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TECHNOLOGY ACTION PLAN FOR CLIMATE CHANGE TECHNOLOGIES, ADAPTATION

This document is an output of the Technology Needs Assessment project, funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Programme (UNEP) and the UNEP Risoe Centre (URC) in collaboration with Environmental Development Action in the Third World (ENDA Senegal), for the benefit of the participating countries. The present report is the output of a fully country-led process and the views and information contained herein are a product of the National TNA team, led by the National Environment Management Authority-Kenya (NEMA-Kenya).

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This Technology Needs Assessment (TNA) and Technology Action Plan for Climate Change Report for Mitigation is an output of the Technology Needs Assessment Project under the United Nations Framework Convention for Climate Change.

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I would also wish to thank the Permanent Secretary, Ministry of Environment and Mineral Resources for the overall guidance in this project. The NEMA Board of Management provided an enabling environment that made the completion of this report possible, and to them we are indebted. I further wish to recognize the role played by all NEMA staff especially the Director, Environmental Planning and Research Coordination who supervised the TNA Project Management Unit (PMU). The TNA PMU was headed by the Climate Change Coordinator who was the project's National Coordinator. Finally and none the less the least, I would wish to thank the national consultant, Professional Training Consultants for producing this four part report.

This report has assessed the technology needs for climate change mitigation in Kenya. The report has further prioritized technology needs for mitigation within the energy and waste management sectors using a multi-stakeholder process and a linear additive Multiple Criteria Analysis Framework. A Barrier Analysis and Enabling Framework for the prioritized technologies have been done and measures identified to overcome these barriers. Finally, Technology Action Plans and Project Concepts have been developed. It is my sincere hope that these 4 part report findings will prompt all stakeholders to take timely action in climate change mitigation and that the reports will form an important reference tool to spur all actors to implement the prioritized technologies in order to contribute in addressing climate change in Kenya.

PROF. GEOFFREY WAHUNGU
DIRECTOR GENERAL, NEMA

TABLE OF CONTENTS

List of Tables

ACRONYMS

EIA	Environment Impact Assessment
EMCA	Environmental Management and Coordination Act
IISD	International Institute for sustainable Development
IPCC	Intergovernmental Panel on Climate
KENGEN	Kenya Electricity Generating Company
KIPPRA	Kenya Institute for Public Policy Research and Analysis
MDGs	Millennium Development Goals
MSD	Medium Speed Diesel
MW	Mega Watt
NEAP	National Environment Action Plan
NMVOCs	Non Methane Volatile Organic Compounds
REDD	Reduced Emissions from Deforestation and Forest Degradation
SREP	Scaling Up Renewable Energy Programme
TAP	Technology Action Plan
TNA	Technology Needs Assessment

EXECUTIVE SUMMARY

This report presents technology action plan for three selected climate change mitigation technologies, two in the energy sector and one in the waste management sector. Chapter one of the report presents technology action plans for the energy sector while Chapter two presents the one for the waste management sector.

The energy sector is the main driver of the national economy being the source of energy for domestic, industry and commercial uses. The principal sources of energy in Kenya are biomass contributing 68% of the national demand, fossil fuels contributing 22% and electricity contributing 9%.The sector is also a major contributor of greenhouse gas emissions in Kenya. The last estimation of the sector's GHG emissions was made in the country's First National Communications to the UNFCCC which gave a figure of 6,397 Gigagrammes CO_2 equivalent. According to Stiebert (2012), CO_2 emissions in 2010 in the energy sector were 18,020 GigagramsCO_2 equivalent.

Selected technologies in the energy sector include Solar Home Systems (SHS) and solar dryers.
A basic SHS comprises a solar panel that transforms solar energy into a direct electric current (DC), a battery to store the DC and an inverter that converts DC into alternating current (AC) The AC is used for lighting, and powering electronic equipment.

SHS has potential to provide electric power in the rural areas where over 6 million household are not connected to the national grid. Currently, there are 200,000 households using SHS in the country. The target for the plan is 165,000 units annually totaling to 3 million in 2030.

The identified barriers to the diffusion of SHS are:

a) Economic and Financial Barriers

High Initial Cost of SHS

A complete SHS including wiring (8 to 20 watts) costs about US 2,000. This amount is beyond the reach of an ordinary Kenyan.

b) Non-economic Financial Barriers

i) Inadequate information and awareness on the availability and benefits of SHS.
ii) Theft of solar panels
iii) Inadequate research and development
iv) Limited number of local technical personnel
v) Inadequate distribution networks
vi) Inadequate enforcement of standards

The proposed measures to address the identified barriers to the transfer and diffusion of SHS are:

a) Economic and Financial Measures

Solar Home Systems costs will become affordable through:

i) Encouraging the private sector to establish industries for local production of SHS component parts.
ii) Provision of subsidies for SHS components
iii) Establishment of a revolving fund from which potential users of SHS can get loans at low interest rates.

b) Non-Economic Financial Measures

i) Mounting information and awareness campaigns to sensitize the public on SHS.
ii) Provide security for SHS
iii) Enhanced R&D for SHS
iv) Enforcement of SHS standards

v) Mounting specialized training of technicians
vi) Increasing SHS distribution networks

The existing enabling framework for SHS includes:

- **Finance Policy**
  Through the Finance Policy, the government has zero rated import duty on solar photovoltaic cells, modules and panels and also removed VAT on imported and locally produced solar batteries, SHS parts and components. At present time VAT is exempted only when one buys a complete SHS package. There is need therefore to remove VAT on SHS individual components.
- **Introduction of Scaling-up Renewable Energy Program (SREP)**
  This program will support Kenya's initiative towards achieving transformational changes that will lead towards low GHG emissions development pathway by harnessing the abundant renewable energy sources such as solar energy and especially SHS.
  The Energy Act 2006.
  The Energy Act (2006) established the Energy Regulatory Commission whose function among others is to enforce and review regulations, codes and standards for the energy sector. The Energy Act has substantially reformed the Energy Sector with an effective institutional, regulatory and legal framework The energy Act does not specifically address SHS technology and in this regard it needs to be reviewed to address SHS technology given its potential impact on rural development.
- **Sessional paper no. 4 of 2004 (The energy policy document).**
  This policy framework aims at promoting development of energy for industrial, commercial and domestic use. It lays special emphasis on development of renewable energy But still requires to be renewed to articulate issues of SHS technology.
- **Green Energy Fund**
  The government is setting up a Green Energy Fund Facility under the National Taskforce on Accelerated Development of Green Energy and whose purpose is to lend funds to viable renewable energy projects including SHS on concessional rates.

The proposed technology action plan for Solar Home Systems includes the following measures:

i) Provision of subsidies to 625 households per county in 24 counties within 10 years. The subsidies will be funded by the government in collaboration with development partners to the tune of KShs.2, 400 million.
ii) Strict enforcement of SHS standards by the Kenya Bureau of Standards, Kenya Private Sector Alliance and the Kenya Revenue Authority within 5 years.
iii) Monitoring of information and awareness campaigns to sensitize the public on availability and benefits of Solar Home Systems within 5 years. The measure will be implemented by county government. Kenya Private Sector Alliance at a cost of KShs 235 million
iv) Training of technical personnel in SHS technology to create a critical mass of technicians to handle installation, repair and maintenance of SHS. The training will be funded by county governments in collaboration with NGOs and Public Private Partnerships at a cost of KShs 47 million within 5 years.
v) Enhancement of R&D activities for SHS by county governments and the Ministry of energy and private sector at KShs 470 million within 10 years.

vi) Expansion of SHS distribution networks by encouraging public private partnerships in SHS. This will be done by the private sector in collaboration with the county government at a cost of KShs 47 million.
vii) Enhancement of security for solar panels. This measure will be funded by the county governments, Ministry of Industrialization and the local people.

The technology action plan for Solar Dryer gives a description of the technology, proposes targets for technology transfer and diffusion, identifies barriers to technology diffusion and proposes measures to address the barriers.

The Solar dryer technology entails conversion of sunlight to heat which is then trapped and used to absorb moisture from the product being dried.

The target for Solar dryer technology in Kenya include family units, commercial farmers and companies, co-operative societies and tea factories. It is estimated that by 2030 the number of commercial farmers using the technology will be 20000 while those of family units will be about 100,000 and all the 65 tea factories will be using the technology.

The main barriers to the diffusion of Solar Dryer technology have been identified as:
i) High initial cost
ii) Inadequate skilled manpower
iii) Inadequate awareness
iv) Inadequate policy, legal and regulatory instruments.

