Republic of The Sudan

Ministry of Environment, Forestry and Physical Development

HCENR

**Higher Council for Environment and Natural Resources**

# Technology Needs Assessment for Climate Change Mitigation

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**Disclaimer**

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 the Regional Centre, Environmental Development Action in the Third World (ENDA), 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 products of the National TNA team, led by the Higher Council for the Environment and Natural resources, Ministry of Environment, Forestry and Physical Development

**This document is composed of four parts namely:**

**Part 1:** Technology Needs Assessment**.**

**Part 2:** Barrier Analysis and Enabling Framework.

**Part 3:** Technology Action Plan.

**Part 4:** Project Ideas.

**Foreword**

Technology Needs Assessment for Climate Change (TNA) is a project implemented by the Higher Council for Environment and Natural Resources (HCENR) in collaboration with the United Nations Environment Program (UNEP) Risoe Centre (URC), Denmark, and supported by the Global Environmental Facility (GEF) grant financing. Project execution is assisted by a national team composed of eleven experts representing different government institutions, research centres and universities.

TNA is considered as a prospect for Sudan to prioritize technologies suitable for its local conditions and contribute to reducing Greenhouse Gases (GHGs) emissions and to moderate vulnerability to negative impacts of climate change; these technologies will go in line with the national development priorities of the country.

TNA also allows Sudan to come up with ideas for sound projects on appropriate technologies for both adaptation and mitigation. TNA will also contribute to the success of implementation of the United Nations Framework Convention on Climate Change (UNFCCC) as long as the developed countries take a leading role in providing financial assistance and facilitating technology transfer for developing countries.

TNA is a participatory process; it requires consultation of wide range of stakeholders during different steps of the process. Stakeholders participated in the groundwork of these studies will eventually add more to the preparation and success of the TNA as they have diverse views, background and experiences in climate change. Identified sectors and sub sectors for the TNA were built upon previous studies conducted earlier such as the National Adaptation Program of Actions and National Communications.

Environment and poverty alleviation have also been recognized as the cross-cutting issues in the Five-Years Strategic Plan of the country (2007 – 2011). Sound, environmentally benign technologies are needed to be incorporated in the environment conservation and poverty alleviation. The government exerts great emphasis on the improvement and development of mutual relations with international partners, and it is concerned by augmenting a mechanism for benefiting from the latest research, expertise and technologies to enable the country to achieve these goals. TNA in Sudan can go beyond prioritizing technologies to practical approach to spread the use of the technologies identified, as Sudan faces many barriers in the technology transfer such as limited resources, lack of training, poor dissemination tools. In conclusion, TNA will help to overcome these barriers.

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**Chairman of the Higher Council for Environment and Natural Resources.Minister of Environment, Forestry and Physical Development**

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# TECHNOLOGY NEEDS ASSESSMENT

## PART 1

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| | |
|---|---|
| AFOLU | Agriculture, Forestry and Other Land Use |
| CC | Climate Change |
| CFL | Compact Fluorescent Lamp |
| $CO_2$ | Carbon dioxide |
| FNC | Forests National Corporation |
| Gg | Giga gram |
| GHG | Greenhouse Gases |
| GWh | Giga watt hour |
| HCENR | Higher Council for Environment and Natural Resources |
| ICL | Incandescent Lamp |
| ICS | Improved Cook Stoves |
| kW | Kilowatt |
| LPG | Liquid Petroleum Gas |
| LUCF | Land use Change and Forestry |
| MCA | Multi Criteria Analysis |
| MDG | Millennium Development Goals |
| MEA | Multilateral Environmental Agreements |
| MWRE | Ministry of Water Resources and Electricity |
| MO | Ministry of Oil |
| NG | National Grid for Electricity |
| PP | Prioritization Process |
| TFS | Technology Fact Sheet |

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## Executive Summary

The Technology Needs Assessment Project (TNA) is done based on the agreement signed between the Republic of Sudan represented by the Higher Council for Environment and Natural Resources (HCENR) and the United Nations Environmental Program (UNEP) Risoe Centre (URC), Denmark, and supported by the Global Environmental Facility (GEF) grant financing. The UNEP, through its Division of Technology, Industry and Economics (DTIE) is responsible for the implementation of the project and provide overall project oversight and strategic coordination. Energy, Environment and Development Programme(ENDA)provides technical and process support to the participating countries in Africa.

Technology Needs Assessment (TNA)is a tool through which Non Annex I countries, could assess /identify the most applicable technology required for adapting /mitigating to Climate Change.

The (TNA) project covers two Climate Change Areas: Mitigation and Adaptation. This report is concerned with the mitigation sectors which identify technologies that can limit GHG emissions growth within the context of sustainable development. The main objective of this work is to identify mitigation options that are most applicable and useful in Sudan without affecting /hindering its developmental plans. The work in mitigation sectors has further been divided into two main parts. The first part is to identify the prioritized sectors and sub-sectors. The second part is to identify the most suitable technologies that are most effective in emission limitation.

The first step in this work is to establish project implementation structure including project coordinator, the national team and the stakeholders. Management unit of this project is hosted within the climate change unit of the Higher Council for Environment and Natural Resources (HCENR). Great attention has been given to the continued consultation process with the stakeholders in every step of the project. One of the main outcomes of project methodology is the establishment of a motivated network that can further assist in implementing the outcomes of this study or even any other climate change project.

The second step is to set a methodology that allows identifying and prioritizing sectors, sub sectors and areas of interest. The procedure adopted to carry out this selection and the identifying processes had to meet

(parallel wise) two criteria; reduction of GHG emission or increase of sink in terms of increasing sequestration rate. The second criterion incorporates the contribution to sustainable developmental priorities within Sudan developmental strategic plans. As Sudan is a least developed country then these priorities include issues like poverty eradication, food security and improved social services. Hence, the current situation has been studied for each sector with a focus on its emission and its relationship to current and future contribution to development in Sudan. This has resulted in selecting the following sectors, Agriculture, forestry and other land use (AFOLU). Agriculture comprises livestock, and crop production. The second sector is energy which includes energy production and consumption from fossil fuel. The thirds sector is industry; which embraces GHG emission from both energy sources and process origin. After these steps, specific sub-sectors with high emission, as indicated in the First National Communication; have been considered for further analysis. This has resulted in identifying the enteric fermentation, manure management, and forest conservation/ management in the AFOLU sector. For the energy sector, electricity supply and demand (production/consumption), transportation and household have been highlighted as main sub-sectors. Within the industry sector attention has been given also to growing industries that are now not considered as emission sources such as agricultural processing industries. The main current emission sources come from construction industries under the category of mineral and non-mineral products; the cement industry has been recorded as the first emitting source. Further a long list of technologies has been prepared by the national team for each sector/area, special care has been given to short and medium range technologies; considering their degree of compatibility with the technical and economic setup in Sudan. Ultimately the most efficient technologies (whether currently available or not) have been suggested. Hence a long list has been created. Technology facts sheets (TFS) have been filled for the technologies and presented in the second local workshop with the stakeholders for further discussion. Subsequently, this long list has been shortened through mutual discussion and finally subjected to Multi Criteria Analysis (MCA) procedure by stakeholder using a self-generated, MS excel-based program. The criteria suggested included the GHG reduction potential/high sequestration potential and the developmental criteria which include environmental, social and economic criteria. The main step in this process is proper

selection of the most suitable indicator, whereby technologies with the highest ranking have been selected for further analysis (barrier and cost benefit analysis).

The national team and the stakeholders' consultation process had identified the following sectors: Agriculture, Forestry, and other land use (AFOLU), Energy and industry as highest prioritized sectors. The identified priority technologies selected for the AFOLU sector are bio gas unit and improved stoves.

For the Energy sector, mass transportation has been identified within transportation sub-sector and selected as priority one in addition to the Compact Fluorescent Lamps (CFL) for the electricity demand sub-sector.

In the industry sector, among the identified technologies, Efficient Boilers with dual fuels have been selected as priority technology.

# Chapter 1
# Introduction

## 1.1Background

Sudan is the third largest African country with an area of 1,882.00 km2; it extends between latitude 22° N at its northern border and 7 ° N southward. At longitude base it is found between 22°E at its western border and 38°E East. Sudan is a land of multi ecological zones, from desert to rich savannah. Sudan (population ~33 million) is one of the least developed countries. Issues of poverty, food security and low service level are the main developmental challenges.

### Developmental priorities

Explained by its under-developed state; Sudan aims towards achieving quicker growth rates. However, its developmental strategic plans do not consider development from the fiscal point of view only, but also put great emphasis on ensuring sustainable developmental mode (conservation of resources, securing biodiversity, reduction of GHG and pollution). These goals are clearly stated in different development planning documents such as the Strategic Plan document 2007-2033. Hence it is very justifiable that objectives like poverty alleviation, food security and provision of adequate services like water, energy, and waste management are given high priority. On the other hand, concerning the strategic and future perspective there is high encouragement for sectors that can contribute more to increasing Sudan's GDP (e.g., export).

**Table 1- Summary of developmental priorities**

| Objective | Poverty alleviation | Food security | Services | GDP Increase | Natural resource management |
|---|---|---|---|---|---|
| Indicators | -Increase of Income<br>-Reduction of negative expenses e.g. illnesses | Increase food commodities productivity and production | -Increase of population percentage which have access to each services<br>- Increased service level | Export increase | -Percentage of resource utilization |

**Source: Compilation of the TNA Team**

## About the (TNA) Project

This work is done based on the agreement signed between the Republic of Sudan represented by the Higher Council for Environment and Natural Resources (HCENR) and the United Nations Environmental Program (UNEP) Risoe Centre (URC), Denmark, and supported by the Global Environmental Facility (GEF). The programme of Energy, Environment and Development (ENDA) provides technical and process support to the participating countries in Africa.

TNA is taking place in 36 different developing countries all over the world and it is a multi-disciplinary work that aims mainly towards addressing both the adaptation/mitigation technology needs of the specific country. It is seen as part of the global effort to respond to climate change phenomena in the context of sustainable development. Furthermore, TNA could be considered as part of the experience exchange and technical know-how provision at the three levels; national, regional and global. The main outcome of TNA is to support the countries in their sustainable development process by providing a Technology Action Plan (TAP) for environmental sound technologies. The project is composed of four parts starting by technology identification/prioritization, followed by barrier analysis and enabling framework needed for developing a technology action plan. Ultimately, these results will facilitate the preparation of profound project ideas.

## TNA Project Objectives

• To identify and prioritize, on the basis of country-driven participatory processes, technologies that can contribute to mitigation/adaptation goals of the participating countries, while meeting their national sustainable development goals and priorities (TNA).

• To identify barriers hindering the acquisition, deployment and diffusion of the prioritized technologies for the mitigation option.

• To develop Technology Action Plans (TAP) to that specify activities and enabling frameworks necessary to overcome the barriers and to facilitate the transfer, adoption and diffusion of selected technologies in Sudan.

## 1.2 Existing national policies about climate change mitigation

Sudan, a least developed country, has a voluntary general obligation for adopting a low carbon development approach. The Republic of Sudan has been among the first countries to ratify the United Nations Framework Convention on Climate Change UNFCCC in 1993 and Kyoto Protocol in 2005. Consequently, Sudan adopted within its national implementation strategy to combat climate change two main pathways namely; adaptation and mitigation (First National Communication, 2003)

Sudan has implemented several activities under the multilateral environmental agreements (MEAs) which have direct relations to climate change adaptation/mitigation and development priorities. The outcomes of these tasks include number of assessment reports, strategies and action plans. The major types of these initiatives are as follows:

• Government Policies and Strategies: these are country-driven policy responses to environmental challenges motivated by either commitments under MEAs or national development objectives;

• National Programs: these are specific measures designed to meet specific needs and objectives of national policies, to be funded by national budget and/or bilateral donors;

• Intergovernmental/Multilateral Processes: these are scoping studies that address critical areas affecting or impeding national development;

• Other Multilateral Activities: these are assorted projects, largely funded through GEF, and focused on capacity building and sector development priorities.

In Sudan there are several government policies and strategies that are complementary to overall climate change goals:

• The Environmental Protection Act has been enacted in 2001 to provide a framework to policies, legislations and executive actions of federal state organs. The objective of the Act is to implement the general policy in collaboration with the governmental departments and the private sector.

• The 25-Year Strategy (2007 – 2033) provides the policy directions to all economic and social sectors, and incorporates the country's environmental strategy, which states clearly that environmental issues must be embodied in all development projects. Examples of key national programs are fuel switching to LPG and solar for cooking in the household sector, dissemination of improved stoves and promotion of water harvesting techniques. Moreover, key intergovernmental/multilateral processes that relates to climate change are: Poverty Reduction Strategy which is linked to climate change mitigation/adaptation issues such as promoting livelihood of the communities.

# Chapter 2
# Institutional Arrangement for the TNA and the Stakeholders' Involvement

## 2.1 TNA team, national project coordinator

Overview for TNA organizational setup

The TNA study in Sudan has been undertaken in an interlinked multi-disciplinary mode. This has been translated into various circles, each of specific responsibility. The details of each circle components are also highlighted.

**Focal Point:** The Higher Council for Environment and Natural Resources (HCENR) acts as a National Focal Point for the UNFCCC and other MEAs and plays an advisory policymaking role with regard to climate-related initiatives within the government. The HCENR hosted TNA in Sudan hosted TNA and its management and coordination including all correspondence and project inquiries through the Project Coordinator.

**The National Coordinator** represents the climate change unit in HCENR and manages the overall process of technology needs assessment.

**National Team:** Composed of 6 national experts, each works closely with a group of stakeholders thus forming working group for each sector. The national team is representing different institutions related to GHG mitigation efforts in Sudan, namely forestry, technology research, conventional and renewable energy, in addition to environmental economics. The national team is responsible for conducting the technical process including data collection, document revision and facilitating stakeholders' consultation. Within the national team, each member is responsible for one sector depending on his/her experience and specialization working in close collaboration with sectoral core stakeholders. Series of meetings and working sessions have been regularly held at a working group level, mitigation group level and at the whole TNA project level (with the adaptation group). The main duties assigned are studying

and investigating the selected sectors with respect to specific points such as GHG emission share, importance and role played in country development, future plans, and existing technologies related to climate change mitigation. Furthermore, the national and sectoral developmental plans have also been revised with the objectives of identifying current and future goals. The designated team leader, with help of team members, is responsible for preparation of documents required for the local workshop, e.g. scoping papers, technology status in addition to assisting project coordinator in preparing regional workshop documents, and finally preparing the project report. The project coordinator and the two team leaders (Adaptation and Mitigation) have attended a regional capacity building workshop organized by the UNEP Risoe Centre and ENDA in Naivasha in June 2011.The knowledge and the experience gained from the workshop have been shared with the rest of the national team.

**Stakeholders:** The stakeholders for the TNA project represent a

wider group of concerned institutions composed of different bodies including:

- Government institutions.
- University and Research Institutes.
- Private sector
- Non-Governmental Organizations.

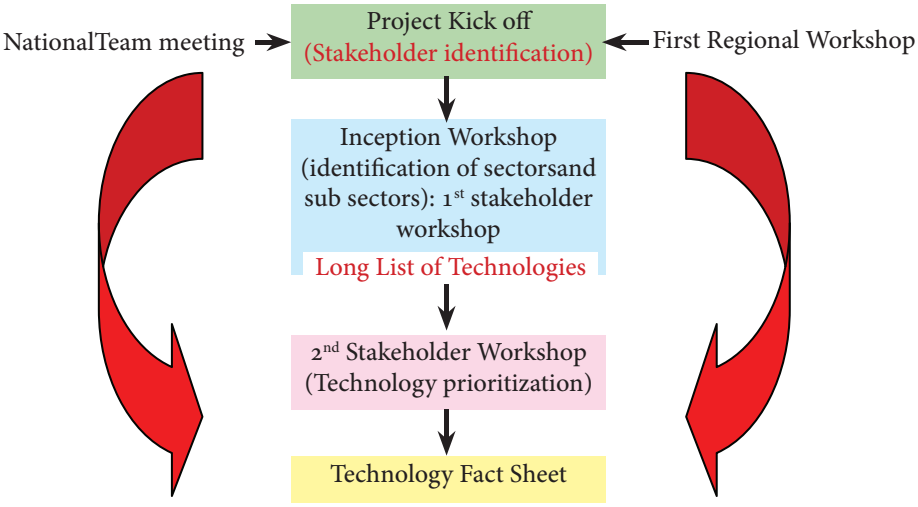
The role of stakeholders are to identify and prioritize/select the optimum technology under Sudan's conditions including providing information to prepare the technology fact sheets. Ultimately, they are expected to facilitate the adoption of such technologies within the context of gaining the ownership of the process. A list of stakeholder institutions can be found in Annex II.

