UNIVERSITY OF CAMBRIDGE | Electricity Policy Research Group

INTERNATIONAL SUPPORT FOR DOMESTIC CLIMATE POLICIES

Policy and Regulatory Framework for Renewable Energy and Energy Efficiency Development in Ghana

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Policy summary:

- Karsten Neuhoff. International Support for Domestic Climate Policies: Policy Summary

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To effectively communicate insights into climate change policy, Climate Strategies works with decision-makers in governments and business, particularly, but not restricted to, the countries of the European Union and EU institutions.

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Abstract

Energy is crucial to sustainable development and poverty reduction because it influences all aspects of development. Achievement of the Millennium Development Goals (MDGs) is not possible, without an improvement in the quality and quantity of energy services. The purpose of this paper is to carry out a policy case study on Ghana's Renewable Energy (RE) and Energy Efficiency (EE) sub-sectors. The paper examines the key domestic policies already in place, and identifies those which are slow-moving and will require international support and cooperation. These policies may require external support in order to increase the scope and scale of Renewable Energy Technologies (RETs) and Energy Efficiency (EE), and accelerate the time-line for meeting the government's 10% RE target before the year 2020.

The study concludes that with international cooperation and support, Ghana can accelerate the transition to affordable and reliable RE and possibly exceed the government target of 10% in the energy mix before 2020. Incorporating mini-grid and stand-alone systems into Ghana's rural electrification policy has the potential to reduce the average transmission and distribution network losses from about 17% to 10%-12%, and save annual network capital investment of about US$60 Million. The study also found that a well-implemented EE policy would reduce the need for electric network capacity investment, ensure energy security, improve industry profitability and competitiveness, while reducing Greenhouse Gas (GHG) emissions.

1. Introduction

Despite increasing deployment of low-carbon technologies, GHG emissions from fossil fuels have continued to increase (IPCC 2001). According to Sim et al. (2007), in the absence of effective policies by governments, energy related GHG emissions from fossil fuel combustion are estimated to rise from a global figure of 26.1 Gt CO_2 equivalent in 2004, to between 37-40 Gt CO_2 equivalent. by 2030. To achieve a decarbonised world, policies which recognize both energy and non-energy co-benefits, and which internalize environmental costs and other externalities, need to be formulated by government. No single policy instrument is enough to ensure a low-carbon economy by any country. Policy intervention will involve complex and interrelated issues with respect to energy security, subsidy issues and environmental externalities, to achieve overall sustainable development (Sim et al 2007). Renewable Energy (RE) and Energy Efficiency (EE) policies, if well implemented, can enable countries to meet increased demand for energy at least cost.

Background

Ghana is endowed with abundant renewable energy resources comprising Solar, Wind, Biomass and Hydro. These energy supply resources can be harnessed in order to diversify the country's energy sources and ensure energy security. In Ghana, the annual solar irradiation ranges between 4.4 and 5.6 KWh/m^2 -day (or 16-20 MJ/m^2 -day) (Akuffo 1991). Currently, the installed solar electricity generating capacity is just above 1.0 MW (Energy Foundation 2000).

Series of measurements to establish the suitability of wind technology in Ghana for generating electricity was carried out by RISO (Denmark) in 2002, at heights of 12m and 40m, where they recorded wind speeds between 4.9 m/s to 5.9m/s (Energy Commission 2006). There is also high potential using solar thermal energy for hot water production in the commercial sector. If implemented, the policy would reduce the use of electric water heaters in that sector. There is also potential to use solar energy in the agro-industrial and wood processing sectors.

Biomass also holds much promise for electricity generation in Ghana. Currently, there are five institutions in oil plantations and lumber mills, which use biomass as fuel. Biogas for electricity has been piloted in Ghana and has proven to be a useful source of power for rural communities. Untapped medium-hydro potential (i.e. hydro systems between 10MW and 500 MW) is about 1,300 MW while untapped potential for small scale-hydro (i.e. hydro systems less than 10MW) is 24MW (Akuffo, 2003).

The focus of this paper is to present a policy case study to provide insight into RE and EE policies in Ghana. Although significant results have been achieved in the RE and EE sub-sectors, it is important to identify which domestic policies are 'slow moving', and can therefore be accelerated with the aid of international support and cooperation to achieve a low-carbon economy.

Co-benefits of Climate Policies

This section of the paper identifies which of the climate co-benefit policies are slow moving and therefore require some form of support through international cooperation. Co-benefits from policies refer to two or more benefits that can be derived from a single measure or set of measures. Co-benefits can be generated either intentionally or unintentionally. Unintentional benefits stem from policy decisions with a single aim, which are later observed to have resulted in additional benefits. Policies in the energy sector relating to plant efficiency, fuel switching, introduction of renewables, energy efficiency and demand-side management may result in a wide range of co-benefits. Such co-benefits can mitigate air pollution impacts, enhance energy security and diversification, reduce fuel costs and rural-urban migration.

Co-benefits from GHG emission reduction policies should be part of a country's overall economic policy, with the view to facilitating long-term sustainable development. To focus this discussion, co-benefits are considered positive benefits provided one of the achieved benefits reduce GHG emissions.

