Promoting Technology Transfer and Deployment for Renewable Energy and Energy Efficiency in Ghana

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ISDA Project

This paper is part of the project International Support for Domestic Action (ISDA). Case studies from five developing countries assess the barriers and drivers of actions that shift individual sectors onto low-carbon growth paths. Five cross-cutting papers then explore how international financial mechanisms, technology cooperation, intellectual property aspects, and suitable monitoring and reporting arrangements can enhance the scale, scope and speed of their implementation. The project is coordinated by Karsten Neuhoff, University of Cambridge; individual reports are available at http://climatestrategies.org/our-reports/category/43.html

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Executive Summary

There is no doubt that the international community is giving increasing attention to the threat of climate change. Even though there are many opportunities to increase the scale and scope of adoption of renewable energy (RE) and energy efficiency (EE) technologies in Ghana, the level of utilisation of these policies has been limited due to a number of barriers. This country case study has been undertaken to explore what actions can be adopted to overcome these barriers and also ascertain how international support can be used to leverage domestic policy to enhance the scale, scope and speed of implementing RE and EE technologies in Ghana. Since 1997, the government of Ghana has initiated reforms in the energy sector that led to the development of the National Strategic Energy Plan; the plan outlines policy for the period 2006 to 2020 and sets a target of 10% of RE in the country's energy mix. The Plan also sought to promote EE activities through Demand Side Management (DSM).

The results of the study suggest that in order to increase the penetration of RE technologies in Ghana, a combination of appropriate market mandated policies (i.e. portfolio standards, a quota system, and feed-in tariff regime, etc), use of the Clean Development Mechanism (CDM), as well as the incorporation of other policy options. These policy options include, among others, use of international support to enhance the regulatory framework, develop an all-inclusive energy policy, build domestic technical capacity, bridge the gap between policy makers and academics, leverage the domestic financial environment and develop innovative business models which ensure RE and EE project are technically and financially sustainable.

The results also show that, based on conservative estimates, if international support is used to leverage domestic policies, Ghana has the potential to avoid at least *14 million tonnes of CO_2 emissions* over the life time of the RE projects. For energy efficiency, the avoided CO_2 emission is estimated to be at least *70,000 tonnes* over the implementation period.

Needs: Barriers and Drivers

As part of this study, a stakeholder workshop was organized in Accra, Ghana, on April 8th 2009, to identify barriers and discuss possible options for overcoming them. It emerged from the workshop that even though barriers may occur at various stages along the policy pipeline; in Ghana, the barriers are more likely to occur during the *implementation and roll-out stages*. Implementation barriers are those which affect the deployment, diffusion, distribution and commercialization of RE technologies. These barriers were identified inter alia as lack of capacity to innovate, inadequate regulations, absence of all-inclusive energy policy, lack of access to long-term finance, and lack of domestic technical capacity for technology absorption and adoption. During the roll-out phase, barriers are considered limitations that affect the *sustainability and future replication* of RE and EE projects: these were identified mainly as *institutional, technical and financial.* The key barriers are shown in the table below.

Key Barriers	**Initiation**		**Implementation**		**Roll-out**	
Lack of capacity to:	RE	EE	RE	EE	RE	EE
Innovate			Lack of critical mass of human capital.			
Regulate			Inadequate policy, legal and regulatory framework; Lack of all-inclusive energy policy	Lack of clear policy and capacity to regulate	Lack of regulatory capacity for project sustainability	Lack of technical standards and codes.
Adopt			Weak domestic capacity	Lack of appropriate technical standards		
Operate & Maintain			Lack of technical capacity		Lack of technical capacity for sustainability	
Finance			Lack of access to long-term capital; High cost of capital.	Lack of finance for ESCOs and private sector	Adoption of inappropriate business model	Lack of distribution outlets for EE equipment

Barriers based on outcome of discussions from Accra workshop

Options for Addressing Barriers

The study proposed actions and options for addressing the barriers: adoption of **the** innovation centre concept, enhancing domestic technical and regulatory capacity, using international financial support to leverage the domestic financial environment, and creating stakeholder awareness. RE projects can be made *institutionally sustainable* if the capacities of the government agencies and regulatory institutions are developed, and if the overall enabling environment is created to reassure private sector investment.

Technical sustainability requires that a *critical mass* of technical skills is developed through hands-on training to enable the country to use local expertise to maintain and operate all future projects. The study recommends among other things, that the fee-for-service business model which was adopted for previously funded donor RE projects should be modified. To ensure financial sustainability of future RE projects, the customer tariff should be set in accordance with consumers' willingness-to-pay, to ensure that the operation and maintenance costs can be recovered.

Suitable Indicators

The study also explored how performance indicators could be used to measure the progress of RE and EE projects towards achieving policy objectives. The pros and cons of the choice of indicator type are examined, as are the tradeoffs of the various types of indicators using the discussion by Neuhoff et al. (2009); focusing on *Input, Process, Output and Outcome indicators*. The author has used output indicators in the study because of their ability to measure short-term results, usually between 3-5 years.

1. Introduction

The growing global concern about the threat of climate change has been the focus of international debate. The stock of Greenhouse Gas (GHG) emissions in the world's atmosphere is known to be directly related to the flow of anthropogenic-induced GHG emissions (Avato and Coony 2008). Increasing attention given to the potential adverse effects of climate change is confirmed by the Fourth Assessment Reports of the IPCC (2007) and the Stern Review on the Economics of Climate Change (HM Treasury 2006). Both reports point to the urgent need to direct efforts to mitigate the negative effects of climate change. The Johannesburg Plan of Implementation [1] also called on governments and other stakeholders to make efforts to substantially increase the global share of renewable energy (RE) sources as a matter of urgency[2], with the objective of increasing the percentage of (RE) in the total energy supply (United Nations 2006). Although GHG emissions are caused by the energy, transport, industry and land use sectors, the energy sector has been identified to be responsible for a greater proportion of anthropogenic emissions (OPIC 2000).

At the thirteenth session of the Conference of the Parties (COP) held in Bali[3], the key decisions adopted by the COP included inter alia, the need to develop effective mechanisms to remove the barriers and provide financial incentives to scale-up development, diffusion and transfer of affordable environmentally sound technologies to developing countries (UNFCCC 2008a). The COP also decided on methods to develop enhanced actions which would ensure improved access to adequate, predictable and sustainable financial resources and technical support to developing countries. A comprehensive climate change strategy would encompass coherent policies and actions for mitigation and adaptation, through *technology transfer* and mobilization of *public and private sector funding* and *investment* (UN 2008; UNFCCC 2008a).

