ECOWAS Regional Electricity Regulatory Authority was created in 2008. Its aim is to ensure the regulation of cross-border exchanges in electricity and provide substantial support for member state national electricity regulators.

In 2008, the ECOWAS Regional Centre for Renewable Energy and Energy Efficiency (ECREEE) was established by the ECOWAS energy ministers. They were supported by the Governments of Austria and Spain and had technical assistance from the United Nations Industrial Development Organisation. ECREEE was founded in 2010 in Praia, Cape Verde, and is expected to further galvanise efforts previously initiated in several ECOWAS member states. These were aiming to mainstream renewable energy into their national energy policies. The creation of ECREEE greatly facilitated the subsequent development of an ECOWAS Renewable Energy Policy (EREP). This was adopted by member countries in November 2012 with several objectives. These include improving energy supply safety and sustainability and reducing imported fossil fuel dependency and exposure to volatile hydrocarbons. Its other objectives include promoting rural and urban energy access, creating a favourable environment for private sector investment and using renewable energy to drive the industrial, social and economic development (EREP, 2012). Table 3 displays the EREP targets.

Figure 3: Schematic of WAGP pipelines



Source: WAGPCo, 2014

Table 3: ECOWAS Renewable Energy Policy Targets

	2010	2020	2030
EREP renewable energy options (MW)	0	2,425	7,606
Total renewable energy penetration (incl. medium and large hydro)	32%	35%	48%
EREP renewable Energy options (GWh)	0	8,350	29,229
Total renewable energy production (incl. medium hydro)	26%	23%	31%
Off-grid (mini-grids and stand-alone) share of rural population served form renewable energy (%)		22%	25%
Biofuels (%)		5%	15%
Improved cookstoves (percentage of population)		60%	100%
Efficient charcoal production		60%	100%
Solar water heating and industrial water preheating technologies		25%	50%
• Residential sector & district health centres, maternities, school kitchen and boarding schools			
• Agro-food industries		10%	25%
• Hotels for hot sanitary water		10%	25%

Source: ECREEE, 2012

In co-operation with ECREEE and the International Atomic Energy Agency, IRENA has created a modelling tool for West African countries called the ECOWAS Renewable Energy Planning Model. This is for power sector planning that meets various system requirements including reliability. It also accounts for the optimal economic configurations — including both investment and operation costs — of the system to meet daily and/or seasonally fluctuating demand. Using this tool, IRENA developed a transition scenario for the renewable power sector in ECOWAS countries. This shows that the share of renewable technologies in the region could increase from 22% of electricity generation at present to as much as 52% in 2030 (IRENA, 2013). This is in line with the EREP targets outlined above.

Ghana is positioning itself as a major player in the ECOWAS regional electricity market by strengthening and extending transmission interconnections to neighbouring countries. Apart from the existing supplies to Togo and Benin, it plans to export power to Burkina Faso and Mali in 2014 and 2016 respectively (GRIDCo, 2011). To this end, a new 330 kV interconnection between the Volta region in Ghana and Lome in Togo was planned for 2013. A new 225 kV interconnection with Burkina Faso from Bolgatanga is expected to be commissioned in 2014 (*ibid*). It is expected that by 2015, the transmission systems upgrade would enable transmissible power capacity of about 191 MW to Burkina Faso. The Ghana Grid Company (GRIDCo) is also planning a new 225 kV interconnection from Bolgatanga to Mali via Burkina Faso in 2016. By 2020, a new 225 kV interconnection with the grid in Ivory Coast will be established through Prestea in the Western Region of Ghana. A generation master plan has been prepared in keeping with Ghana's long- term strategy of meeting domestic needs while increasing energy exports. This would increase generation capacity from 2,680 MW in 2012 to 5,500 MW by 2026. The first phase of capacity additions means converting single cycle into combined cycle plants and therefore increasing their capacities by about a third.

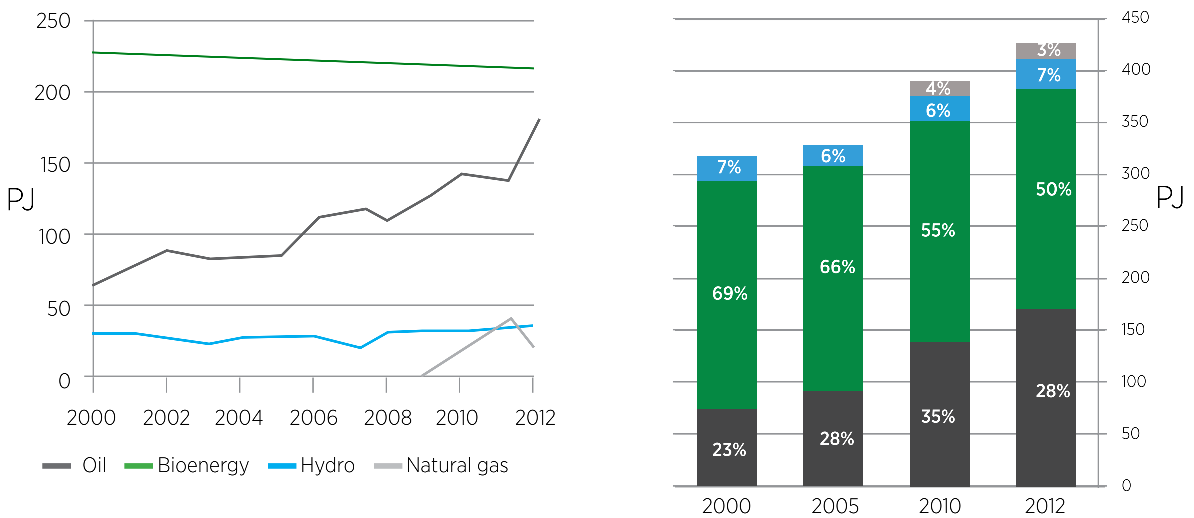
2.2 Energy Supply and Demand in Ghana

Biomass consisting mainly of wood fuel, like firewood, charcoal and to a lesser extent crop residues, accounts for half the Total Primary Energy Supply. Oil is the second most widely used form of energy in Ghana, accounting for 40% of primary energy supply, while hydro and natural gas account for 7% and 3% respectively (see figure 4). The main petroleum products are gas oil (diesel), petrol, kerosene and LPG, with gas oil being the most widely consumed. The main use of gas oil is transport, namely dry and wet cargo haulage, road and water passenger transport, and rail, but also in electricity generation, farming, fishing and industry. According to the 2010 Population and Housing Census, 17.8% of Ghanaians use kerosene as their main source of lighting. LPG is used as a cooking fuel in more than 18% of households. Other fuels (electricity, kerosene, etc.) are used for cooking by less than 1% of households in Ghana (Energy Commission, 2014).

Natural forests supply the bulk of wood fuel consumed in Ghana - up to 90%. The remainder comes from wood waste, like sawmill residue and plantations (Government of Ghana, 2012) and accounted for 38% of total final energy consumed in 2012. Charcoal has been steadily growing in importance compared to firewood. Since 2009, Charcoal's share of total biomass supply has increased by 26% while firewood production has increased by an almost negligible amount of 1%. Trends in biomass consumption mirror this pattern. Charcoal consumption increased by 18% in 2009-2013 compared to a 1% growth in firewood consumption over the same period (Energy Commission, 2014). Total national petroleum product consumption has doubled over the 12-year period. Hydropower and natural gas accounted for 7% and 3% primary energy supply respectively.

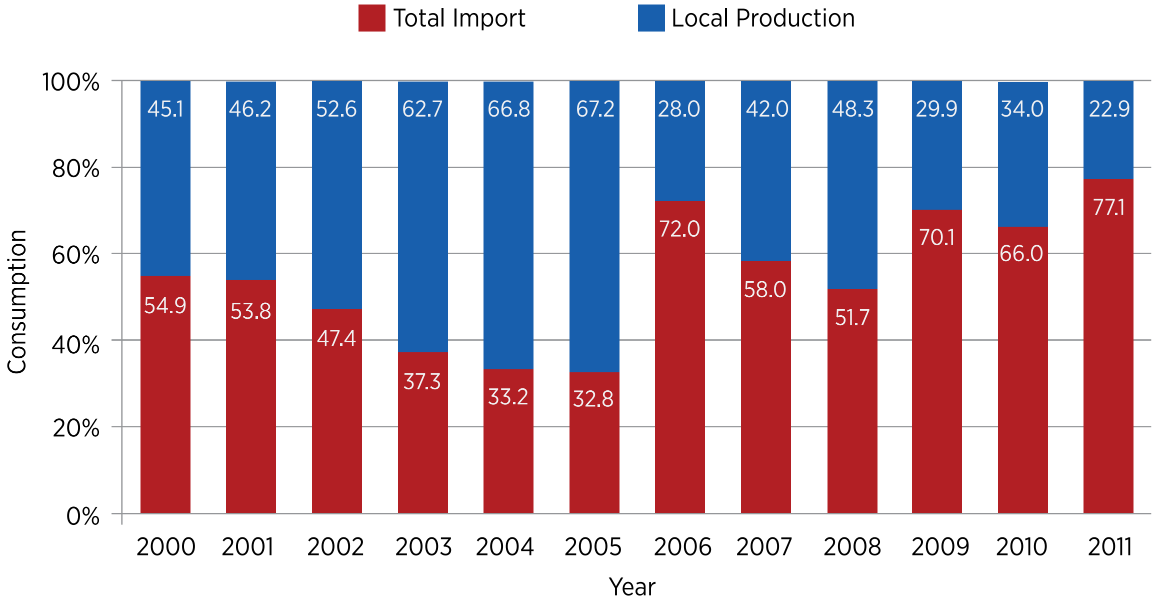
The Tema Oil Refinery is unable to meet daily national demand for petroleum products of 60,000 barrels per day. Imports compensate for the supply shortfall, as shown in figure 5. Rising oil product imports had a direct impact on the country's petroleum import bill. This has been growing consistently from USD 0.56 billion in 2003 to USD 3.44 billion in 2012. Petroleum import costs

Figure 4: Total Primary Energy Supply



Based on: IRENA data from the International Energy Agency and the Energy Commission of Ghana

Figure 5: Trends in Petroleum Imports (between 2000 and 2011)



Source: National Petroleum Authority, 2012.

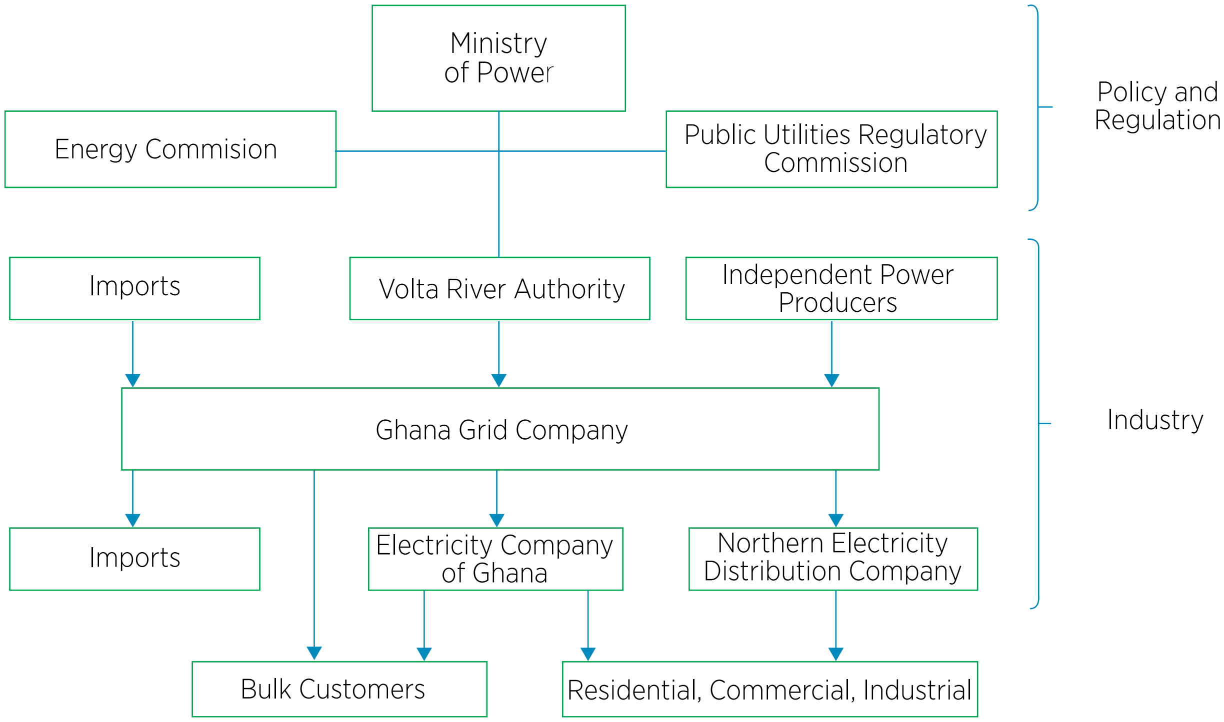
are susceptible to the international crude oil price and the high demand for petroleum products in all sectors of the Ghanaian economy. Although this represented about 8.5% of Ghana's GDP in 2012, it put a great deal of strain on Ghana's foreign exchange reserves, as it accounted for around 19% of total merchandise imports of USD 17.7 billion and 63% of gross international reserves in 2012.