Energy Co-benefits

The attempt to reduce GHG emissions in Ghana's energy sector, has yielded both direct and indirect co-benefits which are discussed below.

Diversification of Energy Supply Sources

The policy to integrate renewable energy will reduce the percentage composition of higher emitting fossil fuel in the country's electricity generation mix by at most 30%. Such a policy would also improve energy security, and ensure better management of the hydro reserves, to forestall the problem of power rationing or load-shedding during times of poor rainfall.

Fuel Switching

In the electricity sector, it is government policy to use natural gas as the main fuel for thermal power generation, hence the government's support for the construction of the West African Gas Pipeline from Nigeria to Ghana. Fuel switching from light crude oil to natural gas for power generation is expected to contribute to GHG emissions reduction. Natural gas possesses the lowest carbon content of any fossil fuel, and therefore its use for power generation will no doubt reduce CO_2 emissions. The policy also aims at converting existing single-cycle light crude oil-fired thermal plants to natural gas combined-cycle plants. Switching from single-cycle plants to combined-cycle mode at the Takoradi II Power Plant in Ghana, is expected to enhance thermal plant efficiency from 32% to 50%.

Network Capital Cost Savings and Loss Reduction

The Government's of policy to integrate renewable energy into the country's electricity generation mix can deliver co-benefits to the transmission and distribution networks through savings in network investment costs and improving network reliability, resiliency and loss reduction. Specifically, incorporating RE development as part of rural electrification policy through the promotion of stand-alone PV and mini-grid systems can reduce total transmission and distribution network investment by about 30% (IEA 2002).

Well-located stand-alone and mini-grid systems, which avoid the cost of extending the national grid to remotely located areas or rural communities, can reduce total transmission and distribution network loss levels from the current estimated value of 17%[1] to between 10%-12%. Conservative estimates by I3EM (2008) suggest the total avoided annual electric network investment is in the order of US$ 60 Million.

Environmental Co-Benefits

Renewable and Energy Efficiency policies in Ghana are also associated with environmental co-benefits such as impacts on public health, the natural ecological systems, agricultural system, and the building industry. These co-benefits are briefly discussed below**:**

Impact on Human Health

GHG mitigation policies are known to be associated with positive health impacts due to improved air quality. It is in this regard that the Johannesburg Plan of Implementation (UNDESA 2002) called on all countries to develop polices and measures that contribute towards reduction of GHG emissions and also control air pollution. According to Smith (2002), Lang et al. (2002) and Bruce et al (2002), respiratory infection, chronic obstructive lung disease, cancer and pulmonary disease can be traced to lack of access to high quality modern energy for cooking. It is therefore not surprising that the World Health Organization, (WHO 2002), has ranked indoor air pollution emanating from burning solid fuels as the fourth most important risk factor in least developed countries.

In Ghana, the government has realized that air quality can be enhanced if access to modern energy services is provided for the population. For instance, the government is encouraging households to shift from the use of wood fuel, which creates deforestation, to the use of Liquefied Petroleum Gas (LPG) to decrease indoor air pollution. This policy also helps to increase overall end-use energy efficiency over the entire domestic energy cycle. Data available from Ghana's Energy Commission (2002), shows that the annual domestic market delivery of LPG by the country's oil refinery increased from 6,086 Metric Tonnes in 1990 to 67,576 Metric Tonnes in 2004.

[1] This comprises an average transmission network loss level of 3% and an average distribution network loss of about 14%

Ecological Systems

Reduced air and agricultural pollution from less GHG emissions can yield co-benefits to strengthen and sustain natural ecological systems. The government's policy to enhance energy efficiency and integrate renewable energy into the generation supply mix is likely to lower NO_x emissions and hence reduce ozone concentration. According to EPA (1997), high levels of ozone concentrations in the troposphere can be damaging to both vegetation and to human health.

Despite the benefits of GHG emission reduction on the ecosystem, there appears to be lack of co-ordination among the Ghana Environmental Protection Agency, the Forestry Commission, and the other institutions in the energy sector. Though empirical data to support the measurement of environmental impacts of air pollution is readily available in Ghana, the required analytical tools and technical capacity for the analysis of co-benefits and both direct and indirect effects, appear to be missing.

Economic Co-benefits

Economic co-benefits from climate mitigation have a crucial influence on the decision criteria of policy makers, yet in most cases the net co-benefits are not monetized or quantified by decision makers. Attempts to assess climate mitigation measures in terms of their economic impact are important, as the results of the exercise will influence policy decisions on the strategic level and timeframes of GHG mitigation action.

As noted by Kassels and Bakker (2005), although the majority of co-benefits may have short-term impacts, they may support long-term mitigation efforts by linking climate policy to sustainable development objectives. The economic impact of emission reduction measures can have direct, indirect and induced effects. Direct effects relate to initial investment, employment and income earned by newly employed workers due to GHG emission control measures or strategies. Often a co-benefit policy will require an input of goods and services, which also generates additional investment, employment and income: these are the indirect effects of the policy measure. Indirect effects support the economy in terms of overall employment and income, thus generating induced effects.