The proposed measures to address the barriers include:
i) Making up-front cost of solar dryers affordable by assuring access to credit
ii) Development of human skills by training of technical staff
iii) Creation of public awareness

The existing enabling framework for the solar dryer technology includes the following:

- **Introduction of Scaling-up Renewable Energy Program (SREP)**
  This program will support Kenya's initiative towards achieving transformational changes that will lead towards low GHG emissions development pathway by harnessing the abundant renewable energy sources such as solar energy and especially Solar Dryers.
  The Energy Act 2006.
  The Energy Act (2006) established the Energy Regulatory Commission whose function among others is to enforce and review regulations, codes and standards for the energy sector. The Energy Act has substantially reformed the Energy Sector with an effective institutional, regulatory and legal framework The energy Act does not specifically address Solar Dryers technology and in this regard it needs to be reviewed to address Solar Dryers technology given its potential impact on rural development.
- **Sessional paper no. 4 of 2004 (The energy policy document).**
  This policy framework aims at promoting development of energy for industrial, commercial and domestic use. It lays special emphasis on development of renewable energy But still requires to be renewed to articulate issues of Solar Dryers technology.
- **Green Energy Fund**
  The government is setting up a Green Energy Fund Facility under the National Taskforce on Accelerated Development of Green Energy and whose purpose is

to lend funds to viable renewable energy projects including Solar Dryers on concessional rates.

The technology action plan for Solar Dryers contains the following measures:

i) Undertaking public awareness campaigns by the Ministry of Agriculture, Ministry of Information and the civil society at a cost of US dollars 2.4 million within 10 years.
ii) Training of technical personnel by the Ministry of Agriculture and the civil society at a cost of US Dollars 14.8 million within 10 years.
iii) Provision of financial incentives to enable farmers access credit. This will be done by co-operative societies at a cost of US dollars 9.6 million.
iv) Undertaking marketing campaigns by farmers, cooperative societies and the civil societies at a cost of US dollars 2.4 million within 10 years.
v) Review of policy, legal and regulatory instruments by the attorney general, farmers and the civil society at a cost of US dollars 1.0 million in 5 years.
vi) Enhance research and development by research institutions, farmers and the academia at a cost of 1.0 million in 5 years.

Methane capture from bio-digesters technology was the only selected technology in the waste sector.

Methane capture from bio-digesters involves anaerobic decomposition of organic matter to produce methane gas and recovering it for domestic use. The process entails construction of an enclosed chamber in which the organic material is placed to decompose anaerobically. The gas can then be siphoned through pipes for such purposes as cooking or lighting.

The target for diffusion of methane capture from bio- digesters in Kenya includes households, institution and commercial enterprises both rural and urban areas. The target for this action plan is 120,000 units by the year 2030.

The barriers to the diffusion of methane capture from bio- digesters are

i) High cost of construction
ii) Lack of skilled technical personnel
iii) Low awareness of the benefits of bio- digesters
iv) Lack of training for bio- digesters users
v) Limited space for construction of larger bio- digesters.

The identified measures to address barriers to the diffusion of methane capture from bio-digesters include:

a) Economic and financial measures
    i) Waiver of import duty on imported components
    ii) Provision of low interest loans
    iii) Tax waiver on locally produced components
    iv) Tax waiver on gas cookers and lamps

b) Non- Economic and financial measures
    i) Customized training of bio-digesters construction and maintenance technicians
    ii) Training of bio- digesters users
    iii) Conducting public awareness campaigns
    iv) Research and development on improvement of the existing technology.

The enabling framework for the diffusion of methane capture from bio- digesters includes:

i) Review the Public Health Act (1998) to provide guidelines for designating sanitary landfills as methane generating sites
ii) Revise EMCAs waste disposal regulations 2006 to address methane capture technology
iii) The Local Government Act (1998)
iv) The Environmental Management and Co- ordination Act (1999)
v) The Energy Policy (2004)
vi) The Energy Act (2006)

The proposed technology action plan for methane capture from bio- digesters has the following measure:

i) Provision of grants for construction of at least 4,000 bio- digesters per year for the first 5 years.
   The grants will be given by the Ministry of Energy, Ministry of Agriculture and development partners totaling to US Dollars 15 million for the first five years.
ii) Provision of low interest loans to farmers to make them afford acquisition of technology accessories.
iii) Setting of standards for construction of bio- digesters by the Kenya Bureau of Standards within 5 years at a cost of US dollars 0.5 million.
iv) Training of construction and maintenance technicians with the funding from the Ministry of Energy, Ministry of Agriculture and development partners totaling US dollars 1 million in ten years.
v) Training of technology users on safe and efficient use of technology. The training will be conducted by the Ministry of Energy, Ministry of Agriculture in collaboration with technology suppliers and will be funded by the Ministry of Energy, Ministry of Agriculture in collaboration with development partners.
vi) Conducting public awareness creation campaigns by the Ministry of Energy, Ministry of Agriculture, technology suppliers and the civil society at a cost of US dollars 1 million in ten years.
vii) Conducting research and development on improvement of the bio- digesters by local research and development of institutions with funding from the Ministry of Energy and Ministry of Agriculture totaling US dollars 2.0 million within 10 years.

CHAPTER 1
TECHNOLOGY ACTION PLAN FOR THE ENERGY SECTOR

1.1 Actions at Sectoral Level

1.1.1 Description of the Sector

a) Role of the Sector

The energy sector is the main driver of the national economy. It is one of the infrastructural "enablers" of Kenya's Vision 2030. The sector is a source of energy for domestic industry and commercial users.

The main sources of energy in Kenya include; biomass which contributes 68% fossil fuels 22% and electricity 9%.

b) Greenhouse Gas Emissions and Trends

The energy sector is a major contributor of greenhouse gas emissions in the country. The main source of GHG emissions in the sector are energy generation and energy consumption/ demand, industrial and residential, commercial and transport sub-sectors.

The main GHG emitted from the transport sub-sector are carbon dioxide (CO_2), Non-Methane Volatile Organic Compounds (NMVOCs) and Nitrous Oxide (N_2O).

The energy sector is among the largest contributors in Kenya. According to the country's First National Communication to UNFCCC, the most significant GHG emitted in the sector in 1994 was CO_2 with emissions of 4522 Gigagrams. According to Stiebert (2012) CO_2 emissions had increased to 18,020 Gigagrams in 2010. GHG emissions trends in the sector are shown in table 1.1 below.

Table 1.1: Greenhouse gas emissions trends in energy sector

Year	CO2 Emissions in Gigagrams
2000	11,430
2005	12,510
2010	18,020

Source: Stiebert (2012)

c) Existing Policies and Measures Related to Energy Sectors Development and Technology Development

A number of policies and measures related to the energy sector's development and technology deployment have been put in place to enable the transfer and diffusion of energy technologies in the country. These include:

i) The National Climate Change Response Strategy (NCCRS)

Kenya's National Response Strategy (2010) contains sub-section on the impacts of climate change on the energy sector and also gives recommendations on actions that need to be taken to mitigate these effects.

ii) The Kenya National Environment Action Plan

The Kenya National Action Plan (NEAP) of 1994 was developed as a basis for environmental management in the country. It made fundamental

recommendations including a proposal for a new institutional framework, review and harmonization of environmental legislation and implementation of Environmental Impact Assessment (EIA).

iii) **Scaling-up Renewable Energy Programme (SREP)**

The SREP is Kenya's investment plan for the scaling up of funding for the country's renewable energy programme. The programme aims at supporting initiatives towards achieving transformational changes that will lead to low GHG emissions development pathway.

iv) **Exemption of Import Duty and Value Added Tax**

The government has zero rated import duty and removed Value Added Tax on renewable energy equipment and accessories.

Existing Policies and Laws

The main policies and laws that have a bearing on the energy sector are summarized in table 1.1 below

Table 1.2: Existing Policies and Laws Related to Energy sectors Development

Name of Policy/Act Legislation	Date Formulated/ Enacted	Main Contents
The National Energy	2004	The National Energy Policy advocates for provision of adequate, reliable, cost effective and affordable energy to meet Kenya's development needs while protecting and conserving the environment.
The Forest Policy	1968 and revised in 2012 (Draft)	The Forest Policy was published in 1968 and subsequently revised in 2004 but is still in draft form. However, the objectives of the draft policy have been given legal basis by the Forest Act (2005). The main contents of the Draft Forest Policy include the following: • Contribute to poverty reduction and employment creation through sustainable use, conservation and management of forests. • Contribute to sustainable land use through soil, water and biodiversity conservation. • Promote participation of private sector, communities and other stakeholders in forest management. • Promote farm forest to produce timber, wood-fuel and other forest products.
Energy Act	2006	The Energy Act 2006 provides for • Establishment of an institutional framework for the regulation of the sector. • Development and supply of electrical energy. • Regulation and trade in petroleum and natural gas • Development and use of renewable energy • Making of regulation to give effect to the Energy Act
The Forest Act	2005	The main provisions of the Forest Act 2005 include: • Establishment of institutional framework for management of all types of forest. • Private and community participation in the management of state forests. • Management of forests for carbon sequestration and other environmental services

d) Selected Technologies

This Technology Action Plan deals with two selected technologies for the energy sector namely solar home systems and solar dryers.