Concerted efforts are required to accelerate the development and deployment of affordable cleaner energy, energy efficiency and transfer of these technologies to developing countries (UN 2002). Mitigating the severity of climate change impacts pose a huge challenge for both developed and developing countries, especially in the energy sector, and this will require shifting to low-carbon technologies within the next 10-20 years (Avato and Coony 2008). The IPCC, the Stern Review and the IEA have all noted that a truly sustainable energy future can only be achieved if new and improved low-carbon technologies are developed and deployed (Avato and Coony, 2008). Tomlinson et al (2008) have noted that technology transfer is about the *institutions, structures and organization*. In that regard, smaller developing countries such as Ghana that would require international support, must adopt a system-wide approach to enhance technology transfer. Technology transfer to developing countries requires the adoption of both "hardware" and "software" technologies (i.e. information technology, management, planning, etc) for mitigating climate change (Avato and Coony 2008).

In the light of these discussions, this case study explores the various barriers hampering the adoption of RE and energy efficiency (EE) technologies in Ghana. The study also examines the various options that can be adopted to overcome the barriers in order to enhance the scale, scope and speed of utilising RE and EE technologies.

2. Policy Description

Overall, Ghanaian government policy on RE and EE is aimed at removing the barriers which have hampered the exploitation of the country's renewable resources, thus attracting investment, building local capacity and accelerating the transition to a sustainable market. The government also hopes to achieve adequate security of energy supply and reliability, and increase access to modern forms of energy. The government's commitment to RE and EE development led to the

[1] Further details on the Johannesburg Plan of Implementation (2004) can be obtained from the UN Department of Economic and Social Affairs, Division for Sustainable Development, UN.

[2] in United Nations 2006 paragraph (e).

[3] i.e. 1/CP.13

development of a Strategic National Energy Plan which set a target of 10%[4] of RE in the country's energy generation mix (i.e. energy delivered) to be achieved by 2020. It is estimated, that RE contribution would reach at least 1,630 GWh between 2020 and 2030, which is equal to about 4.4 %[5] of total electricity energy generation. Currently, the percentage of RE in the country energy generation mix is less than 1%. Total energy in use is 237 petajoule (PJ) which is equivalent to about 12 gigajoule (GJ) per capita. The level of per capita commercial energy use is 4.5 GJ, which is less than one tenth of the world average (United Nations 2006).

The policy aims to create a level playing field to enable RE technologies to compete with other conventional energy sources. The Strategic National Energy Plan, for the period 2006 to 2020, also seeks to enhance EE through Demand Side Management (DSM) activities and achieve high levels of end-use efficiency.

The next section provides a brief assessment of the incremental costs and expected climate benefits of technology transfer in Ghana.

Incremental Costs[6] and Overall Climate Benefit

Based on extrapolation of the World Bank (2006) estimates, for 4 planned and identified grid-connected small hydro and wind projects of 50 MW each, Ghana can avoid a total of about 12MtCO_2,[7] over the project lifetime. For the mini-grid systems the World Bank (2006) has estimated that for 4 MW small hydro schemes comprising 2 small hydro projects and about 10 village hydro projects, 5 MW biomass cogeneration plants comprising 4 biomass cogeneration plants, and 5MW wind energy projects made up of 2 pilot projects, Ghana can avoid a total of about 2MtCO_2,[8] over the project life time.

For stand-alone systems, an extrapolation of the World Bank (2006) estimates show that with about 20,000 solar home systems, Ghana can avoid a total of 60,000 tonnes of CO_2 emissions, over an assumed life time of 25 years for solar PV systems[9]. It is estimated that for a total of 600KW (1KW each) of small-scale wind turbines, the country has the potential to avoid about 41,000 tonnes of CO_2 emissions over the projects' lifetime.

Based on the above, it is estimated that Ghana has the potential to avoid a total of at least 14 MtCO_2 emissions over the lifetime of RE projects, if implementation barriers are removed and international support is utilized to leverage domestic policy. The World Bank (2006) has estimated that a total of $10 US million and $1 US million is expected to be invested in energy efficient activities during the implementation and roll-out stages respectively, via international and domestic financing institutions. Based on similar projects in other developing countries, it is estimated that between 70,000 tonnes and 600,000 tonnes of CO_2 emissions[10] could be avoided from EE and energy conservation activities (World Bank 2006) during the implementation and roll-out phases.

As shown in table 1 below, Ghana has the potential to exceed the government target of 10% share of RE in the country's energy generation mix in the long-term, conditional on barrier removal and international support and cooperation to leverage domestic policy.

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[4] Excludes large hydro systems greater than 500 MW, but includes wind, small hydro systems (<500MW), mini, micro and picro hydro systems < 10MW and solar PV.
[5] This is a base case scenario, which is achieved without policy reforms and international support.
[6] Measured with respect to baseline costs
[7] The author assumed that the grid-connected RE systems would displace marginal baseline power provided by Combined Cycle Gas Turbine, with fuel emission factor of 56,100 gCO_2 per G.Joule, See details of emission factor values in OPIC (2000).
[8] For mini-grid systems, it is assumed that the RE projects would displace marginal baseline power provided by diesel-powered plants, with fuel emission factor of 74,050 gCO_2 per G.Joule. See details of emission factor values in OPIC (2000).
[9] It is assumed that solar PV system would displace kerosene and candles usage by the rural community, while off-grid wind turbines are expected to displace baseline diesel powered generators.
[10] Refers to absolute emissions savings or avoided

	Initiation 1 – 5 years		**Implementation 5- 10 years**		**Roll-out 10 – 25 years**	
	RE	EE	RE	EE	RE	EE
CO_2 benefit	0	0	2.8 – 6 million tonnes of CO_2 emission avoided	40,000 – 70,000 tonnes of CO_2 emission avoided	6 – 14 million tonnes of CO_2 emission avoided.	70,000 – 700,000 tonnes of CO_2 emissions avoided
Share of RE in energy sector (%)	0		2 - 10		13 - 40	
Incremental Cost:			**136**	**10**	**7**	**1**
Grid-connected			110		5	
Off-grid connections			20		1.5	
Standalone systems			6		0.5	

Table 1. Climate change benefit and incremental cost of technology transfer (Source: Adapted from incremental cost analysis based on World Bank 2006)

As shown in table 1 above, the incremental cost of $136 US Million during the RE implementation phase is mainly for addressing institutional, capacity and financial barriers for both grid and off-grid systems. The $7 US Million estimated for the follow-up phase is to ensure project sustainability, such as providing support to the financial institutions, and supporting operation and maintenance activities in off-grid systems. For EE, the incremental cost of $10 US million for the implementation phase is to increase financing for the Energy Service Companies (ESCOs) and enhance the activities of the Energy Foundation. The estimated $1 US million for the follow-up phase is to assist the private sector in establishing distribution outlets country-wide to support operation and maintenance activities and increase the penetration of EE equipment in Ghana. Table 2 below identifies and quantifies the expected financing sources required to meet the incremental costs.

