GHANA'S CLIMATE CHANGE TECHNOLOGY NEEDS AND NEEDS ASSESSMENT REPORT

UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

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PREFACE

As a Party to the United Nations Framework Convention on Climate Change, Ghana has strived, (to the extent that her capacities allow), to meet her commitments under the Convention. This is clearly evidenced by the preparation and submission of her Initial National Communication to the Conference of Parties (COP) in 2001.

In response to the COP decision, Decision 4/CP.4, Ghana has prepared this Technology Needs and Needs Assessment Report. This report has been prepared not just to allow Ghana to fulfil her commitments under the Convention, but to demonstrate Ghana's preparedness to join efforts with the global community in addressing the ever-increasing threat of climate change.

Evidently, for lack of financial resources, this report addresses only climate change mitigation technologies in the energy and waste sectors. This should not be construed to mean that Ghana is a net greenhouse gas emitter and therefore needs to undertake mitigation actions to reduce her greenhouse gas emissions. Neither does it mean that Ghana is not affected by climate change and hence does not need technologies that may be useful for her to adapt to climate change. Initial vulnerability assessments indicate that our water resources; agriculture and coastal zone are vulnerable.

The selection of the energy and waste sectors as requiring technology transfer was informed by the current development needs and prevailing national sectoral policies. The technologies identified in this report are seen, as those that will help Ghana to meet her sustainable development goals. It is envisaged that this report will serve as the blue print for the transfer of climate friendly technologies to Ghana recognising, however, that this report would need to be revised to take into consideration Ghana's developmental needs and aspirations at any point in time.

Our government recognises the tremendous progress the global community has made towards addressing the issue of climate change. We hope that the international community would support Ghana in the implementation of prioritised technology transfer programmes to make our effort a worthwhile.

Honourable Professor Dominic K. Fobih
Minister, Ministry of Environment & Science

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Indeed the value of this report depends on the individuals mentioned above and we thank them for their time and effort.

LIST OF ACRONYMS

CDM	Clean Development Mechanism
CFLs	Compact Fluorescent Lamps
CH_4	Methane
CIDA	Canadian International Development Agency
CNG	Compressed Natural Gas
CO_2	Carbon dioxide
COMAP	Comprehensive Mitigation Analysis Process
CROPWAT	Crop and Water Model
CSIR	Council for Scientific and Industrial Research
CTI	Climate Technology Initiative
DA	District Assemblies
DANIDA	Danish International Development Agency
DFID	Department for International Development
DVLA	Driver and Vehicle Licensing Authority
ECG	Electricity Company of Ghana
ECOWAS	Economic Community of West Africa States
EET	Energy Efficiency Technologies
EPA	Environmental Protection Agency
ERG	Energy Research Group
ESCO	Energy Services Companies
GCMs	Global Circular Models
GDP	Gross Domestic Product
GEAP	Ghana Environmental Action Plan
GEF	Global Environment Facility
GHAESCO	Ghana Association of Energy Services Companies
GHASES	Ghana Solar Energy Society
GHASTINET	Ghana National Scientific and Technological Information Network
GHG	Greenhouse Gases
GOG	Government of Ghana
GPRS	Ghana Poverty Reduction Strategy
GRATIS	Ghana Regional Appropriate Technology Industrial Service
GSB	Ghana Standards Board
GTZ	German Technical Cooperation
GWC	Ghana Water Company
ICTP	International Centre for Theoretical Physics
IEAC	Industrial Energy Assessment Centre
IFC	International Finance Corporation
IGO's	International Governmental Organisations
IIR	Institute of Industrial Research
INC	Intergovernmental Negotiating Committee for Framework Convention on Climate Change
INSTI	Institute for Scientific and Technological Information
IPP	Independent Power Producers
ITTU's	Intermediate Technology Transfer Units
JICA	Japanese International Corporation Agency
KNUST	Kwame Nkrumah University of Ghana
KVIP	Kumasi Ventilated Improved Pit

LPG	Liquefied Petroleum Gas
MA	Municipal/Metropolitan Assembly
MDA's	Ministries, Departments and Agencies
MES	Ministry of Environment & Science
MOE	Ministry of Energy
MPSD	Ministry for Private Sector Development
N_2O	Nitrous oxide
NEP	National Environmental Policy
NES	National Electrification Scheme
NGDS	Natural Gas Distribution System
NGO	Non-Governmental Organisation
NRCD	National Redemption Council Degree
NREL	National Renewable Energy Laboratory
OECD	Organisation for Economic Cooperation and Development
PURC	Public Utilities and Regulatory Commission
PV	Photovoltaic
R & D	Research and Development
RESPRO	Renewable Energy Services Project
RETs	Renewable Energy Technologies
S & T	Science and Technology
SADC	Southern African Developing Countries
SHEP	Self-Help Electrification Programme
SIDA	Swedish International Development Agency
SMME	Small, Micro & Medium Enterprises
STEPRI	Science and Technology Policy Research Institute
SWDS	Solid Waste Disposal Sites
TAAP	Technology Transfer And Acquisition Plan
TCPD	Town and Country Planning Department
TNA	Technology Needs Assessment
TOE	Ton oil equivalent
TOR	Terms of Reference
UNCED	United Nations Conference on Environment & Development
UNDP	United Nations Development Programme
UNESCO	United Nations Education, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
VAT	Value Added Tax
VRA	Volta River Authority
WAGP	West African Gas Pipeline project
WEAP	Water Resource Evaluation Analysis and Planning Model
WHO	World Health Organisation
WWT	Waste Water Treatment

1.0 EXECUTIVE SUMMARY

Background

Ghana has been working with the global community in finding solutions to problems that threaten the very existence of humankind on earth. It is against this background, that Ghana signed the United Nations Framework Convention on Climate Change (UNFCCC) at the Rio de Janeiro Earth Summit in June 1992, after the Convention was adopted on 9 May 1992. The Climate Convention entered into force globally on 21 March 1994 and specifically for Ghana on 5 December 1995 after ratification on 6 September 1995.

There is enough scientific evidence to prove that the potential negative impacts of climate change are immense, and Ghana is particularly vulnerable due to lack of capacity to undertake adaptive measures to address environmental problems and socio-economic costs of climate change. These include climate change associated health problems, climate induced disruption of agricultural systems, flooding of coastal areas which are already undergoing erosion and low operating water level of the only hydro-generating dam in the country, (which produces 80% of national electricity supply), as a result of reduced levels of precipitation.

Throughout the Convention process, the Conference of Parties (COP) to the UNFCCC has recognised the important role environmentally sound technologies play in averting the threat of climate change. Therefore the COP, by its decision 13/CP.1, recalled the relevant provisions of the Chapter 34 of Agenda 21 on "Transfer of Environmentally Sound Technology, Cooperation and Capacity Building" and requested the Convention Secretariat to prepare itemized progress report on concrete measures taken by Parties listed in Annex II to the Convention, with respect to their commitments related to the transfer of environmentally sound technologies and know-how, necessary to mitigate and facilitate adequate adaptation to climate change.

The COP's decision 7/CP.2 also requested the Convention Secretariat to give high priority to the development and completion of a survey of the initial technology needs, as well as, technology information needs, of Parties not included in Annex I to the Convention (non-Annex I Parties), with a view to providing a progress report to the subsidiary Body for Scientific and Technological Advice at its fourth session.

Decision 4/CP.4 also urged non-Annex I Parties, in the light of their social and economic conditions to submit their prioritised technology needs, especially those relating to key technologies to address climate change in particular sections of their national economies, taking into account state-of-the-art environmentally sound technologies. Further by its decision 4/CP.4, the COP requested Subsidiary Body for Scientific and Technological Advice (SBSTA) to establish a consultative process aimed at achieving agreement on a framework for meaningful and effective actions to enhance implementation of Article 4.5

Following decision 4/CP.4, three regional workshops were held in Africa, Asia and the Pacific Region, and Latin America and the Caribbean. Through the consultative process, a

framework for technology transfer was developed. This framework became the subject of negotiation during the second part of the Sixth Conference of Parties (COP6 bis) as part of Bonn Agreement for implementation of the Buenos Aires Plan of Action.

At the Seventh Conference of Parties (COP7), by decision 4/CP7 the framework for meaningful and effective implementation of Article 4.5 was formally adopted. The development of this needs assessment report is therefore in fulfilment of the above relevant decisions of the COP of the UNFCCC and also assisting Ghana to meet her commitments under the UNFCCC.

Apart from fulfilling Ghana's commitment to the UNFCCC, the preparation of this technology needs and needs assessment report emphasizes Ghana's preparedness to join efforts with the global community to avert the climate change threat. The preparation of this report, however, has not been without challenges.

Notwithstanding the lack of information on most of the climate friendly proven technologies, Ghana, assisted by the Climate Technology Initiative (CTI) of the OECDhas put together this report. The report lists quite a number of desired technologies, which have been prioritised and further developed into a Technology Transfer and Acquisition Plan (TAAP). Within the TAAP three priority technologies have been selected based upon national set of criteria.

The three priority technologies selected include:

a. Energy Efficient Lighting using Compact Florescent Lamps (CFL)
b. Industrial Energy Efficiency
c. Landfill Methane Gas Recovery

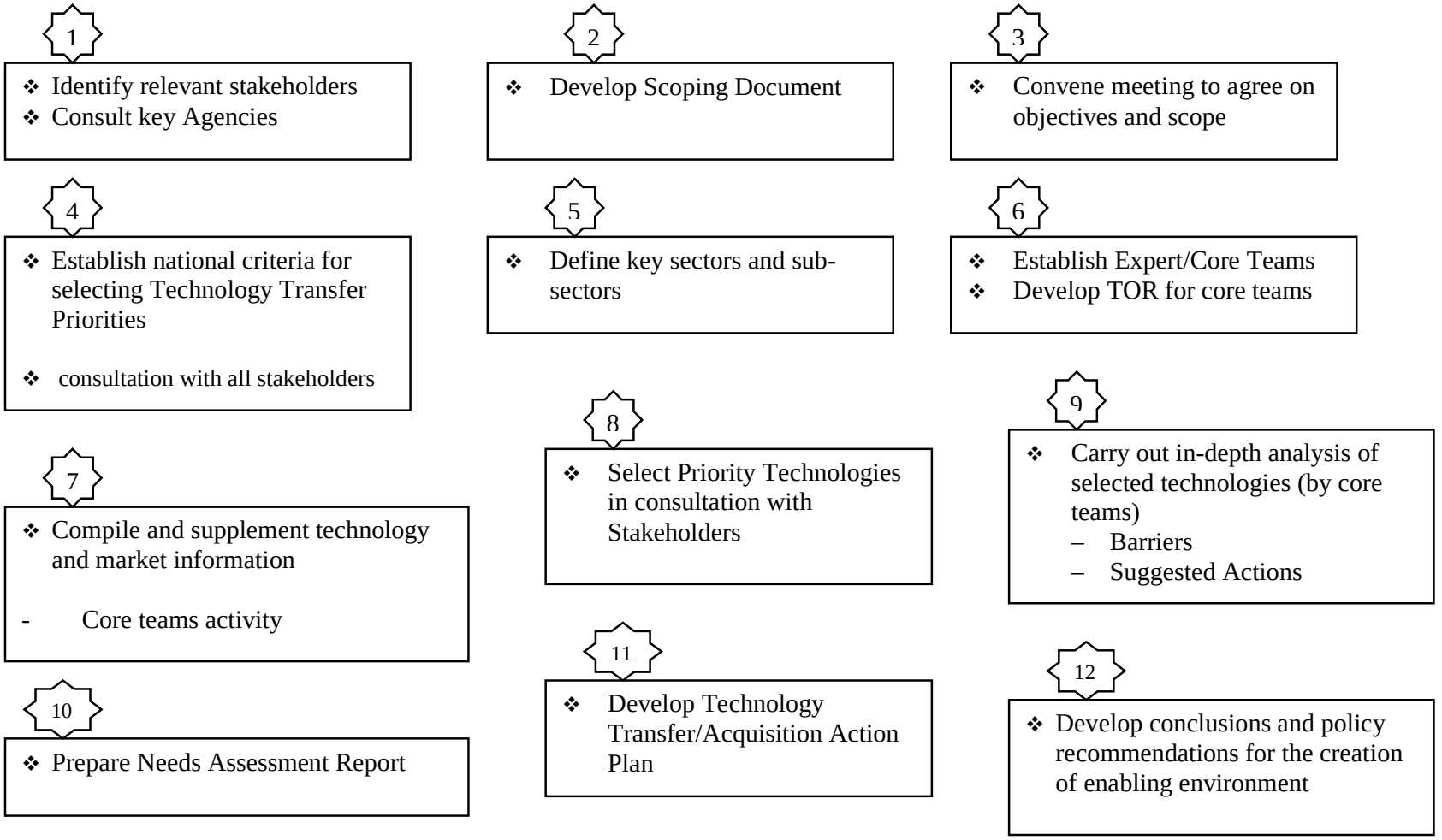
This version of the technology needs and needs assessment report, (which is regarded as a life document), would be updated and new action plans developed from it. This technology needs assessment (TNA) report is intended to specifically highlight the nation's climate change relevant technological requirements and also give some indication as to the efforts the country is making towards sustainable development. Moreover, it re-emphasizes the support Ghana needs if she is to contribute meaningfully towards finding solutions to the global problem of climate change.

The preparation of this report has undoubtedly contributed to capacity building in the country. It is hoped that if the necessary resources are made available through bilateral, multilateral and private sector initiatives, for the implementation of some programmes that will eventually lead to the transfer of the identified technologies, the nation could further be empowered to pursue sustainable development pathways. The effective transfer of these technologies may require the development of national policies that address regulatory instruments and tax incentives that can create the enabling environment for the transfer and use of climate friendly technologies and thus contribute to the achievement of the ultimate objective of the Convention. A preliminary version of the national climate change technology policy framework has been included in Appendix IV of this report.

Ghana's Approach to Technology and Needs Assessment

The approach used by Ghana in carrying out her technology needs and needs assessment is summarised in Figure 1.

Figure 1. Ghana Technology Needs Assessment Process



Technology Needs Assessment (TNA) is country-driven and must be done through a consultative process that engages all relevant stakeholders. To achieve that, the National Climate Change Co-ordinator brought all stakeholders to a common level of understanding of the TNA process by developing introductory materials for them. This material referred to as the ' Scoping Document' defined in general the TNA process and outlined the purpose and the generic approach to TNA. In addition, the scoping document gave a brief background to the United Nations Framework Convention on Climate Change, indicating in particular the status of technology transfer negotiating process.

In developing the scoping document, reference was made to the experiences of other countries and regions. The Southern African Development Cooperation (SADC), TNA report was greatly consulted. The focus of the scoping document makes it a very important piece of information for stakeholders and an important step in the TNA process.

The scoping document was developed in collaboration with Climate Technology Initiative (CTI) of the OECD. In the scoping document relevant stakeholders were, to the extent possible identified. The list of stakeholders included five main groups of bodies viz: government, business/private sector, academia, NGOs and International Technical/Financial Agencies.

The scoping document defined the extent of the TNA process by identifying a preliminary list of sectors to be covered during the TNA. In doing this, a personal consultation was made with the relevant sector policymakers. The initial selection of sectors was informed by the national development agenda (Ghana's Poverty Reduction Strategy, 2000-2004), Ghana's Initial National Communication, the national energy and sanitation policy documents. In order to make the scoping document attractive and easy to read, it was limited to just a few pages.

After the development of the scoping document and circulation to all stakeholders, a one-week national stakeholders' meeting was organised. The first stakeholders meeting also described as 'scoping meeting' addressed the following objectives, which were contained in the agenda for the meeting:

- Discussion of the Scoping Document
- Seeking stakeholder consensus on the selected sectors,
- Introduction of the TNA process,
- Development of a national technology selection criteria,
- Identification and prioritising of the technologies,
- Identification of common barriers to technologies transfer,
- Formation of core (expert) teams,
- Development of terms of reference for the core team members and
- Development of the outline for the TNA report.

National Criteria Development

At the scoping meeting, a national criteria for the selection of relevant technologies within the agreed sectors, was developed by all stakeholders.

The criteria included contribution to addressing climate change, development benefits and market potential of the selected technologies. From these three principal criteria, the stakeholders further developed sub-criteria for the selection process,

The following sub-criteria were identified:

Development Benefits
- Job Creation
- GDP Growth
- Wealth creation
- Capacity Building (Innovation)\
- Health Improvement
- Social Acceptance of Technology
- Good effect on balance of trade
- Use of local resources (Human and Material)

Market Potential
- Finance (capital to pay for it)
- Affordability (money to pay for it)
- Investment sustainability
- Low maintenance – Durability
- Commercially available
- Replicability

Climate / Environmental protection
- Low GHG emissions
- Minimal harm to environment
- Enhance sinks
- Waste resource recovery

Preliminary Priority Setting
The stakeholders, guided by the National Climate Change Co-ordinator and the CTI resource person, identified the following preliminary list of technologies.

Energy Sector
The identified list of technologies that have the potential of contributing to addressing the climate change problem in the energy sector were:

- Industrial energy efficiency improvement/demand side management.
- Solar PVs
- Natural gas combined cycle
- Natural gas distribution systems
- Management technologies and efficiency improvement in the transport sub-sector
- Biomass for power generation
- Wind
- Solar Water Heating
- Energy efficient lighting

Waste Sector
The preliminary waste sector technologies identified by the stakeholders included:

- Landfill methane gas capture for power generation.
- Anaerobic and CH_4 generation technologies for wastewater handling (Biogas technologies)
- Composting technologies
- Combined heat and power generation from sawmill residue (co-generation)
- Incineration technologies

Using the national criteria developed, the stakeholders prioritised the identified technologies.

For the energy sector, the decreasing order of priority was as follows
i. Biofuels
ii. Industrial energy efficiency improvement
iii. Energy efficiency lighting
iv. Solar PVs
v. Natural gas combined cycle, Natural gas distribution system mini and small hydro
vi. Management technologies and efficiency improvement in transport sub-sector
vii. Wind
viii. Solar water heating
ix. Small and mini-hydro

For the waste management technologies the decreasing order of priorities was as follows:
i. Biomass for power generation (Co-generation from sawmill residue)
ii. Landfill methane gas capture for power generation
iii. Anaerobic and CH_4 generations technologies for waste water handling (Biogas technologies)
iv. Incineration

Barriers to Technology transfer
The stakeholders identified the following as barriers common to all technology transfer programmes in the country:

i. High initial cost associated with the technologies
ii. Inadequate human and institutional capacities
iii. Access to technology information (e.g. cost, performance, vendors, etc.)
iv. Lack comprehensive technology transfer policy
v. Weak local currency
vi. Inadequate capacities in estimating and certifying potential greenhouse gas reductions associated with the technologies

In-depth Analysis
Sectoral core/expert teams were selected from amongst the stakeholders to carry out in-depth assessment of the preliminary prioritised technologies. The energy sector core team consisted of six experts whilst the waste sector core team had four experts.

The terms of reference (TOR) for the core teams were developed by the stakeholders. The TOR requested the core teams to carry out in-depth analysis covering:

- Background information of the selected technology
- Specific and perceived barriers to the transfer of the technology
- Suggested actions to remove these barriers. The action should include
  - National actions
    - Existing national programmes and policies
    - Additional national actions
  - Actions expected from the international community

- Expected results from the transfer of the selected technology, including:
  - Market perpetration and sustainability
  - Development and economic benefits
  - GHG reduction potential and other environmental benefits

- Specific capacity needs. Consideration must be given to:
  - Institutional
  - Human
  - Systemic (legislative framework etc.)
- List of possible stakeholders both national and international
- Conclusions and recommendations for the creation of the enabling environment by national and the international community

The core group was also tasked to put together the TNA report using the outline developed at the stakeholders meeting; make presentations of the work at stakeholders meetings and put together the action plan for technology transfer.

Final Approval And Adoption By Stakeholders

After the core groups have finalised their work on the TNA report, the report was circulated to all stakeholders, and at the final stakeholder meetings, comments were received to improve on the TNA report. The stakeholders agreeing to the amendments made, unanimously adopted the report.

Conclusions And Recommendations

Following from the in-depth analysis, the expert group came out with the under listed conclusions and recommendations.

Conclusions

Experiences gained during the preparation of this report indicate that general information on listed and prioritised technologies, in particular the cost, are lacking in the country. This makes in-depth analysis of the technologies very difficult. This Technology Needs Assessment (TNA) activity only considers climate change mitigation technologies and does not address adaptation technologies.

The extent to which Ghana can implement the prioritised technologies and help in addressing the global problem of climate change, will depend on the provision of adequate technical and financial resources by developed countries and the creation of an enabling environment.

The general conclusions are:

a) Having regard to the role the Climate Technology Initiative played in Ghana's TNA activity, it is evident that there is the need for technology transfer intermediaries that will link Ghana with the private and public sector institutions in the developed world to enhance the effective transfer of climate technologies.

b) A critical review of the existing policy, legislative and institutional framework for addressing technology transfer, reveals that, there are enormous challenges that need to be overcome if any programme in this area is to succeed.

c) In respect of policy, there is sufficient evidence expressing the government's commitment to take the necessary steps in the waste and energy sectors to achieve the objectives of sustainable development. Lack of the necessary financial resources, adequate capacities and a culture of technology development have, however, undermined the laudable policy directives. Fiscal and economic instruments have also not been given adequate attention.

d) The Technology Transfer Regulations, 1992 (L.I. 1547) falls short of what is required to address the broad spectrum of capacity needs in the area of technology transfer.

e) With respect to institutional structures, there are a lot of inadequacies. In a number of areas, there is an urgent need to re-focus the operational policies of the institutions to make them relevant to the challenges posed by modern technologies.

The specific conclusions are:

a) Renewable Energy Technologies (RETs) are inexhaustible and offer many environmental benefits over conventional energy sources. Most of them do not release pollutants during operation. However, they have relatively high initial capital cost and lack of comprehensive regulations in the country further hinders their nationwide deployment.

b) Woodfuel still remains the most affordable source of energy for the majority of Ghanaians, and would continue to contribute substantially to national energy demand. This resource serves as carbon sink and if not sustainably managed, would significantly alter the balance of GHG emissions in Ghana.

   Biomass resources other than woodfuel such as crop residues, sawdust and energy crops (e.g. Jathropha, cassava, sugarcane, etc.) have strong potential for energy production. Development of energy crops to provide fossil fuel substitutes on a commercial scale has a potential to help in the national poverty reduction drive. It will create jobs in the rural areas and also reduce foreign exchange requirement for imported fuels.

c) There is a national drive to achieve a comprehensive energy efficient economy. The main hurdles have been the development of appropriate regulations, policies, approximate uneconomic tariffs, and availability of financial resources. Financing, technology transfer and a favourable economic environment will make the energy efficiency initiative a success. Energy efficient technologies will minimise peak demand and reduce operating cost.

d) Ghana has a substantial mini hydro potential and harnessing this resource could contribute to the overall energy production capacity of the nation.

e) At present, natural gas resource availability in the country would not make the deployment of the natural gas distribution technology sustainable. A sub-regional approach is therefore necessary if Ghana is to make a head way in natural gas energy distribution systems.

f) Combined cycle technology is rapidly becoming the power generation technology of choice compared to single cycle technology. It can be built faster and at a lower cost than a conventional steam turbine plant of equivalent capacity.

g) Compressed natural gas (CNG)- has become one of the relatively less expensive alternative fuel choices for vehicles. In addition, as an alternative fuel for power generation, natural gas is a cheaper option to crude oil.

h) Even though solar water heaters identified in the country are installed by local producers, there is limited expertise in the design of industrial solar water heaters. The public is not well informed about their benefits and potential. The lack of regulation, code of installation and practice do not promote the development of this technology.

i) There are adequate wind speeds that could be utilized for power generation in Ghana. However, the lack of dependable countrywide data makes it comparatively difficult to assess the wind energy potential as a whole.

j) Given the widely accepted importance of waste management to national health and environmental protection, the government has over the years demonstrated commitments to develop appropriate policies and programmes. However, these policies and programmes have not adequately addressed the integration of methane recovery systems. There is the need to shift to systems that incorporate methane recovery and its utilisation for power generation.

Recommendations

1. The national climate change focal point and other relevant existing institutions (e.g. CSIR – INSTI) should be strengthened to serve as technology information clearinghouses. Technology needs will continue to change and government must ensure that this TNA report is frequently updated and new action plans developed for implementation.