The technologies were selected through a participatory process involving mitigation thematic groups. Multi Criteria Analysis, a computer based model was used for technology prioritization process.

i) Solar Home Systems

Solar Home Systems (SHS) involves the use of solar energy to provide electric power to households for lighting and operation of electronic equipment such as television sets and radio cassettes. Solar electricity is the electric power generated from solar energy using devices called solar cell modules. The solar cell modules transform solar energy into electricity that can be stored in solar batteries and used in solar home systems. A complete solar home system comprises a solar panel, a static converter, a solar battery and a lighting kit.

The target for solar home systems includes rural households and institution such as schools, health centres and prisons. Currently there are over 200,000 SHS units in the country. This action plan targets an annual installation of 165,000 units in order to cover about 3 million household by year 2030.

ii) Solar Dryers

Solar Dryer technology involves the use of direct solar radiation to remove moisture from produce so that it can be safely stored for a longer period. The principle of solar dryer technology involves trapping solar energy by heating up the air volume in a solar collector and conducting the hot air to an attached enclosure in which the produce to be dried is placed. A simple solar dryer design uses wooden frames inside which screen trays are laid. An ultra violet resistant plastic film is used to cover the frame. The heat trapped in the covered frame is then conducted to the attached enclosure using either natural convection dryer or a forced convection dryer.

There is great potential for applying solar dryers in Kenya to dry cereals, tea leaves, legumes, fruits and vegetables. Targets for solar dryer technology include small scale and commercial farmers, companies, co-operative societies and families.

Currently there are about 1,000 commercial farmers applying solar dryers in Kenya. This action plan targets an annual diffusion of 120 solar dryers to reach a total of 2,000 units by the year 2030. 100,000 family unit solars dryers are expected to be in place while all the 65 tea factories will have access to solar dryer technology.

1.1.2 General Barriers and Proposed Measures for SHS and Solar Dryers

1.1.2.1 General Barriers

There are a number of general barriers to the diffusion of both the solar home systems and solar dryer technologies in the country.

In Kenya, the main barriers to technology transfer and diffusion in the sector include:

i) Economic and Financial

The high initial costs of both solar home systems and solar dryer technologies may not be affordable to the targeted rural households. The high cost of these technologies is due to the fact that they are all imported.

The initial costs of these technologies could be lowered by encouraging the private sector to establish industries to manufacture components of the various technologies locally. Additional cost cutting can be achieved by the government in collaboration with the private sector providing subsidy for some components of the technologies such as solar batteries to enable households afford the cost of technologies. The proposal by the government to establish a Green Facility Fund could go a long way in lowering costs of solar technologies. The fund is intended to lend funds to viable renewable energy projects at concessional rates.

ii) Non-Economic and Financial

- **Inadequate Information and Awareness**

  There has not been adequate awareness creation on solar technologies in the country. Consequently most of the rural communities have little or no information on these technologies and their benefits. The barrier can be addressed by mounting information and awareness campaigns throughout the country targeting the potential beneficiaries to sensitize communities on solar energy technologies.

- **Lack of Technical Capacity**

  Technical capacity to install, maintain and repair SHS technology in Kenya is generally lacking especially in rural settings.

  This barrier will be addressed by creation of critical mass of trained technical personnel through increase local training on solar energy technologies.

1.1.2.2 Technology Specific Barriers and Measures

The technology specific barriers and measures for the selected technologies are summarized below:

a) Specific Barriers for Solar Home Systems

The identified barriers to the transfer and diffusion of Solar Home Systems technology are:

Economic and Financial Barriers

i) High cost of SHS

Non-Economic and Financial Barriers

i) Inadequate enforcement of standards
ii) Inadequate distribution network
iii) Inadequate information and awareness
iv) Inadequate information on market
v) Lack of capacity in installation repair and maintenance.
vi) Inadequate research and development
vii) Theft of solar panels
viii) Weak regulatory framework

b) Specific Measures for Solar Home Systems

Economic and Financial Measures

The measures to address the above barriers include:

i) Making Solar Home Systems initial cost affordable by:

- Manufacturing some components locally
- County governments, NGOs, development partners providing subsidies
- Providing low interest rates, affordable loans from the Green Energy Fund Facility

Non-economic measures

i) Strict enforcement of standards
ii) Ensuring critical mass of local trained personnel
iii) Ensuring adequate information on the market
iv) Undertaking information and awareness creation campaigns
v) Establishment of SHS distribution networks
vi) Enhance Research and development
vii) Provision of security for solar panels
viii) Strengthening regulatory framework for SHS

c) Specific Barriers for Solar Dryers

The identified barriers for transfer and diffusion of solar dryer technology include:

Economic and Financial Barriers

- High initial cost of dryers

Non-Economic and Financial Barriers

i) Inadequate skilled manpower
ii) Inadequate awareness
iii) Inadequate policy, legal and regulatory instruments

d) Specific Measures for Solar Dryers

Economic and Financial Measures

i) Ensuring access to credit for consumers to obtain low interest loans

Non-financial measures

i) Formulation of enabling policies and legislation
ii) Strict enforcement of policies and legislation
iii) Development of requisite skills for solar dryer technology
iv) Provision of relevant information and awareness creation.

1.2 Action Plan for SHS

1.2.1 Solar Home Systems Technology

Kenya lies along the Equator. Solar energy resources are available in many areas of the country in quantities that are commercially viable. Solar Home Systems provide household lights, and electrical power for televisions, cassette players and small appliances. This forms the bulk market for photo-voltaics in Kenya.

A number of PV cells in a serial configuration is known as a solar module. When numerous solar modules are linked together in either a parallel or serial configuration they are known as a solar panel. Sunlight strikes the solar cells causing electrons in the cells to move in one direction producing direct current (DC). The electrons then flow through wires that connect the cells. Many solar cells are connected together to produce the voltage and current needed to power the inverter. The inverter is a solid-state electronic device that converts solar generated direct current into alternating current (AC) to power electrical equipment and appliances. AC is used in the home to provide light, power most appliances such radios, televisions and charge mobile phones. A SHS unit comprises solar panels, inverters, charge controllers, battery and compact fluorescent lights (CFLs).

An estimated 200,000 rural households in Kenya have solar home systems. This success has been largely due to private sector activity. Most units are in the power range of 10 to 100 Wp. However, still many rural households find it difficult to buy SHS due to their relatively high costs in unsubsidised market. High prices are due to the fact that the SHS parts and components are imported using hard currency whose exchange rate keeps on fluctuating due to instability of Kenya shilling. The high technology involved in SHS and raw materials required for SHS make SHS expensive. A complete SHS including wiring and installation charges amounts to about US$ 2,000. The price of compact fluorescent lights (CFLs) ranges between US$ 2.5 to US$ 5.6 (for 8- 20 watts).

The SHS technology has potential to provide electric power in the rural areas where about 95%of the population is not connected to the grid. There is a large potential (about 6,000,000 rural households) for its diffusion in the country. There is additional potential of SHS technology to provide electricity to the already grid connected households in both the urban and rural areas as a backup measure to ensure continuous power supply in view of frequent power outages. The uptake of SHS has been slow (see table 1.3) below due to various reasons such as relative high cost of the technology and low awareness on the potential socio-economic and environmental benefits of the technology among others.

Table 1.3: Trade and Production of SHS Parts and Components in Kenya: Mean (2004-2008)

Short Description	Units	Imports	Production	Consumption
Static converters [e.g. rectifiers and inductors and inverters for converting dc power to ac power]	Number	305,995	-	305,690
Photovoltaic system controller [charge controller for voltage not exceeding 100V]	Number	185,171	-	114,113
Photovoltaic cells, Modules and Panels	Number	118,322	-	112,908
Other lead-acid accumulators [Deep discharge (solar)]	Number	173,740	<50,000	1112,015

Source: Moses Ikiara, KIPPRA (2009)

SHS technology has potential to replace the use of polluting kerosene lamps and candles for lighting in rural households and therefore contribute to reduction of emissions of GHGs.