Financing Source	**Classification**	**Type**	**Estimated Amount (US$ Million)**
World Bank	Multilateral	Loans/Credit	20
Private Sector	Local and International	Equity	28
Financial Institutions	Local and International	Loans	102
Rural Banks	Local	Loans	4
TOTAL			**154 US$ Million**

Table 2. Financial Assistance Sources and Types (Adapted from: World Bank 2006)

3. Needs: Drivers and Barriers

Although Ghana is endowed with abundant renewable energy sources, these resources, to date, have not been harnessed due to the barriers outlined in table 3 below, which were identified at a workshop held in Accra, Ghana[11], which was organised to discuss how to create an enabling domestic environment for RE and EE technology transfer. Even though barriers may occur at various stages of the policy pipeline, it was manifestly clear from the Accra Workshop that for Ghana, barriers are mainly related to the implementation and roll-out sages, as shown in table 3 below and explored in detail in the next section.

Since 1997, when the country initiated reform of its energy sector, the government has decided to put the necessary legal, policy and institutional frameworks in place. In this regard, the country has been able to overcome the initiation barriers. The main problem is how to enhance the operations of the regulatory agencies, policymakers, and other stakeholders to unlock domestic policy to catalyse technology transfer during the implementation and roll-out stages.

Key Barriers	**Initiation**		**Implementation**		**Roll-out**	
Lack of capacity to:	RE	EE	RE	EE	RE	EE
Innovate			Lack of critical mass of human capital.			
Regulate			Inadequate policy, legal and regulatory framework; Lack of all-inclusive energy policy	Lack of clear policy and capacity to regulate	Lack of regulatory capacity for project sustainability	Lack of technical standards and codes.
Adopt			Weak domestic capacity	Lack of appropriate technical standards		
Operate & Maintain			Lack of technical capacity		Lack of technical capacity for sustainability	
Finance			Lack of access to long-term capital; High cost of capital.	Lack of finance for ESCOs and private sector	Adoption of inappropriate business model	Lack of distribution outlets for EE equipment
Stakeholder Interest			Enhanced stakeholder awareness	Information on EE equipment; Enhanced stakeholder awareness		
Stakeholder Concern			Platform to bridge gap between policy makers and stakeholders, particularly, academics.	Platform to bridge gap between policy makers and stakeholders, particularly, academics.		

Table 3. Policy Pipeline: Barriers based on outcome of discussions from Accra workshop

[11] See details in Gboney, W. (2009), Workshop Report: Summary of discussions during workshop in Accra, Ghana, on April 8th 2009, which is also available on project website: www.eprg.group.cam.ac.uk/isdahome/

3.1 Initiation Phase Barriers

As has been stated in the previous section, the outcome of the Accra workshop revealed that most of the barriers hampering the adoption of RE and EE technologies in Ghana are related to the implementation and follow-up phases. The main problem confronting the country is how to enhance the operations of the regulatory agencies, policymakers, and ensure project sustainability and adoption.

3.2 Implementation Phase Barriers

Implementation barriers include lack of domestic capacity to innovate and ensure effective regulation of RE systems, and lack of capacity to adopt and carry out effective operations and maintenance of the systems. These barriers affect the country's capacity to ensure deployment, distribution, and commercialisation of RE and EE systems. Such barriers are explored further below.

Absence of All-inclusive Electrification Policy

Though there is an energy policy which covers renewable development, the policy has failed to clearly define rural electrification policy vis-à-vis grid extension plans and off-grid programmes. This policy gap has affected the deployment, diffusion and commercialization of RE technologies in rural areas. For example, RE projects were funded with international financial support for some communities in Northern Ghana who were then connected to the national grid (World Bank 2006), thus rendering the projects redundant.

Inadequate Domestic Capacity

Inability to innovate in Ghana and most developing countries can be attributed to inadequate human capital in terms of the level of education and training within the general population (Jallow 2003). Innovative approaches are therefore required to prevent failures similar to past RE programmes in Ghana which were implemented with international support. These projects could not be sustained because of lack of domestic technical support for maintenance services after installation. The weak technical capacity of private entrepreneurs in the installation and maintenance of RE technologies, especially solar PV systems, has been identified as one of the key technical barriers. It is therefore not surprising that the COP recommended[12] that developing countries should organize training programmes in the management, operation and maintenance of clean technologies, and organize seminars and workshops, in order to build capacity for technology transfer in developing countries (UNFCCC 2008a).

There have been previous attempts by a company called Deng Limited to build technical capacity through specialized training programmes in Ghana. The company has been offering periodic training courses in solar PV home systems and installations (World Bank 2006), but it has been observed that more of such training programmes are required to develop a critical mass of skilled workers for technology transfer. This assertion is supported by Brandzaeg and Hansen (2005) who noted that in developing countries, even though some skilled workers may exist, the inability to develop innovative mechanisms can be attributed to lack of critical mass of technical skills necessary for technology innovation and transfer.

The stakeholders' workshop in Accra also raised the issue of a general lack of capacity in both the banking and non-banking financial institutions in RE, infrastructure project finance, project risk allocation, and review of power Purchase Agreements (PPAs). Other capacity barriers that have been identified included a lack of technical, financial and business development skills by private project developers, amongst other factors.

[12] In decision 1/CP.13

Inadequate Capacity to Regulate

One of the barriers affecting independent power producers (IPPs) who want to invest in RE technologies in Ghana is the ***inadequate legal and regulatory framework for the RE sector***. From the Accra workshop, it emerged that the absence of network access rules and a transparent network pricing framework is hampering the development of grid connected RE. Even though current government policy seeks to encourage the development of mini-hydro and other mini-grid connected RE technologies, the absence of well-documented tariff principles and lack of regulatory capacity on mini-grid systems, has continued to act as a barrier. For instance a local power company called Tropical Energy Resources who wanted to construct a grid-connected 50MW waste-to-energy power plant had to go through three different public institutions, namely the Public Utilities Regulatory Commission (PURC), the Electricity Company of Ghana (ECG) and the Ministry of Energy for determination of the tariff for its long-term Power Purchase Agreement with ECG[13]. Under the country's power sector reforms, the PURC is mandated by an Act of Parliament[14], to deal with all electricity tariff issues in Ghana. Therefore, for Tropical Energy Limited, dealing with two other agencies in the tariff determination process was time consuming and provides a clear manifestation of how an inadequate RE regulatory regime can become a disincentive to the private sector.

Furthermore, there is no incentive for the development of stand-alone systems because there is no suitable pricing framework which requires owners of such systems to sell-back power to the electric distribution company. Such problems have been identified by the UNFCCC and this compelled the COP15 to recommend that developing countries should endeavour to develop the necessary enabling environment to accelerate the development and transfer of environmentally sound technologies (UNFCCC 2000a).

Implementing Appropriate Market Mandated Policies.

Based on results of energy modelling by the United Nations (2006), it is has been recognised that in order to promote RE energy in Ghana's electricity generation mix three policy options; namely, adoption of appropriate mandated market policies (i.e. portfolio standards, RE quota systems, feed-in tariffs), Public Benefit Funds (PBF) which impose a levy on electric utilities on power transmitted, and the CDM which raises finance through the sale of certified emission reductions generated by RE on the international market, are also required.