2. Donor support should be sought to carry out a national strategic renewable energy resource assessment including biomass resource assessment.

3. Government must promote private sector involvement in the transfer of the identified technologies. In addition, policy guidelines that will address issues like subsidies, ownership, tariffs, awareness, standardization, quality control, institutional set up and the right of supply, must be developed.

4. The climate change needs and needs assessment process must be institutionalised to ensure its continued usefulness. In this light the proposal on the setting up of a National Climate Change Secretariat should be considered as critical. The implementation of the identified technologies would help ensure the process of transformation of the country into a middle-income status and lead to poverty alleviation. Future TNA activities should also address issues on adaptation technologies.

5. Developed country Parties should provide Ghana with technical and financial resources to ensure the effective implementation and transfer of prioritised technologies in a timely manner. Additionally, developed country Parties that own these technologies must show the commitment to transfer them. Also, Ghana's development partners should use this report and any action plans there from as the basis for engaging in technology transfer processes aimed at addressing the climate change problem.

6. CTI and other relevant bilateral, multilateral, International Governmental Organisations (IGOs) and NGOs, that are in the position to do so, should play the role of technology transfer intermediaries by matchmaking investors in the developed countries with relevant Ghanaian entrepreneurs. These intermediaries could play these following additional roles, matchmaking with finance providers, training for in-country businesses and for the intended end users of the new technologies, technical assistance to policy makers on creating an enabling environment.

7. Government's policy direction must take into account the capacity needs in technology transfer consistent with the obligations assumed under the UNFCCC.

8. The obligations arising out of the UNFCCC and its attendant legal instruments must be translated into national legislation.

9. The judiciary must be well informed through training, seminars, workshops and related activities to enable them function more effectively in respect of environmental matters.

10. Ghana must work towards acquiring and developing critical technologies that can be employed to address the climate change problem.

11. Regulations must be developed to ensure that technologies that are transferred come with information on their environmental risks and other pertinent information so that informed choices can be made.

12. Imported technologies must also be compatible with social, cultural, economic and environmental priorities. Where possible, the imported technology can be combined with local innovations to evolve new technologies.

13. There must be training for organisations which will manage the technologies and conduct environmental impact and risk assessments.

14. General stakeholder participation must be ensured in the technology transfer processes.

15. Indigenous capacities must be developed because an exclusive dependence on imports, can prove harmful in the future.

16. Renewable energy technology friendly attitude must be developed and a suitable pricing framework in competitive applications must be instituted. Also, RETs must be incorporated in energy conservation and efficiency strategies of the country.

17. Government must pay more attention to the woodfuel energy sector to ensure that it is sustainably managed. Productive uses of sawdust resources need to be encouraged with regulations restricting their improper disposal.

18. The Government must develop policy, regulations and enforcement capacities for increased public and private participation in energy efficiency programmes, taking into consideration the programmes already implemented by the Energy Foundation.

19. A requisite policy to implement the development and utilization of renewable energy resources and incentives to attract investment capital for renewable energy technologies must be put in place.

20. The West African Gas Pipeline (WAGP) Project would have to be supported and expedited for Ghana to utilise natural gas. Legal processes for inter-regional cooperation in energy resource utilisation must also be put in place. Government's efforts to identify and develop new natural gas fields should be intensified. Government should develop special investment package that will attract private sector and the donor community to intensify efforts to identify and develop new national fields.

21. In order to develop capacities for combined cycle technology transfer and utilisation, programmes must be put in place to ensure the development of the requisite skills, e.g. through exchange programmes and international attachments. Financial support must be provided for upgrading existing single cycle plants to combined cycle systems.

22. Local production of standardized solar water heaters should be encouraged and the public well informed about their benefits. Also regulations, code of installation and recommended practices should be developed.

23. Donor support is sought to recover methane from existing landfills and closed landfill sites.

24. Government should formulate policies and strategies that will make it mandatory for all future sanitary landfills to integrate methane recovery systems for energy utilisation. Development partners should help with technical and financial resources to implement the strategy and for acquiring the necessary technology pieces.

25. Local authorities should be resourced to develop institutional framework to ensure effective waste management.

26. Stakeholders should be involved in the planning, operation and maintenance of waste management facilities to ensure their improved performance and sustainability.

27. The local authorities must undertake public education and promote waste segregation at source. Also, the public must be encouraged to use compost.

28. The Technology Transfer Regulations need to be reviewed so as to allow the incorporation of issues consistent with the criteria for encouraging the introduction of these technologies, in particular the reduction of GHG emissions.

2.0 TECHNOLOGY TRANSFER IMPLEMENTATION PLAN

2.1 ENERGY SECTOR

The energy group identified, prioritised and undertook an in-depth analysis of the technologies for the development of the technology transfer implementation plan under the climate technology needs assessment of Ghana. The technologies considered are listed below:

1. Energy efficient technologies, including energy efficient lighting and industrial energy efficiency
2. Solar PV- technology
3. Small and mini hydro
4. Natural gas development and distribution technologies
5. Natural gas combined cycle technologies
6. Solar water heaters
7. Wind
8. Biomass for power generation
9. Transport (use of biodiesel from Jathropha)

As an introduction, an overview of the energy sector in Ghana is presented after which the identified technologies are considered in detail.

2.1.1 Overview

2.1.1.1 Demand Scenario By 2020

Electrification is viewed mainly in the context of providing electrical energy to urban households and industries. Its demand was projected to increase from 6.58 TWh in 1997 to about 20 - 21 TWh by 2020[1]. The Volta River Authority (VRA) projects 16 TWh as the low growth scenario. Average demand growth has been between 6-8% per annum for VRA and about 7% per annum for Electricity Company of Ghana Ltd. (ECG). The Government plans to expand the power system in order to meet this projected demand. However, as the country increases its electricity capacity, there are many decisions concerning different options of power generation that the government will have to make. The government will also have to decide as to whether to use centralised or decentralised power solutions.

[1] VRA forecast indicates 20 TWh by 2020 considering the average economic growth from 1990-2000..
Acres International (1991), A study conducted by Acres International on behalf of the Republic of Ghana

¤Essandoh –Yeddu et. al. (2001). Sustainable energy scenarios for Ghana's long term development plan. M.Sc. Thesis-Chalmers University of Technology/Götenburg University Sweden.

The present power sector is dominated by hydropower on the Volta River – Akosombo (912 MW) and Kpong (160 MW); which constitutes about 65% of the nation's installed capacity. To meet the growing demand for electricity, the thermal power capacity at the Takoradi plant is expected to be upgraded from 550MW to 660 MW.

Natural gas as a fuel for electricity is expected to replace light crude oil by 2005 should the West African gas pipeline project commence as planned and is projected to overtake hydro as the dominant primary fuel for power generation by 2010. However, depending on natural gas from the West African gas pipeline alone could put the nation's energy security at risk.

2.1.1.2 National Electrification

Universal access to electricity was initiated in 1988 as National Electrification Scheme (NES) at a time when access to electricity by the entire population of the country was 33% (Acres, 1991) The objective of the electrification programme was to support the economic recovery programme, which had been initiated in 1983, to increase the overall socio-economic development of the nation. It was anticipated that extension of electricity to rural areas would open up the country for economic development and slow down migration of the population from the rural areas to the urban centres. Since the inception of the NES, all regional and district capitals have been connected to the national grid system. As a complementary activity to the NES, the Self-Help Electrification Programme (SHEP), which aims at assisting rural communities to obtain access to grid power was initiated. Despite the achievements made under these projects, it is still very expensive for government to extend grid power to some remote rural communities. Some of these communities are scattered islands on the Volta Lake. Also, the low-density population of such off-grid rural communities requires the installation of longer low-line voltage per new customer.

It has been estimated that around 23% of the population would still have no access to electricity by 2020. Ghana is therefore seeking to develop all the available sources of energy for electricity generation by opening up the way for private sector investment. Various forms of energy enhancement measures are also being considered and notable among them are:

i. the energy conservation programmes
ii. expansion of VRA's thermal plant at Aboadze
iii. the construction of the 400 MW Bui Hydro project
iv. harnessing the renewable energy resources of the country.

This brings into focus the role the renewable energy technologies could play in rural electrification. Particularly, it could contribute to sustainable development by reducing the generation of carbon dioxide emissions in the country.

2.1.2 Energy Efficient Technologies

2.1.2.1 Background

There had been in existence various energy conservation efforts since the early 1990s, but the aftermath of the 1998 energy crisis spurred the adoption of energy conservation as an important scheme to help alleviate the national energy crunch. Building power plants faces time constraints and require substantial financial commitments. The least expensive route was

identified with energy conservation programmes, which will reduce peak levels and curtail waste.

The adoption of the Energy Policy Framework (EPF) by the Ministry of Energy (MOE) is a major step in support of the energy efficiency drive in the country. The EPF is the vision of the energy sector. It is to develop an 'Energy Economy" that would ensure reliable supply of high quality energy services for all residential, business and industrial entities, and transport systems.

There are a number of programs already in place for the promotion of Energy Efficiency Technologies (EET). The Energy Foundation (EF) has been the liasing organisation for the energy conservation programmes. The Energy Foundation collaborates with the private sector, government institutions, regulatory bodies and donor agencies to implement specific programs and projects.

- Compact fluorescent lights in residential and commercial applications
- A comprehensive strategy to start a sustainable energy services companies (ESCO) industry in the country
- Energy efficient motors in industrial applications and power factor improvement

2.1.2.2 Barriers

1). Lack of national energy efficiency quality standards.
2). Lack of awareness on energy efficient technologies at the national level.
3). Lack of credit and loans for investments in the energy efficient technologies.
4). Inadequate local capacity for the installation, operation and maintenance of some energy-efficiency technologies.
5). Approximately uneconomic utility tariff.
6). Lack of a national policy on energy efficient technologies.
7). High import duties on energy efficient devices (approximate 30%)

2.1.2.3 Suggested Actions to Remove Barriers

Ghana Actions

Existing Programmes and Policies

(a). The Energy Foundation, Energy Commission, Ministry of Energy, VRA, ECG, industrial concerns, and some international agencies (USAID, UNDP, Alliance to Save Energy and DANIDA) have teamed up in different capacities to introduce, recommend and implement some energy efficient projects.
(b). The Energy Foundation has embarked on:
    i. A national lighting retrofit programme to introduce compact fluorescent lamps (CFL) to replace mainly incandescent onion bulbs, owing to the potentially large savings that could be made in electricity for lighting.

    ii. Industrial Energy Conservation Programme
        – Motor Replacements
        – Variable Speed Drives

- Capacitor bank installation for power factor correction and Industrial Load Management, this focuses on improving the end-use power factor.

iii. Energy Demand Management Project aimed at reducing energy consumption in industrial, commercial and public buildings.
- Local Capacity Building, involves the training of local energy service experts to offer energy management services.

- Energy Management and Targeting Pilot Project to improve energy efficiency in industry

iv. Institution of Energy Efficient and Conservation Process
- institute a well functioning national network of energy service expertise to provide energy efficiency service to small and medium enterprises (SMEs) and commercial buildings backed by a financing mechanism and funds for implementation of energy saving measures.
- Demonstration projects for cottage industries to show the benefits of productive uses of electricity and training for beneficiary communities;
- Adopt a framework for use of co-generation facilities in Ghana and design of a pilot co-generation plant.
- Strengthened capacity of the Energy Foundation and Energy Services Companies (ESCOs) through training and provision of financial resources

v. Coordination between Energy Foundation and Ghana Standards Board (GSB) to develop and introduce energy efficiency labels and standards for selected range of appliances.

Additional Actions

(a). Ensure that the public has full knowledge of the energy efficiency ratings of appliances on the market
(b). Discourage use of inefficient equipment in the country.
(c). Prepare a legal framework and establish institutions for the implementation of standards
(d). Set standards and develop test procedures and laboratory services, for energy efficient appliances.
(e). Maintain, enforce and monitor the impact of the standards
(f). Facilitate financing schemes by development of partnership between Government and donor agencies, for example, one combining a Ghana-funded education, training and technology promotion programme with a revolving loan, loan guarantee, and insurance programme funded by donors.
(g). Institute and enforce policies that will gradually eliminate interest in inefficient technologies.

Actions Expected from International Community

(a). Favourable bilateral trade agreements should be put in place to prevent the proliferation of sub-standard products in the country.

(b). Encourage trade missions and international businesses to help promote energy efficient products in the country and the West African sub-region, especially the case of CFLs.

(c). International financial institutions should facilitate financial assistance in the form of guarantees (both bilateral and multilateral). They should help to create an enabling environment for favourable monetary transactions.

(d). Donor/funding agencies should help with the development of local capacity to handle energy efficient technologies.

2.1.2.4 Expected Results

Market Penetration And Sustainability

(a). A nationwide introduction and promotion of energy efficient technologies. Programmes focusing on public education and the provision of technical support to energy intensive customers have been initiated.

(b). Energy efficiency technologies and implementation programmes contribute to the development of a sustainable and energy efficient industrial sector. This could be sustained through the acquisition of energy efficiency technologies and financial support for the implementation of energy efficiency measures to residential, business and industrial enterprises

Development and Economic Benefits

Implementing a minimum energy performance standard for refrigerators could result in savings of up to US$50 million by the year 2010 for consumers and reduction in carbon dioxide emissions by 230,000 tonnes over the same period[2] assuming that electricity from crude oil combustion[3] is the marginal source of supply. In addition, 10% savings in both electricity consumption for room air conditioners and residential (urban) lighting could save consumers nearly US$8 million and US$6 million respectively.

(a). The project will increase energy efficiency in industry, commercial and public facilities thereby reducing the energy intensity of most activities. [The development benefits come as a result of the effects mentioned: E.g., cost savings resulting from energy conservation, improved balance of trade from reduced fuel imports, health benefits from lower power plant air emissions, jobs created in new energy efficiency businesses, etc. Many of these measures can also be quantified. Given a quantified goal for amount of energy saved, the development and economic benefits can be estimated.

(b). It will release additional power in the electric grid that could be shifted to expand the rural electrification project[4], reduce the dependence on fossil fuel as a source of energy and create employment and increase technical knowledge of the population.

1991[2] Energy Foundation (1999), Ghana Residential Energy Use and Appliance Ownership Survey. A work sponsored by US Department of Energy and conducted by Lawrence Berkerley National Laboratory, California, USA. LBNL-43069. US. DOE Contract No. DE-AC03-76SF00098.

[3] Takoradi Thermal Combined Cycle Power Plant. It has multi-fuel firing capacity; can combust distillate fuel, light crude oil and natural gas. At present fuel use is light crude, but it is hoped that there will be a switch to natural gas when the West African Gas Pipeline project is completed.

[4] The Energy Foundation reports that about 20MVA of reactive power has been freed into the national grid under its Power Factor Improvement Programme. It is also estimated that modest improvements in production efficiency at VALCO, a

(c). It will contribute to productive uses of electricity in rural grid-connected communities and lead to increased economic activities, job creation, poverty alleviation and improved living standards nation wide. Women in the rural communities stand to benefit from these activities.
(d). Encourage innovation and entrepreneurial participation in the provision of energy equipment in Ghana through increased capacity to capitalize on energy efficiency opportunities expected to be embodied in new enterprises working in that field.

Greenhouse Gas Reduction Potential and other Environmental Benefits
The transfer and use of energy efficient technologies will help address the country's energy needs and reduce environmental problems (pollution, land degradation, etc). Reduced energy consumption yields a favourable environmental impact in the form of reduced atmospheric discharge of toxins.

2.1.2.5 List Of Stakeholders

National - Energy Foundation, Association of Ghana Industries (AGI), Local Financial Institutions, Ghana Employers Association, Ministry of Energy, Energy Commission, Electricity Corporation of Ghana, Volta River Authority, Volta Aluminium Company

International – National Renewable Energy Laboratory (NREL) – US, World Bank, OECD – IEA, US – DOE/USAID, DANIDA, France (CDF), British (DFID), Swedish Energy Agency, UNDP, IFC, EXIM, AFNET

2.1.2.6 Capacity Needs
Several steps have been taken to build capacity for the development, implementation and sustainability. The Ghana Association of Energy Services Companies (GHAESCO) groups various private consulting companies in energy conservation projects. Its member companies have been working with the Energy Foundation for the identification and development of energy conservation projects.

An Industrial Energy Assessment Centre (IEAC) has been established at the Kwame Nkrumah University of Science and Technology (KNUST) through a Ghana-US technical cooperation agreement. It provides practical training for engineering students in the field of energy management. This has increased professional knowledge and technical expertise in energy conservation.

The current expertise level is by no means adequate and additional resources are required to handle new technologies that will be implemented in terms of maintenance and monitoring. In view of this:
- A national comprehensive energy regulation should be developed to ensure investor confidence.
- Energy efficiency project management capacities must be developed
- Existing energy enterprises in support of commercial operations should be promoted.

major power consumer, alone will reduce its present energy consumption from 16 MWh to 14 MWh per tonne of aluminium. This would free up 445 GWh (a 60 MW thermal plant equivalent) per year to the national grid.

2.1.3 Renewable Energy Technologies

Renewable energy technologies are technologies used for harnessing renewable energy resources. They are inexhaustible and offer many environmental benefits over conventional energy sources. Each type of renewable energy has its own special advantages that make it uniquely suited to certain applications. None of them releases gaseous or liquid pollutants during operation. In their technological development, the renewables range from technologies that are well established to those that need further research and development.

Some of the identified technologies mentioned for the technology implementation plan are here considered under the more general heading of Renewable Energy Technologies (solar PV- technology, small and mini hydro, solar water heaters, wind, and biomass). They are subsequently considered one after the other based on their individual merits. Renewable energy technologies such as solar, wind and biomass are indigenous and capable of guaranteeing optimal supply security for the power sector.

2.1.3.1 Barriers

1). High initial capital costs.
2). Comparatively low tariff for grid electricity without similar incentives for renewable energy electricity.
3). Low output or energy intensity hence making the cost of energy high.
4). Monopolistic utility model where the utilities are vertically integrated and no one has choice of supplier.
5). Local production of system components attract higher taxes such that it is cheaper to import PV systems than to assemble or produce locally.
6). No legal and regulatory mechanisms for Independent Power Producers (IPPs) and lack of access codes to guarantee open access to the grid network for energy providers.

2.1.3.2 Actions To Remove Barriers

Ghana Actions

Existing Programmes and Policies

(a). The Public Utilities Regulatory Commission (PURC) and the Energy Commission have been established to facilitate private investment in the power sector.
(b). Import duties and sales tax on "solar generation systems" have been removed by the government as a measure to encourage the use of solar energy as an alternative source of energy. With the introduction of the Value-Added Tax (VAT) solar electric systems remained exempt from import duties but VAT is charged.
(c). The Ministry of Energy (MOE) is working with the appropriate authorities to seek complete removal of duty on all PV system components. In this regard, care must be taken to make sure that this initiative does not work against the development of indigenous industries in the sector. It is therefore suggested that, a 100% waiver on PV systems be limited to the modules and sealed batteries, which are relatively very expensive and complicated to produce locally.

(d). The Government is committed to reforming the energy sector in order to attract private sector participation and to overcome power shortages. Renewable energy IPPs can obtain license and operate as Embedded Generation Facilities (EGF). They also have the option to operate in remote or off-grid areas as localised power generation facilities.
(e). The Renewable Energy Services project (RESPRO), a joint UNDP-GEF and Government of Ghana (GOG) funded fee-for-service project has been implemented to test the financial viability of a rural energy services enterprise. RESPRO also serves as a pilot project for the use of PV-systems for lighting in rural areas.

Additional Actions

(a). Institute a renewable energy technology (RET) friendly pricing framework in competitive applications such as grid-connected electricity supply.
(b). Create a level playing field for both renewables and grid electricity by extending incentives enjoyed by grid customers to solar users as well to allow solar PV to be deployed in rural communities in a way, which is economically beneficial to the country.
(c). Encourage utility companies, namely Electricity Company of Ghana (ECG), Volta River Authority (VRA) and VRA-Northern Electrification Department (NED) to adopt renewable energy technologies in their supply mix by granting tax holidays and other incentives.
(d). Local producers of renewable energy technology component should be exempted from company tax and excise duties in order to stay competitive. In addition more tax incentives should be made available to encourage local production or assemble of the modules.
(e). Incorporate renewable energy technologies in energy conservation and efficiency strategies.
(f). Create a comprehensive, viable framework for IPP businesses, particularly in rural applications.

Actions Expected From The International Community

(a). Help identify donor funding agencies to support renewable energy technology, technological development and capacity building, especially for solar, biomass and wind.
(b). Donor agencies should help identify international organizations to set up demonstration projects for RETs that can serve as learning curve for the local people.
(c). International agencies should assist in providing funding support for non-grid connected renewable energy technology.
(d). Help identify international independent power producers (IPPs) to invest in the energy sector.
(e). Provide funding support for non-grid connected renewable energy technologies for economic (particularly in agriculture) and social services.
(f). Support technological development and cost reduction through pilot demonstration projects and local production of components of renewable energy technologies.

2.1.4 Solar Photovoltaic Technologies

2.1.4.1 Background

Solar Photovoltaic Technologies include – the off-grid solar home system, PV for grid integration, public/street lighting, vaccine refrigeration, irrigation and water pumping.

Ghana has an annual sunshine duration of 1800 – 3000 hours. The average solar radiation across the nation ranges between 4.0 – 6.0 sun hours per day.

Solar PV technology can utilise Ghana's abundant sunshine to meet basic electricity needs of off-grid rural communities.

(i) Off-Grid Solar Systems (e.g. Solar PV for Public/Street Lighting)

Every customer of ECG and NED is surcharged for street lighting, even though lighting is not found in every street of grid connected areas. The long term objective therefore, is to provide streetlights in all grid-connected areas. Most of the streetlights in Ghana, as specified by ECG, are of the class B type (conventional lamp of 250 Watt, rated 26,000 lumens). Street lighting (ECG & substation) consumption in 1997 was 13.35 GWh implying that, about 12,000 units of streetlights were installed as of the end of that year.

There are about 58 solar streetlights with an average of 3,000 lumens per 26.35 Watt per streetlight lamp. The lumens requirements and the cost per unit for solar equivalent is quite high and as such impractical to use in the urban areas where other alternatives are available. Solar street lighting is thus, more suited for rural environments and for park lighting. In this case, apart from the favourable economics, the possibility of damage to the installations is relatively very low.

(ii) Solar PV For Irrigation

Out of Ghana's total land area of about 24 million hectares, 57% is arable. About 10,000 hectares of the arable land is under gravity-fed irrigation schemes. Almost all the irrigated farms in the country use the gravity-fed method. Major electric powered large-scale irrigation farms are at Dawhenya, Weija (both in the Greater Accra Region) and Kpong in the Eastern Region. Diesel powered irrigated farms are located mainly in the Volta Region and around the Eastern Region part of the Afram Plains.

Solar PV systems are suited for small-scale irrigation when there is the need for external power to pump water from a lower depth to a higher plain. For instance, from a low-lying stream to a higher plain plantation. These systems are recommendable for areas far from the national grid and where the construction of gravity-fed dams are relatively difficult and comparatively expensive.

(iii) Solar PV Water Pumping

Pipe-borne water in the country is provided mainly by the Ghana Water Company (GWC). Pipe-borne water is distributed mainly by electric power (in grid-connected areas) and also,

by mechanised pumps. In 1998, GWC consumed 156.576 GWh of electricity in its operations (Energy Foundation, 2000).

The company relies on the more expensive diesel powered mechanised pumps to deliver pipe-borne water in non-grid areas. From 1997 – 1999, the GWC used between 331,000 - 400,000 tonnes of diesel for its operations. This generates a significant amount of GHG emissions. A possible solution to this problem is to encourage solar PV water pumping in the non-grid areas.

Solar PV water pumping system is best suited for communities that experience seasonal potable water problems and where the water table is relatively very low. Even though it is more expensive than boreholes, it provides perennial potable water supply since it can pump water from greater depths. Borehole pumps are unable to operate effectively[5] where the water table is relatively very low. Solar water pumping also facilitates distribution through piping and for that matter it is more convenient to use.

More than 50 solar PV water pumps have been installed in the rural areas of the country by various organisations including GWC and some NGOs.

It is envisaged that access to surface water based pipe-borne water could be difficult due to increasing population and limited water exploitation, particularly by 2020. Annual surface water has been projected to fall from 4,950 cubic metres per capita in the 1990s to about 950 cubic metres per capita by 2025 which will be below the 1000 cubic metres per capita water availability threshold limit for water crisis (IWS, 1993)[6]. Solar PV water pumping then becomes potentially viable for extracting potable water from relatively low but perennial water tables.