2.3 Electricity System

Electricity accounted for about 13% of total energy consumed in Ghana in 2013 (Energy Commission, 2014). However, access to electricity is skewed towards urban households, with over 87% having access to grid electricity. This compares with just under half of rural households using electricity as their main lighting source (Ghana Statistical Service, 2012). Overall, electricity demand is estimated to be growing at about 10% per annum. According to the Ghanaian Strategic National Energy Plan (SNEP), electricity demand is due to grow from less than 9,000 GWh in 2012 to about 24,000 GWh by 2020. This will require generation capacity to rise to over 3.5 gigawatts (GW) by 2020.

The institutional arrangement of Ghana's electricity sector is displayed in figure 6. MoP is responsible for policy formulation and some aspects of its implementation. The Public Utilities Regulatory Commission (PURC) and the Energy Commission are the economic and technical regulators of the energy sector respectively. As the Ghanaian power industry is unbundled and consists of state-owned utilities. The generation Utilities are the Volta River Authority (VRA) and Bui Power Authority. GRIDCo, the Electricity Company of Ghana (ECG) and Northern Electricity Distribution Company (NEDCo) are responsible for transmission and distribution along with IPPs — Sunon Asogli and CENIT Energy.

Figure 6: Ghana Electricity Sector Institutional Structure



Generation

Total installed electricity generation capacity at December 2013 is 2,847 MW (Energy Commission, 2014). Hydropower capacity constitutes 64% of total generation capacity and thermal capacity 36%. Hydropower generation capacity includes the Akosombo, Kpong and Bui hydropower generation facilities. Thermal capacity sources include the Takoradi Power Company, Takoradi International Company, Sunon-Asogli Power, Tema Thermal Plant 1, Tema Thermal Plant 2, Mines Reserve Plant and CENIT Energy. The country's total electricity generated through the grid was 12,870 GWh (see table 4). Recent constraints in natural gas supply caused by damage to the WAGP have severely curtailed the capacity of thermal power plants to meet peak demands of about 1,745 MW. Sunon-Asogli Power, which runs exclusively on natural gas, was particularly affected. Increasingly frequent shortfalls in generation have forced the utilities to apply periodic load shedding since August 2012. Load shedding is expected to be reduced when the recently commissioned Bui Hydro project reaches full generation capacity of 400 MW, and gas supply from the WAGP is fully restored.

To guide public and the private sector investment in generation, the country's 2011-2026 generation master plan was commissioned by GRIDCo in close collaboration with all stakeholders in the energy sector. This long-term plan was developed with a least-cost assumption. It reflected technical and economic constraints such as geographical distribution, power demand evolution, operational constraints and fuel availability. The plan considered a total installed renewable energy capacity share of 10% by 2020 in order to comply with the national renewable energy target. The total required dependable capacity for the base case scenario amounts to 4,200 MW in 2020 and 5,550 MW in 2026. The corresponding installed renewable energy capacity would thus amount to 420 MW and 550 MW respectively.

Table 4: Electricity Generation by Plant

Plant Type	Installed Capacity (MW)	Total generation (GWh)				
		2009	2010	2011	2012	2013
Hydro Generation						
Akosombo	1,020	5,842	5,961	6,495	6,950	6,727
Kpong	160	1,035	1,035	1,066	1,121	1,144
Bui*	266	—	—	—	—	362
Sub-Total	**1,446**	**6,877**	**6,996**	**7,561**	**8,071**	**8,233**
Thermal Generation						
Takoradi Power Company (TAPCO)	330	453	1,234	1,137	1,061	1,783
Takoradi International Company (TICO)	220	1,040	1,160	657	1,168	1,032
Tema Thermal 1 Power Plant (TT1PP)	110	570	591	559	622	475
Tema Thermal 2 Power Plant (TT2PP)	49.5	—	28	50	141	94
Mines Reserve Plant (MRP)	80	18	20	12	20	—
Sunon-Asogli Power Ltd. (SAPP)	200	—	138	1,224	848	694
CENIT Energy Ltd (CEL)	110	—	—	—	94	454
Takoradi T3	132	—	—	—	—	102
Solar Generation						
VRA Solar Plant*	2	—	—	—	—	3
Sub-total	**1,234**	**2,081**	**3,171**	**3,639**	**3,954**	**4,634**
Grand Total	**2,682**	**8,958**	**10,167**	**11,200**	**12,025**	**12,870**

*Bui and Navrogo were commissioned in 2013
Source: Ghana Energy Commission, 2014

Transmission and Distribution

The power generated in Ghana is carried through 4,000 km of transmission lines across the country to 51 operational transformer substations. The lines operate at various voltages including 330 kV, 225 kV and 161 kV as depicted in figure 7. The transmission company GRIDCo has the mandate to provide all participants in the power market with open access to the transmission grid. One aim is efficient power delivery, and transmission losses average 4.8%. For distribution purposes, power is ramped down to lower voltages including 34.5 kV and 11 kV for major bulk customers such as ECG and NEDCo. Technical and commercial distribution losses are estimated at 23.6% and 21.3% respectively for each company.

The drive for national electrification has led to an expansion in the national transmission and distribution grid since the late 1980s. Several programmes and projects have extended the electric grid to the Brong Ahafo, Northern, Upper East and Upper West regions of Ghana and also supported the national electrification efforts. These are the National Electrification Scheme, Northern Electrification Programme, the Northern Electrification and System Reinforcement Project, the Rural Electrification Programme, and the Self-Help Electrification Project.

Figure 7: National Interconnected Transmission System of Ghana

Source: Ghana Grid Company Limited (GRIDCo)

Production Costs and Tariffs

The cost of power generation in Ghana varies from plant to plant depending on a number of factors. These include cost of construction, fuel type and non-variable costs. Hydropower constituted about 60% of the electricity supply, with generation cost at 0.033-0.09 USD/kWh. Thermal generation accounted for about 40% with costs at 0.09 USD/kWh for natural gas and 0.21-0.32 USD/kWh for light crude oil and diesel.

The average end-user tariff in Ghana is broken down into bulk generation charge, transmission service charge and distribution service charge. In 2012 these were estimated at 0.053 USD/kWh, 0.013 USD/kWh and 0.05 USD/kWh respectively, resulting in an average end-user tariff of 0.012 USD/kWh (PURC, 2011). Electricity consumers are grouped into three main categories - residential, non-residential (or commercial) and special load tariff. These are further subdivided into low, medium and high voltage customers based on their maximum demand. Residential and non-residential customers are further segregated into separate tariff categories.

Ghana's electricity mix was historically dominated by hydropower, so residential tariffs were low and did not reflect costs. However, with growing electricity demand and hydropower variability due to low rainfall, the electricity mix has increasingly shifted to costlier thermal generation. This has had a negative impact on the financial position of utility service providers and justifies tariff reform. The utility service providers therefore requested a 166% upward adjustment in electricity tariffs to cover their operational and maintenance costs. In 2013, PURC approved a tariff increase of 78.9% for all customer categories except for the lifeline tariff,[2] which was granted a 65% increase. The increases were part of efforts to acquire full cost recovery of electricity generation and distribution costs. The aim is to introduce this over a scheduled period using an automatic adjustment formula.

2.4 Renewable Energy Resource and Potential

Ghana is well endowed with renewable energy resources, particularly biomass, solar, wind energy, and to a limited extent, small- and mini-hydro energy as shown in table 5. When combined with aggressive measures to promote energy efficiency, renewable energy development can contribute substantially to expanding energy access, while reducing the latent crises of energy insecurity stalking the country.

Table 5: Renewable Energy Priority Projects

Potential Renewable Energy Projects	Expected Installed Capacity (MW)	Investment Requirement (US$)	Accelerated Timeline	Status
On-grid solar PV plants	50	100 – 150	2012 – 2014	2 MW constructed; construction of a 20 MW plant on-going
Medium – small Hydro	150 – 300	200 – 650	2018 – 2020	230 MW feasibility study ongoing
Grid-tied Rooftop Solar (net metered)	50	100 – 150	2012 – 2014	19 existing installations with total capacity of approximately 1 MW
Wind parks	150 – 300	200 – 600	2018 – 2020	Wind resource assessment underway at 16 sites sponsored by VRA and the Energy Commission

Source: MoEP, 2014; VRA, 2014

Biomass Potential

Ghana's total stock of direct wood fuel is around 832 million tonnes. Unless there are dramatic improvements in energy efficiency, demand for wood fuel, the dominant energy source, is expected to rise. The increase from 14 million tonnes in 2000 is projected to reach 38-46 million tonnes by 2015 and 54-66 million tonnes by 2020. If this trend were to continue as projected, it would put pressure on the nation's dwindling forests, leading to major deforestation, with all the associated consequences for climate change, agriculture and water resources. However, wood fuel consumption seems to have stabilised over the last decade or so, with a 14.6% reduction in demand between 2000-2014.

Timber logging uses 2.0-2.7 million cubic metres (m^3) biomass annually, producing 1.0-1.4 million m^3 of logging residues each year. These include edgings, offcuts, peeler cores, slabs, sawdust and residues from plywood manufacturing. The Kumasi area in particular has a concentration of residues due to the number of sawmills and plywood manufacturers located there, whereas Accra has large-scale furniture mills in its vicinity. Several smaller-scale furniture producers are distributed throughout the country. Potential wood residue may also be obtained from road construction, forest skidding trails for harvested timber haulage, forest clearings for agriculture and surface mining sites.

Estimates by Duku, Gu and Hagan (2011) and Mohammed, *et al.* (2013), place bioenergy potential from crop residue at 75-100 terajoules with about 47.6 terajoules from animal manure. Approximately 976,000 m^3 of forestry residues were generated in 2008, a potential source of bioenergy production (Duku, Gu and Hagan, 2011). There are several other biomass potential reserves, for example, trees unsuitable for commercial sale that are removed from plantations and residues from lumber grade tree harvesting, which could also count as potential sources of energy.

Several oil palm and timber processing firms have taken advantage of their residue streams to generate electricity for internal use and also for export into the grid. Table 6 lists some of the companies already generating electricity from their waste resources. Much more can be extracted out of the biomass sector.

Urban areas generate large quantities of organic municipal waste, with Kumasi and its suburbs generating up to 1,600 tonnes daily, while Accra and its surrounding areas produce up to 2,500 tonnes daily. Municipal waste generation in the metropolitan centres ranges from 600-800 tonnes per day. As it is convertible to energy, this is a potential source of bioenergy.

Besides wood residues and municipal waste, energy crops could be used for biofuel production in Ghana. They include jatropha, oil palm, sunflower, soybean and coconut for biodiesel and cassava, maize, sugar cane and sweet sorghum for ethanol (Ahiataku-Togobo and Ofosu-Ahenkorah, 2009). Maize and cassava are important staple food crops in Ghana. Maize is grown across the whole country. In 2008, about 1.5 million tonnes of maize were harvested from an area of about 850,000 ha, increasing to about 1.9 million tonnes produced in 2010. There has been significant rise in cassava production. In 2010, about 13.5 million tonnes of cassava was harvested from an area of about 875,000 ha according to the Food and Agriculture Organisation Statistics Division in 2013. High-yielding new varieties of cassava as part of the President's Special Initiative on cassava production, have been in part responsible for the increase in production since 2000. In 2013, the Food and Agriculture Organisation Statistics Division estimated Ghana sugar cane production at 145,000 tonnes in 2010. In Ghana, sorghum is cultivated in the savannah zones. Food and Agriculture Organisation crop statistics reported Ghana sorghum 2010 production of about 324,000 tonnes from an area of about 253,000 ha. Ghana jatropha plantations currently cover about 1,534 ha and oil palm plantations about 320,000 ha.

Small- and medium-scale hydropower potential

The prospect of harnessing the hydropower potential of small rivers in Ghana has been investigated for many years, and many potential mini-hydropower sites have been identified. ECREEE defines small hydropower as plants with production capacity less than 30 MW, but hydropower schemes of up to 100 MW qualify for renewable electricity Feed-in Tariff (FiTs) under Ghana's Renewable Energy Act. Table 7 shows potential hydropower sites in the different regions with individual capacities of 4 kilowatt (kW) to 2,000 kW. Table 8 also shows small- and medium-scale hydropower sites with a total capacity of 837 MW also qualifying for the FiT. According to its national energy policy, the Government of Ghana intends to support the development of these additional hydropower capacities. Detailed technical and financial feasibility studies are under way at five selected sites. VRA is carrying them out at Juale, Pwalugu, Kulpawn and Daboya while the MoP is conducting the Hemang study.