The results from the modelling work shown in table 4 show that even though all the policy measures can lead to increases in the share of RE in the country's generation mix, the adoption of market mandated policies create the highest increase in RE share, even though the PBF and CDM may possess economic advantages in terms of higher investment for RE technologies, since they are partly financed either by internal funds or earnings from carbon markets. This analysis suggests that a combination of all 3 of the measures, plus other policy options identified in this study, is the best approach for accelerating implementation of the 10% RE in the energy generation mix.

[13] This issue was confirmed during discussions with the Managing Director of Tropical Energy Resources, Major. I. Rida, by the author and the ISDA Project Manager, Karsten Neuhoff in Accra, Ghana on April 8th 2009.

[14] Act 538

[15] as part of its decision 1/CP.13.

Policy Type	2010 (Base Case)	2030	Investment Cost	Operating & Maintenance Cost
Mandated Market Policy	2%	40%	Highest	Lowest
Public Benefit Fund (PBF)	2%	20%	Moderate	Highest
CDM	2%	13.1%	Lowest	Moderate

Table 4. Modelling results for share of RE in electricity generation mix, in terms of capacity (Megawatts). Source: United Nations (2006)

Limited Scope of Operations for Energy Efficiency Activities by the Energy Foundation

Although the Energy Foundation has made some modest gains in promoting energy efficiency activities, the Foundation's activities have been limited to the capital city Accra and a few regional capitals. This has affected the country's ability to adopt energy management practices in most Ghanaian industries. Figure 1 depicts the relationship between the EE activities and regional share of population. As shown in figure 1, most of the Foundation's activities are based in Accra, Ashanti, Central and Eastern regions of Ghana. It is important that the Foundation's activities are extended to the other regions if the country aims to make a significant contribution towards reducing global GHG emission.

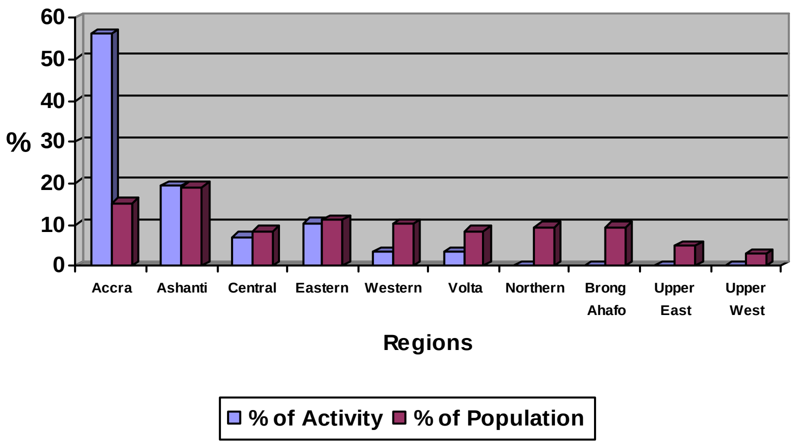

Figure 1. Relationship between population distribution and Energy Foundation's activities in the regions

The graphical depiction from figure 1 indicates that additional domestic effort and international support is required to enable the Energy Foundation intensify its activities, and enhance the scale and scope of its operations country-wide.

Financing Barriers

Another barrier that has been identified is the general reluctance on the part of the domestic financial institutions to finance RE and EE projects and technologies (United Nations 2008b). Ghana possesses a well-developed financial sector comprising of 25 banks; made up of commercial, merchant and development banks, with over 310 branches country-wide. In spite of this, access to long-term credit has not been available because of the risks perceived for RE projects and the inability of private entrepreneurs and Energy Service companies (ESCOs) to present bankable proposals.

Lack of access to capital by private developers in Ghana can also be attributed to excessive collateral requirements, poor credit ratings, and the short loan terms relative to the project payback. In addition, the interest rate charged is too high in comparison to returns from projects.

3.3 Roll-out Barriers

According to the World Bank (2006), some RE projects which were undertaken in Northern Ghana could not be sustained because of technical, institutional and financial roll-out barriers. Projects can not be institutionally sustained because existing policy and regulatory frameworks were not adequate to incentivise the private sector to invest in the RE projects after project completion. In addition, regulatory agencies and financing institutions failed to build the domestic capacity required to be able to handle similar RE projects in future. Technically, these projects could not be sustained because no plans were put in place to provide hands-on training through leaning by doing, in order to promote technology adoption and replication.

A UNDP/GEF renewable energy project that was implemented in Northern Ghana, and which involved the installation of over 2,000 solar home systems, could not be financially sustained because the customer tariff was too low and did not recover the operation and maintenance costs. The fees charged to customers were based on the assumption that rural consumers have low ability to pay, even though experience has shown that consumers have higher willingness-to-pay[16] than has previously been assumed (World Bank 2000b). For off-grid RE systems to be financially viable, they must be operated as a business, which implies that the business model for the project must ensure that sufficient revenue is generated to at least recover the operation and maintenance costs, and if possible also make a partial contribution towards recovering the capital cost.

Another reason for the failure of RE projects was that grid supply to rural communities, occurred as the solar home systems were installed. For instance the Spanish government supplied 10 communities with solar home systems, street lights and schools, only for 8 of these communities to be immediately connected to the grid, soon after the RE project was completed (World Bank 2006). Like the UNDP/GEF RE project, the Spanish project could not be sustained financially because of low consumer tariffs which could not recover the operation and maintenance costs.

A third project which could not be financially sustained was the DANIDA project, under which 14 solar battery charging stations were established in the Northern part of Ghana, with the rural and community banks (RCBs) providing credit to consumers to buy the batteries. The first barrier was that the bank transaction cost for the loans was so high that it served as a disincentive to consumers. For customers who managed to eventually secure the loans, the repayment rate was very low (World Bank 2006). Based on experiences from the previous internationally financed projects, it is imperative that innovative financial mechanisms are developed to assist the rural and peri-urban areas to purchase stand-alone systems.

Inability to sustain the projects can thus be attributed to inappropriate implementation of the fee-for service business model and lack of micro-finance for small and medium scale enterprises that would want to invest in off-grid and mini-grid systems.

3.4 Drivers

In the light of the above barriers, the Accra workshop identified the following factors as the *key drivers* that can ‘unlock’ domestic policy, and provide a conducive environment for RE technology transfer.

(a) Enhancement of appropriate regulatory and legal frameworks to incentivise the private sector to invest in RE and EE projects.

[16] Further details on willingness-to-pay studies can be found in: Barnes, F., Fitzgerald, K., and Peskin, H. (2002), “The benefits of rural electrification in India: Implication for education, household lighting”, Draft Manuscript, and Cust, J., Singh, A. and Neuhoff, K. (2007), “Rural Electrification in India: Economic and Institutional Aspects of Renewables”, EPRG Working Paper, University of Cambridge, UK.

(b) Development of standards for technology performance. The workshop recommended that codes, standards and certification be developed to provide end-users with performance awareness.