2.1.4.2 Barriers

1). *Off-grid Solar Systems for Public/Street Lighting*
   i. Limited application and use.
   ii. Higher tariff charges than grid users.
   iii. Lack of favourable credit facilities for interested users.
   iv. Weak local currency make systems more expensive to import day by day.
   v. Lack of standards and recommended practices
   vi. Low level of information about PV systems in general

2). *PV for grid integration*
   i. Lack of skilled labour
   ii. High initial cost
   iii. Depreciation value of the cedi since almost all components are imported
   iv. Lack of interconnection standards
   v. Limited understanding of issues of integrating renewables into the grid within utility companies.

[5] Borehole pump depends on atmospheric pressure to pump water and are thus ineffective at higher depths. Solar PV water pump is electricity driven and thus independent of atmospheric pressure. Solar water pump extracts water and store it in over-head tanks for distribution during no sunshine hours.
[6] IWS, (1993), The 19th International Water Supply Congress & Exhibition Proceedings, October 1993, Budapest, Hungary.

3). PV for vaccine refrigeration

i. High initial cost.
ii. Lack of commercial market
iii. Need for a system to maintain the systems in rural clinics.
iv. Lack of organization framework for pursuing this application.

4). Solar PV for irrigation

i. High initial cost
ii. Expensive option for irrigation

5). Solar PV Water Pumping

i. High initial cost
ii. Lack of commercial market
iii. No credit and financing
iv. Demand and resource availability mismatch

2.1.4.3 Suggested Actions to Remove Barriers

Ghana Actions

Existing programmes and policies:

(a). The Ministry of Energy has assessed the solar energy potential of the country.
(b). The Ministry of Energy has produced solar maps to facilitate design and installation of solar systems in the country.
(c). The Ministry of Energy has taken an inventory of PV installations in the country and estimated that the installed solar PV capacity exceeds 1MW. Also, technical specifications for solar home systems and communal systems for schools, community and health centres have been produced.
(d). Ghana Telecom has installed about 100kW capacity of PV systems to operate its wireless mobile network, microwave repeater and exchange stations.
(e). The Ministry of Energy has a 50kWp PV-grid integrated roof demonstration facility at its premises.
(f). The Social Security and National Insurance Trust is using solar units to operate its wireless communication systems and as a back-up power system for some of its country side offices.

The Ministry of Energy has implemented a number of solar photovoltaic projects since the late 1980s to investigate the conditions necessary for formulating policy on the wide scale use of renewable energy for electrification. Survey of the projects provided the following revelations:

- Lighting is among the major, about second or third developmental needs of rural communities in terms of priorities.
- Automotive batteries are used in the rural communities to operate television sets and sound systems. The batteries are then sent to the nearest grid-connected town for re-charging.
- There is a desire for reliable electricity by NGOs and rural based institutions to meet their business and social obligations.

- Rural communities could be motivated to accept the solar PV option if adequate information on the systems is made available to them.
- Adoption of new energy technologies could be encouraged through credit incentives and other purchase arrangements that would allow the rural inhabitants to use the systems on rental or hire purchase basis.

Additional Actions

(a). *Off-grid Solar Home Systems for Public/Street Lighting*
   i. Mount public education at targeted beneficiaries.
   ii. Requires grant financing for implementation.
   iii. Produce most of the system components locally.
   iv. Involve ECG and VRA in the training of manpower.

(b). *PV for grid integration*
   i. Stabilisation of the local currency.
   ii. Fabricating some of the components locally

(c). *Solar PV for vaccine refrigeration*
   i. Integrate into primary health care delivery by using it to sustain the Cold Chain requirements in non-grid rural and remote locations. These is for maintaining vaccine temperature at + 8^0C to –8^0C from point of production to distribution and usage.

Actions Expected from the International Community

Opportunities abound for the promotion of PV technology in the West African sub-region. Ghana can be used as the gateway for such a project. Already, the Government of Ghana has set up free trade zones where incentives exist for international companies to set up production plants.

(a). Operation in the form of joint-venture initiatives could be set up in these industrial enclaves to fabricate subsystem components such as regulators and assemble PV modules for market in Ghana and the rest of West Africa.
(b). Promote cooperative programmes between researchers in local universities, research institutions, public and private sector institutions to have access to facilities in advanced countries in order to help update and improve skills and consequently strengthen the local capacity.
(c). Assist Ghana to develop code of installation and practice as well as regulations for the local PV industry.

2.1.4.4 Expected Results

Market Penetration and Sustainability

Distributed solar photovoltaic system is the option for remote communities since it is less complicated to install and operate PV comes in modules and with battery storage could provide electricity during the day and night.

Solar PV roof systems in grid-connected areas could serve as back-up for commercial and residential applications. Replicating the MOE 50kWp solar PV grid system in 100 government ministerial buildings to operate lighting, fans and office equipment during working hours could free 5 MW grid power per day and in addition pump excess power into the grid as well as serve as back up during grid outages.

Development and Economic Benefits
Even though, widespread use of Solar PV has been hampered by their high initial capital cost coupled with low economic status of rural dwellers, it is envisaged that, the social viability and the life cycle cost competitiveness of Solar PV for rural electrification will over-ride its high initial cost and rather improve the standard of living of rural dwellers.

Kerosene is the main lighting fuel in off-grid communities. Penetration of kerosene for rural households in 1997 was around 83.2% (GLSS, 2000). By 2020, Ghana's population is projected to exceed 30 million. Kerosene demand in rural areas beginning 2002 to 2020 is estimated at 2,306TOE (2.1 million tonnes), an average of about 110 thousand tonnes per year. The planned installation of a secondary conversion unit at Tema Oil Refinery (TOR) is meant to boost output of mainly gasoline and LPG, which means, kerosene will have to be imported to meet any shortfall. This could be shortened by just mentioning the fact that PV would displace imported kerosene, which is the main point.

Replacing kerosene with solar PV for rural lighting will make available the kerosene, which would otherwise have been used in the rural areas, for blending as aviation fuels. which is more economically beneficial besides the better lighting quality solar PV provides.

GHG Reductions and Other Environmental Benefits
Assuming a fifty percent (50%) penetration of solar PV as an alternative for lighting in rural areas now until 2020 will lead to about 450,000 tonnes savings in kerosene and over 1.4 million tonnes avoidance of carbon dioxide emissions. CO_2 figures look a little high for the kerosene figures.

An issue of concern is the disposal of spent storage batteries, since nationwide mass promotion of solar home systems would involve a large disposal of spent batteries after some few years. Improperly disposing of the electrolyte, lead sediments and plates could leak into the air as PM_{10} into the ground with likely contamination of soil and groundwater.

Long term programme for battery recycling or safe disposal should run along side PV programmes and built into maintenance programmes.

2.1.4.5 Existing Capacity

(a) Local Universities

The CIDA-UR/KNUST project of the Kwame Nkrumah University of Science & Technology (KNUST) has contributed to the development and strengthening of local capacity within the university. It has a well-equipped solar energy applications laboratory (SEAL) to provide technical and managerial back-up support in design, development and the manufacture of renewable energy products with big sales potential in Ghana. The project designed, developed and produced 18W DC Fluorescent lamps, Battery Cut-outs (Low-Voltage

Disconnect), 5W Halogen lamps, adapters, solar distillation units, solar battery charging units, etc. Ordinary kerosene lantern has been adapted to operate on rechargeable batteries and light emitting diodes under a brand name K-Electric lanterns.

The Physics Departments of the Universities of Ghana and Cape Coast have also been equipped to train graduates for the solar industry.

(b) Energy Research Group, Ghana

Energy Research Group, Ghana (ERG) is an umbrella for solar researchers in the country. Its objectives include avoiding duplication of research and rather enhance the nation's capacity to develop and promote utilisation of renewable energy technologies.

It has been organising and sponsoring national energy symposia and workshops since 1986. It receives most of its funding from the sector ministry and international research organisations such as the International Centre for Theoretical Physics (ICTP), a UNESCO institution based in Trieste, Italy.

(c) Ghana Solar Energy Society

Ghana Solar Energy Society (GHASES) is the Ghana Section of the International Solar Energy Society with the objective to promote nationwide penetration and commercialisation of renewable energy technologies. Membership covers researchers, the local solar industry and enthusiasts. Most of the reliable dealers in solar energy systems in the country belong to the organisation. GHASES organises seminars and workshops in the country in collaboration with ERG. It is at the moment implementing a GEF small grant project to support the financial base of local improved charcoal stove producers. Funding of its activities is mainly by the sector ministry, membership fees and donations.

2.1.4.6 Capacity Needs

Capacity building for material resource development to facilitate technology transfer in setting up PV assemble plants and the local manufacture of PV components such as regulators, inverters etc. Needs more elaboration. Also could include capacity development of small-medium size enterprises to provide rural power services.

2.1.4.7 List Of Stakeholders

National - Meteorological Service Department, Environmental Protection Agency, Ministry of Energy, Energy Commission, local solar dealers, Ghana Solar Energy Society, District Assemblies, Electricity Company of Ghana (ECG), Volta River Authority (VRA), VRA-Northern Electrification Department (NED), Ministry of Health, Health related NGOs, Irrigation Development Authority, Ministry of Food and Agriculture, Ghana Water Company, Local Universities, Energy Research Group, Ghana Solar Energy Society.

International – National Renewable Energy Laboratory (NREL) – US, World Bank, JICA, GTZ, CIDA, European Union, SIDA, US – DOE/USAID, DANIDA, France (CDF), British (ODA),

2.1.5 Small and Mini Hydro

2.1.5.1 Background

Ghana's gross potential for exploitable hydropower resource has been estimated at 10 TWh/yr (Abrahamson, 1993) or about 2000 MW of which about half is already in use. VRA has catalogued about 16 small-medium hydroelectric sites with total capacity of 1297 MW. Capital costs range from US$2000-US$5000 per kW.

There are also some identified minihydro sites of total maximum capacity of 24.5 MW (Ametefe, 2000) but dispersed over 70 sites. The Dayi River in the Volta Region passing through about nine towns including Hohoe, Kukurantumi and Adofe holds the best prospects for grid exploitation and would likely be of interest to utilities including independent power producers. The exploitable resource of Dayi is estimated at 2.1 – 5 MW peak (Ametefe, 2000), which means the optimum extraction in good hydrologic periods would be around 3 MW depending on the technology and could serve as back-up for the surrounding communities in times of main grid outages.

In 1982, the government issued new policy guidelines for the energy sector. One of the areas highlighted for rural energy development was micro/mini-hydro schemes up to 500 kW capacity to provide decentralised electric power to isolated rural communities. In order to achieve this objective, the energy sector ministry commissioned the state architectural enterprise, Archtectural and Engineering Services Company Limited (AESL) to undertake a systematic assessment of mini hydro potentials in selected regions of Ghana which did not feature in the meduim term plans for extending the national grid. By 1984, over 40 sites had been identified across the country. Others have also been identified through topographical maps and preliminary hydrologic studies. Initially transportation restrictions hindered the inspection of many sites. Presently, routes to many of the sites have been developed and the opportunity is available for detailed studies to be conducted.

Table 1: Mini hydro station development potential

Region	***Minimum kW***	***Maximum kW***
Volta	3117	12065
Eastern	226	1150
Brong Ahafo	364	1900
Western	472	2870
Northern	913	4420
Upper East / West	499	2100
Total	5591	24505

2.1.5.2 Barriers

1). Limited capacity and know-how.
2). Lack of policy to implement the development of mini hydropower.
3). High investment cost and long pay-back period.
4). Uneconomic electricity tariffs.
5). Lack of sufficient incentives to attract private capital for renewable energy projects.
6). Ineffective coordination in implementing government projects

2.1.5.3 Suggested Actions to Remove Barriers

Ghana Actions

Existing Programmes and Policies

(a). Extensive studies have been done in the country in the identification of potential sites by the Architectural and Engineering Services Limited (AESL) and Acres International.
(b). Currently The Energy Foundation is reviewing the various studies conducted in the country on small hydro sites with the view to updating them

Additional Actions

(a). Encourage appropriate training and development of pilot projects that would provide hands-on experience for personnel.
(b). Liberalise the utility market.
(c). Private Power Purchase Tariff to feed into ECG grid and some other regulatory provisions to enable the establishment of viable IPPs.
(d). Attracting private capital (Ghana and abroad) for investment requires specific actions designed to accomplish this

Actions Expected from the International Community

(a). Identify and attract private capital from abroad
(b). Provide expertise for appropriate training leading to capacity building and development of pilot sites.

2.1.5.4 Expected Results

Development And Economic Benefits

Implementation of a reliable source of energy generation and the transfer of expertise in small hydro technology to local companies will lead to confidence building in investors in renewable energy projects. This will in turn lead to a reduction of expenses in foreign exchange to the state, due to reduced imports of fossil fuels for electric generation.

GHG Reductions and other Environmental Benefits

(a). Reduction of greenhouse gas emission.
(b). Reduced emssions of other air pollutants

2.1.5.5 List of Stakeholders

National - Architectural and Engineering Services Limited, District Assemblies/Local Government, Ministry of Food and Agriculture, EPA, Electricity Company of Ghana, PURC, Energy Commission, Energy Foundation.

International – UNDP, JICA, GTZ, CIDA, SIDA, European Union, World Bank, DANIDA, France (CDF), British (DFID),

2.1.6 Natural Gas Distribution Systems (NGDS)

2.1.6.1 Background

This will involve the construction of pipelines to distribute natural gas to all parts of the country. Gas distribution is a business that should be able to support itself. Commercial-loans with guarantees and insurance from donors, and technical assistance to the distribution businesses might be a viable approach.

The success of NGDS is contingent upon the construction and operation of the West African Gas Pipeline project (WAGP), a sub-regional natural gas pipe project which is of high priority to the Ghana government. It will transport natural gas from gas fields in the Niger Delta of Nigeria to Ghana through Benin and Togo and is expected to be operative by 2005.

The pipeline and the compressor stations will be constructed to deliver an initial quantity of around 70 MMscfd (usually use "MMCFD" for this acronym) on commissioning to about 530 MMscfd by 2021, resulting in about 200 BCF/year (PLE, 1999). Ghana needs the natural gas for its fledging energy industry which is hampered by debilitating energy shortfalls.

In addition to the WAGP there are other potential natural gas fields which are under different levels of exploration and development. The Tano and Saltpond gas fields, and gas fields in neighbouring Ivory Coast are also available for eventual connection to the WAGP for utilization. Recoverable volumes from the Tano and Saltpond gas fields are estimated at 193 and 20 billion cubic foot (BCF) respectively

The WAGP is primarily being constructed to deliver natural gas to operate power plants in western Ghana. Maximum outputs of all the proposed power plants would leave an excess natural gas volume of approximately 156 MMscfd by 2010 and about 195 MMscfd.

2.1.6.2 Barriers

1). Lack of investment capital:
2). Problems associated with right-of-way
3). Excessive government regulation
4). Ineffective law enforcement
5). Lack of human and institutional capacities for NGDS

2.1.6.3 Suggested Actions to Remove Barriers

Ghana Actions

Existing Programmes and Policies

(a). The Government of Ghana has signed agreements with international consortium in respect of the West African Gas Pipeline project (WAGP), which will transport natural gas from Nigeria to Ghana.
(b). The Government of Ghana is currently exploring the Tano and Saltpond gas fields for development.

Additional Actions

(a). Pursue total privatisation of the utility industry.
(b). Provide expeditious legal process for land acquisition and other property rights
(c). Facilitate competitive atmosphere to eliminate monopoly without impeding successful implementation and operation of the NGDS.

Actions Expected From The International Community

(a). Organise a consortium of international financing agencies to finance the project.
(b). The international implementation partners should participate with local participants to formulate, define and design institutional and capacity building solutions for project implementation.
(c). Help to quantify the financial benefit from the climate mitigation aspect of the project.

2.1.6.4 Expected Results

Market Penetration and Sustainability

(a). The natural gas distribution should start with major industrial customers
(b). Extend to cover entire country
(c). Extend to other sub-region areas

Economic tariffs should form the basis for the operation of the utility. The possible establishment of gas-fired power plants at remote locations to increase national power capacity would help enhance sustainability.

Development and Economic Benefits

The natural gas distribution system will be a beneficial extension to the WAGP. In terms of industrialization, power generation, elimination of wood fuel, and enhanced forest resource management.

It will also forestall the looming energy crisis, help in industrial development, pave the way for wealth generation, and provide employment opportunities.

GHG Reduction Potential And Other Environmental Effects

The successful establishment of the utility industry will be of tremendous ecological benefit. The ultimate is to minimise the use of wood as fuel.

2.1.6.5 List Of Stakeholders

National - EPA, Ministry of Environment and Science, Ministry of Energy, WAGP, VRA, Private & Public business, Energy Commission, PURC

International - NREL, CTI, CPC, UNDP, International Finance Company, EXIM Banks, World Bank, UNIDO, UNEP, SHELL, CHEVRON

2.1.6.6 Capacity Needs

Human and material resources for technology transfer in these areas will include:

(a). Trenchless piping installation and maintenance to minimize environmental impact.
(b). Installation and improvement of tank farms for bulk storage.
(c). Gas compression, pigging and controls (SCADA).

2.1.7 Combined Cycle Power Plants

2.1.7.1 Background

Combined cycle technology provides the highest thermal efficiency of any large thermal power plant and is rapidly becoming the power generation technology of choice around the world where natural gas is available as a fuel. Whilst efficiency of combustion and steam turbines hover around 20 – 30%, combined cycles have efficiencies of up to about 45%. A combined cycle plant can be built faster and at a lower cost than a steam turbine plant of equivalent capacity. It is also more compact and can be installed at a smaller site than a steam plant[7].

Combined cycle is flexible in the sense that combustion turbine plant can be upgraded into combined cycle configuration by the addition of waste Heat Recovery Steam Generators (HRSG) and conventional steam turbine. Plant output is increased by some 50% with no necessity for additional fuel.

The normal arrangement for the combined cycle is to have each combustion turbine generator (CTG) exhausting into its own heat recovery steam generator (HRSG). The output of a number of HRSG is then combined to supply the steam turbine generator (STG). It is important to note that when specifying a turbine, it is important to note that the power output diminishes as ambient temperature increases.

The Takoradi Thermal Power plant was envisaged as a 660MW combined cycle plant comprising 4x110MW CTGs and 2x110MW STGs. However, the present installed capacity of 550MW is made up of a first phase 330 MW combined cycle (2x110MW CTG and 1x110MW STG) and a second phase 220MW (2x110MW CTGs) simple cycle plant. The HRSGs and STG are yet to be installed for the second phase.

The Takoradi thermal system is a dual fuel system capable of firing light crude oil (LCO) and natural gas. Presently, only LCO is being used due to the non-availability of gas. The efficiency of the single and the combined cycle units are 28.5% and 42.8% respectively.

2.1.7.2 Barriers

1). High initial cost compared to combustion turbine.
2). Uneconomic electricity tariffs, which discourages potential investors.
3). Inadequate skilled manpower.

[7] VRA Generation and Transmission System Master Plan, Volume 1, Final Report, July 2001, Acres International.

2.1.7.3 Suggested Actions to Remove Barriers

Ghana Actions

Existing Programmes and Policies

(a). VRA's thermal power complementation plan envisages an additional total installed capacity of 2200 MW to existing capacity by 2020. The combustion turbines of 1540 MW capacity will be upgraded to combined cycle system that will provide additional 660 MW capacity.
(b). Review of electricity tariffs to attain economic levels is on going.

Additional Actions

(a). Develop a viable financial mechanism to raise funds.
(b). Develop capacity and training programmes.

Actions Expected From The International Community

(a). Help build capacity in design, financial analysis and operation and maintenance through external training/exchange programmes
(b). Help source funding to support investment.

2.1.7.4 Expected Results

Market Penetration And Sustainability

Intensify power distribution in the ECOWAS sub-region through export.

Development And Economic Benefits

(a). Generating at comparatively cheaper rates with gas from the WAGP and Effasu projects.
(b). It is cheaper to generate power from combined cycle plants than single cycle plants.
(c). Contribute to meet the growing demand for electricity and provide energy security.

GHG Emission Reductions And Environmental Benefits

The environmental impact of a combined cycle plant is low. Such a plant operating on natural gas produces considerably lower emissions than a comparable oil-fired plant. Oxides of sulphur and particulates are essentially absent from the exhaust when firing natural gas.

2.1.7.5 List Of Stakeholders

National - Volta River Authority, VALCO, Ministry of Mines, Ministry of Energy, PURC, Energy Commission, Mining Companies, Association of Ghana Industries.

International – International Financial Institutions, European Union, World Bank, NREL, CTI

2.1.8 Solar Water Heating

2.1.8.1 Background

Most solar water heaters identified in the country are in the rural health posts and installed by local producers. There has been some penetration in the high income residential areas by dealers in foreign brands. The Ministry of Energy had taken inventory of local installations and commissioned a local manufacturer to install some demonstration units in selected hospitals. The demonstration units, however, failed due to poor engineering (Essandoh-Yeddu, 1997)[8].

2.1.8.2 Barriers

1). No data on hot water consumption in hotels, restaurants and industries.
2). Limited expertise in design of industrial solar water heaters.
3). Relatively high initial capital cost as compared to conventional heating methods.
4). Weak and unstable local currency does not favour importing the systems in to the country.
5). Fluctuating performance due to diurnal solar variations.
6). Lack of standardisation
7). No regulations and code of installation and practice.
8). Perceptions of poor performance from initial unsuccessful trials.

2.1.8.3 Suggested Actions to Remove Barriers

Ghana Actions

Existing programmes and Policies

(a). Government has sponsored a number of workshops on the benefits of the technology
(b). The Ministry of Energy had taken inventory of some local installations and commissioned a local manufacturer to install some demonstration units in selected hospitals.

Additional Actions

(a). Funding must be sought and made available to entrepreneurs.
(b). Technical support to local manufacturers through partnerships with solar water heaters (SWH) manufacturers in other countries
(c). Regulations and code of installation and recommended practices should be developed.
(d). Local production of solar water heaters should be standardized.
(e). The public must be educated and well informed about the benefits and potential of solar water heaters particularly for the purposes of preheating.
(f). Upward adjustment of electricity tariffs to economic levels to reduce reliance on grid electricity for water heating.

[8] Essandoh-Yeddu, J., (1997), *Current Solar Energy Utilisation in Ghana*, Renewable Energy, No.2 Vol.10, 1997, page 433 – 436, Elsevier Science, U.K

Actions Expected From The International Community

(a). Help in exposing local engineering enterprise to modern production techniques and adopting backward integration of the technology for long-term sustenance of the local industry.

(b). Help in identifying international funding sources for SWH production and use.

2.1.8.4 Expected Results

Market Penetration And Sustainability

Solar water heating could have great potential in hotels and restaurants considering the rapid growth of the tourism sub-sector. Adaptation of the technology would, however, be necessary in order to achieve remarkable acceptance and penetration.

Growths in the number of hotels and restaurants are linked to the growth of tourism in the country. Available data suggests that tourism is the third largest contributor to foreign exchange earnings of the country.

Solar water heating could be used to reduce the peak demand for electricity by hotels and restaurants in the country.

GHG Reductions And Other Economic Benefits

Emits no GHG and other gaseous pollutants during operation.

2.1.8.5 List Of Stakeholders

National - Meteorological Service Department, Environmental Protection Agency, Ministry of Energy, Energy Commission, Energy Foundation,

International – National Renewable Energy Laboratory (NREL) – US, World Bank, JICA, GTZ, CIDA, European Union, SIDA US – DOE/USAID, DANIDA, France (CDF), British (DFID),

2.1.9 Wind

2.1.9.1 Background

Earlier wind data compiled suggested average wind speeds of less than 2.4 m/s at a height of 2 metres (MoE, 1991). However, most of the data were collected at meteorological stations with sensors installed at street-level heights (about 2 metre high) with objectives other than energy applications and at sites deliberately selected for their low wind regimes.

Data compiled by the Energy Commission at six coastal sites east of Tema in 1999 indicate the existence of fairly strong winds that could be utilised for power generation. The data

somehow validates a six year satellite-borne measurement provided by the U.S National Renewable Energy Laboratory (NREL), which suggests that Ghana has wind resource for power generation[9] (see table 4.4).

