Implementation of Renewable Energy Technologies – Opportunities and Barriers

Ghana Country Study

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Ghana Country Study.
Published by: UNEP Collaborating Centre on Energy and Environment,
Risø National Laboratory, Denmark, 2001.

ISBN: 87-550-3010-6

Available on request from:

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Cover photo: courtesy Wisdom Ahiataku Togobo, Ministry of Energy, Ghana

Print: Pitney Bowes Management Services Denmark A/S, 2002

Acknowledgements

The authors would like to thank Prof. Fred Akuffo, Mr. Ben Hagan, Dr. Rudith King and Dr. Jyoti Painuly for their critical but helpful comments and suggestions in the preparation of this report.

To all personnel of the Ministry of Mines and Energy and the Energy Commission who provided useful information and participated in the workshops we express our profound gratitude. Various contributions from many other stakeholders are gratefully acknowledged.

Thanks are also due to Ms. Kylee Roberts, a CIDA-funded intern from Policy Research International, Ottawa, Canada who edited the report.

Finally our special gratitude goes to the UNEP Collaborating Centre on Energy and Environment (UCCEE) at Riso National Laboratory in Denmark, who provided institutional leadership for this project, and to DANIDA for funding the project.

DEDICATION

This report is dedicated to the late Dr. John Kofi Turkson (1954 – 2000) who until his untimely death was the project co-ordinator. May his soul rest in perfect peace.

CONTENTS

List Acronyms and Abbreviations

AESC	Architectural Engineering Services Corporation
AESL	Architectural Engineering Services Limited
AREED	African Rural Energy Enterprise Development
AWEA	American Wind Energy Association
BOHS	Battery Operated Home System
BRRI	Building and Road Research Institute
BWEA	British Wind Energy Association
CBA	Cost Benefit Analysis
CDM	Clean Development Mechanism
CEPS	Customs, Excise and Preventive Services
CIDA	Canadian International Development Agency
DBEDT	Department of Business, Economic Development and Tourism
DCEP	District Capital Electrification Programme
DENG	Danafco Engineering
DNC	Declared Net Capacity
EC	Energy Commission
ECG	Electricity Corporation of Ghana
ECOWAS	Economic Community of West African States
EFL	Electricity Feed Law
EPA	Environmental Protection Agency
ERG	Energy Research Group
ERP	Economic Recovery Programme
ESDP	Energy Sector development Programme
ESMAP	Energy Sector Management Assistance Programme
FFL	Fossil Fuel levy
FPIB	Forest Product Inspection Bureau
GEF	Global Environment Facility
GHASES	Ghana Solar Energy Association
GHG	Green House Gas
GIS	Ghana Institution of Surveyors
GTZ	*Gesellschaft fur Technische Zusammenarbeit*
GWC	Ghana Water Company
GWSC	Ghana Water and Sewerage Corporation
IIR	Institute of Industrial Research
IPP	Independent Power Producer
KNUST	Kwame Nkrumah University of Science and Technology
LPG	Liquefied Petroleum Gas
LRMC	Long-Run Marginal Cost
MEST	Ministry of Environment, Science and Technology
MFP	Ministry of Fuel and Power
MME	Ministry of Mines and Energy
MOFA	Ministry of Food and Agriculture
MOH	Ministry of Health
MORE	Modern Renewable Energy
MSHG	Multi-Stakeholder Small Hydro Group

NASEP	National Solar Energy Programme
NEB	National Energy Board
NEF	National Electrification Fund
NEFB	National Electrification Fund Board
NEP	National Electrification Project
NEPS	National Electrification Planning Study
NES	National Electrification Scheme
NFFO	Non-Fossil Fuel Obligation
NFPA	Non-Fossil Purchasing Agency
NGO	Non-Governmental Organisation
NRES	National Renewable Energy Strategy
PNDC	Provisional National Defence Council
PPA	Power Purchase Agreement
PSDP	Power Sector Development Programme
PURC	Public Utilities Regulatory Commission
PV	Photovoltaic
R&D	Research and Development
RECs	Regional Electricity Companies
REDP	Renewable Energy Development Programme
RESA	Renewable Energy Sources Act
RETs	Renewable Energy Technologies
RPS	Renewable Portfolio Standard
SCD	Solar Crop Dryer
SHEP	Self-Help Electrification Programme
SHP	Small Hydro Power
SOHLS	Solar Home Lighting System
SRMC	Short-Run Marginal Cost
SSC	Solar Service Centres
SWH	Solar Water Heater
SWP	Solar Water Pump
TSWH	Thermiosiphon Solar Water Heater
UNDP	United Nations Development Programme
UNEP	United Nations Environment programme
UNICEF	United Nations Children Fund
USAID	United States Agency for International Development
VRA	Volta River Authority
WHO	World Health Organisation

Executive Summary

This report presents the experience of Ghana in the development, utilisation and promotion of Renewable Energy Technologies (RETs). The report gives a general overview of the state of RETs, describes past/existing institutional, regulatory and policy framework, identifies key barriers to and opportunities for RETs, and recommends directional changes needed to remove barriers and promote wide-scale adoption of RETs in Ghana. A total of eight RETs – biomass-fired dryers, sawdust stoves, sawdust briquette, biogas, solar crop dryer, solar water heater, solar water pump and small hydro power – are covered in the report. Analyses of barriers to the eight RETs are carried out using a framework approach that categorises barriers into socio-technical, economic and crosscutting barriers. Financial analyses, as opposed to economic analyses, have been carried out for all the selected RETs. The report also incorporates stakeholders' perspectives and views on barriers and how they can be removed.

To put the barrier analyses and policy recommendations in perspective, Chapter two of the report is devoted to conceptual issues in energy policy. The chapter describes the main instruments and measures at the disposal of energy policy makers the world over and examines how they could be used to promote the development and deployment of RETs. Specific measures and instruments used both in developed and developing countries to promote RETs are also captured in this Chapter, the rationale being that Ghana can draw on these experiences in promoting RETs.

Key Findings and Recommendations

- Ghana is endowed with several renewable energy resources like solar radiation, small hydro, biomass, and wind. Most of these resources (save small hydro and wind) have been harnessed through various renewable energy technologies (RETs). Technologies used to harness the solar energy resources include solar water heaters (SWH), solar crop dryers (SCD), solar water pumps (SWP), solar refrigeration and solar lighting while pyrolysis, improved cookstoves, biomass fired dryers, sawdust briquette, improved charcoal production, biogas and cogeneration are the biomass technologies that have been experimented with, demonstrated and disseminated to date. Most of the technologies are proven ones.

- Exploitation of Ghana's renewable energy resources has been carried out under two main policy regimes – PNDC Law 62 (1983) and the Energy Sector Development Programme (ESDP). The former established the National Energy Board (NEB) and amongst other things mandated the NEB to direct the development and demonstration of renewable energy projects throughout Ghana while the latter is the policy framework that has been guiding the development of RETs since 1996 till the present.

- Several measures and instruments have been employed in the implementation of renewable energy policies. The main measures used are research and development, information and education, and some normative measures (like the passing of PNDC Law 62 and the Energy Commission Law). Some economic instruments, such as subsidies, taxes, pricing, financing and duty waiver/reduction, have been used as well but only to a limited extent.

- The effective development, implementation and dissemination of all the RETs studied are hampered by several barriers, which can be grouped into three main categories – socio-technical barriers, economic barriers and crosscutting barriers. Socio-technical barriers refer to resource-based, technological, environmental, and social barriers. Economics barriers constitute those related to the market, costs and benefits, and finance. Under crosscutting barriers, informational, institutional and policy barriers are considered.

- For the three solar energy technologies considered in this study – SWP, SCD and SWH – SWP came out as having the least number of barriers. The most important barrier identified for SWP is high initial cost with often-unquantified long-term benefits and a general lack of information.

- For the biomass technologies, biogas was studied in more detail because of the huge environmental/sanitation and agricultural benefits associated with the technology. The most important barrier to biogas in Ghana is resource availability. "Best practice" suggests that biogas should be packaged more as sanitation or agricultural project with energy as spin-off.

- For small hydropower (SHP), even though over seventy (70) sites have been identified, none has been developed so far; the only pilot project commenced was never completed and has since 1983 been abandoned. Absence of a policy framework for the development of SHP has been found to be the most important barrier to harnessing the SHP resources. Other important barriers identified are lack of information, low resource level and lack of financing.

- A general lack of information on the potential benefits of RETs was found to be a major barrier with regard to the government and end-users alike. Energy policy analysts in Ghana will therefore need to remove these barriers by generating the necessary information and disseminating it as widely as possible using various techniques ranging from lobbying parliamentarians to advertising in the mass media.

- Notwithstanding the barriers identified, there are some opportunities for the dissemination and widescale adoption of RETs in Ghana. These are the government's rural electrification programme, ongoing power sector reform programme, and the establishment of the Energy and National Electrification Funds. It is expected that if these opportunities are capitalised on, the "frontier" of RETs will be pushed forward.

- Existing renewable energy policy framework is not potent enough to ensure commercialisation and widespread utilisation of the RETs they seek to promote. This is because the framework has no targets, investment plan or financing mechanisms and in most cases relies heavily on government budgetary allocation and donor funding which are inadequate and unsustainable. The policy framework can also be faulted on the grounds that it "discriminates" against some RETs (notably small hydropower) by making no provision for their development.

- There is therefore the need for government to set targets for the renewable (20% recommended) and design ways of achieving these targets. In addition the government must assign a specific role to renewable in the National Electrification Scheme (NES), especially with respect to rural areas where about two-thirds of Ghana's population live with limited or no access to electricity. Consequently, the government's Rural Electrification Programme (REP) and Self-Help Electrification Programme (SHEP) must shift focus from grid-extension to renewable, which in many cases constitute a cheaper option.

- In general low electricity tariffs have made renewable expensive and also served as a deterrent to private investors. The Public Utilities Regulatory Commission (PURC) should therefore institute an upward review of tariffs or a premium price for renewably generated electricity.

- In view of the fact that RETs are expensive but clean technologies compared with conventional energy, donor support will be crucial for widespread utilisation of renewable in the rural areas where ability to pay is low.

1 Introduction

Renewable energy is an energy source that replaces itself within a human lifetime. It is therefore inexhaustible. Some renewable energy sources include solar, biomass, hydro and wind. Several technologies have been developed to harness energy from renewable sources and these are collectively referred to as Renewable Energy Technologies (RETs[1]). Some notable examples of RETs are hydropower (large and small), solar photovoltaic, windmills, cogeneration, geothermal, etc.

In principle RETs can contribute broadly to energy service needs such as electricity, fuels for transport, heat and light for buildings, power and process heat for industry. With proper management the impact of RETs on the environment is minimal (and in some cases nil), with little or no emissions of GHG or air pollutants, water contaminants, or solid waste. Thus RETs can, to a large extent, help combat the threat of global warming. More importantly, RETs can reduce imports of foreign oil.

However, in the developed world, conventional energy sources continue to dominate, with renewable energy remaining on the margins. This does not do justice to the numerous advantages of renewable energy sources. Use of RETs is on an even lower scale in developing countries, which is ironic since they possess most of the world's renewable energy resources.

It is against this background that this project, "Implementation of Renewable Energy Technologies (RETs) – Opportunities & Barriers", was jointly initiated by UNEP, UNDP, and Riso National Laboratory in three countries, Egypt, Ghana and Zimbabwe. According to the Terms of Reference, the project will use case studies of renewable energy implementation projects in the three countries to identify the reasons for success or failure of specific projects and/or technologies. In particular the study will seek to identify the main barriers to increased utilisation of RETs and accordingly the means to dismantle them.

1.1 Objectives

The general objectives of the project are:

- to improve knowledge, skills, and confidence of project partners so that they can identify situations in which renewable energy technologies can contribute to national energy needs;
- to strengthen institutional capacity for analysis and implementation of RET projects in the participating countries;
- to generalise the experiences from the three participating countries and disseminate the findings internationally, so that other groups can benefit from the knowledge gained.

[1] According to Goldemberg (1998), RETs is an acronym for solar energies.

The specific objectives of the sub-project in Ghana are:

- to determine the merits of selected policy instruments (subsidies, tax concessions, duty drawbacks, etc) in enhancing, or possibly inhibiting, the dissemination of RETs;
- to develop a framework approach for analysing barriers to the wider diffusion of RETs; and
- to identify and document the factors that have led to successful diffusion of RETs in Ghana and to apply these factors to selected number of potential RETs with a view of ensuring their successful implementation.

1.2 Methodology

Initially desktop research was conducted. All existing national energy policies were reviewed and any shortcomings identified. National studies and reports on RETs projects in Ghana were also reviewed in order to identify the reasons for their success or failure. Based on this review, a number of RETs were selected under biomass, solar and small hydro for more detailed analysis. The purpose of this preliminary selection was to focus the information collection and workshop discussion on a limited number of relevant RETs. After the preliminary selection of RETs, an Advisory Committee was formed and interviews (no questionnaires were administered at this stage) conducted with relevant stakeholders. This was conducted in order to obtain specific information on the current status of the selected RETs, adequacy of RET policies and plans, institutional, financial and legal mechanisms, and barriers to RETs. The responses received through the interviews were analysed and the findings presented to the Advisory Committee.

After this a national stakeholders' workshop was organised. This workshop had three aims: first, to introduce the project to relevant stakeholders; second, to elicit information on experience and views on past RET projects; and third, to obtain feedback on the findings from interviews. About forty stakeholders – drawn from government institutions, experts, NGOs, consumers, RETs installers/service firms, financial institutions and other stakeholders including the media – were invited to attend the workshop. Following feedback received from stakeholders at the First National Stakeholders' Workshop, a final selection of RETs was made for detailed analysis. A total of eight RETs were chosen for detailed analysis: four under the category of biomass, three under solar and also small hydropower.

Additional information was gathered on the eight selected RETs by conducting further interviews and administering structured questionnaires. At this stage it was necessary to visit some of the specific project sites to discuss various issues with the project operators and owners. Most of the information on barriers and options for their removal were collected through these interviews. Some questionnaires (mainly on biomass and solar technologies) were also administered.

The barriers identified for each of the technologies were then analysed in detail using a framework. This framework categorises barriers into three main groups – Socio-technical barriers; Economic Barriers; and Cross-Cutting Barriers. Socio-technical barriers refer to resource-based, technological, environmental, and social barriers. Economics barriers constitute those related to the market, costs and benefits, and finance. Under crosscutting barriers, informational, institutional and policy barriers are considered. See Appendix 1 for the framework.

After this detailed analysis of barriers, three RETs came out to be significantly promising by virtue of having few barriers to their implementation. A workshop was then organised to present the findings of the project to stakeholders, but also to get a stakeholders' perspectives on the barriers. The stakeholders were required first to identify the key barriers to the three RETs, second to do a ranking of the barriers according to the extent to which they each inhibit the implementation of the selected RETs, and third to recommend how best each of the barriers identified could be removed. Based on the stakeholders' perspectives, in particular on ways to remove barriers, three projects are proposed as follow-up projects.

1.3 Structure and Scope of the Report

The report is divided into nine chapters and presents the findings of the various activities carried out in the project. Chapter One is this introductory chapter.

Chapter Two surveys the policy instruments available to energy sector policy makers the world over, policy instruments applicable to RETs and gives examples of specific policy instruments being used in other countries to promote RETs.

Chapter Three contains an overview of energy sector policies in Ghana, with particular attention given to those policies having a direct impact on RETs.

Chapter Four deals with Biomass, Solar and Small Hydropower respectively under different sub-sections. The sub-sections on biomass and solar contain a technology-by-technology, as well as project-by-project review. At the end of the sections, a few technologies are selected for further study.

Chapters Five, Six and Seven contain detailed analysis of the selected RETs. These chapters analyse barriers to the development and implementation of these RETs and advances strategies to overcome them.

Chapter Eight discusses the opportunities for development and utilisation of RETs while Chapter Nine presents a summary of the key findings and distils the policy implications flowing from the findings.

2 CONCEPTUAL ISSUES IN ENERGY POLICY

2.1 Concepts

A **policy** may generally be defined as 'a set of ideas or a plan of what to do in particular situations that has been agreed officially by a group of people, a business organisation, a government or a political party.'[Cambridge International Dictionary of English, 1996] Simply put, a policy is a statement of intent, which can be expressed in various ways. Policies are sometimes expressed as visions; as goals and objectives; as organisational strategies; as programme strategies; as targets; as implementation plan; as a minuted decision; as a regulation or guidelines; or as a directive [Asamoah-Baah, 1998]. A policy can be formal or informal. Formal policies are usually recorded in written documents while informal policies are seldom recorded, remaining as a common understanding between parties about what should be done.

A policy should specify relevant **policy instruments** or **measures,** which will be used for implementation. A policy should also specify the appropriate time frame within which the policy objectives must be achieved, and for which the instruments are relevant. Policies are normally formulated for specific sectors, sources or areas of activity. Thus policies may be prescribed for example, for the energy, environment or health sectors.

2.2 Some Definitions

Many of the concepts we will be using in this conceptual framework have been variously defined. For the purpose of this report however, we define the concepts as follows:

- **Energy Policy** means government plans, programmes, and initiatives in the energy sector.
- A **Plan** means a set of decisions by a government or a public institution about how to do something in the future.
- A **Programme** means an ordered list of events or procedures to be followed or a schedule.
- Policy **instruments** and/or **measures**. Defining these two concepts is a bit tricky since there does not seem to be any clear distinction between them. In principle, both **measures** and **instruments** are ways or means by which policy objectives are achieved. Consequently the terms have in most cases been used interchangeably in the literature. In this report however we have used **instruments** to refer to only market-based or economic mechanisms used to achieve energy policy goals or objectives. All other mechanisms or approaches are referred to as **measures**.
- A Policy **strategy** is another term, which has been used to mean different things. While in certain cases it is used to mean a plan, which outlines the direction to be followed by a government or a group over a relatively long period of time, it is on other occasions used to refer to a means (as in the case of measures and instruments) of implementing plans and programmes. In this report, strategy is use in the context of the latter.

2.3 Measures and Instruments of Energy Policy

2.3.1 Introduction

The purpose of this section is to conduct an overview of policy instruments and measures available to policy makers in the energy sector, with emphasis on those options applicable to renewable energy. The most important measures and instruments are economic instruments, information and education, normative measures, research and development (R&D) and more recently, sectoral reforms [DANIDA, 1990]. These measures however are not mutually exclusive and are accordingly often introduced simultaneously. For example, the effectiveness of new tariffs or taxes (economic) in limiting energy consumption could be increased by simultaneously offering the consumers detailed information (information and education) on how they can save energy.

The following is a discussion of various measures and instruments available to the energy sector policy maker.

2.3.2 Economic or Incentive-based Instruments

An "economic incentive" is something that encourages people through economic means to direct their production and consumption efforts in certain directions. Thus economic or incentive based instruments are those instruments which when introduced by the energy policy maker offer producers and consumers of energy services incentives to alter their production and consumption decisions. Specific examples of economic instruments include taxes, subsidies, tariffs and favourable financing schemes.

2.3.2.1 Taxes

An energy tax is simply a compulsory levy imposed by a government or a public agency on an energy source. A typical example is taxes on petroleum products. Energy taxes provide incentives for energy saving and fuel-switching; different levels of tax on different fuels and sources of energy will have a significant effect on energy supply and demand patterns. In an ideal world situation, a tax on an energy resource or form will tend to increase the price and cause the demand of the particular energy resource to either decrease or remain the same as consumers, who are assumed rational, react to the price increase brought about by the tax. Demand for alternative energy sources, is ceteris parabus, likely to increase as consumers substitute away from the taxed energy source. This increase demand for alternative energy sources is likely to induce an increase in their supply. Thus taxes can be used to harness market forces to produced desired policy outcomes.

Taxes can be formulated as volume taxes (as in case of Denmark) where rates of taxation are per unit of volume of the different fossil fuels. Alternatively, the tax can be imposed as a value tax – this sets the tax as a percentage of the value of the different fuels. Energy taxes can also be constructed as 'environmental taxes' where fuels are taxed according to the degree of pollution they cause.

2.3.2.2 Subsidies

A subsidy can be direct or indirect. Indirect subsidies come in the form of tax deductions and exemptions. Subsidies open up the possibility of granting selective support for certain objectives such as developing new energy technologies or providing energy to the urban or rural poor. Subsidies can be used to encourage private investment. The private sector is often unwilling to invest in new technologies due to a perception of high risk; that is, the technologies are new and unproven, and there is likely to be high development costs. Even once the technologies have been developed the price may remain too high for the poor, in which case subsidies can be introduced to make the technologies affordable to them poor.

The use of subsidies as a tool for energy policy however, has recently come under harsh criticism.[2] . Some have argued that subsidies stultify innovation, distort markets and support the already rich rather than the poor [Barnet and Khennas, 2000]. However because subsidies are in certain cases essential and do have some benefits, a new tool – the smart subsidy – has been coined to put some distance between the current forms of subsidies and the earlier forms. The smart subsidy focuses on technologies that have a high potential of becoming commercially viable. Closely related to the smart subsidy is the concept of a "declining subsidy" or "subsidy with a sunset clause"[3]. A declining subsidy is whereby the subsidy is gradually lowered commensurate with the technology's development.

Subsidies are normally administratively demanding, as there most often will be conditions attached to granting them. In addition, subsidies make demand on public finances as opposed to taxes, which by contrast generate funds.

2.3.2.3 Tariffs

The price of any commodity is a function of demand for that commodity. Pricing policy can therefore influence demand for that commodity. When an increase in the price of a commodity is forecasted or announced, people normally take steps to reduce their consumption of that commodity. All things being equal, high tariffs imposed on one energy source will result in a decrease in the demand for that particular energy source. Thus pricing is an important tool in formulating energy policies.

In an ideal market scenario, the price of a commodity should be at least equal to cost of producing and delivering the product before the market will supply the commodity in question. This is not the case with the energy sector as it is viewed by government the world over as a strategic sector crucial to international competitiveness, economic and social development, and national security. Consequently government has taken major decisions in the sector with state utilities for electricity, gas, and sometimes coal and oil, being used as instruments for implementing energy policies in many countries [EC/UNDP, 1999]. Many governments have subsidised electricity and petroleum products so that their price to all or some of the final consumers is lower than the real cost of production and delivery. Thus conventional electricity and fuels are almost universally priced below their marginal cost. This approach however encourages energy wastage as interventions to increase say energy

[2] Subsidies in general have come under harsh criticism as well.
[3] A subsidy with sunset clause means that it is temporary.

efficiency are more expensive (financially) than the energy that is saved. Furthermore, the approach creates a barrier to the introduction of new forms of energy, in particular renewable, which are not subject to the same large volumes of subsidisation. [EC/UNDP, 1999].

Presently however, world-wide movement towards increased reliance on market mechanisms has led to major reforms in the energy sector. A key component of the reform process is the upward-review of tariffs following the withdrawal of subsidies. In the industrialised countries, policy is now focussed on ensuring that prices reflect the real costs of energy. Over and above this, appropriation for future investments may be included in the price, but over a number of years there must be a balance between revenue and expenditure. In the case of many developing countries that are implementing reforms in the energy sector, tariffs are gradually moving towards economic levels.

Two key economic pricing instruments normally used when constructing tariffs for electricity are the Short-Run Marginal Cost (SRMC) and Long-Run Marginal Cost (LRMC) principles. These principles are meant to ensure that the costs of the companies are covered and that the consumers are protected from paying more than the energy actually costs.

2.3.2.4 Financing Schemes

Favourable financing schemes for energy saving measures or for fuel switching from conventional fuels to renewable, is another incentive-based tool available to the energy sector policy maker. The need for affordable credit financing for the development and implementation of non-conventional energy forms cannot be overemphasised; non-conventional energy forms face formidable economic and institutional barriers to market entry due to the massive dominance of fossil fuels. Most new and renewable energy technologies have relatively large up-front costs, which few private sector operators, dealer or consumers can afford outright. Governments are generally also no longer prepared to finance renewable energy projects on the scale needed to drive costs down, nor are conventional fossil fuel players (like the oil companies[4]) not naturally drawn to renewable energy projects. As a result, appropriate means of financing have to be devised.

Barnes et al [1998] have stated, " there is no magic fix for the challenge of renewable energy finance. And that responding to the challenge involves patiently cultivating the right mix of supporting institutions, reforms, policies, market, and infrastructure, based on the country and circumstances." Brennand [1998] also submitted that renewable energies could only approach their potential as a main contributor to meeting the growth in world's energy demand "if governments help to create an institutional framework capable of attracting large amounts of private sector finance."

Different models can be adopted as financing options. However, the particular financing model selected depends to a large extent on the type of borrower and what security is to be provided to the lender. Specific examples of financing mechanisms include third party financing, initiator funds and guarantee schemes, dealer model, concession model and retailer model.

[4] There are a few exceptions as in the case of Shell Oil.

It should be noted however that economic instruments are implemented on the assumption that their target group acts in an economically rational manner. Unfortunately this precondition of economic rationality does not hold for all users and producers of energy. To the extent that consumers and producers do not act in accordance with economic signals, there is the need to supplement the economic instruments with other measures, which are discussed as follows.

2.3.3 Information and education

Information and education is another indispensable tool in the arsenal of the energy sector policy maker. Energy end-users need to be well informed on available energy options, otherwise new energy saving and environment-friendly technologies will remain under-utilised. An effort can be made to lower the knowledge barrier (where it exist) by means of general information, consultation, inspection schemes, energy labelling etc. It is relatively inexpensive and cost effective to initiate these measures. Furthermore, consumers seldom find the measures intrusive, as it is most frequently a voluntary matter whether or not use is made of the information offered.

However, a general problem for public and private information programmes is that they must compete with the general, considerable flow of information. In addition, there is the tendency for knowledge and motivation built up through information to disappear over time. This of course reduces their effects and increases the cost involved in establishing and maintaining a certain level of information in the target groups. Therefore in each case it should be considered how information could be more effective and optimally goal-oriented. Introducing labelling on a number of electrical household appliances is an example of such goal-oriented information.

2.3.4 Normative Measures or Command-and-Control Measures

A command-and-control approach to energy policy is whereby political authorities simply mandate the desired behaviour in law, and then use whatever enforcement machinery is necessary to get people to obey this law.
The normative measures in energy policy have their authority in legislation and involve little administrative costs.[5] Examples of normative measures are standards, prescriptions and prohibitions. Standards for example are useful in ensuring a certain degree of energy efficiency in the production of new appliances, construction of new buildings, etc. When setting standards, it is important to ensure that they contribute to dynamic development and do not instead delay development. Setting ambitious yet also realistic future goals in conjunction with industry and other stakeholders is the key.

2.3.5 Research and Development

If significant reductions in the environmental impact of the energy sector are to be achieved, then new, efficient and environment- friendly energy technologies must be introduced at a

[5] In some case however, "enforcement costs" could be high.

faster rate. Ongoing research and development on sustainable energy technologies is needed to find new solutions, develop better ways to apply them, and improve their costs and performance in order to facilitate their diffusion. In conjunction with this, care must be taken to ensure these goals are achieved without compromising economic development. This requires carefully developed support schemes for research, development, demonstration and market development of new energy technologies. It is necessary that all the links in the chain from the initial basic research to the market development of a new product be followed if the swift and broad introduction of a new energy technology to the market is to be ensured. The progression from an idea for a particular technology to the development of a dependable and profitable technology can take a long time and require considerable resources.

2.3.6 Reforming the Energy Sector

The measures and instruments described above were the predominant ones used when the public sector had the primary responsibility for energy policy decisions. As mentioned earlier, the emphasis has now shifted and there is increased reliance on market mechanisms as policy instruments for the energy sector. This is because the market has been found to allocate energy resources with greater efficiency. Many of the reforms occurring in the energy sector have taken place in the electric power sector; however, they have had impacts on other energy sub-sectors, especially the renewable.

For instance it is has been submitted, “good power sector reform is a good renewable energy development policy,” [Barnes, et. al, 1998]. The higher priority now given to energy saving and renewable forms of energy has led to the necessity for an organisational strengthening, by governments, of these areas at all levels in the energy system from planning to performance and evaluation. Apart from the need to strengthen the energy sector institutions, there is also the need for fundamental restructuring of the energy sector institutions as they were designed to promote and sustain energy systems based on conventional fuels. The priority is to construct new regulatory and legal frameworks that define the “rules of the game” in energy markets. These rules must also help to advance social priorities such as poverty reduction and rural development in conjunction with the growth of sustainable energy enterprises and markets [EC/UNDP, 1999].

2.4 Policy Instruments and Measures for Renewable Energy Technologies

The world-wide policy objective with renewable energy technologies is to develop and disseminate the technologies in order to diversify the energy mix and ultimately reduce the global dependence on non-renewable. Interest in RETs has been motivated by global concern for the harmful effects of continuous burning of fossil fuels. RETs also provide decentralised options for supplying energy to the rural populace. As mentioned earlier however, most RETs have large up-front costs, which few operators, dealers or purchasers can afford outright. There is therefore the need to devise appropriate policy instruments and measures, which will facilitate easy adoption of RETs. According to Goldemberg [1998], whatever instrument or measure is adopted should be;

- effective in quickly establishing reasonably large production and market demand levels, allowing companies to scale up production with the confidence that there will be market for them;
- efficient in driving down cost as a cumulative production increases;
- minimally disruptive of existing energy-financial systems during the transition period;
- able – within available financial resources – to support a diversified portfolio of options;
- easily and transparently administered and require minimal administrative overheads; and
- temporary, with 'sunset' provision built into the commercialisation incentive scheme ab initio, but long enough to catalyse the desired activity.

In practice all the instruments / measures described above have been used to promote renewable energy. In several instances, these measures and instruments have been used simultaneously to achieve specific policy objectives. There are cases where taxes have been imposed on one energy source (fossil fuel) and the money raised used to support R&D as well as demonstration projects/programmes in renewable. Several financing mechanisms have also been developed to help the poor gain access to renewable forms of energy.

One instrument that has featured quite prominently in the ongoing reforms in the energy sector is pricing. Pricing has become an important tool following the observation that throughout much of Africa and a greater part of the developing world, energy-pricing policies have tilted the playing field against sustainable and equitable energy development. This is due to the fact that conventional electricity and fuels are almost universally priced below their marginal cost [EC/UNDP, 1999]. This situation, amongst others, creates a strong disincentive for investment in energy efficiency and lowers the ability of renewable energy to compete with conventional sources. There is therefore the need for an upward adjustment of tariffs.

Some specific examples of policy instruments and measures that have been used to promote RETs include the following.

2.4.1.1 Non-Fossil Fuel Obligation (NFFO)

In the United Kingdom (UK), the government provides support for electricity generated from renewable sources principally through the Non-Fossil Fuel Obligation (NFFO) in England and Wales, the Scottish Renewable Obligation (SRO) in Scotland and the Northern Ireland NFFO (NI-NFFO). The NFFO was adopted as part of the Electricity Act of 1989, which privatised the electric power sector. The NFFO evolved from the need to find a means of supporting nuclear power, after it was realised that nuclear power could not survive privatisation without subsidy[6] [UNDP, 1997]. Later on the NFFO came to be understood to include both renewable and nuclear energy [Mitchell, 1995]. Despite its origin, the renewable NFFO has turned out to be a major boost for renewable. The NFFO has been used mainly as a mechanism for moving market-ready RETs into the marketplace, and for increasing the number of independent power producers (IPPs). The aim of NFFO was to bring into

[6] It should be noted that however that since the end of 1998, subsidy to the nuclear industry has been withdrawn.

operation, by the year 2000, a base load of 1500 MW_e of renewable electric supplies[7] [Goldemberg, 1998].

The renewable NFFO requires the Regional Electricity Companies (RECs) to buy a fixed amount of nuclear and renewable electricity from non-fossil fuel power producers. Thus NFFO is a scheme by which electricity companies are "obliged" to buy a fixed amount of power from non-fossil power producers. The RECs pay the generators a premium price for the renewable electricity and the difference between the premium price and the average monthly pool purchasing price is reimbursed to the RECs by the Non-Fossil Purchasing Agency (NFPA) from the Fossil Fuel Levy (FFL)[8] on electricity, paid via customer electricity bills.