### 2.2 Stakeholder Engagement Process followed in TNA – Overall assessment

The stakeholder engagement process has involved continuous consultation at different phases of the project. The aim is to establish

a sense of ownership towards the project. This process has been undertaken in several steps. The first step has been dedicated to sectors selection during a one day inception workshop on 27 th July, 2011. The workshop's main objective is to select sectors and sub-sectors which are seen to have higher priority in relation to mitigation of the greenhouse gases emission; this process has taken the stakeholders' views in consideration. The inception workshop has been attended by 110 participants representing 45 institutions from government, academia, research and technology institutes, NGOs and private sector (listed in Annex II). The second step has taken place after the national team has prepared a long list of technologies which has been presented and revised during this workshop on 8th February 2012. The technology fact sheets have then been prepared and a short list for technology selection has been generated.

**Figure 1 - Graphical representation of TNA project sequences – Sudan**



# Chapter 3

# Sector Selection

## 3.1 Overview of sectors, GHG emissions status and trends of the different sectors

This chapter displays GHG sources in Sudan as documented in the First National Communication, analysis of these sources in relation to development and hence expected trend of GHG emission. Also, this chapter explains the prioritization process that has been undertaken in order to identify the most prioritized sectors and sub-sectors in terms of potentials for GHG mitigation and development.

The sectors have been identified based on the following:

• Sudan's First National Communication under the United Nations Framework Convention on Climate Change and drafts of the Second National Communication (http://unfccc.int/resource/docs/natc/sudnc1ann.pdf)

• IPCC Guidelines (1996, 2000 and 2003)

• Guidebook for Conducting Technology Needs Assessment for Climate Change

• The development priorities (including the sectoral ones) according to the National Strategic Plan

• Sudan's Millennium Development Goals (MDGs) Document

• National Team members' experience

• Suggestions and confirmations by working groups and stakeholders

### Classification of sectors

The Identified sectors that have been considered in the TNA sector prioritization process are as follows:

• Agriculture, forestry and other land use (AFOLU). These sectors are grouped together as technologies used in the agriculture sector could enhance the GHG mitigation in land use change and forestry

• Energy

• Industry

• Waste management

## 1: Agricultural Forestry and Other Land Use (AFOLU) Sector Agriculture Sub-sector:

According to the First National Communication, agriculture includes two areas, namely crop production and livestock

**a. Crop Production:** Agriculture productivity is declining in most of the cultivable lands. Soil erosion, loss of soil fertility, flooding and loss of biodiversity are increasing in both irrigated and rain fed areas. The situation will become worse in future due to climate change. Emissions from agriculture originate from burning agricultural residues(1) , savannah burning, and soil disturbance, or as a result of applying synthetic fertilizers. Improvements in the agriculture sector through different technologies and practices such as improved seeds or zero tillage is to contribute to both GHG reduction and efficiency improvement of agricultural practices. However, according to the first national communication, emissions from crop production are low compared to those of the livestock, hence crop production has been seen more as an adaptation sector candidate rather than as a mitigation area.

**b. Livestock:** The largest source of methane in the agricultural sector is enteric fermentation and manure management. Sudan is famous for its livestock wealth which is estimated at more than 130 million head. The dung production is estimated to be 4-5 kg/day/animal in open husbandry; in a closed system by 10 kg /day/animal fresh weight. Main challenges facing the livestock sector are their mobile nature and the continuous conflicts between pastors and farmers. Conflicts are mostly initiated by the dryness of the normal pasture, due to many reasons including low fertility of land. Other dimensions of pastoral life are the very low access to basic services such as potable water and electricity. The development plans have highlighted these problems and any mitigation effort should consider this situation. Within the climate change context two areas are sources of GHG

(1) The productivity and production are highly fluctuating every year, hence the rate of carbon sequestration in re-growth is not well proved.

emission, namely manure management and the enteric fermentation:

**• Manure Management**

Besides its GHG emitting issues, manure is also a source of pollution and health hazards. Currently, manure is used in Sudan mainly as
- Building material, which requires dung fermentation in specific processes, therefore it adds to GHG emissions
- For energy provision; this is done through combustion in a very inefficient mode. This process contributes additionally to air pollution.
The suggested solution must inhibit open fermentation and minimize side effects on human beings and environment. This could be met by technologies such as naerobic fermentation (biogas units) which produce heat/electricity, or through compost technology that produces fertilizer. These technologies could reduce GHG emissions and also provide energy, or contribute to improvements of soil characteristics. Both benefits are to positively affect the rural welfare level.

**• Enteric fermentation**

Enteric fermentation is a natural phenomenon. Studies have revealed that this is much related to the genetic formation and the feed rations. In spite of the fact that the open husbandry system is traditionally prevailing in Sudan, the feed control is limited, however, the closed or semi closed system is increasingly growing. Ration and feed control for different objectives such as increasing milk production are already practiced.

**Forestry Sub-sector:**

Forests in Sudan are seen as a multifunction system, for example income from forest products contributes to food security. Forest revenue makes up about 15% of country's hard currency provides about 15% of employment opportunities in rural areas. Sudan's forests provide all requirements of hardwood and about 70% of the national energy consumption. Additionally, forests play an important role in encouraging ecotourism, sustaining biodiversity and soil fixation. The forest situation in Sudan has witnessed high deterioration especially

after separation of Sudan into North and South. Forest cover has been reduced from 46.5% in 1958 to 29.4% in 2005, to reach 11.6% in 2010. The annual removable rate has arisen from 0.74% to 2.2% and the forest density is 200-500 tree/feddan(1) . Forests in Sudan face different challenges in two areas namely, forest management and forest conservation.

- Forest management is concerned with offsetting issues of excessive cutting/destroying forests to satisfy wood need such as energy, furniture etc. as well as to offset activities which affect forest situations such as over-grazing, forests fires etc.
- Forest conservation includes offsetting the encroachment of local communities into forest areas causing soil erosion, land degradation, destruction of habitats, and contributes to desertification and biodiversity loss. This encroachment is founded/ catalysed by extension of mechanized agriculture area, traditional shifting cultivation and implementation of infrastructure projects.

## 2. Energy Sector

The mitigation team has agreed on considering these two main sub-sectors within the energy sector:

- Electricity supply and demand
- Other Fossil fuel consumption which includes transportation and household

### Overview

The electricity service in Sudan is based on two systems; the first system is the national grid that supplies mainly central and eastern Sudan; and the second system is the off-grid system which is composed of isolated small scale thermal power plants that supply remote cities or regions. According to the Ministry of Water Resources and Electricity (MWRE) statistics until 2011 only around 27.8% of the population have been able to benefit from the electricity services. The strategy of MWRE is to concentrate on the household sector and

(1) A feddan (Arabic: فدّان, faddān) is a unit of area. 4200 m2 It is used in Egypt, Sudan, and Syria. The feddan is not an SI unit and in Arabic, the word means 'a yoke of oxen': implying the area of ground that could be tilled by them in a certain time. A feddan is divided into 24 Kirats (175 m²) (source: Wikipedia)

hence to provide access to electricity to over 83% of the population by 2030 and to increase the power usage by 50% in the industrial sector and by 100% in the agricultural sector. The main challenges facing the mitigation measures in the electricity sector are as follows:

**- Expansion need:** The main source for GHG emission in the electricity production area is the burning of fossil fuel (Heavy fuel oil (HFO), Gas oil, Heavy Coke Gas Oil (HCGO), Diesel oil,) in the thermal power plants. Although the electricity demand is increasing, the total $CO_2$ emissions decreased from 1,027 Gg in 1995 (First National Communication) to 471.096 Gg in 2010 due to the introduction of Marowi dam (1250MW). As the hydroelectric option is limited by seasonality factors (e.g., silt accumulation), other power generation options should be considered. These include clean/renewable energy resources and highly efficient power plants. Additionally in the short run improving maintenance plans and upgrading the operation systems could improve the production conditions increase the energy generated quantity hence kW/Litre will be higher. GHG emissions are expected to be reduced.

**- Electricity distribution:** The National Grid (NG) which consists of large hydro power plants and large thermal units has a relatively low emission factor (0.301) due to the significant hydropower contribution. NG covers limited geographical zones mainly in Central and Eastern Sudan. The other parts of Sudan are served by the thermal based off Grid options which have high GHG emissions and higher operation costs compared to NG. Extension of NG is believed to lower the load on the off Grid, and thus lowers the GHG emissions.

**- Demand Profile:** MWRE statistics have revealed that the total consumed power has increased from 5,044.7 GWh in 2009 to 6,026.0 GWh in 2010 (19.5%). The major groups that consume electricity in Sudan are the residential and services sector with around 80% of the total electricity consumed (Table 2). This is mainly utilized to satisfy the lighting and cooling demands. Normal incandescent lamps, that are widely used in Sudan, with an average of 10 lamps per household

and therefore lead to an overall high consumption rate although they have relatively low consumption (60-100 watt) compared to fans or refrigerators (150-250 watt). According to theMWREstatistics the number of contracted consumers is estimated at 1.5 million. Considering the use of about 10 lamps per premises for 4.5 hours a day, the total of 2460 GWh per year is demanded. Based on this analysis energy efficiency options should be highly considered. Additional energy efficiency options could be considered, city and house architecture or utilization of efficient appliances. However, these options have not yet been developed during the stakeholder discussions due to lack of specific data and information.

**Table 2 – Electricity Consumption by Sectors (2009-2010)**

| Sector | Consumption (GWh) | | Share ( % ) 2010 | Evolution 2009-2010*1% |
|---|---|---|---|---|
| | 2009 | 2010 | | |
| Residential | 2,595.8 | 3,093.8 | 51.3 | 19.2 |
| Industrial | 714.3 | 888.4 | 14.7 | 24.4 |
| Agricultural | 192.8 | 978.3 | 16.3 | 407.4 |
| Governmental | 699.0 | 841.2 | 14.0 | 20.3 |
| (Standardized)*2 | 842.8 | 224.3 | 3.7 | (73.4) |
| Total | 5,044.7 | 6,026.0 | 100.0 | 19.5 |

*1Evolution mean what is the improvement done on each sector in 2010 comparing with 2009, it is the percentage increase from 2009 to 2010.

*2 standardized include the commercial and light industrial sectors

**Source: MWRE**

Energy Demand: Energy demand incorporates two areas, namely transportation and households.

Transportation area overview: The statistics of the Ministry of Oil (MO) show that fossil fuel consumption in the transportation sector represents about 65% of the total fossil fuel consumption

in Sudan (Table 3). The biggest consuming transport mode is road transportation with a share of more than 84% of the total consumption in the transport sector.

Due to the increase of economic activities which enhance mobility, improving infrastructure (paved roads) and the reduction of other modes of transportation like railways, the road transport sector is expected to expand further. Hence, it has been given higher attention.

**Table 3 - Petroleum Consumption by sectors in KTOE (2003-2008)**

| Sector/Years | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| Transport | 2241.7 | 2042.8 | 2011.1 | 2381.7 | 2534.1 | 2576.7 |
| Household | 143.1 | 134.4 | 180.2 | 208.2 | 227.0 | 224.1 |
| Industry | 846.0 | 731.4 | 919.1 | 1122.4 | 1200.8 | 1276.8 |
| Total | 3230.8 | 2908.7 | 3110.3 | 3712.4 | 3962.0 | 4077.6 |

**Source: Ministry of Oil**

**Household area overview:** Cooking has been agreed upon to be a major issue in the household energy consumption. Currently, in Sudan LPG is encouraged as an alternative to both biomass and kerosene in order to mitigate indoor pollution and safety hazards. Hence, LPG consumption has increased from 127 thousand tonnes in 2003 to 269 thousand tonnes in 2008.

The mitigation team has suggested 3 options for discussion with the stakeholders:

**- Expansion of LPG Stoves**

LPG is a relatively cleaner fuel from the emission point of view than kerosene (107,900 kg $CO_2$eq/TJ for LPG versus 157,400 kg $CO_2$eq/TJ for kerosene, 112 000 kg $CO_2$/TJ for wood). Hence expansion programmes have always been encouraged. However, within this context, LPG availability is a controversial issue as some opinions connect it to limited supply of crude oil and limited capacity of the local refineries. This situation can end up in having LPG as an imported

commodity. These conditions will have negative implications on its availability and affordability.

**- Expansion of Improved biomass stoves or renewable energy stoves solar cookers (zero emission) or biogas-based burners**

The TNA team has opted to consider this option under the forestry sub-sector rather than the fossil fuel consumption. The main reasons for this are:

- Around 70% of the energy demand in Sudan is covered by biomass. Cutting trees without reforestation constitutes the main reason for lowering the sink level in Sudan. Annual deforestation rate of 0.4 – 0.7 million hectares are stated by various authors such as World Bank 1985, FRA 2005, Daak 2007, Elsiddig et al. 2007). Therefore, using improved stoves will respond to the deforestation issue more than the reduction of emissions from the household sector.
- In Sudan the main executive governmental body responsible for managing improved biomass stoves is the Forests National Corporation (FNC).

**- Changing cooking practices;**

Cooking practices include factors such as meal times, cooking time and type of meals. This option has not been seen to be applicable as it includes cultural issues such as changing meal time and type of food which require long term behavioural and perception changes.

Therefore, the stakeholders have not given the household sector under energy a higher priority as TNA candidate and as result of stakeholders' consultation has not been subjected to further analysis.

**3: Industry Sector**

**Overview**

Industrial production in Sudan contributes to food security, employment opportunities, GDP increase, and export earnings and to the diversity/comprehensiveness of national production. Its growth rate has increased from 7.9% in 2009 to 8% in the end of 2010. Revenues from the manufacturing industry production amounted to US $2.958.5 million corresponding to 9.45% of GDP. Mining

production earnings have grown from 7.69% of GDP in 2006 to 8.89% in 2008. Within this framework, the contribution of large-scale enterprises is 82%. The food and beverage industry contributes by 5.5% to Sudan's GDP. Industry has to overcome many hurdles (e.g., obsolete/archaic equipment and inefficient process designs). This results in exploiting unnecessary energy and raw materials. This situation is intensified by the low level of technical know-how in relation to process optimization. At the institutional level there is an absence of regulation that mandates energy, resource audit or control of equipment standards. Therefore, mitigation efforts in the industrial sector have to be directed to fill these gaps.

**GHG emissions sources in industry**

GHG emissions in the industrial sector are due to two main sources, namely:

**- Energy:** especially at off grid/self-status, is the main source for GHG emissions, whether for electricity, heat or steam/hot water satisfaction. According to the Forest National Corporation in 1994 the industrial sector has utilized 7.6% of the total biomass specifically fuel wood (1,050,174 m3) and charcoal (11,673 m3). In addition, MWRE has estimated that in 2010 14.7% of the electricity consumption in the county has been used in the industry sector with an increased rate of 24.4% compared to the previous year. Regarding fossil fuels, according to MO statistics, industrial consumption can be estimated at around 30% of total consumption (e.g., in 2008 it was 1276.8 out of 4077.6 million tonnes). This type of emission is a cross-cutting issue for all industries but for the sake of this work, further analysis is only to be undertaken for growing industries.