Table 6: Modern Energy from Biomass Resources

Plant location	Installed capacity (kW)	Average annual energy (GWh)
Kwae Oil Mills	2,500	6.8
Benso Oil Mills	500	1.9
Twifo Mills	610	2.1
Juaben Oil Mills	424	1.5

Source: Government of Ghana (2012)

Table 7: Identified Mini Hydropower Sites in Ghana*

Region	Number of sites	Potential minimum power (kW)	Potential maximum power (kW)
Upper East and Upper West	8	499	2,100
Northern	16	913	4,420
Brong Ahafo		364	1,900
Western and Central	9	332	2,150
Ashanti	4	140	720
Eastern	9	569	1,150
Volta	17	4,919	12,065

* Individual site potential ranges from 4 kW to 2,000 kW.

Table 8: Potential Small- and Medium- Hydropower Sites

River basin	Potential (MW)	Average annual energy (GWh)
Black Volta		
Koulbi	68	392
Ntereso	64	257
Lanka	95	319
Jambito	55	180
Total:	**282**	**1,148**
White Volta		
Pwalugu	48	184
Kulpawn	36	166
Daboya	43	194
Total:	**127**	**544**
River Oti		
Juale	90	405
Total:	**90**	**405**
River Tano		
Asuaso	25	129
Sedukrom	17	67
Jomoro	20	85
Tanoso	56	256
Total:	**118**	**537**
Pra River		
Awiasam	50	205
Hemang	90	336
Abatumesu	50	233
Kojokrom	30	136
Total:	**220**	**910**

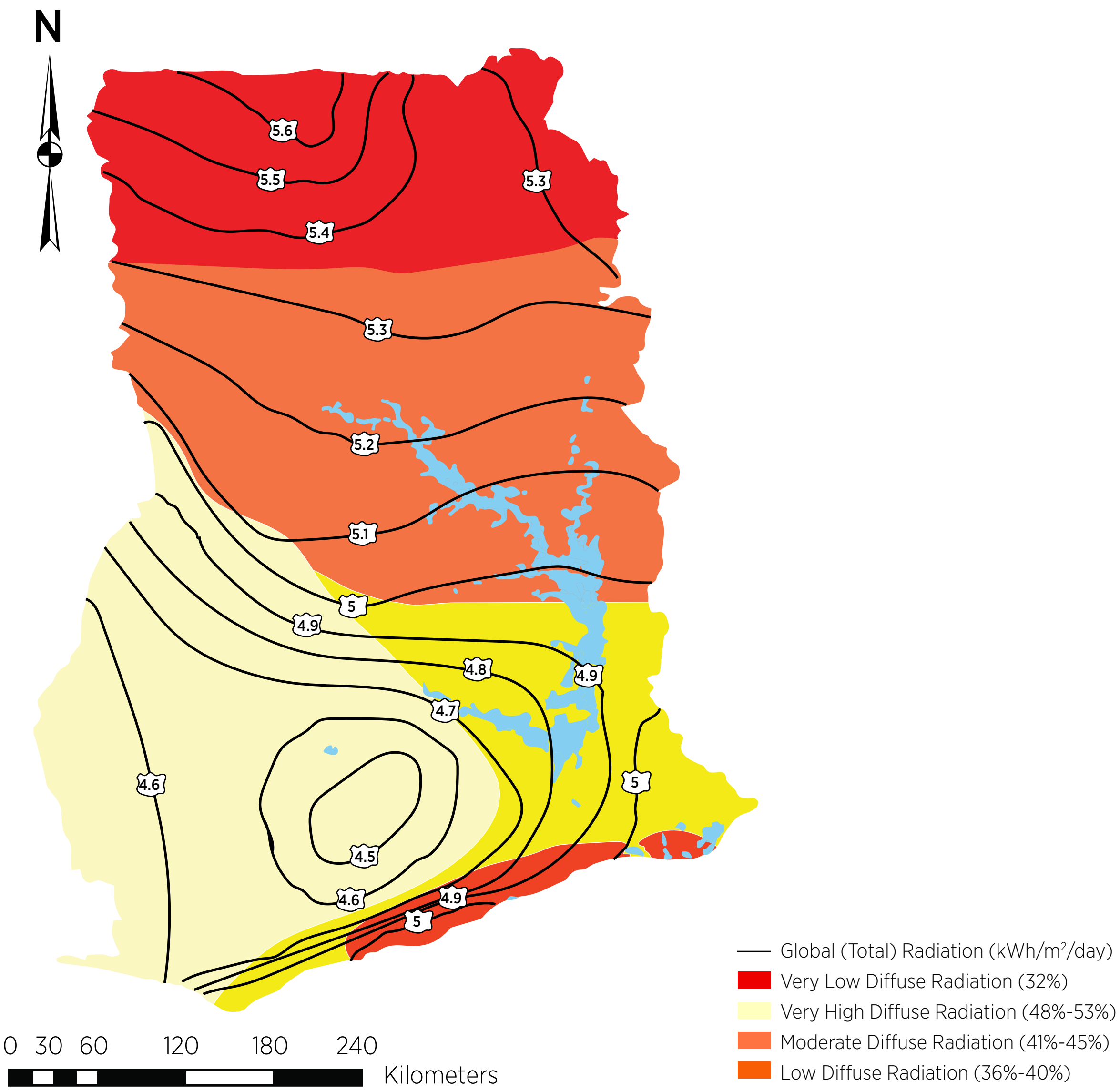
Source: Energy Commission (2010)

Solar Energy Resource

The Ghana Meteorological Services Agency Data has been collecting for over 50 years, data on the solar radiation and sunshine hours. The probable error for the daily irradiation data is 15%. The Mechanical Engineering Department at Kumasi's Kwame Nkrumah University of Science and Technology (KNUST) measures hourly global and diffuse irradiance, where the probable error is 5%. The monthly average solar irradiation in Ghana ranges between 4.4-5.6 kWh/m^2/day, this includes 5.3 hours at Kumasi in the cloudy semi-deciduous forest region to 7.7 hours at Wa in the dry savannah region.

Northern Ghana, including northern parts of Brong-Ahafo and the Volta, have a monthly average of 4-6.5 kWh/m^2/day, which is very high. This area also experiences a major rainy season between July and September, and the Harmattan, a hot, dry wind, between November and February. Ashanti, parts of Brong-Ahafo, Eastern, Western and parts of Central and Volta regions have monthly average radiation level range of 3.1-5.8 kWh/m^2/day (Energy Commission, 2012). Greater Accra and the Central and Volta coastal regions have monthly average radiation levels between 4.0-6.0 kWh/m^2/day (see figure 8; Energy Commission, 2012).

Figure 8: Global Solar Irradiation in Ghana



Source : Ministry of Power

About 15,000 solar systems have been deployed in rural areas with an estimated installed capacity of about 3.2 MW. This was achieved through the Ghana Energy Access and Development Project (GEDAP) funded by multiple donors. It is being implemented by MoEP.

VRA commissioned a 2.5 MW grid-connected solar plant in Navrongo in 2013 as part of its Renewable Energy Development Programme. This aims to install a total capacity of 10 MW in its first phase. The Navrongo plant is the first "large-scale" solar plant to be integrated into the national grid. It comprises six PV arrays covering 3.9 ha. The China Wind Power Company completed the installation for USD 8 million funded by VRA, which is receiving a grant of EUR 22.8 m from KfW[2] to add another 12 MW at Kaleo and Lawra in the Upper West Region. The state generator is also negotiating another 57 ha of land for grid-connected solar electricity generation at Bongo in the Upper East Region. It hopes to add another 100 MW over the next six years in increments of 20-25 MW annually. This would ensure the 10% renewables target (wind and solar) in the energy portfolio is reached by 2020.

Small-scale grid-connected solar PV systems have been tested in Ghana, and there are 19 existing installations with a combined capacity of around 1 MW. One of these is the KNUST grid-connected solar PV system on the roof of its College of Engineering. The total installed capacity is 24 kW and has monitoring equipment that takes readings at hourly intervals. The system serves as a tool for research and teaching and has been used to assess grid-connected solar PV grid-connected systems.

A number of international and national developers have shown a growing interest in developing utility-scale solar PV plants. Blue Energy has announced it plans to build a 155 MW solar PV plant in the Western Region of Ghana.

A section of the solar PV panels of KNUST's 24 kWp system
Photo: Ministry of Power

2 Formerly the Kreditanstalt für Wiederaufbau Bankengruppe (KfW banking group), meaning Reconstruction Credit Institute — a German government-owned development bank, based in Frankfurt.

Wind Energy Resource

Ghana's technical wind power potential has been estimated at more than 5,000 MW. Average wind speeds are 6.4-7.5 metres per second (m/s), corresponding to wind class categories 3 and 4 shown in table 9. Overall, the most promising areas for deployment of wind power plants are along the mountains in the south-eastern part of the country and along the eastern coastal areas of the country. It has been estimated that 200-400 MW of onshore wind power could be established there with wind speeds in excess of 8 m/s (Essandoh, Osei and Adam, 2014).

The VRA has entered into agreements with two wind infrastructure manufacturers and project developers - Vestas Mediterranean and Elsewedy - to develop two wind parks, capable of producing 150-200 MW. It has also signed contracts for additional wind speed measurement at six sites to determine which are best for wind power development: Anloga, Lekpoguno, Akplabanya, Mankoadze, Amoma South and Gambaga.

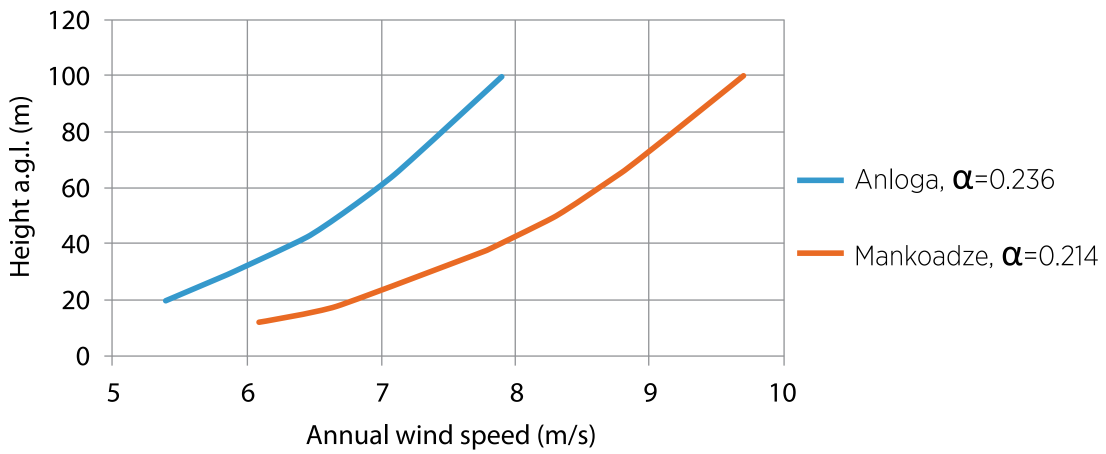
To encourage grid-connected wind energy systems, a technical and financial assessment was conducted at KNUST Energy Center. It was conducted using wind data collected at Mankoadze and Anloga. Wind speeds at Mankoadze averaged 6.1 m/s and were taken at 12 m heights between January 2001 and July 2002. Anloga wind speeds were lower, at an average of 5.4 m/s taken at 20 m heights between May 2006 and December 2007. Figure 9 shows that the annual mean wind speed for Mankoadze increases from 6.1 m/s at 12 m above ground level, reaching 9.7 m/s at 100 m.

Table 9: Gross Wind Resource Potential of Ghana

Wind Resource Utility Scale	Wind Class	Wind Power at 50 m	Wind Speed at 50 m	Total Area	Percent Windy Land	Total Technical Capacity
		W/m²	m/s	km²	%	MW
Moderate	3	300 - 400	6.4 – 7.0	715	0.3	3,575
Good	4	400 – 500	7.0 – 7.5	268	0.1	1,340
Very Good	5	500 – 600	7.5 – 8.0	82	<0.1	410
Excellent	6	600 – 800	8.0 – 8.8	63	<0.1	315
Total				**1,128**	**0.5**	**5,640**

Where: W is Watt
Source: Ministry of Energy, 2013

Figure 9: Annual Mean Wind Profile for Mankoadze and Anloga



Source: KNUST

III. ENABLING ENVIRONMENT FOR RENEWABLE ENERGY

Historically, the institutional framework of the energy sector and associated human capacities was designed to support large-scale, centralised energy infrastructure. For the most part, however, renewable energy development requires more decentralised governance approaches, including the creation of new policies, regulations and plans that catalyse the active participation of new players in the public and private domain. In addition, renewable energy development often requires fundamental changes in the roles and responsibilities of key actors making up the energy sector institutional framework. This section reviews the key energy stakeholders and the policy, regulatory, financing and investment framework of the country's energy sector.