Table 2: Average wind speeds for coastal Ghana; between Lat. 5^{o}–6^{o}N and Long.0^{0}-1^{0}E

Sensor Height[10]	**July (m/s)**	**Aug (m/s)**	**Sept (m/s)**	**Oct (m/s)**	**Nov (m/s)**	**Dec (m/s)**
12 metres	4.56	5.41	5.49	6.36	5.08	4.74
40 metres	5.41	6.31	6.54	7.54	6.02	5.18
Satellite (NREL)[11]	5.4 – 6.0	4.6 – 5.2	4.8 – 5.3	4.5 – 5.0	3.5 – 3.7	3.6 – 4.2

2.1.9.2 Barriers

1). Lack of dependable country-wide data.
2). Weakening and unstable local currency does not favour importing the systems in the country
3). Lack of standardisation
4). There are no regulations and code of installation and practice.
5). Lack of expertise in wind energy technology
6). High initial capital investment
7). Uneconomic tariffs for grid electricity without similar incentives for renewable energy electricity

2.1.9.3 Suggested Actions to Remove Barriers

Ghana Actions

Existing programmes and Policies
(a). The Energy Commission and other private organizations have been able to put together data indicating that the wind speeds in Ghana are sufficient to be harnessed for energy.
(b). The Government is negotiating with IPPs to establish and generate power from wind.
(c). Wind energy is being harnessed in Ghana for standalone applications in off-grid area

Additional Actions
(a). Provide expertise in wind technology through exchange programmes and technology transfer.
(b). Help put in place regulations and code of installation and practice.
(c). Introduce more appropriate equipment to harness energy from low wind speeds.
(d). Carry out country-wide data collection for wind energy production as part of the strategic renewable energy resource assessment.
(e). Encourage utility companies to adopt renewable energy technologies in their supply mix, through incentive packages that can help level the playing field vis a vis uneconomic tariffs.

[9] A wind energy system usually needs an average annual wind speed of at least 4 m/s to be practical.
[10] These are monthly average wind speeds at Tema and four other surrounding coastal towns, namely; Kpone, Lolonya, Adafoah and Pute in 1999 compiled by the Energy Commission. Source: (Ofosu-Asiedu, K., 2000)
[11] Extracted from Wind speed data from 1988 – 1994 for Ghana Coastal Region compiled by NREL and computed from Satellite Ocean Wind Measurement conducted by U.S satellites.

Actions Expected From The International Community

(a). Help in building expertise in the installation and management of wind mills
(b). To facilitate the identification of reliable wind technologies
(c). To help identify sources of concessionary loans and grants and provide loan guarantees.
(d). Support to install wind measurement equipment nation wide and undertake measurement and analyses of the data.
(e). Facilitate partnerships with technology suppliers in donor countries.
(f). Provide technical support in estimating and certifying the carbon reductions, and facilitate discussions with potential purchasers of carbon reduction credits on international markets.

2.1.9.4 Expected Results

Market Penetration and Sustainability

Indications based upon the provisional analysis of the Energy Commission's data suggest that the total proven wind resource along the coast of Ghana is about 200 MW[12]. Assuming an average wind speed of about 5.1 m/s at 12 meter height, a capital cost of between 700 – 1500$/kW for a wind plant has been suggested. An annual operation and maintenance cost is estimated at 32 $/kW, i.e. about 2.9% of the investment cost and a plant capacity factor of about 20%. Considering a wind power plant costing 1100 $/kW and assuming a wind farm of 200 MW gives an electricity cost of 8.5 cents per kWh.

Ghana has steel plants to facilitate local manufacture of support structures. Fabricating the support structure locally is likely to bring the installation cost down and as well create in-country jobs.

Development And Economic Benefits

(a). It will contribute to meeting the growing demand for electricity
(b). Create employment for artisans and also revamp the local steel industries
(c). It will reduce the amount of foreign exchange used in importing Light Crude Oil (LCO) for power generation.
(d). Enhance the energy needs and security of Ghana.

GHG Reductions And Other Environmental Benefits

(a). Emits no GHG and other gaseous pollutants during operation.
(b). Other environmental concerns like noise emissions and interference with birds' habitats are far minimised if the existing environmental assessment and management guidelines are strictly adhered to.
(c). If wind generators are used in place of the Takoradi Thermal Power Plant (TAPCO), the wind generators will displace between 110,000 -113,000 tons of carbon dioxide per year if (TAPCO) was run on light crude oil. On the other hand, if it was run on natural gas, it will displace around 83,000 tonnes of carbon dioxide per year.

[12] Figure provided by Prof. F.O. Akuffo, Department of Mechanical Engineering, KNUST, Ghana based on provisional evaluation of the EC wind data. The technical consultants were from Riso, Denmark. April 2001.

2.1.9.5 List Of Stakeholders

National - Meteorological Service Department, Environmental Protection Agency, Energy Commission, Ministry of Energy, Private Sector

International – National Renewable Energy Laboratory (NREL) – US, World Bank, JICA, GTZ, CIDA, European Union, SIDA US – DOE/USAID, DANIDA, France (CDF), British (DFID),

2.1.10 Cleaner Transport Fuels (Compressed Natural Gas)

2.1.10.1 Background

Rapid industrialisation would require efficient freight transport for production and distribution of goods and services. Ghana would still rely substantially on gasoline as transport fuel by 2020. This, however, threatens the air quality in the industrial and highly populated cities of Tema, Accra and probably Kumasi and Sekondi- Takoradi due to prevailing low street-level wind speeds in the cities which are in most cases not adequate to disperse toxic pollutants.

Besides, reducing traffic congestion, introducing mass transits, improvement in land-use planning and transport infrastructure as part of overall transport management, compressed natural gas(CNG) could supplement the use of diesel and gasoline for vehicles. Natural gas can also be used to produce methanol for blended fuels or gasohol. Gasohol is widely used in Zimbabwe, Brazil and India as transport fuel. Moreover, importation of crude oil and petroleum products and debt-servicing have been a drain on the nation's hard currency earnings chopping off about 40% of export earnings early in the 1980s but dropping to an average of 13% by end of the millennium (Table 3.5).

Table 3: Ghana's fossil fuel imports (1997-1999)

YEAR	**1997**	**1998**	**1999**	**2000***
Oil Imports (US$ m)	234	221	323	N.A
% of Imports (fob)	11	10	12	27

Source: CEPA, Ghana Macroeconomic Review and Outlook,

Thus any attempt to introduce alternative fuels that would reduce cost of oil imports and transportation cost is likely to enhance the sustainability and fuel security of the transport sector.

Compressed Natural Gas (CNG) Vehicles
CNG is speedily becoming the alternative fuel of choice for vehicles. The City of Stockholm coordinates a European project called ZEUS[13] (1998 – 2001) to demonstrate CNG and other environmental vehicles in some European cities. In Bremen, Germany, a party to ZEUS, the city is offering financial incentives to vehicle users who convert to CNG.

[13] ZEUS – Zero and low Emission vehicles in Urban Society. The project started with eight cities (Swedish Eng., 1998)
∗ - Estimated.

2.1.10.2 Barriers

1). Lack of commercially viable natural gas deposits
2). High initial capital cost for conversion from gasoline to CNG use, and for distribution and filling station infrastructure
3). Non-existent skilled labour.
4). The lack of efficient means of distribution of CNG countrywide.
5). Lack of public awareness of the use of CNG as a utility.

2.1.10.3 Suggested Actions to Remove Barriers

Ghana Actions

Existing Programmes and Policies
(a) Ghana is intensifying the exploration of hydrocarbon reserves.

Additional Actions
(a). Regulations and standards will have to be put in place for the use of CNG based vehicles in the country
(b). Create regional awareness and interest in the WAGP through community participation programmes.
(c). Source funding by developing viable financial mechanisms.
(d). Capacity building and training for the acquisition and adaptation of the technology.
(e). Create public awareness for the technology through media releases.
(f). Put in place an enhanced distribution network

Actions Expected From The International Community
(a). Transfer of the know-how of the CNG technology into the country by providing technical support and ensuring continued capacity building activities through exchange programmes and international attachments.
(b). Funding for setting up the initial infrastructure and also launch the market.

2.1.10.4 Expected Results

Market Penetration And Sustainability
CNG fuel is generally less expensive than liquid fossil fuel. There is a high potential of shifting from liquid transport fuel to the CNG.

Development and Economic Benefits
To convert a vehicle from gasoline/diesel use to CNG the vehicle needs to be retrofitted with a cylinder, about US$ 1000 for two 90-liters cylinders and US$ 450 for other kits and labour costs (Table 3.6)

Table 4: Investment costs for CNG Vehicle Technology

SERVICE	COST (US$)
Retrofitting a gasoline vehicle (a heavy-duty lorry)	1,450
Incremental cost of buying a CNG car compared to a gasoline car	400 – 2,000
The incremental cost for a CNG heavy truck compared with a diesel heavy truck	11,200
Building infrastructure for a CNG distribution network	2.78 – 3.5 per GJ

Sources: Ming Yang et al., 1997; Azar et al (2000)[14]

The capital cost of a CNG filling station with a capacity of 500 cubic metres (17.725 GJ) per hour, including installation and training is estimated at US $220,000. The total refueling and distribution cost is between US$ 4.13 - 4.93 per GJ[15]. Azar et al (2000) used a value of US$ 6 per GJ. CNG vehicles are assumed being 10 % more efficient than gasoline vehicles but as efficient diesel fuelled vehicles.

CNG cars are among the most competitive, it has lower life cycle cost than gasoline type even at a crude oil price of US$ 24 per bbl. CNG retrofit vehicles are also cost competitive at US$24 per barrel for large vehicles.

If environmental and health costs were included in evaluation the natural gas would without any doubt be the most competitive choice.

CNG is less expensive than gasoline and diesel and therefore will relatively reduce the foreign exchange expenses on fuel import.

GHG Emission Reductions And Environmental Benefits

It is estimated that the carbon monoxide (CO) emissions are reduced by 97 %, total hydrocarbons (HC) by 72%, NOx by 39 % and CO_2 by 25 % when using CNG instead of a gasoline vehicle (Ming Yang et al., 1997). The major disadvantages of CNG vehicles are the increased weight of the vehicle and the decreased available vehicle space.

There would be reduction in leaded gasoline, if the latter will still be in use by 2020.

2.1.10.5 List Of Stakeholders

National - Commercial Transport Associations, DVLA, Tema Oil Refinery, Ministry Of Energy, Energy Commission, EPA,

International – National Renewable Energy Laboratory (NREL) – US, World Bank, CIDA, European Union, SIDA, US – DOE/USAID, DANIDA, France (CDF),

[14] Ming Yang, Kraft Oliver T., et al., *Compressed Natural Gas Vehicles: Motoring Towards a Cleaner Beijing*, Applied Energy, Volume 56, p.395 – 405, 1997, Elsevier Science, UK.
Azar C., Lindgren K., Andersson B. A., (2000), Hydrogen or Methanol in the Transport sector, Physical Resource Theory, Chalmers University of Technology/Gothenburg University, Sweden.

[15] If we assume a load factor of 10 %, 20 years lifetime and a discount rate of 6 %, the capital cost per GJ is US$ 1.24 per GJ . The annual cost of labour and spare parts for the refueling machine is around 33759 annually resulting in US$ 0.11 per GJ (Ming Yang et al, 1997). This gives a refueling cost of US$ 1.35 per GJ.

2.1.11 Biomass

2.1.11.1 Background

Ghana depends predominantly on biomass energy in the form of woodfuel (fuelwood and charcoal) to meet the bulk of its energy requirement. Woodfuel alone accounts for about 69% of total energy consumption.

Biomass consumption has been growing with population at a constant rate of about 3% per year. Total firewood and charcoal consumption in 2000 was estimated at 3.94million TOE. The bulk (89%) of which is consumed mainly by the residential and commercial sector for cooking, water heating and other domestic and commercial purposes. The industrial sector accounts for the remaining 11%.

Production of woodfuel in 1996 was estimated at 11.8 million tonnes. Supply of biomass other than wood is estimated at less than 0.5million tonnes, which is far below their potential.

However, the long-term prospects for sustained supply of firewood and charcoal is threatened by deforestation and desertification in all parts of the country. This is further worsened by the inefficient conversion from wood to charcoal and the inefficient utilisation and burning of these fuels in stoves to provide the heat energy required.

These problems are caused mainly by having to meet the increasing energy needs of a rapidly expanding population pressure by timber industry in the high forest, bush fires and shifting agricultural practices; inefficient production and use of charcoal and firewood.

The problems of biomass energy could best be addressed through the following:

- Ensuring sustainable management of woodfuel resources in the country
- Promotion of efficient technologies for conversion and utilization of woodfuel in all sectors.
- Promote the development and use of biomass resources other than woodfuels.

Resources of biomass other than woodfuel that are environmentally friendly include crop and sawdust residues, animal and municipal waste. In addition, energy crops such as sugar cane, palm, jatropha etc., which are high energy yielding crops could be processed to liquid fuels as substitutes for petroleum products. Unfortunately the use of these resources have not been encouraged and developed for energy purposes.

This section discusses the following three biomass technologies recommended to mitigate climate change in Ghana:

1. Efficient woodfuel stoves
2. Production and extraction of liquid bio-fuels to supplement the use of fossil fuel
3. Utilization of sawdust for combined heat and power production.

2.1.12 Improved Woodfuel Stoves

2.1.12.1 Background

Cooking is undertaken predominantly using firewood, crop residues or charcoal as fuel on a traditional three-stone fireplace or on a simple charcoal stove. The use of these types of cooking methods has a number of disadvantages, including:

- They are very inefficient and therefore consume more fuel.
- Cooking is very slow as most heat is lost to the surrounding.
- Smoke from the fuel cannot be controlled or channelled out of the cooking environment.
- Women and their children therefore inhale smoke and this has serious health consequences on the lifestyle of women, children and the environment.
- Babies and children are at serious risk from the exposed flame from the stove.

Current traditional stoves (three stone and coal pot) have efficiencies ranging from 10-20%, which are considered inefficient. Meanwhile, there exist improved stoves with efficiencies between 25-35% which when promoted could reduce total woodfuel consumption by about 40%

2.1.12.2 Barriers

1. Inadequate programme formulation and implementation strategy.
2. Local tradition and practices not taken into consideration during the design of improved cook stoves.
3. Lack of woodfuel conservation policy.
4. Low cost of woodfuels (firewood/charcoal) offers little or no incentive for investment efficient stoves.
5. High cost of improved woodfuel stoves production and marketing resulting in low patronage.

2.1.12.3 Suggested Actions To Remove Barriers

Ghana Actions

Existing programmes and Policies

(a). The Ministry of Energy with support from DANIDA is developing and testing efficient production, utilization and management of woodfuels resources in pilot communities in the northern parts of the country

(b). The Ministry of Energy in 1989 developed and promoted the Ahibenso Improved Charcoal Stove nation-wide. Over 20,000 of this model of stoves were disseminated to all regional capitals within three years of the project. Local artisans were trained in all the regional capitals to produce and fabricate these stoves.

(c). The Ministry of Energy is encouraging research and production of low cost cook stoves. UNDP-GEF is supporting local artisans in Accra to buy metal sheets in bulk to enable them produce the Ahibenso stoves at lower cost.

Additional Actions

(a). Develop national woodfuel conservation policy.
(b). Implement national action programme to combat drought and desertification.
(c). Support public awareness programmes to demonstrate environmental and social benefits.
(d). Undertake public education and awareness for efficient improvement of stoves and related health implications.
(e). Introduce tax on woodfuels supplied to urban centers to support afforestation.
(f). Implement programmes and strategies for improved cookstoves.
(g). Involve end-users in the research and development of improved cookstoves.
(h). Encourage aforestation and agro-forestry for the purpose of fuelwood production.

Actions Expected From The International Community

(a). Provide funding to support development of policy, public awareness programmes and to develop affordable improved stoves
(b). Support capacity building for sustainable forest management (agro-forestry, bushfire controls and sustainable logging practices.
(c). Provide technical support in selling carbon credits attributable to reduced wood fuel use.

12.1.12.4 Expected Results

Development and Economic Benefits

(a). Improved quality of life through reduction of smoke-related diseases
(b). Creating employment through production of the improved stoves
(c). Improved stoves with efficiencies of 25 –35% over the 10 – 20% of traditional stoves could greatly reduce woodfuel consumption by more than 50%. (MOE-1990)*
(d). It will lead to south–south cooperation through transfer of such technologies to other developing countries.

Market Penetration and Sustainability

(a). Woodfuel will continue to provide the bulk of the countries energy requirements for cooking for the foreseeable future leading to more exploitation. Improved cook stoves therefore have the potential to reduce the demand for woodfuel
(b). Policy to regulate and manage woodfuel resources when put in place and implemented will ensure judicious use of woodfuel.
(c). High cost of woodfuel will lead to increase demand for improved cookstoves. Increase in public education will lead to increase awareness and demand for improved cook stoves.

GHG Reductions and Other Environmental Benefits

(a). Less emission of biogenic CO_2, NO_x and other gaseous pollutants per unit of cooking service as compared to the traditional stoves.
(b). Less consumption of woodfuel means more trees to serve as carbon sinks.
(c). Improvement in indoor air quality

2.1.12.5 List Of Stakeholders

National - Financial Companies, District Assemblies, Ministry of Lands and Forestry, Energy Commission, Ministry of Energy, Forestry Commission.

International – National Renewable Energy Laboratory (NREL) – US, World Bank, JICA, GTZ, CIDA, European Union, SIDA, US – DOE/USAID, DANIDA, France (CDF), British (DFID), Community Power company (CPC), Swedish Department of Energy.

2.1.13 Liquid Biofuels – Jatropha

2.1.13.1 Background

Ghana is a tropical country and has the potential to grow a variety of energy crops from which liquid fuels could be produced as substitute for fossil fuel (petrol and diesel) in combustion engines.

This has become necessary due to the increasing dependence on imported petroleum and its associated problems. Extraction of liquid biofuel as a substitute for petrol is obtained through fermentation of sugar bearing crops such as sugarcane, starch, sweet potatoes to ethanol and methanol. This fuel could be used to blend petrol for use in engines.

Biofuel substitution for diesel is obtained from high oil yielding seeds and nuts such, as jatropha, sunflower, and coconut. These vegetable oils can be purified into ethyl or methyl esters which are closer to the properties of diesel fuel.

Ghana has about 71,000km^2 of savannah woodland, 60,000km^2 of fallow bush and about 36,000km^2 of rangelands. These lands could be utilised for energy crop plantations such as Jatropha, which is a high oil-yielding vegetable. Jatropha is a shrub available in almost every community in Ghana. It thrives under harsh conditions, drought resistant and evergreen and usually planted as hedges to serve as fire-belt and also to provide shade for domestic animals. The added advantage of the jathropha plant is that the oil extracted is not edible and therefore will not compete with edible oil.

2.1.13.2 Barriers

1). Inadequate awareness of the potential of bio-diesel or uncertainty about the economics of the bio-fuels production cycle, particularly in the Ghanaian environment.

2). Potential land competition with food crop for energy crop plantation unless marginal lands are used.
3). Competition for use of energy crop such as sugarcane, oil palm etc., for other uses such as food, soap preparations etc.
4). Lack of local capacity for adoption of combustion engines to run on liquid biofuels.
5). Lack of know-how for efficient and cost effective extraction of liquid biofuels.
6). Lack of capacity in purification and blending of biofuels with corresponding fossil fuel

2.1.13.3 Suggested Actions to Remove The Barriers

Ghana Actions

Existing Programmes and Policies

(a). Recent test on bio-diesel by Tema Oil Refinery (TOR), Ghana Standards Board (GSB) and Environmental Protection Agency (EPA) confirmed that it compares favourably with diesel and could be used in an engine without modification. In addition, it fulfils the requirement for low sulfur diesel.

(b). Extensive work on the commercial utilization of Jatropha bio-diesel is being undertaken by the private sector, NGOs and research institutions in the country. Anuanum Projects, New Energy, GRATIS Foundation, Technology Consultancy Centre (TCC) among others.

(c). UNDP-GEF/SGP and ADRA have taken the lead and currently supporting farmers in Jatropha plantations in the country.

Additional Actions

(a). Demarcate lands for energy crop cultivation.
(b). Identify energy crops that will survive on non-arable lands.
(c). Promote energy crops. Much more detail needed here.
(d). Support capacity building and training of personnel for the biofuel industry in the areas of production (agriculture) and marketing
(e). Promote the use of biofuels for vehicles and other combustion engines through educational campaigns.
(f). Include biofuels in the petroleum ex-pump mix.

Actions Expected From the International Community

(a). Technology for efficient extraction and purification of bio-diesel
(b). Funding for setting up initial infrastructure either through loan guarantees or insurance.
(c). Support for public awareness in the production, use and the potential of bio-diesel
(d). Technical assistance in quantifying and certifying carbon reductions form biofuels.

2.1.13.4 Expected Results

Market Penetration and Sustainability

(a). Once the cost of liquid biofuel is competitive with petroleum fuel, demand for its use is expected to grow.

Development And Economic Benefits

(a). Commercial production of Jatropha seed has potential push to Government's poverty reduction drive and therefore create jobs in the rural areas
(b). Liquid biofuels can be produced locally to supplement petrol and diesel fuel leading to job creation. Savings in foreign exchange which will otherwise be used to import fossil fuel.
(c). Ensuring security of supply of transport fuels.
(d). It is possible to blend with fossil fuel with little or no engine modification.

GHG Reduction and Other Environmental Benefits

(a). The use of liquid biofuels reduces net carbon dioxide emissions by something like 95% on a life-cycle basis.
(b). Establishment of biofuel plantations will also serve as carbon sinks to further reduce net CO_2 emission.
(c). Gasohol will eliminate the need to add lead as an octane enhancer in gasoline.

2.1.13.5 List of stakeholders

National - Anuanom Industrial Projects Limited, Adventist Development Relief Agency (ADRA), Gratis, TCC, Department of Agriculture (KNUST), New Energy, EPA, Ministry of Energy, Tema Oil Refinery, Energy Commission.

International - UNDP-GEF, World Bank, GTZ, UNEP, UNIDO, Rojac Herbs & Extracts (India)

2.1.14 Sawmill Residue

2.1.14.1 Background

The wood processing industry is estimated to generate over 380,000 tonnes of residues annually, which include slabs, offcuts, cores, veneer waste and sawdust. It is estimated that over 132,000 tonnes of sawdust is generated annually of which 90% is unutilized. Large quantities of sawdust have therefore been stockpiled around the wood processing facilities particularly in Kumasi, Oda and Takoradi over the years posing environmental hazards.

Technically sawdust could be exploited for producing process heat and electricity (Co-generation). The estimated un-utilised sawdust of 132,000 tonnes has the potential to generate up to about 15MW if it were all used for electricity generation.

2.1.14.2 Barriers

1). Approximately uneconomic low electricity tariff
2). High cost of processing sawdust as fuel
3). No incentive to encourage the generation of clean electricity
4). High capital cost in the importation of combined heat and power (CHP) plants

2.1.14.3 Suggested Actions to be Remove Barriers

Ghana actions

Existing programmes and policies
Combined heat and power (CHP) generation has been used in wood processing industries and oil palm plantations over the past 20 years. Table 3.7 below shows some of the biomass-fired CHP plants in Ghana.

Table 5: CHP plants in Ghana

Name of Project	***Location***	***Industry Type***	***Capacity (MW)***
Mim Timbers	Sefwi-Wiaso	Sawmill	0.40
STP Ltd	Kumasi	Sawmill	1.20
Samatex Ltd	Samreboi	Sawmill	0.55
Benso Oil Palm	Benso	Oil palm	0.50
Twifo Oil Palm	Twifo	Oil palm	0.70
Kwae Oil Palm	Kwae	Oil palm	2.10

Currently the Swedish Energy Agency (STEM) is exploring the possibility of taking the CHP project in Kumasi as a Clean Development Mechanism (CDM) project.

Additional Actions

(a). Encourage the productive use of sawmill residue
(b). Ensure disposal of sawmill residue in an environmentally friendly manner.
(c). Enforce realistic and economic national tariff for electricity

Action Expected from the International Community
(a). Transfer of efficient sawmill residue processing CHP to reduce cost of power generation
(b). Assist to identify sources of soft loans and grants

2.1.14.4 Expected Results

Market Penetration and Sustainability
Currently Ghana has abundant sawmill residue and with sustainable forest practices enough feedstock will be available for CHP plant. A ready-market exists to purchase the heat generated for industrial purposes.