**- Process:** Specific process (e.g., during cement formation) has been considered as the main source of GHG emissions. Although industry have lower emission compared to other emissions sources in Sudan, but some types of industry are growing and are anticipated to further growth in the future. Below is an overview of the main industrial activities in Sudan.

**Food Industries**

This sector is continuously growing and the increase is expected to continue in the future as a result of population increase and comparatively `encouraging investment` process. This sector is generally characterized by inefficient energy systems e.g. old boilers, high losses throughout the different processes e.g. non-insulated pipes and very poor housekeeping. A special criterion for the food sector is its relatively high need for steam and hot water which calls for special consideration at the energy side. This could include better housekeeping and introduction of renewable energy sources. Currently, many industries are considering the use of LPG as an alternative since it does not require major modifications to the existing plant. This alternative is especially attractive when combined with more efficient boilers that use dual fuel. The dual characteristic will minimize the risk of LPG scarcity.

**Minerals and Non-Mineral Product Industries**

**- Cement Industry:** This has been one of the most rapidly growing industries in the last few years. The production has increased from 621.7 thousand tonnes in 2009 to 2,112.6 thousand tonnes in 2010. Accordingly, investment in the cement industry is estimated at US$ 1,995 Million. Cement industry is interlinked with all infrastructure projects and housing strategies. By definition, the cement industry is energy consuming; it contributes to GHG emissions during the production process itself. The main mitigation options involve energy reforms such as energy saving techniques or using less polluting fuels like waste tyres and process modification, e.g. by using pozzolans[1] .

**- Other Industries:** This includes ceramic, gypsum and brick industries. The main emission sources in these industries are fossil fuel combustion to satisfy their energy needs. Currently,

(1) A pozzolan is a siliceous or siliceous and aluminous material which, in itself, possesses little or no cementitious value but which will, in finely divided form and in the presence of water, react chemically with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties. The broad definition of a pozzolan imparts no bearing on the origin of the material, only on its capability of reacting with calcium hydroxide and water. (source: Wikipedia)

energy supply in the ceramic industry is satisfied through LPG and electricity. LPG consumption is estimated to be about 1500-1800 tonne/month. The main problem that this sub-sector faces is the high prices of electricity and LPG. Within the gypsum industry, the main GHG emission comes from the energy side. Currently, the industry uses fossil fuel and wood for the heating step (one of the steps in the gypsum making process), hence alternative heat sources are encouraged. Again, here LPG seems to be a suitable option from a technical point of view. Considering the building brick industry, there are about 800 traditional units and four factories with a total production of 455 million blocks/ year. However, in 2002 the demand is estimated at 1500 million blocks/ year. Therefore, energy is required in this industry to satisfy the demand gap. The common energy forms used include firewood for traditional brick and fossil fuel for factories. The factories need is estimated at 2000 tonnes/ factory in addition to about 40 thousand litre of oil for ignition. The main mitigation options considered are utilizing alternative fuel or substituting the fire brick with other products such cement blocks.

**GHG emission Status in Sudan**

The main reference used in preparing this part is the First National Communication (2003) in which an inventory has been carried out using 1995 as the base year. It indicated that the total national emissions amounted to 89,220 Gg $CO_2$ equivalents. Table 4 shows the summary emission levels, by sectors and gases, for the national GHG inventory in the year 1995.

**Table 4 - Greenhouse Gas Emissions: Sudan; 1995 (Gg)**

| GHG Source & Sink Categories | Net $CO_2$ Emitted | $CH_4$ | CO | $N_2O$ | Others (NOx, NMVOC, HFCs) | Total $CO_2$-eq (Gg) |
|---|---|---|---|---|---|---|
| Energy | 4,328 | 150 | 2,104 | 1 | 323 | 16,706 |
| Industrial Processes | 173 | 0 | 0 | 0 | 16 | 173 |
| Agriculture | 0 | 1,713 | 388 | 30 | 46 | 50,083 |
| Land-use change & Forestry | 15,577 | 90 | 787 | 1 | 23 | 21,184 |
| Waste | 0 | 33 | 0 | 1 | 1 | 1,055 |
| Total National Emissions and Removal | 20,077 | 1,985 | 3,280 | 33 | 409 | 89,220 |
| Total $CO_2$ emissions from biomass | 21,936 | 0 | 0 | 0 | 0 | 21,936 |

**Source: Sudan's First National Communication under UNFCCC – Sudan (HCENR), 2003.**

## Analysis of GHG emission by Gas

Figure 2 reveals that the main gas emitted is carbon dioxide ($CO_2$) (20,077 Gg) which constitutes more than 75% of the 1995 total GHG emission, followed by carbon monoxide (3,280 Gg, 13%) and methane (1,985 Gg, 8%). Small amounts of other gases such as NMVOC, $NO_X$, $N_2O$, have also been recorded.

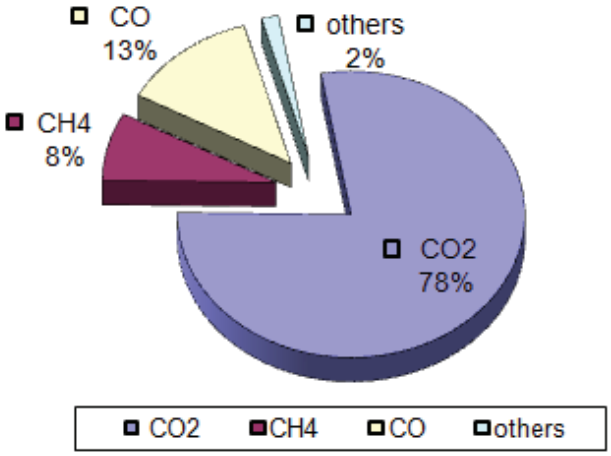



**Figure 2 Percentage Contribution by Gas to the Total GHG Emissions in terms of $CO_2$ equivalents in 1995**

**Analysis of GHG emissions by Sector**

In Figure 3 it is clear that the contribution of the sectors considered in the inventory study varies considerably.

Land-use change and forestry, instead of constituting a $CO_2$ sink, are found to be the main emitter of $CO_2$, that mounted to 15,577 Gg or more than 75% of total $CO_2$ emitted. In turn, they are the second contributor for the aggregated GHG emissions in $CO_2$ (equivalent 24%, 1995).

In the energy sector, $CO_2$ emissions from fossil fuels are estimated at 4,328 Gg – about 22% of the $CO_2$ total. The energy sector emits the major share of $CO_2$ and NMVOC (3280 Gg and 274 Gg respectively). Its share contribution in the aggregated GHG emissions in $CO_2$ equivalent in 1995 is 20%. It is important to note that biomass energy is estimated to emit about 21,936 Gg of $CO_2$, constituting more than 80% of total $CO_2$ emitted in the energy sector, which is consistent with the energy balance of the inventory year. However, emissions from biomass energy have not added to total energy emissions, because it accounts, instead, to the land-use change and forestry sector.

Agriculture is the dominant sector in $CH_4$ emissions; it is estimated

to contribute 1,713 Gg, or more than 86% of total $CH_4$ emissions in Sudan. Its share in the aggregated GHG emissions in $CO_2$ equivalent in 1995 is (56%), and it is the largest contributor.

GHG emissions from the industrial process sector are mainly $CO_2$. Their contribution to the aggregated GHG emissions in $CO_2$ equivalent in 1995 is less than 1%.

The results of GHG emitted from different types of waste management in Sudan showed that Methane is clearly the most important gas. The key waste sources are solid waste, domestic/commercial wastewater and industrial waste water and sludge. However, their contribution in the aggregated GHG emissions in $CO_2$ equivalent in 1995 is only about 1%.

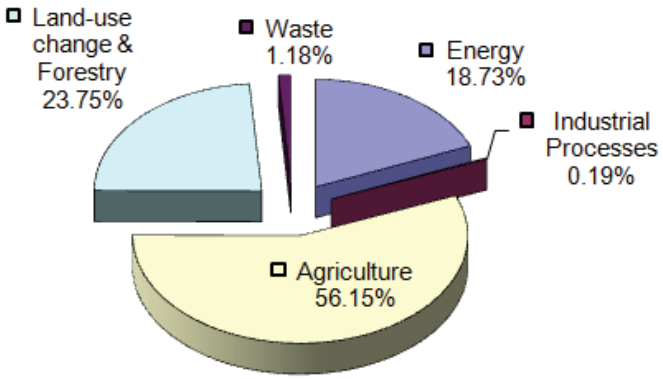



**Figure 3 Percentage Contribution by Sector to the Aggregated GHG Emissions in $CO_2$ equivalent in 1995 (Inventory)**
**Source: First National Communication (2003) and compiled by the National Mitigation Team Analysis of Sectors in relation to**

**Development priorities**

The next step after identifying sectors with high GHG emission is to carry out an analysis of these sectors from the development point of view. The analysis includes assessing their social and environmental benefits which include issues such as contribution to basic needs (food, welfare services).

Following these criteria and considering the above selected sectors it could be seen that energy contributes much to services by providing electricity which is a crucial need for the different aspects of development. Contribution to GDP in terms of export increase or providing employment is relatively low. Forestry, agriculture and other land use (AFOLU) provide more than 70% of Sudan's employment chances and produce major exports commodities. Furthermore, development of the AFOLU sector is highly connected to food security. Therefore; Sudan's National Strategic Plan calls for giving special attention to the AFOLU sector after the oil boom, many projects have been rehabilitated or established with special emphasis on environmental conservation and substantial natural resource management. In this context, forests and other wood land areas that help combat desertification and sustain biodiversity have been given considerable attention.

On considering industry and waste sectors, it has been found that although both have minimum contributions to GHG emissions, industry plays an important role in the economics by encouraging export, providing food commodities, support employment etc. Under Sudanese conditions, it could be fairly stated that in spite of the negative aspects associated with waste management such as health and environment hazards and the economic and environmental benefits of some waste technologies such as recycling, industry should be given higher priority when considering the comparative importance of the two sectors.

**Table 5: Developmental Analysis of Main GHG Emission Sectors**

| Sector | Share in Emission ( Inventory data) | Contribution to Socio-/ Environmental Benefits | Level of Economic Benefits | |
|---|---|---|---|---|
| | | | Employment | GDP |
| Energy | High | Services | Low | Low |
| Agriculture, Forestry and Other Land Uses | Very high | Food security, biodiversity, desertification, | High | High |
| Industry | Low | Food security | Low | Moderate |
| Waste | Very low | Pollution, health hazard and resources conservation | Very low | Very low |

## 3.2 Process criteria and results of sector/sub-sector selection Prioritization Process (PP):

The process started by consulting the relevant documents, followed by identifying development priorities with focus on potential benefits to the specific sectors and sub sectors. This step followed discussions within the mitigation team and consequently agreeing on the relevant criteria for the sectors prioritization. The second level of prioritization has been done to select (sub-) sectors. The overall objective of this step is to identify areas where intervention would make a strong contribution in meeting the identified development priorities beside its ability to reduce GHG emissions/increase sink. The final decision on the sectors has been taken in close consultation with the stakeholders during the inception workshop.

### Criteria used

The criteria used for identifying a TNA candidate sector are as follows:

- Contribution to greenhouse gas emission.
- The role in meeting the development priorities in the context of

sustainable development in Sudan.

• Future development and GHG emission projection.

**Results of Sectors/sub-sectors selection**

The above analysis (table 5) resulted in identifying the following **sectors:**

• Agricultural, Forestry and Other Land Use (AFOLU)

• Energy

• Industry

An overview of the sectors and sub-sector selection procedure can be seen in figure 4 which shows the steps followed in the selection process.

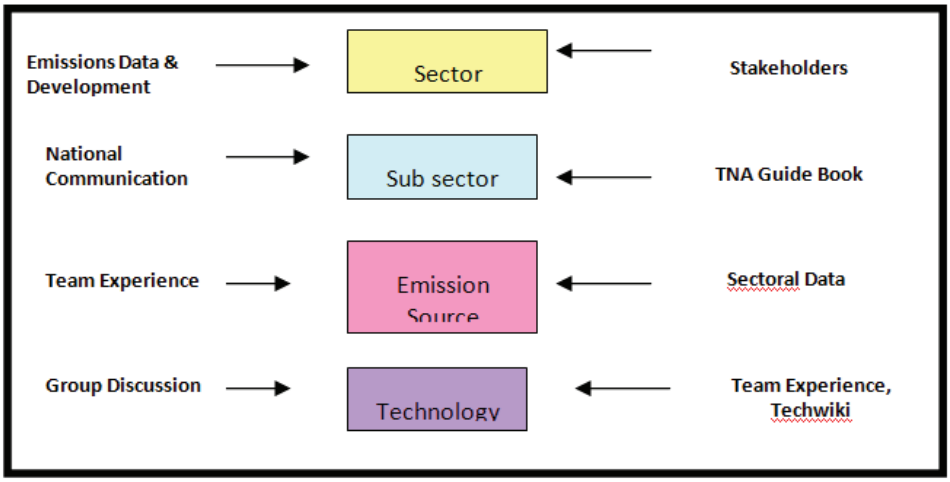



**Figure 4 Sector Selection Process**

The results of the prioritization process are summarized in table 6 which shows the sector, sub-sectors and areas of much consideration.

## Table 6 - Summary of the prioritized sub-sectors/ areas

<table>
<tr><th colspan="4">AFOLU Sector</th></tr>
<tr><td colspan="2">Sub-Sector: Agriculture</td><td colspan="2">Sub-Sector: Forestry</td></tr>
<tr><td colspan="2">Livestock</td><td rowspan="2">Forest Conservation</td><td rowspan="2">Forest management</td></tr>
<tr><td>Manure management</td><td>Enteric fermentation</td></tr>
</table>

| Energy Sector | |
|---|---|
| Sub-Sector: electricity supply and demand | Sub-Sector: other Fossil fuel consumption |
| Thermal electricity r generation and electricity demand management | Transportation |

| Industry Sector | |
|---|---|
| Sub-sector: Mineral (cement and other construction material industry) and construction industries | Sub-Sector: other Fossil fuel consumption |

# Chapter 4
# Technology Prioritization for Energy Sector

## 4.1 GHG Emissions and Existing Technologies of Energy Sector

The main GHG emission sources in this sector are the energy industries with 1,027 Gg of $CO_2$ and transport with 1,923 Gg of $CO_2$. Other consumption area includes residential energy consumption which produces 617Gg of $CO_2$.

The main existing technologies are the use of renewable energy-based technologies especially in the electricity production and consumption sub-sectors.

## 4.2 An overview of Possible Mitigation Options in the Energy Sector and their Mitigation Benefits

### Electricity supply and demand

For the supply side the main goal is to reduce the consumption of the fossil fuel used in thermal power plants. This could be achieved through utilization of renewable energy technologies such as hydro, solar, wind and geothermal. On comparing solar and wind to geothermal, we could find that geothermal has higher plant availability and shorter transformation cycles, thus higher efficiency. Specifically (MWRE) calculation assumes 90% availability for geothermal, and an average of 29-30% for wind and solar (photovoltaic and CSP). From the potential point of view, geothermal potential in Sudan is estimated to be 500 MWe until 2030 (according to Kema Study). On the other hand, wind profile in Sudan is not favouring large power plants (limited areas of wind speed 7m/s and above). For solar energy, in spite of high solar radiation 6.4 kW/m2/day, but the high ambient temperature of >35°C is a limiting factor for photovoltaic systems. Another factor is the scattered solar radiation caused by atmospheric dust which reduces solar system efficiency up to 40%. For real development, solar is very expensive and to a great extent is still a new technology. In general, the stakeholders opinion is that MWRE can consider building demonstration plants for solar and

wind but these projects will be limited. Instead, real reduction in GHG (alternative to thermal) can only be achieved through bigger projects such as geothermal. For stakeholders geothermal is a commercial technology with extensive technical know-how and the high production expected can counter the high costs for connection to NG.