3.1 Key Energy Stakeholders and Institutions

The Ghana energy system is managed by the public sector. MoP is responsible for formulating, implementing, monitoring and evaluating power sector policies. VRA and Bui Power Authority are state-owned utilities that generate the bulk of the country's electricity supply. GRIDCo manages the national transmission and system operation and supplies electricity to industrial and mining units as well as to the two VRA electricity distribution companies ECG and NEDCo.

A number of regulatory agencies have been established by acts of parliament. This is to ensure all players in the energy sector function properly, and to create a conducive environment for protecting and enhancing private investment in the sector. These agencies are the Energy Commission, PURC and the National Petroleum Authority. The Energy Commission advises government on energy policy and strategy. It is also involved in indicative planning of energy and electricity system expansion and licensing energy sector operators (Energy Commission, 2006). Established in 1997, PURC is the prime body for setting tariffs and framing customer service regulations. The National Petroleum Authority is an independent regulator which reviews world market price developments, the prices of imported finished products and the operations of Ghana's oil refinery.

The sector also has several active non-governmental organisations (NGOs), research institutes and universities as well as industry associations involved in a range of activities. These include renewable energy promotion, research and deployment. Table 10 lists the institutions whose actions can most influence the renewable energy trajectory in Ghana and briefly describes their functions.

Table 10: Key Institutions in Ghana's Energy Sector

Institutions	Functions
	Policy and Regulation
Ministry of Power (MoP)	Formulates, implements, monitors and evaluates power sector policies
Ministry of Energy and Petroleum	Formulates, implements, monitors and evaluates energy sector policies
Energy Commission (EC)	Licenses, regulates and monitors energy service providers, develops indicative national energy plans and advises the minister on energy policy
Public Utilities Regulatory Commission (PURC)	Regulates tariffs and enforcement of customer service obligations of all public utilities and IPPs
National Petroleum Authority (NPA)	Regulates, oversees and monitors activities in the downstream petroleum industry
Petroleum Commission (PC)	Regulates and manages the utilisation of petroleum resources, and co-ordinates policies on petroleum resources
Environmental Protection Agency (EPA)	Distributes, monitors and enforces environmental policies, including the energy sector
Ghana Investment Promotion Centre (GIPC)	Encourages and promotes investments in Ghana, providing for the creation of an attractive incentive framework and a transparent, predictable and facilitating environment for investment
	Implementation
Volta River Authority (VRA)	Generation and transmission of electricity
GRIDCo	Electricity transmission services
Electricity Company of Ghana (ECG)	Distribution of electricity in southern Ghana
Northern Electricity Department (NED)	Distribution of electricity in northern Ghana
Tema Oil Refinery (TOR)	Crude oil and petroleum product import, crude oil refining and bulk sale of petroleum products to OMCs and bulk consumers
Ghana National Petroleum Corporation (GNPC)	Oil and gas exploration
Bulk Oil Storage and Transportation Company (BOST)	Planning for laying and managing strategic petroleum product stocks
Oil Marketing Companies (OMCs)	Distribution and marketing of petroleum products
	Education and Research
The Energy Center, KNUST	Carries out research, development, demonstration and educational activities in energy technology, policy and management
University of Energy and Natural Resources (UENR)	Provides training in science, technology and management of energy and natural resources
Council for Scientific and Industrial Research (CSIR)	Pursues the implementation of government policies on scientific research and development
	Non-governmental Organisations
KITE	Energy policy studies and analysis/clean energy enterprise development
Association of Ghana Solar Industries (GSI)	Promotes and raises the profile of the solar industry, improves quality, develops standards and arranges renewable energy training
Energy Foundation	Promotes energy efficiency/conservation measures and renewable energy technologies.
New Energy	Develops and implements clean energy initiatives
CEESD	Dedicated to technologies that offer engineering solutions to climate change, energy poverty and environmental degradation

3.2 Policy and Regulatory Framework

During the second half of the 1990s, the Government of Ghana initiated a broader energy sector reform. This allowed the creation in late 1997 of PURC and the Energy Commission through two acts of parliament, Act 538: the Public Utilities Regulatory Commission Act and Act 541: the Energy Commission Act. The Energy Commission was tasked with the technical regulation of the energy sector, while PURC was mandated to handle the economic regulation of the energy and water sectors. In that same year, the vertically integrated VRA was to be unbundled into separate transmission and system operation companies. It retained the task of electricity generation and distribution in the North through its Northern Electricity Department. This later became NEDCo while ECG was tasked with electricity distribution in southern Ghana. IPPs were allowed to enter the market, and the first one was created in 2000.

The Strategic National Energy Plan (SNEP)

completed by the Energy Commission in 2006 comprehensively examines the energy resources available to Ghana. It considers how and when to tap them economically to ensure a secure and adequate energy supply for sustainable economic growth to 2020 (Energy Commission, 2006). The SNEP goal is to enable the development of a sound energy market that would provide sufficient, viable and efficient energy services for Ghana's economic development. It will be achieved by articulating a comprehensive plan identifying the optimal path for developing, utilising and efficiently managing the energy resources available to the country. The plan identified renewables (including wind, solar and biomass) as key energy sources for long-term development and sustainable electricity supply. Unfortunately the huge potential of SNEP to create a market for renewable energy was not fully realised. This is because it was not formally adopted by the government. One of the challenges facing renewables development today is finding a way to redress this situation and make SNEP a binding policy document.

The National Energy Policy

was completed by the Ministry of Energy in 2010. It envisages the development of an "Energy Economy" that will allow a secure and reliable supply of high quality, environmentally sustainable energy services for all sectors of the Ghanaian economy. At the same time, the country would be transformed into a major exporter of oil and power by 2012 and 2015 respectively (Ministry of Energy, 2010a). The specific goal of the policy on renewable energy is to increase its proportion in the national energy mix and ensure its efficient production and use. This objective is to be reached via a number of routes. One is to promote the efficient use of biomass and improve production while increasing regeneration. Another is to convert most waste generated in municipal activities, industrial and agricultural operations to energy. Another is to create fiscal and pricing incentives to enhance the development and use of renewable energy. Finally, Ghanaian engineers and scientists are to collaborate with international experts to bring down the cost of solar and wind energy technologies (*ibid*).

The Energy Sector Strategy and Development plan

was also completed by the Ministry of Energy in 2010, building on SNEP, developed in 2006 by the Energy Commission. Three main objectives concerning the renewable energy sub-sector are to be implemented under this strategy. The first is to increase the renewable energy supply in the national energy mix to 10% by 2020. The second is to create legislation to encourage renewable energy technology development and utilisation by adopting a renewable energy law. The third is to manage municipal industrial and agricultural waste for energy production (Ministry of Energy, 2010b).

The Renewable Energy Law

was adopted by Act 832 in 2011. It provided for the development, management, utilisation, sustainability and adequate supply of renewable energy for heat and power generation and related matters. This law provides for the establishment of two policy instruments. The first is the FiT, a pricing incentive. The second is the Renewable Energy Purchase Obligation (RPO). They are available to all electricity distribution utility or bulk customers, and aim to boost renewable energy technology deployment in Ghana in a sustainable way. The law also provides rules for connecting a renewable energy generator to the transmission and distribution systems and the establishing a renewable energy fund, the REF. The FiT rate was developed by PURC and published on 1 September 2013 (see table 11). It is guaranteed for a period of ten years and subsequently subject to review every two years.

Table 11: . Ghana Feed-in Tariffs (Gazetted in 2013)

Renewable Energy Technology	FIT effective 1st September 2013 (GHS/kWh)	FIT effective 1st September 2013 (US cent/kWh)[a]
Wind	32.1085	15.15
Solar	40.210	18.97
Hydro < 10 MW	26.5574	12.53
Hydro (10 MW > < 100 MW)	22.7436	10.73
Landfill Gas	31.4696	14.84
Sewage Gas	31.4696	14.84
Biomass	31.4696	14.84

Source: PURC
[a] At 2013 exchange rate of 1 USD = 2.12 GHS

3.3 Financing and Investment

There would have been no progress in renewable energy development in Ghana, however modest, without substantial inflows of foreign investment. These are buttressed by donor funding to support "soft" activities such as pilot testing of technologies, business model development and institutional capacity building. Most energy projects in Ghana are carried out with the assistance of development partners. These include, for instance, the World Bank, ARB Apex bank, the United Nations Development Programme, Danish International Development Agency and the Global Environment Facility. Similarly, the United Nations Environment Programme runs the African Rural Energy Enterprise Development Programme. For instance, GEDAP is a USD 227.5 million multi-donor project involving the World Bank's International Development Association, Global Environment Facility, African Development Bank, Global Partnership on Output Based Aid, Africa Catalytic Growth Fund and the Swiss Agency for Development and Co-operation.

The GEDAP development objective is to improve the operational efficiency of the power distribution system and increase the population's access to electricity. This helps move Ghana to a low-carbon economy through the reduction of greenhouse gas emissions. Electricity access expansion and renewable energy development are subcomponents of GEDAP with a total project cost of USD 101.5 million. It is a multifaceted approach aimed both at grid extension and isolated grids.

The country also borrows from the international financial markets to fund energy projects. For instance, the funding for the Bui Hydroelectric Project is a hybrid credit facility comprising of a concessional loan and a buyer's credit facility between the Government of Ghana and Exim Bank of China.

The government has made some efforts to set up national funds into which levies on energy consumption are paid to finance specific development activities in the power sector. These include: (i) the Rural Electrification Levy paid into the National Electrification Fund, (ii) the Street Lighting Levy (iii) the Power Factor Surcharge Levy paid into the Electricity Demand Management Fund. This funding mechanism is slowly being applied for raising internal funds for renewable energy from conventional fuels. For example, a levy of 0.26 USD/litre[3] on gasoline, kerosene and diesel fuel products supports research, development and promotion of Ghana's natural energy resources — particularly renewable energy. The levy goes into a fund called the Energy Fund and yields an average USD 500,000 per annum.

The recent establishment of a renewable energy fund under the Renewable Energy Act is possibly the most important event affecting renewable energy development. The point of the fund is to mobilise financial resources for the promotion, development, sustainable management and utilisation of renewable energy resources. Monies from the fund are to be used to promote the following:

- Innovative approaches, including new business models for developing and utilising renewable energy sources
- Scientific, technological and innovative research into renewable energy

[3] Equivalent to 0.78 GHS/kWh using exchange rate of 1 USD = 3.00049 Ghana cedi (GHS) on 6 January 2014

- Designing and implementing standards for utilising 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

As part of efforts to further stimulate private investment in the renewable energy sector, the Ghana Investment Promotion Centre Act was passed in 1994. It provides for import duty exemptions on renewable energy technologies given that most of this technology and equipment is imported.[4] For investors importing generators to invest in the renewable energy sector, the following specific incentives are available:

- Total exemption from import duty on renewable energy generators, including solar generators, wind turbines and technologies for generating energy from municipal waste;
- VAT exemption on imports of renewable energy products if the components are brought in as a single piece (*i.e.* not taken apart beforehand); and
- Customs import duty exemption on plant, machinery, equipment and accessories imported specifically and exclusively to set up an enterprise

Good Practice Demonstration: Creating a Favourable Climate for Private Renewable Energy Investors

Due largely to the policy measures taken by the government to promote investments, Ghana has witnessed growing inflows of financing into the renewable energy sector, the bulk of it targeting the proven renewable energy resources for on-grid electrification. DEG, a German development financier with focus on the private sector in developing countries is keen on increasing its investments in IPPs with renewable energy sources in the West African sub-region, Ghana being a key prospective market for its mission. The private sector financing institution is currently finalising arrangements with some independent power producers (IPP) to build a biomass power plant and a couple of other plants to generate power from renewable sources. Out of the EUR 1 bn portfolio DEG has in Africa, a third is in West Africa, amounting to about EUR 300 million. With a standing portfolio of about USD 270 million in Ghana, DEG has made investments of about USD 40 million in 2012, and were expected to repeat that feat in 2013 (Ghana Daily Graphic, 2012; 13 November Issue).

[4] Solar systems are exempted from VAT if the components are brought in as a unit. However, if batteries and inverters are brought in separately, they are subject to VAT.

Solar PV street lighting in island community
Photo: Ministry of Power

IV. EMERGING ISSUES IN THE DEPLOYMENT OF RENEWABLE ENERGY

There are opportunities in Ghana to deploy renewable energy systems capable of meeting a large variety of service needs. However, resources have to be allocated only to priority needs, the satisfaction of which can generate high impacts at low costs. This section focuses only on those service-resource pairs prioritised during the RRA. In each case, we take a more in-depth look at the key concerns and barriers as renewable energy technologies are scaled up. It concludes with key action recommended by the RRA.