(c) Development of innovative financing mechanisms, which would permit bundling of small projects to enhance their financial viability.

(d) Public awareness and establishment of information centres, to provide potential users with information and data on equipment costs and performance.

(e) Enhancing the level of interest from academics, private entrepreneurs, regulators and policy makers to enable these stakeholders to make a meaningful contribution towards developing a comprehensive domestic strategy. This would make the deployment and diffusion of RE technologies in Ghana *demand driven.*

(f) For EE, a key driver has been the recent limited power supply to households and industries, as well as the high price of energy relative to average household income. Stakeholders are becoming increasingly aware that adopting good energy conservation activities can yield significant energy savings; this can represent an alternative energy resource, which is less costly than constructing new energy infrastructure.

4. Options for Addressing the Barriers

This section of the study examines in detail the policy options that can be adopted to address barriers, and leverage domestic policy to facilitate rapid deployment and diffusion of RE technologies. Although a number of barriers were outlined in section 3, this section will focus on the three major barriers shown in table 5 below namely, Policy and Regulatory barriers, Weak Domestic Capacity and Financing barriers. The different policy actions and options for tackling the barriers are discussed below.

4.1 Policy and Regulatory Barriers

Developing an All-inclusive Energy Policy

The current energy sector policy does not clearly define rural electrification policy vis-à-vis grid extension plans and off-grid programmes. To promote technology transfer of RE, it is imperative that policies should clearly define the role of RE off-grid systems and identify areas where implementation of off-grid RE projects would be the most economically viable option. A well-defined rural electricity policy, which recognizes off-grid RE systems, would enhance deployment, diffusion and commercialization of RE technologies in the rural and peri-urban areas.

Project sustainability would require re-definition of the country's energy policy. This would prevent the recurrence of the problem of installing RE projects in some communities, only for these communities to be immediately connected to the national grid, thus rendering the RE projects redundant.

Enhancing the Regulatory Framework

Regulatory frameworks and enabling environments are pre-requisites for private sector investment in RE. Regulatory frameworks refer to standards and regulations (i.e. appliance or building efficiency standards, feed-in tariffs, etc) that promote or require investments in clean energy technologies. An enabling environment refers to a set of policies that generally reduce investment risk and promote technology transfer (Staley et al. 2008). It was manifestly clear from the Accra workshop that increasing the scale and scope of RE utilization would require policy support in the form of conducive legal and regulatory frameworks.

Although a regulatory framework has been established in Ghana, the existing framework requires more support to make it 'RE friendly'. For instance, international support is required to develop a robust regulatory regime and legislation to catalyse private participation and public sector investment in RE. Inability to sustain previous RE projects, which were funded with international support, can partly be attributed to a lack of incentives which would have attracted the private sector to undertake RE projects. One way of surmounting this barrier is to create favourable policy, legal and regulatory environments to encourage participation of local entrepreneurs in RE activities.

Key Barriers	Type of Policy Action	Initia-tion	Implementation	Roll-out
1. Policy and Regulatory	1. Domestic		Development of all-inclusive policy framework for RE and EE.	
	2. Domestic and International		Enhanced regulatory and policy framework, such as development of Mandated Market Policies.	Enhanced regulatory framework
	3. Domestic and International		Development of technical standards	
2. Weak Domestic Capacity	1. International		Enhanced technical capacity. Development of critical mass of technical skills	Enhanced technical capacity
	2. International		Enhanced capacity for financing institutions in RE and EE lending.	
	3. International		Enhanced capacity for regulatory agencies and policy makers	
	4. International		Innovation centre and centre of excellence	
	5. Domestic and International		Stakeholder capacity enhancement through awareness creation.	
3. Financing	1. Domestic and International		Leveraging the domestic financial environment	
	2. International		Multilateral financial support	
	3. Domestic and International			Adoption of appropriate business model to ensure financial sustainability
	4. Domestic and International			Adoption of business model to ensure availability of EE technologies.

Table 5. Major barriers and options for overcoming

Developing Technical Standards

The efforts by the Energy Commission on standards and labelling for CFL, air conditioners and refrigerators are commendable because these have the potential to pull consumer demand towards utilization of more efficient appliances and lighting. To promote utilisation of such appliances would require the imposition of stringent requirements from the Energy Commission to stimulate more efficient behaviour, through energy performance standards for appliances and adopting energy building codes.

Despite the modest achievements by the Energy Commission, it is imperative that codes, standards and certification of EE equipment are implemented to reduce the high risks and negative perceptions associated with technology diffusion and commercialization in Ghana. This action can enhance the country's capacity to adopt new technologies and catalyse the scale, scope and speed of adopting EE technologies. In this regard, the Standards Board, in collaboration with the Energy Commission, can be supported with international financial support to establish test and certification facilities in various parts of the country to provide purchasers of EE equipment with performance assurance.

4.2 Weak Domestic Capacity

Technical Capacity Enhancement

The weak technical capacity of entrepreneurs in the installation and maintenance of RE technologies, especially for solar PV systems, has affected the country's *capacity to adopt* these technologies. It is therefore important that the technical capacity of local entrepreneurs is enhanced so that they can manage and generate the technological change required to enhance the country's absorption capacity of new RE technology.

The weak technical capacity of entrepreneurs in the installation and maintenance of RE and EE technologies has affected the country's *capacity to sustain such* projects. It is therefore important that the technical capacity of local entrepreneurs is enhanced to enable them to manage and generate technological change. The "centre of excellence" concept can be leveraged to offer special training programmes on proper installation and maintenance of RE and EE technologies, in order to enhance the country's absorption and adoption capacity for technology transfer.

It is also important that the domestic capacity is enhanced with international support for effective monitoring of RE and EE projects, including monitoring emission reductions. This is important since it would enable the country to be able to monitor energy savings and energy improvement due to enhanced DSM, and enable the country access to carbon financing.

Achieving technical sustainability during the *roll-out phase* requires that all completed projects are *technically sustained* and replicated in future. Technical sustainability can be achieved through hands-on learning, whereby local technicians and engineers learn from a foreign counterpart by participating in pilot projects. If this action is well-implemented, it would assist Ghana to achieve technological *'leapfrogging'*, so that the country can accelerate the development of its human and institutional capacities to handle future projects for technology replication.

Capacity Building for Financial Institutions

International financial support can be used to train staff in financial institutions in infrastructure project finance, project risk allocation, credit risk analysis, review of PPAs and undertaking cash flow analysis, using the appropriate technical and financial assumptions. Capacity building for financial institutions is required to support them in enhancing their understanding of the specific resources, technology and operational risks required for RE lending, and to support the design of appropriate loan procedures. In addition, local financing institutions need to be trained in RE and EE projects to build their confidence in RE lending so that such projects would, over a period of time, benefit from future long-term credit from the local financing institutions.