Considering the demand side it has been concluded that that the residential sector is the major consuming sector for electricity. The consumption is projected to increase as more people are using more appliances. A large share of this consumption can be identified as unnecessary, due to the use of inefficient appliances. In addition, the stakeholders have mentioned that the city and house design is affecting the consumption especially at cooling and lighting systems. However, improvement of `city and house architecture` is looked into as a vague and not specific option. As a result of hard discussions, about reducing demand versus increasing supply, the main mitigation options considered is labelling the appliances. This system is envisaged to control the import of high energy consuming devices. Given the high electricity consumption for household lighting, special emphasis has been put on lamp bulbs (lighting). It has been calculated that if the CFL lamps were replaced for only 6 million lamps then a saving of 835,200.00 MWh equivalents to 251,395.20 GHG reduction ($CO_2$/year) could be attained.

**Transportation**

Transportation is a very crucial service in a vast country like Sudan. The main option for transportation is fossil fuel vehicles. One of the main consuming sectors is private transportation which is mainly done through cars or small buses, which leads to high emissions per person per km. The major mitigation options have been looked into as follows:

• Fuel switch: This option affects GHG emitted/m3 of fuel. It requires switching/blending of fossil fuels with cleaner fuel such as bio- fuel or LPG with the objective of reducing the total GHG emissions

from the vehicle. In this context, another factor that encourages the utilization of bio-fuel in Sudan is the establishment of the national project for bio- fuel with the overall objective of replacing the politically sensitive petroleum products. However, this option still needs extensive research programmes directed towards identification of the local values required for adopting a feasible implementation plan.

• Mass transport: This option (Vehicle type) affects fuel consumption/ person, hence, the total GHG emitted for group of people in (per person/per Km). It involves encouraging the utilization of mass transport system verses private cars. It is found that the most common vehicles used in big cities of Sudan for person transport are either private cars or small buses with the capacity of less than 25 persons. This situation results in higher emission of GHG than that is expected when big buses of 60 + are used. It could be estimated that buses had 1/60 of the private car's emission per passenger/km, if fully occupied. A mass transportation system seems to be a very applicable and feasible option as it reduces pollution. In addition, mass transportation is expected to reduce road congestion and save travel time.

• Road building and design and driving mode: This factor includes in turn different sub factors such as driving style, traffic rules and road design which affects fuel consumption/km of roads. Some sub-factors are identified as more or less vague and not well defined such as driving style, and some issues such as traffic laws and street modification are expected to require complex financial and legal measures. Nevertheless, the sub-factor road design has been considered for the ranking process. It has been identified as a long term but effective factor. Considering a current average mileage of about 5 km/litre then any improvement towards attaining the car industry mileage of 50-70 km/gallon will have positive similar effects on GHG.

### 4.3 Criteria and process of technology prioritization

Multi-criteria analysis has been used as a tool for prioritizing the suggested technologies. This has been done using an excel sheet provided by the team members. The criteria of selection adopted have been similar for all sectors and included the technology GHG reduction potential and second group of criteria related to developmental aspects (i.e., environmental, social and economic). Any technology is scored from 0 to 10 for GHG reduction and from 0 to 15 for the development criteria (i.e., 0 to 5 for social; 0 to 5 for environmental and 0 to 5 for economic). The total is therefore equal to 25.

In the second workshop, the stakeholders agreed on indicators that are most suitable for each criterion. The ranking process in the energy sector has been undertaken according to the following indicators. As of result of absences of quantitative values for the different criteria more emphasis has been given to stakeholder's opinion based on their experience.

**In electricity generation the indicators used are as follows:**

**• GHG reduction potential**

Criterion 1 (Cr 1)**:** GHG emission reduction

This criterion deals with how much GHG is expected to be reduced on applying the specific technologies at a reasonable scale. In this context, geothermal has been given higher priority as it provides nearly zero emission and has high replacement potential. CFL has also been highly ranked as it highly reduced quantities of GHG emitted

**• Environmental Criteria**

Criterion 2 (Cr 2): Pollution minimization

This criterion relates to the overall pollution level resulting from the power plant. Hence, due to hot water pollution, geothermal has been ranked lower in this criterion. On the demand size, it is connected to health hazards associated with utilization; hence, cooling system

(e.g., Air Conditioning) has been ranked lower as a result of health hazards with which is associated (e.g., respiratory system dieses).

**• Social criteria**

Criterion 3 (Cr 3): Contribution to services
On the supply side, this criterion deals with the contribution to increased generation (service level increase). So, geothermal has been ranked higher due to its high availability factor. On the demand side, lighting has been looked into as an important factor in family welfare so CFL is highly ranked.

**• Economic criteria**

Criterion 4 (Cr4): Contribution to the reduction of State expenses by erecting high profitable power plants
On supply side, technologies that have a long lifetime span and low costs are encouraged. All technologies have equally ranked because there is no significant difference between them to stakeholders.
On the demand side, the effect of the technologies on electricity bill reduction has been considered as an important indicator. The stakeholders have concluded that the high numbers of lamps/ household in Sudan compared to the number of Air conditioning system results in equal electricity cost.

**In Transportation the indicators are as follows:**

**• GHG reduction potential**
Criterion 1 (Cr1)
Fuel switch, in particular bio fuel, is highly ranked due to its biomass sequestration nature.

**• Environnemental criterion**
(Cr2): Pollution minimization
Within this criterion it is clear that mass transport always generates less pollution per km compared to the car, even if car consumption of fuel/km is lower than the bus, the pollution per person remains high. Bio-fuel technology has highly been scored as it contributes to the environmental conservation.

• **Social criteria/Criterion**

(Cr3): Contribution to services

The cost of private car is relatively high in Sudan, and hence, mass transportation facilitates the public mobility. In this context, stakeholders have highly scored the bio-fuel in this criterion for its contribution to employment.

• **Economic criteria/Criterion**

(Cr 4): Total cost needed and profit expected (investment, O&M, profit etc.)

Mass transport is cheaper compared to road design and building and to fuel switch options.

Bio-fuel based transportation is considered a new technology therefore requires additional economic efforts compared to the two other options.

After scoring the technologies against the 4 criteria and during the stakeholder consultations, the standardization and the weighting steps have been undertaken and led to the results presented in tables 7 and 8 below.

## Table 7 - Multi - Criteria Analysis for Electricity generation and consumption sub-sector– Sector Energy

**MCA Energy**

**Electricity generation and consumption**

**Scoring**

| | | Criteria 1 Cr 1 | Criteria 2 Cr 2 | Criteria 3 Cr 3 | Criteria 4 Cr 4 |
|---|---|---|---|---|---|
| Tech 1 | CFL | 9 | 4 | 4,5 | 4 |
| Tach 2 | Geo | 9 | 2 | 5 | 4 |
| Tech 3 | Wind | 8 | 3 | 4 | 4 |
| Tech 4 | AC | 8 | 3 | 3 | 4 |
| Tech 5 | CSP | 8 | 3 | 3 | 4 |
| Tech 6 | SPV | 8 | 3 | 3 | 4 |

**Standardization**

| | | Criteria 1 Cr 1 | Criteria 2 Cr 2 | Criteria 3 Cr 3 | Criteria 4 Cr 4 |
|---|---|---|---|---|---|
| Tech 1 | CFL | 9 | 4 | 4,5 | 4 |
| | | 1 | 1 | 0,75 | 1 |
| Tach 2 | Geo | 9 | 2 | 5 | 4 |
| | | 1 | 0 | 1 | 1 |
| Tech 3 | Wind | 8 | 3 | 4 | 4 |
| | | 0 | 0,5 | 0,5 | 1,00 |
| Tech 4 | AC | 8 | 3 | 3 | 4 |
| | | 0 | 0,5 | 0 | 1 |
| Tech 5 | CPS | 8 | 3 | 3 | 4 |
| | | 0 | 0,5 | 0 | 1 |
| Tech 6 | SPV | 8 | 3 | 3 | 4 |
| | | 0 | 0,5 | 0 | 1 |

**Weighting**

| | | Criteria 1 Cr 1 | Criteria 2 Cr 2 | Criteria 3 Cr 3 | Criteria 4 Cr 4 | Total | |
|---|---|---|---|---|---|---|---|
| Weight - Absolute | | 10 | 5 | 5 | 5 | 25 | |
| Weight - Relative | | 0,4 | 0,2 | 0,2 | 0,2 | 1 | |
| Tech 1 | CFL | 1 | 1 | 0,75 | 1 | | Ranking |
| | | 0,40 | 0,20 | 0,15 | 0,20 | 0,95 | 1st |
| Tach 2 | Geo | 1 | 0 | 1 | 1 | | |
| | | 0,40 | 0,00 | 0,20 | 0,20 | 0,80 | 2nd |
| Tech 3 | Wind | 0 | 0,5 | 0,5 | 1 | | |
| | | 0 | 0,10 | 0,10 | 0,20 | 0,40 | 3rd |
| Tech 4 | AC | 0 | 0,5 | 0 | 1 | | |
| | | 0 | 0,10 | 0,00 | 0,20 | 0,30 | 4th |
| Tech 5 | CPS | 0 | 0,5 | 0 | 1 | | |
| | | 0 | 0 | 0 | 0 | 0,30 | 4th |
| Tech 6 | SPV | 0 | 0,5 | 0 | 1 | | |
| | | 0 | 0,10 | 0 | 0,20 | 0,30 | 4th |

Where: CFL = Compact Fluorescent Lamps; GEO= Geothermal '; Wind = Wind Turbines; AC= Energy Saver Air Conditioner Systems; CPS = Concentrated Solar Power; SPV = Solar Photovoltaic

**Table 8 - Multi - Criteria Analysis for Transportation – Sector Energy**

**Transport**

**Scoring**

| | | Criteria 1 Cr 1 | Criteria 2 Cr 2 | Criteria 3 Cr 3 | Criteria 4 Cr 4 |
|---|---|---|---|---|---|
| Tech 1 | MS | 8 | 4 | 4 | 5 |
| Tach 2 | FS | 8 | 5 | 4 | 3 |
| Tech 3 | RBD | 6 | 3 | 5 | 4 |

**Standardization**

| | | Criteria 1 Cr 1 | Criteria 2 Cr 2 | Criteria 3 Cr 3 | Criteria 4 Cr 4 |
|---|---|---|---|---|---|
| Tech 1 | MS | 8 | 4 | 4 | 5 |
| | | **1** | **0,5** | **0** | **1** |
| Tach 2 | FS | 8 | 5 | 4 | 3 |
| | | **1** | **1** | **0** | **0** |
| Tech 3 | RBD | 6 | 3 | 5 | 4 |
| | | **0** | **0** | **1** | **0,5** |

**Weighting**

| | | Criteria 1 Cr 1 | Criteria 2 Cr 2 | Criteria 3 Cr 3 | Criteria 4 Cr 4 | Total | Ranking |
|---|---|---|---|---|---|---|---|
| Weight - Absolute | | 10 | 5 | 5 | 5 | 25 | |
| Weight - Relative | | *0,4* | *0,2* | *0,2* | *0,2* | *1* | |
| Tech 1 | MS | 1 | 0,5 | 0 | 1 | | |
| | | **0,4** | **0,1** | **0** | **0,2** | **0,7** | 1st |
| Tach 2 | FS | 1 | 1 | 0 | 0 | | |
| | | **0,4** | **0,2** | **0** | **0** | **0,6** | 2nd |
| Tech 3 | RBD | 0 | 0 | 1 | 0,5 | | |
| | | **0** | **0** | **0,2** | **0,1** | **0,3** | 3th |

WhereMS=Mass Transport (buses); FS= Fuel Switch; RBD= Road Building and Design

### 4.4 Results of technology prioritization

#### Electricity

The MCA resulted in selecting the compact fluorescent lamps technology (CFL) as a priority within electricity supply and demand area.

#### Transportation

The results of the MCA place the mass transport technology (buses; 60+) as the first priority within the transportation sub sector. Therefore the two technologies selected in the energy sector are the CFL and the Mass Transport/Buses (+60).

# Chapter 5
# Technology Prioritization for AFOLU Sector

## 5.1 GHG Emissions and Existing Technologies for AFOLU Sector

The main emission sources in the agricultural sub-sector are enteric fermentation and manure management in the livestock, representing 1,632 Gg and 62 Gg of $CH_4$ respectively amounting to 34,272 Gg $CO_2$eq and 1,302 Gg $CO_2$eq respectively.
Within the forestry sector, a total of 15,577 Gg of $CO_2$ have been emitted as a result of change in forests and other woody biomass stock and forests and grassland conversion. Emissions from forestry represent 75% of total $CO_2$ emitted in Sudan. The main current technology involves afforestation and proper land management.

## 5.2 An Overview of Possible Mitigation Technology Options in AFOLU Sector and their Mitigation Benefits

### Forestry

**The mitigation options technologies can be classified into two main groups:**

Technologies related to the afforestation option aim at increasing the sequestration rate. This option includes the application of mechanized systems to replace the manual-labour system used in the different steps of land preparation, tree plantation etc. Alternatively, planting fast growing species with higher sequestration rate is an option to reduce $CO_2$ emissions. However, the introduction of new suitable species with high sequestration rate is a complicated option and requires considering different aspects such as water requirements, soil type, matching to the ecosystem, socio economics benefits, etc. Hence this option has not been favoured.
The other options is related to the management technologies which tend to reduce the GHG emissions resulting from the forest utilization such as establishing fire line to control haphazard forest fires or utilization of improved stoves to reduce forest cutting. Considering

the energy issues main fuel wood consumption sector, it has been found that most traditional stoves are inefficient because of their improper design and material selection. Improved stoves that have better efficiency or stoves that use other fuels such as agricultural residues have been suggested. In addition, biogas based burner or solar cooker have also been considered. As result of stakeholders consultation, preference has been given to the commonly known "improved mud stove" (Butana) due to its simplicity and wide utilization in the rural and semi urban areas of Sudan.

**Livestock**

The mitigation technology available for manure management includes aerobic or anaerobic fermentation processes. Anaerobic process is conducted through either biogas or compost reactors that prevent releasing fermentation gases (mainly methane) to the open air. Both anaerobic paths reduce GHG emission and produce fertilizer. The biogas path provides an extra clean energy source that contributes to the provision of light, heat and the reduction of fuel wood uses.

Regarding the enteric fermentation which is a natural process, the mitigation options available are either feed change or improved digestion process by modifying the genetic formation through breeding and inter crossing. However, within the Sudanese context, improved feeding practices (ration changes) or the use of specific additives that suppress methanogenesis (the chemical process that creates methane) will be only more suitable than breeding for closed husbandry systems. When dealing with open systems, breeding can be more suitable as the interference only occurs once; then it goes by itself. However, from an application span and technical know-how perspective, ration change has been considered for application as presented in the fact sheet.

## 5.3 Criteria and Process of Technology Prioritization

### Forestry

The designed methodology as explained in the energy sector has also been adopted in the AFOLU, hence, the criteria is the increase of GHG sequestration/reduction of GHG emission and developmental criteria namely social, economic and environmental. Under these criteria the following indicators have been selected.

In forestry the criteria and related indicators are as follows:

**• GHG reduction potential**

Criterion 1: GHG emission reduction/carbon sequestration:

For this criterion the Improved Stoves (IS) is firstly ranked because it saves existing sink in immediate term. Other technologies tend to establish new forest stands which needs time. Tractor technologies have secondly been ranked due to the fact that they enhance forest operation and practices in a relatively short time.

**• Environmental criteria**

Criterion 2: forest environmental benefits (non forest products, pollution reduction, sustaining biodiversity):

Within this criterion, IS has highly been ranked because it conserves trees immediately and hence sustains the forest function. The tractors come second as they have relatively quicker effects than the other technologies. Water technology has highly been ranked as it improve the overall environment of the region.

**• Social criteria**

Criterion 3: Contribution to improved livelihood patterns and welfare of local communities:

Stakeholders consider that supporting rural communities can be accomplished by increasing non-wood benefits, (e.g., gum, fibre, dye, medicine and food). Keeping forest stands will partially contribute to rainfall pattern and soil fertility. This results in local people having higher levels of welfare. However, tractors have low been ranked as they are likely to reduce employment. In addition, water collection points resulting from water technology may attract outsiders thus initiating conflicts so it has lower been ranked.