Economic Co-benefits from Energy Efficiency and Impact on Industrial Competitiveness

Energy efficiency activities undertaken by the Energy Foundation in Ghana within the residential and industrial sectors have yielded significant monetary savings for consumers. Two case studies (Energy Foundation 1999, 2000) on energy efficiency measures undertaken by the Energy Foundation are summarised below. The results show that if energy efficiency is properly pursued, this can lead to improvement in energy security, and ensure industrial profitability and competitiveness.

Case Study 1: Ministry of Energy (MOE)

Objective of study: To demonstrate the benefits of electrical energy saving

Key Tasks undertaken:
(a) Energy Auditing
(b) Installation of capacity banks to improve power factor
(c) Replacement of 40W fluorescent lamps with Energy Efficient 36W fluorescent lamps

(d) Relocating window type air conditioners from the floor level to a height of about 1.5m-2.0m.

(e) Installation of occupancy Passive Infra–Red (PIR) sensors. These sensors automatically switch off lights and air conditioners, when there is no one in the office

(f) Replacement of louver blades, with sliding aluminium frame windows

Results:

(i) Installation of a 100 kilovolt-amperes (KVA) automatic capacitor bank improved the power factor from 0.80 to 0.96. The maximum electricity demand was reduced from 90 kilovolt-amperes (KVA) to 80 kilovolt-amperes (KVA). The exercise resulted in significant savings in electricity bills by the MOE.

(ii) The office lighting exercise resulted in a maximum demand saving of 7.2 kilowatt (KW) and an energy saving of 15,577 kilowatt-hour (KWh) per annum. This exercise also resulted in significant reduction of electricity bills. The payback period of the lighting retrofit was two months.

(iii) The installation of the PIR sensors yielded a 17% in energy consumption in the first month, followed by a further 25% reduction in the second month, and a 7% reduction each in the third and fourth months. The installation of the sensors enabled the MOE to save a total of 11,330 KWh in four months.

Case Study 2: Ghana Cylinder Manufacturing Company

Objective of the study: To demonstrate that good energy management practices can yield significant benefit and enhance company competitiveness, by reducing the energy component of its production cost[2]

Key task undertaken :

Installation of capacitor banks

Results:

(i) The company's maximum demand consumption reduced from 240 KVA to 160 KVA

(ii) The factory's power factor improved from 0.82 to almost 1.00

Savings:

The monthly savings achieved in electricity bills gave a pay back period of about 5 months.

Emission reduction measures can also influence the production cost of generation in energy intensive firms and impact on their competitiveness. The Energy Foundation in Ghana has studied and measured such effects in most industries. One of such studies is described below.

Case Study: Integrated Energy Management at Ghana Textiles Printing Company Limited

Project Objective: To demonstrate that integrated energy management can be used to improve energy utilization and hence reduce a company's total cost of production.

[2] The project was sponsored by the International Institute for Sustainable Development, Winnipeg, Manitoba, Canada.

The results showed that integrated energy management through effective Demand Side Management (DSM), can have a positive impact on a company's cost of production and enhance its competitiveness.

Measure	**Savings**	**Amount saved (Ghana cedis)***
Electrical Energy	207,000 kWh	3,519
Water Saving	234,500m^3	30,400
Fuel and chemical saving	310,000kg	18,160
Total		**152,079**

Table 1. Summary of results at the Ghana Textile Manufacturing Company Limited (Source: Energy Foundation 1999) *1.60 Ghana Cedis (GH¢) = 1.00 US $.

2. Policy Description

Institutional Framework

Government policy on Renewable Energy (RE) and Energy Efficiency (EE) aims to impact on socio-economic development goals by removing the barriers which have hampered the exploitation of Ghana's renewable energy resources. Another aspect of the RE and EE policy is to attract investment, build local capacity, and accelerate the transition to a sustainable market.

In order to integrate RE and EE development into the energy sector reforms, the Government established two regulatory agencies in 1997, namely, the Energy Commission (EC) and the Public Utilities Regulatory Commission (PURC). The Energy Commission was established by an Act of Parliament (Act 541) to recommend the development and utilization of Ghana's indigenous energy resources, through the preparation of a strategic national energy plan. In accordance with its mandate, the EC is also required to develop a renewable energy regulatory framework and a legislative framework, which will ensure a wider adoption of renewable energy into Ghana's energy mix (Energy Commission Act, 1997). The EC is the principal advisory body to the country's Energy Ministry and is also responsible for issuing licenses for renewables.

The second regulatory agency, the PURC, was also established by an Act of Parliament (Act 538) to be responsible for price and quality of service regulation. The PURC is responsible for developing the appropriate feed-in tariffs for renewable energy, and also in conjunction with the EC, for developing the necessary rules and regulations which will facilitate the connection of distributed and renewable energy technologies into the national grid (Public Utilities Regulatory Commission Act 1997).

A third institution is the Energy Foundation, which was, created in 1997 as a Public-Private Partnership institution. The primary aim of this institution is to focus on the promotion of energy efficiency development. The Foundation also specializes in providing energy solutions, particularly for industrial and residential consumers. The establishment of the three agencies as part of the reforms in the energy sector, culminated in the country's Ministry of

Energy (MOE) losing some of its regulatory and operational functions, even though it is still responsible for policy formulation for the energy sector.