Enhanced Capacity for Policymakers and Regulatory Agencies

As part of creating an enabling environment, it is crucial to enhance the capacities of professional staff in the country's Ministry of Energy and the two regulatory agencies (i.e. Energy Commission and the Public Utilities Regulatory Commission), in both the regulation of off-grid RE systems and the development of a comprehensive rural electrification policy. Capacity building would be required to develop model Power Purchase Agreements (PPAs) for small RE technologies (less than 10 MW). This action will incentivise private developers to negotiate long-term PPAs with the power utility companies, at a tariff level which would make RE projects financially viable (World Bank 2006).

To assist in the development of Ghana's RE resources, international financial support for the Energy Commission is urgently needed to enable the commission to conduct comprehensive RE resource assessments of the country's viable RE projects and develop a database which would provide vital information to private developers.

Innovation Centre and Centre of Excellence

As the international community continues to explore innovative ways to accelerate the deployment and diffusion of low-carbon technologies in developing countries, the concept of low-carbon Energy Technology Innovation Centres has emerged. The establishment of a network of innovation centres in developing countries could accelerate the transition to low-carbon technology by overcoming financial barriers, while increasing access to electricity for the population. These centres can serve as regional technology hubs to stimulate capacity building, improve access to information and facilitate international cooperation for a group of countries (Staley et al. 2008). Such centres would therefore enhance information flows with international energy and climate agencies, such as the UNFCCC, while assisting in the development and strengthening of local enterprises. If well-implemented, the centre can be used to address other barriers, such as regulatory difficulties, limited access to capital, and unsuitability of technologies to domestic condition.

Stakeholders at the Accra workshop suggested a *two-tier approach,* which creates a local centre as the first tier and a regional centre as the second tier. It was also suggested that the local centre should be established at the University of Ghana, in Accra. *The local centre could serve as a "centre of excellence" or a stakeholder forum which would bring experts from academic, business, government and finance sectors to identify and address barriers, and discuss climate innovation and finance issues in a more focused manner.*

The innovation centre / centre of excellence concept received a big boost with the recent announcement by the Economic Community of West African States (ECOWAS), that a regional centre for renewable energy would be established in the sub-region[17], to enable the West African countries to complement the efforts of each other for sustainable energy supply. The West Africa sub-regional centre can *then network with other regional centres* so that both local and international barriers can be addressed simultaneously, to pave the way for effective technology transfer to West African countries.

If suitably-implemented, the network nature of the centres would ensure that lessons learned in one African country can be disseminated across the West African countries to accelerate the process of technology transfer. The regional dimension of the innovation centres would also catalyze *technology leapfrogging* in Ghana and other African countries, and ensure that successes and lessons learned in one country can be replicated in other countries over shorter time periods.

Promoting Stakeholder Awareness

One way to expand the utilization of RE and EE technologies is for the Energy Commission and Energy Foundation to increase potential consumer's awareness about costs, benefits and equipment performance, as well as to develop after-sales service opportunities available in Ghana. Information dissemination should also be extended to assist builders and architects to take account of RE and EE in their building designs by leveraging the innovation centre concept discussed above.

[17] The announcement was made by the Chairman of ECOWAS, Dr. Mohammed Ibn Chambas in Abuja, Nigeria, on June 22, 2009.

The Energy Foundation should intensify its educational programmes to be able to effectively communicate the savings potential of EE equipment, in order to catalyse public demand for energy efficient equipment for industries and buildings as well as for households. More promotional programmes on appliance labelling and consumer education to influence consumer behaviour would be useful. In addition, the Energy Commission should liaise with the Energy Foundation to ensure that market data for specific energy efficiency equipment, such as high efficiency motors and industrial equipment, are made easily accessible to stakeholders.

Ensuring sustainability of future projects requires effective domestic stakeholder involvement through awareness creation and effective information dissemination. If this is done, local communities, financing institution, cooperatives, local entrepreneurs, academics and business communities can become involved in RE and EE projects. It is imperative that a *demand-driven approach* is adopted, since it would be difficult for international support alone to provide the assistance required to overcome the barriers to enhance technology transfer to Ghana.

4.3 Financing

Leveraging the Domestic Financial Environment

Ghana possesses a well-developed financial sector comprising of *25 banks and 44 non-bank financial institutions*, located in the regional capital cities and large towns. In addition, there are about *130 rural and community banks (RCBs)*, which specialize in micro-credit evaluation, delivery and recovery. These rural community banks (RCBs) were established to expand savings mobilization, provide micro-finance and credit services in areas not served by the commercial and development banks (United Nations 2008). These banks can be encorporated to play a key role in RE diffusion in the rural areas.

Currently, the Ghanaian government provides almost 100% capital subsidy for grid- connected systems, while off-grid system receive no subsidy support. The situation is exacerbated by lack of credit access for the rural community banks to provide finance for the rural population to purchase solar home systems. Inability to scale-up the use of mini-grid systems can also be attributed to the absence of long-term credit facilities to project developers, which matches the long payback period of RE projects.

The existence of RCBs can be leveraged by the World Bank and other multilateral agencies to provide financial support to Micro, Small and Medium Enterprises (MSMEs). The support can be in the form of a World Bank Partial Credit Guarantee (PCG) and provision of a credit facility to the rural community and commercial banks, so that these banks would be willing to offer long-term credit to the MSMEs, interested in developing mini-grid RE projects. The World Bank Partial Credit Guarantee (PCG) can be used to protect private lenders against risks during a specific period of the financing term of debt for public investment (World Bank 2008a).

Multilateral Financial Support for Grid and Mini-grid Connected Systems

For large grid connected systems, international financial support is required to support private developers. One approach that can be used is the World Bank Partial Risk Guarantee (PRG) scheme to lower the perceived risk assumed by international lenders who are reluctant to support private sector initiatives in the RE sector in Ghana (World Bank 2006). The guarantee can cover areas such as policy, regulatory, political, currency convertibility and transferability. To ensure that the PRG can indeed facilitate the construction of large-scale grid connected systems, financial support can initially be designed for pilot projects comprising of small hydro systems, wind energy, and waste-to-energy plants. The selection of qualifying projects would then be based on a competitive bidding process, so that only developers who possess the experience to develop, construct and operate such systems at the least cost are selected for the financial support.

Ghana can also enhance the scale, scope and speed of using EE and grid-connected RE systems by taking advantage of the World Bank's Clean Technology Fund (CTF)[18]. The CTF was developed to increase investment in projects and programmes that contribute to the *demonstration, deployment and transfer* of RE technologies and other low-carbon technologies in developing countries (World Bank 2008a). The advantage of the CTF is that it can be used to provide grants and concessionary financing and/or risk mitigation instruments to developing countries. The fund can use a blend of public and private resources to scale up deployment of RE technologies.

It emerged from the Accra workshop that, so far, the country has not been able to take advantage of the Clean Development Mechanism (CDM), even though several opportunities exist in the energy sector, particularly the electricity sub-sector. 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 RE technologies to qualify as CDM projects. In 2002, after realizing the benefit of mini-grid systems for reducing the GHG emissions, the Word Bank 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 they can be developed as one larger CDM project[19].