Development and Economic Benefits
(a). Savings in foreign exchange used for importing fossil fuel
(b). Ensuring security of power availability
(c). Contribute to meeting the growing demand for electricity

GHG Reduction and Other Environmental Benefits
(a). Reduction of greenhouse gas emissions
(b). Minimise the dependence of fossil for heat and power production

2.1.14.5 List of Stakeholders

National - STP Ltd., Mim Timbers, Samartex, Wood processing industries, KITE, Energy Commission, MoE, Forestry Services Division, Forestry Commission, EPA, ECG.

International - Swedish Energy Agency, DFID, GTZ, EU, etc.

2.2 WASTE SECTOR

2.2.1 Methane Gas Capture and Power Generation at Wastewater Treatment Plant

2.2.1.1 Background

Ghana has a high urban population growth rate and real GDP growth ranging between 4-5% per annum for the past 20 years. Over this period, economic development is faced with challenges of municipal wastewater disposal problems with its associated health and environmental hazards. Consequently, substantial investments have been made over the past 10 years to develop wastewater treatment infrastructure. Public investments in wastewater treatment (WWT) in the country have been very high due to the rehabilitation, upgrading and maintenance of facilities built in the 1960's. (e.g. Tema Sewerage treatment works). Waste management has predominantly been financed and managed by the public sector. Private sector investment has grown significantly in recent times particularly in the solid waste management services.

The human waste disposal facilities in most urban areas comprise of domestic and/or private facilities and sewerage networks. These systems are made up of Kumasi ventilated improved pits (KVIP), cess-pools, pit latrine and water closets. The existing collection systems include manual desludging, mechanical desludging and sewerage. The treatment and final disposal technologies are trenching, digester pits, stabilization ponds and sewage treatment works.

Ghana's Environmental Sanitation Policy (1999) provides the framework for the public health protection through the improvement of human waste and industrial wastewater treatment. Wastewater treatment (WWT) technology transfer under this policy implementation is a mix of aerobic and anaerobic systems.

The anaerobic WWTP installed and commissioned is the Accra Korle Lagoon Treatment Plant which is the first of its kind in Africa. The treatment technology is an upflow anaerobic sludge blanket (UASB). The plant has been constructed with assistance from Department of

International Development of the British Government (DFID). The installed capacity of the plant is 11,010 kg BOD_5 per day equivalent to 222,020 kg COD (biological organic load) per day. The designed BOD of the effluent discharge is 20mg /l which meets the national environmental quality guideline value of 30mg/l.

The design and operation of anaerobic WWT plants do not integrate methane gas recovery systems for profitable end-use such as energy generation.

2.2.1.2 Barriers

1). Limited financing
2). Limited Institutional Capabilities
3). Lack for support for research and development
4). Institutional arrangement and jurisdictional complexity
5). Inadequate community involvement:
6). Inadequate of private sector participation in liquid waste management
7). Problems of social acceptance
8). Land acquisition problems for siting of WWTs.
9). Uneconomic electricity tariffs.

2.2.1.3 Suggested Actions to remove

Ghana Actions

Existing Programmes and Policies
The Government of Ghana has promulgated the Local Government Act (Act 462) and has adopted the National Environmental Sanitation Policy, (1999). The purpose is to ensure sustainable collection, disposal and treatment of waste as well as improving planning, monitoring and enforcement of appropriate regulations at the local level. An anaerobic WWT plant has been installed at Korle Lagoon treatment site. It has a relatively low operating and maintenance cost compared to the aerobic system installed in Tema.

The Ministry of Energy has demonstrated the potential utilization of methane for power generation at Appolonia. A few small sized biogas plants have been installed to produce methane (biogas) for cooking.

Additional Actions
(a). Integrating Climate Change issues into the National Waste Management Policy and Implementation Plans
(b). Put in place viable financial plan to enhance private-public sector partnership.
(c). Organise workshops to create awareness

Actions Expected From The International Community
(a). Assist in the identification of other efficient anaerobic systems.
(b). Support establishment of anaerobic waste treatment plant in municipal assemblies for energy generation

(c). Assist in capacity building in the installation, operation and maintenance anaerobic systems
(d). Support transfer of low cost small to medium size plants for rural farms and public toilets
(e). Assist in selling of CO_2 credits from the GHG offsets from these plants.

2.2.1.4 Expected Results

Development And Economic Benefits
(a). Anaerobic treatment plants have relatively lower operation and maintenance cost compared to aerated systems.
(b). Treatment of municipal waste before disposal will lead to improvement in sanitation, health and quality of life.
(c). The slurry is a good quality manure that can be used to boost agriculture and create more employment in the agricultural sector.
(d). Generation of power from methane will reduce reliance on fossil fuel to generate electricity.
(e). Electricity generated from plant can supplement the energy required for the operation.
(f). The construction and use of the anaerobic systems will create employment and professional skills.

Market Penetration and Sustainability
(a). Demand for anaerobic treatment plants are expected to increase as their operational cost turn to be lower than aerated technologies.
(b). Following the successful demonstration of the plant in Accra, it is expected to replicate the system in other metropolitan areas.

GHG Reduction and other Environmental Benefits
(a). Production and use of methane gas for power generation will reduce the emission of methane, which has a higher global warming potential than CO_2.
(b). It will also save the country the use of fossil fuels which otherwise would have been used for generating electricity for the treatment of the waste.

2.2.1.5 List Of Stakeholders

National - Ministry of Local Government and Rural Development, Environmental Protection Agency, Ministry of Works and Housing, Water Resources Commission, Environmental Service Providers Association, NGOS, CBOs, FBOs, Ghana Real Estate Development Association.

International - Department for International Development – UK (DFID), Danish International Development Agency (DANIDA), Canadian International Development Agency (CIDA), German Technical Cooperation (GTZ), Japan Technical Cooperation Agency (JICA), World Bank, International Fund for Agriculture (IFAD), CTI

2.2.1.6 Capacity Needs

(a). Local training needs and assessment
(b). Information exchanges with Development Partners

2.2.2 Waste Composting Technologies

2.2.2.1 Background

Degradable organic materials make up the bulk of Ghana's discarded Municipal Solid Waste (MSW). A study on the composition of MSW conducted in 1997 by the Accra Metropolitan Assembly (Waste Management Department) showed that about 65% of the waste stream consists of organics. Inert material arising from the practice of hand sweeping sand constituted about 17.1% of the waste stream. Together, both organics and inert material accounted for about 82% of the waste. The trend is no different from most urban centres of the country. This high percentage of organic material has often led to the suggestion that composting can be an appropriate and viable disposal MSW technique for the country.

2.2.2.2 Barriers

1). Unsegregated domestic waste at communal level.
2). Lack of comprehensive waste management policy and legislative framework.
3). Inadequate institutional capacities
4). Inefficient institutional co-ordination
5). Low budgetary allocation
6). Lack of adequate cost recovery and internal resources mobilization by District Assemblies
7). Unwillingness of the public to pay for waste management services
8). Inadequate private sector participation.
9). Poor social acceptance of compost use.
10). Poor monitoring mechanism and enforcement of standards and guidelines.
11). Land acquisition problems for composting
12). Scattered legislative instruments.

2.2.2.3 Suggested Actions

Ghana Action

Existing Programme and Policies
Waste composting is practiced nation-wide on limited scale by mostly small-scale farmers. The technology mostly used is simple aerobic methods of composting through surface windrowing. The only large scale composting plant being operated in the country was established in 1979 with technical assistance from the Swiss Government. This plant is located at Teshie-Nungua in the Accra Metropolitan area. The plant was designed with a

production capacity of 200 tonnes/day. However since its establishment, the plant has been running under capacity (about 40%).

The Environmental Sanitation Policy underscores the promotion of simple affordable technologies and low maintenance cost for composting on decentralized basis by District Assemblies. This policy will ensure affordability of the technology by farmers and other investors.

Additional Actions

(a). Promotion of source separation of domestic waste at communal level.
(b). A clear policy direction by way of the development of District/Regional/National Waste Management Action Plans/Strategies.
(c). Develop innovative financing mechanisms that are a combination of governmental infrastructure development and management.
(d). Undertake education and public awareness.
(e). Introduce indirect taxation and cross subsidies as a means of meeting full cost of service delivery and cost of production of compost.
(f). Promote private sector participation in waste management.
(g). Encourage research and development into compost technology
(h). Promote community involvement and partnerships in the production and usage of compost.
(i). Introduce properly package-finished products.
(j). The Ministry of Food and Agriculture should promote, as a matter of policy, the use of compost by farmers. A programme to de-emphasize the use of inorganic fertilizers should be drawn and implemented.

Actions Expected from International Community

(a). Technology transfer in compost production (e.g. magnetic waste separators and short duration composting technology).
(b). Capacity building in operation, management and maintenance of composting equipment.

2.2.2.4 Expected Results

Market Penetration and Sustainability

The use of inorganic fertilizer alone has proved to be ineffective in maintaining soil fertility and has the added environmental adverse consequence of underground and surface water pollution. Large-scale compost production is a good substitute for imported inorganic chemical fertilizer. Generally, apart from cost savings, compost has the added advantage of controlling soil erosion through improvement of soil particle aggregation. With the high percentage (65%) of organic content in the waste stream, Ghana stands at an advantage in harnessing available compost technologies and exporting compost material to the West African sub-region.

The Ministry of Food and Agriculture spends large amount of foreign exchange annually on inorganic fertilizer imports. The promotion of compost use among Ghanaian farmers will save the country some foreign exchange.

Ghana being an agricultural country and with a population growth rate of 2.5%, implies that there will be continuous and sustained supply of organic waste for compost production.

Development and Economic Benefits

(a). Composting production can create jobs for NGOs, farmers, and other end-users (e.g. horticulturalists, florists etc)
(b). Compost as a substitute for chemical fertilizers will also contribute to increased food production and higher GDP growth for the agricultural sector.
(c). Farmers will acquire the techniques of soil conditioning practices and compost production.
(d). Raw materials in terms of organic matter are available in abundance.

GHG Reduction Potential and other environmental benefits

Composting replaces carbon dioxide emissions from the manufacture of inorganic fertilizers and also serves of a carbon sink. To date, however even though Ghana generates an estimated 1.9 million tonnes[16] of degradable organic waste per year, its potential, as climate change friendly technology has been fully utilized.

2.2.2.5 List of Stakeholders

National - Ministry of Local Government and Rural Development, (Metropolitan/Municipal and District Assemblies), Environmental Protection Agency, Ministry of Works and Housing, Ghana Water Company, Environmental Service Providers Association, NGOS, FBOs, CBO's. Water Resources Commission and Assembly members, Ghana Real Estate Development Association.

International - Department for International Development - UK (DFID), Danish International Development Agency (DANIDA), Economic Community of West Africa States (ECOWAS), Canadian International Development Agency (CIDA), German Technical Cooperation (GTZ), Japan Technical Cooperation Agency (JICA), World Bank, International Fund for Agriculture (IFAD), Food and Agricultural Organization (FAO), United Nations Development Programme (UNDP).

2.2.2.6 Capacity Needs

(a). Local training needs assessment and promotion
(b). Information Exchanges with Development Partners.

[16] Municipal Solid Waste generation rate of 0.5 kg per cent per day and DOC of 65%

2.2.3 Methane gas capture from landfills

2.2.3.1 Background

The only engineered landfill site under construction in the country at Kwabenya does not integrate methane recovery. It will be serving Accra and the Ga District which together has a population of between 2-2.5million [17]This population generates on average solid waste of about 1,100 tonnes/day with an organic content of about 65%.

Against this background, it will be viable to recover methane from landfill sites for power generation. There has been donor interest and support in the design and construction of the Kwabenya landfill for sanitation, health and safety purposes. However, additional support is required to secure methane recovery.

2.2.3.2 Barriers

1). Poor social acceptance of technology
2). Difficulty in land acquisition for landfill sites
3). Lack of stakeholder participation in decision making
4). Lack of education and awareness creation
5). High initial capital cost
6). Lack of legislation to prevent indiscriminate dumping
7). Non segregation of waste at source
8). Inadequate enforcement of waste management policies and regulations.

2.2.3.3 Suggested Action

Ghana Actions

Existing Programmes and Policies

Ghana's National Environmental Sanitation Policy, calls for a shift from the existing waste handling practices to engineered landfill systems. Organized collection and engineered landfill site operations will be implemented for five (5) metropolitan/municipal assemblies, namely Accra, Tema, Kumasi, Sekondi-Takoradi and Tamale.

Additional Actions

(a). Initiate awareness creation programmes
(b). Town and Country Planning Development (TCPD) should integrate engineered landfill in development plans.
(c). District assemblies should carry out education and information of the development plans of TCPD
(d). Encourage public hearing during Environmental Impact Assessment studies to ensure social acceptance.
(e). Enforce existing laws on waste management.
(f). Encourage the private sector participation in the development and management of landfill sites

[17] 2000 Population Census, Ghana Statistical Service

(g). Ensure enforcement of existing laws and bylaws by DA, MA, Police
(h). Encourage segregation to be done at landfill site.
(i). Undertake review of the urban environmental sanitation project plans (Urban 4)

Action Expected from International Community
(a). Assist in the design, installation and management of methane recovery systems.
(b). Assist in the development and implementation of education and training programmes including the training of experts in this field.

2.2.3.4 Expected Results

Market Penetration and Sustainability
The Kwabenya project will serve as demonstration project for replication in the country and in the sub-region..

Development and Economic Benefits
(a). Job and wealth creation
(b). Proper disposal of solid waste through engineered landfills will lead to improvement of sanitation, health and quality of life.
(c). Generation of power methane will reduce reliance on fossil fuel for electricity generation.
(d). The construction and use of engineered landfill systems will create employment and professional skills

GHG Reduction and other environmental benefits
(a). The capture and use of methane for power generation will reduce the emissions of methane which has a high global warming potential than CO_2
(b). It will reduce the use of fossil fuels for power generation.

2.2.3.5 List of Stakeholders

National - TCPD, Chiefs and Elders, Community leaders, District Assemblies, EPA, Land Title Registry, Lands Commission, Land Valuation Board and NGO

International - Department for International Development- UK (DFID), Danish International Development Agency (DANIDA), Economic Community of West Africa States (ECOWAS), Canadian International Development Agency (CIDA), German Technical Cooperation (GTZ), Japan Technical Cooperation Agency (JICA), World Bank.

2.2.3.6 Capacity Needs

(a). Training of the private sector in the design, operation and maintenance of engineered landfills
(b). Training of operators, separators and collectors.
(c). Capacity development in the inventory and monitoring of greenhouse gas emissions.

3.0 ENVIRONMENTAL CONTEXT

In the 1980s, scientific evidence linking greenhouse gas emissions from human activities with the risk of global climate change started to arouse public concern. Governments held a series of international conferences that echoed this concern by issuing urgent calls for a global treaty to address the problem. The United Nations General Assembly responded in 1990 by establishing the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change (INC). The INC drafted the Convention and adopted it on 9 May 1992. The Convention was opened for signature in June 1992 at the Rio de Janeiro Earth Summit.

Ghana signed the United Nations Framework Convention on Climate Change (UNFCCC) in June 1992 and ratified same in September 1995. Since 1996 Ghana has undertaken a series of activities in fulfilment of her obligations under the Convention. These activities include:

- Greenhouse gas inventory preparations
- Greenhouse gas abatement analysis
- Vulnerability and adaptation assessment, and
- Preparation of her initial national communication.

3.1 INVENTORY OF GREENHOUSE GASES

The initial national greenhouse gas (GHG) inventories of emissions by sources and removals by sinks, from 1990 to 1996, was carried out and published in Ghana's Initial National Communication to the Untied Nations Framework Convention on Climate Change (UNFCCC). This was in fulfilment of Ghana's obligation under Articles 4.1 and 12 paragraph (a) of the UNFCCC. The inventories were reported in accordance with the annex to decision 10/CP2. The base year used was 1994.

The economic sectors considered in the greenhouse gas inventories were Energy, Industrial Processes, Agriculture, Land Use Change and Forestry and Waste. The GHG inventories of emissions by sources and removals by sinks covered carbon dioxide (CO_2), methane (CH_4) and Nitrous Oxide (N_2O).

3.1.1 Sectoral GHG Inventories

Table 4.1 provides a summary of the sectoral greenhouse gas inventory from 1990 – 1996.

Energy

The emissions from this sector grew by 6.6% from 1990 - 1996. The sector contributed about 49% (7, 122 Gg) to the total CO_2 equivalent emissions in 1994. The share of fuel combustion was 3,048 Gg from the sector, while biomass burned for energy accounted for 4,073 Gg. The country's per capita CO_2 emission from commercial energy was relatively low for the inventory period. This was due to the fact that only 20% of the national energy consumption

was attributable to fossil fuel combustion, which leads to CO_2 emissions. The other 80% of the national energy consumption comes from hydropower (10%), and biomass energy (70%). Non-CO_2 emissions from fossil fuel combustion were not estimated.

Industrial Processes

The contribution of the industrial processes sector to total CO_2 equivalent in 1994 was 2% (281.8 Gg). The significant CO_2 source categories in the sector were aluminum smelting, limestone use, and iron and steel scrap melting plants. The CO_2 emissions from the sub-sectors in 1994 are aluminum (248.3 Gg), limestone use (28.0 Gg) iron and steel (3.18 Gg). Thus aluminum and limestone use contributed over 98% of total sectoral CO_2 emissions. Cement is currently produced from clinker processing and therefore does not contribute to CO_2 emissions. The emissions from the aluminum sector decreased from 1994 due to reduction in hydropower production, which supplies power to the aluminum plant. This was also due to low water levels arising from the low precipitation in the Volta basin, which suggests the vulnerability of the water resources to climate variations.

Agriculture

The non-CO_2 emissions from the agricultural sector for 1994 are CH_4 (220.6 Gg) and N_2O (2.01 Gg). The total CO_2 equivalent emissions thus amounted to 6,049 Gg, contributing about 42% of the total national greenhouse emissions. The significant source categories in the sector were burning of savanna and enteric fermentation. The CO_2 emissions from burning of savanna and agricultural residue were considered zero since there is re-absorption during re-growth. Burning of savanna in the agriculture sector contributed 68% whilst enteric fermentation accounted for 28.4% of CH_4 emissions in 1994. About 95% of the total N_2O emission in 1994 in this sector was due to savanna burning.

Land Use Change and Forestry

The net CO_2 equivalent removal by sinks in the land use change and forestry sector was -19,410 Gg for 1994. The sector is therefore very important in providing the country's capacity for CO_2 sequestration. The total non-CO_2 equivalent emissions of CH_4 and N_2O from on-site burning of forest were very low, estimated at 467 Gg, CO_2 equivalent representing only 3% of the total emissions.

Ghana's sink capacity reduced drastically from –32,805 Gg. (1990) to as low as -18,960 (1996). The sharp decline is attributed to the following national circumstances:

- Seasonal biomass clearings annually for farming, grazing lands, mining and settlements.
- Charcoal and fuelwood use has been increasing over the years.
- Restoration of deforested lands was minimal.
- High population growth led to shortening of fallow periods.
- Stocking levels of timber in the high forest area has fallen.

Waste Sector

The methane emissions from the various sub-categories were very low due to the absence of waste management practices. The methane emissions from Solid Waste Disposal Sites (SWDSs), based on the recommended IPCC methane correction factor of 0.40 for shallow unmanaged SWDS (<5-m depth), ranged from 4.8 Gg in 1990 to 7.50 Gg in 1996. The

increase may be the result of increased population and/or increase in the volume of solid waste disposed to SWDSs. The total estimated methane emissions from domestic and industrial wastewater handling source categories increased slowly from 17.35 Gg in 1990 to 22.35 Gg in 1996. The increase was attributable to urban population growth.

The estimated nitrous oxide (N_2O) emissions from human sewage increased from 0.12 Gg/yr. in 1990 to 0.15 Gg/yr. in 1996 as a result of increased population. The relatively low N_2O is accounted for by the low protein intake per person per year, estimated at approximately 10% of WHO level of 25.55 kg/person/year.

On the whole GHG emissions from the waste sector contributed to only 4% of total national emissions.

Table 6: Summary of Sectoral Contributions to the Total CO_2 Equivalent Emissions GHG by Sources and Removals by Sinks, 1990 - 1996 (Gg)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
TOTAL (NET) GHG EQUIVALENT EMISSIONS BY SOURCES AND REMOVABLE BY SINKS	**-20,417**	**-21,191**	**-15,586**	**-8,807**	**-5,411**	**-5,971**	**-4,082**
1. All Energy	**5,512**	**5,265**	**5,827**	**6,748**	**7,122**	**7,323**	**7,616**
1.1 Fuel Combustion (CO_2)	2,831	2,320	2,418	2,974	3,048	3,240	3,533
1.2 Biomass Burned for Energy (Non-CO_2	2,681	2,945	3,409	3,774	4,073	4,083	4,083
2. Industrial Processes (CO_2)	**293.0**	**295.6**	**298.3**	**311.1**	**281.8**	**277.6**	**268.1**
Mineral Production							
2.1 Cement Production							
2.2 Lime Production			0.005	0.040	0.16	0.22	0.22
2-3 Limestone Use			0.210	0.450			
2-4 Soda Ash & Sodium Bicarbonate				0.85	0.95	1.33	3.9
Chemical Industry							
2-9 Calcium Carbide Use			1.49	1.11	1.30	1.38	0.89
2.11 Metal Production							
2-11 A Iron and Steel		0.022	0.544	1.61	3.18	3.0	3.6
2-11B Aluminum	293.0	295.6	296.3	307.0	248.3	243.0	230.6
4. Agriculture (CH_4 and N_2O)	**6,118**	**6,216**	**5,990**	**6,396**	**6,049**	**6,087**	**6,398**
4.1 Enteric Fermentation	1,588	1,662	1,446	1,860	1,509	1,525	1,525
4.2 Rice Cultivation	104.1	112.0	104.1	95.8	95.1	117.6	123.5
4.3 Prescribed Burning of Savannas	4,384	4,384	4,384	4,384	4,384	4,384	4,384
4.4 Field Burning of Agriculture Residues	19.17	27.78	28.32	28.32	39.10	40.60	39.63
4.5 Agriculture Soils	22.72	30.72	27.20	27.52	20.50	20.20	19.84
5. **Land Use Change and Forestry**	**-32,805**	**-33,458**	**-28,258**	**-22,810**	**-19,410**	**-20,236**	**-18,960**
5.1 Changes in forest and other woody biomass stock (CO_2 emissions from biomass)	-35,719	-36,372	-31,172	-25,724	-22,324	-23,150	-21,874
5.2 Forest and grassland conversion (CO_2 emissions from biomass)	5,738	5,738	5,738	5,738	5,738	5,738	5,738
5.3 On-site Burning of Forest (CH_4 & N_2O Emissions from Biomass Burning)	467.9	467.9	468	467.9	467.9	467.9	467.9
5.4 Abandonment of Managed Lands (Total CO_2-uptake)	-3,292	-3,292	-3,292	-3,292	-3,292	-3,292	-3,292
6. **Waste (CH_4 & N_2O)**	**464.7**	**490.0**	**557.4**	**548.9**	**546.5**	**577.4**	**596.3**
6-1 Solid Waste Disposal Sites (SWDs)	118.1	142.1	191.1	171.5	159.3	177.1	183.5
6-2 Domestic & commercial	293.8	293.8	311.2	321	330.8	341	351.3
6-3 Industrial Waste Water Handing	13.48	13.48	13.48	13.48	13.48	13.48	13.48
6-4 Human Waste (Indirect N_2O)	39.36	40.64	41.60	42.88	42.90	45.80	47.00

3.2 IMPACT, VULNERABILITY AND ADAPTATION

The assessment of Ghana's vulnerability to climate change was carried out to evaluate how changes in climate may affect some important sectors of the national economy. These include water resources, coastal zone and some agricultural crops. The assessments consisted essentially of the analysing of the scope and severity of the potential effects of climate change, as a result of probable temperature rise, decreased precipitation and rise in sea level.

Water Resources

Water resources in Ghana are vital for socio-economic development. Impacts of climate change on the water resources can put the country at risk, and therefore assessment is necessary for planning and management to reduce such effects.

The country's water resources may be classified into two broad categories, namely surface and groundwater resources. Surface water resources depend on the magnitude of river discharges or runoffs, and the groundwater on recharge and capacities of the aquifers.