Several Orders of projects have been developed under the renewable NFFO. To date five NFFO Orders have been made in England and Wales, two equivalent Orders in Northern Ireland and three in Scotland. The first Order (NFFO-1) was made in 1990 for 75 projects and 150 MW declared net capacity (DNC), NFFO-2 was made in 1991 for 122 contracts and 472 MW DNC, NFFO-3 was made in 1994 for 141 contracts and 627 MW DNC and NFFO-4 made in 1997 for 195 contracts and 843 MW capacity. The fifth and the largest Order (NFFO-5) was laid in September 1998 for 1,177MW. The first two SRO Orders led to 56 projects and with a combined capacity of 189 MW. SRO-3 was laid in February 1999 for 150 MW. Contracts for the first three NFFO orders (NFFO 1-3) expired in 1998 and out of the estimated DNC of 1250 MW, 650 MW of electricity plants were commissioned. The NFFO has been abolished[9] since 1999 but existing NFFO contracts will run till March 2014. With the abolition of NFFO, the UK government intends to provide future support for renewable by imposing an obligation on electricity suppliers to contract (or "buy-out" their obligation to contract) an increasing percentage of electricity from renewable sources.[10]

It is clear that the NFFO utilises a range of economic instruments, supported by a normative measure of legislation to realise its goal of bringing on board 1500 MW of renewable energy. The NFFO has also made cost convergence between renewable and the conventional energy an explicit goal over the last several years. In fact, there have been substantial cost reductions in the electricity supplied mainly from wind – from an average price of 7.2 pence/kWh for NFFO-2 to 4.35 and 3.46 pence/kWh for NFFO-3 and NFFO-4, respectively. Prices for NFFO-5 averaged 2.71 p/kWh.

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[7] The current target is for renewable to provide 5% and 10% of total UK electricity requirements by 2003 and 2010 respectively.

[8] The levy was set at between 10% and 11% of electricity price at its inception in 1990 but has been reduced to 2.2% by 2000. According to Mitchell (1995), the renewable premium prices have been paid for by 1-5% of the FFL; the rest of which has gone to support the nuclear industry until 1998 when subsidy to the nuclear industry was withdrawn.

[9] Future supporting arrangements for renewable will be an obligation on electricity suppliers to contract (or "buy-out" their obligation to contract) an increasing percentage of electricity from renewable sources.

[10] The UK government plans to oblige all electricity suppliers to buy 10% of their power from renewable sources once existing NFFO contracts expire.

2.4.1.2 Renewable Portfolio Standard (RPS)

The RPS is policy tool being explored in many states and also at the federal level in the United States to encourage the use of renewable energy sources. The RPS has been described as " a flexible, market-driven policy that can ensure that the public benefits of renewable energies continues to be recognised as electricity markets become more competitive" [AWEA, 1997]. The RPS ensures that a small but increasing minimum percentage of qualifying renewable energy (specified by the state or federal government) is included in the portfolio of electricity resources serving a state or country. The aim of the policy is to guarantee a minimum market for the renewable industries, thus allowing them to make the investments needed to bring down costs and eventually attain full competitiveness [DBEDT, 2000]. Because it is a market standard, the RPS relies almost entirely on the private market for implementation.

Central to RPSs is the system called renewable energy credits (RECs) or "credits". A credit is a tradable certificate of proof that one kWh of electricity has been generated by a renewable-fuelled source. The RPS requires all electricity generators (or retailers, depending on policy design) to demonstrate, through ownership of credits, that they have supported an amount of renewable energy generation equivalent to some percentage of their total annual kWh sales. Investors and generators make all decisions about how to comply, including: the type of renewable energy to acquire, which technologies to use, what renewable developers to do business with, what price to pay, and which contract terms to agree to. Generators decide for themselves whether to invest in renewable energy projects and generate their own credits, enter into long-term contracts to purchase credits or renewable power along with credits, or simply to purchase credits on the spot market. Only the bottom line is enforced: possession of sufficient number of credits at the end of each year. Through credit trading, the RPS relies on the initiative of businesses to ensure that the standard is met at the lowest possible option. Thus electricity providers have great flexibility in meeting their requirements.

The administrative requirements of government are less under a RPS than under NFFO, because the market, rather that an administrative process, is expected to choose the winning technologies and suppliers. The role of the government will then be limited to certifying credits, monitoring compliance, and imposing penalties if necessary. In spite of its flexibility and extensive reliance on the private market for implementation, there is little actual experience with the functioning of RPS. A review of the status of RPS programmes in the United States identified only eleven states[11] that have implemented RPS [DBEDT, 2000]. Of the eleven states that currently have renewable energy requirements, the earliest start is in the year 2000; most programmes have been scheduled to be implemented between 2001 and 2003 [DBEDT, 2000]. The terms of RPSs vary among states. However, each RPS reflects the state's specific energy situation and the types of renewable energy resources that are technically feasible.

[11] The states are Arizona, Connecticut, Iowa, Maine, Massachusetts, Minnesota, Nevada, New Jersey, Pennsylvania, Texas, and Wisconsin.

2.4.1.3 Electricity Feed Law (EFL)

The German Electricity Feed Law (1991) obliges electricity utility companies to purchase, at a premium price, electricity generated from renewable energies in their supply area. For electricity from generation facilities not located in the area supplied by a system operator, the EFL imposed the obligation to buy on the utility closest to the site of the generation facility and has a system technically suitable to feed in the electricity. The price payable for renewable such as hydro power, landfill gas, sewage gas and biomass (with capacity not exceeding 5 MW) was set at a minimum of 80% of the average revenue per kWh from the delivery of electricity by utilities to all final consumers. In the case of wind and solar energy, the price was set at a minimum of 90% of average revenue per kWh.

At the time of inception in 1991, the EFL did not place any limit on the amount of renewable energy the utilities were obliged to purchase. The EFL was consequently opposed by the utilities because they deemed its implementation burdensome. Efforts by the electric utilities to have the EFL declared unconstitutional failed, but it resulted in the amendment of the law in April 1998 by the German Parliament. The amendment *inter alia* introduced a 5% cap on the amount of electric power the utilities are obliged to buy. The 5% cap means that the utilities are not obliged to buy more that 5% of their total electricity from renewable sources. The EFL has since February 2000 been replaced by the Renewable Energy Sources Act (RESA) which pays a guaranteed price for various forms of renewable.[12]

The EFL provided an impetus mainly for wind energy because of the compensation rates (higher price) paid for wind energy. Between 1991 and end of 1999, approximately 4,400 MW of wind energy was installed under the EFL. The story has however not been the same for the other renewable, especially solar and biomass. This is due partly to the fact that the compensation rates for PV and biomass have not been sufficient to stimulate large-scale market introduction of the technologies. Consequently, the compensation rates have been modified in the Renewable Energy Sources Act, 2000 [Renewable Energy Sources Act, 2000].

2.4.2 Examples of Financing Mechanisms

Three main models – Dealer, Concession and Retail (classified by intermediary)– are discussed in this section. The World Bank as its new approach to rural renewable energy delivery is employing these models. The objectives of these models are to: lower transaction costs, reduce barriers to market entry, spread and absorb risks, build service networks in rural areas, and develop specialised skills to manage local businesses and credit mechanisms [World Bank, 1998].

[12] The main purpose of the RESA is to achieve a substantial increase in the percentage contribution made by renewable energy sources to power supply in order at least to double the share of renewable energy sources in total energy consumption by the year 2010 (RESA, 2000)

2.4.2.1 The Dealer Model

The dealer model is the most well known among the three and mostly used for the delivery of PV systems. Under this model, banks transfer the collateral problem from the end-user (who in most cases cannot provide collateral security to the banks) to the dealer, by lending to the dealers who in turn lend to purchasers using payment schemes compatible with their income. Thus, the dealer model ensures that the high start-up costs, which characterise many RETs, are "lowered" and deferred through a credit mechanism arranged for customers by dealers through the banking system. The dealers bear the financial risk on top of technical risk. This model is best suited to large, relatively high-income rural markets and depends on either cash or credit-based sales. In Kenya, the market for PV developed when dealers began selling systems through existing small rural sales points such as general stores. Now more than 100,000 households in Kenya use PV systems; these are usually purchased piece by piece and in low watt increments (12 watts is almost standard)[World Bank, 1998]. The dealer model is also being pursued in the World Bank's Solar Home Systems Project in Indonesia; in contrast to Kenya however, sales are credit based.

2.4.2.2 The Concession Model

The concession model, also for PV system delivery, employs a very different set of incentives and is characterised by a risk profile, which is different from that of the dealer model. The model depends more on regulation by contract than market forces, but helps ensure that large scale-economies are achieved. Here the government contracts and pays a local company to provide energy services to meet development objective: e.g. PV lighting for schools. This provides entry capital for the company to offer credit and expand its business to other local markets such as PV for households, health clinics and community centres. In Argentina, for example, franchise rights for rural service territories have been granted to concessionaires that offer bids with the lowest subsidy to service rural households and community centres. Concessionaires can select from a range of off-grid technologies, although solar PV is anticipated to be the most cost-effective choice in the majority of cases. Users pay a connection fees and monthly service fee (set by the government), and a declining subsidy is provided to the concessionaires based on the provisions of their contracts. Concessionaires are provided with partial financing of their start-up costs through the projects.

2.4.2.3 The Retailer model

The small electricity retailer model is a community-based approach to renewable energy delivery that has been employed by the World Bank in projects for Sri Lanka and Laos. Under this model a community, organisation, or entrepreneur develops a business plan to serve local demand for electricity. The plan is submitted to the project's off-grid electrification committee and if approved, a loan is given. The retailer deploys the system and through fee-based service arrangement recovers cost, repays the loan, and earns profit.

2.4.3 Demonstration Projects

Demonstration projects are a policy tool, which have been used to develop and disseminate RETs, mainly in the developing world. Such projects have been supported by a large number of bilateral funds (in some cases multilateral as well) from the developed countries and some of them can be viewed as instruments to support industry and employment in the donor countries. As observed by Goldemberg, "for significant result to be achieved, these demonstration projects cannot be isolated experiments but should be tied up to local schemes in developing countries to commercialise these experiments and promote their acceptance by local countries. Otherwise they will remain experiments and be viewed with mistrust by local beneficiaries" [Goldemberg, 1998].

2.5 Overview of the Experiences of Some Asian Countries

This section has been included to give a picture of what pertains in certain Asian countries, some of whose economies are not very different from Ghana's. The aim is to explore how best the experiences of these countries can be drawn upon to 'push the frontiers' of renewable forward in Ghana. The main thrusts of policy initiative in these countries are separate laws and regulations, fiscal and non-fiscal incentives and institutional set-ups. The most significant thing about the RETs programmes being implemented in these countries is the issue of targets; almost all the countries surveyed had specific targets to be met within a given time period. In addition most of the projects being implemented are financially supported by international donor agencies. What follows is a tabular presentation of the overview of six Asian countries, namely India, China, Indonesia, Nepal, Philippines and Thailand.

As can be seen in Table 2.1, a country like Nepal with a GDP per capita of US$210 has set a target for renewable aimed at bringing on board 38,000 solar home systems, 300 solar crop dryers, 90,000 biogas plants, 250,000 improved cookstoves and 5.2 MW of micro hydro plants over a five year period (1998-2002). In principle, Ghana with a GDP per capita of US$390 should be able to set more ambitious targets for renewable once the resource potentials exist.

Table 2.1 An Overview of RETs Programmes and Projects in Six Asian Countries

COUNTRY	INSTITUTIONAL SETUP	LEGISLATION	PROGRAMMES/ PLANS	INCENTIVES
CHINA	1. Ministry of Sciences & Technology (MST) 2. State Development and Planning Commission (SDPC) 3. State Economic & Trade Commission (SETC)		Programme on New & Renewable Energy in China (1996-2010) **Targets**: 13.4million ha. Fuel wood plantation; 4 billion m^3 biogas supply to 12.35 million households; 117 GWh electricity from small hydro; 4.67 mtce of solar energy; 1000-1100 MW of wind power; 50 MW tidal power capacity	Loans granted @ 6%; tax incentives for renewable.
INDIA	1. Ministry of Non-Conventional Energy Sources (MNES) 2. Indian Renewable Energy Development Agency (IREDA) – corporate financing arm of MNES.		Ninth Five-Year Plan (1998-2003) **Targets**: installation of SWH in 125,000 homes, $250,000m^2$ of solar collectors in industrial and commercial establishments, 70 MWp solar PV including 50,000 solar lanterns, 150,000 SHS, 5000 solar pumps, 750,000 biogas plants and 11 million improved cookstoves.	Financial Assistance from IREDA - loans up to 90% of project cost and 80% of equipment costs at rates ranging from 0-17% with maximum 10 year repayment period; US$390 m World Bank / Asian Development Bank credit to promote private sector participation in NRE; Solar Energy - 50% subsidy for SHS; 50% & 67% subsidies respectively for isolated and grid-connected solar energy-based power projects; up to US$42 subsidies for solar lanterns

				Wind – concessional import duties, income tax holidays etc.
INDONESIA		Small Power Purchase Law. Aim: authorizes state electric utilities to purchase electricity generated by non-conventional energy producers.	Sixth Five Year Development Plan (1993-1998) **Targets**: 50 MWp PV rural electrification programme. This involves the installation of 1 million SHS to provide electricity to 10% of total non-electrified rural households; 16 PV pumping stations with 600kWp total capacity; PV Systems for 5480 rural health centre; PV lighting for 20,000 fishing boats etc.	
NEPAL		1.Hydropower Development Policy (1992) 2. Water Resource Act (1992) 3. Electricity Act (1992)	Ninth Five Year Plan (1998-2002) **Targets**: 38,000 units of SHS; 300 solar dryers; 90,000 biogas plants; 250,000 Improved Cookstoves; 5.2 MW of micro hydro plants.	No permission needed to install micro-hydro plant of up to 100kW; No license required to generate hydropower of up 1MW; no royalty or income tax payable on plants of 1 MW; facilities for exchange of foreign currency to investors; private producers given the liberty to fix tariffs for plants not connected to the grid; assistance given in acquisition of land for power plants; loans @ 17% rate of interest; subsidies of up to 75% for rural electrification schemes,

				50% subsidy for SHS, subsidy of up to $180 for biogas installations
PHILIPPINES		1. National Non-conventional Energy Programmme Act (1994) 2. Renewable Energy Bill 3. Mini Hydro Law	Window III Programme – devised by Development Bank of Philippines. This programme provides credit facilities to service providers using NRE.	i) Tax and duty exemptions for domestic capital equipment and duty exemptions on imported ones ii) Up to 6yrs income tax holidays for renewable based electricity producers iii) Deduction for labour expenses iv) Deduction from taxable income of expenses on infrastructure
THAILAND		Energy Conservation and Promotion Act (1992)	Energy Conservation Programmme (ENCON) – an Energy Conservation Fund was created under the ENCON	50% subsidization for roof-top PV systems during the pilot phase; up to 31.5% subsidy for SWH provided total cost is not greater than US$675

Source: Renewable Energy World, Vol. 2, July 1999.

3 RENEWABLE ENERGY POLICY INSTRUMENTS AND MEASURES IN GHANA

3.1 Introduction.

The evolution of national policies having a bearing on RETs can be traced to the enactment of PNDC Law 62 in 1983; this provided the statutory foundations for the establishment and operations of a board known as National Energy Board (NEB). PNDC Law 62 remained in force as the guiding legislation for the implementation of projects in renewable energy until 1996 when the Energy Sector Development Programme (ESDP) was introduced. Other relevant legislation for the energy sector includes the Energy Commission Act, 1997 (Act 541) and the Public Utilities Regulatory Commission Act, 1997 (Act 538). These Acts mainly introduced institutional and administrative reforms into the energy sector.

In this chapter we will be reviewing and evaluating all these policies for the purpose of assessing their effectiveness and/or appropriateness in enhancing and promoting renewable energy technologies in Ghana.

3.1.1 Background to the National Energy Board Law (PNDC Law 62)

A number of local and international initiatives led to the setting up of the National Energy Board (NEB). In 1979, in response to a major crisis in the supply of petroleum, the government – through the Ministry of Fuel and Power (MFP) – created a special committee which was known as the Committee on Energy Resources to review short, medium and long-term options to improve energy security and to accelerate the pace of energy sector development. The committee, in collaboration with the oil marketing companies and the University of Science and Technology (UST), Kumasi, organised a national symposium on renewable energy at UST in October 1980. The purpose was to collate information on energy sources and projects and personnel who were working in the energy field. The symposium was also intended to serve as a national preparatory activity for the impending UN conference on New and Renewable Sources in Nairobi in 1981. Amongst other things, the Committee recommended the establishment of a permanent capacity in the government (a Board, to be called the National Energy Board) for energy policy and strategy work.

A meeting of ECOWAS Heads of State held in May 1982 also precipitated the creation of NEB. At the said meeting three protocol decisions relating to energy were taken. Within the context of the ECOWAS Protocol, a number of policy objectives were formulated for member States to pursue in achieving the decisions taken at the meeting. One of the policy objectives was for every member state to establish, by law, a body within the machinery of government to be charged with the responsibility of co-ordinating and supervising all energy functions and activities [Akuffo, 1992][13]. Following the ECOWAS protocol, the Provisional National Defence Council (PNDC)[14] government approved the setting up of the NEB as the single advisory body to the Ministry of Fuel and Power and in 1983 passed a law (PNDC Law 62) to establish NEB. The NEB however became operational only in 1986.[15]

The functions of the Board as contained in Sections 2(1) and 2(2) of PNDC Law 62 included the following:

a) Formulate recommendations on energy policy and submit these recommendations to the council (PNDC);
b) Plan comprehensively for the development and the utilisation of national energy resources;
c) Assess the range of energy resources available to the nation and the extent of present day utilisation;
d) Direct development and demonstration projects in renewable energy throughout the country;
e) Monitor the operations of public bodies with responsibility for the regulation and management of energy development as well as utilisation of energy resources;
f) Secure comprehensive data on national energy resources.

Thus NEB was inter alia responsible for energy planning, energy efficiency and conservation and R&D of new and renewable energy technologies. In carrying out its function, the NEB created five key departments, one each for petroleum planning, electricity planning, renewable energy programmes, energy conservation programmes, and energy information. The NEB initiated a number of projects in the areas of renewable, electricity, petroleum, energy conservation and demand management; and policy analysis, planning and institutional management. A total of 135 projects and programmes were initiated by the NEB between 1989 and 1991, out of which 29 were on renewable energy [Akuffo, 1992]. Table 3.1 contains all the renewable projects and programmes initiated by NEB from 1989 to 1991. The NEB was abolished in March 1991 and all its assets and staff placed under the direct control of the Ministry of Energy, which had been created to replace the Ministry of Fuel and Power. It is however not clear as to how many of the projects were completed or abandoned before the board was abolished: there were many progress reports, but few final reports.

[13] Prof. F. O. Akuffo was the National Energy Policy Consultant from 1990-1992.
[14] The PNDC was the military government that ruled Ghana from December 1981 to December 1992.
[15] According to Akuffo (1992), two factors – staffing and funding – delayed the implementation of the NEB.

Table 3.1: RETs Projects Under NEB Between 1989 and 1991

1989	1990	1991
1. Strategies for improving Charcoal Production in Ghana	10. Strategies for improving charcoal Production in Ghana	22. Strategies for improving charcoal Production in Ghana
2. Improved Charcoal Stove Programme	11. Improved Charcoal Stove Programme	23. Improved Charcoal Stove Programme
3. Rural Energy Planning Studies	12. Rural Energy Planning Studies	24. Improved Firewood Stove Project.
4. Appolonia Biogas Village Project	13. Appolonia Biogas Village Project	25. Appolonia Biogas Village Project
5. Public Latrine Biogas Project	14. Integrated Biogas Projects	26. Monitoring and evaluating the performance of Solar PVs in Ghana
6. Monitoring and Evaluation of the performance of Solar PVs in Ghana	15. Biogas Resource assessment	27. Solar and Wind Energy Resource Assessment
7. Solar and wind Energy Resource assessment	16. Establishment of Biogas Laboratory and Workshop	28. Prospects for Solar Water Heating
8. Prospects for Sawdust Briquettes as Renewable Energy source In Ghana	17. Monitoring and evaluation of the performance of Solar PVs in Ghana	29. Prospects for Substituting Solar Energy for Oil in Large scale Commercial Crop Drying
9. Demonstration of Integrated Solar Power for villages	18. Demonstration of Integrated Solar Power for Villages	
	19. Promotion of Sawdust Briquettes as Renewable energy Source in Ghana	
	20. Solar and Wind Energy Resource Assessment in Ghana	
	21. Feasibility Study of Substituting Solar Energy for Oil in Large scale Commercial Crop Drying	

Source: Akuffo, 1992

3.1.2 Measures Adopted by NEB to Implement Programmes and Projects

The NEB embarked on publicity campaigns to encourage people, in particular vehicle owners, to reduce their consumption of petroleum products. The NEB also publicised RETs through its campaigns, although renewable energy was not targeted specifically as a substitute for petroleum products.

We must now consider the impact of the establishment of the NEB on the development and adoption of RETs. From Table 3.1 above, it is obvious that certain RET projects were developed and demonstrated. Since these projects mark the genesis of national effort to develop Ghana's renewable resources, one can say that the NEB made a significant contribution to the development and adoption of RETs in Ghana. The main measures used by NEB in carrying out its renewable projects were R&D, demonstration as well as education and information.

What NEB could not achieve however was the formulation of a comprehensive long-term plan for renewable and other sub-sectors of the energy economy.[16] This was seen as the "weakest area of the NEB's activities [Akuffo, 1992]. As a result Akuffo (1992) recommended "the development of a comprehensive and implementable framework for establishing a national energy strategy, which will provide a long-term perspective for the development of the energy sector in general." Perhaps the response of the MME to this recommendation, some four years later, was the institution of the Energy Sector Development Programme (ESDP) in April 1996. We will now turn our attention to the ESDP, which is the current policy document guiding the development of the energy sector.

3.2 The Energy Sector Development Programme (ESDP), 1996-2000

3.2.1 Policy Framework and Strategic Objectives[17]

According to Part II of the ESDP document, Ghana energy sector policies are shaped by the following realisations:

i) The need to plan for the sustained provision and security of energy supplies;
ii) The need to increase the reach of energy resources to all sections of the country to facilitate their socio-economic improvements, especially the majority rural people;

[16] With the exception of the electricity sector, no formal strategic document was prepared.
[17] The strategic objectives and implementation strategies described under the ESDP are presented exactly as contained in the original policy document. Many of the activities are already being carried out. Some Implementation strategies have currently changed, these changes are incorporated in the sections on biomass and solar.

iii) The need to overcome the constraints in existing energy resources via measures to resuscitate dilapidated infrastructure and institutional weaknesses in the energy operating entities;
iv) The need to consolidate the gains achieved since the inception of the Economic Recovery Programme (ERP);
v) The need to enhance private sector investment in the development of the energy sector.

Within the framework of meeting the country's energy requirements for sustained growth and development, the energy sector's goals are:

i) to restore improved productivity and efficiency in the procurement, transformation, distribution and use of all energy resources;
ii) to reduce the country's vulnerability to short-term disruptions in the energy resources and supply bases;
iii) to consolidate and further accelerate the development and use of the country's indigenous energy sources, especially woodfuels, hydro-power, petroleum and solar energy; and
iv) to secure future power supply through thermal complementation of the hydro-based electricity generation.

3.2.2 Energy Sector Programmes and Implementation Strategy

The action programme and activities developed for the energy sector have been set within the framework of the ERP. Within this context and in line with the strategic policy objectives for the energy sector, the MME has established both short and medium to long-term priorities for its action programme. The programmes and projects being implemented by the MME and the Energy sector institutions fall under the following five broad areas:

i) The Renewable Energy Development Programme (REDP);
ii) The National Liquefied Petroleum Gas (LPG) Promotion Programme;
iii) The Power (Electricity) sub-sector;
iv) The Petroleum sub-sector; and
v) The Energy Efficiency & Conservation Programme

For our purposes, we will focus on (i) and (iii) above. We will be considering the power sector because sound sectoral reform and rational incentives in the sector are necessary to make the power sector a friendly environment for renewable.

3.2.3 Renewable Energy Sector

The MME acknowledges the long-term potential of renewable in providing opportunities for the improvement of the country's energy security and sustainability by substituting for some of the other energy types such as fossil fuel. According to the MME, improved development and use of renewable energy, particularly woodfuel and other biomass resources such as crop residues and biogas, would bring enormous upliftment to most of the population, with added socio-economic benefits to the country as a whole. The broad short-term objectives for the future development of the renewable energy resources of the country are:

i) Improve the efficiency of production, conversion and use of woodfuel;
ii) Demonstrate and evaluate renewable energy technologies with the potential to meet the needs of prioritised socio-economic well-being of the people;
iii) Provide support for research, development and demonstration of RETs with the greatest potential to increase and diversify the country's future energy supply base;
iv) Promote the development of renewable energy industries that have strong indigenisation prospects over the short and medium term; and
v) Develop the relevant information base on the stock and status of renewable energy resources, suitable technologies and end-use patterns for the purposes of establishing a planning framework for the rational use of the country's renewable energy resources.

The medium-term objectives of the Renewable Energy Programme are:

- To demonstrate and evaluate renewable energy technologies with the potential to meet the needs of prioritised socio-economic well-being of the people;

- To provide support for research, development and demonstration of RETs with the greatest potential to increase and diversify the country's future energy supply base; and

- To develop the relevant information base on the stock and status of renewable energy resources, suitable technologies and end-use patterns for the purposes of establishing a planning framework for the rational use of the country's renewable energy resources.

The medium-term activities have been designed to improve the production and use of wood energy resources, expand the productivity and use of existing bioenergy resources such as production of charcoal briquettes from logging and wood processing residues and substitution of other energy sources such as LPG and electricity for cooking. The programme will also examine and implement incentives that will be required to encourage private sector investment in woodlots. To complement the above measures, policy guidelines for environmentally friendly production of charcoal and fuelwood at the district / community level need to be developed.

The Renewable Energy Development Programme covers a number of specific projects, which can be grouped under two broad headings of biomass and solar energy.

3.2.3.1 Biomass

To tackle woodfuel supply and attendant environmental problems, the MME is implementing a number of projects, some of them pilot. The aim is to determine the most technologically and cost effective solutions for optimising the use of existing resources, resuscitating degraded areas and increasing the country's sustainable bio-energy resource base. The strategy adopted for the achievement of the above objectives for the biomass sub-sector seeks to:

i) Conserve forest resources through improved methods of charcoal and firewood production

ii) Decrease consumption of firewood and charcoal by using more efficient cooking devices. Amongst the measures is the development and introduction of improved woodfuel cookstoves. The chief outcome of this measure is a locally designed stove called " the Ahibenso improved coalpot"; which saves between 35-40% of charcoal as compared to the traditional coal pot.

iii) Expand the productivity and use of existing bio-energy resources such as production of charcoal briquettes from logging and wood processing residues;

iv) Examine the use of animal and human wastes to provide biogas for cooking, lighting and electricity generation. In pursuing this, a community based-biogas project has been established at Appolonia, a village near Tema. This project aims to determine the socio-economic conditions necessary to ensure the success of the technology. This information will be used to promote and popularise the technology in other areas of the country;

v) Plan for future security of biomass supply through the implementation of sustained programme of forest regeneration and afforestation, especially in areas where intense charcoal production activities have destroyed the land and created environmental and ecological problems. The MME is collaborating with the Ministry of Lands and Natural Resources, the Forestry Commission, Ghana Timber Association, as well as the District Assemblies in the major charcoal producing areas to enforce measures that require charcoal producers to cultivate sustainable woodlots to support their activities; and

vi) Substitute LPG and other fuels such as electricity for firewood and charcoal.

3.2.3.2 Implementation Strategy

From 1996, the MME planned to implement all Renewable Energy projects on a demand-driven basis. Thus Renewable Energy Development Projects were to be evaluated within the framework of the following criteria: sustainability, payment for service and cost recovery, full involvement of potential users, environmental considerations and the basic needs of the community or users. Also in recognition of the fact that the promotion and the commercialisation of most of the RETs were and still are in the early stages of the learning curve, the MME proposed to provide some subsidy, at least in the beginning, for interested investors. This is intended to encourage accelerated penetration of RETs in the market.

3.2.3.3 Solar Energy

The MME has instituted a National Solar Energy Programme (NASEP) to assess, demonstrate and evaluate the technical, economic and social viability of appropriate solar energy technologies. It is also concerned with solar applications that are able to facilitate the attainment of the major goals of the ERP, especially the development of rural areas. The solar energy activities that are being implemented are focused around a strategy whose principal objectives are:

- to evaluate the technical and economic viability of proven solar technologies capable of meeting prioritised socio-economic and developmental needs of the country;
- to promote the development of solar energy industries that have strong indigenisation prospects over the short to medium term future.

Activities undertaken under NASEP include:

- Solar and Wind Energy Resource Assessment
- Evaluation of Solar Photovoltaic Systems in Ghana
- Demonstration of Integrated Power for Villages
- Solar Water Heating
- Solar Crop Drying
- Off-grid Solar Photovoltaic Electrification Pilot Project
- Wind Energy Development in Ghana
- Feasibility Study of Pilot Solar Thermal Plant in Ghana

3.2.4 Project Financing and Benefits

An amount of ¢339 million was estimated to be spent on renewable energy projects in 1996. The proposed expenditure over 1996-2000 is 1,200 million and this amount was to be sought from government budgetary sources. The successful implementation of activities related to woodfuels is expected to reduce the country's excess dependence on this resource and minimise the threat of deforestation and other related environmental problems. It will also complement the Government's rural development efforts by ensuring that the poorest sections of the population get access to energy.

3.3 Power Sector

3.3.1 Power Sector Development Programme

The strategies and action plan in the power sector are aimed at achieving the following objectives:

- Rehabilitation and expansion of deteriorated infrastructure, with restoration of effective maintenance of generating plants, transmission and distribution equipment, extension of distribution and sub-transmission systems;

- Extension of reach of electricity to all parts of the country, especially to the rural areas, under a National Electrification Scheme (NES) by the year 2020;

- Assuring future supply of power by developing new hydro resources as well as complementing the predominantly hydro power generation capacity with other energy sources such as thermal generation;

- Reducing electricity wastage through energy conservation and Demand Side Management Programmes; and

- Instituting structural reforms in the electricity industry in order to enhance efficiency and competition.

To achieve the above objectives, a number of programmes have been implemented, which include the extension of transmission and distribution systems, increasing the capacity of power generation systems, and legal and institutional reforms to strengthen the sector's operational efficiency and improve competitiveness. Each of these programmes is discussed below.

3.3.1.1 Extension of Transmission and Distribution Systems

Under this programme, the two utility companies, the Electricity Corporation of Ghana (ECG) and the Volta River Authority (VRA) have developed and implemented major investment programmes aimed at rehabilitating existing infrastructure and extending supplies to new customers in areas already served with electricity. ECG has completed the first phase of a programme, which started in 1987, to rehabilitate the electricity distribution system serving its major customers, who are mainly industrial consumers. A second phase of the programme, which will reinforce the sub-transmission system, was started in 1992 and completed in 1997. The VRA, on the other hand, has completed the National Electrification and System Expansion project. Under this it has extended the national grid to all major load centres in the northern parts of the country. [18] The VRA is also involved in the implementation of the National Electrification

[18] Until 1987 when the Northern Electricity Department (NED), a subsidiary of VRA, was created to distribute electricity in the northern part of Ghana, VRA was only into generation and transmission of power from the Akosombo hydroelectric plant.

Project (NEP) and the Self-Help Electrification Project (SHEP) in the northern parts of the country where it is responsible for distribution.