Economic, Social and health benefits include:

i) **Employment creation**. By targeting 3 million households with SHS by 2030, many jobs will be created for retailing, distribution, installation, maintenance and repair of SHS.

ii) **Reduces fire risks**. If kerosene lamps and candles are not handled properly especially by children, they have a likelihood of causing fires in grass thatched rural houses. The use of SHS will reduce such risks.

iii) **Good learning opportunities for students in the evenings**. Indoor use of SHS will increase the ability of school children to do their homework effectively leading to enhanced academic performance.

iv) **Improved health**. Traditionally families in rural areas use paraffin lamps and candles as source of light. These lamps/candles produce fumes which are harmful to human health.

Climate Change Mitigation Benefits

SHS will replace fossil fuel sources of energy such as kerosene lamps and candles which emit CO_2.

The mitigation potential is in the range of 1,000 ktCO_2 /year in2030 (Saidi et. al., 2012). Assuming that a rural household hason average two kerosene lamps/candles, SHS will replace use of 330,000 lamps/candles annually and 6,000,0000 lamps/candles by 2030.Given that a household consumes about one litre of kerosene for lighting/week, the country would save 8,580 tonnes/year of imported kerosene.

1.2.2 Targets for Technology Transfer and Diffusion

About 80% of the Kenyan population has no access to electricity from the grid (6 million).

About 165,000 SHS units annually are targeted for installation and rising to 3,000, 000 units by 2030. The target for SHS technology therefore is 50% of the 6 million households i.e. 3 million households by 2030. Other targets comprise mostly rural based institutions such as schools, hospitals, dispensaries, prisons and government offices.

Even households connected to the grid may wish to have a SHS as a power back-up for purpose of having a reliable power supply.

1.2.3 Barriers to the Technology's Diffusion

Barrier identification process was based on the following:

i) A desk study of policy papers and other pertinent documents
ii) Economic and other relevant assessments of the SHS
iii) Workshop by technology working groups and which included a brainstorming session. This workshop was held on 25th July 2012 at Laico Hotel, Nairobi (See Annex 2)
iv) Expert and stakeholder consultation (one on one basis)
v) Market mapping tool -consumer goods and capital goods. The elements in the market environment and the relation to the market chain were used to identify barriers for SHS.

1.2.3.1 Economic and Financial Barriers

The following are the economic and financial barriers to transfer and diffusion of SHS low carbon emission technology:

i) Solar Home Systems Require High Initial Investment Costs

SHS face several economic and financial barriers. These are barriers which make SHS to require high initial investment costs.

- **High cost of solar panels and batteries**

  Most of SHS parts and components such as solar photovoltaic cells, solar PV modules and panels, charge controllers, compact fluorescent lamps (CFLs) and solar batteries are imported. However, there is a local company in Kenya which also manufactures solar batteries including car batteries. High prices are due to the fact that the SHS parts and components are imported with hard currency whose exchange rate keeps on fluctuating due to instability of the Kenya shilling. High technology involved and raw materials required for SHS are also expensive. A complete SHS including wiring and installation charges amounts to about US$ 2,000. The price of CFLs ranges between US$ 2.5 to US$ 5.6 (8 -20 watts).

- **Lack of Subsidies**

  The government of Kenya does not provide subsidies for one to purchase a SHS. Due to relative high costs of SHS, this has made the SHS to be inaccessible to the rural poor households for who this technology is targeting.

- **High Costs of Installation, Repair and Maintenance**

  There are no institutions in the country providing focused and practical training courses on design, manufacturing/production of static converters, photovoltaic system controllers, photovoltaic cells and modules in the country. Technical colleges and other tertiary institutions offer general courses on electronics and electrical engineering. As a result, hands on skills are limited. Due to scarcity of trained local personnel to install, repair and maintain SHS, the costs of SHS are relatively high.

- **High Interest Rates**
  Financial institutions charge interest rates ranging between 15% and 30% for people wishing to get loans. The same interest rates are applicable to those wishing to access loans to purchase SHS**.**

1.2.3.2 Non-Financial Barriers

i) Inadequate information and Awareness

The majority of Kenyans living in rural areas have little information concerning the potential social, economic and environmental benefits of the SHS. Little information and awareness on SHS is due to the fact that neither the government nor the private sector has committed financial resources to use both the print and electronic media to provide information and awareness on the importance and potential benefits of SHS to the public at large**.**

ii) Theft of Solar Panels and Batteries

Many users of SHS have experienced frequent thefts of solar panels. This has tended to make potential users of SHS hesitant to acquire the technology.

iii) Inadequate Research and Development (R&D) and Unfocused Training

R&D targeting SHS is lacking. Due to lack of development of SHS technology in the country most of the SHS components are imported.

iv) Limited Number of Local Technical Trained Personnel (engineers and Technicians)

LocalUniversities and technical colleges in the country offer courses on electronics and electrical engineering. These courses are theoretical in nature and do not focus on practical aspects of the SHS technology such as design, manufacture and application of the technology. As a result, the country has limited number of trained technical personnel to install, repair and maintain SHS.

v) Few Distribution Networks

There are few distribution networks for SHS countrywide. As a result some customers have to travel long distances to access them besides incurring substantial costs on travel.

vi) Inadequate Enforcement of Standards for SHS

Due to inadequate legal and regulatory framework and corruption, low quality solar panels, batteries and compact fluorescent lights (CFLs) end up in the country. Low quality solar panels are unreliable and breakdown shortly after installation while low quality CFLs also last for a short duration after being installed. These low quality SHS products are sold at lower prices to unsuspecting customers

1.2.4 Action Plan for SHS

1.2.4.1 Proposal for Enabling Framework

In order to build on success of over 200,000 SHS installations country wide, and the proposed annual target aimed at installation of 165,000 SHS units per year, it is proposed that the Ministry of Energy and county governments in collaboration with the private sector, civil society, development partners and the beneficiaries of the SHS technology should support the following enabling framework:

i) The Energy Act 2006

The Energy Act (2006) established the Energy Regulatory Commission whose function among others is to enforce and review regulations, codes and standards for the energy sector. The Energy Act has substantially reformed the Energy Sector with an effective institutional, regulatory and legal framework. It is

proposed that the Act should be revised in order to give appropriate incentives for wide diffusion of SHS.

ii) Green Energy Fund

The government is in the process of setting up a Green Energy Fund Facility under the National Taskforce on Accelerated Development of Green Energy and whose purpose is to lend funds to viable renewable energy projects on concessional rates. This fund will be operationalized for the benefit of those wishing to access SHS technology and other green energy technologies.

iii) Kenya Anti-Corruption Commission

The government has established through an Act of Parliament the Kenya Anti-Corruption Commission to check corruption in all sectors of the economy. However, there has not been goodwill from authorities to ensure enforcement of the laws. The Anti Corruption Laws will be enforced in order to eradicate corruption and therefore ensure that only high quality SHS parts and components are sold in the country.

iv) The National Climate Change Response Strategy

The Government of Kenya has formulated a National Climate Change Response Strategy whose objectives include conducting periodic climate change threat and risk assessments at national and local levels; developing a national capacity building framework in strategic climate change areas; identifying specific research and development needs to address climate change; and opportunities for technology development, absorption and diffusion among others.The action plan needs to be implemented as soon as possible in order to support climate change programmes at the county level.

1.2.4.2 Proposed Measures

Identification of measures process was based on the following:

i) TNA consultants own experience
ii) Workshop by technology working groups and which included a brainstorming session. This workshop was held on 25th July 2012 at Laico Hotel, Nairobi (See Annex 2)
iii) Market Mapping Tool
iv) Logical problem analysis (objective tree)

The following measures for diffusion of SHS technology are being proposed.

a) Economic and Financial Measures

Affordable SHS will become affordable through a combination of both economic and financial measures and non- financial measures. These measures are discussed below.

i) Low Costs for solar panels and batteries

Low costs for SHS parts and components will be realized by encouraging the private sector to establish industries to locally manufacture and assemble SHS parts and components such as solar panels, inverters, lighting kits and charge controllers.

ii) Provision of Subsidies

The current cost of SHS technology is beyond the financial reach of the common man in rural areas. The county governments, Ministry of Energy, NGOs, development partners, private sector will consider providing subsidies to the poor households wishing to buy SHS in order to make them affordable.

iii) Low Interest Rates

The Ministry of Energy in collaboration with the development partners and local financial institutions will establish a revolving fund whereby potential users of SHS could borrow at low interest rates to access SHS. The low interest will be meant for managing the fund. Potential borrowers from this fund will be encouraged to form groups. These groups will guarantee loans borrowed by their individual members.