The policies which underpin the development of he RE and EE are briefly discussed below:

Resource Development and Supply Policy

The Resource Development Policy aims to ensure that renewable energy contributes at least 10% of the grid electricity by year 2020**.** Achieving this target will require support to the development of mini-grid systems, including the deployment of PV mini-grid and off-grid systems for rural communities. Policy also favours the promotion of grid-connected wind power and biomass based Combined Heat and Power (CHP) and the dissemination of solar home systems in grid-connected urban homes, through favourable regulatory and fiscal regimes.

The RE supply policy is expected to increase access to renewable energy technologies through private sector participation, support rural electrification and support off-grid and stand-alone rural electrification systems using wind, mini/micro hydro, and biogas. From the energy efficiency perspective, the policy is expected to encourage the use of cleaner fuels such as LPG and biogas, as a substitute for wood fuel use in homes.

Investment and Market Development Policy

Investment policy of the renewable energy (RE) sector aims to create a conducive environment to promote private sector participation, both domestic and foreign. The investment climate can be enhanced through the provision of fiscal and financial incentives and the establishment of an effective legal and regulatory framework to encourage private sector participation.

The policy on market development is to accelerate the transition towards the development of sustainable markets for RE. The current government policy of full-cost recovery with well-targeted subsidies, will in the long-term, eliminate subsides granted to electricity supply from traditional generation sources.

Human Resource Development Policy

Human resource development is also an important aspect of capacity building and institutional development policy. Although the DANIDA Energy Sector Programme Support in 2000 sought to build capacity within the Energy Commission and the Renewable Energy Unit of the Ministry of Energy, capacity building is still required in RE policy analysis, project management and monitoring, as well as in the installation and maintenance of RETs.

Energy Efficiency and Conservation Policy

The Energy Foundation (EF) has made progress in energy efficiency and conservation, however, there are still some gaps relating to standards for appliances, large equipment and buildings that must be developed. Such standards can be enforced through effective monitoring of imports and local production of RE and EE equipment and components.

Investment in EE can be enhanced if the Foundation can develop the capacity to market EE concepts to companies, identify, design and appraise specific projects. To do this effectively, the EF will require international support to enhance capacity to define target markets, market outreach programmes and identify project opportunities at end-user facilities.

Instruments for Policy Implementation

This section examines the various domestic policies being pursued in the energy sector, with specific reference to the renewable energy and energy efficiency sub-sectors.

Policy	Description and Instrument Used	Target Area	Status
1. Resource capacity development	Expand exploitation and development of RE resources. 10% RE in overall energy mix by 2020: Policy Processes	Policy Framework: Creation of Energy Commission	In force
2. Supply Policy	Increase access to RE services and enhance private sector participation: Policy Processes and Regulatory Instruments	Power, Industry	Initial phase in place
3. Renewable Energy Law	Establish legal and regulatory frame-work for RE and EE, feed-in tariff, connection, subsidies etc	Power	Under Preparation. Expected to be ready by end of first quarter of 2009
4. Energy conservation in homes and buildings	Public Education and demonstration projects: Policy Processes and Regulatory Instruments	Domestic and Public Building. Creation of Energy Foundation	In force
5. Energy Efficiency in intensive industries energy	Policy processes and educational programmes. Power Factor enhancement to at least 0.90	Industry	In force
6. Energy Efficiency and Labelling	Mandatory for room air conditioners and Compact Fluorescent Lamps	Appliances	In force
7. Market Development	Create and expand market for RE service. Increase demand for RETs: Policy Processes and Regulatory Instruments	Power and Industry	In force
8. Institutional Policy	Creation of conducive regulatory environment: Policy Processes	Power	In force. Energy Commission and PURC were set up in 1997

9. Increase efficiency of thermal power plants	Fuel switching from light crude oil to natural gas. Convert single cycle thermal plants into combined cycle plants: Policy Processes and Regulatory Instrument	Power	First introduction expected in 2009. Gas supply expected from the West African Gas Pipeline Project.
10. Domestic cooking fuel efficiency	Switch from wood-fuel to LPG	Domestic: Policy Processes	In force
11. Improved Cook stoves	Use of new cook stoves called AHIBENSO	Domestic: Policy Processes, Education and Outreach	In force. To provide 30% fuel savings, compared to traditional stoves
12. Bio-fuel	Encourage cultivation of Jatropha plant for bio- diesel production: Policy Processes	Transport and power	Production in commercial quantities yet to commence
13. Biogas	Support development of biogas technology from domestic and municipal waste, through anaerobic digestion	Domestic and Industry	At pilot stage
14. Solar PV	Used for lighting, telecommunication, water pumping, vaccine refrigeration: Policy Processes	Multi-Sectoral	In force, but increased penetration required.
15. Solar Water Heater	Policy Processes and R,D & D	Buildings	Institutional drive is weak. More effort required to promote use.
16. Solar Crop Drying	Policy Processes and education programmes	Domestic	Weak institutional structure. Lack of information dissemination

Table 2. Renewable and Energy Conservation Policies, Instruments and Processes used and status of implementation.