3.3.1.2 Increasing the Capacity of Power Generation System

Following the 1983 drought, which reduced the Volta Lake to very low levels and resulted in drastic curtailment of electricity production and supply to all sectors of the country, the government has been prompted to pursue a programme of expanding the power generation base. This is to be achieved through the development of other potentially more stable hydro basins in the western parts of the country, especially the Pra, Tano and Ankobra Rivers, thereby reducing the nation's over reliance on the Volta basin. In addition to these hydro schemes the Government has concluded financing arrangements for VRA to install a 330 MW thermal power plant in the country. Ghana National Petroleum Company has also finalised financing arrangement to install a 150 MW power plant to utilise natural gas from the Tano Gas Fields.[19]

3.3.1.3 Institutional Reforms and Independent Power Producer (IPP)

These reforms are aimed at improving the operations of the power sector and reducing public monopoly in the sector. The principal policy objectives that are being pursued by the government to effect the reforms are:

(i) Enhancing more effective commercialisation of the operation of the existing power utilities;

(ii) Effecting structural changes that will move the power sector away from existing monopolistic and centralised structure (i.e., for the planning and operation of the power system) towards a more decentralised structure that will expose the public utilities to competition in both the generation and distribution of electricity;

(iii) Encouraging private sector investment in the power sector through the establishment of Independent Power Producer (IPP) schemes;

(iv) Reducing the extent to which government is called upon to apply public investment resources to provide sovereign guarantee to cover the debt contracted by the public monopoly utilities for power generation and thereby targeting the application of the sovereign guarantees to address non-commercial (country specific) risks; and

(v) Establishing a regulatory framework that is transparent and enables healthy competition to occur in the sector.

[19] The above represents the plan for expanding the power generation base at the inception of the ESDP. The situation has however changed and plans are seriously underway to source funding for the development of Bui Hydro power. The VRA thermal generation has so far installed 440 MW capacity plant at Aboadze, near Takoradi.

In practice the generation, transmission, distribution and supply of electricity will be separated viz.:

(i) Generation would be open to competition;

(ii) Transmission would be 'open access' to third parties but regulated;

(iii) Distribution would be ultimately subject to third party but regulated; and

(iv) Supply will be open to competition for service above a certain franchise level but with tariffs under the purview of a regulator.

The power sector is expected to gain three major benefits from the reforms:

(i) Injection of private sector financing;

(ii) Price competition in power supply;

(iii) Provision of the opportunity for the development of small independent renewable energy power generation enterprises to service isolated rural communities remote from the national electricity supply grid.

3.3.2 The National Electrification Scheme

The Government of Ghana instituted the National Electrification Scheme (NES) in 1989 as the principal instrument to achieve its policy of extending the reach of electricity to all parts of the country by the year 2020. The specific objectives of the NES are:

(i) to connect all district capitals to the national electricity grid by the year 1997;
(ii) to supply power to rural communities through a Self Help Electrification Programme (SHEP);
(iii) to construct new and reinforce existing generation and transmission facilities to support the NES; and
(iv) to promote the productive use of electricity in order to improve the standard of living of the people and hence accelerate socio-economic development of the nation.

Under the NES, all rural/urban settlements with population of 500 people and above are programmed for connection to the national grid over a period of 30 years, between 1990-2020. However, communities who were eager to receive electricity supplies ahead of the NES scheduled dates were encouraged to initiate their own project through SHEP. Under the SHEP, communities who have raised funds to purchase local materials such as low-tension poles and are ready to provide communal labour to erect the poles are assisted to complete their electrification projects. The government provides all other technical and financial support needed for the extension electricity to this community.

To qualify for assistance under SHEP, the community should be within 20 kilometres of an existing 33KV or 11KV sub-transmission line, which will serve as a suitable source of power supply to the proposed distribution network. In addition, the community should be able to purchase all the low tension poles required for the projects and a minimum of 30% of the houses within the community should be wired.

The proposed expenditure over the period 1996-2000 for the NES is 411,243 million cedis made up of 306,177 million cedis in foreign currency and 105,066 million cedis in local currency. The foreign currency component for the NES was to be financed by a US $185 million syndicated loan to be provided by the IDA, ORET of Netherlands, DANIDA, Nordic Development Fund (NDF) and Caisse Development de France (CDF).

3.4 Administrative and Institutional Arrangements

The Ministry of Mines and Energy (MME) was, at the inception of the ESDP, given the responsibility for the overall planning and policy formulation for the sector. The MME was also tasked with the supervision of the operations of the public sector energy entities. The energy administration of Ghana at the inception of the ESDP was composed of 11 institutions:

- Ministry of Mines and Energy (MME)
- Volta River Authority (VRA)
- Electricity Corporation of Ghana (ECG)
- Ghana National Petroleum Corporation (GNPC)
- Tema Oil Refinery (TOR)
- Ghana Oil Company (GOIL)
- SHELL Ghana Ltd.
- Mobil Ghana Ltd.
- ELF Ghana Ltd.
- Unipetrol Ghana Ltd.
- The local authorities – who together with the local communities, are expected to participate in the Self-Help Electrification Programme by contributing materials to the various projects.

To enable private sector investments to play a bigger role in the development of the energy sector, the ESDP acknowledges the need for major reforms of the legislative framework of the sector. The Electricity and Petroleum sub-sectors were particularly mentioned as needing such reforms. The reforms in the power sector will require a restructuring of existing institutional set-up of the MME and the utilities. Also an appropriate legal framework (The Electricity Law) was to be put in place to establish an arms' length relationship between the MME, the arrangements for regulating power sector operations and the power utilities.

3.5 Evaluation of Energy Sector Development Programme (ESDP)

The question to be addressed here is whether the ESDP contains adequate provisions for successful development and implementation of RETs. In other words, is the ESDP effective enough to establish reasonably large-scale utilisation and dissemination (leading to a reduction in cost) of RETs by 2020?

One clear defect in the ESDP is that it is a document full of strategic objectives but lacks an investment plan, or set targets. The initial budgetary allocation of ¢1,200 million was to be provided by the government, (which is unlikely to be sustainable) and was earmarked for demonstration projects. Now most of the RETs are proven technologies. What is needed is a strategy that will ensure that the technologies move from the demonstration stage to the dissemination and diffusion stage. To achieve this the government will have to set implementable targets for renewable, as seen for example in the case of the NFFO and then create an institutional framework capable of attracting large amounts of the private sector finance. This tells the business and financial communities that renewable energy is to be taken seriously. A cue could be taken from the overview of some Asian countries (see above), which contains mechanisms used by governments in those countries to push the renewable forward.

Another defect in the ESDP is its failure to classify small hydropower as a renewable. As the document stands, there is no express provision for the development of the country's small hydro resources. Hydropower development has been placed under the Power Sector Development Programme of the ESDP with emphasis on the development of the western rivers. These rivers are by definition large hydro schemes, which are not likely to be developed – probably just as the construction of Bui dam has remained on the drawing board.[20] Meanwhile, as will be seen later on in this report, small hydro sites abound in the country and unlike their larger counterparts have greater possibility of being developed because of the relatively small initial costs associated with it.

We are also of the opinion that the National Electrification Scheme (NES) embarked upon under the Power Sector Development Programme (and even before the PSDP) was a missed opportunity for renewable. The approach used by the government under the NES was to extend grid electricity to rural areas. What the government could have done was to have used this programme to promote renewable in areas where grid connectivity will be uneconomical.[21]. Nevertheless, since the government's 'Self-Help Programme (SHEP) is still being implemented, we will examine the possibility of packaging some of the renewable for rural communities later on in this report.

[20] At the moment the government is seriously pursuing the Bui project.
[21] According to Monition et al (1984) mini hydropower plants for example are less expensive means of producing electricity than using solar or diesel unit, or connecting to existing grid further than 25 km away.

3.5.1 Other Policies Measures

The administrative and institutional structures described above represent those that were in place at the inception of the ESDP. However significant changes have since been made with the establishment of the Energy Commission (EC) and Public Utilities Regulatory Commission (PURC) by two legislative instruments both promulgated in 1997. Each of these Acts has a bearing on RETs.

3.5.1.1 Energy Commission

The Energy Commission Act, 1997 (Act 541) established the Energy Commission with the object of regulating and managing the utilisation of energy resources in Ghana and co-ordinating policies in relation to them. The specific objectives of the Commission contained in Section 2 (2) are as follows:

(a) Recommend national policies for the development and utilisation of indigenous energy resources;

(b) Advise the Minister on national policies for the efficient, economical, and safe supply of electricity, natural gas and petroleum products having due regard to the national economy;

(c) Prepare, review, and update periodically indicative national plans to ensure that all reasonable energy demands are met;

(d) Secure a comprehensive database for national decision making on the extent of development and utilisation of energy resources available to the nation;

(e) Receive and assess applications, and grant licences under this Act to public utilities for transmission, wholesale supply, distribution, and sale of electricity and natural gas;

(f) Establish and enforce, in consultation with the Public Utilities Regulatory Commission, standards of performance for public utilities engaged in the transmission, wholesale supply, distribution and sale of electricity and natural gas;

(g) Promote and ensure uniform rules of practice for the transmission, wholesale supply, distribution and sale of electricity and natural gas;

(h) Receive and assess applications, and grant licences under this Act for refining, storage, bulk transportation, marketing and sale of petroleum products;

(i) Establish and enforce standards of performance for bodies engaged in the supply, marketing, and sale of petroleum product;

(j) Promote competition in the supply, marketing and sale of petroleum products;

(k) Maintain a registry of public utilities, petroleum products marketing companies, retail station and resellers outlets licensed under the Act in the country;

(l) Pursue and ensure strict compliance with this Act and regulation made under the Act; and

(m) Perform any other functions assigned to it under the Act or any other enactment.

An important provision under the Act is the establishment of the Energy Fund in Section 41. The sources of money for the Fund shall be:

(a) Such proportion of government levy on petroleum products, electricity and natural gas as may be determined by Cabinet and approved by Parliament;

(b) Moneys that accrues to the Commission in the performance of its functions; and

(c) Grants.

Monies generated through the Fund shall be applied as follows:

(a) Promotion of energy efficiency and productive uses of electricity, natural gas and petroleum products;

(b) Promotion of projects for the development and utilisation of renewable energy resources, including solar energy;

(c) Human resource development in the energy sector; and

(d) Such other relevant purposes as may be defined by the Commission.

The functions of the Commission in respect of the Fund are as follows:

For purpose of managing the Fund, the Commission shall:

(a) Formulate policies to generate money for the Fund;

(b) Determine the allocations to be made towards the objectives of the Fund; and

(c) Determine annual targets of the Fund.

The Commission is permitted under Section 41 (2) to invest such part of the 'Fund' as it considers appropriate in such manners as may be approved by the Minister in consultation with the Minister of Finance.

3.5.1.2 Public Utilities Regulatory Commission (PURC)

The PURC Act, 1997 (Act 538) established the Public Utilities Regulatory Commission, 1997 (Act 538) to regulate and oversee the provision of utility services by the public sector to consumers and related matters. The specific functions of the PURC, which are listed in Section 3 of the Act are as follows:

(a) Provide guidelines for rates chargeable for provision of utility services;

(b) Examine and review rates chargeable for the provision of utility services;

(c) Protect the interest of consumers and providers of utility services;

(d) Monitor standards of performance for provision of services;

(e) Initiate and conduct investigation into standards of quality of services given to consumers;

(f) Promote fair competition among public utilities;

(g) Conduct studies relating to economy and efficiency of public utilities;

(h) Make valuation of property of public utilities as it considers necessary for the purposes of the Commission;

(i) Collect and compile such data on public utilities as it considers necessary for the performance of its functions;

(j) Advise any person or authority in respect of any public utility;

(k) Maintain a register of public utilities; and

(l) Perform other functions as are incidental to the foregoing.

The main activities of the PURC up till now have been to rationalise the tariff structure by raising electricity prices from their prevailing low level to economic levels. This, it is hoped, will help attract private investment in power generation. Upward review of tariffs is also expected to create a level playing field in the energy sector, for renewable.

3.6 Synthesis

When viewed in the context of the conceptual framework discussed in Chapter Two, it can be seen that Ghana's renewable energy policies have so far tended to favour the use of "measures" more than "economic instruments" in their implementation. A cursory glance at the functions and activities of the NEB reveals that research, development and demonstration as well as education and information were the main measures used. Again under the ESDP, these measures have tended to be the favoured options as evident from both the short and medium term objectives of the Renewable Energy Development Programme (REDP). Subsidies are the only economic instrument explicitly mentioned under the REDP [see section 3.2.4.3. of the ESDP]. Some normative measures – mainly formulation and promulgation of legislations – have been used as well but no standards or targets have been employed. Reforming the energy sector, especially the power sector, has also been embarked upon to revolutionise operations in the power sector. The main institutional reforms have been the setting up of the Energy Commission and the Public Utilities Regulatory Commission, with the later being mandated amongst other things to rationalise the tariff structure in Ghana.

Having said all that, it needs be acknowledged that although subsidy is the only economic instruments explicitly mentioned in ESDP, others economic instruments (although were not mentioned in the ESDP), have been employed during implementation. These are discussed below.

3.6.1 Economic Instruments

3.6.1.1 PV Import Duty Waiver and/or Reduction

In May 1999 the then Minister of Mines and Energy Mr. Ohene-Kena, announced the government's decision to reduce the import duty on solar panels from 27% to 5%. This was after two earlier publications stated that there would be a complete waiver of all duties on panels. Further investigation revealed that the true position is a complete waiver of duty on the panel but the panels still attract value-added tax. According to officials of MME, the 5% represents the value added tax payable on panels. Thus a solar panel imported into Ghana attracts a consolidated 'tax rate' of 5%. Meanwhile all other components of the solar generating set such as batteries and inverters are dutiable and taxable. So we must consider what the impact of this policy directive has been on the PV market.

An attempt was made to compare the market situation before and after the introduction of the policy. However, this was not possible because there were no records on PV imports at the harbour and private dealers were not prepared to disclose business performances. Even if such figures had been available they would not have given a true picture of the effect of the policy on demand because of other exogenous factors such the energy crisis in 1998. This notwithstanding, interviews conducted with key solar dealers pointed to the fact that the policy instrument has not been very effective if the overall objective was to increase the usage of solar PVs. They argued that the waiver or tax reduction does not bring about a sufficiently large reduction in the cost of the system. Furthermore, because the policy was vague, it was subject to the interpretation of customs officials. Most of the dealers suggested that at the least the waiver should have been on all other PV components. Meanwhile one of the dealers opined that instead of the waiver, the government could have collected the duty and paid it into a fund; this fund could then be used to offer credit on favourable terms to people who cannot afford the high start-up costs of PV systems.

3.6.2 Tax Instrument

3.6.2.1 Petroleum Taxes

Since the mid-1980s the Government of Ghana has financed sustainable energy projects using small levies on petroleum products [see Energy Fund below]. The levy, which started at 0.3% of the pump prices for petrol and diesel fuel and slightly less for kerosene, is currently set at one Ghana Cedi (¢) per litre. Using the 1998 annual consumption of petroleum products of about 1.2 million metric tonnes, Tse [1999] estimated that around US$ 600,000 could be generated annually from the tax. These sums are paid into the Energy Fund and used inter alia to promote renewable energy and energy efficient projects.

3.6.3 Financing Scheme

3.6.3.1 Energy Fund

The fund is established under Section 41 of The Energy Commission Act and fed primarily by a proportion of government levy on petroleum products, electricity and natural gas.[22] Monies generated through the Fund are supposed to be used inter alia for the promotion of projects for the development and utilisation of renewable energy resources and rural electrification. Table 3.2 shows the disbursements made from the fund to the technical wing of the MME for a three-year period. As evident from Table 3.2 the apportionment of monies from the Fund is skewed towards electricity planning (National Electrification Scheme). Up to about 64% of total disbursement for each year went into electricity with figures rising in absolute terms from about ¢15 billion in 1996 to ¢24 billion in 1998. These figures far outweigh the allotments for the development of the renewable. Even a comparison with figures for the promotion and development of LPG still leaves the renewable relatively under-financed.

What could be inferred from the above is the fact that limited financial support from the Energy Fund has gone into the development of renewable vis-à-vis other programmes being implemented by MME. It also reiterates a point made earlier that the rural electrification programme was a missed opportunity for the renewable. Had the programme targeted the renewable, several RETs would have been disseminated rather than the money being spent on grid extension.

[22] The levy on petroleum products is ¢1/litre while that on electricity is ¢1.70/kWh

Table 3.2 Payments made from the Energy Fund for Projects within the Technical Wing of the Ministry of Mines and Energy

	1996		1997		1998	
Details of Expenditure	**Recurrent (¢m)**	**Dev't (¢m)**	**Recurrent (¢m)**	**Dev't (¢m)**	**Recurrent (¢m)**	**Dev't (¢m)**
1. Project Monitoring & Management	26.4		28.09		30.39	
2. Corporate Planning & Finance	33.6		41.5		38.0	
3.Petroleum (including LPG)	14.0	4,089	14.03		27.325	5,313
4. Renewable Energy	55.86	339	80.05	339	116.41	
5. Energy Information Centre	31.98		26.51		45.45	
6. Energy Conservation	26.56	1,532	79.76	1,532	252.17	783
7. Resources & Environmental Plg.	13.96		22.83	150	33.99	
8. Electricity Planning	13.0	15,598.2		16,695		24,080
TOTAL	**215.36**	**21,558.2**	**292.77**	**18,716**	**543.74**	**30,176**

Source: Technical Wing, Ministry of Mines and Energy, 1999.

3.6.4 Pricing Instrument

Low electricity tariffs have been cited as one of the main causes of inefficient use of electricity in Ghana. Many African countries including Ghana have tried to overcome this problem through a gradual phase-in of full marginal-cost pricing, especially of grid electricity. This can have a positive impact on the take up of energy efficiency as well as improving the competitiveness of renewable. However this effect is usually weakened or wiped out by high inflation rates combined with strong public objection to the price increase. The government of Ghana accepted the principle of long-run marginal cost (LRMC) pricing for domestic electricity in 1987, but by the end of 1995 residential and bulk supply tariffs had risen only to about 50% of LRMC. In May 1997 tariffs were increased by some 300%. The tariff increases were later suspended following a massive public outcry only to be reintroduced a year later in 1998. It is anticipated that this will inter alia make the unit price of renewable more competitive.

4 RENEWABLE ENERGY RESOURCES AND TECHNOLOGIES IN GHANA

4.1 Introduction

This section of the report discusses the renewable energy resources available in the country. After this it presents the findings on the information collected on past and on-going RET projects. This is done in order to evaluate them in the context of national energy sector development plans and sustainable development policies as spelt out in task 2 of the terms of reference for the project. The RETs projects are grouped into three broad areas namely: biomass, solar (cum wind) and small hydro.

An overview of each area under consideration is presented, followed by a consideration of the availability of this resource in Ghana. Projects which have been implemented are then reviewed and an evaluation done. This enables the RETs suitable for further detailed studies to be identified.

4.2 Biomass Energy

4.2.1 Introduction

Biomass – abbreviation for biological mass – is any organic matter produced by plants, both terrestrial and aquatic. All fuel energy derived from biological sources, whether directly or indirectly, is termed ‘biomass energy’. Examples of biomass include woodfuel (made up firewood and charcoal), wood residues, crop residues and human/animal waste. In Ghana biomass is the dominant source of energy with about 69% of the total national energy consumption being accounted for by biomass in either the direct or processed form [National Energy Statistics, 1998]. It is used in the domestic sector for cooking and many other heat applications such as water heating. Biomass is also used in many commercial and educational establishments throughout the country. Woodfuel is the dominant biomass form used in Ghana. Most rural dwellers, which represent about 70% of Ghana’s population, and a sizeable proportion of poor urban dwellers depend heavily on fuel wood and charcoal for all their domestic and other commercial activities that require heat. .

4.2.2 Resource Assessment

4.2.2.1 Forest Resources

The forest resources in Ghana are categorised into the open (savanna) and the closed (high forest) zones. The savannah zone covers an estimated total area of 9.6 million hectares of which 2.9 million hectares is bush fallow [Nketia, 1992]. The remainder is degraded savannah. The closed forest zone covers a little more than a third of the country's total land area and has a size of about 8.2 million ha, 20% of which is demarcated either as forest reserves or fuelwood plantations [Nketia, 1992]. Altogether forest reserves in the country cover about 2.47 million hectares, which constitute about 10.5% of the total land area. The reserves are categorised into production reserves, covering 1.2 million hectares and protective reserves, covering 1.3 million hectares. The production reserves are managed for sustainable production of timber and non-timber forest products, and the protective reserves managed solely for environmental protection, thus closed to timber exploitation. About 680 tree species have been identified in Ghanaian forests. The estimated national growing stock of wood in 1986 was 322 million tons with a gross mean annual increment of 12.3 million tons [Nketia, 1992].

Although Ghana's forest resources have dwindled considerable – due mainly to unsustainable logging and farming activities – it is still estimated that a total of 1.4 cubic metres of timber can be produced annually for an indefinite period of time assuming a felling cycle of 60 years [FORIG, 1992].

4.2.2.2 Logging Residues

The merchantable wood material extracted from the forest is principally the fairly straight, sound bole volume part of the tree, which constitutes about 49.6% of the total volume of tree. All other parts of the plant such as the stump, butt-end off-cut, crown-end off-cuts and branch wood are considered as logging wastes and left in the forest by loggers. In 1990 an estimated 688,262 tons of residue was generated from logging activities alone. The logging residues are sometimes used for particle board and fibreboard production and sometimes as raw material for the manufacturing of products such as flooring, tool handles, wooden crates and pallets. However in a great majority of cases only a small percentage of logging residues find any use at all.

4.2.2.3 Wood Processing Residue

The processing of timber into lumber, veneer, plywood, etc generates a lot of residue or waste. For example, out of 806,000 cubic metres of log equivalent processed in Ghana in 1993, 518,000 cubic metres (representing some 51.8% of the annual allowable cut[23]) went to waste [FPIB, 1993]. Wood processing wastes can be classified into "solids" and "fines". Examples of "solids"

[23] The Annual Allowable Cut (AAC) is the maximum amount of timber that timber concessionaires are permitted by law to fell in a year.

include barks, slabs, edgings, off cuts, veneer waste and cores. The "fines" include sawdust, planes, shavings and sander dust. The "solids" constitute a greater percentage of wood processing residue produced in Ghana. In 1988, 79% of processing waste was "solids" and 21% "fines" [UNDP/ESMAP, 1988]. Table 4.1 shows production of sawmill residue in Ghana from 1990 to 1994 in cubic metres of Solid Weight Equivalent (m^3 SWE)

Table 4.1: Sawmill Residue Production (m^3 SWE)

Year	*Slabs and edgings*	*Off-cuts*	*Sawdust*	***Total***
1990	*38,220*	*393,120*	*158,340*	***589,680***
1991	*35,490*	*365,040*	*147,030*	***547,560***
1992	*39,935*	*410,760*	*165,445*	***616,140***
1993	*41,510*	*426,960*	*171,970*	***640,440***
1994	*38,850*	*399,600*	*160,950*	***599,400***

Source: Forestry Commission, 1995

From Table 4.1, off-cuts (a solid) are the most abundantly produced sawmill residue. In 1994, for example, 399,400 m^3 SWE out of a total of 599,400m3 SWE of wood residue generated in sawmills were off-cuts. This represented about 67% of the total residue for 1994. Sawdust (a fine) represented about 27% of the residue generated in 1994 with the remaining 6% going into slabs and edgings (solids). The percentages are no different for the other years.

More than half of the wood-processing residue generated in the sawmills is used off-site. Of the residue used off-site, about 30% is used directly as firewood for food preparation, and about 70% converted to charcoal in earth mound kilns. Most of the solids have economic values and are normally sold as domestic/industrial fuel or construction material. On the contrary, the fines (mainly sawdust and shavings) are usually considered as waste material. They normally pose disposal problem to the sawmills. They often have a negative value as resources are employed to burn the material on site or transport to disposal sites elsewhere. However, the common method of disposal is burning of the waste and this causes a great deal of pollution and is a nuisance to the general public.

4.2.2.4 Crop Residue And Animal Wastes

Agriculture is the backbone of the Ghanaian economy contributing about 42% of GDP. The sector is also the main source of employment to the over 65% of the country's population living in the rural areas. All kinds of tropical crops are cultivated in Ghana, which generate a lot of post-harvest residue suitable for the production of biomass energy. Examples of agricultural residue include maize cobs, rice husks, palm branches, shells and nuts. . These residues are normally popular fuels that burn rapidly; they are usually used in relatively small quantities to supplement or augment ignition when the main fuel is forest wood or charcoal. There are many instances where they are used exclusively for heating purposes such as in traditional palm oil processing, fish smoking, small scale smelting and palm kernel oil processing. Table 4.2 below shows the production of some major crops and their residue in Ghana in 1990.

Table 4.2: Production of Some Major Agricultural Residues in Ghana.

Crop	Residue	Residue Production (t/t crop)	Total Crop Production '000 tonnes	Residue Production '000 tonnes
Maize	Cob	1.00	553	553
Oil Palm	Shells	0.45	429	193
Paddy Rice	Husk	0.23	81	19
Sorghum	Stalk	1.00	136	136
Millet	Stalk	2.00	75	150
Groundnut	Shell	0.50	113	56
Total			1,387	1,107

Source: Letus Power Plant, Hagan, 1997.

Another form of energy that can be derived from agricultural waste is in the form of animal waste. Livestock rearing is a major occupation of people living in the northern regions of Ghana. A lot of dung is therefore produced each day and this can be used as a major feedstock of biogas plants. In addition there are abattoirs and slaughterhouses in many cities and towns in the country and a lot of dung is generated. Biogas is the product (mainly methane) of the biological action of certain bacteria on organic matter such as dung. The resulting combustible gaseous product can be used like LPG in stoves for cooking, gas lamps for lighting and be used to provide motive power for water pumping and grain milling applications.

4.2.3 Implemented Projects And Studies

Biomass conversion technologies currently being used in Ghana are very inefficient with as much as 89% of the biomass going to waste. This section on biomass tries to review the many studies and renewable energy technologies projects undertaken to date in Ghana. They are then evaluated in terms of their viability and environmental impacts. Attention is also given to the reasons for the success or failure of the projects. Seven main technologies covering all biomass projects undertaken in Ghana are considered and reviewed. What follows is a summary of the main findings.

4.2.3.1 Pyrolysis

A six-tonne pyrolytic plant fuelled on sawdust was set up to provide alternative fuel oil for brick kilns at the Building and Road Research Institute (BRRI) in Kumasi in 1980. BRRI had financial assistance from USAID and teamed up with personnel from Georgia Institute of Technology (GIT), USA, to set up this plant. This demonstration plant which was only 6% to 13% efficient is no longer in operation.

Evaluation and Lessons Learnt

Problems encountered included poor supply cycle of raw materials, inefficient drying of sawdust and manual process control leading to low yields. Lack of funds for major repairs and modifications was also a major problem. A well planned management team involving the organised participation of potential commercial users with good technical support was seen as the solution to achieving a self sustaining plant which could have given a payback of about three years.

4.2.3.2 Improved Cookstoves

The Ministry of Mines and Energy is the pioneer of the dissemination of improved Charcoal Cookstoves (Ahibenso) in the country. The Ministry's project started in 1989 and dissemination began in 1992. This project is still on going. Another project being carried out involves sawdust cookstoves. This project is being managed by the Agricultural Engineering Department of UST with support from GTZ. The project commenced in 1983. The BRRI and other private entrepreneurs have been identified to have various designs of cookstoves on the local market.

Evaluation and Lessons Learnt

The technology is only effective in the urban areas where income levels are not so low and where stoves are already being bought (regardless of their efficiency). About 30,000 Ahibenso and 5,000 sawdust stoves are known to have been disseminated. Benefits of improved stoves range from savings in amount of fuel to reduced cooking time, reduced accidental burns and cleaner, more hygienic cooking conditions. Problems with sawdust stoves and other improved cookstoves are principally lack of funds for promoting agencies, social acceptance of these stoves and poorly organised marketing strategies.

4.2.3.3 Biomass-Fired Dryers

The technology considered under this category is locally produced equipment for use by farmers for drying their crops. The projects identified are a GTZ support programme at the Agricultural Engineering workshop at the Kwame Nkrumah University of Science and Technology (KNUST) and a private venture. The technology has not been commercialised as yet. The dryers manufactured are used for drying agricultural produce such as maize and by poultry farmers for drying feed.

Evaluation and Lessons Learnt

The design and manufacture of the dryers are done locally. Maintenance is likewise done locally as and when necessary. About four main units have been disseminated so far and the technology though in its initial stages with no organised management has been quite successful.

4.2.3.4 Sawdust Briquetting

The largest sawdust briquette project was a 2,200 tons/year capacity plant producing uncarbonised sawdust briquettes. This was a private effort by a Taiwanese entrepreneur and a Ghanaian partner at Akim Oda in the eastern region of Ghana. The plant operated for 5 years (1984-1989) before it collapsed. A new private plant is known to be in operation in Kumasi but products from this plant have not as yet entered the market; specimens are still being tested. Apart from manufacturing briquettes, there are plans by management to design a special residential cookstove that will use the briquettes to be produced.[24]

Evaluation and Lessons Learnt

The briquettes produced by the Akim Oda plant were found to be too expensive. Secondly, they could not be used in the domestic sector since no cookstove were designed for briquettes. They were mainly targeted at commercial consumers like brick makers and bakers and the demand for the briquettes were very high (in spite of the cost), in some cases far outstripping the supply. Nevertheless, there were some problems, which included operational inefficiencies, inadequate sawdust drying capacity and poor storage facilities for the sawdust. The main problem however was poor management, which led to the closure of the plant in 1989.

4.2.3.5 Biogas

There are a number of interesting biogas projects that are currently on-going. These include:

- MME's biotoilet at Ofori-Panin Secondary School: Initiated in 1996, this facility produces gas for lighting the toilet and its surroundings.
- MME and Institute of Industrial Research (IIR)'s demonstration project at Appolonia: Gas produced is used for direct cooking in 27 homes as well being used together with diesel in a mini-grid producing 12.5 kW_{el}.
- A 100m^3 digester capacity plant utilising human waste commissioned by Guinness Ghana Limited and Water for Life (UK). Gas generated is used for community lighting, cooking in a local school and to run a community corn mill.

Evaluation and Lessons Learnt

[24] Sawdust briquettes are usually unsuitable for residential users partly due to the need for special cookstoves they would use.

Biogas can facilitate decentralised electricity generation as well as serving as a low cost waste recycling process. However studies in 1994 by the MME indicated that the cost of using biogas to generate electricity was 14 times higher than the cost of generation from hydro. Secondly the use of biogas as fuel for cooking is unpopular.

4.2.3.6 Cogeneration

Two sawmills – AT&P in Samreboi and STP in Kumasi – have been reported to be currently producing heat and power simultaneously using their processing waste. Other progress in this area comes mainly from studies on commercial power production from sawmill waste and agricultural residues. Studies to date include:

- Quaye, E. C. (1988)“Potential For Cogeneration from Wood Residues: Case Study of Three Cities In Ghana”.

- Hagan, E. B. (1997) “Pre-feasibility Study on Letus Power Plant”.

- KITE, (1999) “Prefeasibility Study on a Wood Waste Power Plant for MOW”.

Evaluation and Lessons Learnt

Low electricity tariffs prevailing in Ghana have been responsible for the virtual absence of this technology in the country. All studies to date indicate that where electricity is priced at full economic cost, the economics of cogeneration is very attractive. KITE’s 1999 study established that Maxwell Owusu Timbers could generate 1 MW_{el} from all their own wood processing residues. The internal rate of return was 21 –27% with a discounted payback period of 5 – 7 years.