As an example of the aforesaid, the government is in the process of setting up a Green Energy Fund Facility under the National Taskforce on Accelerated Development of Green Energy and whose purpose is to lend funds to viable renewable energy projects on concessional rates.

b) Non-Economic Measures

i) Adequate Information and Awareness on SHS

Information and awareness campaigns will be launched by the private sector in collaboration with county government and NGOs to sensitize the communities on the SHS technology. Funding for this measure will be provided by county governments, private sector, NGOs and development partners.

ii) Provide Security for Solar Panels and Batteries

Most of people who steal solar panels and batteries do so because they are poor and unemployed. Public education and awareness creation, community policing and empowering the youth to access different sources of livelihoods are some of the methods that will be employed in order to make SHS secure.

iii) Enhanced R&D

R&D activities for SHS technology will be addressed through– legal, institutional, policy, regulatory and technical components and where absent will also be enhanced. Funding for R&D activities will be provided by the private sector, county governments, Ministry of Energy, NGOs and development partners.

iv) Provision of Critical Mass of Local Trained Personnel (technical manpower)

Critical mass of trained technical personnel will be achieved through increased local training and technology transfer for imported SHS equipment. Local village polytechnics and technical colleges in collaboration with private and public R&D institutions will be empowered to offer courses on design, production and application of SHS. As a result, the country will have a critical pool of trained technical personnel to assemble, install, repair and maintain SHS in the country.

v) Increase Distribution Networks

In order to increase diffusion of SHS in the country, SHS distributors will be encouraged to increase their distribution networks by making sure that these products are available within the mobility range of potential customers, typically less than 20km from the customers home. This will be done by the private sector.

vi) Enforcement of SHS Standards

The Kenya Bureau of Standards in collaboration with the customs section of the Kenya Revenue Authority will ensure enforcement of existing national standards for SHS.

The proposed action plan for SHS is shown below in table 1.4.

Table 1.4: Technology Action Plan: Solar Home Systems

Name of Measure	Why measure is needed	Main actors	Time-frame	Cost	Justification	Indicators of success	Risks
Provision of subsidies	Relative high cost of SHS	Ministry of Finance; county governments, local banks; and development partners	5-10 years	KShs.240 million. Funding will be provided through county governments, development partners, NGOs and PPPs.	Target per county is 625 households. Proposed subsidy per household is KShs. 16,000. Total subsidy is KShs. 16,000x625x24=KShs. 240,000,000	Adequate subsidies such as soft loans; revolving funds (Green Energy Fund) for SHS in place	Support from government; development partners; PPPs and NGOs
Enforcement of national standards for SHS	Currently low quality SHS are being imported into the country through the backdoor. Solar panels and lighting kits break down frequently requiring high maintenance costs	KEPSA; Kenya Bureau of Standard and immigration section of the Kenya Revenue Authority (KRA)	0-5 years	Kshs.1,000,000 funding will be provided through the Kenya Bureau of Standards	The officers from Kenya Bureau of Standards and Kenya Revenue Authority are already in place.	Enhanced and enforced standards for SHS in place	Lack of collaboration between Kenya Bureau of Standards and the immigration section of KRA

Name of Measure	Why measure is needed	Main actors	Time-frame	Cost	Justification	Indicators of success	Risks
Information and awareness campaigns will be launched to sensitize the rural households on the SHS technology	In most rural areas, there is generally inadequate information and awareness on SHS technology. This is evidenced by the fact despite many socio-economic and environmental benefits associated with use of SHS, many rural households (over 6 million) continue to use highly polluting fossil fuel based energy for lighting kerosene lamps and candles.	County governments, PPPs; KEPSA ; media; and NGOs	0-5 years	KShs. 23.5 Million. Funding will be provided by county governments, NGOs, private sector, development partners and by ministry of energy	Since there are 47 counties in Kenya, KShs. 500,000 will be allocated per county for information and awareness campaigns	Information and awareness campaigns conducted	Lack of interest from NGOs and industry
Provision of critical mass of technical man-power. This will be facilitated through increased local training; technology transfer for imported SHS equipment with support of local technical training colleges and R&D institutions	To increase technical capacity of personnel involved in installation, repair and maintenance of SHS. There are only five companies in Kenya involved in Solar PV market. Many of these companies are involved in importation and wholesale aspects of the technology while only one deals specifically with retailing of SHS.	County governments; PPPs; NGOs	0-5 years	Kshs. 47 million. PPPs, NGOs and development partners	KShs. 1,000,000 will be availed per county for capacity building	Trained man power in place	Lack of funding

Name of Measure	Why measure is needed	Main actors	Time-frame	Cost	Justification	Indicators of success	Risks
Research and Development. R&D activities for SHS will be enhanced. Issues such as – legal, institutional, policy and regulatory and technical components and where absent will also be addressed and enhanced.	Both the R&D institutions; academia; and the private sector are not providing funding to support focused R&D targeting SHS technology	County governments R&D institutions; Ministry of Enery; NGOs; and private sector	5-10 years	KShs. 470 million. The funding will be given by counties from current allocations, PPPS, development partners and NGOs. Part of government R&D funding will be directed to support R&D on SHS technology.	KShs. 10 million per County	Provision of funds for R&D on SHS technology in place	Lack of funding
Adequate distribution networks. Distribution networks will be increased such that SHS customers travel less than 20 Km to access them.	Potential buyers of SHS technology have to travel long distances and incurring substantial travelling costs before they can access SHS technology	Private sector	0-5 years	KShs. 47 million. County governments, NGOs, development partners and PPPs will provide the funding	At KShs. 1 million per county.	Distribution net-works within reasonable reach	
Provision of security for solar panels and batteries. This will be achieved through public education, awareness campaigns, community policing and improvement of livelihoods by agro-processing activities for value addition. These activities will create employment in the rural areas.	Theft of solar panels and batteries	NGOs, media; public and local administration, local business men; PPPs and development partners	0-5 years	KShs. 47 million. The county governments; Ministry of Industrialisation; Ministry of Higher Education, Science and Technology and the community will provide the required funding.	At KShs. 1 million per county.	Public education and awareness campaigns conducted and community policing in place	Lack of funding

1.3 Action Plan for the Solar Dryer Technology

1.3.1 General Description of Solar Dryer Technology

Direct solar drying has traditionally been used for processing and preserving cereals, legumes, vegetable, fruits and other products by laying products out in the sun to dry.

In many countries of the world, the use of solar thermal systems in the agricultural area to conserve cereals, legumes, vegetables, fruits, coffee, tea leaves and other crops has shown to be a practical, economical and acceptable approach environmentally. Solar heating systems to dry foods and other crops can improve the quality of the product, while reducing waste and use of traditional fuels; thus improving the quality of life.

In Kenya the National Cereals and Produce Board is responsible for drying cereals especially wheat, rice, maize and beans. The main source of energy used is diesel.

In the tea estates of Kericho, one company has installed machines that use solar energy to wither the tea leaves as part of the processing. Personal communication with the Kenya Cleaner Production Centre in 2012 revealed that adoption of this technology has been able to reduce the costs of energy by 50%.

There are different categories of solar dryer systems according to the intended use of each type of system. Individual family units are those systems designed to dehydrate small quantities of units, vegetables or herbs for purpose of extending the availability of those products at the family level.

Medium scale systems are meant to meet the need of individual and groups, cooperatives or associations to supply a greater quantity of product to reach more markets. Large scale commercial applications require greater capitalization, and are designed to dry very large quantities of product for village cooperatives as well as large commercial farming operations.

So far in Kenya some of the examples which use solar dryer include:

i) Network for Ecofarming in Africa, Kenya Chapter. NECOFA Kenya necofakenya.wordpress.com/tag/solar-dryer
ii) FARM-Africa MATF Maendeleo Agricultural Technology Fund matf maendeleo-atf.org
iii) Solar Drying Technology www.scode.co.ke
iv) Muranga farmers preserve fresh produce with Solar Dryer farmbizafrica.com

Characteristics

The solar dryer technology entails conversion of light to heat which then is trapped and absorbs moisture from the product and thus making it dry. This prevents especially food from decay and spoilage.

Economic Benefits

- Although it has not been calculated the running cost will be low compared to use of fossil fuel and electricity
- Employment creation and earnings to the community
- Improved food security as a result of reduced post harvest loss

Environmental Benefits

- Quality and hygiene ensured as opposed to drying cereals on tarmac roads
- Reduced GHG emission
- No air-pollution hence good health

If solar dryers replace the use of fuel wood, fossil fuel and thermal electricity, there would result in reduced GHG emissions. However there is lack of baseline data on the levels of GHG emissions.