3. Benefits

Renewable Energy (RE) and Energy Efficiency (EE) contribute to reliable, affordable and clean energy. This reduces GHG emissions, and minimizes negative health and environmental impacts of air pollution, compared to fossil-fuel power plants and traditional biomass cook stoves. Other benefits of RE and EE include reduction of the country's dependence on energy imports, diversification of the energy supply mix, through expanding the portfolio of energy resources, and thereby contributing to energy security and economic stability. If renewable energy is applied to productive use in the rural areas, it can support income generating activities, improve social services such as health and education, food security and enhance other socio-economic benefits.

The table below shows the short- and long-term climate benefits emanating from different policies.

Policy Objective	Benefits	GHG reduction
Increased access to affordable energy services and improved rural electrification	Enhance access to modern energy service through promotion of**:** • Off-grid electrification • Mini-grid renewable systems, modern bio-mass and other systems	• Reduced GHG emissions from power generation. Emissions reduction not yet estimated
Renewable Energy Law	• Ensure minimum of 10% renewable energy in generation mix in the long-term. • Remove barriers to RE development • Incentivise IPPs to invest in RETs	GHG reduction, but not yet estimated quantitatively with respect to a baseline value
Stimulate Economic Development	• Remove barriers and facilitate investment in RETs • Develop model or standardized Power Purchase Agreements • Ensure energy efficiency	• Reduce CO_2 emissions • Demand-side management leading to annual reduction of CO_2 emissions
Energy-related environmental impact	To improve air quality through reduction of energy related emission, for example through use of LPG instead of wood fuel for cooking.	More research required to quantify relationship between air pollution and GHG reduction.
Diversification of Energy Supply Sources	• Increase percentage of RE in electricity generation to 10% by 2020 • Use natural gas from the West African Gas pipeline project from Nigeria • Develop large hydro projects e.g.: the 400 MW Bui Dam • Develop large scale wind and solar thermal IPPs	Reduction of Co_2 emissions, with respect to baseline emission projections for bulk electricity.

Table 3. Development objectives and climate co-benefits.

Metrics for Measuring Performance Intervention

Studies carried out on Ghana and other developing countries have shown that policies which are linked to climate change can emerge as co-benefits of sustainable development policies in the RE and EE sub-sectors. In an attempt to capture the effect of general development policies on climate change, the metrics of performance intervention have been selected to reflect the economic, social, and environmental dimensions of sustainable development. These policy areas and metrics measurements are presented in table 4 below.

Policy Area	Metrics of Performance Measurement
A. Economic: *Renewable Sector*	• % of RE in energy mix • Energy consumption per capita • Accessibility and costs • Energy sector investment
Energy Efficiency (Industry)	• System Peak (MW) reduction • Industry Power Factor Improvement • Maximum Demand (MW) Savings • EE Investment • Equipment Regulating Standard • Avoided electric network investment cost
Energy Efficiency (Residential)	• Electricity Accessibility • Average reduction in electricity (kWh) consumption • % of incandescent lamps replaced by Compact Fluorescent Lamps (CFLs) • Reduction of lighting load • Avoided investment in electricity generation capacity cost • Building codes (commercial, public and residential) standards
Growth	• Increase in revenue from income generation activities
Employment	• Number of people working and man– hours spent • % of working population
B. Social: *Local Participation*	• Direct participation of local firms in RE projects
Poverty Alleviation	• Income creation and working opportunities (both formal and informal) for the poor
Education	• Literacy Rate • Percentage of population with basic and tertiary education
Health	• Life expectancy rate • Infant Mortality

Table 4. Metrics for Measuring Performance Intervention

4. Domestic Drivers and Barriers

The main goal of Ghanaian government policy on renewable energy (RE) and energy efficiency (EE), is to increase the population's accessibility to electricity[3] and modern energy services, and promote energy efficiency. Current volatile world crude oil price and the

[3] Electricity accessibility in Ghana currently stands at about 50%

negative impacts that fossil-fuel energy resources are having on the climate, has increased the focus on RE and EE. This section explores in detail the barriers with respect to grid, mini-grid and stand-alone RETs. The barriers identified for these systems are classified as Economic, Legal and Regulatory, Financial and Institutional in the discussion below.

One of the economic barriers in Ghana is due to lack of a favourable pricing framework for renewable energy technologies (RETs). The current pricing approach used for conventional generation sources, if adopted, will undervalue future price risks and ignore environmental and health costs of fossil-fuelled power plant emissions. Furthermore, the existing pricing methodology does not factor environmental externalities of fossil-fuelled power plants into the calculations. The inability to develop a friendly-tariff regime for RETs has served as an economic barrier, thus skewing the “playing field” in favour of conventional generation sources (DANIDA 2002).

Financing and institutional barriers relate to investors inability to secure financing for investment in RETs, and lack of sufficient technical and commercial information to enable market participants in Ghana, make well-informed decisions. These barriers are discussed below with respect to grid, mini-grid and stand-alone RETs. The development and implementation of Energy Efficiency activities are institutional development issues and so any EE financing issue must take cognisance of this requirement. Some barriers which have been recognised in Ghana are lack of domestic sources of capital for financing and inadequate organisational and institutional system for project development.