4.3 SOLAR AND WIND ENERGY

4.3.1 Overview

Solar energy is one of the most clean and sustainable energy forms in the world. . Ghana is generously endowed with solar energy (particularly in its Northern regions) receiving an average annual solar radiation of 16-29 MJ/m^2. Conditions are therefore ideal throughout the country for the exploitation of Ghana’s solar energy resources through various conversion technologies. Solar energy already makes substantial (but unquantified) contribution to the nation’s energy supply. Applications include traditional activities such as sun drying of crops, fish, fuelwood and clothes. Many wood processing and brick and tile industries also rely heavily on direct sun drying. However, application of solar technologies in Ghana is rather small, mostly confined to the areas of telecommunications, rural health installations and water supplies [MME, 1998].

4.3.2 Resource Assessment

4.3.2.1 Solar

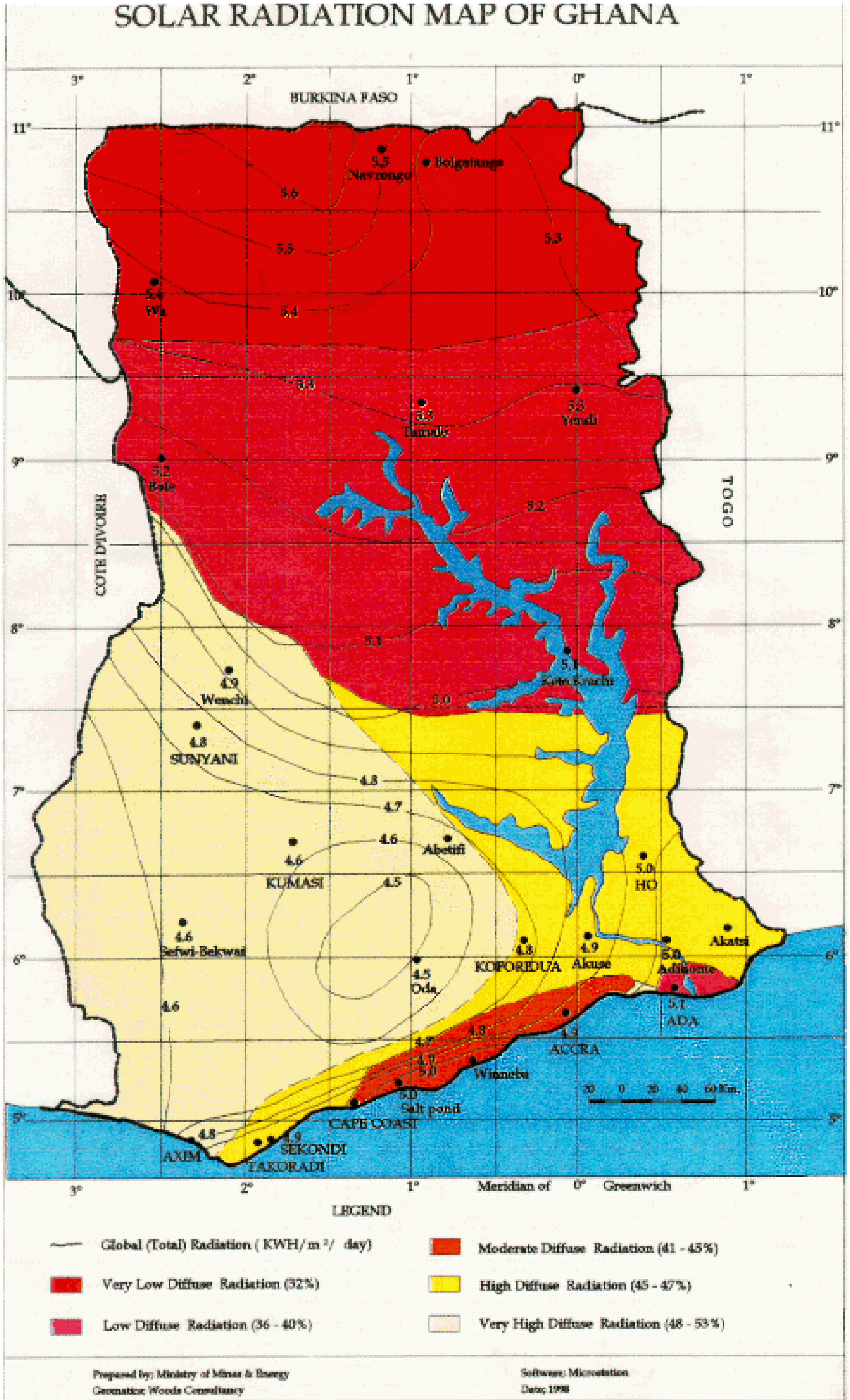
By virtue of her location in the tropics (between lat. 4^{o} and 12^{o}N and longitude 30^{0}W and 1^{o}E), Ghana is well endowed with solar energy resources, receiving daily solar irradiation of between 4 and 6 kWh/m^2 and a corresponding annual sunshine duration of 1800 - 3000 hours. The MME has developed a solar map of the country (Figure 4.1), which is useful for the design and installation of solar systems. The map shows that most of the Southern parts of the country have very high diffuse radiation levels (over 45%) with the North having moderate levels of diffuse radiation (between 32 and 45%).

4.3.2.2 Wind

Until recently[25] wind speeds in most parts of the country had been assessed to be low and inadequate for power generation. Figure 4.2 below depicts the generally low wind profile observed across the country. However the perception of Ghana having low wind profiles is gradually changing with new and improved instrumentation and measuring heights. Studies by the Energy Commission and other private concerns have identified sites along coastal Ghana with wind speeds adequate for power generation. This discovery has rekindled interest in wind energy in Ghana but so far no wind park has been established in Ghana

[25] As recent as 1999 and 2000

Figure 4.1 Solar Radiation Map of Ghana



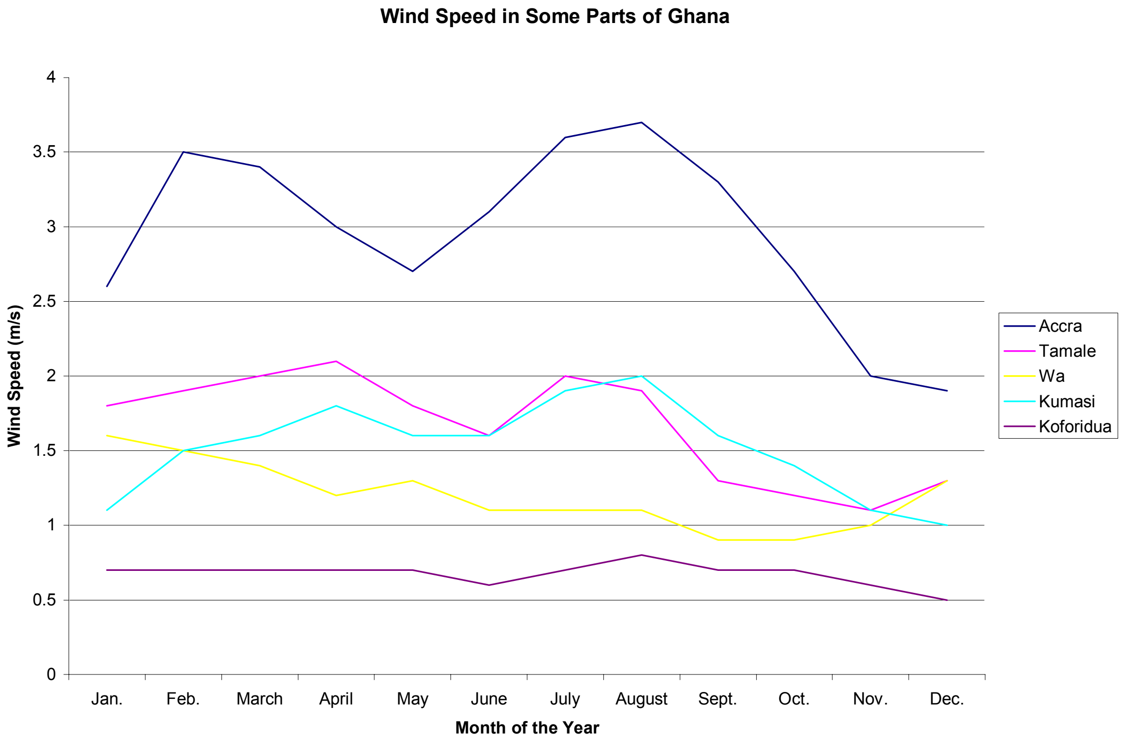


Figure 4.2: Wind Speed Variation in Some Parts of Ghana

4.4 Implemented Solar Projects

4.4.1 Solar PV Systems

Projects employing PV technology include:

4.4.1.1 The DANIDA / Ministry of Health (MOH) Solar Project

Under this project, the MOH has received solar energy units in some hospitals and clinics in 9 regions of the country. The project has so far installed 15 solar refrigerators, 4 solar water pumps and 14 solar water heaters in 29 different sites. Many solar powered communication devices have also been installed under this project. In addition most of the sites are equipped with 3 portable solar powered lights, each comprising a 14W panel and a rechargeable fluorescent light. The main beneficiaries have been remote areas, particularly in the Upper West Region [DANIDA, 1999].

The project is wholly supervised and implemented by DANIDA personnel in close collaboration with Danafco Engineering (DENG)

Key Findings and Lessons Learnt

The impact of this project has been felt very strongly on storage of vaccines remote communities. This has provided strong supports for Ghana's vaccination campaign, which include mobile programmes where ice packs are needed to preserve the vaccines. The solar pumps and heaters installed so far have almost been problem-free. Three different solar heaters have been installed. These are Solarhart, Alpha and DENG.[26] So far the Solarhart systems is proving to be more efficient. It is followed closely, in terms of efficiency, by the Alpha. The main problems encountered in this project are bad co-ordination, poor installations and lack of consistent leadership. There is lack of co-ordination between technical advisors and administrators of the project, especially when it comes to purchasing equipment and sub-contracting. This has resulted in many faulty or poor installations by mediocre contractors culminating in equipment failure. Frequent change and/or transfer of leadership have also created distortions in manning and supervision [Interview with DANIDA Chief Project Advisor, 2000].

4.4.1.2 TU-Berlin/UST Solar Pump Project

The Mechanical Engineering Department of KNUST in mid 1995 received a GTZ grant to construct, install, test and evaluate the performance of a PV radial flow centrifugal water pump in collaboration with the Technical University (TU) of Berlin. The aim of the project is to identify and recommend a suitable solar powered irrigation pump for rural communities. The research team has so far designed and fabricated a centrifugal pump, which is being run in a test tank on a 330W D.C. motor. A 600W PV array supplies power to the motor and also to electronic measuring devices and data loggers [Williams, 1998].

4.4.1.3 CIDA-University Of Regina/UST Renewable Energy Project

This project is a combined effort between the University of Regina, Canada, and KNUST, Ghana, with funding provided primarily by the Canadian International Development Agency (CIDA). The participating universities are also making a substantial in-kind contribution. The project which started in 1992 has an overall goal of strengthening the capacity and capability of KNUST to respond more effectively to national developmental priorities and aspirations, particularly the practical implications of rural development as well as the need for self sustaining economic growth" [Catania and Kessey, 1988]. The purpose of the project was to transfer essential skills through teaching, on-the-job training, field training and developmental research activities in areas of biomass, biogas, solar, energy policy and planning, socio-cultural-economic and environmental issues, as well as extension and community outreach programmes.

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[26] The Solarhart is produced by Solarhart Industry, an Australian Company; the Alpha produced by Sole S. A., a Greek company; and DENG's system produced locally by Danafco Engineering.

The project has so far saw the establishment of Solar Service Centres (SSC) in three communities in the country. The following are the major achievements of the project:

1. The project has designed and installed solar battery charging services including solar distilled water plants at the SSCs in the three communities. Small Solar Home Lighting Systems (SOHLS) and Battery Operated Home Systems (BOHS) have also been sold under a hire purchase scheme to people in the pilot areas.

2. The project has designed, manufactured and sold nearly 100, 18W fluorescent lamps, 100 Battery Cut -outs (LVD) and 60, 5W Halogen Lamps. The traditional kerosene lantern has been modified to operate on solar charged batteries (K-Electric Lanterns).

3. Following the success story of the pilot centres, the MME in 1997 and 1998 contracted the project team to build two SSCs at Appolonia in the Greater Accra Region and Wechiau in the Upper West Regions of Ghana. The Wechiau centre has battery charging facilities, lights, TV, radio, fan and solar distillation units. Forty-one domestic homes at Wechiau have also been equipped with BOHS on hire purchase basis.

4. In collaboration with NGO's such the Energy Research Group (ERG) and Ghana Solar Energy Society (GHASES) and with the support of MME, the project has organized training workshops for technicians, engineers, entrepreneurs and some "solar enthusiasts".

Key Findings and Lessons Learnt

Socio-economic surveys conducted under the project have revealed that rural communities rate rural lighting, as one of their top developmental needs. The project established that using solar PV to charge batteries for TV and radio operation was financially profitable and therefore carried out the installation of centralised battery-charging stations. However, the earnings from the Battery Charging Centre was very low even with 2 lines each capable of charging a 50AH battery daily. It was found that this was due to the fact that nearly all the batteries were unserviceable car batteries. The project therefore decided to offer a hire- purchase scheme for co-operative members to acquire new batteries. It was also revealed that it is economical to replace kerosene lanterns with portable 5W halogen lights. Furthermore, some individuals were able to buy their own 66W PV systems and pay them off in less than a year, suggesting high ability to pay within the community.

4.4.2 The Ministry of Mines and Energy's Projects

4.4.2.1 The Wechiau Project

This is a National Solar Energy Programme to assess, demonstrate and evaluate the technical, economic and social viability of appropriate solar technologies to support the government's rural development programmes. The project is demonstrating and evaluating the concept of integrated solar power in Wechiau, a village in the Upper West Region through a government fund worth 84 million cedis. The project was implemented with the support of KNUST.

4.4.2.2 The Spanish Solar Project

The Spanish Government has offered MME a concessionary loan of US$5 million to implement off-grid solar electrification in 10 villages. As at 1998, 975 home systems had been installed in 5 villages. A total of 1600 home systems, 5 school systems, 4 community systems, 2 solar pumps and 200 streetlights is expected to be in place by mid–2000 The systems are being offered to households on fee-for-service basis [MME, 1998].

4.4.2.3 The UNDP/GEF Project

The project involves preliminary studies for using solar energy to electrify 13 remote villages in the Mamprusi East District in the Northern Region through encouraging the adoption new of technologies. Primarily PV and PV/diesel hybrid power systems are being employed. These technologies will be used for individual applications and centralised electrification of off-grid communities not technically or economically viable for electrification through the national grid extension. GEF is providing a grant of $2.5 million dollars whilst the Ghanaian Government is contributing $0.5 million. The project was conceived as a pre-investment project, designed to spearhead future investments by private sector or in public-private partnership, in rural energy and infrastructure service companies. The project is scheduled to be implemented over a four-year period, i.e. 1996-2000. [MME, 1998; Abavana 1999]].

It is anticipated that the impact of the project will include the establishment of Africa's second private-sector renewable energy-based rural energy services company (RESCO), to provide electricity services to off-grid communities for household, community, and economically productive uses.

Socio-economic surveys and evaluation exercises have been completed. Computer simulations have been conducted at the National Renewable Energy Laboratory (NREL), USA using local climatic data to design various electric generators. The household energy/economic survey indicated that the inhabitants of the selected communities are willing and capable of paying for a variety of desirable and useful energy services [Abavana 1999].

4.4.2.4 Streetlight Projects

Forty-six solar streetlights have been installed on three university campuses by MME to determine the feasibility of using them to replace conventional streetlights [MME, 1998].

4.4.3 The Ministry of Health's Solar Refrigerating Project

In April 1987, the Ghana Supply Commission signed an agreement with the Swiss company RJM to supply 30 PV refrigeration systems (PVR) to the Ministry of Health (MOH). The equipment was supplied that same year but the company RJM wound up its activities and operations in 1989 and appointed the local agent RELTUB to do the installation. Three months after the installation of the PVR's, they all ceased to function. A consultant appointed by the World Health Organisation (WHO) to review the systems recommended that parts of the PVR's be replaced with new ones. Through the World Bank, the MOH requested UNICEF to order new replacements [Puplampu, 1992]. The main causes of the PVR failures were found to be to low quality equipment, wrong installations and poor user training to handle the equipment. Measures taken by the MOH to rectify the problems yielded great dividends due to improved supervision and a proficient technical framework to support such a project. Thus this solar refrigeration project is a prime example of the successful application of PV technology in Ghana.

4.4.4 Solar Thermal Systems

4.4.4.1 Evaporative Cooler for Food Storage

This project, which was managed by the Department of Mechanical Engineering at KNUST, was utilising passive cooling techniques, particularly evaporative cooling for preserving agricultural produce. The project was conceived in 1974 by two members of the Department and received funding in 1979 when the co-operative programme in Alternative Energy Resources was initiated. The programme was sponsored by the Federal Republic of Germany acting through the German Agency for Technical Co-operation, *Gesellschaft fur Technische Zusammenarbeit* (GTZ). The first object of the project was to design, construct and test systems, which utilise alternative energy sources. The second object was to select and develop promising models into prototypes for field demonstration and evaluation.

Findings and Lessons Learnt

The results of the project indicated that even under humid tropical conditions, the passive evaporative cooler could be successfully employed to reduce the ripening rates of matured green plantain and tomatoes. The quality of chamber-ripened items was better as compared to those ripened naturally. However, the cost of the materials required for the construction of the unit was too high for the ordinary farmer. The project recommended the replacement of all the expensive materials like galvanised sheets with locally available ones like bamboo to make the unit more affordable [Akuffo and Kwame, 1983].

4.4.4.2 Ministry of Mines and Energy's Solar Thermal Projects

MME has installed two solar crop dryers on a pilot basis. The systems have since been sold to a private company Cashpro, who dries crops for export. Effective strategies are being formulated to diffuse the technology and encourage its commercialisation [MME, 1998].

The Ministry has also embarked on pilot projects to demonstrate the feasibility of deploying Solar Water Heaters (SWHs) in the commercial and domestic sectors of the economy. This effort is expected to lead to the formulation of a comprehensive information database on hot water generation and utilisation patterns in Ghana. In this vein the MME contracted a vocational institute – Abetifi Vocational Institute – to produce and install 30 SWHs with a total capacity 2,100 litres in 4 hospitals.

Findings and Lessons Learnt

The SWHs produced hot water of average temperature 49^0C in the afternoons and 35^0C in the mornings. The maximum temperature recorded was 63^0C. Unfortunately, no hot water is produced by the system on cold days and the output of hot water in the mornings is very low, much to the disappointment of the users. Generally, these systems have not been impressive with regards to performance and reliability. This is attributed to the fact that these are first generation of SWHs.

4.4.4.3 The Cylindro-Parabolic Solar Collector Project at KNUST

The Solar Energy Laboratory of the Department of Mechanical Engineering, KNUST, in collaboration with STEVEN Foundation of the USA embarked on a project, which involved the construction and testing of cylindro-parabolic solar collectors. These concentrator collectors were meant to generate steam for a solar pump and ammonia for a solar refrigerator.

Findings and Lessons Learnt

The device could provide 4 hours of pumping on a clear day and results showed that the collector could also be used for cooking within the period of 11am to 4pm. Though the project results were impressive, it failed to make any major impact on the society. This was due to the technology being so new, and hence sophisticated and expensive. [Obeng, et. al, 1986].

4.4.4.4 The Thermiosiphon Solar Water Heater Project at KNUST

The Solar Energy Laboratory of the Mechanical Engineering Department, UST constructed and tested a thermiosiphon solar water heater (TSWH). The average temperature obtained was about 55^0C between 8am and 4pm. The heat loss during the night was not significant. An analytical model was further developed to predict its long-term performance and hence its economic viability. The project failed to make an impact on the commercial sector due to the fact that it was set up purely for academic purpose [Akuffo, et. al, 1988].

4.4.5 Solar Technologies in Perspective

The above analyses have revealed the status, barriers and opportunities of specific solar technologies in Ghana. Table 4.3 below is a fisheye view of the features of various solar technologies available or potentially available in Ghana.

Table 4.3: Solar Technologies in Perspective

Solar Technology	***Status in Ghana***	***Barriers***	***Opportunities***
Home Systems, etc	Commercialisation is underway in both rural and urban areas.	High cost, low information & education, lack of standards	*Production* of components; *Marketing* of systems
Battery Charging Station	Demonstration and commercialisation	Long payback period Equipment abuse Training required	*Production* of components; *Commercialisation*
PV Refrigeration	Application confined to health sector.	High cost, poor user handling, system sizing	
Communication	Institutionally based	High cost	
Water Pumping	Community based		Custom designs
PV Utility Systems	Absent	No investment mechanism	Grid Integrated systems Standardization Utility privatisation
Cooking	Limited activity	Cooking time is dependent on the weather condition and the quantity of food being cooked Cooking has to be done outdoors	*Solar Ovens* could make an impact (as in Uganda etc) *Replacement* of woodfuel in domestic and small-industrial sectors
Drying	Limited	High costs Poor dissemination Low response from private sector	*Promotion* of food storage in agric sector *Cost* reduction measures *Commercialisation*
Evaporative cooling	Widely unknown Few past experiments	Ignorance Technological barriers	*Promotion* of food preservation
Water heating	Very few systems Production unit exists	Poor dissemination, low private sector involvement	*System* could serve several hotels, clinics *Potent* energy saver
Distillation	Few demonstrations	Information barriers;	Rural water treatment
Water treatment (UV, pasteurisation)	Widely unknown Few past experiments	Lack of demonstrative projects	Rural water treatment

4.4.6 Wind Energy Projects

Two companies, one each from UK and Germany, have signed a letter of intent with the Ministry to assess wind energy resources along the eastern part of the coastal belt as a prelude to establishing wind farms [MME, 1998]. The results of the German study have indicated that with the right technology, heights of measurements and tariff structure the first ever wind farm in West Africa could be in place in Ghana by 2001.

4.5 SMALL HYDRO POWER

4.5.1 Definitions

Hydropower can be classified into large, small, mini, micro and Pico, depending on the capacity of energy that can potentially be generated. There is no international consensus on the definition of Small Hydro Power (SHP): the upper limit varying between capacities of 2.5 and 25 MW in different countries. However, a value of up to 10 MW is becoming generally accepted [REW, 1999]. Also there seems to be some consensus as what constitutes a “Pico hydro system”, that is, a hydro installation of less than 10kW. The same however cannot be said of “mini” and “micro” hydro. These two categories of hydropower have been variously defined. For instance there is not a uniform classification of micro and micro hydro with various authors setting different upper limits for micro hydro technology.[27] In Ghana there is no clear classification of hydro plant sizes at all either. KITE is therefore proposing the following classification for the various categories of hydropower to be adopted in Ghana.

Hydro Classification	Capacity
Large	Greater than or equal to 500MW
Medium-sized	<500MW and >10MW
Small	<10MW
Mini	<500kW
Micro	<500kW and >10kW
Pico	<10kW

From the classification above, it can be said that mini, micro and Pico hydro are all subdivisions of small hydro since they fall within the < 10MW upper limit. Hence in this section and throughout the rest of the report, we will use the term ‘small hydro’ to incorporate all hydro systems less than 10MW, therefore incorporating mini, micro and Pico hydro systems.

[27] See REW, July, 1999; Khennas and Barnett, 2000; Taylor, 1990; Hothersall, 1984.

4.5.2 Resource Assessment

Until late 1997 and early 1998, virtually all of Ghana's electricity was produced from two hydro dams at Akosombo and Kpong, which have a combined installed capacity of 1,072 MW. It is estimated that Ghana may have the potential for additional 2,000 MW of hydropower.[28] About 1,205 MW of this total is expected to be produced from proven large hydro sources while the rest will come from medium to small hydro plants.[29] According to Odai [1999], about 70 SHP sites have been identified in Ghana. Appendix 2 contains a list all identified SHP sites in Ghana.

Preliminary studies to assess the SHP potential of Ghana began in 1979 under the auspices of the then Architectural Engineering Services Corporation (AESC) – now AESL.[30] About 40 potential small hydro sites were identified based on analysis of available data including topographical sheets. Later, under a Ghana-India Technical Co-operation Agreement, funds were released for the development of the first pilot SHP schemes at a site near Likpe-Kukurantumi on the Dayi River, in the Volta Region. Unfortunately, this project was never completed.

Then in 1982, the Government of Ghana issued new guidelines for the energy sector. This included plans to develop SHP schemes up to 500kW to provide decentralised electric power to isolated rural communities. To achieve this objective, the Ministry of Fuel and Power (as it was then called, now MME) commissioned AESC to carry out a systematic assessment of SHP potential in selected regions in Ghana. The selected regions were those that did not feature in the medium term plans for extending the national electricity grid. In December 1985 and December 1986, the AESC, in collaboration with the Technical Division of the then Ministry of Fuel and Power, completed interim reports on Phase I and Phase II of the micro-hydro component of the 'Ghana Energy Project'. The two phases cover an assessment of 14 potential SHP sites, markets for the power to be generated, preliminary layouts and sketches, as well as cost and benefit estimates.

Following the AESC studies, ACRES International[31], in 1991 - under the National Electrification Planning Study (NEPS), carried out another study, which covered the following areas:

- A review of the studies undertaken by AESC. This review included analysis of basic data (hydrology, plant parameters, layouts) as well as the assessment of the feasibility and attractiveness of the considered sites;
- An economic assessment of three representative projects;
- An extrapolation of the representative projects in order to assess the small hydro potential of Ghana;
- Development of a work plan for the future comprehensive inventory of Ghana's small hydro potential; and
- An outline of technical and technological problems related to investigations, engineering construction, and operation & maintenance (O&M) of SHP projects in Ghana.

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[28] Ampofo, K. (1998)
[29] Akuffo, F. O. (1998)
[30] AESL stands for Architectural Engineering Services Limited.
[31] ACRES International is a consulting firm from Canada. It has for many years been undertaken consultancy services in Ghana, mainly for the Volta River Authority (VRA).

ACRES International investigated 16 small hydro sites in their study –14 of them were carried over from Phase II of the AESC study – and two sites were newly identified. Table 4.4 contains characteristics and potential output of SHP sites studied in Ghana while Figure 4.3 shows the location of studied SHP sites.

Table 4.4: Studied Mini-Hydro Sites

No	Mini-hydro Project	River	Heads (Gross) (m)	Installed Capacity (kW)	Potential Output at Site (MW h)
1	Wli Falls	Nuboi	264	325	10,747
2	Nuboi River downstream of Wli Fall	Nuboi	38	45	1488
3a	Tsatsadu Falls I (Falls only)	Tsatsadu	54	100	3343
3b	Tsatsadu Falls II (rapids below falls)	Tsatsadu	38	70	2340
3c	Tsatsadu Falls I+II	Tsatsadu	92	170	4683
4	Menusu	Menu	7.5	65	2178
5	Ahamansu	Wawa	6.2	125	4201
6	Dodi Papase	Wawa	9.2	210	7015
7	Asuboe	Wawa	6	100	3340
8	Sanwu Falls	Sanwu	80	20	701
9a	Nworannae Falls A	Nworannae	24	12	560
9b	Nworannae Falls B	Nworannae	40	20	933
10	Randall Falls	Pumpum	16	4	422
11	Fuller Falls	Oyoko	15	7	698
12	Kokuma Falls	Edam	27	60	1751
13	Nkoranza	Fia	4.3	35	981
14	Maaban	Kwasu	12.2	15	604
15	Buomfoum Falls	Ongwam	18.5	10	292
16a	Wurudu Falls A (falls only	Wurudu	39	30	668
16b	Wurudu Falls B (falls & lower rapids)	Wurudu	60.5	45	1003
17	Likpe-Kukurantumi	Dayi (V/R)		400-600	

Sources: ACRES (1991)) & Ampofo (1998)

ACRES International in their study also came up with a rough assessment of the Ghana's SHP potential. . The approach used in this estimation was as follows:

- Estimate the number of technically viable sites which could be developed within a framework of 15-20 years;
- Extrapolate the characteristics (capacity, output) for the already investigated set of representative projects to the technically viable sites identified above.

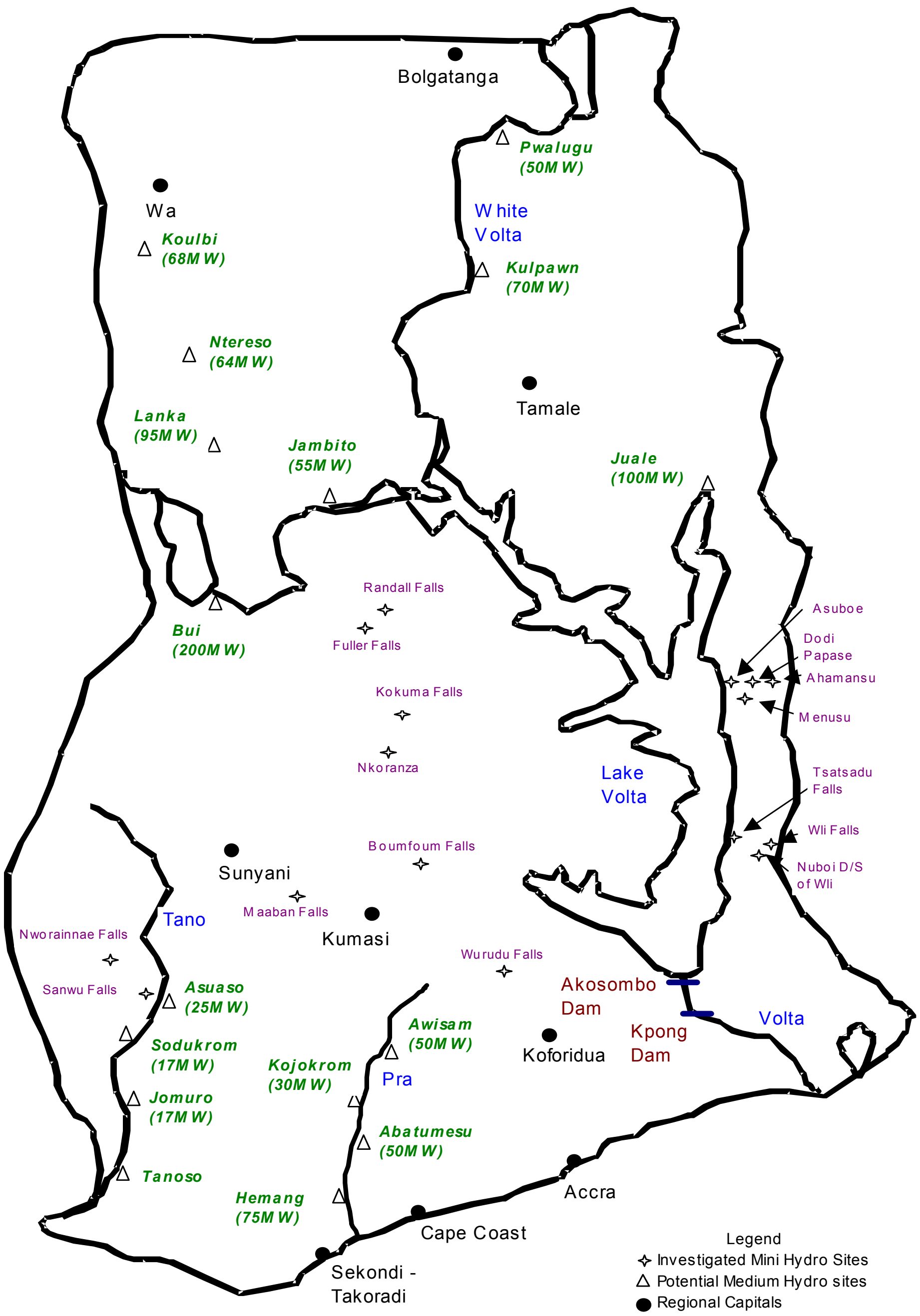

Figure 4.3. Map of Ghana Showing Identified Medium and Small Hydro Sites

The number of potential viable and implementable sites was then estimated for several scenarios – minimal (cautious), maximal (optimistic) and medium. Under these assumptions, the small hydro potential of Ghana was assessed as contained in Table 4.5 below.