Social Benefits

- Improved health conditions of the workers and farmers
- Improved nutritional conditions

1.3.2 Targets for Technology transfer and Diffusion

The targets for solar dryer technology include small scale family units (50,000) and commercial farmers and companies (1000), cooperative societies and associations (100), vegetable processers and tea factories (65). It is estimated that the number of commercial farmers and family units using this technology will double (i.e. 2000 and 100,000 respectively by 2030). All the 65 tea factories will also be using solar dryer technology by 2030.

1.3.3 Identification of Barriers for Solar dryer technology

The process of barrier identification was based on:

- Consultant's own knowledge
- Adesk study and literature review
- Stakeholder workshops and individual consultations (see Annex 2)
- Guidance from the TNA Guidebook series: Overcoming Barriers to the Transfer and Diffusion of Climate Technologies
- Logical problem analysis tool (problem tree)
- Market chain actors and links

1.3.3.1 Economic and Financial Barriers

i) Cost of the Systems (High Up-front Cost).

This is the central barrier to transfer and diffusion of solar dryers technology. The costs of the different categories of the Solar Dryers range from $50 to $1,500. This amount may not be readily available to the ordinary farmer in the rural area. The farmer in the rural area has limited access to financial institutions and to credits.

ii) High Interest Rates

Local banks charge between 15% and 30% interest rates for those who take loans. Borrowers need collateral before they can get loans. The interest rates are a disincentive to those willing to borrow money from banks to buy solar dryers since they cannot afford loan repayments.

1.3.3.2 Non-Financial Barriers

i) Inadequate Skilled personnel

There are no skilled personnel to install and operate the technology. The farmers are largely not familiar with the technology and cannot therefore readily use it.

ii) Inadequate Awareness

Generally there is an absence of good information about solar dryer technology despite the fact that solar food processing is most needed in the country. The farmers do not have information on the product, benefits, costs, financing sources and market potential. The civil societies should be encouraged to popularize this technology.

iii) Inadequate Policy, Legal and Regulatory Framework

The Government has not shown commitment in promoting Solar Dryers by formulating the necessary policies and legislations especially in the Agricultural Sector with a view to ensure food security.

1.3.4 Action Plan for Solar Dryer System

1. 3.4.1 Proposal for Enabling Framework

i) Revision of the Energy Act 2006 to focus on solar energy particularly solar dryer.
ii) Implementation of the National Climate Change Response Strategy.
iii) Ensure the Green Energy Fund is established and operationalised.

1.3.4.2 Measures

- Setting up of local assembling industries for solar dryer parts and components and enhancing R& D for Solar Dryer
- Land funds to viable renewable energy projects on concessional rates under the future Green Energy Fund facility
- Conduct adequate information and awareness campaigns through print and electronic media Establish critical mass of locally trained personnel
- Formulate enabling Policy, Legal and regulatory framework for solar dryer technology

Table 1.5: The proposed Action Plan for Solar Dryers

Measure	Why the Measure	Main Actors	Time-frame	Cost (US Dollar)	Indicators	Risks
Public Awareness Campaigns	Educate and sensitize farmers and others in the industry	Media; civil society ;Departments of Agriculture and Information	5-10 years	2,400,000	Knowledgeable farmers	Farmers will accept to be sensitized
Training of manpower	To enable farmers and technicians use the technology	Ministry of Agriculture; private sector and civil society	5-10 years	14,880,000	Trained manpower	Willingness of the people to be trained
Provision of financial incentives to enable farmers access credit	To enable poor farmers access credit	Cooperative societies County Budget	5-10 years	9,600,000	Availability of credit from County Budgets Banks Cooperative Societies	Cooperative societies and banks will be ready to give credit
Marketing Campaigns	To provide markets to the farmers	Farmers, cooperative societies, private sector and civil societies	5-10 years	2,400,000	Markets established and used	Farmers will use the markets
Review of Policy Legal and Regulatory Instruments	To guide and regulate the use of solar dryers	Attorney General farmers civil society	1-2 years	50,000	Revised policy laws and regulations Guidelines	Goodwill from the Government
Research and Development	To get requisite data and information	Research institutions academia farmers	1-2 years	50,000	Reliable data and information in place	Willingness and ability to undertake research

CHAPTER 2
TECHNOLOGY ACTION PLAN IN WASTE MANAGEMENT SECTOR

2.1 Actions at sectoral level

2.1.1 General Description of the Sector

Almost all human activities generate wastes of different types and quantities. Wastes can be categorized as solid, liquid or gaseous. The categories can also be based on their sources of generation. Some types of wastes are bio-degradable under natural condition while others are not and can last over a long period of time if not taken care of.

Currently, it is estimated that there are about 5,000 bio-digester units in the country. The target is to construct about 120,000 units by 2030.

a) Role of the Sector

The role of waste management sector is conservation of the environment through the various existing or new waste management technologies depending on the types of wastes.

b) Greenhouse gas emissions, levels and trends

Depending on the methods utilized for their management, different types of wastes emit greenhouse gases.

If they are disposed of through combustion processes such as on farm burning or open air burning of municipal wastes the main gases emitted are carbon dioxide and nitrous oxide.

If the method involves bio-degradation under anaerobic conditions such as those in municipal landfills or biogas digesters then the main gas emitted is methane and small amounts of carbon dioxide.

According to Siebert (2012) emission of greenhouse gases from the waste sector in Kenya was as follows in (in GigagramsCO_2 e):

Table 2.1: Greenhouse gas emission trends in waste sector

Year	CO_2e Emissions in Gigagrams
2000	410
2005	570
2010	780

Source: Stiebert (2012)

c) Existing policies and measures for waste management.

There are a number of policies and measures that have been formulated to regulate and give guidance on waste management of various types in the country the main ones being the following:

i) **Public Health Act (1986):** The Act requires every local authority to take responsibility of maintaining their areas in clean conditions in order to protect the public from harmful effects of wastes. In this regard they have to provide suitable waste disposal sites.

ii) **Water Act (2002): The Act** gives legal guidance on disposal of wastes of any nature and any source in any way that may cause pollution of water resources.

This Act has the effect of enhancing the safety of drinking water from various sources.

iii) **Local Government Act (1998): The Act gives lo**cal authorities powers to establish and maintain sanitary services for the removal and destruction of or otherwise dealing with all kinds of refuse and effluent and if any such service is established to compel the use of such service by persons to whom such service is available.

The Act provides mechanisms and procedures for disposal of municipal wastes including their enforcement. This is a crucial act because human activities in urban areas generate large amounts of wastes and urban areas in Kenya are growing rapidly on account of rural to urban migration.

iv) **Environment Management and Coordination Act (1999):** The Act provides legal framework for coordinated management of the environment and natural resources. It gives legal guidelines for waste management including setting of standards, waste disposal sites licences and control of various types of wastes.

The Act requires that any major project in the country must undergo Environmental Impact Assessment (EIA). Wastes generation and management is a key component of EIA.

In 2006, wastes management regulations for various types of wastes were developed. These are comprehensive guidelines since they cover practically all types of waste that are generated through human activities.

v) **Energy policy (2004):** The policy promotes renewable energy technologies including energy generation from wastes. The policy led to formulation of Energy Act in 2006.

vi) **Energy Act (2006):** The Act gives the minister for energy authority to take measures to facilitate environmentally friendly energy generation including generation from wastes.

This Act provides opportunities for the private sector to take advantage of financial incentives. It provides to promote development of renewable energy resources. In this regards a number of companies have developed Clean Development Mechanism (CDM) projects in energy generation from wastes.
The Act needs to be revised to address more comprehensively financial incentives for renewable energy development.

vii) **Kenya Vision 2030 (2007):** The Vision proposes plan to relocate Nairobi's Dandora landfill to a more suitable location to facilitate more efficient management. The landfill is reputed to be the biggest in Africa. The relocation of the site will enable it to be designed and constructed in a way that will lead to methane capture.

viii) **Kenya Climate Change Response Strategy Action Plan (2012):** The Action Plan outlines strategies for the wastes management in the country including their reuse, recycling and energy generation**.**

Table 2.2 below shows existing policies and measures that address waste management sector.