Grid connected systems

Economic Barriers

Attempts to encourage grid connected RETs have not yielded the desired results because, aside from ignoring environmental cost and benefits, the pricing framework does not take cognizance of risks and fluctuations of the world crude oil price faced by fossil-fuelled plants. Though RETs avoid this fuel risk, this benefit is not factored into their price calculation.

Legal and Regulatory Barriers

Despite the government’s commitment to the development of renewable energy, the absence of a comprehensive legal and regulatory framework has been a major barrier for independent power producers (IPPs) to invest in renewable energy technologies. Another barrier which appears to be hampering the development of RETs in Ghana is the absence of network access rules and a transparent network pricing framework. Non-discriminatory access to the network is very crucial for RET development, especially for third-party sales between the renewable energy producer and the final consumer. The access rules become very important for RETs like wind farms and biomass, which tend to be sited further away from the nearest grid connection point or substation.

Under the power sector reforms, the Public Utilities Regulatory Commission (PURC) is tasked to develop pricing rules and conditions for open-access to the transmission and distribution networks. In the absence of binding open-access rules, the utility companies tend to negotiate Power Purchase Agreements (PPAs) with Independent Power Producers (IPPs) on an ad-hoc basis, which constitutes a barrier for third-party sales. In the absence of comprehensive pricing rules, the utilities are likely to charge unregulated access tariffs, which will penalize RETs, especially the intermittent RETs such as wind and solar energy.

Financing and Institutional Barriers

Renewable energy technologies are associated with higher upfront capital costs compared to fossil-fuel plants. This makes the cost of capital for RETs higher than for conventional plants which are considered "tried and tested". Also RETs are typically smaller than traditional power plants, which leads to higher transaction costs on a per-kilowatt basis. One of the financing barriers identified is the reluctance on the part of the banks and other financial institutions to finance RETs in Ghana (World Bank 2008). Lack of financing can be attributed to the perception by the financing institutions that RETs are more risky compared to conventional energy sources. This 'high risk' perception tends to increase the cost of capital and make capital unavailable in Ghana.

As part of the DANIDA sector support for the development and management of renewable energy in Ghana, schemes were developed for bank guarantees. Existing rural banks were identified and selected to provide financial intermediation to Renewable Energy Service Centres and rural customers. The beneficiaries of the loans make regular payments to the banks to cover the cost of the PV items they were provided with. These payments from the beneficiaries are managed by the identified rural banks as "seed funds", on behalf of the project (DANIDA 2002).

Mini-Grid Connected Systems

Economic Barriers

The Ghana government's policy to promote mini-grid renewable energy development has been not been tied to the promotion of rural electrification. Rural areas which are far away from the national grid are the principal candidates for mini-hydro systems. Such systems have been found to be more cost-effective means of supplying energy to rural population, instead of extending the main grid extension. According to DANIDA (2002) and World Bank (2008), the development of mini-grid systems faces severe economic barriers, however, such as:

(i) High investment and transaction costs
(ii) Difficulty in assessing financing sources
(iii) Inability to make robust resource supply projections
(iv) Absence of government subsidies or incentives to promote mini-grid based systems

The above barriers are further exacerbated by the following market and business risks such as:
(i) Inability of rural customers to pay their electricity bills
(ii) Inability to create community involvement and responsibility
(iii) Lack of community-based management to develop and operate the systems
(iv) Lack of expertise by communities in tariff design and developing appropriate tariff structures

Legal and Regulatory Barriers

Though the power sector policy seeks to also encourage the development of mini-hydros and other mini-grid RETs in Ghana, the following has been identified as the legal and regulatory barriers which hamper the realization of the government policy objective:

(i) Lack of well-documented tariff principles
(ii) Non-existence of appropriate capacity and technical know-how regarding the development of a suitable regulatory framework for mini-grids.
(iii) Existing gaps in government policy support for cooperatives, and encouragement to the private sector to develop rural electricity systems

According to Akuffo (2003), about 40 small scale potential hydro sites capable of generating up to 10 Mega watts (MW) have been identified in Ghana, with the total potential estimated to be about 24MW. Also potential, medium Hydro sites (capable of generating between 10MW to 50MW each) with a total generation potential of 1,300 MW have been identified in Ghana. The absence of effective legal and regulatory framework for mini-grid systems, however, remains a barrier to harnessing the huge energy from these sites.

Financing and Institutional Barriers

The following financing and institutional barriers for mini-grid RETs have been identified:
(i) High upfront capital costs
(ii) High transaction cost on per kW basis
(iii) Lack of requisite skills in communities to manage the system

Stand-Alone Systems

Economic Barriers

The government's policy seeks to encourage the usage of stand-alone systems such as solar home systems and pico hydro systems for the rural areas. Although fuel-independent stand-alone systems have the potential to serve as a complement to grid-based power supply and also contribute to reduction of GHG emissions, they face economic barriers such as high initial cost and lack of finance.