4.1 On-grid Electricity

As discussed in section 2.4, Ghana enjoys an abundance of renewable energy resources in the form of solar, wind, mini-hydropower and biomass. These resources are together theoretically capable of generating far more than the targeted 550 MW electricity from renewables by 2020 prescribed in the generation master plan. This consists of 300 MW from hydropower and 250 MW from variable renewable energy. However planned and announced renewable energy projects amount to about 2,000 MW of installed capacity at the moment. This includes 900 MW for solar PV, 800 MW for wind and 300 MW for hydropower. This is around four times more than expected in the generation master plan. This is partly due to the approval of the FiTs, which has attracted investor interest. However, several problems still need to be solved if Ghana is to raise its share of renewable energy in the national electricity mix to help close the gap between electricity supply and demand.

Target Setting

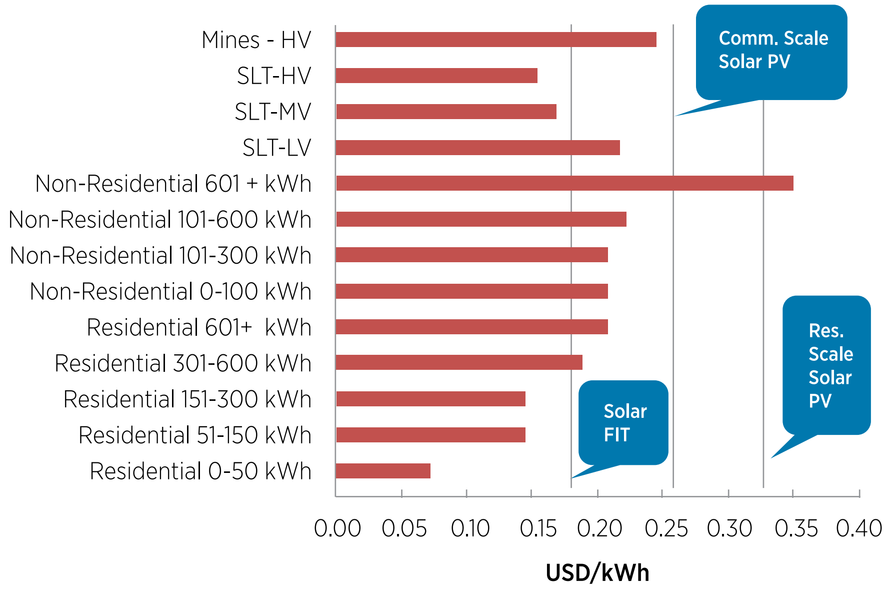
The National Energy Policy objective of using renewable energy for 10% of total energy production by 2020 was translated into the generation master plan as 10% of the electricity mix. This focused exclusively on grid-connected applications, which means 6% dispatchable and 4% variable renewable energy power. Investor interest in developing variable renewable energy power has increased at a time when thermal power generation is expensive and backup capacity almost nil. The time has therefore come for the government to assess the grid conditions for accommodating variable renewable energy. This will further help establish technology-specific targets and related definite capacity additions, thereby increasing market confidence and competition. This should drive costs down.

Grid Integration of Variable renewable energy

Ghana has developed a comprehensive grid code revised most recently in 2009. This establishes the requirements, procedures, practices and standards governing the development, operation, maintenance and use of the high voltage transmission system in Ghana. In its present form, this grid code lacks two prerequisites that would further enable the integration of utility-scale variable renewable energy in the grid. These are generation forecasting and priority dispatch. At the moment, the Ghana grid code requires generators to submit their production capability and availability one day ahead so that the system operator can prepare the next day's generation schedule. However, operators of variable renewable energy plants can best provide accurate information on electricity output on an hourly or sub-hourly basis. The grid code thus needs to be revised and include specific conditions accommodating renewable energy generators to provide accurate data. This also has some implications for the system operator, which would have to adapt by developing the necessary capacities and procedures in its daily operation. The grid code should in addition provide for the priority dispatch of renewable power.

The RPO imposed on distribution utilities in the Renewable Energy Law opens the door for consumers to sell renewable electricity to the grid. Net metering solar PV electricity is therefore an option to be further explored. Key net metering drivers in Ghana, include high solar irradiation, increasing electricity retail tariffs, the declining cost of solar PV and import tax exemptions on solar PV panels. Indeed, the 2013 tariff reform, which increased the retail price by 78%, offers a real opportunity to reduce electricity expenses. This is especially true for households consuming over 300 kWh and for all non-residential customers, allowing them to become PV "prosumers" (figure 10).[5]

Figure 10: The 2013 Electricity Tariffs Compared with Long Run Marginal Cost of Solar PV



Source: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), 2013

In addition, both distribution utilities (NEDCo and ECG) are taking various initiatives to increase their readiness to adopt smart grid technologies. This will help scale up grid-connected rooftop solar PV systems as these distribution utilities will be better able to manage and integrate them into the grid. There is therefore a need to raise awareness of these savings opportunities for these potential PV prosumers. This business opportunity needs to be marketed to local financial institutions to design tailored-made financial products for this sector. The government therefore needs to engage in developing standards and codes for grid-connected rooftop solar PV as well as supporting capacity building efforts for local financial institutions.

Financial Support Mechanisms and Payment Guarantees to IPPs

As mentioned above, the Renewable Energy Law provides the basis for developing grid-connected renewable energy. This is because it establishes supportive instruments like FiTs and the RPO for distribution utilities and bulk consumers and requires all transmission or distribution operators to connect a renewable energy generator within their area. However the proportion of renewable energy in the electricity mix of bulk consumers has yet to be defined. It should therefore be developed in the context of the target for the entire renewable energy sector. The Renewable Energy Law also provides for the establishment of a renewable energy fund[6]

[5] The term prosumer is used in the electricity industry to refer to energy consumers who also produce their own power from a range of different on-site generators (*e.g.* diesel generators, combined heat and power systems, wind turbines and solar PV systems).

to offer financial incentives, capital subsidies, production subsidies and equity participation for renewable energy power generation.

This RRA finds that the establishment of a new FiT regime, though necessary, is not sufficient to unleash the maximum flow of investment into on-grid electrification projects. A remaining concern is the provision of payment guarantees to IPPs, which will affect the commercial viability of renewable energy projects. This is due to the fact that distribution companies ECG and NEDCo are saddled with debt. The two utilities are unable to meet their payment obligations to present suppliers and thus cannot credibly offtake any renewable energy investment. ECG has already signed power purchase agreements (PPAs), but none of these projects has yet been implemented. Given the minimal experience of FiTs in Ghana, setbacks are likely at the earliest stage of the scheme. It is important that appropriate structures are put in place to resolve such challenges, focusing on capacity building for relevant public, private and civil society organisations.

The average FiT rate was equivalent to 0.14 USD/kWh in 2013 when it was adopted. Since then the Ghana cedi has fallen over 21% to a rate of GHS 3/USD within a year. This is because foreign exchange reserves are diminishing as the country struggles to reduce its budget deficit. This could have major implications for the development of renewable energy projects, as investments are most likely to be denominated in foreign currency while revenues are expected in cedi. Ghana needs to consider designing effective currency risk mitigation instruments that will help increase investor confidence in financing renewable energy projects.

Streamlining IPP Market Entry for Renewables

To enter the electricity market, a renewable energy IPP has to interact with a number of regulatory agencies in the power sector once detailed feasibility studies have been completed. These include the Energy Commission and PURC, the Environmental Protection Agency, MoP, the Ministry of Finance and the Ghana Investment Promotion Agency. These provide various licences, approvals, clearances and incentives linked to the development of the renewable energy project (see figure 11). This complex and lengthy procedure can lead to significant administrative and transaction costs, and may discourage potential investors and project developers from entering the market. Thus there is a need to set up a one-stop shop, which may help reduce complexity and assist IPPs working through the bureaucracy.

[6] The Renewable Energy fund is expected to be sourced by moneys approved from the parliament, premiums payable by bulk consumers who fail to meet RPOs, donations, grants and gifts received for renewable energy activities, moneys approved by the board of the Energy Fund, and money generated by the Energy Commission from the provision of services for renewable energy activities

Figure 11: Procedures for Entry into the Electricity Market with Renewables

IPP undertakes pre-feasibility study

↓

IPP identifies a buyer or an off-taker (*e.g.* ECG or another bulk customers)

↓

Detailed feasibility studies to ascertain technical feasibility and financial viability of the project

↓

IPP interacts with relevant regulatory agencies, such as the Energy Commission (EC) (licensing and technical regulations) and PURC (pricing regulations)

↓

IPP obtains site clearance by Environmental Protection Agency (EPA) and EC.

↓

IPP obtains environmental permit from EPA

↓

Concluding a memorandum of understanding between IPP and off-taker after securing PURC's no-objection in principle

↓

Obtaining license from the Energy Commission

↓

IPP obtains relevant approvals of identified relief's from governmental agencies, such as (GIPC), Ministry of Power (renewable Energy Law) and Ministry of Finance & Economic Planning, etc.

↓

IPP concludes PPA with off-taker

4.2 Decentralised Renewable Energy Applications

Off-grid Electricity with Solar PV

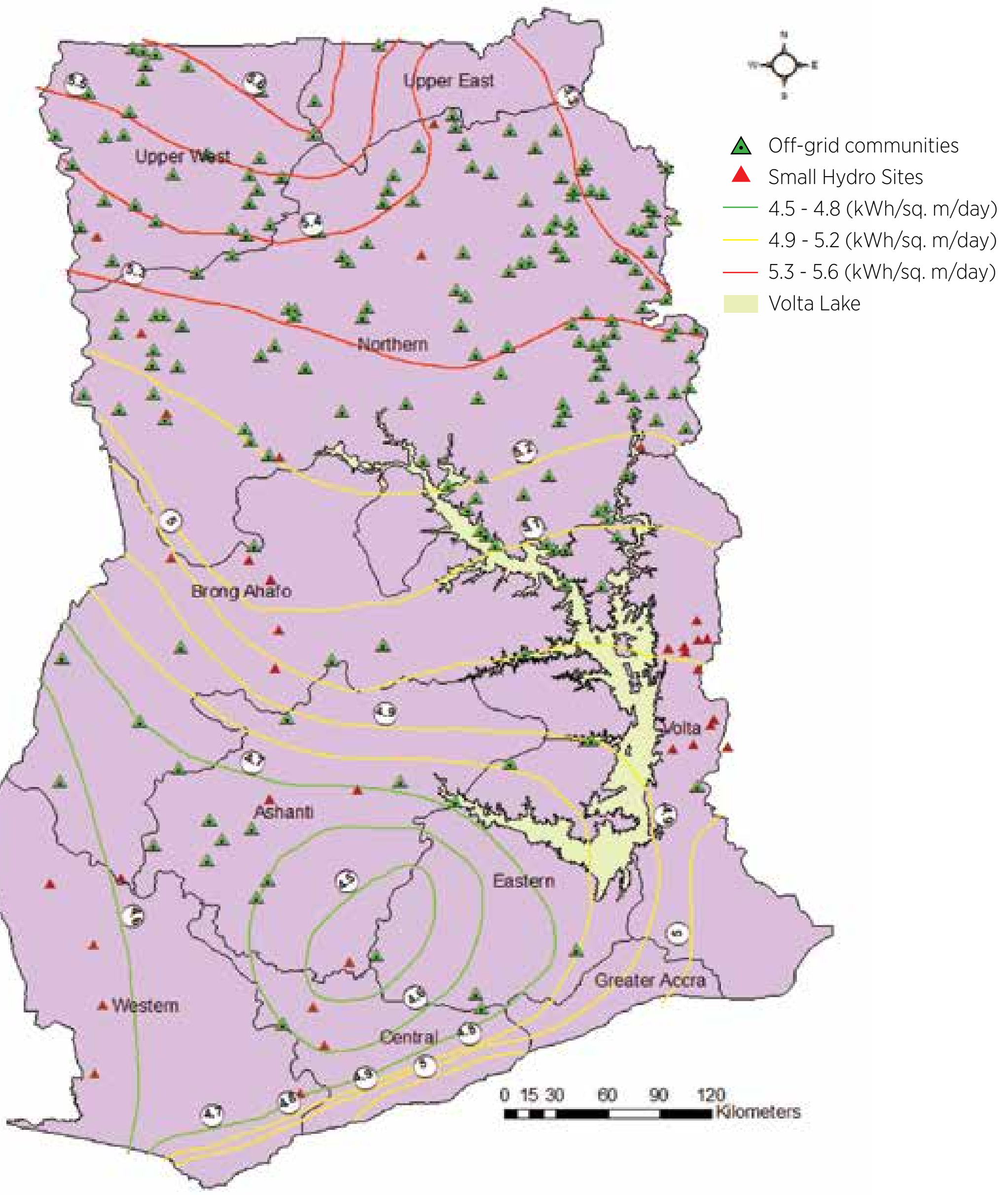
The MoEP has promoted off-grid solar PV for more than two decades. It has focused primarily on lighting and other rural community household needs. The main systems promoted on the Ghanaian electricity market are solar home systems and solar lanterns. These are being promoted across the whole of Ghana, and over 6,000 solar systems have been installed in about 89 communities throughout the country. They satisfy a range of uses including basic household lighting, radio and television use, vaccine refrigeration, hospital and classroom lighting. Other applications are distance learning using television, street lighting, water pumping for irrigation and rural mobile phone charging systems. The total small-scale solar capacity throughout the country is outlined in table 12. The recommended off-grid communities are shown in figure 12.