Ghana can also build its capacity to take advantage of the Carbon Partnership Facility (CPF) which has been introduced by the World Bank to scale up investment in longer-term low carbon investment in developing countries. The CPF can be used in areas such as power sector development, energy efficiency, gas flaring, integrated waste management system and urban development (World Bank 2009).

Multilateral Support for Stand-alone Systems

According to a World Bank (2008b) study on Ghana, most rural consumers cannot purchase *low-cost small-scale solar PV systems on a cash basis, unless some form of credit financing is introduced.* Under the rural bank micro-financing scheme, most of the micro-financing institutions are unable to offer loans with a repayment period exceeding 20 months. The short repayment period is clearly unsuitable for rural consumers because it does not match the rural consumers' ability to pay.

One approach which can be adopted to increase consumer affordability is provision of international financial support to the rural banks and other micro-financing institutions to co-finance credit for stand-alone systems. The financial support will also seek to enhance consumer ability to repay the loan by extending the *15 to 20 months loan repayment period.* This action is expected to increase the scale of deployment and diffusion of stand-alone systems to rural consumers, and make a significant contribution towards accelerating the attainment of the *10% target* of RE in the country's energy mix by 2020.

Adopting the Appropriate Business Model for Financial Sustainability

To overcome the problem of low tariffs associated with the RE projects, which affect their financial sustainability, it is imperative that an *appropriate business model* is adopted in future projects. The fee-for-service model that was adopted in the previous RE projects was inappropriately implemented, hence the failure of such projects. The fee-for-service model was successful in China, and the Dominican Republic (World Bank 2008b) because the tariffs were set at the right level (i.e. at consumer's willingness-to-pay level). This model may therefore be a

[18] The CTF was created under the Carbon Investment Fund (CIF), which is designed to provide scale-up of funding support to developing countries, to enable them mitigate the impact of GHGs and adapt to climate change. On September 26th 2008 the world's leading industrialized nations pledged more than US$ 6.1 billion to the CIF (http//www.worldbank.org/WBSITE/EXTERNAL/TOPICS).

[19] The main difference between CDCF and other World Bank funds is the generation of community benefits by the project it finances. In addition, the projects should have clear non-carbon benefits.

very useful one for technology adoption in Ghana, as this enables intensification of the use of stand-alone and other off-grid systems in the rural communities.

A variation of the fee-for-service model, which may be adopted, is where an ESCO sells the energy service from the stand-alone system by making bulk purchase of the solar home systems and installing them on consumer sites, while retaining ownership. The ESCO then collects monthly payments from beneficiaries, while providing maintenance services. This model can be used to enhance the scale of adoption of stand-alone systems, if public, government or multilateral agencies can collectively provide the finance required to the ESCOs at a concessionary rate, for bulk purchase of the systems. This is very important since local financing institutions are not willing to provide financing with a pay-back period exceeding 5 years to the ESCOs because of weak balance sheets that have affected their credit status.

Another business option that may be utilized to ensure financial sustainability of off-grid systems is the *dealer-sales model.* With this model, the dealer purchases components from manufactures and sells them directly to households and other industrial customers. The customers own the system but are responsible for maintenance after the expiration of the dealer warranty period. To ensure financial sustainability, the RE technology is made affordable to rural households by offering the systems on affordable cash sale basis to the low-income rural population, or providing the households with consumer credit.

According to the World Bank (2008b), with international financial support from the GEF, this model has proved to be very successful in China, Kenya and Uganda. There is no doubt that with international financial support, the *dealer-sales model* can be a good business model that can be adapted and replicated in Ghana, to enhance the utilisation of off-grid systems in poor and rural households and to deepen RE market penetration.

Overcoming Financial Barriers and Ensuring Availability of Technologies

To ensure project sustainability, it is important that programmes are designed to make EE appliances available on local markets accessible across the country. In this regard, a dealer incentive programme can be created with international support to reduce the initial cost of establishing distribution outlets and encourage private entrepreneurs to establish a distribution network of outlets throughout the country. The regional distribution outlets would be responsible for the sale of EE equipment as well as providing after sales maintenance to end-users.

5. Suitable Performance Indicators

The significance of performance monitoring for measuring a project's progress towards achieving short and long-term objectives, compelled the COP[20], to request the Expert Group on Technology Transfer (EGTT) of the UNFCCC, to develop a set of *performance indicators* that could be used by the Subsidiary Body for Implementation (SBI), to regularly monitor and evaluate the effectiveness of the implementation of the technology transfer framework (UNFCCC 2008b). The scope of work includes development of a set of performance indicators which would measure the intended change defined by the technology transfer framework. In developing indicators one is faced with unavoidable trade-offs which may affect the indicators' ability to achieve the intended objectives. The main dimensions and tradeoffs that informed the selection of indicators for this study are discussed below.

5.1 Qualitative versus Quantitative

According to the UNFCCC (2008b), the final set of indicators could be *qualitative or quantitative,* but they should be objectively verifiable. Based on the barriers identified in the study, both qualitative and quantitative indicators that are objectively verifiable have been

[20] by its decision 3/CP.13

used since the indicators may be expressed as numeric values, percentages, scores and indices.

5.2 Collection Cost versus Usefulness

Developing and implementing indicators involves data collection and verification costs, which must be assessed against the marginal benefit of new information (Neuhoff et al. 2009). In selecting suitable indicators, this paper acknowledges the trade-off between data collection cost and indicator usefulness by posing the following questions: who is responsible for the *data collection, analysis, processing, reporting and verification*? Is the data *available in the appropriate format* when needed? What is the *cost of collecting, measuring, reporting and verification?* To minimise cost, the indicators have been carefully selected to elicit as much information as possible at the least cost, while ensuring coordination between policymakers and regulatory agencies such as the Energy Commission, the Public Utilities Regulatory Commission, the Energy Foundation, the Environmental Protection Agency and the Ministry of Energy.

This paper also considers whether the final set of indicators is *easy to interpret,* and whether they assist in *tracking and managing* change over time. The number of indicators was carefully chosen to make it possible for policy makers to understand the measures and be able take the necessary actions for implementation. The extent to which indicators are *useful, applicable and relevant* to the technology transfer framework is also considered.

5.3 Input versus Outcome Indicators

Neuhoff et al. (2009) classify indicators as *Input, Process, Output and Outcome*[21]. For this study, the author has used *output indicators* because they can be used to monitor *intermediate outcomes,* manage change over time and are therefore likely to facilitate learning from input to final project outcome. In addition, *output indicators* can be used to measure *intermediate outcomes and immediate results of input activities,* and can therefore be used to monitor immediate results of a programme. Even though they may not provide the relevant feedback for policy learning, they have an additional advantage of being easily quantified, since they are usually measured for short periods between 3-5 years.