Legal and Regulatory Barriers

Development of stand-alone systems in Ghana has continued to remain a mirage due to the following legal and regulatory barriers**:**
(i) Absence of a pricing framework which will enable such stand-alone systems to sell power to the distribution network.
(ii) Unavailability of technical standards from the Energy Commission to ensure quality, safety and effective after sales service to customers.

Financing and Institutional Barriers

For the stand-alone RETs, the following financing barriers were identified:
(i) High upfront cost for end users
(ii) Inability to secure access to finance on favourable terms

5. International Cooperation

This section focuses on how international cooperation and support can be utilized to overcome the barriers identified in the previous section to increase the scale and scope of RE and EE, and accelerate the time-line of policy implementation by building on domestic support to achieve the 10% RE in the energy mix before 2020.

Development of a comprehensive policy and regulatory framework

The development of a comprehensive regulatory and legal framework, which includes a standard tariff-setting methodology and Power Purchase Agreements, would accelerate the time-line of government policy to increase the share of RE in the country's energy mix by at least 10% before 2020. The programme could be executed by adopting a bottom-up approach by the Energy Commission on behalf of the Ghana Government and supported by the World Bank and the Global Environment Facility (GEF). The two regulatory bodies (i.e. Energy Commission and the PURC) could further assist an independent consultant to finalize the draft legal and regulatory framework.

Development of an all-inclusive electrification policy

The government's rural energy policy should address both grid and off-grid expansion and identify rural and peri-urban areas earmarked for electrification. This objective can be achieved if the energy policy considers mini-grid and stand-alone systems as part of the overall rural electrification policy. Integrating mini-grid and stand-alone systems into the government's overall rural electrification policy has the potential to accelerate the 2020 time-line for achieving the 10% RE share.

Capacity Building

Economic Valuation of RETs

The non-inclusion of cost of externalities in the financial analysis of RETs tends to skew investment decisions in favour of fossil-fuel power plants. Increasing private sector participation in the power sector, requires staff in the two regulatory agencies (i.e. Energy Commission and PURC) to be trained properly in economic evaluation of RETs projects.

The World Bank has developed guidelines for carrying out economic evaluation and how to deal with environmental externalities. The economic evaluation methodology has been applied in China, Croatia and South Africa (World Bank 2008). Ghana can benefit through twinning programmes with advanced countries via South-North cooperation.

Quality Improvement Support

One of the barriers affecting the development of RETs in Ghana is the general lack of capacity and inability to disseminate information to policy makers, regulators, technicians and financial institutions. Specifically, one example of how Ghana could benefit from international support and cooperation to build capacity, is through improvement of the commercial capability of companies who want to expand and sustain PV business. Support could also be used to assist the Energy Foundation, Energy Commission and the Ghana Standards Board to develop and enforce appliance labelling standards, ensure improvement in the quality of products and services to consumers, and enhance access to information to suppliers, dealers, consumers and other stakeholders.

Financing Mechanisms

The high capital costs generally associated with RETs, can be reduced through one-off capital cost subsidies from the Ghana government, possibly by sourcing funds or grants from GEF or from funds generated from the Rural Electrification Fund. Since the banks and financial institutions in Ghana are reluctant to finance renewable energy because of the perceived risks associated with such projects, the country's Ministry of Finance could develop a Credit Support Facility (CSF), with international support from bilateral and multilateral donors. This would facilitate commercial debt finance, and support long-term debt financing. The CSF could also be used to provide credit enhancement in order that the risks associated with renewable energy are shared by both the Ghana Government and the financial sector.

Funds for the Credit Support Fund could come from the Rural Electrification Levy, which is charged to all consumers of electricity, the IDA and other bilateral donors. To ensure that funds from the Rural Electrification Levy are effectively managed, it is suggested that an autonomous body, separate from the Ministry of Energy, be established to manage the fund.

Taking Advantage of Community Development Fund for mini-grid systems

Ghana can benefit from financing under the Clean Development Mechanism *(CDM)*. Since most of the rural areas in Ghana still use wood-fuel (which leads to deforestation) and kerosene, the carbon reduction potential resulting from use of alternative sources, is likely to be significant enough to enable mini-grid RETs qualify as a CDM project. In 2002, realizing the benefit of mini-grid systems for reducing the GHG emission, the Word Bank and the Global Environmental Facility (GEF), created the Community Development Carbon Fund (CDCF). This fund is aimed at extending carbon financing to small projects, including mini-grid renewable systems. It is designed to reduce the CDM transaction cost of mini-grid renewable energy systems by allowing small-scale projects to be bundled together into a portfolio, so that it can be developed as one larger CDM project.

Support to Energy Foundation

Although the Energy Foundation appears to have made modest gains in promoting energy efficiency in Ghana, further efforts are required to promote energy efficiency practices to cover the entire country. The activities of the EF are limited to just a few cities because of financial constraints. To enable the EF to extend its outreach programme to assist industries in all parts of the country, international financial support is required to enable the Foundation to establish regional offices. International support and cooperation is also required to train technical staff in modern methods and practices required for energy efficiency applications, measurement and analysis.