Table 2.2: Existing Policies and measures that address waste management sector

Name of the Act	Date enacted	Main contents of the act
Public Health Act	1986	Requires every local authority to take all lawful, necessary and reasonable measures for maintaining its district at all times in a clean and sanitary condition
Water Act	2002	Prohibits disposal of wastes any nature and from any source in any way as to cause pollution of water resources
Local Government Act	1998	Gives local authorities power to establish and maintain sanitary services for removal and destruction of or otherwise dealing with all kinds of refuse and effluent
Energy Act	2006	Provides measures to be taken to promote development of renewable energy resources including wastes
Kenya Vision 2030	2007	Proposes to relocate Nairobi's Dandora landfill to a different site to facilitate more efficient management
Kenya Climate Change Response Strategy- Action plan	2012	Outlines strategies for waste management in the country

d) Technology Profile of Selected Technology in the Waste Management Sector

A number of waste management technologies are currently available that can be used to mitigate climate change and also provide socio-economic benefits to the country.

Process and results of technology selection

Technologies were selected on the basis of their socio-economic and environmental benefits and greenhouse gas abatement potential.

The process of selection involved consultation with stakeholders and experts and using the following criteria:

i) Technology has not been successfully implemented in the country.
ii) Technology is innovative.
iii) Technology is facing barriers to its implementation.
iv) Technology has potential for developing projects that can attract donor funding.

The criteria used for prioritization of technologies in the waste management sector were as follows:

i) Contribution to national development.
ii) Technical feasibility and adaptability to local conditions.
iii) Acceptability by the communities and hence sustainability.
iv) Employment creation and poverty reduction.
v) Contribution to climate change mitigation.

Based on the above criteria the results of prioritization of waste management technologies with MCA were as follows:

i) Methane capture from bio-digesters.
ii) Waste paper recycling.
iii) Waste composting.
iv) Waste plastic recycling.
v) Methane capture from landfills.
vi) Waste reuse.

During the stakeholders meeting held at the Ministry of Works Club in Nairobi on 29th November 2012, the information from the private sector was that the waste paper and plastic recycling technologies are fully deployed in Kenya. In fact the main barrier at present is that the quantities of the waste papers and plastics do not meet the demand. For this reason justification of the technology was abandoned.

The technology action plan was therefore developed for the methane capture technology.

2.1.2 General Barriers and Proposed Measures

2.1.2.1 General Barriers

i) Unregulated private sector participation
ii) Lack of waste management policy
iii) Low rate of solid waste recovery
iv) Weaknesses in municipal councils waste management programmes

2.1.2.2 General Measures

i) Formulate regulations and guidelines for private sector participation in waste management
ii) Develop a policy for waste management
iii) Acquire appropriate technologies for waste management
iv) Municipal councils to develop effective program for waste management since the largest amount of waste are generated in urban and settlement areas

2.1.2.3 Specific Measures for Diffusion of Methane Capture Technology

a) Economic and Financial Measures

i) Low construction costs
ii) Low interest rates
iii) Low maintenance costs
iv) Low cost of cooking stoves and light pressure lamps.

b) **Non-financial Measures**

i) Skilled technical personnel are available.
ii) Bio-digesters are modified and improved to meet the emerging needs
iii) Market links are established

2.2 Technology Action Plan for Methane capture

2.2.1 General description of Methane Capture technology

Methane capture from bio-digesters is done by constructing bio-digester chamber of desired size into which waste materials are deposited and the chamber enclosed to create conditions for anaerobic decomposition of the materials. The decomposition process produces methane gas and small amounts of other gases such as carbon dioxide. The closed chamber prevents oxygen from going in so that almost full anaerobic process is achieved. It also prevents the methane from escaping to the atmosphere. The gas can then be siphoned through pipes to equipment that use it for purposes such as cooking or

lighting. The gas can also be compressed into gas cylinders for storage or transportation to users. The bio-digesters can be constructed in different sizes depending on whether the gas is for single households or for groups of them or commercial purposes.

The technology was selected for the following reasons:

It caters for individual small scale farmers who have access to the required waste materials such as livestock wastes.

i) It also caters for groups who can combine resources to construct and maintain the bio-digesters.
ii) It can be commercialized for income generation and poverty reduction.
iii) It leads to conservation of forests because it reduces demand for biomass energy by communities and hence contributes to climate change mitigation.
iv) Methane capture reduces emissions of the gas into the atmosphere as is the case where anaerobic decomposition takes place in open places. Global warming potential of methane is 25 times that of carbon dioxide.
v) The residues from digested wastes are very rich in plant nutrition as compared to ordinary manure. The bio-digesters therefore provide farmers with opportunities to enhance crop production and income generation towards poverty reduction.
vi) The use of biogas instead of biomass for household energy reduces indoor air pollution and hence reduces incidences of respiratory diseases among residents.
vii) The bio-digester is sustainable at low cost because once it is constructed the waste materials are obtained from livestock on the farm and other activities that generate wastes.
viii) The cost of constructing a medium size bio-digester including accessories is about 1,600 US Dollars but the benefits to the communities as shown above are many. With appropriate technical and financial enabling measures it can be diffused widely in the country.

2.2.2 Targets for technology diffusion

For the methane capture technology it is estimated that about 600,000 people will have access to bio-gas for cooking and lighting by the year 2030 which is target of Kenya's Development Vision. Assuming that, on the average, 5 people will be served by 1 biogas unit this target means that about 6,000 households, institutions and commercial enterprises should be able to install bio-digesters per year during the first 5 years increasing to 4000 during the next 5 year, 8000 during the following 5 years and on to 10,000 during the following 5 year. This will result in 120,000 households, institutions and commercial enterprises having access to bio-digesters by the year 2030.

2.2.3 Identification of Barriers to Diffusion of the Methane Capture Technology

Identification of barriers to diffusion of methane capture technology was done through:

i) Consultation with stakeholders
ii) Consultant's experience and literature review.
iii) Logical Problem Analysis (Problem Tree)

2.2.3.1 Economic and Financial Barriers.

a) High cost of construction of bio-digesters.

Most of the construction materials are available locally but are expensive to the small scale farmers who are the largest potential users of the technology. Some of the accessories have to be imported and they are also expensive especially when import duty and value added tax is charged.

i) **High interest rates on loans.**
The banking institutions in Kenya charge high interest rates which are often the main barriers to potential borrowers leave alone small scale farmers.

ii) **Lack of financial incentives**.
The Government has zero rated duty and VAT on renewable energy equipment. However for the small scale farmers the cost of a bio-digester including other accessories is still high.

iii) High maintenance costs.
Although a good number of bio-digesters have been constructed by farmers in the country in recent years experience shows that most of them do not operate for long periods mainly because of high cost maintenance including replacement of accessories**.**

2.2.3.2 Non- financial Barriers

i) Lack of skilled technical personnel
Construction of high quality bio-digesters and their maintenance is essential in order to make them attractive to potential users. Lack of qualified technical people is a barrier to the diffusion of the technology.

ii) Low awareness of the benefits of bio-digesters.
Bio-digesters are sources of clean and reliable sources of household energy. Their use also improves indoor environment and reduces incidents of respiratory diseases. However such information may not be available to potential users.

iii) Lack of training for bio-digester users.
The technology uses animal and other related wastes as raw materials. Handling of these wastes can be a barrier because of cultural beliefs and also general perception that raw animal wastes are dirty. In addition, operation of the equipment for efficient production of methane and its delivery to the point of use will require training of the operators.

iv) Lack of space for large bio-digesters
Most small scale farmers practice mixed farming and hence must utilize the available space as much as they can. They therefore may not have available space for construction of large bio-digesters but can afford adequate space for small ones.

2.2.4 Proposed Action Plan for Methane Capture

2.2.4.1 Proposal for Enabling Framework for methane capture technology

There are a number of legal measures that have been formulated to regulate and give guidance on waste management of various types in the country the main ones being the following:

i) **Public Health Act (1986):**
The Act requires every local authority to take all lawful, necessary and reasonably practicable measures for maintaining its district at all times in a clean and sanitary condition, and for preventing recurrence therein of or remedying or causing to be remedied any nuisance or condition liable to be injurious or dangerous to health and to take proceedings at law against any person causing or responsible for the continuation of the nuisance.

However, there are now many new issues associated with environment and health in regard to waste management. This Act therefore needs to be amended

to provide regulations for establishing waste disposal site especially with respect to biogas production.

ii) **Local Government Act (1998)**

The Act gives local authorities powers to establish and maintain sanitary services for the removal and destruction of or otherwise dealing with all kinds of refuse and effluent and if any such service is established to compel the use of such service by persons to whom such service is available.

The Act provides mechanisms and procedures for disposal of municipal wastes including their enforcement. This is a crucial act because human activities in urban areas generate large amounts of wastes and urban areas in Kenya are growing rapidly on account of rural to urban migration. The Act should therefore be amended in order to respond to more effectively to the new issues related to waste reuse, recycling and biogas energy production.

iii) Environment Management and Coordination Act (1999)

The Act provides legal framework for coordinated management of the environment and natural resources. It gives legal guidelines for waste management including setting of standards, waste disposal sites licences and control of various types of wastes.