Table 12: Small-scale Solar PV Systems in Ghana

Solar PV Systems	Installed Capacity (kW)	Average Annual Production (GWh)
Rural home system	450	0.70-0.90
Urban home system	20	0.05-0.06
School system	15	0.01-0.02
Health centre lighting	6	0.01-0.10
Vaccine refrigeration	42	0.08-0.09
Water pumping	120	0.24-0.25
Telecommunications	100	0.10-0.20
Battery charging system	10	0.01-0.02
Solar street lights	10	0.04-0.06
Total	**793**	**1.34-1.82**

Source: Energy Commission 2011

Figure 12: Map of Recommended Off-grid Communities Showing Solar Radiation Levels



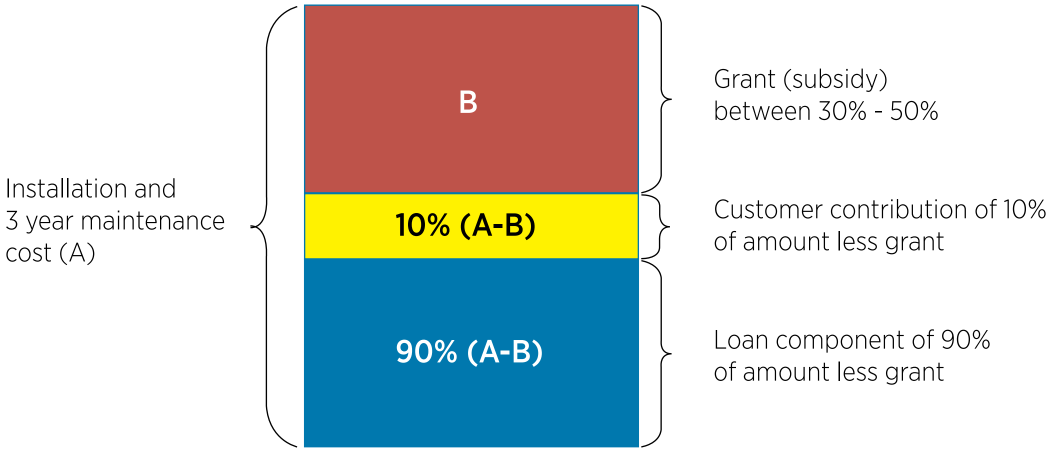
Source: Ministry of Energy (2012)

One of the most successful examples of solar PV finance for off-grid rural populations is the ARB Apex bank Ghana model. This comes under Electricity Access and Renewable Energy, part of GEDAP. This helped install 15,000 systems for 90,000 rural people unlikely to be connected to the grid in the next five or ten years.[7] The model rested on three main pillars. The first was capacity building using Global Environment Facility funds to involve rural and community banks and market to target populations. The second, funded by the International Development Association, was to remove finance barriers by providing credit lines to rural off-grid households to purchase solar PV systems. The third, funded by the Global Partnership on Output Based Aid, was the provision of partial grants for obtaining the relevant incentives for solar PV systems and making loans affordable.

Through this model, systems are paid using a 10% cash contribution from the beneficiary, a rural bank loan from the International Development Association fund and grant support from the Global Partnership on Output Based Aid. Installation, operation and maintenance is carried out by locally recognised companies (see figure 13).

[7] Rural electrification in Ghana aims to extend the grid to all communities apart from islanders/lakeside inhabitants who cannot be reached due to their geographical position.

Figure 13: ARB APEX BANK GHANA Project Financing Plan



Source: ARB Apex Bank, Ghana, 2011

The project has overcome many barriers. Although, not enough well-trained solar installers were available and solar systems were perceived as weak compared to grid-connected electricity due to usage limitations and previous installation failures. Financial institutions had a poor knowledge of solar products, financing costs were high and politicians interfered.

The experience revealed that quality after-sales service, well-designed products and repayment plans alongside participating private sector company financial engagement are key to the success of such projects.

Mini-grid Electricity with Hybrid Systems (Solar PV + Wind or Fossil)

Mini-grids based on renewable energy have been relatively unusual in Ghana. The Government of Ghana has been implementing the Northern Electrification Programme to ensure electricity access becomes a reality. Its target is universal access by 2020 via grid extension. However, certain remote communities, such as those in Ghana's 200-plus islands and Volta river lakesides, cannot be connected to the national grid due to their geographical location. The main activities of these communities are fishing (accounting for over 75% of household incomes), crop farming and trading. These households spend about USD 54.5 on energy per month, of which USD 11.5 is kerosene lighting and batteries for portable lights. Charcoal and fuel for gensets account for the bulk of the expenditure. The present lighting requirement of these island communities suggests each household has an average electricity consumption of 125.7 kWh per year amounting to 2.4 kWh per week. If the budget spent on lighting were replaced by electricity payments, each household could afford to pay 1.3 USD/kWh. This is much higher than the on-grid electricity tariff in Ghana at the moment.

The total installed cost for solar PV mini-grids per kilowatt-peak (kWp), including all island community taxes, is around USD 9,830. The total delivery cost for a 50 kWp mini-grid system will be USD 491,500 for a maximal annual output of 70,000 kWh.[8]

To establish the technical and economic feasibility of solar PV mini-grids, an analysis was conducted for Alorpkem, a typical island community of around 1,000 inhabitants. It included a 50 kWp planned solar PV plant with distributed energy. Based on similar rural electrification projects in Ghana, the initial consumption in Alorpkem[9] was estimated at 44,929 kWh/year. For electricity tariffs of 1.3 USD/kWh for households and 1.4 USD/kWh for commercial and municipal users, the total revenue from electricity sales is 60,928 USD/year. These mini-grids produce an internal rate of return of 10.9% and a break-even point in year 15 where 100% finance is provided. The underlying assumptions are a cost of capital of 7.5%, inflation rate at 3%, annual amortisation rate at 7.5%, operations and maintenance at 5% and annual PV degradation of 0.6%. The break-even point is in year 12 for 50% debt finance and year 10 for 0% debt finance.

However, the uniform tariff policy of 0.07 USD/kWh applies to mini-grids in Ghana, which means they

[8] Breakdown of 2 x 25 W lights on for 4 h/day 7 days a week is (1.4 kWh), 3 x 5 W mobile phones charged for 8 h/week is (0.84 kWh) and 1 x 10 W portable lamp charging for 2 h/day for 7 days a week (0.14 kWh). Total is 2.38 kWh/week.

[9] Residential use 19,740 kWh per year on the basis of 125.73 kWh per household and commercial/municipal use 25,190 kWh per year.

are not feasible from a private sector perspective. This is despite the huge motivation shown by around 97% of households and commercial businesses to pay for electricity if their whole community gets connected. This was revealed by a 2011 survey for the Government conducted on islands and at lakesides. The government should either set up special tariffs for mini-grids or provide subsequent support to private operators willing to invest in mini-grids. The small size of these systems means they are not attractive to foreign investors, so the sector will probably be left to local operators who face financial and technical constraints.

Electricity access and renewable energy, part of GEDAP, intends to remove the capacity and finance barriers to accelerate mini-grid renewable energy such as small hydropower, wind, and biomass below 10 MW. This will be achieved by providing business support to local renewable energy developers, energy saving companies and commercial banks. However, the Government of Ghana should think of a more long-term sustainable support mechanism as GEDAP is funded by donors. When commissioned, the REF can help lower this barrier, as it aims to provide financial incentives for mini-grid renewable power systems for remote areas and islands.

Many electrification projects fail due to the lack of a clear definition of competencies and responsibilities as well as political power and relationships between different stakeholders. There is a need to design reliable operating schemes on the basis of local political frameworks and infrastructure to realise a sustainable, functional socio-economic system for mini-grids in Ghana.

There is currently very little expertise in mini-grid management in Ghana. For the government, it has become a concern lately due to the challenges associated with the electrification of island communities in Lake Volta. For NGOs and research institutions, mini-grids are becoming interesting concepts, because they could rely on freely available renewable energy resources to generate electricity for remote rural communities. However, much more needs to be done to scale up the deployment of these technologies.

Solar drying/Agro Process Heat with Solar Thermal

In Ghana, crops are traditionally dried using the sun. The disadvantage of this method is that crops and grain may be damaged by birds, rodents, wind and rain or contaminated by dust and dirt.

Recent studies addressing solar dryer performance, demonstrates the potential of practical solutions

Figure 14: Locations of DTI Solar Dryer Tests in 2002

Source: Jensen, 2002

to these challenges. A 2002 report by the Danish Technological Institute (DTI) captures interesting results from a DANIDA-funded solar crop drying project involving the design, construction and testing of three pilot solar dryers at the premises of three commercial operators in the Greater Accra and Central Regions (See Figure 14).

The solar dryer at Silwood Farms (on which the rest of this section will concentrate) the total cost (without VAT) per unit was USD 2,525, and the full cost of the installation including civil works amounted to nearly USD 14,000. Though the report did not cover the economic benefits gained by Silwood Farms from the solar crop dryers, the DTI report concluded that in general, the dryer realised achieved sound technical performance — consistently reducing moisture content in up to 600 kg of maize from approximately 20% to 10% within 6 days at 35°C – 38°C. The tests also demonstrated that solar crop dryers of this particular design can achieve similar results with other locally grown crops such as cassava, pepper, okra and pineapple (Jensen, 2002).

These favourable performance results notwithstanding, the high capital cost of solar crop dryers is an obvious limiting factor to their accelerated uptake amongst low income farmers who make up the bulk of the potential market. Additionally, there are critical issues concerning the maintenance of the systems to keep them operating at peak performance. The seasonality of crop production in the country, also means that the cost per tonne per year of using solar dryers may be too high, given that the dryers may only be needed for less than 2 months in a year in some cases. These high upfront capital and operating costs often make traditional sun drying, even in the face of postharvest losses, a cheaper option for farmers. Commercial farmers who use irrigation facilities and are able to cultivate a variety of crops throughout the year may consider the use of solar dryers, but again this will only succeed if there is adequate policy support in place for acquiring these technologies, including the promotion of credit schemes.

The cost barriers to deployment of solar drying technology will eventually require that government allocates sufficient amounts of public funding in support of the aforementioned solutions and other measures. However, it is also reasonable to expect that these macro-level costs may be offset by several developmental benefits that are attributable to solar crop dryers, including:

- Job creation, especially where all or some of the components are eventually manufactured locally or sourced at competitive prices from least-cost suppliers
- Wealth creation resulting from the reduction in post-harvest losses, as well as general improvements in quality of produce, leading to increased revenues from sales in high value domestic and export markets
- Local capacity building — closely related to job creation, while contributing to reduction in the involvement of costly foreign technicians in the design, implementation, testing and mass production of crop-dryers.

With new market opportunities opening up (new foreign direct investment in industrial production), Ghana should consider promoting solar drying as a way to improve agricultural productivity, while stimulating local agro-industrial growth for economic and food security. This will help the country to achieve the objectives set in the Food and Agriculture development Policy (FASDEP II) adopted in 2007. Although the existing tax exemption on imported renewable energy technology is an asset, additional incentives should be put in place for easing the acquisition of solar dryers as well as for the development of solar drying markets. The REF aims, amongst others, to apply for provision on financial incentives, capital subsidies and production based subsidies for renewable energy projects for non-electricity purposes, however the fund is still not operational.

4.3 Modern Cooking/Heating with Biomass

More than 70% of households in Ghana continue to rely on firewood and charcoal as their main source of cooking fuel. Campaigns to reduce wood fuel consumption within the biomass sector are targeting the introduction of biodigesters to produce methane for cooking. Improved cookstoves are being promoted to increase efficient traditional biomass source use. Popular improved cookstove brands include Ahibenso, Gyapa and Toyola. Efforts to promote improved cookstoves were stimulated with the recent formation of the Ghana Alliance for Clean Cookstoves This is the local chapter of the Global Alliance for Clean Cookstoves.