In assessing the impacts of climate change on water resources, the representative basin approach was used. A basin was chosen from each of the three hydroclimatic zones spanning the country. The basins are Pra from the Southwestern system, Ayensu from the Coastal system and the White Volta from the Volta system.

Scenarios of potential future climate were developed using three Global Circular Models (GCMs) and a simple climate model. River discharge patterns were simulated with a water balance model, which used climate scenarios of temperature and precipitation for the years 2020 and 2050.

Recharges to groundwater storage were computed from the water balance components. The recharges were then used in estimating the groundwater potential. The sum of the available surface and groundwater resources constitutes the total water supply for the basin.

Estimates for domestic, industrial and irrigation water demands were based on socio-economic indicators for the year 2020 and 2050 were carried out. Water demands for the same socio-economic conditions under climate change scenario were then computed. Irrigation water demands incorporating changes in evapotranspiration and precipitation were estimated using CROPWAT model. Total water demand was computed by aggregating the various demands. Hydropower generation was simulated from WEAP, a water evaluation and application model.

Impacts and vulnerability assessments in each basin were carried out on water supply and demand. The results were then transferred to the whole hydroclimatic zone on the basis of homogeneity of characteristics within each zone. National impact and vulnerability were then finally deduced.

Major findings of the study include the following:

- Temperature rise of about 1^{o}C over a 30-year period and reductions in rainfall and runoff of approximately 20% and 30% respectively, were observed from historical data sets.
- Runoffs or discharges in all the representative basins are sensitive to changes in precipitation and temperature. A 10% change in precipitation or a 1^{o}C rise in temperature can cause a reduction in runoff in excess of ten percent .
- Simulations using projected climate change scenarios indicated reduction in flows between 15-20% and 30-40% for the year 2020 and 2050 respectively in all the basins.
- Climate change may cause reductions in groundwater recharge of between 5% and 22% by the year 2020. Reductions for the year 2050 are projected to be between 30% and 40%.
- Irrigation water demand could be affected considerably by climate change. In the humid part of the country, the projected increase in irrigation water demand referenced to the base period water demand due to climate change by 2020 and 2050 will be about 40% and 150% respectively. . In the scenario without climate change effects, the relative increases in water demands in the same period are 5% and 17% for the year 2020 and 2050 respectively.
- For the dry interior savanna, the corresponding increases in water demand in 2020 and 2050 are projected to be about 150% and 1200% of the base period water demand respectively. Similarly, the relative increases in water demands in the scenario without climate change for the same period of 2020 and 2050 are 4% and 12% respectively.
- Hydropower generation could seriously be affected by climate change. For example the projected reduction by 2020 is about 60% from the base value in the Pra basin.
- From the socio-economic point of view, there may be secondary impacts on energy-based industrial activities, health and nutrition , if proper adaptation options are not embarked upon.
- The use-availability ratios in the country are very small. The values are 2-10% and 5-31% for 2020 and 2050 respectively. As this ratio increases to 40% to meet food security and export, the whole country will be vulnerable. It is worth noting that the marginal vulnerability predicted for 2020 and 2050 are due to projected low use-availability ratios based on our current water consumption patterns.

Agriculture

Analysis of climate change on cereal production in Ghana and adaptation strategies to deal with the potential climate change effects was done. Future climate change scenarios on temperature, solar radiation and rainfall were generated using General Circulation Models. The impact of climate change on cereal production was assessed using the CERES model. CERES MAIZE and CERES MILLET models were used to generate growth and yield of maize and millet, respectively.

The future climate change scenarios generated, indicated that both the maximum and minimum temperatures increased over the years in all agroclimatic zones in Ghana. However, the increases were higher in the Sudan Savanna Zone where temperatures are normally the highest.

The projections indicate that the average maximum temperature is expected to increase by 3^{o}C in the Sudan Savanna Zone, and 2.5^{o}C in all other agroclimatic zones by the year 2100. The average minimum temperature is expected to increase by 2.5^{o}C in the Sudan Savanna,

Guinea Savanna and the Semi-Deciduous Rainforest Zones by the year 2100. For the transition zone and the High Rainforest Zone, the minimum temperature is projected to increase by 3^{o}C and 2^{o}C, respectively, by the year 2100.

The average solar radiation was projected to increase by 1.95MJ/m^2 in the Transition and the Semi-Deciduous Rainforest Zones, 1.0MJ/m^2 in the Guinea Savanna Zone, and 0.75MJ/m^2 in the High Rainforest Zone, by the year 2100.

With respect to projected rainfall, the mean annual rainfall would decrease by 170 mm in the Sudan Savanna Zone, 74 mm in the Guinea Savanna Zone and 99 mm in the Semi-Deciduous Rainforest Zone respectively by the year 2100. In the High Rainforest Zone, however, the mean annual rainfall was projected to increase by 1105mm by the year 2100.

Using the projected climate scenarios and CERES model, it was projected that the yield of maize would decrease in the Transition Zone from 0.5 percent in the year 2000 to 6.9 percent in the year 2020. The yield of millet, however, was not affected by the projected climate change because millet is more drought tolerant and therefore insensitive to temperature rise.

Coastal Zone

The land area of the coastal zone of Ghana defined as the area below the 30-m contour, covers about 7% of the total land area of Ghana. It is home to 25% of the population of the country. Several consequences could be expected from a rise of about 1.0m in sea levels in Ghana. In particular, low-lying sandy coastal areas such as the Volta delta will be profoundly affected. The expected impacts of sea-level rise are: direct inundation (or submergence) of low-lying wetland and dry-land areas; erosion of soft shores by increasing offshore loss of sediment; increases in salinity of estuaries and aquifers; raised coastal water tables; and exacerbated coastal flooding and storm damage. These impacts will in turn influence coastal habitats, bio-diversity and socio-economic activities.

The length of the coastal zone of Ghana is 550km. The zone comprises of the East Coast (149 km), the Central Coast (321 km) and the West Coast (95 km). The sandy East Coast stretches from Aflao to Prampram while the sandy West Coast stretches from the country's border with La Cote d'Ivoire to the Ankobra River. The Central Coast comprises mainly of rocky beaches interspersed with short sections of sandy beaches between 2 - 10 km long.

The assessment adopted the following procedures:

- socio-economic scenario (i.e. the case as at 1994);
- future sea-level rise of one meter;
- a defined response scenario; and
- estimates of the associated cost.

The population is concentrated within the main urban centres i.e. Accra-Tema, Sekondi-Takoradi and Cape Coast. Of the 21 administrative districts in the Coastal Zone, Accra Metropolitan Area has the highest population density of 3,388 persons per km^2 and Jomoro District has the lowest, 45 persons per km^2. Apart from the urban centres, the main economic activities in the coastal zone are fishing and farming. Incomes are low averaging below US$150 per person per year for most districts within the zone.

A preliminary assessment of the impacts of sea-level rise shows that about two-thirds of the total land area potentially at risk of flooding and shoreline recession in Ghana, lies within the East Coast. Other areas that may be impacted adversely are the West Coast and limited sections of sandy beaches within the Central Coast. A total of 1,110 km^2 of land area may be lost as a consequence of a 1 m rise of sea-level. The population at risk is estimated at 132,200. Most of the affected population is within the East Coast.

The loss of land by erosion and inundation will translate into a loss of coastal habitats including important wetlands mostly in the Volta Delta. Increasing water depths and salinization of lagoons as a result of sea-level rise will impact adversely on the feeding sources of migratory and resident birds. The strand vegetation at risk include, *Canavalia rosea, Ipomea pes-caprae, Sesuvium portulacastrum* and *Phylooxeris vermicularis.* Loss of habitat includes those of marine turtles that lay their eggs on sandy beaches and the habitats associated with coastal lagoons. Some species that are less tolerant to salinity increases will be displaced.

Sea-level rise will raise the moisture content of sandy and silty soils along the coastal zone. These soils when subjected to vibrations will liquefy. The structures founded on these soils could thus be at risk of collapse during earthquakes. The rising water table as a result of sea-level rise will increase the risk of earthquake hazards. The highest risk zone is the Accra metropolitan area.

Estimated cost of protecting all shorelines at risk with populations greater than 10 persons per km^2 with seawalls is US$1,144 million. The protection of only the important areas, reduces that cost to US$590 million. On account of the high expenditure involved in offering protection, other alternative measures are proposed. These include the controlled abandonment of areas at risk and the use of set backs to control development along sections of the coast that are currently undeveloped.

3.3 MEASURES CONTRIBUTING TO ADDRESSING CLIMATE CHANGE

Forestry
Detailed studies were carried out on measures to abate climate change through the forestry and land use sector, using the Comprehensive Mitigation Analysis Process (COMAP) model as analytical tool. 1994 was chosen as the base year and 2020, the end of the current National Development Planning Framework, as the end of the analytical period.

Identification and Screening of Abatement Options
Fifteen potential options were initially identified and screened against 12 criteria ranging from impact on GHGs on other pollutants and on other aspects of the environment such as biological diversity; likely direct cost/benefit ratio; consistency with national development goals; to ease of implementation, using an options – criteria matrix. The seven most promising abatement options were then grouped into a Forest Protection Option and a Reforestation/Regeneration Option for further analysis.

Business-as-usual Projections

The base year land use situation was used as a baseline scenario, taking into account the background information on national and sectoral development policies, programs and projects.

The projections indicated that under a business-as-usual scenario, the natural forests in the managed and protected Tropical High Forest Reserves would decrease by 45,000 ha as a result of the conversion of part of the 127,000 ha severely degraded portions (the Conversion Forest) to planted forest. Total closed forests would decrease by 343,000 ha mainly as a result of deforestation. The natural Savanna Woodlands would similarly decrease by about 600,000 ha, again through deforestation. Planted forests would increase from 68,000 ha in 1994 to 154,000 ha by 2020. The biomass pool on all forested lands (excluding the bush fallows, etc) would be reduced from 240,300 tB to 230,485 tB.

The Forest Protection Abatement Scenario

A Forest Protection Scenario to abate climate change developed involved among others:

- increased surveillance of the protected/managed permanent forest and wildlife reserves and involvement of stakeholders in their protection;
- continued enhancement of stumpage for timber trees and of income generation opportunities from unreserved community natural forests, to increase people's appreciation of the value of unreserved forests as against their removal for other land uses;
- provision of alternate livelihoods for communities protecting/conserving currently unreserved ecologically sensitive, culturally significant forests;
- expansion of activities to encourage integrated management of the natural savanna woodlands by communities.
- education and sanctions to reduce the incidence of uncontrolled bush burning.
- continued improvement in agricultural technologies to encourage intensive agriculture.
- effective enforcement of the ban on illegal chain saw operations

As a result of these protection measures:

- An additional 42,000 ha of unreserved high forests above the baseline situation (which would protect 3,000 ha) would be maintained and managed as productive dedicated forests by communities and landowners;
- 20,000 ha of unreserved high forests on fragile, ecologically sensitive and culturally significant sites would be protected by communities;
- 393,000 ha of unreserved savanna woodland, approximately equal to the area expected to be deforested from 2001 would be protected and managed by communities and individuals;
- The rate of deforestation of intact forests outside the forest and wildlife reserves would be progressively reduced from 5% in 2001 to 2.5% in the high forest zone and from 0.34% to 0.3% in the savanna woodlands zone;
- Total carbon density would increase from 213 tC/ha in 2001 to 272 tC/ha in 2020 in the high forest zone and in the savanna woodland zone from 55 to 62 tC/ha.

The Reforestation Abatement Scenario

This option will ensure that an additional 112,000 ha is reforested, largely as industrial plantations by private enterprises (small, medium and large scale). This area is equivalent

approximately to the unreserved high forests that would be deforested and lost even under the Protection Option between 2001 – 2020. The incremental carbon that would consequently be sequestered is estimated at 6,060 ktC.

Energy Sector

This section examines the abatement of the increase of greenhouse gases (GHGs) in the energy sector. The energy sector is currently the largest emitter of GHGs. The abatement in the sector was considered over a time horizon of 1994 to 2020.

In estimating the baseline emissions, Vision 2020 which was the Government's main development plan and other estimates of energy demand were used. The energy supply situation was also considered. With these as inputs, the emissions of CO_2 equivalent of GHGs was estimated up to the year 2020. This is called the baseline emissions because it considers the national development path without reductions in GHGs. The result showed that the CO_2 equivalent of emissions for the baseline will increase from 7,278 Gg. in 1994 to 118,405 Gg in 2020.

Four abatement scenarios were looked at:

- replacing some biomass with LPG
- use of biogas and LPG to some biomass from 2010 to 2015 when only LPG and biogas will be used with the largest proportion of cooking being of biogas
- gradual penetration of solar PVs to the existing mix
- gradual penetration of biogas instead of a huge penetration as in second and third scenarios

The CO_2 equivalent reductions from the abatement measures of scenarios I, II, III, IV are 495,506 Gg, 700,044 Gg, 712,515 Gg and 543,778 Gg respectively. The cost implications of the reductions are important. The cost of reduction of a Gg. of CO_2 equivalent of emissions for scenarios I, II, III, IV are $32.22, $2,701.56, $6,932.22 and $9,448.86, respectively.

These abatement scenarios identified during the preparation of the initial national communication are, however, considered unrealistic in view of the resource requirements

4.0 TECHNOLOGY PRIORITIES

4.1 BACKGROUND

4.1.1 Overview of National Development Agenda

The Government of Ghana has pronounced a concept of "Golden Age of Business" as part of its development vision aimed at reversing the social and economic decline facing the country and create a favourable environment for strong and sustainable growth and prosperity. The government of Ghana has further promised to pursue the following as its priority developmental objectives:

1) Bringing down the cost of living
2) Creating jobs within the economy
3) Providing more affordable health care
4) Improving access to quality education
5) Alleviating Poverty

4.1.2 Selection of Priority Sectors

The sectoral contributions to the total national CO_2 equivalent emissions of greenhouse gases (GHG) by sources and removals by sinks 1996 (Ref. Table 1); indicates that emissions from the Energy sector was 7,616 Gg, Industrial processes 268.1Gg, agriculture 6,398Gg, Land Use Change and Forestry –18,960Gg and Waste 596.3Gg. From the point of view of GHG emissions it would only appear logical to address greenhouse gas abatement technologies in the energy and agricultural sectors.

However, this technology needs assessment considers the energy and waste sectors leaving out agriculture which was the second highest in CO2 equivalent emissions in 1996. The justification for this is that under the agriculture sector the highest emissions comes from prescribed burning of savanna (Ref. Table 5.1).

With the enactment of appropriate legislation, policy formulation, awareness creation and enforcement this issue of prescribed burning of savanna can be curbed leading to drastic reduction of emissions.

4.1.2.1 Overview of the Energy Sector

The energy sector was chosen because it is the highest GHG emitting sector in the country and it also has the highest potential for the application of clean technologies. The provision of adequate energy supplies is critical for meeting the national development objectives. Biomass is Ghana's most important energy resource in terms of endowment and utilization. Another important indigenous energy resource is hydro whose potential is estimated at about

2,000 Megawatts (MW). About half of the country's hydroelectric power potential is untapped.

By virtue of its geographic location, Ghana is also well endowed with renewable energy resources particularly solar. Estimated solar radiation levels is about 4 to 6 kWh/m^2 and wind speeds are considered moderate along the coastline. Average wind speed along the coastal areas is estimated at 5m/s.

Even though there are indications of oil and gas resources, their potential is yet to be fully exploited. Seventy five percent of about forty-eight (48) exploration wells drilled in Ghana's sedimentary basins have encountered oil or gas and seven have been discoveries.

The energy policy is dictated by national development objectives. In response to these objectives, the vision of the energy sector is to develop an energy economy that would ensure reliable supply of high quality energy services for all Ghanaian homes, businesses, industries and the transport sector while making significant contribution to the export earnings of the country.

The following energy policy objectives have been set:

1) Consolidate and improve the existing energy supply system
2) Increase access to high quality energy services
3) Secure future energy supplies
4) Stimulate economic development
5) Minimize environmental impacts of energy supply and consumption
6) Strengthen institutional and human resource capacity and research and development in energy development

4.1.2.2 Overview of Waste Sector

Environmental sanitation is an essential factor contributing to the health productivity and welfare of the people of Ghana. It is identified in Ghana's programme of social and economic development as set out in the Ghana Poverty Reduction Strategy (GPRS) 2002 to 2004, an agenda for growth and prosperity, as a key element underlying health and human development. The Governments NEAP also places a high priority on environmental sanitation as well as the establishment and implementation of environmental health standards. It is against this background, and in recognition of its importance to national development that greater emphasis must be placed on environmental sanitation in the allocation of national development resources. Ghana's environmental sanitation policy seeks to define a systematic approach and framework within which those resources can be used most.

As a result of rapid urbanization and high urban population growth in the last twenty years of economic development, challenges of municipal waste disposal pose public health and environmental problems. The need for expanded services that address environmental sanitation and public health related problems can therefore not be underestimated. Waste management has predominantly been a public sector investment and managed project. Lately however, private sector interest has increased significantly.

The current waste management situation in Ghana is below expectation. Less than 40% of urban residents are served by solid waste collection services, whilst less than 30% have access to modern toilet facility. Even in those cases where wastes are removed most are disposed off in an unsanitary manner posing serious risks to human health and the environment.

At the household level poor hygienic practices by individuals and communities are compounded by insufficient and ineffective hygiene education. Vector borne diseases such as malaria and bilharzia are rife due to the virtual absence of pest and disease control programmes.

These factors have serious health impacts. More than half of all reported diseases are related to poor environmental sanitation with attendant social and economic costs. Pollution of water resources increases the technical difficulty and cost of providing water. In addition, the sight and odour of poorly managed wastes constitute a loss of aesthetic value to Ghanaians and tourists. Technology transfer in this sector will thus have an objective of improved waste handling, which has corresponding environmental and health benefits, with GHG reduction from the sector.

4.2 INITIAL TECHNOLOGY LIST

The following list of technologies has been proposed for transfer. The stakeholders group selected a subset of this set of technologies as initial priority areas, as described below.

4.2.1 Energy Technologies

1. Power
   i. Wind
   ii. Solar photovoltaics
   iii. Gas fired power thermal (combined cycle)
   iv. Solar thermal power plants
   v. Natural gas distribution systems
   vi. Mini and small hydro plants
   vii. Biomass fired power plants

2. Solar Thermal
   i. Solar water heaters
   ii. Solar crop drying

3. Biomass (non-power)
   i. Improved charcoal production
   ii. Improved cook stoves
   iii. Liquid biofuels such as gasohol and bio-diesels.

4. Demand-side management
   i. Retrofits

ii. Industrial system improvements
iii. Transport Management Technologies

4.2.2 Waste Technologies

1. Landfill
   i. High density aerobic landfill
   ii. Mechanically improved dumping
   iii. Manually improved dumping
   iv. Sanitary land – accepted technology based on the fact that:
      - Greenhouse gas impact is reduced through the conversion $CH_4 – CO_2$
      - Meets the actual objective of climate issues, i.e. sanitary landfill has the highest CH_4 generation potential
      - Has a cost recovery component through the generation of energy on site.

2. Biomass Wastes
   i. Sawdust technologies*:*
      - Co-generation i.e. steam and power
      - Saw dust stoves
      - Briquettes

   ii. Animal & Human waste
      - Anaerobic and CH_4 generation (Biogas)
      - Biological nutrient removal system

   iii. Crop Residue
      - Composting
      - Power production technologies using crop residue streams

3. Incineration
   i. Pure solid waste combustion
   ii. Solid/liquid waste combustion
   iii. Firing mechanism, gas, liquid or solid based firing technologies

4.2.3 Criteria For Selecting Priority Technologies

The procedure to prioritise the areas for Technology Transfer was defined by stakeholders. The following three broad areas were agreed as criteria for selecting the technologies:

i. Development benefits
ii. Market potential
iii. Contribution to Climate Change.

The stakeholders identified the following sub-criteria

Development Benefits

- Job Creation
- GDP Growth

- Wealth creation
- Capacity Building (Innovation)
- Health Improvement
- Social Acceptance of Technology
- Good effect on balance of trade
- Use of local resources (Human and Material)

Market Potential

- Finance (capital to pay for it)
- Affordability (money to pay for it)
- Investment sustainability
- Low maintenance – Durability
- Commercially available
- Replicability

Climate / Environmental protection

- Low GHG emissions
- Minimal harm to environment
- Enhance sinks
- Waste resource recovery

4.2.4 Prioritisation of the Energy Technologies

For the Energy Group, prioritisation of the selected technologies, was graded from one (1) being the highest, to ten (10) the lowest. The Energy Group came out with the top three preferred technology groups (Appendix I).

The Energy Group identified the following key issues pertaining to the promotion of the technology in Ghana. Information in these areas will be required in order to refine this list of technology priorities.

i. Wind

- Data on performance of existing plants
- Cost comparison
- Noise pollution levels
- Impacts on birds
- Materials required.
- Wind resources available in Ghana

ii. Mini-small hydro

- Generation levels
- Marketing
- Potential sites[18]
- Capital cost

iii. Solar photovoltaics

- Cost assessment

[18] Energy Foundation is currently doing some assessment of these sites.

iv. Biomass energy / liquid biofuels

- Biomass quantities
- Energy equivalent/estimation
- Locations and concentration of various types of biomass

v. Natural gas fired power plants

- Sources of natural gas
- Required capacities
- Capital cost
- Right of way issues

vi. Management Technologies and Efficiency Improvement in the Transport Sector

- Railway enhancement.
- Road transport system improvement.
- Providing non-motorised systems as alternative means of transport.
- Fuel substitution -CNG, LPG, gasohol and bio-diesel.

vii. Energy Efficient and Demand-Side Management Technologies

- Capital cost
- Return on investment
- Tariffs
- Required capacities

The consensus among the Energy Group was that the chosen technologies should have the following attributes:

- Enhance sustainable development in the country.
- Promote international trade
- Enhance Climate Change mitigation
- Avoidance of GHG emissions
- Promote sub-regional cooperation with respect to optimisation of energy resources for development.
- Increase public awareness

4.2.5 Wastes Sector Technologies

The Waste Group used a grading system based on one (1) to four (4), where one (1) is lowest positive impact and four (4) the highest. Biomass wastes emerged as most preferred followed by Landfill and then Waste incineration (Appendix II). There was however a consensus on the need for additional information on the technologies. Areas identified as information gaps per technology are as follows:

Biomass waste

- Co-generation technologies
- Composting technologies
- Biological nutrient removal technologies

- Anaerobic and CH_4 generation technologies (Biogas).

Landfill
- CH_4 recovery technologies
- CH_4 energy generation technologies

Incineration
- Various types of technologies

4.2.6 Stakeholders

The list of stakeholders that were involved in the TNA activities is given in Appendix III.

4.2.6.1 Development Partners

Table 7: Development Partners

• United States Agency for International Development	• DANIDA
• Department for International Development (DFID)	• GTZ
• Canadian International Development Agency (CIDA)	• Agence Francais De Development (ADF)
• Japanese International Cooperation Agency (JICA)	• UNIDO
• UNDP	• World Bank
• Netherlands Development Agency	• International Monetary Fund (IMF)
• International Finance Corporation (IFC),	•

5.0 REVIEW OF LEGISLATIVE AND INSTITUTIONAL FRAMEWORK

Ghana has no specific legislation or policy on technology transfer in the very strict sense. However, there are laws, guidelines, standards and related policies, which one would need to take into account if there is an intention to introduce a new technology into the country. The focus of this section is therefore not on technology transfer in stricto sensu but on institutions, policies, guidelines and related framework that may be relevant to technology transfer.

5.1 POLICY

5.1.1 National Environmental Action Plan (NEAP – Volume 1)

Ghana's National Environment Policy (NEP) is contained within the broader framework of the NEAP Vol. 1 (hereinafter Action Plan) which was adopted in 1991.

The principal objective of the NEP is to improve the surroundings, living conditions and the quality of life of the entire citizenry of present and future generations. It seeks to ensure reconciliation between economic development and natural resource conservation, to make a high quality environment a key element in supporting the country's economic and social development and natural resource conservation and to make a high quality environment a key element in supporting the country's economic and social development.

Among other things, the policy seeks to guide development in accordance with quality requirements to prevent, reduce and as far as possible eliminate pollution and nuisances.

- Integrate environmental considerations in sectoral, structural and socio-economic planning at the national, regional district and grassroot levels;
- Seek common solutions to environmental problems in West Africa, Africa and the world at large.