The Act requires that any major project in the country must undergo Environmental Impact Assessment (EIA). Wastes generation and management is a key component of EIA.

In 2006, wastes management regulations for various types of wastes were developed. These are comprehensive guidelines since they cover practically all types of waste that are generated through human activities. Activities that may result in environmental degradation are increasing and the Act needs to be revised accordingly.

But these regulations do not address the issues of biogas production. They should therefore be revised to respond to these emerging issues.

iv) Energy policy (2004)

The policy promotes renewable energy technologies including energy generation from wastes. The policy led to formulation of Energy Act in 2006.

vi) **Energy Act (2006)**

The Act gives the minister for energy authority to take measures to facilitate environmentally friendly energy generation including generation from wastes.

This Act provides opportunities for the private sector to take advantage of financial incentives it provides to promote development of renewable energy resources. In this regards a number of companies have developed Clean Development Mechanism (CDM) Projects in energy generation from wastes.

The Act needs to be revised to address more comprehensively financial incentives for renewable energy development.

vii) Kenya Vision 2030 (2007)

The Vision proposes plan to relocate Nairobi's Dandora landfill to a more suitable location to facilitate more efficient management. The landfill is reputed to be the biggest in Africa. The relocation of the site will enable it to be designed and constructed in a way that will lead to methane capture.

viii) Kenya Climate Change Response Strategy Action Plan (2012)

The Action Plan outlines strategies for the wastes management in the country including their reuse, recycling and energy generation. The action plan needs to be implemented as soon as possible in order to support climate change programmes at the county level.

2.2.4.2 Identified Measures for the Diffusion of Methane Capture Technology

a) **Economic and Financial Measures**

i) Reduce construction costs

It is proposed that the government gives waiver on import duty and other taxes on all the components that will be imported for the purpose of construction and operation and maintenance of methane bio-digesters. This is consistent with the Energy policy (2004) and Act (2006).

The justification will be based on environmental and health benefits and poverty reduction among the small scale farmers.

ii) Reduce interest rates

It is proposed that the financial institutions form partnership with the government to provide low interest loans for development of bio-digesters in order to promote clean energy in rural households towards environmental conservation.

iii) Reduce maintenance costs

It is proposed that the government gives tax waiver to components that will be manufactured locally or imported for the purpose of maintenance of bio-digesters.

iv) Reduce cost of cooking stoves and light pressure lamps.

It is proposed that the government gives tax waiver on the cooking stoves and pressure lamps that use methane gas.

b) Non-financial Measures

i) Skilled technical personnel are available.

Technical training institutions in the country will develop customized training courses for technicians who will undertake construction and maintenance of the bio-digesters.

ii) Bio-digesters are modified and improved to meet the emerging needs

Research and development institutions will be given funds to conduct research and development of appropriate methane capture bio-digesters that will respond to consumer demands such as those that are portable. The funding will come from a special climate fund which will be created by the government.

iii) Training and public awareness campaign is implemented

The responsible institutions within the government in collaboration with research centres and construction companies will conduct training and public awareness campaigns for households on the operation and maintenance of the bio-digesters.

The public awareness campaign will include explaining the benefits of methane energy production on the environment and health and also benefits to the farmers in terms of availability of organic fertilizers which are rich in plant nutrients.

iv) Market links are established

Market links will be developed between the households, potential biogas users, commercial enterprises and the technology suppliers towards increasing the demand for the bio-digesters.

Table 2.3 below shows action plan for methane capture technology.

Table 2.3: Action Plan for Methane Capture Technology

Measure	Why the measure is needed	Responsible institutions	Time frame	Cost of the measure and source of funds in US Dollars	Indicators of success	Risks
Provision of financial grants	The small and medium scale farmers will need to be assisted financially so that they can afford initial construction costs	The Ministry of Finance and international funding institutions and donor countries	1-15 years	15.000,000 USD government allocates 3.000,000 USD international institutions provide 12.000,000 USD	Government allocates at least 3.000,000 US dollars for the project, International institutions and other donors provide at least 12.000,000 USD. At least 4,000 bio-digesters are constructed per year during the first 5 years	**Lower prioritisation of rural energy development** **Weak justification and rationalization of financial assistance.**
Low interest loans to farmers	Even with financial grants farmers may need additional financial resources to meet the rest of the costs	Local financial institutions	1-10 years	5.000,000 USD from financial institutions	Even low income farmers have access to financial resources, Bio-digester for commercial purposes are constructed	**Interest rates remain high**
Maintain duty and VAT exemption for the equipment	This action will help to keep bio-digesters affordable to the small scale farmers	Ministry of Finance	1-18 years	About 500,000 USD loss of revenue by the Government per year	The Government maintains the policy of duty and VAT exception for renewable energy equipment	
Setting of quality standards for construction and equipment for bio-digesters	Low quality construction and equipment lead to frequent breakdown of the system which becomes a barrier to diffusion of the technology	Kenya Bureau of Standards	1-5years	500,000 USD from Government, international institutions and technology suppliers	Bio-digester systems that take at least 1 year without requiring repairs or replacement of equipment	**The number of skilled technical personnel remain low**

Measure	Why the measure is needed	Responsible institutions	Time frame	Cost of the measure and source of funds in US Dollars	Indicators of success	Risks
Training of technicians for construction and maintenance	If the technicians are well trained there will be less technical problems and the technology will be more attractive to users	Ministries of Energy and Agriculture, technology suppliers, and local training institutions	1-10 years	2.000,000 USD from Government, international institutions and technology suppliers	Progressive availability of well trained personnel in different parts of the country	**Institutions put low priority on training programmes for methane capture**
Training of technology users	The users of the technology need to be trained in order to enhance efficiency and reduce frequency of system breakdowns	Ministries of Energy and Agriculture, technology suppliers and local training institutions	1-10 years	1.000,000 USD from Government, international institutions and technology suppliers.	Enhanced efficiency of bio-digester use. Increased attractiveness of bio-digester technology	**Institutions put low priority on training programmes for methane capture**
Conducting public awareness creation campaigns	Lack of awareness of the benefits of biogas use is a major barrier to its wide diffusion within communities across the country and therefore the need to conduct awareness campaigns	Ministries of Energy and Agriculture, technology suppliers and NGOs	1-10 years	1.000,000 USD from Government, international institutions and technology suppliers.	Increasing construction and use of bio-digesters across the country.	**Government places low priority on public awareness creation campaigns**
Research and Development (R&D)	To modify or improve the technology to respond to the emerging demands from the users	Ministries of Energy and Agriculture, technology suppliers and local research and development institutions	1-10 years	2.000,000 USD	Users expressing their needs for technology modification and getting satisfaction with the modified or new products.	**Table 2.2 below shows technology action plan for methane capture technology.**

CHAPTER 3: Cross Cutting Issues

The following are the main cross cutting issues associated with Technology Action Plan for Mitigation

- Reduction of deforestation is an issue of national priority because of its linkage to enhancement of rain producing processes and combating desertification.

In this regard the wider use of Solar dryers and biogas as sources of energy in rural areas also address deforestation and desertification issues.

- Women are usually in the forefront of social and economic activities in the rural areas. These activities include gathering and carrying heavy loads of firewood, food production, preservation and storage. These issues are directly and indirectly addressed by the action plan in terms of reducing work loads of rural women.
- Rural poverty is often associated with dependence on single economic activity. Economic diversification is one of the ways of poverty reduction. This issue is addressed in the action plan in that the identified sources of energy provide opportunities for diversified income generation.
- Children in rural areas are the most affected by poor lighting conditions in their homes because they do their homework in the evenings. This issue is addressed by the action plans for Solar Home Systems and Methane Capture since the main goal is to improve lighting in the rural households.

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ANNEXES

Annex 2: List of participants: Sector Working Group – Mitigation for the 4th TNA Stakeholder's Forum Held on 29th November 2012 at the Ministry of Works Club, Nairobi

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NB: It is to be noted that, in addition to the views expressed during the above stakeholders' forum, consultations were also conducted on one to one basis especially with the following:

i) Eng. Kiva, Director of Renewable Department, Ministry of Energy.
ii) Ester Wangombe, Department of Renewable Energy, Ministry of Energy.
iii) George Keya, Senior Scientist, Kenya Agricultural Research Institute (KARI).
iv) Vincent Oeba, Director, Climate Change Department of Kenya Forestry Research Institute (KEFRI).
v) Ester Magambo, Climate Change Section, Ministry of Agriculture
vi) Alfred Gichu, Focal Point, REDD, Kenya