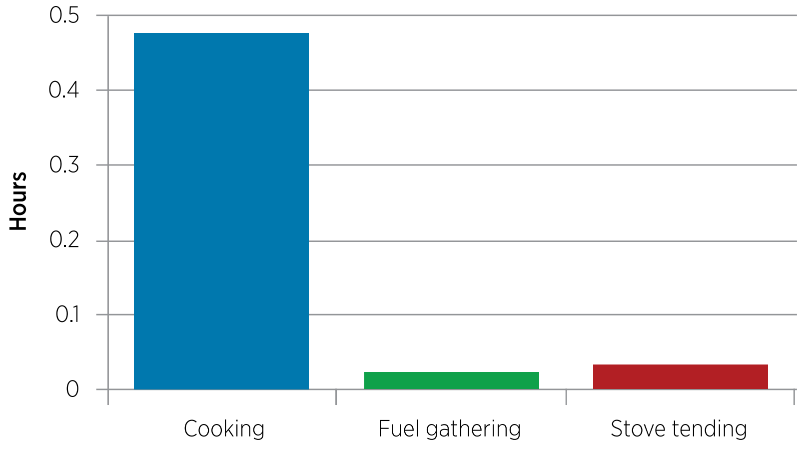
Improved cookstoves have been the subject of several studies evaluating their fuel savings and implications for forest degradation and greenhouse gas emissions. These have provided valuable feedback to guide continuous improvement in their design. The latest biannual survey was conducted in 2012 by Berkeley Air Monitoring group, a Californian monitoring and Evaluation Company, using a team from KNUST Energy Center. It determined fuel savings and other parameters in households that switched from ordinary coal pots to improved cookstoves in four regions: Greater

Table 13: Charcoal Savings (kg/household/day) for Four Toyola Stove Sizes

Improved Stove Size	Charcoal Savings
Large commercial	0.50
Small commercial	0.43
Medium household	0.36
Small household	0.18

Source: Ministry of Power

Figure 15: Average Amount of Time Saved per Day per Stove-Associated Activity



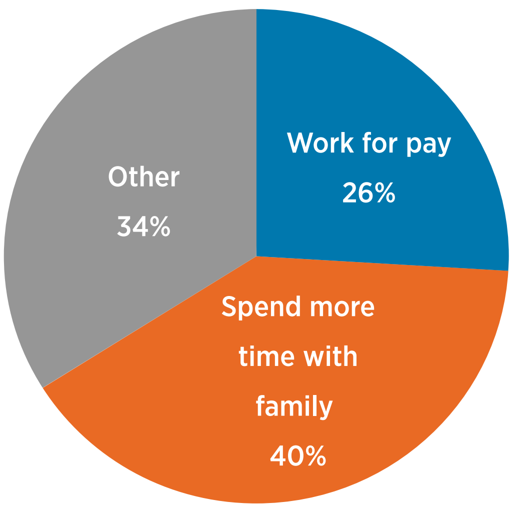
Accra, Brong Ahafo, Eastern and Northern regions. Table 13 shows the results for charcoal savings using Toyola household stoves as well as larger Toyola commercial stoves.

The main benefit of improved cookstoves were judged to be time savings. Average time savings accrued by users of the improved cookstove are estimated at 30 minutes per day during cooking. However, very modest amounts of saved time were reported from fuel gathering, stove tending – the feeding of fuel and maintenance of combustion during cooking activities – and other related activities such as purchasing charcoal (Figure 15).

The average time saved per week, assuming that the majority of women cook every day, is nearly 3.5 hours. Over a quarter of the women (26%) said they used their saved time to work more for pay, 40% reported that they spent it with their families and 34% reported that they used it for other activities such as household chores (figure 16).

However, end-users in Ghana reported similar smoke emissions from ordinary charcoal "coal pots" and improved charcoal cookstoves. Most households were of the opinion that smoke emissions depend more on the quality of the charcoal than the stove. Moreover, rural households will not become enthusiastic enough about the improved cookstoves unless the government runs a thorough and sustainable awareness-raising campaign improving their acceptability.

Figure 16: Alternative Activities for Participants Using Improved Cookstoves



Access to finance is another important barrier to the promotion of improved cookstoves. High interest rates on loans have prevented supply-side investors from expanding their businesses to reach greater production numbers. Lack of support policy initiatives obstructs upstream supply-side organisations from expanding their businesses and reducing costs to end-users. These initiatives need to create the enabling environment for accelerated development and sustainable biomass energy promotion for household energy needs.

Recommendations

Detailed descriptions of the recommendations for each resource-pair can be found in the Annex.

Designing clear policy for off-grid mini-grids

The country's objective of increasing rural access to electricity would be facilitated by creating a level playing field for local private sector involvement. The support announced through the REF should be clearly defined, and reliable operating schemes designed for the small-scale decentralised renewable energy mini-grids. Competencies and responsibilities, as well as political direction and relationships between different stakeholders, should be clearly defined on the basis of local political frameworks and infrastructure. This would provide a sustainable, functional socio-economic background for mini-grids in Ghana.

Increasing political support for promoting sustainable use of biomass energy

The government should continue to create and support policy initiatives towards an environment accelerating the development and promotion of sustainable biomass energy for households. This is needed alongside present policies and goals focused on remedies to deforestation effects caused partly by traditional cookstove use.

High interest rates on loans have prevented supply-side investors from expanding their businesses and raising production. There is a need to further encourage entrepreneurs prepared to invest and support them by building capacity, through grants programmes and by providing access to working capital. Matching government programmes are required to cultivate fast-growing energy wood plots, improve charcoal production technologies and skills, and improve cookstoves production.

Supporting private sector involvement

The relatively small size of the off-grid market means it is not very attractive to foreign investors. This is why the sector would probably be left to local private operators with the support of donors and development partners. Local private operators face technical and financial constraints. These include lack of technical expertise to develop bankable proposals and insufficient working capital due to difficult loan access. Other constraints include high interest rates due to perception of high risk and lack of financial institution expertise in evaluating off-grid renewable energy proposals. There is thus a need to build the capacity of local private operators and financial institutions to develop and appraise bankable decentralised renewable energy project proposals.

The development and operation of certain renewable energy technologies in mini-grids requires expertise in assessing local conditions, installing and maintaining systems. This is particularly the case for hybrid systems because they use a greater range of generation technologies and more complex management systems. Utilities may also perceive the management of mini-grids as expensive, so these may be better managed by small- and medium-sized enterprises and Energy Saving Companies.

Facilitating end-user access and improving cookstove awareness and acceptance

Electricity tariffs for off-grid systems should be reviewed to attract more local private operators. This could be accompanied by end-user access facilitation options. It could include targeted subsidies and deferred payment schemes that could be pre-financed directly by the service providers or through a microfinance institution. A sound business model should be developed for both stand-alone systems and mini-grids. It needs to increase the viability and sustainability of decentralised renewable energy projects and access to electricity services in rural Ghana.

This should be done by getting the REF up and running as well as other finance support mechanisms. These include group lending approaches and sustainable credit programmes for low-income operators and farmers. Researchers should be supported in designing prototypes for solar dryers that could be manufactured locally.

Previous experience in Ghana shows that communities often prefer grid connectivity due to its potential use for higher-wattage appliances. They may consider solar power to be inferior and may even discontinue off-grid systems to put political pressure on governments. This is particularly true where the grid has been extended to neighbouring communities. Most farmers in Ghana have limited knowledge of labour-saving technologies or post-harvest management, especially for perishable produce. There is a need to run awareness-raising campaigns and create communications strategies to educate operators and farmers about the new business opportunities and benefits of off-grid renewable energy.

Existing cookstove technologies need to be improved and new and proven technologies introduced through innovations that not only increase efficiency, but also reduce emissions. This will decrease exposure to household air pollution. It is likely to have an impact on the user health while continuing to support the local production of cookstoves. If consumers are to adopt improved cookstoves in the long term, the government should embark on critical mass education to increase product market penetration and acceptability.

4.4 Opportunities and Constraints Affecting Renewable Energy Expansion

Abundant resources

The RRA has clearly shown in section 2.4 that Ghana is endowed with an abundance of renewable energy resources in the form of solar, wind, mini-hydropower and biomass. Together, these resources are capable of generating far more than the 2020-2025 target for 500 MW renewable electricity. The state generator VRA has taken a leadership position in renewable electricity generation, cementing its earlier status as pace-setter in the power generation sector. Now that the 2 MW solar PV grid-connected system and expected expansion has been commissioned, VRA is actively exploring additional opportunities for solar PV, wind, mini-hydropower and biomass. Admittedly, the renewable energy industry previously suffered from a lack of approved FiTs. These are necessary for the private sector to get engaged in the industry. With the recent publication of the FiTs, this obstacle has been cleared and should stimulate private sector participation.

As far as scalability is concerned, renewable energy projects have an additional advantage in that barriers to entry are lower for local investors. This contrasts with large hydropower and thermal plants. It levels the playing field, enabling smaller IPPs to compete favourably with the big players for grid connection. Apart from grid-connected and off-grid renewable energy systems, there are also opportunities to explore mini-grids in remote rural areas where renewable energy could be targeted to create agro-industries to improve incomes.

Renewable Energy Act and FiTs

The passage of the Renewable Energy Act in 2013 and subsequent release of FiTs effectively removed one of the greatest constraints to renewables-based electricity production in the country. There are, however, a number of outstanding issues that need to be addressed, such as the ability of utilities to absorb the higher costs of FiTs.

Even though Ghana is aiming for 10% renewable energy electricity, it could also explore opportunities in the West African Power Pool with the possibilities of investors generating power for the West African Power Pool using resources in Ghana. This would have socio-economic benefit for Ghanaians, creating jobs and adding income to the economy. Such power would not be subsidised in anyway by the Ghanaian government.

High start-up costs

Start-up costs are one of the barriers preventing a technology from being scaled up. For most renewable energy technologies, start-up costs are high. Even when investment costs are not paid by households, as with mini-grid or grid-connected systems, experience across the world shows that tariffs are higher at present than those of large hydropower and most thermal plants. Investment costs are relatively high for the low-income rural households needing renewable energy technologies such as solar PV and biogas systems.

Where these technologies are installed and marketed as part of social aid projects, tariffs are nonetheless higher than those in urban households that are often subsidised by the state. Coupled with the high investment cost, is the lack of low interest finance for renewable energy technologies. After several years of discussions, no clear solution has been found to these problems. Going forward, there is a need for government support similar to the subsidies enjoyed by grid electricity and urban LPG consumers. These must be appropriately targeted to ensure that remote rural communities benefit from access to electricity and modern fuels.

Expanding off-grid technologies across the country

After several years of promoting renewable energy technologies, efforts are still concentrated in the very large cities like Accra and Kumasi. The majority of solar PV system retailers are either in Accra or Kumasi and are not very visible to smaller communities. Not many business models market solar PV systems on a tariff basis, most require households and businesses to purchase and own the system, which raises the financing challenges discussed above. To create broader awareness of these technologies, renewable energy businesses must be expanded to other parts of the country.

Regulatory transparency

With the state generator entering the renewables sector, there is always the temptation to bully its way through with the utilities in obtaining PPAs. It could use its existing power plants to influence the negotiating process, which could create conflict with the private sector. It is important that everyone who meets requirements set by the regulator is given a fair chance of negotiating. When necessary, bids must be used to prioritise projects. Least cost and quality of service should be the prime criteria. It is important that the regulator, in this case the Energy Commission, is not perceived as biased by the investor community.

Social and environmental compliance

While promoting renewable energy investments, it is important that investors fully comply with strict environmental and social impact reduction. The ambition for liquid biofuel has already sparked major disputes in Ghana, and there are plenty of stories of land grab. Other technologies requiring large areas of land, such as solar and hydropower, could create conflict with the original land users. This is especially the case if the process for obtaining land is not transparent enough. Hydropower projects with the potential for flooding must be particularly well monitored and appropriate compensations paid before project construction is allowed to begin.

V. REFERENCES

Ahiataku-Togobo, W., and A. Ofosu-Ahenkorah (2009), *"Bioenergy Policy Implementation in Ghana"*, COMPETE International Conference, Lusaka.

Bazilian, M., *et al.* (2012), "Energy Access Scenarios to 2030 for the Power Sector in sub-Saharan Africa", *Utilities Policy*, Vol. 20, pp. 1-16.

Ghana Daily Graphic (2012), "GhanaWeb", published 13 November 2012, *www.ghanaweb.com/GhanaHomePage/NewsArchive/artikel.php?ID=256346*, 15 November 2013.

Duku, M.H., S. Gu and E.B. Hagan (2011), "Biochar Production Potential in Ghana: A review", *Renewable and Sustainable Energy Reviews*, Vol. 15, pp. 3539-3551.

ECOWAS (Economic Community Of West African States) (2012), *Ecowas Renewable Energy Policy,* ECOWAS Center for Renewable Energy and Energy Efficiency, Praia.