**• Economic criteria**

Criterion 4: Total cost of establishing the project without considering the technology itself:

According to the discussions carried out, this issue can be tackled as follows: All four chosen technologies, except the water harvesting technology are already known in Sudan's forestry sector. In fact, several projects using these technologies have already been established. Thus the costs to establish a new project are relatively low and hence highly ranked; only the water shed technology is a new project and needs more effort when establishing it.

**In livestock the criteria and related indicators are as follows:**

**• GHG reduction potential**

Criterion 1: GHG emission reduction:

Anaerobic fermentation has highly been ranked as it is a proved technology which reduces the GHG significantly while the others are more or less under research.

**• Environmental criteria:**

Criterion 2: Minimization of pollution and health risks:

Anaerobic fermentation will reduce the health risks caused by the untreated dung. The side effects of ration change and breeding technologies are not well known so they may cause health risk.

**• Social criteria**

Criterion 3: Contribution to local community welfare and services level:

It is the stakeholder agreement that erecting biogas units for anaerobic fermentation to produce combustible gas can support the provision of electricity and cooking fuel for the community.

**• Economic criteria:**

Criterion 4: Contribution to the local economy in terms of improving local economy and jobs creation.

It has been agreed upon that provision of services such as energy from anaerobic digesters, compost from aerobic digesters will improve the local economy so they have highly been ranked. The same thing for the Improved feed ration technology because it incorporates other

feed additives that would improve the livestock health and growth.

**Table 9 - Multi - Criteria Analysis for Forestry Category - AFOLU sector**

**Scoring**

| | | Criteria 1 | Criteria 2 | Criteria 3 | Criteria 4 |
|---|---|---|---|---|---|
| | | Cr 1 | Cr 2 | Cr 3 | Cr 4 |
| Tech 1 | AUM | 8 | 4 | 2 | 4 |
| Tach 2 | WHSWT | 4 | 3 | 2 | 3 |
| Tech 3 | MFSDF | 5 | 4 | 3 | 4 |
| Tech 4 | Compost | 2 | 3 | 4 | 4 |
| Tech 5 | IS | 9 | 5 | 5 | 4 |

**Standardization**

| | | Criteria 1 | Criteria 2 | Criteria 3 | Criteria 4 |
|---|---|---|---|---|---|
| | | Cr 1 | Cr 2 | Cr 3 | Cr 4 |
| Tech 1 | AUM | 8 | 4 | 2 | 4 |
| | | 0,86 | 0,5 | 0 | 1 |
| Tach 2 | WHSWT | 4 | 3 | 2 | 3 |
| | | 0,29 | 0 | 0 | 0 |
| Tech 3 | MFSDF | 5 | 4 | 3 | 4 |
| | | 0,43 | 0,5 | 0,33 | 1 |
| Tech 4 | Compost | 2 | 3 | 4 | 4 |
| | | 0 | 0 | 0,67 | 1 |
| Tech 5 | IS | 9 | 5 | 5 | 4 |
| | | 1 | 1 | 1 | 1 |

**Weighting**

| | | Criteria 1 | Criteria 2 | Criteria 3 | Criteria 4 | | |
|---|---|---|---|---|---|---|---|
| | | Cr 1 | Cr 2 | Cr 3 | Cr 4 | Total | |
| Weight - Absolute | | 10 | 5 | 5 | 5 | 25 | |
| Weight - Relative | | 0,4 | 0,2 | 0,2 | 0,2 | 1 | |
| Tech 1 | AUM | 0,86 | 0,5 | 0 | 1 | | Ranking |
| | | 0,34 | 0,10 | 0,00 | 0,20 | 0,64 | 2nd |
| Tach 2 | WHSWT | 0,29 | 0 | 0 | 0 | | |
| | | 0,11 | 0,00 | 0,00 | 0,00 | 0,11 | 5th |
| Tech 3 | MFSDF | 0,43 | 0,5 | 0,33 | 1 | | |
| | | 0 | 0,10 | 0,07 | 0,20 | 0,54 | 3rd |
| Tech 4 | Compost | 0 | 0 | 0,67 | 1 | | |
| | | 0 | 0,00 | 0,13 | 0,20 | 0,33 | 4th |
| Tech 5 | IS | 1 | 1 | 1 | 1 | | |
| | | 0,4 | 0 | 0,2 | 0 | 1 | 1st |

Where AUM =Afforestation Using Machines; WHSWT= Water Harvesting &Soil Working Techniques; MFSDF= MobileFencing for Sand Dune Fixation Compost = Composting of Forest Residues; IS = Improved Stoves

## Table 10 - Multi - Criteria Analysis for Livestock Category – AFOLU Sector

**Scoring**

| | | Criteria 1 Cr 1 | Criteria 2 Cr 2 | Criteria 3 Cr 3 | Criteria 4 Cr 4 |
|---|---|---|---|---|---|
| Tech 1 | **IF** | 8 | 3 | 4 | 4 |
| Tach 2 | **DA** | 4 | 2 | 3 | 2 |
| Tech 3 | **Breed** | 5 | 3 | 3 | 3 |
| Tech 4 | **ANT** | 9 | 4 | 4 | 4 |
| Tech 5 | **AT** | 6 | 3 | 3 | 4 |
| Tech 6 | **Compost** | 7 | 3 | 4 | 4 |

**Standardization**

| | | Criteria 1 Cr 1 | Criteria 2 Cr 2 | Criteria 3 Cr 3 | Criteria 4 Cr 4 |
|---|---|---|---|---|---|
| Tech 1 | **IF** | 8 | 3 | 4 | 4 |
| | | 0,8 | 0,5 | 1 | 1 |
| Tach 2 | **DA** | 4 | 2 | 3 | 2 |
| | | 0 | 0 | 0 | 0 |
| Tech 3 | **Breed** | 5 | 3 | 3 | 3 |
| | | 0,2 | 0,5 | 0 | 0,5 |
| Tech 4 | **ANT** | 9 | 4 | 4 | 4 |
| | | 1 | 1 | 1 | 1 |
| Tech 5 | **AT** | 6 | 3 | 3 | 4 |
| | | 0,4 | 0,5 | 0 | 1 |
| Tech 6 | **Compost** | 7 | 3 | 4 | 4 |
| | | 0,6 | 0,5 | 1 | 1 |

**Weighting**

| | | Criteria 1 Cr 1 | Criteria 2 Cr 2 | Criteria 3 Cr 3 | Criteria 4 Cr 4 | Total | |
|---|---|---|---|---|---|---|---|
| **Weight - Absolute Ponderation** | | **10** | **5** | **5** | **5** | **25** | |
| **Weight - Relative Ponderation** | | **0,4** | **0,2** | **0,2** | **0,2** | **1** | |
| Tech 1 | **IF** | 0,8 | 0,5 | 1 | 1 | | **Ranking** |
| | | **0,32** | **0,1** | **0,2** | **0,2** | **0,82** | **2nd** |
| Tach 2 | **DA** | 0 | 0 | 0 | 0 | | |
| | | **0** | **0** | **0** | **0** | **0** | **6th** |
| Tech 3 | **Breed** | 0,2 | 0,5 | 0 | 0,5 | | |
| | | **0,08** | **0,1** | **0** | **0,1** | **0,28** | **5th** |
| Tech 4 | **ANT** | 1 | 1 | 1 | 1 | | |
| | | **0,4** | **0,2** | **0,2** | **0,2** | **1** | **1st** |
| Tech 5 | **AT** | 0,4 | 0,5 | 0 | 1 | | |
| | | **0,16** | **0,1** | **0** | **0,2** | **0,46** | **4th** |
| Tech 6 | **Compost** | 0,6 | 0,5 | 1 | 1 | | |
| | | **0,24** | **0,1** | **0,2** | **0,2** | **0,74** | **3rd** |

Where IF = Improved Food Ration; DA = Dietary Additives; Breed = Breeding Technologies; ANT= Anaerobic Fermentation; Aerobic Fermentation; Compost = Compost of Animal Dung

### 5.4 Results of Technology Prioritization for the AFOLU sector

**Forestry**

The results show that improved stoves technology has the higher priority. This selection also fills the gap within the energy sector and household category, in particular energy used for cooking.

**Livestock**

Within this category the anaerobic fermentation technology, biogas unit, has been given the highest grade. Therefore, it has been selected to be the highly prioritized mitigation technology option.

# Chapter 6
# Technology Prioritization for Industry Sector

## 6.1 GHG emissions and existing technologies of Industry Sector

The main sources of GHG emission in the Industrial sector considering process side is estimated at 173 Gg of $CO_2$eq mainly from mineral industries (cement industry, road paving and lime production). Food industries such as sugar, and food and drinks emit 11Gg NMVOCs. Considering the energy utilization component, the industrial sector has recorded 586 Gg of $CO_2$ eq.

## 6.2 An overview of Possible Mitigation Options in Industry Sector and their Mitigation Benefits.

The mitigation option in industrial sectors could be classified into two main options: One is concerned with the increase of energy efficiency through using more efficient boilers or using less polluting energy sources such as tyres, bio-diesel, LPG or through the introduction of renewable energy technologies. The other option for GHG reduction involves a change of process or introducing alternative products. This is specifically applicable in categories like cement through using pozzolans which is a material that can reduce the GHG emitted during cement formation process, or shifting to stabilized bricks rather than the fired bricks.

## 6.3 Criteria and Process of Technology Prioritization

The designed methodology as explained in the energy sector has also been adopted in the industry sector. Consequently, the criterion used reduces the GHG emission. On the other hand, the developmental criteria include social, economic and environmental factors. Under these criteria the following indicators have been selected:
Industry criteria and related indicators are as follows:

**• GHG reduction:**

Criteria 1:
Within this criterion the GHG reduction with efficient boilers is greater than without upgrading the boilers (2nd option). Replacement

of bricks will highly reduce the GHG pollution; however some energy is needed to run the stabilizing machine. Hence, score 9 is given.

**• Environmental criteria**

Criterion 2: It contributes to the pollution reduction and the degree of being environmentally friendly:

**• Social criteria**

Criterion 3: It adds to services with special emphasis on housing and food security; it also contributes to better work environment:

**• Economic criteria**

Criterion 4: It deals with cost effective project establishment and rewarding revenue.

## Table 11 - Multi -Criteria Analysis for Industry Sector

**Scoring**

| | | Criteria 1 Cr 1 | Criteria 2 Cr 2 | Criteria 3 Cr 3 | Criteria 4 Cr 4 |
|---|---|---|---|---|---|
| Tech 1 | EB | 9 | 5 | 4 | 5 |
| Tach 2 | WU | 8 | 5 | 5 | 4 |
| Tech 3 | CSEB | 9 | 5 | 3 | 4 |
| Tech 4 | Pozz | 8 | 4 | 3 | 2 |

**Standardization**

| | | Criteria 1 Cr 1 | Criteria 2 Cr 2 | Criteria 3 Cr 3 | Criteria 4 Cr 4 |
|---|---|---|---|---|---|
| Tech 1 | EB | 9 | 5 | 4 | 5 |
| | | 1 | 1 | 0,5 | 1 |
| Tach 2 | WU | 8 | 5 | 5 | 4 |
| | | 0 | 1 | 1 | 0,67 |
| Tech 3 | CSEB | 9 | 5 | 3 | 4 |
| | | 1 | 1 | 0 | 0,67 |
| Tech 4 | Pozz | 8 | 4 | 3 | 2 |
| | | 0 | 0 | 0 | 0 |

**Weighting**

| | | Criteria 1 Cr 1 | Criteria 2 Cr 2 | Criteria 3 Cr 3 | Criteria 4 Cr 4 | Total | |
|---|---|---|---|---|---|---|---|
| Weight - Absolute Ponderation | | 10 | 5 | 5 | 5 | 25 | |
| Weight - Relative Ponderation | | *0,4* | *0,2* | *0,2* | *0,2* | *1* | |
| Tech 1 | EB | 1 | 1 | 0,5 | 1 | | Ranking |
| | | 0,4 | 0,2 | 0,1 | 0,2 | 0,90 | 1st |
| Tach 2 | WU | 0 | 1 | 1 | 0,7 | | |
| | | 0 | 0,2 | 0,2 | 0,13 | 0,53 | 3th |
| Tech 3 | CSEB | 1 | 1 | 0 | 0,7 | | |
| | | 0,4 | 0,2 | 0 | 0,13 | 0,73 | 2nd |
| Tech 4 | Pozz | 0 | 0 | 0 | 0 | | |
| | | 0 | 0 | 0 | 0 | 0 | 4th |

Where asEB = Efficient boilers With Dual Fuel LPG/Traditional Fuel; WU= Waste Utilization, Energy Efficiency and Saving for Cement Industry; CSEB= Compressed Stabilized Earth Blocks; Pozz = Pozzolans Substitute for Clinker Formation in Cement industry

### 6.4 Results of technology Prioritization and Ranking

The process of the technology prioritization resulted in having efficient boiler with dual fuel (LPG and Diesel/furnace) as the highest prioritized technology

# Chapter 7

## Summary & Conclusion

The Technology Needs Assessment Project (TNA) is performed based on the agreement signed between the Republic of Sudan represented by the Higher Council for Environment and Natural Resources (HCENR) and the United Nations Environmental Program (UNEP) Risoe Centre (URC), Denmark, and supported by the Global Environmental Facility (GEF) grant financing. The UNEP, through its Division of Technology, Industry and Economics (DTIE) is responsible for the implementation of the project and provides overall project oversight and strategic coordination. The technical and process support to the participating countries in Africa have been provided through the Environmental Development Action in the Third World (ENDA).

Technology Need Assessments (TNA) is executed in 36 countries on two rounds. In the first round the project has been executed in 15 countries, in its second round the project has been executed in 21 developing countries in Asia, Africa and Latin America. The main objective of the TNA project is to identify suitable technologies in each country that can contribute to the local efforts paid to mitigate and /adapt to climate change phenomena.

The (TNA) project covers two Climate Change Areas: Mitigation and Adaptation. This report is concerned with the mitigation options which identify technologies that can limit growth in Greenhouse Gases (GHG) emissions within the context of sustainable development.

The first step in this work is to establish project implementation structure including project coordinator, the national team and wide spectrum of stakeholders. The Management of this project is hosted within the climate change unit of the Higher Council for Environment and Natural Resources (HCENR). Great attention has been given to the continued consultation process with the stakeholders in every step of the project. This has been possible by different ways of communication including; two national consultation workshops,

a series of sector meeting and working sessions. One of the main outcomes of project methodology is the establishment of a motivated network that can further assist in implementing the outcomes of this study or even any climate change project. Additionally, two regional workshops have been held in order to facilitate capacity building and experience exchange.

The methodology adopted in the identification process is composed of four consecutive steps. The first step (sectors/subsectors identification) has been undertaken by the national team and presented to discussion in the first consultation workshop. This step has been conducted to identify, rank and select the main sources of GHG emissions in the country as reported in the Sudan's First National Communication under the United Nations Framework Convention on Climate Change (UNFCCC). Secondly the developmental plans and strategies, whether at a macro or sector level, have been thoroughly studied with the aim to identify and classify the developmental priorities in Sudan. Further, modifications of the sector content to match the TNA guidelines have been carried out. Lastly, a process of subdivision into the sub-sectors has been undertaken. Two combined criteria have been taken into consideration for assessing the technologies; contribution to development and to reduction of GHG emissions. The highest prioritized sectors have been chosen for further investigation. Further on, main emissions sources have been identified in each sub-sector. The activities responsible for these emissions have been highlighted and their contribution to the sustainable development has been assessed. This sector/sub-sector identification process resulted in identifying the following sectors:

• Agriculture, Forestry and Other Land Use sector (AFOLU) which includes agriculture, livestock, and crop production, in addition to forest and other land-use such as range.