Table 4.5: Estimated Small Hydro Potential of Ghana

			Scenario		
	Unit	**Typical SHP Project**	**Minimum**	**Medium**	**Maximum**
Number of Plants envisaged	-	-	15	30	50
SHP Plants Sized for Supplying Isolated Consumers					
Installed Capacity	KW	75	1125	2250	3750
Potential Output	MWh/yr	600	9000	18000	30,000
Output absorbed by Isolated consumers	MWh/yr	240	3600	7200	12000
Savings in diesel fuel	10^6L/yr	85	1275	2550	4250
SHP Plants Sized for Connection into Grid					
Installed Capacity Of which: firm	KW KW	275 75	4125 1125	8250 2250	13750 3750
Output	MWh/yr	1360	20400	40800	68000
Of which firm[1] (to local consumers)	MWh/yr	240	3600	7200	12000
Secondary	MWh/yr	1120	16800	33600	56000
Savings in fuel Conventional fuel (6000 cal/g)	t/yr	335	5025	10050	16750

Source: ACRES International, 1991

When considered as simple run-of-river projects, sized to provide power to rural communities not connected to the national grid, the aggregate SHP potential of Ghana was estimated to be around 1.2 MW installed capacity for the minimum scenario and 4 MW installed capacity for maximum scenario. However, this installed capacity could be increased considerably if the SHP plants could be connected to the national electrical grid, which would absorb the excess energy output. Under this scheme, the SHP potential of Ghana, for the same sites, was estimated to be around 4 MW installed capacity for the minimum scenario and 14 MW installed capacity for the maximum case scenario.

Based on this assessment, ACRES International [1991] described the SHP potential of Ghana as "modest". They concluded inter alia that the development of small hydro in Ghana "could only have a marginal effect on the overall fuel and energy balance of Ghana. They however pointed out that the SHP technology could play a very important role in widening the implementation of rural electrification programmes thereby accelerating the incorporation of otherwise isolated communities into the mainstream of economic and social development."

4.5.3 Potential Projects

In spite of the fact that Ghana is not well endowed with SHP sites that can produce several MW of power, the technology has an excellent economic profile. In the AESC study for instance, all the 14 sites studied were adjudged to be economically viable. ACRES International [1991], having reviewed the work of AESC, found that at least 6 out of the 16 sites they reviewed were technically feasible and economically viable. The main characteristics of the six projects (which they termed representative projects) are as contained in Table 4.6 below.

Strangely enough none of the sites has ever been developed to date. The closest Ghana has come to developing its small hydro sites is the Likpe-Kukurantumi project on the Dayi River. After initial preliminary investigation and the construction of a dam, a 100kW turbine unit was imported from India. Unfortunately, this generating facility was never installed and it is to date lying at the Electricity Corporation yard in Accra. No official reason has been given for the abrupt termination of a project that was near completion (though the grid has now been extended to this area) nor has any been given for the non-development of the other recommended sites.

Table 4.6: Parameters of Representative SHP Projects

No.	Project	River	Region	Plants Working Isolated			Plants Tied to Grid		
				Installed Capacity (kW)	Potential Output (MW h/yr)	Energy Delivered (MWh/yr)	Installed Capacity (kW)	Total Output (MWh/yr)	Firm (MWh/yr)
1.	Wli Downstream	Nuboi	Volta	45	363	145	160	845	145
2.	Tsatsadu Falls	Tsatsadu	Volta	170	1368	547	820	3630	547
3.	Asuboe	Wawa	Volta	100	805	322	225	1540	322
4.	Nworannae Falls	Nworannae	Western	20	163	65	130	590	65
5.	Kokuma Falls	Edam	Brong-Ahafo	60	483	193	150	820	193
6.	Wukudu Falls	Wukudu	Eastern	45	362	145	160	755	145
	Average for Group (rounded)			75	600	240	275	1360	240

Source: ACRES International, 1991

5. BARRIER ANALYSIS - BIOMASS TECHNOLOGIES

5.1 Introduction

Out of the many biomass technologies reviewed in Chapter 4, four in particular – biomass fired dryers, sawdust briquetting, sawdust stoves and biogas – have been selected for detailed analysis. The selection of the technologies was based on their potential contribution to socio-economic development, potential for application, availability of information on barriers and environmental impacts and benefits. For all four technologies, information on barriers and how to remove barriers was solicited from local experts and institutions, such as MME, as well as from manufacturers, installers and users/consumers of the products through the administration of questionnaires. Interviews were also conducted, which brought out unbiased and useful information and ideas. In many cases, sites were visited and the various products seen in operation to ascertain things at first hand. The findings from barrier analysis for these four technologies are presented in the second, third, fourth and fifth sections of this chapter.

As part of the barrier analysis process, participants at the 2nd Stakeholders' Workshop were given the opportunity to undertake further analysis of the barriers and barrier removers identified during the desk studies and the surveys, for biogas. The results of that exercise are presented in sixth section of this chapter. The main conclusions are presented at the end.

5.2 BIOMASS DRYERS

5.2.1Background

Only locally produced dryers used by farmers for drying were considered under biomass dryers. The Agricultural Engineering Workshop of KNUST is a pioneer in this technology. The only other known manufacture of biomass dryers in Ghana is a private concern called "Duela Ventures". The dryers are used for drying agricultural produce on a commercial basis and by poultry farmers for drying feed. Three to four main units have been distributed thus far.

5.2.2 Socio-Technical

5.2.2.1 Resources

Biomass dryers are fuelled basically on solid woody materials in the form of forest wood and solid sawmill residues. The farther the dryer is from active sawmill activities, the more likely is the use of forest wood. Fuelwood, both from the forest and sawmills, can be quite scarce and thus expensive during the rainy season. Solid sawmill residue, the alternative for forest wood, (which constitutes about 79% of the total waste) has competitive uses in the wood-processing sector itself and in the domestic sector as well as the construction industry.

5.2.2.2 Technological/Technical

Biomass dryers have so far been proven to be technically ready for the commercial and industrial sectors of the country. Current users have not experienced any major technical problems although the users think some improvements to the size and finish of the product would be appreciated. Locally manufactured components of the dryers have proved so far to be durable.

5.2.2.3 Environment

Deforestation has been a problem in Ghana as timber logging activities out pace the forest's capacity to regenerate. The rate of deforestation has been estimated at 72,000 hectares per annum before 1980 and a stabilised rate of 22,000 per annum since 1980 [KITE, 2000].[32] With the country resources dwindling at such a fast pace, any technology that relies exclusively on the forest is likely to encounter serious environmental obstacles unless dedicated biomass plantations are established alongside to serve as feedstock.

5.2.2.4 Social

Interviews conducted among the few users and manufacturers of the biomass dryers revealed that the technology is socially acceptable: there are no cultural practices that discourage the use of the dryers.

5.2.3 Economic

5.2.3.1 Market

The workshop unit of the Agricultural Engineering Department, KNUST, is the pioneer in locally manufactured biomass dryers. The only other known manufacturer – Deula Ventures - has so far sold only two of the products. From the survey conducted under this study, no other manufacturer of this large-scale biomass dryer was identified. It was realised from the surveys that there was no perceived hindrance to accessing the technology.

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[32] The World Bank has also estimated the annual rate of deforestation in Ghana for the period 1990-1995 to be 1172 km^2 [World Development Report, 2000]

5.2.3.2 Financing, Costs and Benefits

Despite being manufactured locally, the biomass dryers contain imported components, which could be expensive. Even the cost of local components of the dryers was found to be expensive. This makes the unit cost of the dryer, which at the time of the survey was ¢ 7 million, expensive and unaffordable to farmers who are the main target group. There are no financing mechanisms available to support the manufacture and acquisition of the dryers.

5.2.4 Cross-Cutting

5.2.4.1 Information

Although farmers are one of the main targets of this product, only a few have any idea of its existence. The two manufacturers have so far made little effort to get information about the dryers to the targeted groups. In the case of the Agricultural Engineering Workshop at KNUST, the dryers are only manufactured upon request from farmers who are already using the technology.

5.2.4.2 Institutional

Energy-related research and development institutions in the country are biased towards particular technologies; unfortunately biomass dryers are not one of these technologies. Even though the ESDP sought to develop the biomass resources of Ghana, it did not considered biomass dryers. Hence there are no institutions in Ghana promoting widespread adoption of biomass dryers.

5.2.4.3 Policy

There are no policies in Ghana for the promotion of biomass dryers. This is partly due to the fact that the technology is not very well known.

5.2.5 SAWDUST BRIQUETTING

5.2.6 Socio-Technical

5.2.6.1 Resources

Sawdust can be found in abundance near wood processing firms around the country. The amount of sawdust generated in the country annually is at least 200,000m^3 solid wood equivalent. Less than a tenth of this finds any use at all; the rest are simply incinerated on site. There is sufficient sawdust being generated at sawmills to feed any briquette plant. Again wood processing activities are not seasonal and likewise the production of sawdust. The review done as part of this study has confirmed that the properties of the sawdust are favourable for the production of briquettes. Sawdust can be obtained free of charge and transported in trucks from nearby sawmills to a briquette plant, as per the Akim Oda case.

5.2.6.2 Technological/Technical

Major technical problems were encountered in the Akim Oda briquette plant. These technical problems were one of the main reasons for the plant's poor performance and its eventual shut down. Operational inefficiencies were such that a 2,200 tonnes/year capacity plant was only producing 1,100 tonnes of uncarbonised sawdust briquettes in a year. One major factor for the poor performance of the plant was the inadequate drying of the sawdust processed. The flash tube used at the plant was not insulated and the sawdust was being stored in the open and therefore exposed to rain. Experts at the 1st National workshop pointed out that the feasibility study carried out before the setting up of the plant was seriously flawed. They were of the opinion that the energy required to make the briquettes is more than the energy provided. There is at present no research and development capabilities aimed at developing and promoting the technology further.

5.2.6.3 Environment

There are no known environment related barriers to the development and dissemination of briquettes in Ghana.

5.2.6.4 Social

The briquettes were socially accepted by all the customers. Generally they had a strong preference for them over firewood, primarily due to technical reasons. Reasons for the preference included: ease of handling and storage; ease of setting the fire and the uniform temperature of the heat generated; quality of the final product for which heat was needed; and the reduction in labour required. In many of the cases customers were prepared to pay a premium of 10 – 20 % over the energy content adjusted price of fuelwood.

5.2.7 Economic

5.2.7.1 Market

Experience from the defunct Akim Oda plant indicates that the sawdust briquettes produced were mainly used as a substitute for fuelwood consumption in the industrial and commercial sectors, where the premium qualities of briquettes are valued. The products from the Akim Oda plant were mainly sold and used by commercial bakers in the Accra/Tema metropolis and the Ankaful Brick Factory near Cape Coast in the Central Region of Ghana. The potential demand for briquettes from bakers and brick manufacturers alone was estimated to be 45,000 tonnes annually [Hagan, 1994]. Other potential users identified include fish smokers, restaurants (locally called ‘chop bars’) and institutional kitchens. It was estimated by Hagan (1994) that the potential demand for briquettes would increase to 500,000 tonnes/year if fish smokers and restaurants were to switch from firewood consumption to briquettes.

5.2.7.2 Financial Analysis

The cost benefit analysis for sawdust briquette is based on a feasibility study carried out in 1994 for a 30,000 tonnes/year sawdust briquette plant [Hagan, 1994]. The total capital cost of the project was estimated to be US$ 3 million, comprising 75% debt and 25% equity financing. It was assumed that loans were to be raised from development banks in the USA and Ghana at interests of 10% and 25% respectively. It was estimated that 58,000 tonnes/year of sawdust supplemented by 3,600 tonnes/year of off-cuts would be required at the cost of US$ 1/tonne to produce 30,000 tonnes of briquettes annually. It was further estimated that the briquettes would be sold at US$ 72/tonne through out the entire life of the project, which was assumed to be 10 years. Based on these estimations and assumptions, the financial analysis of the proposed briquette plant was conducted under two scenarios – the best case and worst case scenarios.

In the **Worst Case Scenario**, the project was classified as “a priority area of investment”[33] under Section 12 of the Ghana Investment Code thus entitled to the following benefits and incentives:

- Exemption from payment of custom import duties on plant, machinery and equipment, and accessories imported for the project;
- Depreciation of 40% in the year of investment and 20% in subsequent years;
- Reduction of 15% on company income tax payable owing to the proposed location of the project outside Accra; and
- Investment allowance of 7½

In the **Best Case Scenario**, the project is classified under the “areas of special priority”[34] by the Ghana Investment Code (Areas of Special Priority Instrument), 1991 and thus entitled to all the benefits/incentives above in addition to the following:

- Five years tax holiday; and
- 50% rebate on company income tax thereafter.

Table 5.1 contains a summary of the financial analysis while the detailed analysis is captured in Appendix 3a and 3b.

[33] Priority areas of investment refers investments in manufacturing industries that use local raw materials.
[34] Special Priority projects are projects related to indigenous energy supply.

Table 5.1: Summary of Financial Assessment of Sawdust Briquetting Plant

	Worst Case	Best Case
Average Annual Profit in Years 2-10, US$	339,338	478,872
Net Present Value, NPV @ 25%, US$	273,194	486,529
Internal Rate of Return, IRR in %	30	34
Discounted Payback Period @25% in years	4.2	4.0

Source: Hagan, E. B. 1994.

According to Hagan (1994), in the event of a 10% increase in production costs, IRR of the project in the best-case scenario reduces to 28% with a discounted payback period of 5.2 years. In the worse case, the IRR reduces to 26% with a discounted payback period of 5.5 years. In the event of a 10% decrease in the estimated total revenue for the project and production costs remain unchanged, the IRR of the venture, in the best case, reduces to 23% with a discounted payback period of 7 year. In the same situation, the IRR in worst case reduces to 21% with a discounted payback period of 7.2 years. Consequently Hagan (1994) concluded that the project was more sensitive to reduction in project revenue than an increase production cost. The project on the whole was adjudged to be financial viable, especially in the best-case scenario. The analysis may be six years old but the fact that it is denominated in US dollars makes it reasonably indicative of the kind of financial returns prospective investors should be expecting.

Consumers' Perspective

A consumer making a decision to use briquettes will be interested to find out how the price of briquettes compare with the alternative fuel source it will be displacing (in this case perceived to be firewood). Current market estimates indicate that firewood is sold at an average price of US$ 45 per tonne while the briquettes are to be sold at US$ 72, a price differential of US$ 27 per tonne. With this difference in price of firewood and briquettes, no consumer (general assumed to be rational) would opt for briquettes unless there are other benefits associated with the use of sawdust briquettes.

Meanwhile according to Hagan (1994), interviews with several of the users of the briquettes from the Akim Oda plant indicated their strong preference for the products over firewood because of the former's technically superior quality, some of which have been summarised in Section 5.2.6.4. The bakers interviewed indicated that they would be willing to pay up to 20% premium over the energy content adjusted price of fuelwood for the better characteristics of briquettes. Similarly, the brick manufacturer also indicated his willingness to pay between 10-20% premium over the energy price adjusted price of fuelwood for the operational advantages of sawdust briquettes.

5.2.7.3 Financing

Briquetting is a large-scale venture, which requires substantial capital for investment. Initial plant costs are very high and usually require external funding. Donor funding and/or support from national and international financial institutions however is not usually forth coming. Almost all the components of the plant can only be sourced on the international market and import taxes and others duties are prohibitively expensive. Agencies and private investors involved in the technology are often unaware of how to approach financial institutions and are poorly informed on the financial instruments that are available and well suited for their requirements. National and local financial institutions are biased towards more conventional energy options; there is generally poor awareness amongst conventional financial institutions and government-sponsored bodies of the opportunities offered by briquetting technologies. Financial mechanisms such as loans, subsidies, delayed payment arrangements and hire purchase that could allow low-income groups to patronise environmentally benign sawdust briquettes are woefully absent. Access of briquette to international markets is nil and even internally the addition of transportation costs hikes up the price of briquettes making it uncompetitive with other fuel options.

5.2.8 Cross-Cutting

5.2.8.1 Information

The briquettes produced were aimed at a few industrial and commercial consumers and knowledge of the product among these types of users in the country is generally still quite low. Only little efforts have been made to get information about briquettes to a wider portion of the population and there is no mechanism for getting the views of customers already using the product.

5.2.8.2 Institutional

MME is not known to have any briquetting projects in their immediate plan. Their involvement in the development of this technology has been rather on the low side. Other research institutions in the country are not particularly interested in briquetting. Many of the activities seen to date have come from private commercial entrepreneurs.

5.2.8.3 Policy

There is no policy on sawdust briquettes but this has not constituted a barrier to the development and deployment of briquettes in Ghana. On the contrary, existing government policies, such as the Ghana Investment Code, favour briquetting projects. The Ghana Investment Code, 1991 classifies projects that are related to indigenous energy supply under the "areas of special priority". Special priority rated projects are exempt from the payment of corporate tax for the first five years of operation. Although not specifically introduced with briquettes in mind, this provision under the Code offers an attractive incentive to briquetting projects. As can be seen from the financial analysis in section 5.2.7.2 the economics of briquettes becomes attractive with the introduction of tax holidays.

5.2.9 SAWDUST STOVES

5.2.9.1 Background

Sawdust stove designs were pioneered by the Agricultural Engineering Department of UST with support from GTZ in 1983. The project is still on going and the BRRI and other private entrepreneurs have various designs of cookstoves on the local market. The stoves are mainly used in the urban centers; at places close to the wood processing industries. About 5,000 sawdust stoves are known to have been sold. Benefits of sawdust stoves range from savings in amount of fuel to reduced cooking time, reduced burns and cleaner and more hygienic cooking conditions. Problems with the stove and other improved cookstoves are principally lack of funds for promoting agencies, social acceptance of these stoves and poorly organised strategy for the marketing of these.

5.2.10 Socio-Technical

5.2.10.1 Resources

Sawdust is a residue that results mainly from activities of the wood processing industry in the country. As much as 21% of all timber processed turns out as sawdust waste, which finds very little or no use [UNDP, 1988]. Only a handful of wood firms use their generated sawdust. Sawdust usually poses environmental problems as it is disposed of by dumping in landfills, on open land or burning. Sawdust abounds in areas where sawmills are concentrated but absent in other areas. Wood processing activities are not seasonal and sawdust is always available in large amounts throughout the year in the appropriate areas. The availability of sawdust is will therefore be a barrier in so far as sawdust is available only in a few places and is also not easily transported.

5.2.10.2 Technological/Technical

All stoves are manufactured locally and are quite durable. The main problems are the voluminous amounts of soot and smoke that characterise the use of the stoves. Some end-users interviewed in the study mentioned this as an important reason that has discouraged the use of sawdust stoves. Also the stoves cannot be used for ‘heavy’ cooking and cooking of most Ghanaian dishes fall under the ‘heavy’ category. In addition there are no operating manuals; buyers are only instructed orally on the method of operations.

5.2.10.3 Environment

Environmental consideration (finding use abundant sawdust) rather than economic is the primary reason for the introduction of the sawdust stove on the Ghanaian market. Although sawdust is so far free and available in large quantities to those who are near enough to a sawmill, it is plausible if not likely, that a price may be tagged to it once the technology becomes very popular and more stoves get disseminated.

5.2.10.4 Social

The sawdust stove is a socially accepted technology where it is used.

5.2.11 Economic

5.2.11.1 Market

The Agricultural Engineering Department of KNUST is the only recognised market outlet for the stoves. The department has so far disseminated a total of 5,000 stove [Personal interview with a technician at the department]. The department only produced on order and has no retail outlets or supply channels. Apart from the Agricultural Engineering Department, some wayside metal working artisans were identified as manufacturers of the stoves. These artisans have neither an organised retail outlets nor supply channel; their wares are basically displayed in front of their workshops for interested customers to make their purchases. Another 5,000 pieces of the stove are estimated to have been sold by these artisans [Personal interviews with artisans]. Given the potential number of users of the sawdust stove – i.e. all households within the vicinity of the sawmills – it can be concluded that the total estimated sale of 10,000 pieces is on the low side. This could be due to the marketing strategy being used to sell the products and the fact that no conscious effort has been made to promote the widespread adoption of sawdust stoves.

5.2.11.2 Financial Analysis

The financial analysis of sawdust stove under three different scenarios is presented below. The three scenarios considered are:

- a complete switch from the use of traditional charcoal stoves to sawdust stove;
- a 100% switch from improved charcoal stoves to sawdust stove; and
- a 50% switch from traditional firewood stoves to sawdust stoves.

The following are the assumptions used in the analysis:

The average daily charcoal consumption of a household (with an average size of five persons) using the traditional coal pot in Ghana is about 2.5 kg per household. This translates into annual consumption of 913 kg per household. This consumption rate will be reduced to about 557 kg per household if the household switches over from the use of the traditional coal pot to the improved charcoal stove, popularly referred to as "Ahibenso", which has efficiency 39%. Average weekly consumption of firewood per household is estimated to be 40kg and sawdust is assumed to be free. The cost of the sawdust stove is US$14 (50,000 cedis); "Ahibenso" is US$ 7 (25,000 cedis); the cost of traditional coalpot is US$ 3 (12,000 cedis); the price of charcoal is US$ 63/tonne; and price of firewood is US$ 45/tonne.

Scenario 1: 913 kg of charcoal could be saved per family per year with a monetary value of US$ 58. Payback period here is 88 days for the household.

Scenario 2: Annual charcoal savings for a family using an Ahibenso improved stove is 356 kg, which translates to US$ 22. Payback period for this scenario is 232 days (approximately 8 months).

Scenario 3: About 1040 kg of firewood could be saved per family per year translating to annual monetary savings of US$47. Payback period here is 108 days.

Were the sawdust technically capable of performing the same functions as the traditional coalpot, Scenario 1 – with the shortest payback period – would have been adjudged the best case. However as indicated in Section 5.2.10.2 above, the sawdust stove is technically "handicapped" when it comes to the cooking of many Ghanaian dishes. Consequently, Scenario 3, where the household reduces its firewood consumption by 50%, is recommended as the best-case scenario.

5.2.11.3 Financial

There are no low cost, long-term financing schemes for manufacturers of sawdust stoves. This leaves the traditional banking sector as the only source of financing for manufacturers wanting to go into large-scale production of the stove. With the commercial and merchant banks charging high interest rates on loans (between 45-50% per annum) it is unlikely that the artisans and even KNUST can afford to take loans from the banks.

5.2.12 Cross-Cutting

5.2.12.1 Information

Only a small percentage of potential end-users are aware of the presence of the product on the market despite representation of KNUST at, at least two Trade Fairs. The initial impression that sawdust could be obtained freely makes its use appealing to many prospective users. Information on the stove's usefulness, performance, costs and others is very low. Manufacturers have not made any efforts to get information about the stoves to a wider portion of the population and there is no procedure for getting feedback from people already patronising the stoves.

5.2.12.2 Institutional

It was found out from the survey that the institutional capacity in the country is adequate except that there was a lack of collaboration between manufacturers. This could be due to the fact that some products on the market could not be traced to their producers and the known producers had little idea about the operations of their competitors. Government institutions such as MME are not known to have been involved with sawdust stoves. Facilities exist for the training of personnel on the technology and at KNUST many technicians have acquired the technical know how for the manufacture of the stoves.

5.2.12.3 Policy

There is no policy on the development and deployment of sawdust stoves.

5.2.13 BIOGAS

5.2.13.1 Background

A number of interesting ongoing biogas projects include:

- MME's biotoilet at Ofori-Panin Secondary school: Initiated in 1996, this facility produces gas for lighting the toilet and its surrounding areas.
- MME and IIR's demonstration at Appolonia: Gas produced is used for direct cooking in 27 homes as well as being used together with diesel in a mini-grid producing 12.5 kW_{el}.
- Guiness-Kaasi Project: This is a £24,000 project employing a 100m^3 digester capacity plant utilizing human waste commissioned by Guiness Ghana Limited and Water for Life (UK). Gas generated is to be used for community lighting, cooking in a local school and used to run a community cornmill.
- Mampong Hospital Biogas Project: This is a ¢45 million project, which utilizes liquid domestic waste to produce gas. The methane gas to be produced would be used as fuel to generate electricity.

5.2.14 Socio-Technical

5.2.14.1 Resources

Cow dung and human excreta are the main biomass feedstock for biogas generation in the country. Another important input needed in the process is water in large quantities for mixing the dung. Although biogas projects are usually implemented in areas with a high population of cattle and other livestock, dung can be quite scarce at certain times. In many cases the dung has to be collected and transported to points of usage; transportation can be a serious problem. From the survey it was found that several biogas facilities were not in use due to dung and water shortages in certain seasons. Human excreta could be transported in sanitary trucks from nearby cities to serve as feedstock but this is only possible in centralised sewerage systems; management of this type of resource/waste in decentralised systems could be extremely difficult.

5.2.14.2 Technological/Technical

The technology base upon which biogas projects in the country are built is solid enough to ensure sound, efficient and almost trouble-free utilisation of all biogas systems. This is not to say the technology could be classified as top of the range and efforts should be halted or slowed from developing a more improved and low cost system. There was a complete absence of operational manuals for users of biogas installations visited. Servicing of systems was not a common phenomenon although there were a few trained local people to carry out this task.

5.2.14.3 Environment

Perhaps the single most important factor as to why attention is accorded to this technology is the environmental and sanitation advantages that it offers. It is low cost, offers environmentally sound waste recycling, reduces greenhouse gas emissions in particular carbon monoxide, and reduces the occurrence of infectious diseases. Possible environmental barriers associated with the technology include: the dangers of explosion (a risk with all combustible gases); production of hydrogen sulphide, which is foul smelling, poisonous and corrosive; and biogas slurry, which if not handled properly can be environmentally harmful.

5.2.14.4 Social

The use of the biogas technology is normally characterised by positive social outcomes such as improved health and sanitary conditions, enhanced social conditions through the provision of electricity and increased small-scale industrial and constructional activities. In the areas visited during the survey, school children are now able to read and study at night and other activities that hitherto were only carried out when there was daylight could now be done when it was dark. The only social barrier identified with biogas is the unwillingness of people to use biogas for cooking.

5.2.15 Economic

5.2.15.1 Market

The major economic obstacle facing this technology is its high cost. The communities for whom this technology is suited are most often poor. Many of the sites visited had demonstration units which had been provided free but even then, the small monetary contribution needed from the users, that is to transport dung to points of use, to supplement government or donors' efforts, was unavailable. As a result many of the systems were not operating due to a shortage of dung.

5.2.15.2 Cost Benefit Analysis

Based on the field experience of the Appolonia biogas project being managed by MME and the cost of equipment at the prevailing dollar rate in Ghana, the generation cost per cubic meter of biogas is calculated under four different scenarios in Table 5.2 below:

Table 5.2 Production Cost of Biogas

	Scenarios for Biogas Production Options	Biogas Cost ($US/m^3)
1.	Free supply of feedstock but digester and O&M cost considered.	0.26
2.	Feedstock (cow dung & water) supplies, digester and O&M cost considered.	0.93
3.	Human excreta from cesspit truck, digester and O&M cost considered.	0.51
4.	Cost of bio-latrine system with digester and its operation cost considered.	0.28

Labour costs for collecting and transporting dung to the digester is the largest cost component. This is seen in the Scenario 2 where feedstock cost was considered which turned out to be the most expensive option. Cost of water used in mixing the cow dung is another important component; on the average one kilogram of water is required per kilogram of cow dung. Scenario 1 where the supply of feedstock to the location of digester is free (as in the case of a waste disposal site) turned out to have the lowest biogas production cost.

A graphic representation of the cost of supplying Appolonia with 10 kW electric power for 12 hours daily by four different options is shown in the Figure 5.1 below. The analytic basis for the comparison pivots around the economic concept of levelised energy cost (LEC) and is on the basis of financial cost only. Other indirect costs and benefits such as sanitation control, environmental issues, reliability etc are not considered here. It is to be noted that production of electricity by biogas ranked second only to diesel in this case and that cost of grid power extension is distance dependent and only competitive to biogas power for distances below 6 km from the nearest grid line. [35] The financial analysis presented here is however not very conclusive

[35] Applonia is located about 10 km from the nearest grid line.

as a lot of issues would have to be considered in a detailed economic analysis. Producing electricity from biogas is highly inefficient and could be only economic in very peculiar cases.

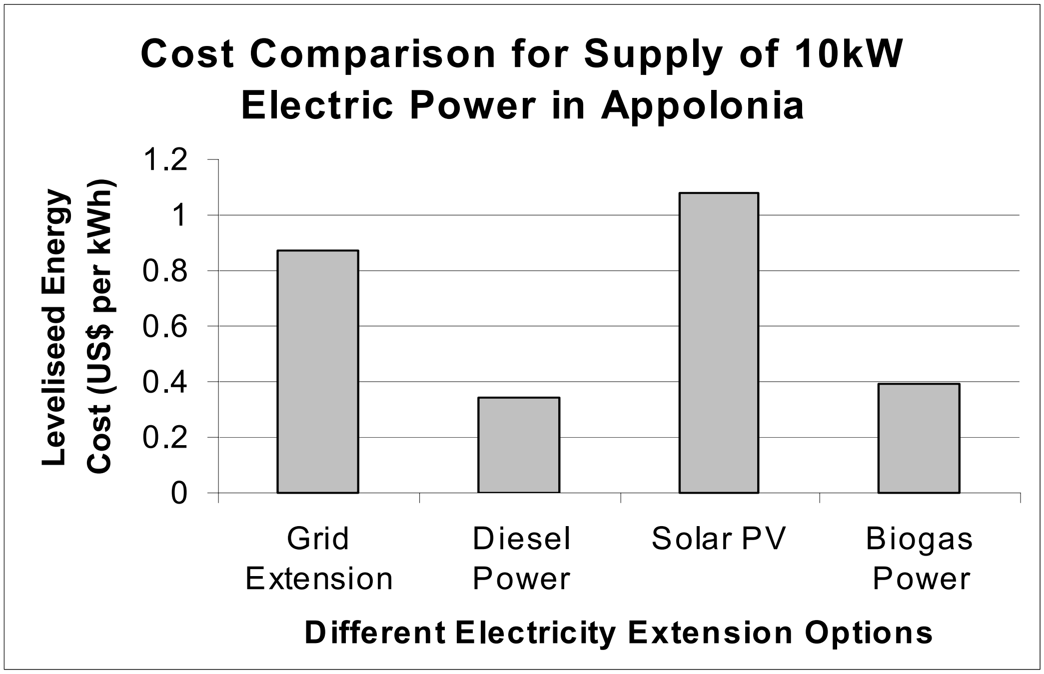

Figure 5.1: Chart of Different electrification Options for Appolonia

5.2.15.3 Financing

The total cost of installation of biogas systems could be very high for rural dwellers, who are the principal end-users. Profitable businesses cannot exist without loans and/or equity and the low involvement of the financial institutions in the production of biogas systems doesn't augur well for its dissemination throughout Ghana. Also missing from the conventional as well as other financial institutions are financing schemes that would encourage consumers to utilise and benefit from biogas systems. Information on procedures and requirements for attaining loans are not readily available to producers and consumers of the biogas systems. Other financial obstacles affecting a wider utilisation of biogas include lack of investment incentives such as accelerated depreciation and grants; production incentives such as production tax credits and direct cash payments per kWh produced; fiscal incentives such property tax and land-use waivers; net metering; power purchase obligations for utilities.

5.2.16 Cross-Cutting

5.2.16.1 Information

Consumer awareness is very high in areas where there are biogas projects and very low in areas where there are not biogas project. The survey indicated that end-user acceptance of the technology is high; where project are not taking place however, acceptance is low and there are many misconceptions about the technology. Mechanisms that are in place for getting views from the communities are not very well established. Although consumers are aware about the usefulness and performance characteristics of biogas systems, they have very little idea about the cost matters as in many of the cases the systems are supplied free of charge.