ECOWAS (2013), "West African Power Pool", *www.ecowapp.org/?page_id=168*, accessed 19 June 2014.

Energy Commission (2006), *Strategic National Energy Plan 2006 - 2010,* Energy Commission, Accra.

Energy Commission (2010), "Data for the Development of GIS Maps", *Alternative Business Development Scenarios and Toolkit for Renewable Energy Planning and Policy*, Energy Commission, Accra.

Energy Commission (2012), "Ghana: Sustainable Action for All, Action Plan", *http://energycom.gov.gh/files/SE4ALL-GHANA%20ACTION%20PLAN.pdf?*

Energy Commission (2014), *"National Energy Statistics 2000 - 2013",* Energy Commission, Accra.

ECREEE (ECOWAS Centre for Renewable Energy and Energy Efficiency) (2012), ECOWAS Renewable Energy Policy (EREP), ECREEE, Praia, pp. 92.

Essandoh, E.O., E.Y. Osei and F.W. Adam (2014), "Prospects of Wind Power Generation in Ghana", *International Journal of Mechanical Engineering and Technology*, Vol. 5, No. 10, pp. 156-179.

Ghana Ministry of Energy (2013), "Ministry of Energy and Petroleum", *www.energymin.gov.gh/?page_id=205,* accessed 19 June 2014.

Ghana Statistical Service (2012), *2010 Population and Housing Census: Summary Report of Final Results*, Ghana Statistical Service, Accra.

Ghana Statistical Service (2013), *Provisional Gross Domestic Product 2013,* Ghana Statistical Service, Accra.

Ghana Statistical Service (n.d.), *www.statsghana.gov.gh/,* accessed 19 June 2014.

GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH) (2013), "Opportunities for RE Market Development in Ghana", *www.giz.de/fachexpertise/downloads/giz2013-en-pep-informationsveranstaltung-pv-ghana-behrle.pdf*.

Government of Ghana (2012), "Ghana Sustainable Energy for All Action Plan" *http://energycom.gov.gh/files/SE4ALL-GHANA%20ACTION%20PLAN.pdf*, accessed 19 June 2014.

Government of Ghana (2013), *Highlights of the 2014 Budget,* KPMG, Accra.

GRIDCo (2011), *Ghana Transmissions and Distribution Master Plan,* Ghana Grid Company, Accra.

IRENA (International Renewable Energy Agency) (2013), *West African Power Pool: Planning and Prospects for Renewable Energy*, IRENA, Abu Dhabi.

Jensen, S. (2002), *Test of solar dryers in Ghana,* Danish Technological Institute, Risoe.

Ministry of Energy (2010a), *National Energy Policy,* Ministry of Energy, Accra.

Ministry of Energy (2010b), *Energy Sector Strategy and Development Plan,* Ministry of Energy, Accra.

Mohammed, Y.S., *et al.* (2013), "An Overview of Agricultural Biomass Based Potential for Decentralised Rural Energy in Ghana", *Renewable and Sustainable Energy Reviews*, Vol. 20, pp. 15-25.

Public Utility Regulatory Commission (2011), "Publication of Electricity and Water Tariffs in the Gazette", *www.purc.com.gh/purc/sites/default/files/decemberbillingcycle2011_0.pdf*.

United Nations Development Programme (2011), *Human Development Report 2011,* Palgrave Macmillan, New York.

Volta River Authority (2014), "Power Generation: Facts & Figures", *www.vraghana.com/resources/facts.php*, accessed 19 June 2014.

WAGPA (West African Gas Pipeline Authority) (2011), "WAGPA", *http://wagpa.org/wagpa.html*, accessed 19 June 2014.

ANNEX

Detailed description of recommended action

ON-GRID

Action	Target setting
Service-resource pair(s)	All renewable energy resources
Description	The Northern Electrification Program objective of meeting 10% of the total energy mix through renewable energy by 2020 was translated into the generation master plan as 10% of the electricity mix. The ministry in charge of energy is responsible for co-ordinating a study assessing the grid condition for accommodating variable renewable energy. This will further help to establish technology-specific targets and related definite capacity additions, thereby increasing market confidence and competition. This should drive costs down.
Actors	Ministry of Power, Energy Commission, GRIDCo, all relevant stakeholders and potential investors.
Timing	End 2015
Keys to success	Broad consultation and engagement of all relevant stakeholders

Action	Grid integration of variable renewable energy
Service-resource pair(s)	All renewable energy resources
Description	Ghana has developed a comprehensive grid code most recently revised in 2009 It establishes the requirement, procedures, practices and standards that govern the development, operation, maintenance and use of the high voltage transmission system. However, the grid code in its current form lacks two prerequisites that would further enable the integration of utility-scale variable renewable energy in the grid. These are generation forecasting and priority dispatch. The ministry in charge of energy and the Energy Commission should carry out consultations with all relevant stakeholders for the revision of the grid code. This is in order to include specific conditions accommodating renewable energy generators to provide accurate data as well as for giving priority dispatch for renewable power. The Ministry of Power and the Energy Commission is also to engage in developing standards and codes for grid-connected rooftop solar PV as well as supporting capacity building for local financial institution.
Actors	Ministry of Power, Energy Commission, all relevant stakeholders.
Timing	Mid-2016
Keys to success	Broad consultation and engagement of all relevant stakeholders

Action	IPP financial support mechanisms and payment guarantees
Service-resource pair(s)	All renewable energy resources
Description	The Renewable Energy Law provides for the establishment of a renewable energy fund known as the Ghana Renewable Energy Fund or REF. This is to offer financial incentives, capital subsidies, production subsidies and equity participation for renewable energy power generation. It is also expected that the REF fills the gap between the FiTs and retail prices in order to reduce the burden on end-users. The Energy Commission is to get the REF up and running given the renewed interest of project developers since FiTs were adopted. The Government of Ghana should make provision for payment guarantees to IPPs which will affect the commercial viability of renewable energy projects. This is due to the fact that distribution companies ECG and NEDCo are saddled with debt. The two utilities are not able to meet their payment obligations to their present suppliers and this cannot credibly offtake any renewable energy investment. The ECG has already signed PPAs, but none of those projects has yet been implemented. Moreover, the instability of the Ghana cedi has some significant implications for the development of renewable energy projects. This is because investment is most likely to be denominated in a foreign currency, while the revenues are expected in cedi. It is therefore important that Ghana considers designing effective currency risk mitigation instruments to help increase investor confidence in financing renewable energy projects.
Actors	Ministry of Power, Ministry of Finance, Energy Commission, PURC, development partners, all relevant stakeholders.
Timing	End 2016
Keys to success	Broad consultation and engagement of all relevant stakeholders

Action	Streamlining renewable energy IPP procedure for entering the electricity market
Service-resource pair(s)	All renewable energy resources
Description	The current process for a renewable energy IPP to enter the Ghana electricity market requires it to interact with regulatory agencies in the power sector once detailed feasibility studies have been completed. These are the Energy Commission and PURC, the Environmental Protection Agency, Ministry of Power, the Ministry of Finance and Economic Planning and the Ghana Investment Promotion Agency. These provide various licences, approvals, clearances and incentives linked to the development of the renewable energy project (see figure 11). This complex and lengthy procedure can lead to significant administrative and transaction costs which may discourage potential investors and project developers from entering the market. Ghana needs to set up a one-stop shop which may help reduce complexity and assist IPPs working through this bureaucracy. The Ministry of Power is to take the lead in this activity jointly with all key stakeholders in Ghana.
Actors	Ministry of Power, Ministry of Finance, Energy Commission, regulatory agencies, all relevant stakeholders.
Timing	End 2016
Keys to success	Broad consultation and engagement of all relevant stakeholders

OFF-GRID

Action	Designing clear policy for off-grid mini-grids
Service-resource pair(s)	Off-grid solar
Description	The Government of Ghana has been implementing the Northern Electrification Programme with the target of achieving universal access by 2020 via grid extension. However, it is not possible to connect the 200-plus island/lakeside communities in the Volta river to the national grid due to their geographical location. Moreover, many electrification projects fail due to a lack of clear definition of competencies and responsibilities as well as political power and relationships between different stakeholders. There is very little expertise in mini-grid management in Ghana. This has become a concern lately due to the challenges associated with the electrification of island communities in Lake Volta. Mini-grids are becoming interesting to NGOs and research institutions because they could rely on freely available renewable energy resources to generate electricity to remote rural communities. However, much more needs to be done to scale up the deployment of these technologies. The country's objective to increase rural electricity access would be facilitated by creating a level playing field for local private sector involvement. The support announced through the REF should be clearly defined, and reliable operating schemes designed for small-scale decentralised renewable energy mini-grids. Competencies and responsibilities, as well as political power and relationships between different stakeholders, should also be clearly defined. The Ministry of Power, alongside the Energy Commission and PURC, need either to set up special tariffs for mini-grids or provide follow-up support to private operators willing to invest in them and facing financial and technical constraints. They are not considered attractive to foreign investors. Once operating, the REF could be an option as it aims to provide financial incentives for mini-grid renewable power systems for remote areas and islands. There is also a need to design reliable operating schemes based on the local political and infrastructural framework to realise a sustainable and functional socio-economic system for mini-grids in Ghana.
Actors	Ministry of Power, Ministry of Finance, Energy Commission, PURC, Development Partners, all relevant stakeholders.
Timing	End 2016
Keys to success	Broad consultation and engagement of all relevant stakeholders

Action	Enhancing political support for promoting sustainable use of biomass energy
Service-resource pair(s)	Biomass for heating
Description	More than 70% of households in Ghana continue to rely on firewood and charcoal as their main source of cooking fuel. Campaigns to reduce wood fuel consumption within the biomass sector aim to introduce biodigesters that produce methane for cooking. They also aim to promote improved cookstoves to increase the efficient use of traditional biomass sources. However, high interest rates on loans have prevented supply-side investors from expanding their businesses and raising production. The government is to continue to create and support policy initiatives enabling an environment that provides accelerated development and promotion of sustainable household biomass energy. This is needed in addition to the current policies and goals focused on remedies to deforestation caused partly by traditional cookstove use. There is also a need to encourage more entrepreneurs prepared to invest, and to support them by capacity building, through a grants programme and by providing access to working capital. Matching government programmes are needed to develop fast-growing energy wood plots, improve charcoal production technologies and skills, and improve cookstoves production.
Actors	Ministry of Power, Ministry of Finance, Ministry of Environment, Energy Commission, PURC, Private Sector, Development Partners, all relevant stakeholders.
Timing	End 2015
Keys to success	Broad consultation and engagement of all relevant stakeholders

Action	Supporting private sector involvement
Service-resource pair(s)	All decentralised renewable energy applications
Description	The relatively small size of the off-grid market does not make it very attractive to foreign investors, which is why the sector would probably be left to local private operators with the support of donors and development partners. Local private operators face technical and financial constraints. These include a lack of technical expertise to develop bankable proposals and insufficient working capital due to difficulty accessing loans. Other constraints are high interest rates due to a perception of high risk and lack of local financial institution expertise in assessing off-grid renewable energy proposals. The Ministry of Power is to lead a capacity building programme for local private operators and financial institutions to develop and evaluate bankable decentralised renewable energy project proposals. This includes, for instance, training on how to assess local conditions and systems, installation and maintenance.
Actors	Ministry of Power, Energy Commission, Private sector, Financial Institutions, Training institutions, Research Centers, all relevant stakeholders.
Timing	End 2016
Keys to success	Broad consultation and engagement of all relevant stakeholders

Action	Facilitating end-user access to technologies and improving awareness and acceptability of cookstoves
Service-resource pair(s)	All decentralised renewable energy applications
Description	As in most of African countries, the upfront cost of renewable energy technologies in Ghana, including those for alternative cooking fuels, are too high for end-users. These are mainly in rural population. To facilitate the spread of renewable energy technologies and their acceptance by the local populace, the Government of Ghana is to establish a set of end-user access facilitation options. These could include targeted subsidies and deferred payment schemes that could be pre-financed directly by service providers or through a microfinance institution. It also needs to establish sound business models for both stand-alone systems and mini-grids to increase the viability and sustainability of decentralised renewable energy projects and access to electricity services in rural Ghana. This should be achieved by getting the REF up and running alongside other financing support mechanisms like group lending approaches and sustainable credit programmes for low-income operators and farmers. Researchers should be supported in designing prototypes for solar dryers that could be manufactured locally. The government is also to lead awareness-raising campaigns and communications strategies improving end-user knowledge of the new opportunities and benefits of off-grid renewable energy systems. If consumers are to adopt improved cookstoves in the long term, the government should embark on critical mass education to increase product market penetration and acceptability.
Actors	Ministry of Power, Ministry of Environment, Ministry of Education, Civil Society, NGOs, Development partners and all relevant stakeholders.
Timing	End 2017
Keys to success	Broad consultation and engagement of all relevant stakeholders

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