• Energy sector which is composed of; (i) electricity supply and demand (production and consumption ) (ii) household and transportation.

• Industry sector is where GHG emissions have been studied from both energy demand and the industrial process perspectives.

The second step involves the process of technology identification. This process started by holding a set of meetings between the stakeholders and the national team members who coordinated this sector. It resulted in the preparation of a long list of technologies; each technology has been described according to Technology Fact Sheet requirements. The third step has taken place during the second national workshop; a process of multi criteria decision analysis (MCDA) has been conducted. The adopted criteria are as follows: high GHG reduction potential/high sequestration potential as main criteria, the second criterion is the developmental criterion which includes environmental, social and economic criteria. The MCDA process starts by agreeing upon the suitable indicator for each sub-sector. Ultimately, ranking process took place and short list of technologies has been created. As result of consultation and information obtained in the second regional workshop, the list has further been refined. The final selected technologies are; for the AFOLU sector/livestock subsector the manure management technology through installing biogas units has first been selected. The use of improved stoves has been identified as the highest ranking technology in the forest subsector. For the energy sector, mass transportation has been identified within the transportation sub-sector. For energy sector, electricity production and consumption, Compact Fluorescent Lamp (CFL) has been selected as the technology of highest priority. In the industry sector efficient boilers using dual fuel has been selected as the highest prioritized technology.

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# Annexes
## Annex 1 Technology fact sheets

**Sector: Energy.**
**Sub sector: Energy supply**
**Technology: Geothermal power technology**

### A.1 Introduction

Geothermal energy originates from the high-temperature aquifers inside the Earth's crust at depths of between 1-4 Kilometres. These aquifers are surrounded by porous, soft rocks and/or sand and are heated by the Earth's heat. Hot water or steam within the aquifers could reach temperatures of over 300$^{o}$ C. This heat can be used for heating of buildings and/or production of electricity.

### A.2 Technology characteristics

Geothermal electricity can be delivered to both macro and mini-grids. Large-scale plants are deliver power for base load purpose. A large-scale geothermal flash plant of (50 MW) capacity could have a load factor of 90%. Geothermal power is a reliable source of energy and commonly has high capacity factor of between 70 and 90% of installed capacity.

### A.3 Country specific / applicability

Sudan has geothermal resource in different parts of the country e.g. (Beoda desert, Red sea, Jabal Mara in western Sudan). A suggested Geothermal project 100MW will reduce 237,300 tonnes of $CO_2$ per year per megawatt hour of installed capacity, based on 2010 grid emission factor 0.301tonnes $CO_2$ per MWh

### A.4 Status of technology in country

Geothermal is unexploited resource in Sudan. Recently Potential studies have been carried and a power project with total of 100 MW (location not identified) is now under study in Beoda desert (North West of Sudan). There is well organized administrative layout for all

renewable energy technologies such as renewable energy Directorate at Ministry of Water Resources and Electricity (MWRE), Energy Research Centre and different universities but the status of technical know-how is limited.

**A.5 Barriers**

• High initial capital cost due to high exploration cost. ; Lack of private sector investment.
• Limited technical Know- how
• The exploration of the geothermal energy systems could be complex.

**A.6 Benefits to economic / social and environmental development**

Economic:
• Contribute to poverty reduction (provide jobs),
• Low operation & maintenance cost.
•Geothermal energy is an indigenous source of energy and reduces the need to import fossil fuels.

**Social**

• Social investment activities. Such as employment increase, upgrading of services level at project areas are expeted

Environmental
• Clean technology but some pollution due to hot water at rejects point is expected. Waste management issue is to be considered as some chemical may be used in the process to prepare the extracted steam to the turbine quality.

**A.7 Costs**

Generally the capital cost of geothermal is very high comparing with conventional thermal plant, the capital cost of a MW of geothermal installation approximately about 4,000,000 USD /MW (Energy Information Administration November 2010) (EIA). The main advantage of this technology is its large scale criteria which lower the operation and maintenance cost/kW. The exploration stage could take about 25% of the total investment costs.

**Sector: Energy.**
**Sub sector: Energy Supply**
**Technology: Wind Energy on-Shore Technology**

## A.1 Introduction:

Wind energy is site specific technology depending mainly on local wind speeds. A large wind turbine primarily consists of a main supporting tower upon which sits a nacelle (the structure containing the mechanical to electrical conversion equipment). Extending from the nacelle is the large rotor (three blades attached to a central hub) that acts to turn a main shaft, which in turn drives a gearbox and subsequently an electrical generator

## A.2 Technology characteristics

Wind Sites in Sudan are grouped into classes based on the yearly average energy available ranging from 1 to 7; class 5-7 is classified as most suitable for electricity generation. However, only limited areas satisfy this condition namely at red sea cost, Doungla area- North Sudan and Nyla area- West Sudan. The primary perceived problem with wind energy is related to the intermittency of supply, the variability of wind on any given day, week or month means that the amount of power that is produced can change significantly accordingly and a stand by energy sources is thus required. Wind levels and thus power generation can be estimated or forecast from meteorological reports with a reasonable degree of accuracy. However, site readings with specific precautions and arrangement is required before final decision could be made. This process is relatively difficult in Sudan

### A.3 Country specific / applicability

Sudan has wind potential for electricity generation in some parts of the country especially at red Sea coast and north Sudan areas, as in Sudan wind atlas 2012.

### A.4 Status of technology in country

Different academic and research institution had considered wind energy with some demonstration projects. Basic know how-how is available. Currently, is erecting some wind energy projects with total of 120 MW: (Dongola 100MW& Nyala (west Sudan) 20MW) and other projects of 180 MW under study (Red sea).

### A.5 Barriers

- Limited wind areas in Sudan
- High initial capital cost.
- Lack of skilled man power.
- Lack of private sector investment.

### A.6 Benefits to economic / social and environmental development Environmental

- Wind is zero air pollution systems however a comprehensive study concerning its effect on biodiversity and the ecological habitat in Sudan is not available
- Reduction of GHG; Dongola 100MW& Nyala 20MW wind farms can prevent the emission of approximately 76,500 & 15,300 tonnes of $CO_2$ per year with 29% power factor and 0.301 t $CO_2$/ year Grid Emission Factor.

**• Social**

It will increase electricity production thus improving the services level, and enhance development.

Economic: Contribute to poverty reduction (provide jobs

### A.7 Costs:

The capital cost of a MW of wind energy installation about 130,000 USD /MW. The level cost of electricity from wind in 2009 (accounting for capital costs, lifetime O&M and typical financing costs) ranges between US$50 -100/ MWh at good to excellent sites (IPCC, 2010).

**Sector: Energy.**
**Sub sector: Energy Demand**
**Technology: Compact Fluorescent Lamps**

## A.1 Introduction

Compact Fluorescent Lamp (CFL) are lamps that provide low energy lighting service through the use of a compact fluorescent light bulb (7-20 W) which replaces the normal Tungsten filament light bulb (60-100W). Replacement of incandescent lamps by CFLs is seen as efficient technology for reducing both electricity demand and GHG emission.

## A.2 Technology characteristics

• CFL contributes to energy security as they reduce the electricity demand.
• Calculations show that CFLs pay back the initial investment within 900 hours of operation and also contribute to a reduction in the electricity bill over the lifetime of the bulb.
• They have a variety of shapes and end fittings for use in all types of uses.

## A.3 Country specific / applicability

The most prevailing lamps in Sudan are tungsten lamps. Savers lamps are of limited use although they can fit well to all electric systems applied.

## A.4 Status of technology in country

Different effort are paid by different groups in this issue e.g. Ministry of Water Resources and Electricity (MWRE), is planning to replace Incandescent Lamps (ICLs) with high quality, long life (10,000 hours) energy efficient Compact Fluorescent Lamps (CFL)

## A.5 Barriers

- Lack of Consumer Information, Consumer bias towards ICLs,
- Availability of CFL especially at poor, remote and rural areas
- High Price of CFL for consumer

• Absence of policy and regulation that encourage /enforce autonomous replacement.

**A.6 Benefits to economic / social and environmental development**

• The savings in energy can be in the order of 10-20 times the initial costs over their lifetime and provide a reliable lighting service. Reducing power consumption for lighting by up to 80% is estimated. CFLs last up to 10 times longer than ICLs. The ICLs collected should be destroyed according to the highest environmental standards, energy saving from replacing 6,000,000 ICLs (100W) by CFL (20W) will be 835,200 MWh annually, and thus this amount of electricity will be available for further expansion hence energy security level will increase.
• Support Poverty alleviation efforts
• Reducing energy bill for families by replacement of (60 W and100 W) (ICLs) by 20 W (CFL)
• Generate jobs in the local manufacturing project
• Introducing concept of Energy Efficiency to households in Sudan by providing them with first-hand experience of cost savings through reduced electricity bills alternatively providing them with extra electricity amount at no additional cost
• Replacing 6,000,000 ICLs (100W) by CFL (20W) will reduce (GHG) emissions by 251,395 tonne $CO_2$ annually and other pollutants.

**A.7 Costs**

The price of integrated CFL is typically 3 to 10 times higher than the incandescent lamp. The cost of the CFL is approximately 2 USD.

**Sector: Energy.**
**Sub sector: Transport**
**Technology: Mass Transport (Buses 60+)**

## A.1 Introduction

Mass or Public transport is a shared passenger transportation service which is available for use by the general public, as distinct from modes such as taxi, car-pooling or hired buses. Public transport modes include buses, trolleybuses, trams and trains, rapid transit (metro/subways/undergrounds etc.) and ferries. Beside economic benefits, concern about air pollution and traffic congestion are the main driving forces for such technology

## A.2 Country specific/ applicability

Mass transport or public transport started in Sudan before the 1950s, particularly in Khartoum the capital. The governmental owned company of mass transport appeared in Khartoum during the seventies and early eighties. During the late eighties and nineties the small scale private mode of transport dominated especially in Khartoum. Recently, a lot of buses are operating in Khartoum State, but still, there is a need to increase the number of buses.

## A.3 Status of technology in country

The technology is well known and there is enough know how about it. The country's national strategies are supporting the expansion in the mass transportation system.

## A.4 Barriers

- Lack of transportation policies which encourage mass transport
- High upfront cost.
- Lack of hard currency to import the required buses
- Need for more road and re- structuring of existing roads
- Cultural aspects; people prefer to use small mass transport vehicles.

### A.5 Benefits to economic / social and environmental development

• Safety and security as mass transportation is generally safer than private cars
• Reduction of air pollution
• Enhance mobility Equality by providing means of transport for disabled, children, elderly etc.
• Create jobs at bus system e.g. drivers, collectors, etc.
• Reduce country consumption on fossil fuel

### A.6 Costs

The average price for the bus (60+) is about 175,000 USD

**Sector: Energy.**
**Subsector: Transport**
**Technology: Blending Fossil Fuel with Biodiesel**

### A.1 Introduction

Biodiesel blend is a well-known technology worldwide it comprises blending of the vegetable oil especially the non-edible oil such as Jatropha oil with diesel fuel with different ratios to make a homogeneous blend that can be used in the diesel engines without any modification to the engine.

### A.2 Technology characteristics

The main characteristic of this technology is that it does not need any modification to the original diesel engine (at specific blend ratio), and it is widely applicable in many countries. The technology also uses a renewable source of energy (Jatropha oil) thus emission sequestration state is attained

### A.3 Country specific / applicability

The blend biodiesel technology can be applied in the country because of the relative simplicity of the technology. However major infrastructure should be found such as blending and dosing platforms The Jatropha tree is planted in Sudan as a pilot project and it shows good growing characteristics. But the reliable local values are not available yet

### A.4 Status of technology in country

The technology is not applied yet but still under research.

### A.5 Barriers

• Technical know- how especial in issues of converting to biodiesel and blending
• Lack of local values required to design a sustainable project
• There are no legislations that regulate the application of the technology.
• No investment in the technology yet.

• The cost may be higher.
• There is no enough awareness to use the technology.

**A.6 Benefits to economic / social and environmental development**

• Income generation to the producers.
• Create new jobs opportunities.
• Reduces pollution due to better combustibility.
• Contribute to the economic development of the country by saving hard currency for diesel importation.

**A.7 Costs**

The cost of using the bio fuel is not estimated yet in Sudan.

**Sector: AFOLU.**
**Subsector: Forestry**
**Technology: Afforestation Using Machines (Tractors)**

**A.1 Introduction:**

This technology is concerned with machine utilization like tractors in afforestation of extensive areas. This technology has the merits of fastness, time saving and minimization of labour cost.

**A.2 Technology characteristics:**

The technology is simple, not complicated and characterized by having more effective results than man power. The main challenge is to manage its scope and coverage. Main issues involve selection of the suitable machine grade and accessory to match the soil and the process.

**A.3 The country specific applicability:**

In Sudan this technology was applied in pilot scales (small scales) for carriage, pulling, road construction and fire lines clearing, seeding/ planting, and transportation in difficult roads and during the rainy seasons in different mechanized agricultural schemes.
In Sudan the annual deforestation rate is estimated to be 2.4%. This gap could never be filled by labour work, especially under the rural – urban migration state. Additionally there is some difficult soil which could only be prepared through machines. The available technical Know- how available in the forestry sector and other sectors such as agriculture make its expansion a very feasible option.

**A.4 Status of technology in country:**

The technology is applied in limited forest areas in Sudan. Hence there is reasonable know how and experience. The main envisaged obstacle is to set up a solid maintenance program and to ensure the availability of spare part.

**A.5 Barriers:**

• High cost for the machine and high operation cost for fuel, maintenance etc.
• Carbon release, GHG emissions through Soil disturbance and Diesel fuel consumption.
• Limited know-how in some specific areas e.g. Advanced maintenance or computer based operation

**A.6 Benefits to economic / social and environmental development:**

• Increase of carbon stock through quicker afforestation rate
• It contributes to food security as it improves and protects soil, ameliorates climate, protects water sources and supports livestock and wildlife.
• Contribute to wood products satisfaction such as energy satisfaction (70% of energy in Sudan is forest dependent).

**A.7 Costs**

The cost of the tractor is approximately 31,000 USD.

**Subsector: Forestry**
**Technology: Improved Cook Stoves (Mud Stoves)**

## A.1 Introduction:

Over-reliance of biomass-based fuels and inefficient technologies such as traditional stoves has placed great pressure on local forests. According to National Forests Inventory the annual clearance of forest area in Sudan is about 36,975 Hectares. This has led to a tangible deficit between the annual consumption of forest products, 21 million $m^3$, and the annual growth rate and reforestation. The later produces only about 10 million $m^3$ annually. The result of such a non-sustainable exploitation of forest resources is continuous depletion of forest area. The share of the population with access to modern fuels in Sudan in 2007 was 7%, and made up of 6% LPG and 1% kerosene in absolute terms.

The total wood fuel consumed annually in Sudan is estimated to be over 4.4 Million tonnes (Forest Products Survey in Sudan, 1995). The traditional stoves cannot achieve complete combustion. Reason being, first; the physical design of these stoves is such that the fuel cannot vaporize and mix sufficiently with air, which is a requirement for complete combustion (Bailis, 2004). Second, the stoves have poor heat transfer efficiency to the cooking pot (Mark et al., 2007), and thirdly, even though these stoves are individually small, they are usually numerous. Improved Cook Stoves (ICS) reduce the rate of desertification as it uses small amount of fuelwood compared to traditional stoves. The average annual per capita consumption of fuel wood in Sudan was approximately 24.3 kg and 10.1 kg for rural and urban households, respectively.

## A.2 Technology characteristics

Improved Cook Stoves (ICS) can be designed and built in various ways, depending on the local conditions. At their simplest, ICS provide an enclosure for the fire to reduce the loss of radiant heat and protect it against the wind. In addition, attention can be given to methods controlling the upward flow of the combustion gases,

so as to increase the transfer of heat to the cooking pot. Many of these stoves are made of mud or sand since both are almost free and readily available. The design of the stove incorporates, among others, use of proper insulating material for insulating the combustion chamber to minimize heat loss and ensure high temperature inside to promote complete combustion. Limiting, limiting the amount of fuel inside the combustion chamber, preheating of combustion air. The improved stoves are 35 % more efficient than the traditional three stone open-fire stoves. The improved Badia stoves proved to be the simplest, efficient, and easy to manufacture by rural artisans using locally available materials (clay, animal dung and locally available metal sheets for lining).