Principles
The NEP also invokes a number of principles deemed to be effective for achieving its objectives. Among these are:

- Use of the most cost-effective means to achieve environmental objectives;
- Use of incentives in addition to regulatory measures; and
- Polluter pays for the cost of preventing and eliminating pollution and nuisances.

Policy Statement
Ghana's specific policy statement on environmental protection is that it must be guided by the preventive approach so that socio-economic activity can take place without undermining the integrity of the environment.

Specifically, Government has promised to do the following:

- commit itself to the environmentally sound use of both renewable and non-renewable resources in the process of national development;
- institute and implement an environmental quality control programme by requiring prior environmental impact assessments of all new investments that would be deemed to affect the quality of the environment;
- promote and support research programmes aimed at better understanding of the different ecozones and the factors affecting them, as well as health-related environmental problems, and the development of appropriate technologies for environmentally sound management and use of local resources, including energy resources; and
- establish an adequate legislative and institutional framework for monitoring, co-ordinating and enforcing environmental matters.

5.1.1.1 Management Of Environmental Resources:- Energy Resources

The NEP recognises that wood fuels constitute the primary source of energy for most Ghanaian households while the industrial sector depends almost entirely on hydro-power. It is acknowledged that this situation poses a serious threat to economic development and to the environment. Serious efforts would therefore be made to develop the country's indigenous energy resources in a manner that will help reduce the impacts of energy development on the environment.

To reduce the pressure on forests for wood fuels, the development of renewable energy resources will be promoted, while the efficiency of production, conversion and use of wood fuels will be improved. Industries will be given the appropriate incentives so they can promote the use of renewable energy sources.

5.1.1.2 Waste Management

NEP acknowledges that the volume of wastes generated is rapidly increasing, especially in the urban areas. It is stated that a substantial percentage of the urban waste in Ghana is biodegradable and therefore potentially re-useable or re-cyclable for raw material or energy but the appropriate technology and resources are not readily available.

With industrialization, an increasing proportion of the waste being generated is toxic or dangerous and deserves special handling. Much of the waste generated is disposed of on land and some into the sea and other water bodies with little or no treatment before disposal.

NEP therefore proposes the adoption of a more comprehensive policy for waste management. Such a policy will cover prevention, reclamation and disposal.
Additionally, the policy will focus on three broad themes: reduction in the volume of waste, increase of recycling and reuse and safe disposal of unavoidable wastes.

5.1.1.3 Energy Policy

To ensure an environmentally sustainable development, the energy sector institutions have committed themselves to the following strategic policy objectives in the energy sector.

a) Strategic Objectives

To ensure sustained provision and security of energy supply to all sectors of the economy and all parts of the country by:

- restoring improved productivity and efficiency in the procurement, transformation, distribution and use of all energy sources;
- reducing the country's vulnerability to short-term disruptions in the energy resources and supply basis;
- ensuring the availability and equitable distribution of energy to all socio-economic sectors and geographical regions;
- consolidating and accelerating the development and use of the country's indigenous energy sources, especially wood fuels, hydro-power, petroleum and solar energy; and
- securing future supply through thermal complementation of hydro-based electricity generation.

b) Renewable Energy

In the short-term, the following were the objectives to guide the development of Ghana's renewable energy resources:

- to improve the efficiency of production, conversion and use of wood fuels in all the socio-economic sectors and
- to promote the development of renewable energy industries that have strong indigenisation prospects over the short and medium terms.

In the medium to long-term, the objectives will be:

- to demonstrate and evaluate renewable energy technologies with the potential to meet the needs of prioritized socio-economic and welfare objectives; and
- to provide support for research, development and demonstration of renewable energy technologies with the greatest potential to increase and diversify the country's future energy supply base.

c) Biomass

The objectives in this area are to ensure better and sustainable use of existing bio-energy resources projects aimed at:

- conserving forest resources through improved methods for charcoal and firewood production;
- decreasing consumption of firewood and charcoal by using more efficient cooking devices;
- expanding the productivity and use of bio-energy such as biogas and the production of charcoal briquettes from logging and wood processing residues;
- conversion of municipal waste and domestic garbage into biogas and electricity;
- planning for the future security of biomass supply through the implementation of a sustained programme of forest regeneration and afforestation; and
- substituting LPG for firewood and charcoal as sources of energy.

d) Solar Energy

Activities on solar energy are focused around a strategy whose principal objectives are to:

- evaluate the technical and economic viability of proven solar technologies to meet the prioritized socio-economic and developmental needs of the country;
- demonstrate appropriate solar energy technologies for selected applications;
- concentrate support for research, development and demonstration on renewable energy technologies with the greatest prospects for operation within local technical and user absorption capacities;
- promote the development of solar energy industries that have strong indigenisation prospects over the short to medium term; and
- exploit the country's enormous solar resources to pump irrigation water, improve communication and health facilities and provide opportunities for access to modern recreational and educational facilities.

e) Power Sector

Policies and actions in this sector has to do with two areas of operation, namely:

- assuring future security of power supply by developing complimentary power generation capacity from other energy sources and improvement of existing hydro-power sources; and
- extension of the reach of electricity to all parts of the country especially the north and rural areas.

5.1.2 National Science And Technology Policy

In recognition of the importance of Science and Technology for the overall economic development of any nation, Ghana has developed a National Science and Technology Policy. The Policy seeks to provide a framework on how science and technology can support the national socio-cultural and economic development goals. The vision of the Policy is:

"to support national socio-economic development goals with a view to lifting Ghana to a middle income status by the year 2020 through the perpetuation of a science and technology culture at all levels of society, which is driven by the promotion of innovation and the mastery of known and proven technologies and their application in industry and other sectors of the economy."

5.1.2.1 Basic Objectives

The basic objectives of the Policy are to:

- seek to master scientific and technological capabilities
- develop infrastructure which will enable industry and other sectors of the economy to provide the basic needs of society and for the citizenry; and
- adopt a science and technology culture.

In the long term, the Policy has as its main objective, the acquisition of endogenous science and technology capacities appropriate to national needs, priorities and resources, and to create a science and technology culture whereby solutions to socio-cultural and economic problems

of the individual, and community and the nation are recognised and sought within the domain of science and technology.

5.1.2.2 Policy Measures

To enable the Policy to have the desired impact, Government will take a number of actions to ensure that the nation derives maximum benefits from the application of science and technology.

Specifically Government will:

- Create the enabling environment and advocacy for the promotion of science and technology as key factors in Ghana's development process;
- Promote the development and utilisation of science and technology capabilities, including entrepreneurial skills development;
- Promote science and technology capacity building;
- Encourage the improvement of the quality of research and development (R&D) activities, especially within private sector institutions;
- Strengthen the protection of intellectual and innovative property rights;
- Ensure environmental sustainability;
- Promote participation of women in science and technology;
- Safeguard the generation, use and application of science and technology;
- Promote international and local co-operation and linkages;
- Promote a science and technology culture; and
- Establish mechanisms for the finance, management and evaluation of the performance of science and technology.

5.1.2.3 Scope of Policy

The Policy covers all sectors of the economy. The sectors covered include: Agriculture, Environment, Energy, Trade, Industry, Natural Resources (Land, Minerals, Water), and Communication.

5.1.2.4 Energy

Under this sector, the objective is to employ science and technology to ensure the supply of sustainable, affordable, safe and reliable energy.

Strategies

The following strategies will be employed to achieve the above objective.

- Promote a research and development programme relating to alternate energy sources such as solar energy, biomass, nuclear, wind and other renewable energy sources to supplement the traditional energy sources;
- Facilitate efforts to acquire and adapt sustainable safe and economical energy technologies for national development;
- Support research aimed at upgrading hydropower energy production technology;
- Promote research and development efforts aimed at popularisation and dissemination of energy technology for rural and urban development; and

- Promote public support for energy conservation and encourage private investment in energy technologies.

5.1.2.4 Financing Science and Technology

Inadequate funding can be a major constraint in the development and application of science and technology. It is therefore important that all sectors of the economy, especially the private sector, recognise the central role of science and technology and provide adequate resources to support activities in this area.

To ensure the availability of funds at all times to meet the demands of innovation, Government will:

- take stock of all existing funding lines established to support development in science, technology and industry with the aim of streamlining them to achieve economies in their operations;
- strengthen and modify the National Science and Technology Foundation to incorporate support for innovation in its sphere of operations;
- encourage the private sector to support the funding of R & D activities, especially to cater for the needs of the small, micro and medium enterprises (SMMEs)
- accelerate the allocation of a minimum of 2% of GDP to support the science and technology sector;
- institute an attractive tax incentive mechanism for contributors to the fund or directly to R & D activities in a way that will not result in the erosion of the national tax base;
- encourage the formation of a venture capital (high risk) fund administering authority for the commercialisation of new technologies from scientific and technological institutions; and
- encourage public procurement of products and services from S & T institutions as a means of facilitating their promotion

In all of the above funding arrangements, Government will solicit the effective participation and contribution of the private sector as an important partner in the management of science and technology for the socio-economic development of the country.

5.1.3 Ghana Poverty Reduction Strategy, 2002 – 2004

The purpose of the GPRS is to develop new and comprehensive policies in support of poverty reduction and growth and to strengthen extant policies and activities. Poverty is defined as an unacceptable physiological and social deprivation and various polices are outlined to address this problem.

Production and employment are identified as important areas that need to be tackled if the existing state of poverty is to be reduced.

5.1.3.1 Rural Energy Supply

The GPRS seeks to improve rural energy provision for production in rural areas. It is admitted that the poor and rural communities rely heavily on biomass for their production of energy needs. Apart from insufficiency in many cases, it is also environmentally harmful.

It is proposed to strengthen the financial viability of the Volta River Authority, the Electricity Corporation of Ghana and the Northern Electrification Department. The purpose will be to enable them expand services to the poor rural communities through the Self-Help Electrification Programme (SHEP). Part of this is to be achieved through a more serious promotion of energy efficiency and conservation measures for domestic, commercial and industrial users.

Additionally, renewable energy sources will be promoted, including solar, wind and biogas. The following activities will be undertaken to improve energy supply for production:

- introduce renewable energy technologies;
- ensure that electricity supply to rural areas is capable of being used for production purposes; and
- promote the productive uses of electricity by rural areas and the poor.

Energy for domestic use will be boosted through:

- assistance to communities to develop woodlots;
- introduction of renewable energy technologies such as solar PVs and biogas; and
- introduction and promotion of energy efficient technologies.

Cost-effectiveness will be ensured in order to maximize the use of energy supplied to rural areas. The promotion of LPG will be stepped up when the West African Gas Pipeline becomes operational.

Widespread fuel-wood extraction would be addressed through the introduction of LPG into rural communities. In addition, a rural kerosene programme will be initiated and implemented to enable communities have easier access to the commodity.

It is expected that the above activities will help reduce the time and effort expended in the search and transportation of fuelwood. Freed time and energy, can then be spent expanding agricultural production or industrial processing and marketing.

5.2 LEGISLATIVE FRAMEWORK

5.2.1 The Environmental Protection Agency Act, 1994 (Act 490)

Act 490 created the Environmental Protection Agency. The Agency has a corporate status and it's the lead agency responsible for the broad concept of environmental protection in Ghana.

Among its functions are, to:

- advise the Minister of Environment and Science on the formulation of policies on all aspects of the environment and in particular make recommendations for the protection of the environment;

- co-ordinate the activities of bodies concerned with the technical or practical aspects of the environment and serve as a channel of communication between such bodies and the Ministry of Environment and Science;
- secure in collaboration with such persons as it may determine the control and prevention of discharge of waste into the environment and the protection and improvement of the quality of the environment;
- issue environmental permits and pollution abatement notices for controlling the volume, types, constituents and effects of waste discharges, emissions, deposits or other source of pollutants and of substances which are hazardous or potentially dangerous to the quality of the environment or any segment of the environment;
- prescribe standards and guidelines relating to the pollution of air, water, land and other forms of environmental pollution including the discharge of wastes and the control of toxic substances;
- ensure compliance with any laid down environmental impact assessment procedures in the planning and execution of development projects, including compliance in respect of existing projects; and
- act in liaison and co-operation with government agencies, District Assemblies and other bodies and institutions to control pollution and generally protect the environment. The Agency is given wide powers including those for enforcement, control and to request for information.

Under Section 28 of Act 490, regulations may be made to deal with, among others;

- standards and code of practice relating to the protection, development and rehabilitation of the environment;
- the type, quantity, conditions or concentration of substances that may be released into the environment;
- the manufacture, importation, use, collection, storage, recycling, recovery or disposal of substances which may be hazardous to the environment; and
- the disposal of waste generally.

5.2.2 Environmental Assessment Regulations, 1999 (L.I. 1652)

The Regulations were made under the E.P.A Act 1994 (Act 490). It details the procedures that must be followed in conducting environmental assessments. The Environmental Protection Agency is responsible for its implementation.

Under Regulation 5 (1) the technology intended to be used, is among the matters to be considered during the screening of an application.

5.2.3 Energy Commission Act, 1997 (Act 541)

The Energy Commission Act (Act 541) established an Energy Commission. It provides for the functions of the Commission relating to the regulation, management, development and utilization of energy resources in Ghana; for the granting of licenses for the transmission, wholesale supply, distribution and sale of electricity and natural gas; refining, storage, bulk distribution, marketing and sale of petroleum products and to provide for related matters.

The principal object of the Commission is to regulate and manage the utilization of energy resources in Ghana and co-ordinate policies in relation to them. Specifically, the Commission is mandated to do, inter-alia the following:

- recommend national policies for the development and utilization of indigenous energy resources; and
- secure a comprehensive data base for national decision making on the extent of development and utilization of energy resources available to the nation.

5.2.4 Local Government

The Constitution of any country constitutes the basic law of the land and any law that derogates from it could be said to be unconstitutional to the extent of the derogation.

Chapter 20 of the Constitution provides for decentralization and local government. It prescribes the features that the decentralized system must possess.

Parliament is given power to enact laws and to provide for the taking of such measures as are necessary to enhance the capacity of local government authorities to plan, initiate, co-ordinate, manage and execute policies in respect of all matters affecting the people within their areas with a view to achieving the localization of those activities.

The Local Government Act and the Ministry of Local Government and Rural Development are the legislative and institutional expressions of the provisions in Chapter 20 of Ghana's 1992 Constitution.

5.2.4.1 Local Government Act, 1993 (Act 462)

The Local Government Act (Act 462) seeks to give a fresh legal expression to governments commitment to the concept of decentralization. It is a practical demonstration of a bold attempt to bring the process of governance to the doorstep of the populace at the Regional and more importantly, the District level.

The District Assemblies created under the law, constitute the highest political authority in each district, municipality and metropolis.

Among the functions of the District Assembly are the following:

- formulate and execute plans, programmes and strategies for the effective mobilization of the resources necessary for the overall development of the district;
- initiate programmes for the development of basic infrastructure and provide municipal works and services in the district; and
- be responsible for the development, improvement and management of human settlements and the environment.

5.2.4.2 Bye-Laws

One of the most important provisions of the law is the power of the District Assemblies to make bye-laws for the purpose of the functions conferred under Act 462 or any other enactment.

Most District Assemblies have adopted bye-laws on sanitation and waste. However, there is still no engineered waste disposal currently in place in the country.

5.2.5 Ghana Investment Promotion Centre Act, 1994 (Act 478)

Under Act 478, a Centre was established to encourage and promote investment in the Ghanaian economy. The Centre is also responsible for coordinating and monitoring all investment activities to which the law applies.

Among the Centre's functions are to:

- initiate and support measures that will enhance the investment climate in the country for both Ghanaian and non-Ghanaian companies;
- identify specific projects and invite interested investors for participation in those projects; and
- register and keep records of all technology transfer agreements relating to investments.

The law contains numerous provisions on incentives designed to create the enabling environment to attract investors.

In respect of technology transfer, Section 33 provides as follows:

- a person who establishes an enterprise may enter into such technology transfer agreement as he considers appropriate for his enterprise;
- all technology transfer agreements aforementioned shall be registered with the Centre; and
- all technology transfer agreements shall be governed by any regulations for the time being in force relating to such agreements.

The Act further provides that the Board may make regulations relating, among other things to technology transfer.

It is pursuant to this mandate to make Regulations that the Technology Transfer Regulations, 1992 (L.I. 1547) was made.

5.2.6 Technology Transfer Regulations, 1992 (L.I. 1547)

The Regulations make compulsory the registration of all technology transfer agreements and provides the procedure for such registration.

The Regulations also provide for unenforceable clauses in such agreements, performance guarantees, management service fees and requirements for training by the transferor of the technology.

Additional obligations imposed by the Regulations on the transferor are:

- to give full description of the technology and to supply all necessary documentation and information in the English language;
- to guarantee the efficient performance of the technology and the continuous availability of essential spare parts during the tenure of the agreement; and

- to inform the transferee of improvements and innovations relating to the technology and shall supply them on terms mutually acceptable to the parties;

Consistent with international rules on intellectual property rights, the Regulations also provide for the confidentiality of the licensed know-how by the transfer.

On duration, a technology transfer agreement shall be for a period not exceeding ten years, but subject to renewal for subsequent terms each not exceeding five years.

The governing law for technology transfer agreements shall be the laws of Ghana. There are also provisions on dispute settlement.

5.2.7 Council For Scientific And Industrial Research Act, 1996 (Act 521)

The Act re-established the Council for Scientific and Industrial Research to promote, encourage and regulate research and the application of science and technology in development and to provide for related matters.

Among the functions of the CSIR are:

- to pursue the implementation of government policies on scientific research and development;
- to advise the Minister for Environment and Science on scientific and technological advances likely to be of importance to national development;
- to encourage co-ordinated employment of scientific research for the management, utilization and conservation of the natural resources of Ghana in the interest of development; and to encourage in the national interest, scientific and industrial research of importance for the development of agriculture, health, medicine, environment, technology and other service sectors and to this end, to encourage close linkages with the productive sectors of the economy.

5.2.8 Standards Decree, 1973 (NRCD 173)

The Decree established the Ghana Standards Board (GSB). The GSB aims at:

- establishing and promulgate standards with the object of ensuring high quality of goods produced in Ghana, whether for local consumption or for export;
- promoting standardization in industry and commerce;
- promoting industrial efficiency and development; and
- promoting standards in public and industrial welfare, health and safety.

Among its functions are the following; to

- prepare, frame, modify, or amend specifications and promulgate standard specifications;
- promote research in relation to specifications; and to provide for the examination and testing of goods, commodities, processes, and practices, and for those purposes the Board may establish such laboratories and other facilities as it thinks fit;

- recommend to the Ministry responsible for Industries to prohibit the sale or manufacture of goods in the national interest as well as in the interest of public health and safety;
- maintain the necessary machinery to ensure that goods prepared and manufactured for export are distinctly marked for export only, and to provide for the issue of a certificate to the effect that goods comply with the known requirement of standards in the country to which they are or about to be consigned, before the export of such goods is permitted;
- recommend to the Ministry responsible for Trade to prohibit the importation into Ghana for the purposes of sale, use of human consumption, any goods, unless the same have been certified by the Board as complying with standards set up by the Board;
- provide for the registration, and regulation of the use of standard marks;
- undertake and encourage educational work in connection with standardization;
- collect and disseminate information relating to standardization and related matters, including the publication of reports, pamphlets, booklets, journals and any other publication;
- assist government departments, local authorities and other public bodies in the preparation of any specifications required by them;
- co-operate with representatives of any industry, or with any government department, local authority, or other public bodies or persons with a view to securing the adoption of standards;
- endorse any international or other overseas specifications as suitable for use in Ghana, so, however, that any such endorsement shall not have the effect of making the specification a standard specification under this Decree;
- appoint agents of the Board in Ghana or any other country for such purpose as it determines; and
- institute training schemes for its staff either in Ghana or elsewhere in furtherance of its aims.

5.2.9 Ghana Standards Board (Food, Drugs And Other Goods)

5.2.9.1 General Labelling Rules, 1992 (L.I. 1541)

This instrument provides for general labeling rules in Ghana. It was made pursuant to powers conferred on the Ghana Standards Board (GSB), under NRCD 173.

In respect of goods other than food and drugs, it is provided that:

No person shall offer for sale, sell, distribute, import or otherwise dispose of the goods specified in the Rules unless the goods are marked or labelled with, among others:

- a name which indicates or describes the nature or kind of goods;
- code marks or numbers indicating the batches of production to which the goods belong;
- an indication of the net content in the form of net mass or volume, where applicable;
- dimensional, mass and volume characteristics where applicable;
- electro-technical or chemical characteristics where applicable;

- instructions or directions for use warnings and precautions that may be necessary, if it would be difficult to make appropriate use of the goods in the absence of such instructions or directions;
- country of origin of the goods; and
- the name and address of the producer, manufacturer, importer, distributor or seller of the goods.

The GSB may prescribe additional or specific labelling requirements for certain specified goods where it deems necessary. Where such a prescription is made, notice of it shall be published in the Gazette.

The First Schedule of the Rules contains a list of goods to which the above labeling requirements apply. Among these goods are:

- Gas Cookers and Appliances
- Refrigerators and Food Freezers
- Electric Fans and Regulations
- Radio Receivers/Cassette Players
- Television Sets
- Room Air-Conditioners
- Electric Lamps
- Electrical Fittings and Accessories
- Electric Motors
- General Household Electrical Appliances and Accessories
  - Immersion electrical heaters
  - Electric Pressing Irons
  - Water Heaters/Electric Kettles, etc.

A number of sanctions and reliefs for the aggrieved are provided under the Rules.

5.2.10 Free Zone Act, 1995 (Act 504)

This is the enabling Act for the establishment of free zones in Ghana for the promotion of economic development. Additionally, it is to provide for the regulation of activities in the free zones and for related purposes.

The Act establishes a Free zones Board. The functions of the Board include the following:

- grant licences to applicants under this Act;
- assist applicants for licences under this Act by providing services for obtaining other relevant licences, permits and facilities;
- examine and recommend for approval agreements and treaties relating to the development and activities of the free zones;
- monitor the activities, performance and development of free zone developers and enterprises;
- ensure compliance by free zone developers and enterprises of this Act and any other laws relevant to free zone activities;

A free zone enterprise has the right to produce any type of goods and services for export except those that are environmentally hazardous.

The enterprises in the free zone may also change their production lines and process as often as they consider it necessary, subject to the approval of the Board.

The Act also provides that the Board may attach to a licence, such conditions as it thinks appropriate concerning employment skills, development, impact on the environment, creation of job opportunities and degree of orientation.

A licence is not transferable without the prior approval of the Board.

5.2.11 Customs, Excise and Preventive Service (Management)(Duties, Rates and Other Taxes) Act, 1994

The Act amended the Customs and Excise Duties and other Taxes Act, 1996 (Act 512). Specifically the amendment affected the import duty rates on some commodities in the First Schedule of Act 512.

However, the Zero Rate (0%) duty continued to apply to, among other things: solar, wind, thermal energy and electric generating sets of 375 KVA and above, solar cells and panels.

5.2.12 Public Utilities Regulatory Commission Act, 1997 (Act 538)

The Act established the Public Utilities Regulatory Commission to regulate and oversee the provision of utility services by public utilities to consumers and to provide for related matters.

The functions of the Commission are to:

- provide guidelines on rates chargeable for provision of utility services;
- examine and approve rates chargeable for provision of utility services;
- protect the interest of consumers and providers of utility services;
- monitor standards of performance for provision of services;
- initiate and conduct investigations into standards of quality of service given to consumers;
- promote fair competition among public utilities;
- conduct studies relating to economy and efficiency of public utilities;
- make such valuation of property of public utilities as it considers necessary for the purposes of the Commission;
- collect and compile such data on public utilities as it considers necessary for the performance of its functions;
- advise any person or authority in respect of any public utility;
- maintain a register of public utilities; and
- perform such other functions as are incidental to the foregoing.

The law imposes specific obligations on service providers. Any public utility licensed or authorized under law to provide utility service shall:

- maintain its equipment and property used in the provision of the service in such condition as to enable it to effectively provide the service;
- make such reasonable effort as may be necessary to provide to the public service that is safe, adequate, efficient, reasonable and non-discriminatory; and
- make such repairs, changes, extensions and improvements in or to the service as may be necessary or proper for the efficient delivery of the service to the consumer.

The Commission is enjoined to issue orders to secure compliance with the above obligations. It may further issue directions for payment of compensation by the service provider where a consumer has suffered loss or damage as a result of non-compliance with its obligations.