International Financial Support for Energy Foundation

Far reaching climate policy will require the need to open-up financing options for domestic financing of EE activities and projects to include both end-user resources and local financial institutions. Financial support from the World Bank and other international development agencies can then be channelled through the Ministry of Finance to the Energy Foundation. To further enhance local financial support, the role of the Energy Service Companies (ESCOs) in Ghana could be expanded so that the ESCOs can serve as project aggregators to which the financing institutions may provide financing for projects. According to Taylor et al. (2008), ESCOs can play a vital role in EE financing if the local institutional environment is conducive.

International support from GEF financing programmes to the Energy Foundation can be very helpful. The support can be in the form of technical assistance and investment support for piloting new projects and covering upfront transaction costs of new schemes. Going into the future, one expects that financial support from the World Bank, multilateral and other bilateral development agencies will gradually shift from pure technical assistance to demonstration and project piloting.

Building capacity for Developing Biodiesel from Jatropha Plant

Even though oil deposits were recently discovered in Ghana in commercial quantities, the government can continue to support the policy to develop bio-diesel from the Jatropha plant for domestic use and export[4]. Oil and other derivatives from the plant can be exported to generate extra revenue to support the economy and thus accelerate Ghana's transition to a middle-income earning country by 2015. Though the Jatropha plant can be cultivated on a large scale in Ghana for biodiesel production, it has been noted that there are still some inherent problems which need to be addressed through further research. For instance, Jatropha oil has been shown to be very acidic, and therefore it tends to degrade quickly, particularly if not handled with care through the supply chain (Parsons 2005). Exposure to air and moisture must therefore be minimized. Also, since the seeds degrade as soon as they are picked, this requires careful storage and handling. In a humid country like Ghana, the degradation can be very rapid.

In order to understand the degradation process, Ghanaian scientists and universities can collaborate with their counterparts through international cooperation to undertake further research work. For instance with funding support from the World Bank, South-South cooperation with the Kirstenbosch Research Centre of South Africa, which is already undertaking research works to study the properties of the Jatropha plant, is possible.

6. Conclusion

Formulating Coordinated and Focused Policies

The study has shown that supply-side polices such as capital subsidies and equipment supply support are necessary, but not sufficient, to catalyze the development of the RE market. To achieve long-tem sustainable RE and EE contribution to GHG reduction, other policies and international support and cooperation are also required.

Improving access to Capital

The study has highlighted the inability of the private sector to access long-term capital as a barrier to promote RE use. Compared to grid-connected RE systems, the total up-front cost requirements for mini-grid systems are relatively low. Donor support could be used in the area of seed-finance for demonstration or pilot projects for rural RETs. In addition to donor funded seed capital funds, a growth capital fund that is a mixture of donor and commercial capital can also be used to finance mini-grid systems.

[4] In 2007, BioDiesel Ltd. (Norway), through Biofuel Ltd. (Ghana) commenced Jatropha cultivation in Ghana. Every hectare is expected to produce about 2,600 kg or approximately 2,900 litres of Jatropha crude oil annually. Another company, Green Fuel Biodiesel Ghana Limited hopes to start the production of biodiesel in Ghana on commercial quantities very soon.

Taking Account of Economic Valuation of RE systems.

The existing methodology adopted in Ghana to value RE systems is based on discounted cash flow analysis. To overcome the "higher cost" barrier associated with RE, the full levelized life-cycle cost should take cognizance of environmental, health and social co-benefits of RE Systems. The World Bank support could be utilised to build local capacity in modelling costs and benefits of externalities in economic evaluation of RETs.

Developing Appropriate Legal and Regulatory Instruments for Mini-Grid RETs

Regulation of mini-grid electricity is generally different from that of grid electricity systems because the benchmarks for quality of service are different. International cooperation and support, as well as twinning-programmes, can be utilised by the regulatory agencies to provide in-depth insight into some of the well-established approaches for regulating mini-grid systems.

Overcoming Market Facilitation Barriers

Market facilitation instruments can provide proper certification of solar components or systems. Such certification should form part of government's energy policy, and could become a requirement for government financial support for renewable energy systems. Lessons can be learnt from the Market Development Support Facility (MSDF), which is currently in operation in Tanzania and Zambia (i.e. South-South Cooperation). The MSDF provides matching grant assistance to help participating PV companies to overcome barriers to business and market development.

Capacity Building

Another outcome of the study is the urgent need to develop comprehensive capacity building programmes in RETs. Many RE projects in both developed and developing countries have been hampered by inadequate attention to the availability of local skills for design, installation, operation, maintenance, repair, spare parts management and technology transfer (World Energy Council 2004). Technical training and overall capacity building can be initiated by the Ministry of Energy in conjunction with the regulatory agencies and the Energy Service Companies (ESCOS), through a 'bottom-up' approach. International financial support can be obtained through South-North Cooperation, with further support from the World Bank, DANIDA and other bilateral donors.

In conclusion, the case study has revealed that with international cooperation and support, there is no doubt that RE and EE can properly be integrated into domestic development policies to enhance Ghana's energy security, reduce reliance on fossil-fuels, and accelerate the attainment of the 10% threshold of RE in the energy mix before 2020.

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