**A.3 Country specific / applicability**

Key economic drivers of deforestation include

• High domestic fuel wood consumption; about 69.5 % of the wood consumption,

• The relative high cost of fuel wood and charcoal in comparison to household energy budget ;

• Minimum change for cooking behaviour.

**A.4 Status of technology in country**

Different institutions have worked on this issue, since mid-eighties, this include research institutes such as energy research centre, government institutes such as Forest National Cooperation, and NGOs such as Sudanese Environmental Conservation Society. Hence a relative basic state of know-how and experience exists. Improved cook stoves both for household and institutional uses are available in Sudan and produced locally by a number of trained artisans. On strategic level, lowering the deforestation is the main issue in all developmental plans.

**A.5 Barriers**

• Low budget for dissemination and training

• Administrative and organizational procedures in establishing

production units
• Needed Budget to further optimize the design parameters
• Relative high cost of the ICS

**A.6 Benefits to economic / social and environmental development**

• Minimize the pressure on forests to provide wood fuel for cooking
• Improve economic situation through Job creation; improving house energy budget
• Improve the health conditions delivered from cooking with relatively a clean smokeless stove
• Saving time for women and children in collecting firewood, and reduce the burden of carrying wood long distances are also avoided

**A.7 Costs**

Main cost of the improved stoves is fixed cost (7 UDS) but the running cost is expected to be less than the traditional stoves.

**Sector: AFOLU.**
**Sub-sector: Agriculture, (Manure Management)**
**Technology: Anaerobic fermentation (Biogas) technology**

## A.1 Introduction

Biogas technology is a technology through which animal dung could be processed an aerobically to produce flammable gas that be used in the different energy purpose. The dung sludge could also be used as fertilizer. The main merit here that the dung is not left to decompose (production of methane) and thus GHG reduction is attained. This is estimated by about 60% /kg VS of manure and further 21 %.which is warming potential percentage of Methane to $CO_2$

## A.2 Technology characteristics

The technology takes place in a specific reactor that can have different designs and sizes; the process is highly affected by both intrinsic factors such as carbon /nitrogen ratio or external such as temperature. A limiting factor is the availability of water as biogas is a water based technology as generally the feed is only about 15% dry matter and the rest is water.

## A.3 Country specific / applicability

Sudan has a high potential of animal dung resulting from livestock population which is estimated by 130 million and dung production up to 10 kg /animal /day and average methane content is 0.24 m3/kg.

## A.4 Status of technology in country

The technology is known in Sudan, different organizations and institutions have built and operate biogas units. The energy research centre had a research unit. Hence the basic know how is available. There is a plan now to disseminate the biogas units to 22,000 families in Sudan

The technology depends on self-built system which is high cost and requires a lot of time and effort. Recently a readymade unit project is being established.

### A.5 Barriers

•Availability of the readymade biogas units
• Social acceptance
• Relative high cost of the unit
• Absence of encouraging political and legal framework

### A.6 Benefits to economic / social and environmental development

• Enhance the employment at local level (dung collection and unit management) beside the provision of energy source for other needs e.g. cooking, lighting, electricity
• Left over dung is a pollution source and health hazard, Improvement of environment is expected as result of manure management
• Households are independent of wood for cooking, which can reduce deforestation levels
• Buying fuel e.g. kerosene, LPG, charcoal or fuel wood is no longer needed

### A.7 Costs

Manufacturing or acquisition costs (production costs) in Sudan is estimated by 2000 US$/ unit of biogas reactor
Operation and maintenance costs (running costs) include: acquisition and handling of the substrate (feedstock), if not acquired externally, feeding and operating of the plant; supervision, maintenance and repair of the plant; storage and disposal of the slurry; gas distribution and utilization;. There is estimate for this cost type

**Sector: AFOLU**
**Sub sector: Livestock (Enteric Fermentation))**
**Technology: Ration Modification for Livestock**

## A.1 Introduction

Ruminant animals have a unique digestive system. Ruminants possess a rumen, or large fore-stomach, in which microbial fermentation breaks down coarse plant material for digestion. Enteric fermentation enables ruminants to eat plant materials, but also produces $CH_4$. During digestion, microbes present in an animal's digestive system ferment food consumed by the animal. This microbial fermentation process is referred to as enteric fermentation and produces $CH_4$ as a by-product, which can be exhaled or eructated by the animal. The amount of $CH_4$ produced and excreted by an animal depends primarily on the animal's digestive system and the amount and type of feed it consumes. Modified Ration feed is a technology that can reduce the methane production in the natural enteric fermentation process through Inhibition of methanogenesis stage in the digestion process or through reducing methane emission per kg of animal. This material includes:

• Halogenated compounds inhibit the growth of methanogenic bacteria (the bacteria that produce the methane), but their effects can also be transitory and they can have side-effects such as reduced intake.

• Condensed tannins, saponins, or essential oils. However, adding such compounds may have the negative side-effect of reduced digestibility of the diet.

• Hormonal growth implants do not specifically reduce methane emissions in itself, but by improving animal performance, they can reduce emissions per kg of animal product.

## A.2 Technology characteristics

An animal's feed quality and feed intake affect $CH_4$ emissions. In general, lower feed quality or higher feed intake lead to higher $CH_4$ emissions. Feed intake is positively related to animal size, growth

rate, and production (e.g., milk production, wool growth, pregnancy, or work). Therefore, feed intake varies among animal types, as well as among different management practices for individual animal types. As $CH_4$ emissions represent an economic loss to the farmer—where feed is converted to $CH_4$ rather than to product output then mitigating this emission is also farmer interest. This can take place either through replacing forages with the feeding which reduce quantity of gas emitted or through concentrates which may reduce the daily methane emissions /kg of animal. Feeding concentrates' benefits depend on whether the number of animals can be reduced or whether slaughter age can be reduced. In addition, it is important to consider how the practice affects land use, the nitrogen content in the manure and the emissions from transporting and producing the concentrates in the first place. In general the technology requires control over feed rations so it is more applicable to closed systems.

**A.3 Country specific / applicability**

Sudan has large wealth of livestock estimated to be 130 million head, The contribution of enteric fermentation is significant estimated by 1,713 Gg of $CH_4$.

**A.4 Status of technology in country**

Ratio control is practiced for different purposes such as increasing dairy production but there is no significant application targeting reduction of GHG.

**A.5 Barriers**

- Limited Technical know –how
- High upfront Cost
- Open husbandry system which is prevailing in Sudan

**A.6 Benefits to economic / social and environmental development**

From the literature the socio-economic development and environmental protection contributions are as of yet not clearly quantified. However in the IPCC (2007) it appears that there is

an economic benefit of improved feeding practices as efficiency increased in the livestock management system. The other aspects are uncertain and require more investigation.

**A.7 Cost**

It is difficult to enumerate the cost of mitigation because the diet manipulation options to reduce $CH_4$ emissions have costs that are related different factors such as feed price, husbandry issues. Furthermore, the availability of certain feed or oil types will vary by region and season in some, so it would be difficult to assign cost on a national level for diet manipulation.

**Sector: Industry**
**Sub sector: Energy Industr**y
High Efficient Boilers for Steam Generation Using Dual Fuel.

## A.1 Introduction

A boiler is a closed pressure vessel in which a fluid is heated for use external to itself by the direct application of heat resulting from the combustion of fuel (Solid, liquid, or gaseous) or nuclear energy. Energy efficiency in industrial power house depend on four factors, fuel type, combustion system limitations , equipment design and steam system operation requirements. The boilers should be designed in low maintenance and high efficiency; the burner should be compatible with boiler.
Boilers are classified as follows:
Fire –tube boilers, which are includes:
a) Locomotive fire-box boilers.
b) Vertical tubular boilers.
c) Horizontal multi-tubular boilers (used in a wide range).
60% out of the total number are using fuel oil which leads to pollution and production of $CO_2$ due to improper combustion control. Type (a) and (b) are using coal, but not widely. Majority of boilers used in Sudanese industry is old in design and inefficient.
Technology improvements for boilers focus on efficiency and low-cost design while giving increasingly more attention to air pollutant emissions which are carbon monoxide, hydrogen chloride , mercury as well as GHG such as $CO_2$ and Nox. The emission depends on fuel type (solid, liquid, gaseous). $CO_2$ emissions are based on input fuel emission factors corrected for boiler efficiency. Basic fuel emission factors are 50.29 kg $CO_2$/TJ for natural gas, for distillate fuel oil 69.33kg $CO_2$/TJ, for residual fuel oil 74.69 kg $CO_2$/TJ, for coal 89.08kg $CO_2$/TJ.

## A.2 Technology characteristics

Improvement of efficiency of industrial boilers can be attained by adding advanced heat recovery and controls measures to the boiler

system. Boiler units with high efficiency should have Maximum Continuous Rating (MCR) The technology involve replacing fuel oil and coal by LPG which has heating value of 32000kJ/kg. The burners should be upgraded by suitable dual burners system to LPG or for fuel-oil. Emission reduction in boilers depends on boiler efficiency and fuel type. Using LPG with (different) efficiency boilers will reduce the $CO_2$ emission compared with other fuel Table 1.

**Table 1 The relation between Boiler Thermal efficiency and $CO_2$Emission for different fuel**

| Boiler Thermal efficiency | Emission preheat output(kgCO2/mm Btu) | | | |
|---|---|---|---|---|
| | Natural Gas(NG) | Distilled fuel oil | Residual fuel oil | Coal |
| 80% | 66.3 | 91.4 | 98.5 | 117.5 |
| 85% | 62.4 | 86.1 | 92.7 | 110.6 |
| 90% | 59.6 | 81.3 | 87.6 | 104.4 |
| 94% | 56.4 | 77.8 | 83.8 | 100.0 |

### A.3 Country specific / applicability

Using high efficiency boilers will contribute positively in saving energy and consequently is saving money and using LPG as alternative fuel in steam generation has potential in Sudan, in spite of the fact that there is scarcity in the availability, some private gas company start to import mainly for industrial sector demand.

### A.4 Status of technology in country

Majority of boilers used in industries have lower efficiency, very few industries uses high efficient boilers. Less than 2% of industries are using LPG as fuel for boilers ignition, burners that designed mainly for LPG are expensive.

### A.5 Barriers

• Specification of high efficiency boilers needs technical know-how with reference to type of industry.
• LPG fuel is flammable and toxic; it is proven to be extremely dangerous, leakage makes cause fire or explosions,
• Special requirement are needed for LPG transportation to industrial sector.
• Scarcity of LPG in market for industrial sector, Household sector is given higher priority.
• Efficient and dual burner boilers are expensive.

### A.6 Benefits to economic / social and environmental development

Environmentally: clean technology reduces the $CO_2$ emission more 70 % in the case of complete combustion.
Economical: Low cost compared with fuel oil.

### A.7 Costs

LPG is less in cost compared to Fuel- oil.
Tonne of LPG is 1200 SDG; Tonne of Fuel –oil is 2000 SDG, considering the Energy content of LPG to be 46.1 GJ/t and of fuel oil to be 42.5 GJ/t. Then the LPG cost is 26 SDG/GJ and fuel oil cost is 47 SDG/GJ
Burner cost 40000-80000 SDG depending on the capacity of the burner.
High Efficiency boiler cost depends on the type and size of boiler.

### A.8 Others

The cost of the Fuel oil in the industrial sector is high and unavailable, so introducing LPG as alternative fuel will be solution for the industrial sector.

**Sector: Industry**
**Sub-sector: Cement**
**Technology: Energy Efficiency and Saving in Cement Industry**

## A.1 Introduction:

The utilization of Waste Materials including the Scrapped Tyres (calorific value 35.6 MJ /kg) has been found since 20-years worldwide as alternative (secondary) fuel in the cement kilns.

Cement kilns are well suited for waste-combustion because of their high process temperature and because the clinker product and limestone feedstock act as gas -cleaning agents.

Used tyres, wood, plastics, chemicals and other types of waste are co-combusted in cement kilns in large quantities.

Plants in Belgium, France, Germany, the Netherlands and Switzerland have reached average substitution rates of from 35% to more than 70%. Some individual plants have even achieved 100% substitution using appropriate waste materials. (Energy Efficiency & Saving in the Cement Plants at http://ClimateTechwiki.org website).

The utilization of scrapped tyres as alternative fuel in cement kiln is a proven safe and effective technology that has already been used in some cement plants in USA, Germany, Japan and Egypt.

The cement industry in the United States burns 53 million used tyres per year, which is 41% of all tyres that are burnt and is equivalent to 0.39 Mt or 15 PJ. About 50 million tyres, or 20% of the total, are still used as landfill (Energy Efficiency & Saving in the Cement Plants at http://ClimateTechwiki.org website).

So, the scrapped tyres as alternative fuel is one of the most recommended types of waste that can be used as a secondary fuel in cement kilns - besides the fossil fuel. Since it has a high calorific value (32 MJ/kg) compared to other wastes and even the Coal (28 MJ/kg).

Besides, it is the safest method of disposal due to its considerable reduction and control in the generated amount of pollution emissions and especially the toxic gases like dioxin, due to kiln high temperature

(900 – 1450 degree centigrade) and short time taken for complete combustion.

So, one metric ton of scrapped tyres can produce in average 6.5 – 8.2 tonnes of cement, and its utilization can represent 20 – 50% from the total amount of fuel been burnt in a kiln. And accordingly, it will reduce our usage of fossil fuels (Heavy Oil) which automatically reduce the extra $CO_2$ emissions generated from fossil fuels – compared to the amount of $CO_2$ generated by scrapped tyres. Besides, a considerable reduction (more than 50%) in the energy (fuel) cost.

Cement manufacturing produces $CO_2$ as it requires very high temperatures to burn raw materials and give the clinker its unique properties.

$CO_2$ is generated from three independent sources: de-carbonation of limestone in the kiln (about 525 kg $CO_2$ per tonne of clinker), combustion of fuel in the kiln (about 335 kg $CO_2$ per tonne of cement) and use of electricity (about 50 kg $CO_2$ per tonne of cement).

There are three central measures by which the cement industry may save direct $CO_2$ emissions in the immediate future:

Improvement of energy efficiency (a maximum of 2% is still feasible),

Reduction of clinker/cement ratio, and

Increase in the use of waste as alternative fuel (national initiatives, adequate national implementation of certain directives regarding specific waste)".

**A.2 Technology characteristics**

The scrapped tyre can be used as a whole piece or in shredded forms – including or excluding (after the removal of) the steel wires. The usage of shredded scrapped tyres without the steel wires is most preferable option.

Firstly, the scrapped tyre should be properly classified and verified. Secondly, they need to be shredded into 25 – 50 mm chips, and then the steel wires will be removed. The third step is to feed the chips through the feeding belt and dosing system into calciner and/or kiln for combustion.

The high temperatures of the Kiln (1400 – 110 degree centigrade) and the calciner (1000 – 900 degree centigrade) will secure complete combustion free of toxic emissions like the generation of dioxin gases.

The combustion parameters & conditions need to be monitored and controlled effectively and carefully to secure complete combustion of tyres chips and to maintain the emissions within the acceptable limits.

**Table (1): Estimated Cement Production per tonne of Fuel used**

| Fuel Type | Approximate CV"(MJ/kg) | Cement (Tonne) |
|---|---|---|
| Furnace Oil | 40 | 11 |
| Coal | 28 | 7.2 |
| Tyres | 32 | 8.2 |

### A.3 Country specific / applicability

Last year the Global demand for cement grew by 17% by the end of year 2011 to reach 3.8 billion metric tonnes – as per worldcement.com.