Although *process indicators are also similar in certain respects to outcome indicators* by their ability to assess the ‘middle’ of a programme, and monitor specific activities and processes required by *inputs* to be *converted into outcomes,* they have not been used in many sectors because of the difficulties associated with assessing the exact activities, processes or the barriers required to achieve the project or programme outcomes. Outcome indicators have also not been used in the study because they measure long-time scales and therefore monitor the longer-term results of a project. As outcome indicators are future oriented, they involve extensive data collection, which is costly to obtain for analysis. This has compelled most project or programme managers to rely on tracking *immediate results using output indicators* (NAPA 2008).

5.4 Domestic and International Harmonised Reporting

In selecting the final set of indicators in tables 6 and 7 below, the author has determined whether the set of indicators are *relevant at the national level*, and/or whether they are *useful for the UNFCCC or international framework on technology transfer* and therefore based on *international guidelines*. The final set of indicators has been carefully selected to reflect both *domestic and international reporting*. For instance the indicators on access to energy services, finance, and climate mitigation are internationally reported by most countries, and would therefore have the advantage of enhancing international comparison across countries while ensuring cost minimisation. The indicators on private sector participation and building domestic

[21] See details in Neuhoff et al. (2009) “Indicator Choices and Tradeoffs: Facilitating the Success of International Climate Policies and Projects”. Climate Strategies and Energy Policy Research Group (University of Cambridge), UK.

capacity were selected based on the barriers identified in the country case study, and are therefore relevant for both *domestic and international reporting*. Issues on private investment and domestic capacity building have been raised by many international agencies including the UNFCCC. These indicators would therefore be useful for programme management and accountability.

Policy Objective	**Intermediate Indicator**
1. Access to energy service	• Installed capacity (MW) of small hydro systems, PV, wind and biomass • Annual production (GWh) • Share of RE in total electricity generation mix
2. Access to financing	• Amount of commercial financing (US$) • Amount of bilateral or multilateral financing (US$)
3. Technical Capacity Building	• Number of technical training programmes for technicians and engineers
4. Private Sector Participation	• Number of private entrepreneurs in the RE and EE sectors. • Number of distribution outlets country-wide.
5. Climate mitigation objective	• Amount of CO_2 reduction (tonnes)

Table 6. Indicators for grid-connected RE and EE systems

Policy Objective	**Intermediate Indicator**
1. Access to energy service	• Installed capacity (MW) of off-grid systems (example mini and pico-hydros, solar PV, biomass and wind) • Amount of annual energy production (MWh)
2. Access to financing	• Availability of suitable consumer credit systems • Amount of credit for off-grid systems (US$)
3. Role of ESCOs	• Number of ESCOs which assemble, install and service off-grid systems
4. Capacity Building	• Number of bank staff trained in solar and other off-grid business • Number of technicians and engineers trained in installation and maintenance of solar and other off- grid RE systems
5. Private Sector Participation	• Number of private developers in off-grid systems
6. Climate mitigation objective	• Amount of CO_2 reduction (tonnes)

Table 7: Indicators for Renewable Energy, off-grid systems

5.5 Data Management

One of the main motivations for using intermediate indicators is to be able to monitor a project or policy impact during implementation. Development of robust indicators is however dependent on data collection and management, which are critical for quality assurance. It is important that as part of the data management process, mechanisms are devised to ensure that the collection methodology and other protocols yield quality data. Effective *data management* should be put in place to ensure that the management system would produce the required information that would allow for *documentation, verification and evaluation* for both national and international reporting.

6. Conclusion

The study has identified barriers and explored options to promote technology transfer and deployment for RE and EE activities in Ghana. It emerged from the study that in Ghana many barriers relate to the *implementation* and the *roll-out* stages. Implementation phase barriers in RE and EE sectors were identified inter alia, as lack of clear policy, capacity to innovate, regulate, adapt and adopt. The other barriers relate to lack of finance, inability to operate and maintain RE and EE equipment after installation, as well as weak capacity of the ESCOs to undertake EE projects.

Lack of appropriate technical standards and stakeholders awareness, and absence of information were also identified as some of the barriers that have affected the scale of utilization of RE and EE technologies in Ghana. The inability to train a critical mass of skilled technicians and engineers to operate and maintain previously installed stand-alone RE systems was also identified as a barrier which needs to be addressed. Human capacity building for government agencies and other stakeholders has therefore been identified as key to 'unlocking' the domestic environment. Previously donor-funded off-grid projects, such as in the Northern Region of Ghana, were not financially sustainable because the tariffs paid by beneficiaries could not even recover the operation and maintenance expenses and had to be abandoned.

To ensure that Ghana can make a significant contribution towards mitigating global climate change, the study has proposed various options which, if suitably implemented, can assist the country in overcoming barriers. The study also brought to the fore the use of international support to leverage domestic policy, develop a more robust and RE and EE regulatory regime and build domestic technical capacity to enhance technology adoption. It emerged from the study that other supporting policy measures include the development of appropriately mandated market policies and public benefit funds, as well as reformulating the energy policy to take into account off-grid RE systems.

The study has suggested that *international support* can be used to establish a regional innovation centre. This would involve the establishment of a centre in one of the West African countries, with a local centre located in Ghana and each West African country. The Accra workshop identified the University of Ghana, as a suitable location for the local centre. The local centre can link-up with the regional centre, with the latter serving as a regional technology hub to stimulate capacity building, improve access to information and facilitate international cooperation. The study also revealed that the country's well-developed financial sector can be leveraged to provide support to the RE and EE sectors to establish distribution outlets, as well as for test and certification centres country-wide. IDA Partial Risk and Credit Guarantees have been identified as options that could be used to reduce the perceived risk assumed by lenders, who are reluctant to commit money into the RE sector in Ghana.

Despite the modest achievements of the Energy Foundation in energy conservation activities, it emerged from the study that the scope of its operations has been limited to Accra and other regional capitals due to a lack of finance to carry out its operations country-wide. The Energy Foundation would require international support to build its internal capacity to ensure that activities cover the entire country, and not be limited to Accra and a few of the regional capital cities.

Carbon financing through the CDM and financial support from the power utility companies, are options which can also be used to support the activities of EE. Support from the power companies would depend, however, on the type of tariff regulation adopted by the country's regulatory body. Other international financing mechanisms, which can be utilized for both the RE and EE sectors, include the World Bank's Clean Technology Fund (CTF) and the Community Development Carbon Fund (CDCF). The study has also recommended that Ghana prepares to take advantage of the Carbon Partnership Facility (CPF) which has been introduced by the World Bank to scale up investment in low carbon investment, in programmatic and sectoral initiatives.

The study concludes that the potential for overall climate benefit potential is a total at least *14 million tonnes of* CO_2 *emissions* that can be avoided over the lifetime of the RE projects[22]. While over *70,000 tonnes of* CO_2 *emissions* can be avoided from EE and energy conservation activities.

[22] based on the extrapolation of World Bank (2006) estimates.

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