Under section 12 (3) of the Act it is provided as follows:

> "Where the technology employed by a public utility is out of date or where any advance in technology which could result in an improvement in the service or in reducing the cost of the consumer, has not been incorporated in the service within a reasonable time, the Commission may in writing direct the public utility to take such measures as the Commission considers appropriate to remedy the omission".

The Commission is also empowered to monitor standards of performance established by licensing authorities of public utilities for compliance by such utilities.

In the event of a failure to meet any required standard of performance, the public utility would be required to pay such compensation as may be determined, to any person adversely affected as a result of the failure. This is without prejudice to any additional remedies open to the complainant.

The Commission is authorized to provide guidelines on chargeable rates and service providers must comply with these rates.

In determining the cost of production of any service provider, the Commission shall be guided by reasonableness. Rates approved by the Commission must be published in the Gazette and the mass media.

The Act also provides for joint use of facilities, complaint and enforcement procedures and duty of licensing authorities to assist or co-operate with the Commission

"Public Utility" is defined as any person engaged in the provision for a fee, whether directly or indirectly of any of the following services to the public:
- the supply, transmission or distribution of electricity;
- the supply, transmission or distribution of water; and
- such other public utility services as the Commission shall by legislative instrument prescribe on recommendation of the Minister with responsibility for the service.

5.3 INSTITUTIONAL FRAMEWORK

There is no institution in Ghana established exclusively for purposes of technology transfer. However, as in the case of general policy and legislative framework, there are a number of institutions that provide focus and direction in this regard.

5.3.1 Ministry of Environment and Science

The Ministry of Environment and Science (MES) was established in 1994. Its creation was in response to a national development need to integrate environmental, scientific and technological considerations into the country's sectoral, structural and socio-economic planning processes at all levels.

The declared mission of MES is to establish a strong national scientific and technological base for accelerated sustainable development of the country to enhance the quality of life for all. Among other things, this will be done through the development and promotion of cost-effective use of appropriate technologies.

Among the main areas of policy thrust for MES, are Sanitation and Waste Management (Technical Options) and Science and Technology promotion, education and acculturation.

5.3.1.1 Functions

The functions of MES are;

- protection of the environment through policy formulation and economic, scientific and technological interventions needed to mitigate any harmful impacts caused by development activities;
- standard setting and regulatory activities with regard to the application of science and technology in managing the environment for sustainable development;
- promotion of activities needed to underpin the standards and policies required for planning and implementation of development projects;
- co-ordination, supervision, monitoring and evaluation of activities that support goals and targets of the Ministry and national sustainable development.

It is noted that MES is the political focal point for UNFCCC in Ghana and therefore plays a key role in activities that arise out of the implementation of the Convention.

5.3.2 The Judiciary

By the Judiciary is meant the complete infrastructure established to hear, adjudicate upon and dispense justice to parties who bring their grievances before properly constituted courts of law.

The Courts constitute the forum for the enforcement of the laws of the land through the decisions they hand down in disputes brought before them. It is therefore crucial to guarantee the independence of the judiciary and ensure that nothing is done to compromise its integrity.

5.3.3 Ministry for Private Sector Development

The government has declared that it is committed to ensure that the private sector (both national and foreign) spearhead efforts aimed at the accelerated growth of the economy. This commitment is consistent with global trends towards liberalization and deregulation.

Government has promised to create the enabling environment to allow the private sector to act as the engine of growth.

Historically, diverse programs for developing the private sector have been spread over several Ministries, Departments and Agencies (MDA's) with attendant problems of duplication and an inability to capture synergies. In addition, private sector operators have had to deal with too many government agencies which has made it difficult for them to interface effectively with government. The creation of the Ministry for Private Sector Development (MPSD) was designed to address these problems.

The MPSD has defined its mission as follows:

To create and sustain "The Golden Age of Business" by facilitating the development and growth of a competitive and vibrant private sector through:

- the co-ordination of sectoral efforts;
- the promotion of positive attitudes towards private enterprise;
- fostering and enabling environment; and
- ensuring the elimination of bureaucratic restrictions and impediments

Recognising the active involvement of several MDAs in private sector development. MPSD will functionally perform an intersectoral role. This includes:

- Advisory role to the President and his economic team on policy;
- Co-ordination of efforts at the sectoral level;
- Responsibility to the private sector on public affairs; and
- Advocacy role on behalf of the private sector

The Ministry's role has been structured into functional activities which reflect an appreciation of the basic requirements for an efficient private sector and consistency with the Ghana Poverty Reduction Strategy (GPRS). The following functions have been identified:

- Institutional reforms – legal and structural;
- Innovation and entrepreneurship;
- Public private partnerships; and
- Policy planning, monitoring and evaluation

5.3.4 Science and Technology Policy Research Institute (STEPRI)

STEPRI is one of the thirteen institutions established under the CSIR. Its mandate is to provide research support for national science and technology policy development monitoring and evaluation.

The Institute is required to assist in the identification of technological needs for a variety of economic activities including:

- the acquisition and analysis of information required on alternative sources of technology from as wide available sources as possible and its delivery to users;
- evaluation and selection of technologies appropriate for the different jobs to be done;
- unpackaging of imported technology, including assessment of suitability, direct and indirect costs, and the conditions attached;
- identifying needed augmenting technologies and those required to support newly-introduced technologies, whether imported or domestic;
- negotiation of the best possible terms and conditions of the technology to be imported;
- advice on available capabilities for adaptation; and
- diffusion of indigenous and foreign technology among users.

The thrust of STEPRI's research so far has been to institutionalize science and technology policy research and to address the following identified policy research issues:

- technology transfer and technology policy formulation through diagnostic studies;
- science and technology culture;
- private sector and technology-led development.

Activities and programmes being undertaken by the Institute include:

- development of science and technology indicators;
- policy research on waste management;
- building capacity in technology management and
- commercialization of technology innovation.

5.3.5 Institute of Industrial Research (IIR)

The mandate of the Institute of Industrial Research is to under take research into process and product design and development and to promote adaptive technology among others.

Among its objectives are:

- to promote technology transfer to enhance the efficiency and competitiveness of Ghanaian industry.

5.3.6 Institute for Scientific and Technological Information (INSTI)

The mandate of INSTI is to develop a national capacity for the efficient and effective provision of scientific and technological information to the Ghanaian society through the publication and dissemination of the results of scientific and technological research in appropriately packaged form.

Among its specific objectives are:

- Development of an efficient system for the bibliographic control of existing and current indigenous scientific and technological literature through a national network system;
- Creation of databases and referral services;

- Improvement and development of systems for the marketing of available scientific and technological information and maintenance of a national microfiche collection; and
- Publication and dissemination of the results of national research and development (R&D) activities, which are crucial for the socio-economic development of Ghana.

5.3.6.1 Divisions

INSTI has a number of divisions. The Library and Documentation Division has been structured on a national network, the Ghana National Scientific and Technological Information Network (GHASTINET). The network also has a number of special resource centres covering inter-alia, agriculture, fisheries and forestry, water resources, energy, industry and technology and transport and communications and building, construction and public works.

The nodal points for the aforementioned resource centres are: Ministry of Food and Agriculture Library; Water Research Institute, Energy Information Centre (under the Ministry of Energy); Institute of Industrial Research Library, Ministry of Roads and Transport Library and Building and Road Research Institute Library.

5.3.6.2 Programmes

Among the main programmes of INSTI are:
- Preparation of policy proposals and plans, procedures and uniform standards for adoption by GHASTINET participants and the co-ordination of these activities to minimise duplication and foster resource sharing;
- Collection of indigenous scientific and technological literature and data on serials holding high level man-power and on on-going research projects for inclusion in national databases;
- Conducting user-need studies and survey on existing facilities, resources and services;
- Collaboration with appropriate agencies in the repackaging and dissemination of information for the benefit of end-users; and
- Production and development of various forms of atlas databases

5.3.7 Ghana Regional Appropriate Technology Industrial Service (GRATIS)

Established in 1987, GRATIS runs a network of Intermediate Technology Transfer Units (ITTU's) located in all the regional capitals of Ghana.

These Units provide training in machining and other industrial skills to apprentices, produce spare parts for local industry and offer manufacturing extension services with particular emphasis on small-scale enterprises.

5.4 GUIDELINES AND STANDARDS

5.4.1 Ghana Landfill Guidelines

The Guidelines is the result of close collaboration between the Ministries of Local Government and Rural Development, Environment and Science and Environmental Protection Agency.

The purpose of the Guidelines is to provide the basis upon which waste management authorities will issue permits for landfill operations in the country.

The Guidelines are also intended to provide adequate and practical information to enable applicants, license holders and their designated advisors and managers to comply with the policy of the District Waste Management Department and related legislative requirements.

Among the objectives that the Guidelines seeks to achieve are to:

- improve the standard of waste disposal operations in Ghana;
- set out options for the environmentally acceptable disposal of solid waste;
- provide a framework of sustainable waste disposal standards within which to operate; and
- provide a framework for upgrading all landfills in Metropolitan, Municipal and large urban areas to high density aerobic (HAD) landfills by the end of 2010 and full sanitary landfills by 2020.

The Guidelines are designed to provide the basis for protecting public health and the environment, employing mainly locally available and adaptable techniques, knowledge and resources. Implementation of the Guidelines will be backed by legislation and licensing arrangements.

5.4.2 Environmental Sanitation Policy

In 1999 the Ministry of Local Government published an Environmental Sanitation Policy.

The Policy describes the objectives of environmental sanitation as aiming at developing a clean, safe and pleasant physical environment in all human settlements, to promote the social, economic and physical well-being of all sections of the population. It comprises of various activities including the construction and maintenance of sanitary infrastructure, the provision of services, public education, community and individual action, regulation and legislation.

5.4.2.1 Technology Choice

On the choice of technologies to be employed to achieve the goals of environmental sanitation, the Policy states that the selection of technologies for waste treatment and disposal shall be governed by technical guidelines to be issued by the Ministry of Local Government and Rural Development or its designated agency from time to time.

Additionally, the choice of technology will be guided by the following principles:

- recycling of waste for industrial, agricultural and other uses shall be practiced wherever it produces a net cost reduction or positive environmental impact;
- waste disposal methods shall, as far as practicable, utilize waste to achieve environmental improvement including land reclamation, use of treated effluents for afforestation, use of compost for soil improvement etc;
- the promotion of waste reduction shall be an integral part of waste management;
- technology shall be adapted to respond to the needs of service beneficiaries, rather than being imposed upon them; and
- environmental pollution and health risks shall be minimized as far as possible whilst ensuring consistency in providing universal and affordable service.

5.4.2.2. Solid Waste Management

The Policy provides that primary responsibility for solid waste management shall rest with the Assembly. However the private sector will be invited to provide the actual services under contract or franchise, as appropriate.

The Policy states the following as technologies for solid waste disposal:
- sanitary landfill;
- controlled dumping with cover;
- incineration;
- composting; and
- recycling

On hospital waste, the Policy provides that all health institutions shall establish an institutional waste management system for primary storage of waste. Where possible, clinical waste must be pretreated (e.g. by autoclaving) prior to storage. Domestic waste must be separated from clinical waste.

Separate collection of hazardous wastes and clinical wastes shall be provided by all District Assemblies or by other arrangements approved by the Assembly

5.4.2.3 Liquid Waste Management

District Assemblies are tasked to ensure the availability of facilities for the safe management of liquid wastes including ensuring their hygienic transfer from the point of generation to the point of treatment and disposal.

5.4.2.4 Guidelines for the Safe and Sound Management of Bio-Medical Waste in Ghana

The purpose of these Guidelines is to enable hospital administrators, engineers, environmental health officers and other para-medical professional to be aware of the requirements for the proper and safe management of biomedical waste. The main objectives are:
- To develop guidelines that will provide an appropriate institutional and administrative framework and procedures within which to manage and monitor bio-medical waste; and
- To make recommendations that will provide the basis for policy formulation and legislation on bio-medical waste management.

5.5 INTERNATIONAL OBLIGATIONS

In Ghana's 1992 Constitution, Government has committed itself to promote respect for international law, treaty obligations and the settlement of international disputes.

Government makes further commitment to adhere to the principles derived from the aims and ideals of international organizations to which Ghana is a member.

It is pursuant to these ideals that Ghana has worked with other members of the international community to negotiate various international legal instruments, which seek to protect the global environment. It is in this context that Ghana must be seen to translate into national action the obligations it has assumed by becoming a party to several international treaties on the environment. Among these are: the United Nations Framework Convention on Climate Change (UNFCCC) and the Montreal Protocol on Substances that Deplete the Ozone layer.

5.5.1 Agenda 21

Agenda 21 was one of the major outcomes of the United Nations Conference on Environment and Development (UNCED). The Agenda is a blueprint for a global partnership aimed reconciling the twin requirements of a high quality environment and a healthy economy for all people of the world.
While not falling within the realm of international law in stricto sensu, Agenda 21 is still important in the class of "soft laws". Indeed the fact that it was adopted by 179 states representing the biggest gathering of heads of government is a clear expression of its importance.

5.5.1.1 Technology Transfer

Significantly the Agenda also addresses technology transfer as a crucial component for sustainable development.

The Agenda affirms that all countries need access to and training in the use of technologies that are cleaner and waste fewer resources. The technologies must be environmentally sound and cover not only hardware but also know – how services, equipment, organisational and managerial skills to make them work.

Due to the peculiarities of developing countries, their need for technology, is greater. They need to upgrade some current technologies and replace others with more environmentally sound substitutes.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The general conclusions are:

a) Experiences gained during the preparation of this report indicate that general information on listed and prioritised technologies, in particular the cost, are lacking in the country. This makes in-depth analysis of the technologies very difficult. This Technology Needs Assessment (TNA) activity only considers climate change mitigation technologies and does not address adaptation technologies.

b) The extent, to which Ghana can implement the prioritised technologies and help in addressing the global problem of climate change, will depend on the provision of adequate technical and financial resources by developed countries and the creation of an enabling environment.

c) From the role the Climate Technology Initiative (CTI) of the OECD played in Ghana's TNA activity, it is evident that there is the need for technology transfer intermediaries that will link Ghana with the private and public sector institutions in the developed world to enhance the effective transfer of climate technologies.

d) A critical review of the existing policy, legislative and institutional framework for addressing technology transfer, reveals that, there are enormous challenges that need to be overcome if any programme in this area is to succeed.

e) In respect of policy, there is sufficient evidence expressing the government's commitment to take the necessary steps in the waste and energy sectors to achieve the objectives of sustainable development. Lack of the necessary financial resources, adequate capacities and a culture of technology development have, however, undermined the laudable policy directives. Fiscal and economic instruments have also not been given adequate attention.

f) The Technology Transfer Regulations, 1992 (L.I. 1547) falls short of what is required to address the broad spectrum of capacity needs in the area of technology transfer. Other related legislations, do not mention technology transfer at all.

g) With respect to institutional structures, there are a lot of inadequacies. In a number of areas there is urgent need to re-focus the operational policies of the institutions to make them relevant to the present challenges posed by modern technologies.

h) The judiciary has not had any serious cases before it on the environment and it is not clear how they will deal with the complexities that has challenged their counterparts in jurisdictions like the United States and India. Another shortcoming is the lack of specialised courts to provide speedy trials.

The specific conclusions are:

i) Renewable Energy Technologies (RETs) are inexhaustible and offer many environmental benefits over conventional energy sources. Most of them do not release pollutants during operation. However, they have relatively high initial capital cost and lack of comprehensive regulations in the country further hinders their nationwide deployment.

j) Woodfuel still remains the most affordable source of energy for the majority of Ghanaians, and would continue to contribute substantially to the national energy demand. This resource serves as carbon sink and if not sustainably managed would significantly alter the balance of GHG emissions in Ghana.

k) Biomass resources other than woodfuel such as crop residues, sawdust and energy crops (e.g. Jatropha, cassava, sugarcane, etc.) have strong potential for energy production.

l) There is a national drive to achieve a comprehensive energy efficient economy. The main hurdles have been the development of appropriate regulations, policies, uneconomic tariffs, and availability of financial resources. Financing, technology transfer and a favourable economic environment will make the energy efficiency initiative a success. Energy efficient technologies will minimise peak demand and reduce operating cost.

m) Ghana has a substantial mini hydro potential and harnessing this resource could contribute to the overall energy production capacity of the nation.

n) At present, natural gas resource availability in the country would not make the deployment of the natural gas distribution technology sustainable. A sub-regional approach is therefore necessary if Ghana is to make a head way in natural gas energy distribution systems.

o) Combined cycle technology is rapidly becoming the power generation technology of choice compared to single cycle technology. It can be built faster and at a lower cost than conventional steam turbine plant of equivalent capacity.

p) CNG has become one of the relatively less expensive alternative fuel choices for vehicles. In addition, as an alternative fuel for power generation, natural gas is a cheaper option to crude oil.

q) Even though solar water heaters identified in the country are installed by local producers there is limited expertise in the design of industrial solar water heaters. The public is not well informed about their benefits and potential. The lack of regulation, code of installation and practice do not promote the development of this technology.

r) There are adequate wind speeds that could be utilized for power generation in Ghana. However, the lack of dependable countrywide data makes it comparatively difficult to assess the wind energy potential as a whole.

s) Given the widely accepted importance of waste management to national health and environmental protection, the government has over the years demonstrated commitments to develop appropriate policies and programmes. However, these policies and programmes have not adequately addressed the integration of methane recovery systems. There is the need to shift to systems that incorporate methane recovery and its utilisation for power generation.

6.2 RECOMMENDATIONS

1. The national climate change focal point and other relevant existing institutions (e.g. CSIR – INSTI) should be strengthened to better serve as technology information clearinghouse. Technology needs will continue to change and government must ensure that this TNA report is frequently updated and new action plans developed for implementation.

2. Government must promote private sector involvement in the transfer of the identified technologies. In addition, policy guidelines that will address issues like subsidies, ownership, tariffs, awareness, standardization, quality control, institutional set up and the right of supply, must be developed.

3. The climate change needs and needs assessment process must be institutionalised to ensure its continued usefulness. In this light the proposal on the setting up of a National Climate Change Secretariat should be considered as critical. The implementation of the identified technologies would help ensure the process of transformation of the country into a middle-income status and lead to poverty alleviation. Future TNA activities should also address issues on adaptation technologies.

4. Developed country Parties should provide Ghana technical and financial resources to ensure the effective implementation and transfer of prioritised technologies in a timely manner. Additionally, developed country Parties that own these technologies must show the commitment to transfer them. Also, Ghana's development partners should use this report and any action plans thereof as the basis for engaging in technology transfer processes aimed at addressing climate change problem.

5. CTI and other relevant bilateral, multilateral, International Governmental Organisations (IGOs) and NGOs, that are in the position to do so, should play the role of technology transfer intermediaries by matchmaking investors in the developed countries with the relevant local Ghanaian entrepreneurs.

6. Government's policy direction must take into account the capacity needs in technology transfer consistent with the obligations assumed under the UNFCCC.

7. The obligations arising out of the UNFCCC and its attendant legal instruments must be translated into national legislation.

8. The judiciary must be well informed through training, seminars, workshops and related activities to enable them function more effectively in respect of environmental matters.

9. Ghana must work towards acquiring and developing critical technologies that can be employed to address the climate change problem.

10. Regulations must be developed to ensure that technologies that are transferred come with information on their environmental risks and other pertinent information so that informed choices can be made.

11. Imported technologies must also be compatible with social, cultural, economic and environmental priorities. Where possible, the imported technology can be combined with local innovations to evolve new technologies.

12. There must be training for organisations which will manage the technologies and conduct environmental impact and risk assessments.

13. General stakeholder participation must be ensured in the technology transfer processes.

14. Endogenous capacities must be developed because an exclusive dependence on imports, can prove harmful in the future.

15. Renewable energy technology friendly attitude must be developed and a suitable pricing framework in competitive applications must be instituted. Also, RETs must be incorporated in energy conservation and efficiency strategies of the country.

16. Government must give more attention to the woodfuel energy sector to ensure that it is sustainably managed. Productive uses of sawdust resources need to be encouraged with regulations restricting their improper disposal.

17. Development of energy crops to provide fossil fuel substitutes on a commercial scale has a potential to help in the national poverty reduction drive. It will create jobs in the rural areas and also reduce foreign exchange requirement for imported fuels.

18. The Government must institute policy regulations and enforcement capacities for increased public and private participation in energy efficiency programmes taking into consideration the programmes already implemented by the Energy Foundation.

19. A requisite policy to implement the development of mini hydro power and incentives to attract investment capital for renewable energy technologies must be put in place.

20. The West African Gas Pipeline (WAGP) Project would have to be supported and expedited for Ghana to utilise natural gas. Legal processes for inter-regional cooperation in energy resource utilisation must also be put in place. Efforts to identify and develop new natural gas fields should be intensified.

21. In order to develop capacities for combined cycle technology transfer and utilisation, programmes must be put in place to ensure the development of the requisite skills, e.g.

through exchange programmes and international attachments. Financial support must be provided for upgrading existing single cycle plants to combined cycle systems.

22. Local production of standardized solar water heaters should be encouraged and the public well informed about their benefits. Also regulations, code of installation and recommended practices should be developed.

23. Countrywide data collection for wind energy must be undertaken and the regulatory agencies should encourage the power producers to include wind energy in their energy supply and distribution mix.

24. The commitment of government and donor support is required to recover methane from existing landfills and closed landfill sites.

25. Government should formulate policies and make it mandatory for all future sanitary landfills to integrate methane recovery systems for energy utilisation.

26. Local authorities should be resourced to develop institutional framework to ensure effective waste management.

27. Stakeholders should be involved in the planning, operation and maintenance of waste management facilities to ensure their improved performance and sustainability.

28. The local authorities must undertake public education and promote waste segregation at source. Also, the public must be encouraged to use compost.

APPENDIXES

APPENDIX I PRIORITISING THE ENERGY TECHNOLOGIES

Priority	Technology	Average	High	Low
1	Industrial efficiency improvements and demand side management	2.4	1	6
2.	Photovoltaics	4.5	1	7.5
	Natural Gas combined cycle	4.9	1	9
	Natural gas distribution	4.9	1	10
	Mini-small hydro	4.9	1	10
3.	Transport management	5.4	2	10
	Biomass	6	2	9
	Wind	6.5	3	9
	Solar Water Heating	7	4	10

APPENDIX II PRIORITISING THE WASTE TECHNOLOGIES

CRITERIA	TECHNOLOGY		
	Landfill	**Biomass waste**	**Incineration**
Development Benefits			
Job Creation	2	4	2
GDP Growth	2	3	2
Wealth creation	1	3	1
Capacity Building	4	3	3
Health Improvement	4	4	3
Social Acceptance of Technology	3	4	3
Effect on balance of trade	1	2	1
Use of local resource	4	4	3
Market Potential			
Financing	3	3	3
Affordability	2	2	2
Investment sustainability	3	3	3
Durability (low maintenance)	2	2	2
Commercial availability	4	4	4
Replicability	4	4	4
Climate Change/Environmental Protection			
Low GHG emissions	3	3	2
Minimal harm on environment	3	3	2
Enhance sinks	0	0	0
Waste Resource Recovery	4	4	4
TOTAL	**49 (2nd)**	**55 (1st)**	**44 (3rd)**

APPENDIX III LIST OF NATIONAL STAKEHOLDERS

Government

- Environmental Protection Agency (EPA)
- Forestry Commission
- Ministry of Environment and Science (MES)
- Ministry of Energy (MoE)
- Energy Commission
- Ministry of Finance
- Ministry of Roads and Transport
- University of Science and Technology
- Ghana Investment Promotion Centre
- National Development Planning Commission
- Public Utility Regulatory Commission
- Ghana Highways Authority
- Ghana Standards Board
- Ministry of Trade and Industry

Business

- Electricity Company of Ghana
- Volta River Authority
- Chamber of Commerce
- Association of Ghana Industries
- Ferro Fabrik Company Ltd.
- Guinness Ghana Ltd.
- Private Enterprises Foundation
- Bank of Ghana
- Ecobank
- Commercial Bank
- Chamber of Mines
- AG Timbers
- Special Timber Products Ltd.

Non-Governmental Organisations

- Kumasi Institute of Technology Energy and Environment (KITE)
- Energy Foundation
- Energy Research Group
- Friends of The Earth, Ghana
- African Environmental Research and Consulting Company

APPENDIX IV – INITIAL DRAFT OF TECHNOLOGY POLICY