5.2.16.2 Institutional

Biogas is a technology that has received considerable attention from MME and agencies promoting RETs in the country. Biases within the energy sector favour this technology. There is enough private sector participation and adequate valuation of social and environmental externalities for implementation of biogas programmes. The single institutional barrier that could be mentioned and said to have impeded any embryonic planning of a large-scale biogas project is lack of interest of the power utilities to bring on board any technology that does not have comparable costs to conventional systems in the country.

5.2.16.3 Policy

Although the biogas technology has been proven to be technically feasible and environmentally sound for sustained socio-economic development, conspicuously absent in the energy policy framework of the MME is a policy that would encourage large-scale development of biogas for power production.

5.2.17 Stakeholders' Perspectives

The above analysis of barriers was presented at the 2nd National Stakeholders Workshop, which was organised as part of the project to present its findings. Apart from the general discussions on the findings and barrier analysis, a syndicate group on biogas (as well as on SHP and solar water pumps) was created for a more focussed discussion on the barriers. The choice of biogas for detailed barrier analysis was mainly because a lot of effort has already been put into developing projects employing this technology and that biogas is still receiving significant attention from both government bodies and the private sector. In all there were seven stakeholders in the biogas syndicate. The terms of reference for the syndicate group were to identify:

- The key barriers to biogas;
- How the barriers can be removed; and
- Specific instruments to be used in the barrier removal process.

In addition to the above, the stakeholders in the syndicate groups were required to rank the barriers in the order of importance by filling in a questionnaire given out during registration.

5.2.18 Key Barriers

Stakeholders in the biogas syndicate group identified six key barriers, which are listed below:

- Unfavourable Policies
- Raw Material Availability
- The Right Financing Arrangements
- Social Acceptance Of The Technology
- Absence of market; and
- Lack information

5.2.19 Ranking of barriers

In terms of which of the barriers identified is the most important, the stakeholders in the biogas syndicate group ranked the "unavailability of raw material" as the most important (all 7 stakeholders ranked it as such). The "raw material barrier" was followed closely by the "policy" barrier (5 out of 6 stakeholders ranked this barriers as the second most important barrier). The two syndicate groups on the other RETs ranked the "absence of right financing schemes" and "cost and benefit" barriers as the most important barriers to the technology (7 out of 10 stakeholders ranked them as such). "Market" and "information" barriers were ranked as the second most important barriers to biogas (5 out of 10 stakeholders listed these barriers as the second most important barriers). Table 5.3 contains the summary of the ranking of barriers by the syndicate groups.

Table 5.3: Summary of Stakeholders' Response on Barriers

Barrier	Number of Respondents/Order of Importance[1]	
	Syndicate Group on Biogas	2 Syndicate Groups on other RETs
Number of Respondents	7	10
Socio-Technical		
Resources	7	5
Technology		2
Environment		2
Social	2	5
Economic		
Market	1	5
Costs and Benefits	1	7
Financing	5	7
Cross-Cutting		
Information	4	5
Institutional	2	3
Policy	6	3

[1] The numbers in brackets represent the ranking for the particular barrier – (1) being the most important – based on the total number of stakeholders who ranked it as most important. The numbers not in brackets represent the total number of respondents who ranked the particular barrier as most important.

5.2.20 Suggested Barrier Removal Procedures

5.2.20.1 Policy

- Enforcement of already existent environmental laws is one way that experts in the syndicate group believed could pave a way forward for biogas technology. There are environmental laws to ensure that all kinds of waste are properly disposed of. The laws are however not followed. These laws could be more stringently enforced through a good liasing with environmental agencies. District assemblies and sanitary authorities must be obliged through the National Sanitation and Environmental policy to oversee to proper disposal of liquid and other domestic waste.

- Workshops intended to disseminate information on biogas technology to policy makers and other stakeholders was also seen as a way that such people could be sensitised to the benefits of the technology.

- Incentives in the form of tax holidays, tax/import duty waivers, tied-in-tariffs etc. for programmes utilising biogas and other renewable technologies should be lobbied for at the policy making level. If such incentives were implemented, they would help to entice and bring on board the private sector and other IPPs.

- The designation of a pre-defined energy mix for the country approved by parliament was also raised as a way to remove a lot of obstacles in the promotion of biogas and other renewable energy technologies.

5.2.20.2 Raw Material

To get around the raw material barrier the experts suggested putting up plants only at studied sites where the resource supply/availability is proven to be adequate during all seasons for the size of plant, and where the focus is more on solving an environmental problem rather than an energy problem. Specific sites mentioned included abattoirs, public bathhouses and latrines, and institutions such as schools and hospitals. For large plants, dumping sites for liquid domestic waste close to cities and towns were suggested.

5.2.20.3 Financing

- Packaging biogas projects in the sanitation direction with energy and agricultural products as spin-off was seen as the most attractive way to get these programmes to be successful. Nevertheless, whichever way one approaches biogas technology, the technology cuts across many ministries – the Ministry of Environment Science and Technology, Ministry of Health, Ministry of Food and Agriculture and the Ministry of Mines and Energy. Funds for biogas projects could be solicited from all or some of these ministries if the necessary platform is laid to bring everyone on board.

- It was put forward that if projects are packaged to international standards, then biogas projects could benefit from such international financial arrangements as Global Environment Facility (GEF), Clean Development Mechanism (CDM) and the African Rural Energy Enterprise Development (AREED).

5.2.20.4 Social Acceptance

- It was raised by the members of the biogas syndicate group that involving people from the benefiting communities to a greater extent in biogas plant development could help dismantle the social acceptance barrier that the technology tends to face. Programmes should as much as possible consider appointing a local supervisor. This will not only help the community's acceptance of the plant, but also enhance the sustainability of the plant once external support is removed.

- Educating and creating awareness amongst the future beneficiaries of biogas projects was also seen to help the technologies get the support they need. One way of doing this is to disseminate information on established plants to people unfamiliar with the technology. Ideally it would be beneficial to bring such people to areas where plants exist.

5.2.21 Follow-Up Projects

Biogas technology has been found through this project to work well and attract investment from a wider audience if programmes are packaged as sanitation or agricultural programmes rather than energy programs. One way of developing a project here would be to find one or more institutions such as boarding schools or hospitals, which have serious waste disposal problems and to do a pre-feasibility study to see if their resources are in quantities that could warrant the setting up of biogas plant. The objective, which would be the idea to be sold to the hospital or school administrator, would be to solve sanitation or an environmental problem, with fertiliser for use in farms and biogas, for energy applications, as spin-offs from the project. The gas to be produced could be used in meeting the energy requirements for cooking and probably lighting in the selected institutions.

Slaughtering of animals (sheep, pig, cattle etc.) in cities and major towns in Ghana is in transition from what used to be uncontrolled and scattered slaughtering of animals to bringing all slaughtering activities under one administration in abattoirs. The programme, which was not welcomed by the people in the industry who put up an initial opposition to the move, is however underway in at least two major cities in Ghana. The feasibility of utilising all the entrails as well as other waste of the two abattoirs in Kumasi and Accra to produce biogas could be explored. As indicated earlier, the project should be packaged to primarily address a sanitation problem. A detailed resource assessment would need to be done to ascertain if the waste being produced is sufficient for good-sized biogas plant and if it would be financially viable. The abattoir in Kumasi is located in the industrial part of the city, which houses the wood processing industry and the major breweries in the region. Also present in the area are a lot of people involved in meat processing. Using biogas for cooking is about 60% efficient compared to the 12% efficiency if it were used for producing electricity. The study could also explore the possibility of using the gas to be produced from the proposed plant to meet the heat demands of the wood or brewery companies (optimistic approach) or meeting the heat needs for food processing (cautious approach).

5.2.22 Comparative Analysis and Conclusion

Generic barriers for the technologies chosen for detailed analysis have been found to be diverse and varied. They range from economic and informational barriers, to lack of marketing techniques and inappropriate policy environments, all of which have been discussed in the preceding section. Sawdust is in abundance and generally has little or no use. Sawdust poses environmental problems through dumping in open spaces and the disposal practice of simply burning it. Sawdust stoves were found to have some problems mainly in the area of dissemination – they can only realistically be used in areas of close proximity to the wood processing centres. The fact that they cannot be used as a solely independent cooking device also hinders their utilisation and dissemination. Sawdust briquettes however were found to have a ready market with consumers even prepared to pay a premium between 10 – 20 % over the energy content adjusted price of fuelwood and charcoal. The main barrier with this technology was technical.

It did come to light in the cases of biomass fired dryers and biogas that although the technology was adequately ready and in place, the resources could be quite scarce at certain times in the year. In the case of biomass-fired dryers, commercial activity not linked to dedicated plantations could have adverse environmental implications for the country, that is, deforestation. Biogas systems were found to be very expensive for the target group of rural dwellers, as their income levels are generally low. Cow dung though available in the right places cannot be found in quantities that would yield large energy production. It is anticipated that if the other barrier removal procedures suggested are adhered to and the right policies are in place, then biogas could break grounds to realize a solution to the increasing demand for reliable, sustainable and clean electricity generation in off grid locations while simultaneously creating opportunities for employment, income generation and effective sanitation management.

Given the results of the detailed study, the environmental and sanitary merits as well as the available technology that utilises human and liquid domestic waste, one technology that has come out clearly as very viable and bankable is biogas. All indications have pointed to the fact that this technology is environmentally beneficial, technically feasible and could be financially viable if applied in the areas where there is sufficient resource availability. All that is posing, as a major barrier to wide scale dissemination is the right policy environment to encourage biogas technology in the country. A policy that could help move this technology forward could be tailored along the lines of the reforestation fund, for example, all sanitary authorities and local assemblies could be obliged to contribute a certain quota to a fund to finance waste management.

6 Barrier Analysis – Solar Technologies

6.1 Introduction

Out of the many solar technologies reviewed in Chapter 4, three in particular – Solar Crop Dryers (SCD), Solar Water Heaters (SWH) and Solar Water Pumps (SWP) – have been selected for detailed barrier analysis. All three solar technologies were selected on the basis of their potential contributions to economic development and the fact that a substantial amount of work has been done by various groups of stakeholders on these technologies. However, despite this, only limited success has been achieved with respect to the wider diffusion of these technologies.

SCD were selected on the basis of their potential contribution to the development of Ghana's agricultural sector while SWH were selected for their potential contribution in helping reduce electricity demand associated with water heating in the residential, commercial and industrial sectors of Ghana's economy. SWP were also selected in view of the critical need for cost-effective water supply systems in rural as well as urban communities. The findings from barrier analysis for these three technologies are presented in the second, third and fourth sections of this chapter.

As part of the barrier analysis process, participants at the 2nd Stakeholders' Workshop were given the opportunity to undertake further analysis of the barriers and barrier removers identified during the desk studies and fieldwork, for solar water pumps. The results of that exercise are presented in fifth section of this chapter. The main conclusions are presented at the end.

6.2 Solar Crop Dryers

6.2.1 Resources

The availability of solar energy is without dispute. However, most harvests take place in the wet season, which is characterized by high humidity levels. This is a major challenge to SCD since the reduction of moisture is the key factor in crop drying.

6.2.2 Technology

SCD are immature technologies still being improved and refined by researchers. There remain quite a number of intrinsic technical challenges as opposed to conventional drying systems:

- The relatively large area-to-energy ratio of SCD present challenges where land area is a limitation;
- SCD are generally slower than conventional systems such as gas dryers. This is especially true for small dyers. Larger dryers (3 tons and above) have a scale advantage but require more land space and effective air-circulation techniques;
- Forced convection SCD normally employed on large systems require auxiliary power supply such as electricity from solar panels. These types of dryers are needed in humid environments of the rain forest areas, which happen to be the major farming areas;
- The durability of most SCD is threatened by compromising robustness with cheaper materials;
- The type of SCD selected for a particular purpose is crucial. Potential users in the in Ghana are however not exposed to a reasonable range of SCD types; and
- There is no proper framework to provide expert technical services to users and potential users.

Several users of SCD were interviewed for this study. One of these users is a small food-processing enterprise, which uses small-scale SCDs manufactured by the KNUST Biochemistry Department and also by themselves. This enterprise, which is owned and managed by a woman entrepreneur, found a technical flaw with the KNUST dryers – they have poor ventilation and absorber design. This flaw caused yellowing and fungal attack on cassava chips. The entrepreneur modified the design to improve performance and commissioned some carpenters to manufacture the new improved design for her.

Another interviewee, a large cash crop marketing company, uses a large-scale SCDs, with a capacity of 2 – 5 tons of pepper, manufactured by KNUST Mechanical Engineering Department. He is generally satisfied with the dryer. This interviewee identified three main barriers including technology itself. He felt that adding heat absorbers and a fan could improve the technology.

6.2.3 Information

Very little is known of SCD in most of rural settings and even amongst commercial farmers. In areas where SCD have been installed, the level of enthusiasm and appreciation has generally been excellent.

One of the users interviewed for this study identified the lack of information as one of the key barriers confronting widespread dissemination of SCD in Ghana. Even though he used a dryer manufactured by KNUST, he had no information of on-going R&D work being carried out at KNUST.

6.2.4 Social

SCD are socially accepted.

6.2.5 Environmental

There are no environmental concerns with respect to SCD.

6.2.6 Market

There is very little market dynamism, in terms of the demand and supply for this technology. There is a lack of demand, which stems mainly from various bottlenecks associated with the barriers discussed above. The supply side is also virtually non-existent, with only a few research institutions undertaking prototype tests and limited field demonstrations.

6.2.7 Cost-Benefit Analysis

There has been limited analysis of the costs and benefits of SCD in Ghana. For the purposes of this study, Cost-Benefit Analysis (CBA) for a 5 ton KNUST solar crop dryer was undertaken. The capital cost of the dryer is ¢24 million. The rate of drying of pepper and maize was assumed to be 2 days per maxi-bag capacity. Based on this and taking care of contingencies, we assumed that 100 batches of dried produce would pass through the dryer yearly. If ¢27 is charged for each kilogram of produce, annual revenue will be ¢13.5 million. With operating and maintenance charges of ¢2.4 million (assumed to be 10% of capital cost), the annual profit will be ¢11.1 million, yielding a simple payback of a little over 2 years. Table 6.1 contains the financial assessment of SCD.

Table 6.1 FINANCIAL ANALYSIS OF FIVE-TONNE KNUST SOLAR CROP DRYER

Capacity of dryer, kg.		5,000				
Cost of Drying Crop, ¢/kg		27				
No. of Batches/year		100				
Capital Cost of Dryer		24,000,000				
Discount rate		36%				
Annual Revenue		13,500,000				
Annual O & M		2,400,000				
Annual Profit		11,100,000				
Year	0	1	2	3	4	5
Cash Flow	-24,000,000	11,100,000	11,100,000	11,000,000	11,000,000	11,000,000
NPV @ 36%	211,836.94					
IRR	36%					

6.2.8 Financing

There are no financial arrangements to support potential procurers or producers of SCD systems.

6.2.9 Institutional

There is a limited supply of skilled and motivated personnel to maintain the few field installations of SCDs. Ownership also constitutes a barrier sometimes. In the case of MME's solar crop dryer at Agona-Asafo[36], the SCD project was undertaken for the community by the government, however there appears to have been political interference. The ownership of the SCD has now been transferred to a private company.

6.2.10 Policy

There is currently no policy to promote the widespread use of SCD at any level.

[36] MME contracted KNUST to install a 2.5 ton SCD at Agona-Asafo. The dryers were later sold to a private company in Accra. The citizens of the community allege that the company has denied them the use of the SCD.

6.3 Solar Water Heaters

6.3.1 Resources

Modern SWH are capable of providing reasonable services for most parts of the year. However, the solar resource is not well matched to the demand, since hot water demand for domestic use peaks in the early mornings and late evenings when the insolation curve is at its minimum. Also, the supply of hot water goes down during the rainy season because insolation is low. One of the interviewees for this study – a doctor of a hospital in the Upper Region – found this to be a real problem because the hospitals hot water needs are not met during these periods.

The Northern regions of Ghana have the best year-round solar radiation and provide the best opportunities for the utilization of stand-alone SWH. SWH face a bigger challenge down south (with the exception of the southern fringes,) and in the forest zones where high humidity and cloudiness result in a lot of diffuse solar radiation, which limits the amount of the more needed direct radiation.

6.3.2 Technology

DENG solar water heaters, which are locally produced, compete well with foreign ones such as ALPHA and Solarhart. The local SWH industry is very small due to the sporadic nature of demand. Orders normally come in from projects, which seek to promote the use of renewable energy. On the manufacturing side, local expertise and materials exist for producing thermosiphon heaters. These SWH are easy to construct but look cruder and bulkier than imported ones. Also, regular maintenance is required on their copper-pipe plumbing systems, which are susceptible to corrosion and blockage due to mineral deposits. Other newer technologies like multi-cross flow channels, as employed in the Solarhart SWHs, require more sophisticated production techniques and repair skills.

Another barrier worth noting is the general lack of perception on how to integrate SWH into existing water heating systems. By providing preheated water, for instance, SWH can achieve substantial energy savings in commercial and domestic kitchens but there is limited expertise in the design and construction of such integrated systems.

In spite of the above, several users interviewed for this study were quite satisfied with the performance of their SWH. In one case the SWH was installed in a Community Health Nursing School and most of the hot water was used in washing utensils; a small amount went into cooking breakfast and for bathing. In another case the SWH was installed in a Regional Hospital and the hot water was used in preheating water for sterilization of surgical instruments. In both cases the users did not see any technical problems with their SWH.

Two other interviewees had experienced serious technical problems with their SWH whereby none of them worked for more than 2 – 3 weeks after installation. A donor agency and a

Government Ministry had commissioned the installations; the users themselves knew very little about the SWH.

6.3.3 Social

The social acceptability of SWH varies according to the degree of exposure to the technology. This ranges from health workers and hospital in-patients in the northern regions of Ghana who have developed a high appreciation for SWH, to rich business people in the south who will have their electric water heaters any way. One of the problems with residential application, in general, is the low priority attached to hot water in the home: most families can do without hot water each day.

6.3.4 Environmental

There are no negative impacts associated with SWH.

6.3.5 Market

The market for SWH is yet to gain momentum in Ghana. Alternative sources of energy for heating water are apparently cheaper and more readily available. The current cost of SWH is also a major deterrence to its market penetration. SWH for domestic use has potential amongst the middle and upper classes of society. The technology has also not been diffused appreciably into the industrial and commercial sectors of the economy where it could either replace existing systems or serve as pre-heaters.

6.3.6 Financial Analysis

The economics of SWH constitute the biggest barrier as capital costs are considered to be high and there are no financial incentives to promote their development. This implies that SWH cannot be produced on a sufficiently large scale since there is hardly any demand and there will continue to be little demand for them until the costs come down or tariffs go up. So what are the costs and potential benefits associated with SWH? A cost-benefit analysis for a 200-litre DENG SWH is presented in Table 6.2.:

Table 6.2. CBA of 200-LITRE DENG SOLAR WATER HEATER

Wattage of Conventional WH, kW	2
Operating Time, hours/day	4
Energy Savings due to SWH, %	70
Average Installed Cost, US$	1,100
Electricity tariff, cents/kWh	0.03
Annual O&M (1% of capital cost)	11
Annual Costs of Heating water	87.6
Annual Gross Savings, US$	61.3
Net Savings, US$	50.3
Payback Period, Years	**22**

As can be seen from Table 6.2, the payback period of the DENG system is about 22 years, which is too long from a purely economic standpoint. The payback period however decreases with increasing tariffs as shown in Figure 6.1 reveals that higher tariffs can significantly increase the attractiveness of SWH to potential investors.

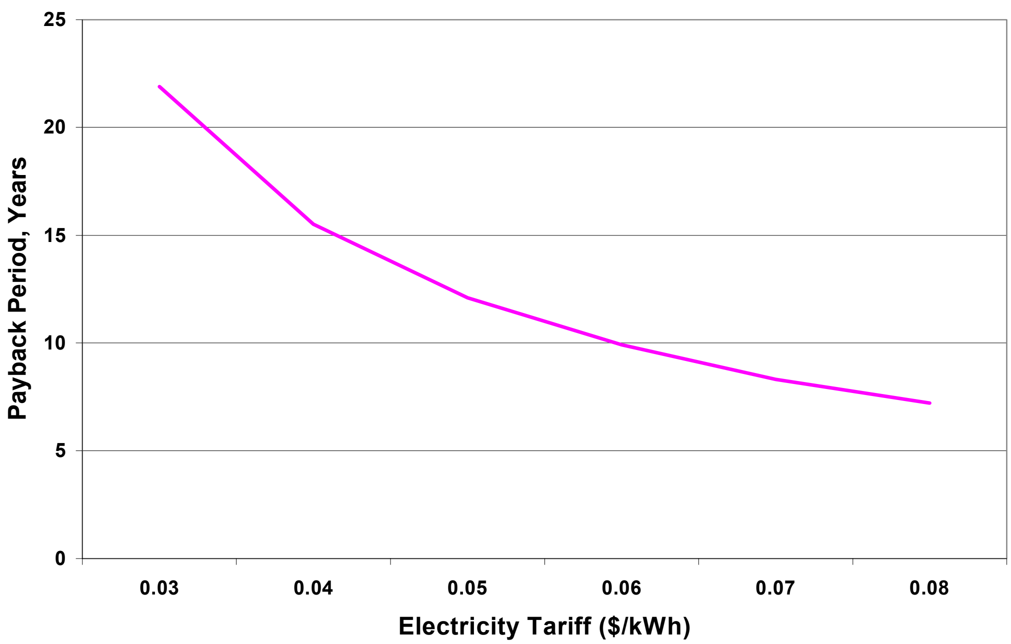

Figure 6.1: Payback Period for DENG Solar Water Heater

6.3.7 Financing

There is no financing mechanism specifically designed for SWH.

6.3.8 Information

One barrier to the diffusion of SHW is the low awareness level of the public. One of the reasons is the fact that water heaters do not play a major role in the lifestyle patterns of the general public.

6.3.9 Institutional

There are several barriers associated with the main government agency, MME, which are listed as follows:

- There are no representatives of MME at district levels to initiate, coordinate and monitor SWH;
- Low budgetary allotment; and
- Insufficient support from government policies.

There are also barriers associated with other key players in the SWH market such as

- Low levels of private sector involvement, and
- Limited availability of architects, contractors and technicians with relevant expertise.

6.3.10 Policy

There is no government policy that promotes SHW in Ghana. Meanwhile, prevailing tariffs, which are general deemed low and uneconomic, have made SWH expensive alternative.

6.4 Solar Water Pumps

6.4.1 Resources

The demand for water peaks in the mornings and evenings when radiation from the sun is low. This characteristic often necessitates a storage tank to compensate for the demand and resource availability mismatch.

6.4.2 Technology

Though there are no limits to how large a solar pump can be built, smaller installations generally require low capital outlay and are easier to install and maintain, thus requiring little skill and equipment. Larger pumps on the other hand have more sophisticated components such as inverters and switches and require specialised skill for maintenance and installation. This skill may be lacking in the rural areas where the technology has a niche. Local R & D on SWP has not had much impact on the dissemination of SWP in Ghana.

6.4.3 Social

SWP remain beyond the financial means of most people in the Ghanaian society. Some organizations have identified the potential of SWP in irrigation and are prepared to launch such projects if feasibility studies are positive.

6.4.4 Market

There is little development of the market with only one company selling SWP. Most SWP in Ghana were provided through donor support.

6.4.5 Costs and Benefits

The capital cost of the installed systems is yet the most unwieldy barrier to the diffusion of SWP on the local scene.

A comparative study of two kinds of solar water pumps available on the local market showed varying economic indicators, as shown in Table 6.3. The small pump is economically viable at a tariff rate of ¢7/litre while the medium SWP is viable at a tariff of ¢4/litre, for water. What the analysis in Table 6.3 depicts is that even though the capital outlay required for smaller installations are low, the unit cost of pumping a litre of water using the small pump is rather high and may be too expensive for consumers. SWP may therefore have a niche only in the medium capacity range but this will require further investigation.

Table 6.3: CBA of Two Different SWP

Various Parameters	Small Solar Pump for a community of 60 People	Medium Pump for a community of 200
Flow rate (litres/day)	3,000	10,000
Usage (days/year)	300	300
Capital Cost (¢)	10,000,000	22,200,000
Economic Tariff (¢/litre)	7	4
Annual Operating and Maintenance Cost (¢)	2,400,000	3,600,000
Annual Revenue, (¢)	7,008,000	13,870,000
Profit (¢)	4,608,000	10,270,000
Discount rate	36%	36%
NPV (¢)	35,914	291,311

A senior official of the Ghana Water Company (GWC), formerly the Ghana Water and Sewerage Corporation (GWSC), was interviewed for this study[37]. He identified the capital costs of SWP as the main barrier to the technology in Ghana. He went on to explain that they consider SWP only when all other options are ruled out and stated that for large capacities SWP are not attractive.

6.4.6 Financing

There are no financing packages for SWH.

6.4.7 Information

The awareness level on SWP is minimal throughout most of Ghana. Information on the usefulness and reliability of the technology has not been adequately disseminated.

6.4.8 Institutional

Act 310, 1965 charges the GWC with the responsibility of extracting, treating and distributing potable water to the general population of Ghana. The Community Water and Sanitation Department of GWC is responsible for providing potable water to rural communities with populations less than 5000, and small towns with populations between 5,000 and 15,000. The sector policy leans towards a demand driven approach to ensure that limited government funds

[37] Ghana Water Company has one SWP in the Central Region, which was installed on an experimental basis.

are channeled to communities that will maintain their systems. A beneficiary community has to contribute 5% of the investment cost and bear the full cost of operation and maintenance. Therefore, the cheapest water pumping systems, by way of their capital costs, get first approval. In the rural areas, such pumps are invariably hand pumps whilst bigger communities prefer conventional pumps. GWC has no concrete plans of investing in SWP. The contribution of SWP is therefore very minimal.

6.4.9 Policy

The government policy to reduce taxes on the importation of solar panels is a booster to the economic viability of SWP. However, taxes are still applied on the importation of pumps and accessories.

6.5 Stakeholders' Perspectives – Solar Water Pumps

6.5.1 Ranking of Barriers

Participants at the 2nd Stakeholders Workshop, organised towards the end of this project, were invited to rank the barriers identified for SWP in Ghana. The choice of SWP for analysis was based on the fact that this particular solar energy technology came out with the least number of barriers in the analysis undertaken in the preceding sections, summarised in Table 6.4. Apart from returning the least number of barrier, SWP was found to be the most promising of the three solar technologies because of the potential role SWP can play in meeting rural drinking water needs.[38] The ultimate aim of this ranking exercise was to identify the critical barriers and suggest ways and policy measures for removing these barriers.

Many stakeholders were of the view that ascribing the "non-existent/weak market" barrier to all the selected solar technologies could be misleading. They argued that, first; the focus should be on the energy service demand and not a particular piece of hardware. Second, it was clear to many that the demand for energy services associated with the selected solar energy technologies, crop drying, water heating and water pumping, is quite high and that the real problem is the existence of conventional alternatives for all these energy services.

[38] GTZ's experience has shown convincingly that, in many cases, SWP not only constitute the least-cost option for rural drinking water supply but are also more reliable than diesel-driven pumps. SWP may be the only practical water-supply solution in many regions where the logistics make it too expensive or even impossible to supply diesel generators with the required fuel (See Posorski, 1996).

Table 6-4: Summary of Barrier Analysis for Selected Solar Energy Technologies

Barriers	Solar Crop Dryers (SCD)	Solar Water Heaters (SWH)	Solar Water Pumps (SWP)
<u>Socio-Technical</u>			
MIS-MATCH BETWEEN **RESOURCE** AVAILABILITY – SEASON/TIME OF DAY – AND DEMAND	X	X	
Immature **technology**	X		
<u>Economic</u>			
NON-EXISTENT/WEAK **MARKET**	X	X	X
LOW ELECTRICITY TARIFFS (DISTORTED **MARKET**)		X	
HIGH CAPITAL **COSTS** AND NO ECONOMIES OF SCALE	X	X	X
NO COMMERCIAL **FINANCING**	X	X	X
<u>Cross-Cutting</u>			
LACK OF END-USER AWARENESS (**INFORMATION**)	X	X	X
INSTITUTIONAL BIAS AGAINST THE TECHNOLOGY		X	X
LIMITED SUPPLY OF PEOPLE WITH REQUISITE SKILLS (**INSTITUTIONAL**)	X		
LIMITED **POLICY** SUPPORT	X	X	

Several stakeholders suggested that the basic reason for "weak markets", as far as the selected solar technologies are concerned, is the lack of interface between R&D and implementation. It was argued that the lack of manufacturing capability and enterprise development with direct linkages to the centres of expertise in the country constitutes an important barrier. Furthermore, the lack of strong emphasis on the productive use of energy services (income generation from energy services) has tended to limit the ability of end-users to pay and hence weaken the potential demand for solar energy technologies.

Another issue raised at the 2nd Stakeholders' Workshop, in connection with the perceived weak markets for solar energy technologies, is the size of the Ghana market in general. The fact that the West African Sub-Region presents a far bigger market was emphasised. It was therefore suggested that more progress might be made if project developers and entrepreneurs target the sub-regional market rather than constrain themselves to Ghana alone.

The actual ranking of barriers associated with SWP was done in syndicate groups organised as a part of the 2nd Stakeholders' Workshop. For the most important barrier with respect to SWP, as shown in Table 6.5, the syndicate group on SWP chose "Costs and Benefits" while the two syndicate groups on other RETs chose "Information". The interesting point, though, is that both parties chose the other's first choice for their second most important barrier. Thus, the two syndicate groups on other RETs chose "Costs and Benefits" as the second most important barrier while the syndicate group on SWP chose "Information" – together with "Resources" and "Policy" – as the second most important set of barriers, all with respect to SWP.

Table 6.5: Ranking of Barriers by Syndicate Groups

Barrier	Order of Importance	
	Syndicate Group on SWP	**2 Syndicate Groups on other RETs**
Socio-Technical		
Resources	2	4
Technology	3	4
Environment	6	-
Social	5	-
Others (… expertise …)	6	-
Economic		
Market	3	3
Costs and Benefits	1	2
Financing	3	3
Others	-	-
Cross-Cutting		
Information	2	1
Institutional	4	5
Policy	2	5
Others	-	-

During discussions by stakeholders in the syndicate group on SWP, it was explained that "Costs and Benefits" had been chosen as the most important barrier because of the very high initial capital cost of SWP and the fact that the benefits were often difficult to quantify. It was pointed out that the "Costs and Benefits" barrier had several dimensions. First, there is the time lag between incurring the costs at the very beginning and reaping the benefits over time, this points to the need for some long-term financing. Second, there is the issue of cheaper alternatives like hand pumps on the small-scale end and grid-connected pumping systems on the large-scale end of the domestic water supply spectrum. Thus there is a need for some form of subsidy if the Ghanaian society at large is to place a premium on benefits associated with SWP. For agricultural purposes the main competitor is the diesel engine/pump but even here it is not clear whether or not SWP have an economic advantage. Third, there is the well-known trend of PV costs coming down over time and the advantages of building the necessary infrastructure now in anticipation of reaping the benefits later in the future but there is also a question as to who should bear the higher costs at this point in time.

Further discussions by the stakeholders in the syndicate group on SWP threw more light on the choice of "Information" among the second most important set of barriers. In this case it was noted that information on the benefits associated with SWP was not widespread and that in general people are simply not aware of the costs and benefits of SWP. It is interesting to note that even though other barriers – Resources and Policy – were ranked together with Information as the second most important set of barriers, the discussion focused almost exclusively on Information.

6.5.2 Barrier Removers

Even though stakeholders in the syndicate group on SWP chose "Costs and Benefits" as the most important barrier and "Information" as the second most important barrier, members of the group were unanimous in their view that the most effective way of removing these key barriers is to start by tackling the information barrier. It was pointed out that information is needed to convince policy makers as well as decision-makers in other sectors of the economy. It was felt very strongly that the way forward is to integrate the promotion of SWP and other solar energy technologies more closely with national programmes that span across areas like infrastructure and youth development. In order to do this effectively, the right information will need to be fed to the relevant programme developers and managers.

Stakeholders in the syndicate group on SWP agreed that various financial incentives like tax waivers and subsidies would be required to promote SWP but the necessary legislation would first be required. Information on the benefits of SWP will therefore have to be packaged with the legislators in mind and direct interaction with them (lobbying) to ensure that this information is well absorbed.

6.5.3 Follow-Up Project

Following from the discussion on barrier removers in the preceding section and upon further consultation with stakeholders, tackling the information barrier and all its associated ramifications appears to be the best course of action by way of a follow-up project on SWP. Such a project would have three dimensions: data collection, data analysis and then dissemination of this data and analysis. The first two dimensions would constitute a study aimed at determining costs and benefits of SWP as well as the competing technologies in both the domestic and agricultural sectors. The third dimension will involve dynamic interactions with policy makers, including sessions with parliamentarians and decision-makers in the relevant public and private sectors. Given that the goal of the project will be to get the necessary policy instruments put in place for the wider dissemination of SWP in Ghana, it will be important to make the third dimension – dissemination – an integral part of the project right from the outset.

6.6 Conclusions

This chapter has analysed three solar energy technologies – Solar Crop Dryers (SCD), Solar Water Heaters (SWH) and Solar Water Pumps (SWP) – and found all of them to have a number of barriers in line with the framework presented in Chapter 1. A ranking of the barriers was done for SWP by stakeholders who identified the key barriers as high initial costs with often unquantified long-term benefits and a general lack of information. Further analysis by stakeholders suggested that the most effective way of tackling these barriers is to generate the required information and disseminate this information among policy makers, especially the legislators who are capable of instituting the necessary policy measures for wider dissemination of RETs in general. A follow-up project was therefore proposed to tackle the information barrier and all the ramifications associated with this.

7 BARRIER ANALYSIS – SMALL HYDRO POWER

7.1 Introduction

As discussed in Chapter Four, Ghana's SHP resources are virtually untapped despite their abundance. The only pilot project ever commissioned in Ghana – Likpe-Kukurantumi – was never completed; even though the civil works for the project commenced and a generating plant was imported from India. So far no official reason has been assigned for the abrupt end of Likpe-Kukurantumi neither has there been any cited reason as to why none of the many other identified sites has been developed. Consequently the project team set out to identify what has led to the absence of SHP technology from the array of renewable energy options that are currently being demonstrated and promoted in Ghana. Relevant stakeholders in MME, AESL[39], E.C.G. and V.R.A. were interviewed to obtain specific information on barriers to the development of SHP in Ghana.

What follows in this chapter is an analysis of barriers to SHP in Ghana. This analysis will involve a discussion of what interviewees and stakeholders perceive to be the key barriers, their suggestions as to how these barriers could be removed and a synthesis of the key issues arising from the discussion. The approach adopted in this chapter for the barriers analysis is the same as that used for other RETs in the two preceding chapters.

7.2 Socio-Technical Barriers

7.2.1 Resources

As shown in chapter four, the SHP potential has been assessed under three different scenarios minimal (cautious), maximal (optimistic) and medium (see Table 4.5). The estimated installed capacity under the optimistic scenario is assessed to be approximately 14 MW if the plant is connected to the grid and 4 MW if plants are to supply to isolated communities. These estimates could be higher since the figures represent only an extrapolation. In assessing the SHP potential

[39] At AESC the main interviewee was an engineer who was involved in the AESC study.

in Ghana, ACRES International [1991] admitted that their estimates were by no means thorough. They added that a rough estimate, based on local maps of two areas, the Volta region and the Eastern region, led to the conclusion that investigated sites represent between 15% and 40% of the area potential. This further suggests that the SHP potential in Ghana could be even greater[40].

ACRES however went on to conclude among others things that “the development of SHP resources can only have a marginal effect on the overall fuel and energy balance of Ghana” [ACRES International, 1991]. They submitted however, that there is a niche market for the technology in the context of rural electrification programmes. This modest assessment for the country’s SHP resources could have rendered SHP unattractive to the VRA – the only body permitted at the time to generate electricity – who had a policy to diversify the electricity supply base from hydro to thermal. Viewed in this respect, resource inadequacy would have been an important barrier to the development of SHP in Ghana. However, none of the interviewees mentioned resource inadequacy as a reason why SHP sites have not been developed in Ghana.

7.2.2 Technological/Technical

As of now there is no known technological barrier, which could have impeded the development of the SHP sites in Ghana, at least the experts interviewed cited none. There is a world-wide consensus that SHP technology is now mature. It has been greatly improved by electronic load controllers, low cost turbines, the use of electric motors, and the use of plastics in pipe work and penstocks (Khennas and Barnet, 2000). Although R&D can bring the cost of generating equipment down, this does not lie within the purview of the Ghanaian engineer, nor is there any economic justification for embarking on such a venture since other countries such as India have a comparative cost advantage so far as the manufacturing of equipment is concerned. The latter point is based on a conclusion drawn by ACRES International [1991] that “the size of the SHP potential in Ghana does not give sufficient scope for considering domestic manufacturing of the main equipment components (turbines, valves, generators)”.

On the technical front, it has been observed that the task of engineering, construction and installation as well as proper maintenance of SHP plants can be carried out entirely by Ghanaian organisations and staff [ACRES, 1991]. Mr. Baidoo, an engineer in the hydro division of Ministry of Works and Housing who was involved in the AESC study, stated that he had no doubt about the technical capability of Ghanaian engineers to handle the technology.

7.2.3 Environmental

SHP technology is generally an environmentally benign technology. However, environmental considerations can potentially impede the development of the SHP sites in Ghana since many of

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[40] There is even evidence from latter studies such as Ametepe, 1995, which points to the fact that there are other sites on the Dayi River which can deliver up 1500kW of power. Total potential of the Dayi River has been assessed by Ametepe (2000) to be between 2000 and 5000 kW.

the sites are waterfalls whose natural scenic beauty may be destroyed should the sites be developed. A typical example is the Wli Falls, which came out as the most attractive site among all the sites considered by ACRES International. Nevertheless, it was still discarded because in the opinion of ACRES International, the discharges of the Nuboi River would not allow for the generation of hydroelectric power as well as the preservation of the flow over the falls during dry periods and thus limiting tourism potential to only the raining seasons. Meanwhile AESC had earlier on adjudged the project to be economically viable and technically feasible. AESC contended that it would be possible to develop the sites – Wli Falls inclusive – and still preserve the tourism potential of the sites. The only environmental issue touched on in the AESC report was a discussion of the potential environmental benefits of the sites if developed. However whether or not the possible negative effect on tourism raised by ACRES will constitute a barrier to the development of SHP in Ghana would depend on what is perceived by the government to be the best use for the site in question, generation of electricity for nearby communities or developing site for tourism.

7.2.4 Social

There has not been any study to assess the social acceptance of SHP technology by communities within which the SHP sites are located: the AESC study only focused on the social benefits expected to accrue from the projects. Neither did the project team conduct any study to assess the host communities' acceptance of the potential SHP projects. However, in view of the fact that small hydro produces one of the most environmentally benign ways of generating power, their acceptability among the host communities normally should not be in doubt. This is because unlike their larger counterparts, SHPs are devoid of such problems as social dislocation and subsequent resettlement. Moreover, SHP can enable involvement from the local community in terms financing, implementation, maintenance and management. "Thus in addition to providing the needed electrical and mechanical energy, SHPs have the potential to resuscitate dying communities by creating jobs through the participation of locals in the projects" [Adamu and Jimmoh, 1990]. Where the host community is not dislodged and job opportunities are created, it is very unlikely that societal objection would arise. The only possible conceivable social barriers are cultural or religious barriers, i.e. where the host communities attach some religious or cultural importance to the sites.

Meanwhile the project team was told by a member of Ghana's Energy Commission that beneficiaries of the Likpe-Kukurantumi are to date pushing for the completion of the site, in spite of the fact that grid electricity has been extended to the town. Thus it can be submitted that social barriers have not and would not pose a barrier to the development of SHP sites in Ghana.

7.3 Economic Barriers

7.3.1 Market Barriers

In Phase I of the AESC's 1985 study, a total of 17 rural electricity consumption areas were investigated in the vicinity of the considered SHP locations. Peak loads, daily energies and load factors were determined for a typical working day. Load factors ranging between 20 % and 51 % were estimated for the areas. ACRES International [1989] built upon AESC calculation by introducing a typical holiday scenario into their analysis. They came up with the finding that rural demand for the power to be generated "appears peaky and of low load factor", 0.36 to 0.50 for a working day, and somewhat lower for an average week. ACRES thus concluded that between 50% to 65% of the potential energy of a run-of-river SHP plant supplying an isolated rural consumer would be lost to spilling even when the available discharges of the watercourse cover the turbine discharge of the SHP plants. From these figures it is apparent that other end-uses such as connection to grid may have to be found for the power to be produced from SHPs if the plants are to service isolated local communities. Absence of market was cited by some experts interviewed as the main reason why the Likpe-Kukurantumi project was abandoned since grid electricity was extended to the targeted communities before the completion of the project.

In this study we have not carried out any market survey to estimate the potential demand for SHP if supplied to isolated rural communities. However we will like to submit that there is a potential market for SHP with the coming into force of the Energy Commission Act. As mentioned earlier on in this report, the Act *inter alia* authorises the Commission to licence Independent Power Producers (IPPs) to generate power and sell to the distribution companies as well as selling directly to consumers. Thus given the right tariff and well-drawn Power Purchase Agreements [PPA][41], which guarantees long term market for the energy to be produced, private investors can venture into the development of SHP in Ghana without being concerned about whether there is an existing local market for the power to be produced.[42]

7.3.2 Financial Analysis

Favourable financial analysis for a technology provides the basic incentive for the adoption and implementation of the said technology. SHP technology exhibits the standard characteristics of all renewable, namely relatively high initial capital costs and relatively low, although not zero, running costs. This high start-up cost for SHP is a potential barrier, which every developer will have to grapple with. However, the high start-up cost of SHP was not mentioned during interviews with experts as the reason why Likpe-Kukurantumi for instance was abandoned.[43]

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[41] According to the RETScreen Software, a PPA will be required if SHP is to be owned privately and will involve legal and other professional advice [RETScreen, 1998]. It has to be acknowledged however that PPA negotiation involves cost, which will further add to the costs of investment.

[42] At current tariffs such investments will not be viable. The EC Act, has removes a major barrier to the operation of IPPs in Ghana. Hitherto, it was illegal for any entity, besides VRA and ECG, to generate power in Ghana

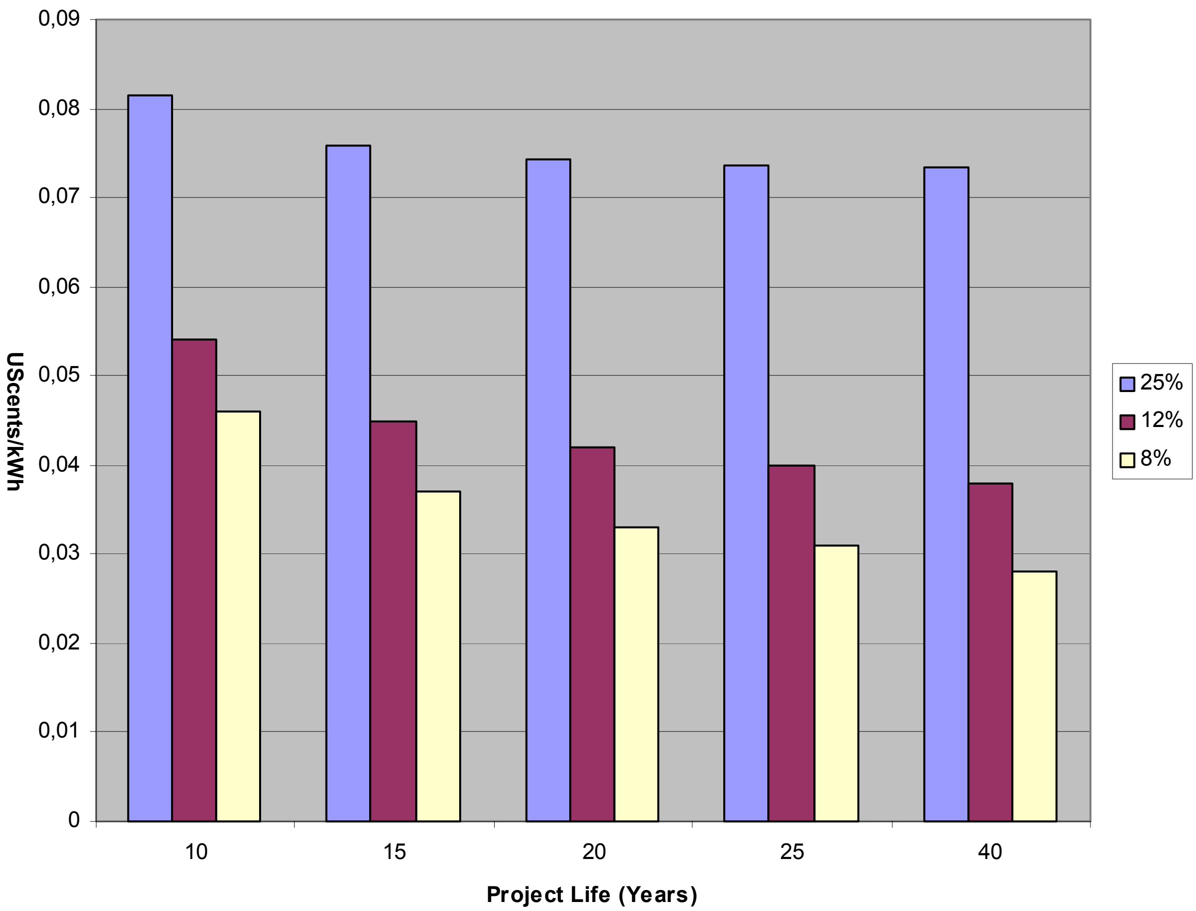
[43] Funding for the Likpe-Kukurantumi project was provided under a Ghana-India Technical Co-operation Agreement.

Regarding the financial viability of the SHP sites, the AESC study adjudged all the sites they studied to be economically viable. According to the AESC, such was the viability of the projects that even in the event of up to 30% increment in project costs or a 30% decrease in benefits, almost all the sites studied would remain viable.

In this project an attempt was made to carry out an independent financial analysis of the sites but this has been hampered by lack of up to date cost estimates and more recent hydrological studies on the rivers. The only cost estimates available were those used in 1986 by the AESC so we have been forced to adapt these figures for our analysis. What we have done is to convert the cost estimates in 1986 to US dollars (using the exchange rate prevailing at the time – ¢90/$1) and extrapolate the 1986 dollar equivalent to the present by assuming an inflation rate of 3% for the dollar. We then calculated the unit cost of production for 2 out of 6 sites selected by ACRES International as representative projects using a discount rate of 12%.[44] The results are presented in Appendix 4 of this report. As can be seen from Appendix 4a and 4b, the Wli Waterfalls, if developed, can potentially generate power at a cost of 3.8 cents/kWh, assuming transmission cost is zero, a plant capacity factor of 75% and a project life of 40 years, while Tsatsadu Falls (under the same assumptions) can produce power at 7 cents/kWh. Figure 7.1 shows the unit cost of generating electric power from the Wli Falls site at varying discount rates and project life.

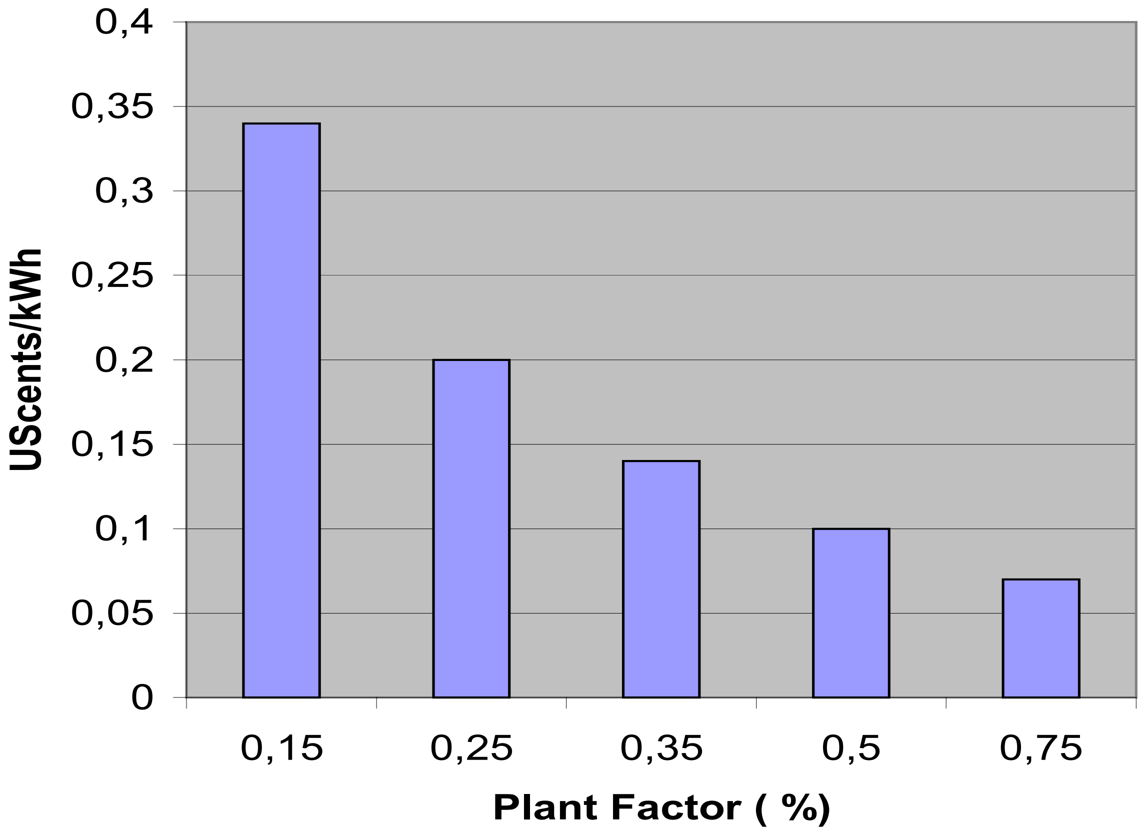
[44] The choice of 12% discount rate was based on the World Bank guidelines of 8-12% for such projects. ([AESC, 1986]. We have only chosen the upper limit for our analysis. .

Figure 7.1 Wli Falls - Unit Cost of Energy at Different Project Life & Discount Rate



A slightly different analysis is conducted in case of Tsatsadu Falls as shown in Figure 7.2, which depicts the relationship between plant factor and the unit cost of energy generated at Tsatsadu Falls. Figure 7.2 shows that for a project life of 40 years, a discount rate of 12% and a plant factor of 75%, unit cost of electric power from Tsatsadu is 9 cents/kWh. If the plant factor falls to 15%, which is the other extreme, unit cost of production rises to 34 cents/kWh. Three major conclusions can be drawn from the analyses done in Figure 7.1 and 7.2, which are:

Figure 7.2 Tsatsadu Falls - Relationship Between Plant Factor & Unit Cost of Energy



- The financial viability of a small hydro plant is largely determined by the plant capacity factor and the discount rate;
- The longer the project life, the more financially attractive is the small hydro power project; and
- Using 1986 extrapolated costs, the cost/kW installed and the unit cost of energy for the two schemes falls within the global range.

What then are the likely economic/financial barriers to the development of the SHP technology in Ghana? Sourcing capital from local financial institutions is likely to be very difficult for any investor because of the following: the amount of initial capital required, prevailing interest rate (between 45% and 50%) and the payback period for the loan (if debt, as opposed to equity financing, is used). This leaves international funding agencies as the possible source of funding. A window of opportunity for funding however appears to have been opened by the Kyoto Protocol, via the Clean Development Mechanism (CDM). Prevailing tariffs, around 2 cents/kWh, for grid electricity can also be a deterrent to any investor wanting to generate power from SHP.

7.4 Cross-Cutting Barriers

7.4.1 Information Barrier

Throughout the study on SHP it became strikingly evident that there is a dearth of information on SHP in Ghana. Getting relevant information on SHP was extremely difficult. A search for the report on the AESC study led to the discovery that there was only one hard copy left in circulation, and this was a personal copy of one of engineers who was involved in the study. Although copies of the report were sent to the then Ministry of Fuel and Power, those copies could not be located at the ministry library. Obtaining the ACRES report, as well as data on current costs was equally difficult. This has led to a near complete lack of information to policy makers, consumers (host communities) and private investors about the usefulness (benefits), prices, resource availability, performance and reliability of SHP in Ghana.

Hence, for private investors, there is insufficient information on which to make an investment decision. It was revealed during the study that a Swedish Company and other private firms are interested in developing some of the SHP sites that have so far been prevented from moving beyond the project idea phase because of the information barrier. The existence of an information barrier was further supported by the fact that during the study three individuals – two in academia and one private investor – contacted the project team for information on the status of SHP in Ghana. Thus it can be stated unequivocally that that lack of information has been an obstacle to the development of SHP in Ghana.

7.4.2 Policy

As mentioned earlier on in Chapter 4 of this report, there is no policy framework in place for the development of SHP in Ghana. Ghana's Renewable Energy Development Programme (REDP) has made no provision at all for the development of the SHP resources in the country. SHP schemes are not even classified under the renewable let alone provision being made for their development. Development of hydropower has been mentioned briefly under the power sector with emphasis on the development of sites, which by definition are not small hydro projects; rather, this is the development of the 'western rivers'. One could argue that if SHP had been brought under the umbrella of renewable energy, a few demonstration projects at least would have been carried out, as with the other RETs, and the advantages inherent in SHP brought to the fore.

Although there are policies to encourage rural electrification, these are usually through grid extension. Many interviewees attributed the abrupt end of the Likpe-Kukurantumi project to the extension of grid electricity to the targeted market before the completion of the project. This is clearly a case of ill-timed policy intervention, which could possibly be the main reason why there has not been a single small hydro project in Ghana.

7.4.3 Institutional Barriers

The main institutional barriers to SHP in Ghana can be gleaned from existing policies. At the moment there is no institution or body in the country assigned with a specific responsibility of ensuring that the SHP resources in the country are developed. Such an institution would not only initiate and implement programmes but would in addition lobby for the policy change required to create an environment of regulation and support in which the SHP technology and its various players can thrive. Another institutional barrier is the fact that until 1997 when the Energy Commission Act was passed, the existing policy framework outlawed the involvement of the private sector in the generation of power.

7.5 Stakeholders' Perspectives – Small Hydro Power

The above analysis of barriers was presented at the 2nd National Stakeholders Workshop, which was organised as part of the project to present its findings. Apart from the general discussions on the findings and barrier analysis, a syndicate group on SHP (as well as on biogas and solar water pumps) was created for a more focussed discussion on the barriers. In all there were eight stakeholders in the SHP syndicate group – 2 from the Energy Commission, 4 from academia/technical backgrounds, one from the media and a facilitator who was a member of the project team. The terms of reference for the syndicate group were to identify:

- The key barriers to SHP;
- How the barriers can be removed; and
- Specific instruments to be used in the barrier removal process.

In addition to the above, the stakeholders in the syndicate groups were required to rank the barriers in the order of importance by filling in a questionnaire given out during registration (see Appendix 5 for a copy of the questionnaire for ranking of barriers).

7.6 Key Barriers

Stakeholders in the SHP syndicate group identified six key barriers, which are listed below:

- Absence of Policy on SHPs;
- Lack of funding/financing;
- Low electricity tariff levels;
- Information barriers;
- Institutional barriers; and
- Acceptability by host communities.

7.6.1 Ranking of barriers

In terms of which of the barriers identified is the most important, the stakeholders in the SHP syndicate group ranked the “policy barrier” as the most important (6 stakeholders out of 7 ranked it as such). The “policy barrier” was followed closely by “institutional”, “information” and “financing” barriers (5 out of 7 stakeholders ranked these barriers as the second most important barriers). The two syndicate group on the other RETs also ranked the “policy barrier” – along with “financing” and “resource” – as the most important barriers to the SHP technology. This was followed by the “Costs and Benefits” barrier. Table 7.1 contains the summary of the ranking of barriers by the syndicate groups).

During discussions by the stakeholders in the SHP syndicate, it was explained that the “policy barrier” was selected as the most important because it has a bearing on the other key barriers identified. For instance the group argued that were there to be a policy framework in place, required institutional infrastructure and funding/financing mechanisms would possibly have been addressed in such a framework. The group however pointed out that there is an inter-relationship between the key barriers because the absence of policy on SHP for instance is due partly to unavailability of information to policy-makers on the usefulness and potential role that SHP can play. Again reliable information on costs and benefits of the technology has an influence on the availability of financing mechanisms. Meanwhile policy could have aided in making reliable information available since the dearth of information on the technology was partly blamed on the absence of a pilot/demonstration project, which the group also attributed to the policy gap.

Table 7-1: Ranking of Barriers by Syndicate Groups

Barrier	No. of Respondents / Order of Importance[1]	
	Syndicate Group on SHP	**2 Syndicate Groups on other RETs**
Socio-Technical		
Resources	4 (3)	9 (1)
Technology	2 (5)	6 (3)
Environment	2 (5)	6 (3)
Social	2 (5)	1 (6)
Others (community ownership)	1 (6)	-
Economic		
Market	1 (6)	2 (5)
Costs and Benefits	3 (4)	7 (2)
Financing	5 (2)	9 (1)
Others (low tariff)	2 (5)	-
Cross-Cutting		
Information	5 (2)	3 (4)
Institutional	5 (2)	3 (4)
Policy	6 (1)	9 (1)
Others (Lack of Promotion)	1 (6)	-
Number of Respondents	7	12

[1] The numbers in brackets represent the ranking for the particular barrier – (1) being the most important – based on the total number of stakeholders who ranked it as most important. The numbers not in brackets represent the total number of respondents who ranked the particular barrier as most important.

7.6.2 Barrier Removers

Having identified lack of policy as the most important barrier, most of the barrier removers suggested by stakeholders in the syndicate group on SHP were directed at what the government should do in order to facilitate the implementation of SHPs projects.

The first barrier remover recommended was the need for the government to recognise the potential contribution of SHP as an alternative way of meeting the energy needs of the rural populace. To be able to do this the government will need relevant information on the usefulness and advantages of SHP. This information can be supplied by a small group of “enthusiasts” (engineers in academia, NGOs etc) through lobbying in parliament, the Energy Commission or the MME. Once the government accepts the role of SHP, the stakeholders recommended that the government then formulate clear-cut small hydro policies. These policies must unambiguously spell out the government's strategy for the development of SHP.

The next barrier remover recommended by the stakeholders was the need for the government to set the pace by developing a couple of sites, or at least one, as a pilot or demonstration project to prove the viability and feasibility of the technology. Funds for such demonstration project(s) according to the stakeholders could be sourced from the Energy Fund or from the donor community.

The stakeholders were also of the view that the "Self-Help Electrification Programme" (SHEP) currently being implemented by the government should be expanded to include community built, owned and managed SHP plants. They thought this should be made an integral part of the SHEP.

Finally the stakeholders emphasised the need for the government to create an enabling environment so that private investors will venture into the development of SHP sites and financial institutions are able to support such projects.

Some specific policy instruments and measures recommended by the SHP syndicate group are as follows:

- Upward adjustment of existing tariffs to economic levels so as to encourage private investors to enter into the development of SHP plants or alternatively to pay a premium price for power generated by SHP plants if tariffs are to remain at current levels;
- Cataloguing information on the potential benefit of SHP by the MME; and
- Educating all stakeholders – government agencies and policy makers, local communities, financial institutions, local communities, District Chief Executives etc on the potential benefits of SHP.

In a discussion which followed the presentation of the SHP syndicate group report, stakeholders in the other two syndicate groups reiterated the point that SHP projects will continue to be unattractive to private investors until such time that the existing electricity tariffs are reviewed upwards.

7.7 Follow-Up Project

Following from the discussion on barriers and the options for their removal in the preceding sections, it appears the most obvious follow-up project would be the development of one small hydro site to serve as a pilot/demonstration project. The project would inter alia provide an up-to-date cost profile of SHP (although costs are site specific), bring out the technological and technical difficulties peculiar to SHP in Ghana and generally provide a sufficient basis for investment decisions. The proposed site for such a demonstration project is the Likpe-Kukurantumi site. This site has been chosen because there is some civil work already in place and the generating plant imported for the original project is still available and in good condition. This will therefore help reduce significantly the amount of initial capital that will be required.

The hydro division of the AESL should be tasked with the responsibility of developing the site because of their involvement in the first project. Initial operation and maintenance of the plant could be assigned to the Electricity Company of Ghana (ECG) with the AESL playing a supervisory role. Meanwhile building of local capacities to manage, operate and maintain SHP should be made an important component of the demonstration projects. Users of the power to be produced will still be same the towns and villages within the vicinity of the project site[45] with excess power being fed into the grid. The project could also explore the possibility of increasing the load factor by developing cash generating end uses for the electricity.

7.8 Conclusion

This chapter has analysed the barriers to the development of SHP in Ghana. There was a general analysis of barriers (identified through interviews and the literature) to assess the extent to which each of the barriers has or could impinge on the development of the technology. This was presented to stakeholders in a workshop, which identified the key barriers and proceeded to rank them according to their degree of importance. There was unanimity among the stakeholders that the absence of policy on SHP is the most important obstacle to the technology. Lack of information, institutional arrangement and financing mechanisms were also identified as the other crucial barriers. Recommendations for overcoming the barriers were basically directed at the government and were to the effect that the government ought to put in place a policy on SHP as well as creating the enabling environment to entice private investors (both domestic and foreign) to enter into the development of the other SHP sites. In view of the fact that there is little information on the technology, a follow-up project was proposed to develop the Likpe-Kukurantumi site.

[45] Some of the towns and villages are currently supplied with single-phase grid electricity, which cannot be used to power machinery such as corn mills.

8 Opportunities for Development of RETs

8.1.1 Introduction

Having identified known and potential barriers as well as possible ways of circumventing them, we will now look at the opportunities that exist in Ghana for the development and promotion of RETs. There are four important developments in Ghana's power sector, which have offered opportunities for widespread utilisation of RETs. These are National Electrification Scheme (NES), Power Sector Reform, the National Electrification Fund, and the Energy Fund. Almost all of these developments have been briefly touched on earlier on in the report. This section is intended to provide a clearer description these opportunities.

8.1.2 National Electrification Scheme

The Government of Ghana in 1989 instituted a National Electrification Scheme as the principal instrument to achieve its policy of extending the reach of electricity to all parts of the country by the year 2020. The implementation of NES was divided into six 5-year phases spanning a period of 30 years from 1990-2020. The primary focus of Phase 1 – called the District Capital Electrification Programme (DCEP) – was to extend the national grid to all 110-district capitals in the country. This phase was completed in 1997. The implementation of the remaining phases of the NES was planned on the basis of most viable projects; the projects with high economic rates of return were implemented first [Oteng-Adjei[46], 2000]. A complementary activity to NES is the Self-Help Electrification Programme (SHEP), which commenced in 1992. The SHEP made it possible for communities that are located 20 kilometres from the national grid to fast-track their electrification projects subject to two provisos – ability of the community to procure all the required low voltage (LV) poles and a minimum of 30% of the houses within the community should be wired.

At the inception of the NES an estimated 4221 communities were without electricity in Ghana. By the year 2000, a total of about 2,450 communities had been connected to electricity under the NES leaving about 2000 communities still without access to electricity. By virtue of their location, it will be very expensive (if not impossible) to extend the national grid to these communities. Some of these communities are located on islands and mountainous regions. Others are just too remote and very far from the nearest grid line. Furthermore, their low population density requires the installation of longer low-line voltage per new customer [Oteng-Adjei, 2000]. According to Oteng-Adjei [2000], it may not be possible for these communities to be connected to the national grid within the NES period. Thus for many of these rural communities, RETs can provide a cheaper and in some cases the only alternative to provide access to electricity.

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[46] Dr. Oteng-Adjei is the Director of Power at the MME.

8.1.3 Power Sector Reform

Ghana's power sector is undergoing reform. The reform model being pursued is "unbundling", a model that requires the separation of the various operations in the electricity supply chain, i.e. generation, transmission and distribution. Perhaps the biggest legacy that reform has "bequeathed" to RETs is the legal status it has granted to private sector generation of electricity; hitherto it was illegal for any entity (except VRA and ECG) to generate and sell electricity. Under the proposed power sector reform, private generators are now permitted to build and operate power plants in competition with the Volta River Authority (VRA). The reform model also guarantees private companies access to the transmission lines, which is currently owned and operated by the VRA. At the distribution level, the country has been divided into five concession zones. The concessions are further broken into "commercialised electrification zones" and "non-commercialised or SHEP electrification zones". The commercial areas will comprise all urban centres covered under the DCEP where customer density is high enough to make the distribution business economically viable. In this zone distribution concessionaires would have the obligation to provide service connections on demand to customers.

The "non-commercial" areas are the poor rural communities where consumer densities and income levels are low and therefore not financially attractive to distribution concessionaires. These areas fall under the SHEP electrification scheme, which currently is being heavily subsidised by the government. The government has indicated its commitment to continue supporting electrification of these areas; the role of distribution concessionaires in the SHEP zones would to provide services under operation and maintenance contracts with the government. The distribution arrangement proposed under reform provides two main opportunities for RETs. First, it provides avenue for RETs to enjoy some public funding when used to meet the energy supply needs of the "non-commercial" concession areas, and second, distribution concessionaires (since they out to maximise profit) will look for cheaper ways of meeting their obligation. As mentioned earlier, RETs in some cases are cheaper and the only alternative.

8.1.4 National Electrification Fund (NEF)

The GOG created the NEF in 1989 to be used to finance the local component of the National Electrification Programme (NEP). The fund is fed by special levies imposed by the government on consumers of electricity. Initially pegged at ¢1.50/kWh, the levies was reviewed upwards to ¢1.70/kWh in 1995 under the Electricity (Special Levy) Act, 1995 (Act 497). The levies payable under Act 497 is collected by the utilities – ECG and the VRA – and administered by the MME. The fund has so far been used to finance rural electrification projects and other associated expenses of the MME electrification programme. Under the on-going reform programme it has been proposed that a National Electrification Fund Board (NEFB) be established to be manage the NEF. The proposed NEFB would have oversight responsibilities for the (i) mobilisation of funds from domestic sources (such as levies), donors, and the private sector and also (ii) for the implementation of mechanisms for the recovery of investments made by the GOG, donors, and the beneficiary communities in the NES/SHEP projects.

Monies raised through the NEF could be used to subsidise the installation of RETs in rural communities.

8.1.5 Energy Fund

As pointed out in Section 3.6.3.1 the Energy Fund has been established under Section 41 of the Energy Commission Act and fed primarily by a proportion of government levy on petroleum products, electricity and natural gas. Monies generated through the Fund are supposed to be used inter alia for the promotion of projects for the development and utilisation of renewable energy resources and rural electrification. Unlike the NEF, the Energy Fund has been set up not only to finance rural electrification programmes, but also to develop and utilise RETs. The Energy Fund thus provides a bankable and reliable financing mechanism for RETs. However as has been shown in Section 3.6.3.1, only a small proportion of disbursements from the Fund have gone into the development of RETs in Ghana.

9 POLICY IMPLICATIONS

9.1 Introduction

In this chapter we will attempt to recapitulate the key findings arising from the study and their implications for policy. Based on the findings, especially the findings on key barriers, policy instruments and measures perceived as necessary for the removal of the barriers and successful implementation of the technologies studied, are suggested and discussed. In addition, this chapter presents recommendations as to how RETs in general can be disseminated on a wider scale in Ghana.

9.2 Summary of Key Findings

The key findings emanating from the study are as follows:

- Ghana is endowed with several renewable energy resources like solar radiation, small hydro, biomass, and wind. Most of these resources (save small hydro and wind) have been harnessed through various renewable energy technologies (RETs). Technologies used to harness the solar energy resources include solar water heaters (SWH), solar crop dryers (SCD), solar water pumps (SWP), solar refrigeration and solar lighting while pyrolysis, improved cookstoves, biomass fired dryers, sawdust briquette, improved charcoal production, biogas and cogeneration are the biomass technologies that have been experimented with, demonstrated and disseminated to date. Most of the technologies are proven ones.

- Exploitation of Ghana’s renewable energy resources has been carried out under two main policy regimes – PNDC Law 62 (1983) and the Energy Sector Development Programme (ESDP). The former established the National Energy Board (NEB) and amongst other things mandated the NEB to direct the development and demonstration of renewable energy projects throughout Ghana while the latter is the policy framework that has been guiding the development of RETs since 1996 till the present.

- Several measures and instruments have been employed in the implementation of renewable energy policies. The main measures used are research and development, information and education, and some normative measures (like the passing of PNDC Law 62 and the Energy Commission Law). Some economic instruments (such as subsidies, taxes, pricing, financing and duty waiver/reduction) have been used as well but only to a limited extent.

- Existing renewable energy policy framework is not potent enough to ensure the commercialisation and widespread utilisation of RETs the framework seeks to promote. This is because the policy framework has neither investment plans nor financing mechanisms and relies heavily on government budgetary allocation and donor funding which are not likely to be sustainable. The policy framework can also be faulted on the grounds that it “discriminates” against some forms of RETs (notably small hydro power) by making no provision for their development.

- The effective development, implementation and dissemination of all the RETs studied are hampered by several barriers, which can be grouped into three main categories – socio-technical barriers, economic barriers and crosscutting barriers.

- For the three solar technologies considered in this study – SWH, SCD and SWP, SWP came out as having the least number of barriers. The greatest barriers identified for SWP are the high initial costs with often-unquantified long-term benefits and the general lack of information.

- For the biomass technologies, biogas was studied in the most detail because the huge environmental/sanitation and agricultural benefits associated with the technology. The most important barrier to biogas is resource availability. Best practice suggests that biogas should be packaged more as sanitation or agricultural projects with energy provision as spin-off.

- For SHP, even though over seventy sites have been identified, none have been developed so far. Only one pilot project has ever been commenced and it was not completed, having been abandoned in 1983. Absence of specific policies for the development of SHP has been found to be the greatest barrier to harnessing the small hydro resources.

9.3 Policy Options

9.3.1 Introduction

In view of the fact that Ghana's renewable energy policies have been found to be inadequate in ensuring widespread utilisation of RETs, a new policy framework will have to be put in place. Such a policy framework should be able to remove identified barriers thereby ensuring commercialisation and widespread utilisation of RETs. Fortunately the ESDP is coming to an end and a new National Renewable Energy Strategy (NRES) is being formulated under the Renewable Energy Component (REC) of the DANIDA Energy Sector Programme Support (ESPS).[47] It is hoped that the NRES will contain all the necessary measures and instruments required to push the application of the renewable forward. Based on our key findings, the following policy options, discussed under solar, small hydropower and biomass are suggested for consideration by the formulators of the NRES.

9.3.2 Solar

With solar technologies, the key barrier has been identified to be the high start-up cost associated with the acquisition of the technology. To overcome this barrier, new and innovative financing mechanisms need to be devised. Consequently, the following options are suggested:

- A fund should be set up in a financial institution to administer soft loans, grants and flexible financing schemes to dealers and end-users. Such a fund could be fed by disbursements from the Energy Fund. Monies raised could be used to run any of the financing mechanisms discussed above. For instance, the dealer model could be experimented with using money from the fund. However because the model thrives well in large and relatively high-income rural markets, areas that satisfy this criterion may have to be targeted for such an experiment. Alternatively the fund can be used to test the concession model as an appendage to the solar services centres (SSC) already existing in certain districts. All these options will help spread the start-up cost.

- Costs can be reduced further if the duty reduction on panels is extended to a complete waiver. However because of difficulties already encountered with this measure, there will need to be a strengthening of the institutional capacity of Customs Excise and Preventive Services (CEPS) as well as the education of CEPS officials through workshops and seminars on the solar components. Meanwhile, any such policy directive authorising a complete waiver should be formal (codified) and unambiguous.

- To help expand the market for solar PVs, rural electrification projects aimed at meeting the basic lighting needs of rural communities should consider the use of solar lighting as

[47] In 1996, the governments of Denmark and Ghana agreed that the energy sector would be one of the priority areas for future Danish-Ghana development Cupertino assistance. Pursuant to this agreement, the Danish government is funding the ESPS. REC is a component under ESPS supporting the development and management of Ghana's renewable energy.

opposed to grid extension. In this regard, we recommend that a body, such as the Ghana Solar Energy Society (GHASES) or the Energy Research Group (ERG), should liase with MME to source funding to be used for conducting studies to determine situations in which between solar and grid extension, the former is a cheaper and more cost effective option for meeting the energy service needs of end-users. Once this is established, there should be a commitment on the part of the government under SHEP to choose solar electrification by paying for a greater proportion of the costs involved, as pertains under SHEP. Alternatively, a model akin to the concession model can be introduced under the SHEP whereby the government contracts and pay a local company to provide energy services to meet the rural electrification objective.

- In the same vein a market can be created for PV systems in the urban areas if PV systems are integrated into urban housing and building schemes, especially peri-urban areas yet to be serviced with grid electricity. However, because the use of the technology is uncommon in the building industry, some education and information programmes will have to be carried out. We therefore recommend that training programmes and seminars should be organised by GHASES for private estate developers, Ghana Institution of Surveyors (GIS), AESL, architects, building contractors, SSNIT, etc. on a periodic basis. The aim of these seminars/workshops will be to introduce participants to ways by which PV applications can be integrated into buildings and their accompanying benefits. Funds for the organisation of such programmes could be sourced from the Energy Commission.

- Meanwhile the government can introduce a normative measure which will stipulate that all government-funded building projects in district capitals and peri-urban areas such as the construction of new schools, district assemblies' offices, and health centres, must incorporate solar PV systems. In addition, a standard can be set for new peri-urban building schemes whereby private developers will be required to incorporate solar RETs into the design of the housing units. Because this will inevitably swell up the cost of the projects, some incentives like tax holidays will have to be provided for the private developers to ensure compliance.

- To help create a market for locally manufactured solar components such as ballasts, low voltage disconnect (LVD) and controllers, a normative measure should be instituted by the government which will stipulate that all government funded and donor-funded projects should use local components where available.

- For Solar Crop Dryers we recommend that educational programmes be run for agricultural co-operatives and farmers' associations to enlighten farmers on the usefulness and benefits of the technologies. These programmes could be tagged to occasions such the National Farmers Day celebrations or organised separately. Ghana Cocoa Board (COCOBOD) can also be lobbied to acquire SCDs for major cocoa growing areas to be operated and managed by agricultural co-operatives and/or district assemblies. Meanwhile, education programmes for COCOBOD, farmers' co-operatives and/or individual farmers should be able to make explicit the advantages of SCD so as to give them an economic incentives to adopt the technology.

- Regarding SWP, we recommend once again that GHASES or ERG should organise training workshops and awareness raising seminars for all the stakeholders in the water supply industry. Stakeholders to be invited should include staff of the Community Water and Sanitation Programme and World Vision International (an NGO constructing boreholes at various parts of the country and district assemblies).

- In the case of SWH, similar training / awareness raising workshops/seminars could be organised for the hospitality and manufacturing industries, also on periodic basis, to provide information on the technology. The government must then provide incentives (in whatever form possible) to serve as a stimulant for the operators in the industry to acquire and use the technology. For instance a tax rebate or holiday could be granted to hotels and manufacturing firms using SWH. Alternatively, firms not using SWH to meet their hot water needs could be made to pay a penalty. In addition, the PURC can devise special tariffs for households using SWH. All these measures will provide economic incentives for the acquisition of the technology.

9.3.3 Biomass

- Existing environmental standards governing urban waste disposal should be reviewed and made more stringent by the Environmental Protection Agency (EPA) in collaboration with the Ministry of Environment, Science and Technology (MEST). Such standards should be enforceable and must contain clearly spelt-out penalties for violators. This will provide an incentive for producers of urban waste to dispose of their waste in an environmentally friendly manner. For instance a legislation which outlaws the burning of wood residue as a means of disposal and imposes punitive fines on violators will most likely cause timber firms to devise strategies for the disposal of their wood residue. Under such a situation, modern biomass technologies such as briquette and cogeneration will become viable alternatives, since they will not only provide a cleaner way of disposal but also generate electricity and revenue.

- Metropolitan, municipal and district assemblies should also be statute bound to disposing of waste in an acceptable manner. With legislative backing, MEST, MME and Ministry of Food and Agriculture (MOFA) must then organise a series of workshops and seminars for the assemblies on ways of utilising waste for biomass energy and organic fertilizer. Private companies contracted by metropolitan authorities to dispose of waste should be invited to such workshops/seminars. Meanwhile education programmes should be run for the general public on the need for ids-aggregating solid waste into organic and inorganic waste. Separate containers should then be provided at waste disposal sites for the public. After these workshops, funds should be sourced by the three ministries (MME, MEST and MOFA) to implement demonstration projects at selected waste disposals sites. This calls for closer collaboration between the three ministries and we propose the setting up of an inter-sectoral working committee to foster collaboration and linkages.

- As an incentive to investors to venture into residue-based power generation the government should introduce some economic instruments. Here we proposed that the five-year tax break currently being enjoyed by investors under Ghana's investment code should be extended for another five years for investments in residue-based power generation. Alternatively import duties on residue-based generating equipment could be waived or a premium tariff should be worked out by the PURC for residue-based generation. The justification for these incentives is that apart from generating electricity, such projects will help clean the environment.

- We also propose that a percentage of the Reforestation Fund (about 5%) be earmarked for plantations that will grow short-rotation trees to be used as feedstock in biomass power plants.

9.3.4 Small Hydro Power

- For SHP we propose the formation of a Multi-Stakeholder Small Hydro Group (MSHG) by the Energy Commission. Stakeholders could be drawn from the MME, EC, Hydrological Service Department, AESL, the universities and NGOs such as KITE and the Energy Foundation. The MSHG will among other things source for funds, from the Energy Fund or other governmental sources to:

    - Complete Likpe-Kukurantumi as a pilot project;
    - Develop local capacity to manage, operate and maintain the Likpe-Kukurantumi pilot project;
    - Review, update and disseminate the assessment of the SHP potentials of Ghana; and,
    - Organise workshops and seminars for districts having SHP resources with the aim of providing information on the benefits and opportunities associated with the development of SHP, particularly the revenue generation potential of SHP where excess power generated will be sold into the grid.

- In addition, the stakeholder group will be expected to work in collaboration with the PURC in fixing tariffs for electricity generated from SHP sources. To be able to do this effectively, the group will have to arm itself with a comprehensive cost-benefit analysis of the sites.

- The stakeholder group when formed will also play an advocacy role by lobbying for the inclusion of SHP in national renewable energy programmes.

9.3.5 RETs In General

- The government must assign a clear role for renewable in its National Electrification Scheme. We recommend the introduction of a "Renewable Energy SHEP Programme" under which communities remote from the grid will be electrified through renewable. Before any community is connected to grid electricity, the MME should consider all supply options and go in for the cheapest option without necessarily relying on grid extension.

- To ensure private sector participation in the renewable energy industry, the government must provide a level playing field. Because conventional energy is heavily subsidised, similar subsidies must be provided for the renewable or else premium tariffs must be paid for the renewably generated electricity.

- Plans and programmes for the extension of grid electricity should be made available to the public to reduce uncertainty about when the grid will reach a particular location. This will enable private investors to identify potential markets.

- On the institutional front we recommend that the Renewable Energy Unit of the MME should be hived off into a full-fledged NGO using the "Energy Foundation"[48] model. This will guarantee autonomy for the unit in pursuit of its objectives.

- A Clean Development Mechanism (CDM) office should be set up by the government and the proposed renewable energy NGO should work with other interested parties to assess and package renewable energy projects that will pass for CDM projects before the CDM becomes operational.

9.4 Concluding Remarks

We have already made a number of recommendations on ways to remove barriers and promote widespread utilisation of RETs in Ghana. Notwithstanding these recommendations, we are of the view that before the renewable can make any significant contribution to the energy balance in Ghana, the government must first set a target for the renewable and then devise strategies to achieve it.

During the First Stakeholders' Workshop organised under the project, we proposed a target of 20% Modern Renewable Energy (MORE) in Ghana's commercial energy sector by the year 2020. We followed up at the second stakeholders' workshop to demonstrate, through what we termed "a Wish List for 20% MORE", how renewable can account for 20% of projected installed capacity for electricity in Ghana by 2020. We showed in the "Wish List" that at GDP growth rate of 10% (as envisioned in Ghana's Vision 2020 document) installed capacity for electricity will have to increase from the current capacity of about 1500 MW to a little over 10,000 MW.

[48] The Energy Foundation is a Non-Governmental Organisation, which was established in November 1997, among other things, to take over the MME's Energy Efficiency and conservation Programme.

Twenty per cent (20%) MORE of 10,000 MW will then translate into 2000 MW. We then proceeded to show how this 2000 MW could be generated from renewable sources.[49] The Wish List might appear ambitious but it has been shown that between modern biomass, solar energy (including wind) and small hydropower the target is achievable. Resource potential and technical capability exist, what is needed is the right policy framework with a range of instruments and measures potent enough to ensure that the target is met.

The biggest obstacle to achieving this target will be how to raise the colossal amount of investment capital required to generate 2000 MW of energy from renewable sources. However, with the right mix of economic incentives, significant amounts of private capital could be mobilised. We see a window of opportunity opening through the CDM and other environment related financing mechanisms to provide the necessary investments in renewable energy.

Furthermore, power sector reforms could provide yet another avenue through which investment capital expected to accompany reforms could be channelled into renewable. Renewable can benefit tremendously from private investments with the rationalisation of tariffs – from current low levels to economic levels – and unbundling of the hitherto vertically integrated industry.

Finally, a target of 20% MORE or a similar target will send clear signals to private investors that renewable could be considered in their investment portfolios and this will also help to mobilise the capital investments required.

[49] See Appendix 5 for the “Wish List”

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APPENDICES

Appendix 1 Framework for Barrier Analysis

SOCIO-TECHNICAL BARRIERS

Resources
Resources too small
Time variations in resources do not fit demand
Shortage of dung (or input) in the case of biogas
Others (specify)

Technology/Technical
Immature in some cases
Low R&D capabilities to develop and promote more affordable RETs
Capacity irreversibility
Lack of access to the technology and maintenance of the systems
No servicing of equipment
No operating manuals
Low durability
Others (specify)

Environmental
Energy prices do not include social and environmental costs
Lack of valuation of environmental externalities
Others (specify)

Social
No social acceptance
No local participation
No local ownership (the community do not cooperate without ownership/responsibility)
Neglect of socio-cultural aspects of technologies

ECONOMIC BARRIERS

Market Barriers
Energy Ministry cannot disseminate
Missing or segmented markets
Bad supply channels
No local access, only in major towns
Limited access to international markets of modern RETs
Others (specify)

Cost and Benefits
Costs too high
Import Duty and taxes on technologies
Energy prices do not include social and environmental costs
Subsidies on fossil fuels
Others subsidies
Others (specify)

Financing
Inadequate financing (local, national, international) arrangements
Missing consumer financing schemes
Others (specify)

CROSS-CUTTING BARRIERS

Information
Low consumer awareness
Lack of end-user acceptance
Lack of information to consumers about the usefulness, prices, reliability, etc
No mechanism for getting views from the communities
Others (specify)

Institutional

Institutional capacity limitations (R, D&D, implementation, etc)
Institutions do not collaborate
No detailed knowledge available at regional and district levels
Structural constraints and biases within the energy sector
Limited involvement of the private sector
Limited supply of skilled labour, professionals and training facilities
No payment rules for sales to the grid from independent power producers
Disparities between national, individual and community objectives
Others (specify)

Policy
Missing policy framework or energy strategy
Unfavourable energy policies and unwieldy regulatory mechanisms
Others (specify)

Appendix 2 List of Identified SHP Sites In Ghana

Ashanti/Eastern Region	**Volta Region**
Boumfoum Falls at Kumawu Kwasu River at Maabang Wurudu Falls near Moseaso Chrimfa at Akubia (Mampong) Ongwam at Kumawu Dwehen at Mmakuro Akrum at Begoro Akrum at Akrum Birim at Kibi Birim at Nsutam Birim at Osino Ayensu at Ayensuaso Abomosu at Abuchem Juafoakwa at Asanakese	Alavanyo Waterfalls on Tsatsadu River Wli Falls on Nuboi River Asukawkaw Likpe Kukurantumi Dayi at Wegbe Klemu at Tokokoe Klemu at Hodzoga Alabo at Agove Konsu at Akonko Konsu at Sakode Konsu at Kwamikrom Avu Lagoon
Upper East/West Regions	**Western Region**
Akunkidbota at Gowri Abimoogar at Bolgatanga Nanpumango on Nansan near Tumu Bele on Anhiwiemu Bogdoo at Walewale	Sanwu Falls at Bimzin Sayere Waterfalls on Sayerano Worannae Falls near Asempanaye Bendiemann River at Sefwi Asaminso Pamunu at Donkot Achim-Abra Dam Hwini at Hwinido Ochi at Assin Manso Ochi at Jamra Ochi at Owumaso Nawyo at Eide near Kuntanaso Nkruntrau at Emissano Saruwi at Simiw

Northern Region	**Brong Ahafo Region**
Doli at Mapeasam	Randall Falls at Kintampo
Doli at Dole	Kokuma Falls at Kokuma
Wurusi at Wurusi near Damongo	Fuller Falls near Kintampo
Gushie at Gushie near Tampion	Fia River at Nkoransa
Peli at Zoggo	Pamu at Kosan near Dormaa Ahenkro
Mboum at Pong near Tamale	Pamu at Atesikurom
Persuo at Savelugu	Pamu at Stromani
Sillum at Sillum near Kumbungu	Yifaw at Yifaw
Kaun Gawni at Gushie	Tain at Berekum
Daka at Yendi	Fia at Nkoransa
Sambu at Yendi	
Machankpeni at Zabzugu	
Badaloo at Takpagaya	
Kuma at Baal near Wulensi	
Kumoo at Mampe	
Achibunya at Busunu	
Sur at MP. 30	

Source: Odai, 1999

Appendix 3a Financial Analysis of 30,000 Tonnes Sawdust Briquetting Plant – Worst Case

Year	0	1	2	3	4	5	6	7	8	9	10
Plant Max. Capacity	30,000										
Operating Capacity (%)	90	90	90	90	90	90	90	90	90	90	90
Est. Selling Price/tonne (US$)	72										
Revenue $	1,944,000	1,944,000	1,944,000	1,944,000	1,944,000	1,944,000	1,944,000	1,944,000	1,944,000	1,944,000	1,944,000
EXPENSES $											
Sawdust & Fuelwood		283,500	283,500	283,500	283,500	283,500	283,500	283,500	283,500	283,500	283,500
Labour		150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000
Fuel (trans./Dryer)		250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000
Utilities		194,880	194,880	194,880	194,880	194,880	194,880	194,880	194,880	194,880	194,880
Admin/Mktg		85,000	85,000	85,000	85,000	85,000	85,000	85,000	85,000	85,000	85,000
Accounting/Legal		5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Plant Maint.		50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Auto Maint.(Tires & Equip.)		50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Spare Parts (Auto & Presses)		25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000
Insurance		15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
Other Supplies		10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Interest on Loan		258,000	216,200	174,400	132,600	90,800	49,000	39,200	29,400	19,600	9,800
Depreciation		621,500	425,500	425,500	425,500	229,500	9,500	9,500	9,500	9,500	9,500
Investment Allowance		152,250	0	0	0	0	0	0	0	0	0
TOTAL EXPENSES		2,150,130	1,760,080	1,718,280	1,676,480	1,438,680	1,176,880	1,167,080	1,157,280	1,147,480	1,137,680
GROSS PROFIT/LOSS(-)		-206,130	183,920	225,720	267,520	505,320	767,120	776,920	786,720	796,520	806,320
INCOME TAX [29.75%]		0	54,716	67,152	79,587	150,333	228,218	231,134	234,049	236,965	239,880
NET PROFIT/LOSS [-]		**-206,130**	**129,204**	**158,568**	**187,933**	**354,987**	**538,902**	**545,786**	**552,671**	**559,555**	**566,440**
EXPENDITURE/CASHFLOW (US$)											
Profit after Tax	0	-206,130	129,204	158,568	187,933	354,987	538,902	545,786	552,671	559,555	566,440
Interest on loans	0	258,000	216,200	174,400	132,600	90,800	49,000	39,200	29,400	19,600	9,800
Depreciation/Inv. All.	0	773,750	425,500	425,500	425,500	229,500	9,500	9,500	9,500	9,500	9,500
Internally Gen. Fund	0	1,031,750	641,700	599,900	558,100	320,300	58,500	48,700	38,900	29,100	19,300
Capital Expenditure	-2,250,000										
Net Cash Flow	-2,250,000	825,620	770,904	758,468	746,033	675,287	597,402	594,486	591,571	588,655	585,740
NPV @25	273,194										
IRR	30%										

Source : Hagan, E.B., 1994

Appendix 3b   Financial Analysis of 30,000 Tonnes Sawdust Briquetting Plant – Best Case

Year	0	1	2	3	4	5	6	7	8	9	10
Plant Max. Capacity	30,000										
Operating Capacity (%)	90	90	90	90	90	90	90	90	90	90	90
Est. Selling Price/tonne (US$)	72										
Revenue $	1,944,000	1,944,000	1,944,000	1,944,000	1,944,000	1,944,000	1,944,000	1,944,000	1,944,000	1,944,000	1,944,000
EXPENSES $											
Sawdust & Fuelwood		283,500	283,500	283,500	283,500	283,500	283,500	283,500	283,500	283,500	283,500
Labour		150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000
Fuel (tran/Dryer)		250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000
Utilities		194,880	194,880	194,880	194,880	194,880	194,880	194,880	194,880	194,880	194,880
Admin/Mktg		85,000	85,000	85,000	85,000	85,000	85,000	85,000	85,000	85,000	85,000
Accounting/Legal		5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Plant Maint.		50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Auto Maint.(Tires & Equip.)		50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Spare Parts (Auto & Presses)		25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000
Insurance		15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
Other Supplies		10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Interest on Loan		258,000	216,200	174,400	132,600	90,800	49,000	39,200	29,400	19,600	9,800
Depreciation		327,500	327,500	327,500	327,500	327,500	107,500	107,500	107,500	107,500	107,500
Investment Allowance		152,250	0	0	0	0	0	0	0	0	0
TOTAL EXPENSES		1,856,130	1,662,080	1,620,280	1,578,480	1,536,680	1,274,880	1,265,080	1,255,280	1,245,480	1,235,680
GROSS PROFIT/LOSS(-)		87,870	281,920	323,720	365,520	407,320	669,120	678,920	688,720	698,520	708,320
INCOME TAX [14.875%]		0	0	0	0	0	99,532	100,989	102,447	103,905	105,363
NET PROFIT/LOSS [-]		**87,870**	**281,920**	**323,720**	**365,520**	**407,320**	**569,588**	**577,931**	**586,273**	**594,615**	**602,957**
EXPENDITURE/CASHFLOW (US$)											
Profit after Tax	0	87,870	281,920	323,720	365,520	407,320	569,588	577,931	586,273	594,615	602,957
Interest on loans	0	258,000	216,200	174,400	132,600	90,800	49,000	39,200	29,400	19,600	9,800
Depreciation/Inv. All.	0	479,750	327,500	327,500	327,500	327,500	107,500	107,500	107,500	107,500	107,500
Internally Gen. Fund	0	737,750	543,700	501,900	460,100	418,300	156,500	146,700	136,900	127,100	117,300
Capital Expenditure	-2,250,000										
Net Cash Flow	-2,250,000	825,620	825,620	825,620	825,620	825,620	726,088	724,631	723,173	721,715	720,257
NPV @25	486,529										
IRR	34%										

Source: Hagan, E. B. 1994

Appendix 4a Financial Analysis of Wli Falls (Project Life 40 years)

Costs in million cedis (1986) =	40,940,000
Cost in million dollars @90 cedis/$1(1986 $rate)	454,889
Year 2001 equivalent of ' 86 estimates ass. 3% infl.=	708,702
Year 2001 equivalent of dollars in cedis @ 7000/$1=	4,960,914,469
Cost less transmission cost =	30,936,000
Dollar equivalent @ 90 cedis/$1=	343,733
Year 2001 equivalent of ' 86 estimates ass. 3% infl.=	535,525
Year 2001 equivalent of dollars in cedis @ 7000/$1=	3,748,677,333

	Transmission Cost Incl.		**Less transmission cost**	
	$	**¢**	**$**	**¢**
Capital Cost =	708,702	4,960,914,469	535,525	3,748,677,333
Discount factor =	0.12	0.12	0.12	0.12
Annualised Capital Cost (A) =	85,968	878,003,301	64,961	550,396,699
Annual O&M (B) =	14,174	99,218,289	10,711	74,973,547
Total Annual Costs (A+B) =	**100,142**	**977,221,590**	**75,672**	**625,370,246**
Installed Capacity (Wli Waterfalls), kW	300	300	300	300
Plant Capacity Factor	0.75	0.75	0.75	0.75
Total Energy Generated	1,971,000	1,971,000	1,971,000	1,971,000
Unit Energy Cost (cents/cedis/kWh)	**0.051**	**496**	**0.038**	**317**
Cost/kWh installed (US$)	**2,362**			

Appendix 4b Financial Analysis of Tsatsadu Falls (Project Life, 40)

Costs in million cedis (1986) =	49,470,000
Cost in million dollars @ 90 cedis/$1(1986 $rate)	549,667
Year 2001 dollar equivalent of ' 86 estimates ass. 3% infl.=	856,363
Year 2001 dollar equivalent in cedis =	5,994,539,297
Cost less transmission cost =	36,090,000
Dollar equivalent @90 cedis/$1=	401,000
Year 2001 equivalent of ' 86 estimates ass. 3% infl.=	624,745
Year 2001 dollar equivalent in cedis =	2,374,030,749

	Transmission Cost Incl.		**Less Transmission Cost**	
	$	**¢**	**$**	**¢**
Capital Cost =	856,363	5,994,539,297	624,745	2,374,030,749
Discount factor =	0.12	0.12	0.12	0.12
Annualised Capital Cost (A) =	103,880	727,159,350	75,784	287,978,537
Annual O&M (B) =	17,127	119,890,786	12,495	47,480,615
Annual Costs (A+B) =	**121,007**	**847,050,136**	**88,279**	**335,459,152**
Installed Capacity (Wli Waterfalls), kW	200	200	200	200
Plant Capacity Factor	0.75	0.75	0.75	0.75
Total Energy Generated	1,314,000	1,314,000	1,314,000	1,314,000
Unit Energy Cost ($/cedis per kWh)	**0.09**	**645**	**0.07**	**255**
Cost/kWh installed (US$)	**4,281.81**			

Appendix 5 20% MORE: A Wish-List for RETs in Ghana.[1]

	Solar	**Modern Biomass**	**Wind**	**Small and Medium Hydro**	**Total**
Short Term (2000-2005)	10	10	50	5	**75**
Medium Term (2005-2010)	50	100	200	200	**550**
Long Term (2010-2020)	200	500	500	300	**1,500**
Total	**260**	**610**	**750**	**505**	**2,125**

Source: KITE, 2000.

[1] Proposed targets (MW installed) for Electricity from Renewable Energy in Ghana.