In Sudan, as per Ministry of Industry Records, the demand for cement and the design capacity of the cement plants during the previous three years – from beginning of year 2009 to end of year 2011, have been increased by almost 500%, reaching 3 million tonnes as consumption by end of year 2011, and 6.97 millions of metric tonnes as a total design capacity.

In Sudan the annual imported amount of tyres for different applications is estimated last year by 20,000 tonnes, and expected to reach 40,000 tonnes by end of year 2012.

Generally the new tyres lose about 20% of its weight before it has been scrapped. The steel wires represent about 15 – 25% of the tyre weight which encourage some people to burn the tyres in open areas to get use of the steel wires which has a considerable value.

### A.4 Status of technology in country

This technology is of shredding & burning tyres is not introduced in Sudan yet.

### A.5 Barriers

• Inaccurate dissemination of information; increases the worries of public and governmental authorities about managing (controlling & monitoring) pollution emissions; especially the toxic emissions like dioxin gas.
• The scrapped tyres are spread into wide areas all around the country, so it will be a difficult job to collect, classify and storing them properly, considering all the necessary precautions especially fire.
• The feasibility study will cost about 50,000 Euro, while the tendering, selection and purchase of equipment like shredding system, fuel handling and dosing system and the minor modifications need to be made in the cement kiln will cost about 1.6 million Euro in addition to 1.6 million Euro for civil work, erection, installation, commissioning, project management fees, consultancy fees and site preparations, etc.
• The duration for the execution of the project including the preparations of the pre-feasibility, comprehensive feasibility study will take about one year, including 7 months for supply and manufacturing of equipment.

### A.6 Benefits to economic / social and environmental development

• The plan is to shred 25,000 tonnes/ year of scrapped tyres during the first four years of production to produce 5,000 tonnes/year of steel wires which cost more than 650,000 Euro per year. Moreover it produces about 150,000 tonnes of cement which will save about 15,000,000 SDG per year.
• The high revenue of the project will encourage the usage of other waste besides the scrapped tyres. The collected house hold waste in Khartoum state only is above 2,000 tonnes/ day, considering that the

five big cement kilns located at 320 km north Khartoum can burn the majority of waste types and all the quantities available in Sudan.

**A.7 Costs**

A. Shredding System
• Equipment Cost = 1,000,000 Euro
• Other Costs = 1,000,000
B. Fuel handling & dosing System
• Equipment Cost = 600,000 Euro
• Other Costs = 600,000 Euro
C. Operational Cost
• Cost for 25,000 tonnes of scrapped tyres = 12,500,000 SDG (500SDG per tonne)
Other Costs = 7,500,000 SDG (General Estimation)

**Sector: Industry.**
**Sub sector: Building**
**Technology: Compressed Stabilized Earth Blocks (CSEB)**

## A.1 Introduction

A compressed stabilized earth block (CSEB) is a new product, made of soil and stabilizer. The soil, raw or stabilizer, is slightly moistened, poured into a steel press (with or without stabilizer) and then compressed either with a manual or motorized press in the desired shape and size. This technology allows building of thin, water resistance and high walls which have high compression strength. Equipment for CSEB is available from manual to motorized tools ranging from village to semi industry scale

## A.2 Technology Characteristics

It is a simple technology that doesn't requires previous skills; efficient training centre can transfer the technology in a week time. CSEB allow unskilled and unemployed people to learn a skill, get a job Since then, the production is made on the site itself or in the nearby area and utilizes local material then transportation chain will be shorter. The technology is more environmentally friendly by using bio-degradable material, parallel it doesn't consume fuel wood as the traditional bricks.

## A.3 Country specific/applicability

There is good potential for the stabilizer material in different areas of Sudan. Explained by its technical characteristics the products have low technical performances compared to fired bricks is limited. Since the majority of the family houses in Sudan are single story building then the technology will have social acceptance. According to the local context (materials, labour, equipment, etc.) the final price will vary, but in most of the cases it will be cheaper than fired bricks. Furthermore, it will reduce imports of expensive materials or transport of heavy and costly building materials over long distances.

### A.4 Status of technology in country

Different programs for CSEB building had been applied in different states in Sudan and proved to be appropriate and acceptable. The National Centre for Research had modified different types of machine and extended training programs for private sector and organizations (UN-HABITAT). Additionally, different machines had been designed and manufactured locally.

### A.5 Barriers

• Lack of awareness among stakeholder and absence s of promotion programs.
• Limited technical know –how
• Proper soil identification is required.

### A.6 Benefits to economic/ social and environmental development

• This technology reduced of pollution and GHG emission compared to fired bricks.
• Pollution emission (kg of $CO_2$ /$m^2$): 2.4 times lower than wire cut bricks and 7.9 times lower than fired bricks
• Energy consumption (MJ): 4.9 times lower than wire cut bricks; 15.1 lower than fired bricks

### A.7 Costs

The main cost factors are distributed as follows: Labour: 20 - 25 % Soil & sand: 20 - 25% Cement: 40 - 60 % Equipment: 3 - 5 %,

**Sector Industry**
**Sub sector industrial process- cement**
**Technology: Using Pozzolans in Cement Industry**

## A.1 Introduction

Pozzolan is a material which when combined with calcium hydroxide, exhibits cementitious properties. Pozzolans (the technical term is cement extender), are commonly used as an additive to Portland cement concrete mixture to increase the long term strength and to reduce the material cost of concrete.

Pozzolan is a siliceous or aluminosiliceous material which is highly vitreous. Pozzolans materials can be added to cement to extend its volume without a significant loss of properties .Generally Pozzolans materials do not require pre-processing and therefore can save very significant quantities of energy and lower $CO_2$ emissions when supplementing regular cement.

**Modern use:**

Modern pozzolanic cements are a mixture of natural or industrial pozzolans and clinker of Portland cement, the high alkalinity of pozzolans makes it especially resistant to common forms of corrosion from sulphate. Once fully hardened it may be stronger than Portland cement only, due to its lower porosity, which also makes it more resistant to water absorption.

Some laboratory tests were carried out in Italy and industrial testing took place in Africa and India to Pozzolanic Material Activators (PMA's)

Low dosage (LD) of PMA between 300-500g/t

High dosage (HD) of PMA between 800-1200g/t

The results of industrial tests in the Table (1)

**Table (1) : Industrial Trials, Pozzolan and fly Ash base cements-strengths MPA**

| Time | 30% of Pozzolana in Africa | | | 26% of Pozzolana in India | | |
|---|---|---|---|---|---|---|
| | Blank | LD | HD | Blank | LD | HD |
| 24 hr | 12.1 | 14.8 | 16.2 | 14.3 | 17.4 | 19.2 |
| 2 days | 17.5 | 20.0 | 22.4 | 24.7 | 27.3 | 29.9 |
| 28 days | 34.1 | 38.6 | 40.1 | 45.9 | 50.4 | 52.0 |

**Source: J. Bogerd, Italy (2011)**

## A.2 Technology characteristics

The availability of clinker substitutes is sufficient to allow the cement –to- clinker ratio to be reduced to 0.7 globally, theoretically enabling a saving of a further 15 tonnes of thermal energy. The global intensity of cement production could be reduced by 0.9GJ/t of cement produced, with significantly higher saving possible in many countries and regions (IEA2010). As calculated by the IEA2008 in total the savings potential for blended cements amounts to 300 Mt $CO_2$ to 450 Mt $CO_2$ by 2050.

## A.3 Country specific / applicability

Pozzolana is found in Sudan in Bayoda desert in north Sudan and Darfur in west Sudan. So the technology could easily be applied due to presence of natural material. The Pozzolana should be grinded and added to clinker after the ignition of lime stone and the added per cent could be 15- 35%. To be applied in building sector

## A.4 Status of technology in country

The technology is new and has not been properly introduced in Sudan.

## A.5 Barriers

• lack of research to know the specification of type of Pozzolana that exist in Sudan

• lack of awareness within the private sector mainly the cement factories, to use Pozzolana to reduce cost and emission.

• Lack of information regarding its applicability in building in Sudan compared to normal cement.

**A.6 Benefits to economic** / social and environmental development
This Pozzolanic cement is more environmentally friendly, it reduces GHG emissions and it also reduces the cost of industry.

**A.7 Costs**

Adding Pozzolana is assumed to reduce the cost in cement industry but exact information was not available

**A.8 Others**

Generally using Pozzolana will lead to huge saving in terms of costs and $CO_2$ emissions, thus generating vast opportunities business to create long-term growth in competitive and sustainable setting.

## ANNEX II: List of Stakeholders Participating in the Inception and the Second Workshop

| Names | Institute |
|---|---|
| Somaya Alsayid | Ahfad University for Women |
| Nawal Hussain | Sudan Academy for Communication Sciences |
| Nazik Hassan Ali Alawad | Ministry of Water Resources and Electricity |
| Nuraldin Ahmed Abdalla Saaid | Meteorological Authority |
| Nouralla Yassin Ahmed | National Energy Research Centre |
| Iman Alrashid Diab | National centre for Research |
| Sawsan Abdalla Ali | Forests National corporation |
| Issam Aldin Ibrahim Abdalla | Ministry of Agriculture |
| Haythum Kamal Aldin Abdalla | Kenana Sugar Company |
| Almothana Saad Mohamed | Kenana Sugar Company |
| Igbal Salah Mohamed Ali | Ministry of Water Resources |
| Widad Motwakil Saadalla | Ministry of Water Resources |
| Tarig Algamri Atta Almanan | National Centre for Research |
| Hassan Wardi Hassan | Ahlia University |
| Mona Mahjoub Mohamed Ahmed | Institute of Environmental Studies |
| Aboubaida Alboukhari Ibrahim | Sudanese Industrial Chamber Association |
| Abdelrahman Altahir Ahmed | Kenana Sugar Company |
| Salah Aldin Ali Mohamed Nour | Ministry of Petroleum |
| Abdelazim Widaa | Ministry of Petroleum |
| Alrabia Mohamed Altahir | Ministry of Petroleum |
| Mostafa Mohamed Altahir Atti | Ministry of Water Resources and Electricity |
| Ikhlas Abdelaziz | Industrial Research Centre |
| Sayed Hajalnour Ahmed | Ministry of Environment , Forestry & Physical Development |
| Thuraya Najib | Practical Action |
| Ahmed Sulaiman Alwakeel | Free Lance |
| Arig Jaafar Mohamed | National Energy Research Centre |
| Taghrid Abdelrahim Mohamed | Ministry of Water Resources |
| Alwalid Abas Mohamed Alsaid | National Energy Research Centre |
| Ali Omer Ahmed | National Energy Research Centre |
| Hanadi Attaalfadil Mohamed | Ministry of Industry |
| Amani Abdelmahmoud Ali | Ministry of Environment , Forestry & Physical Development |

| | |
|---|---|
| Ismail Fadlalmoula Mohamed | Sudanese Meteorological Society |
| Quosay Awad Ahmed Babiker | University of Khartoum, Petroleum Department |
| Mohamed Saad Ibrahim Abdellatif | Ministry of Animal Wealth |
| Najla Mahgoub Hamadain | Forests National corporation |
| Awatif Abdalla Mohamed | Ministry of Animal Wealth |
| D.Suad Ibrahim Jalalaldin | Ministry of Agriculture |
| Naima Abedlgadir Hilal | Industrial Research Centre |
| Farough Ismail Abdeljalil | Ministry of Industry |
| Salah Yousif Mohamed Ahmed | Forests National corporation |
| Amira Hasan Alam | Salam Company for Cement Production |
| Ahmed Amer Mohamed | Shamal Company for Cement Production |
| Abdelazim Yasin Abdelgadir | University of Khartoum, Faculty of Forestry |
| Alyas Ahmed Alyas Ahmed | University of Khartoum, Faculty of Forestry |
| Mohamed Ali Hamed | United Nations Development Program |
| Osman Taha Alzaki | National Centre for Research |
| Hayfa Hasan Fadul | Ministry of Science and Technology |
| Omayma Mohamed Ahmed | Ministry of Agriculture |
| Donya Hasan Khalafala | Ministry of Agriculture |
| Somaya Ahmed Alzaki | Institute of Environmental Studies |
| Asya Adlan Mohamed Abdalla | Institute of Environmental Studies |
| Ali Mohamed Korak | Sudanese Association for Rural Afforestation |
| Mohamed Yousif Mohamed Adam | Institute for Water Harvesting Research |
| Sawsan Khair Alsid Abdelrahim | Range and Pasture Administration |
| Alamin Sanjk Mohamed | University of Khartoum, Faculty of Forestry |
| Mirghani Abnauf | Free Lance |
| Dawoud Abas Osman | Sudanese Industrial Union |
| Imadaldin Ahmed Ali Babiker | Agricultural Research Authority |
| Abedlrahman Khidir Osman | Free Lance |
| Mawahib Altayeb Ahmed | National Centre for Research |
| Alfadil Biryma Hamed | National Energy Research Centre |
| Salahaldin Hasab Elgabo | Ministry of Water Resources and Electricity |
| Adam Musa Mohamed | University of Neelain |
| Adel Abdalla Rabih | Ministry of Water Resources and Electricity |
| Osama Salah Mohamed Ibrahim | Ministry of Water Resources and Electricity |
| Zuhair Mohamed Alsheikh Dafalla | Ministry of Water Resources and Electricity |
| Samya Yousif Idris Habani | National Council |

| | |
|---|---|
| Amiral Elnour | Ministry of Industry |
| Abdelrahman Altahir Ahmed | Kenana Sugar Company |
| Mustafa Mohamed Salih Agha | Ministry of Water Resources and Electricity |
| Dirar Hasan Nasr | University of Red Sea |
| Ali Mohamed Ali | Higher Council for Environment & Natural Resource |
| Mutasim Bashir Nimir | Higher Council for Environment & Natural Resources |
| Amal Abdelgadir Hasan | Ministry of Agriculture |
| Mahasin Balla Ahmed Babiker | Ministry of Agriculture |
| Alawiya Yousif Mohamed | Ministry of Agriculture |
| Maha Ali Mohamed | Ministry of Agriculture |
| Ayman Mohamed Abdin | Ministry of Agriculture |
| Dirar Ibrahim Dirar | Ministry of Agriculture |
| Khalid Ahmed Ali | Ministry of Agriculture |
| Asma Abobakr Ismail | Higher Council for Environment & Natural Resources |
| Adel Mohamed Ali | Higher Council for Environment &Natural Resources |
| Yasir Alzain Ahmed | Higher Council for Environment & Natural Resources |
| Mohamed Ahmed Yousif Hamad | Higher Council for Environment & Natural Resources |
| Mohamed Yousif Mohamed | Technology Transfer and Agricultural Extension |
| Amani Abdelmahmoud Ali | Ministry of Environment , Forestry & Physical Development |
| Nadir Mohamed | Sudanese Environmental Conservation Society |
| Taysir Ismail Idris | Ministry of Agriculture |
| Howida Mirghani Almrdi | Ministry of Agriculture |
| Wigdan Mohamed Ibrahim | Higher Council for Environment & Natural Resources |
| KhadijaYounis Abdelmawla | University of Bahri |
| Hasan Bashir Nimir | University of Khartoum, Petroleum Department |
| Nagmaldin Goutbi Alhassan | Higher Council for Environment & Natural Resources |
| Ahmed Mohamed Abdelkarim | Meteorological Authority |
| Hiba Mahjoub Hasan | Higher Council for Environment & Natural Resources |
| Mohamed Altahir Mohamed | Higher Council for Environment & Natural Resources |

| | |
|---|---|
| Dinan Babiker Elkhalil | Higher Council for Environment & Natural Resources |
| Mahjoub Hasan | Ministry of Environment , Forestry &Physical Development |
| Ahmed Ibrahim Ahmed | Ministry of Transportation |
| Abdelrahmen Elamin | EWASCO Company |
| Hana Hamadalla Mohamad | Higher Council for Environment & Natural Resources |
| Fathalrahman Ahmed Mohamed | Ministry of Agriculture |
| Daoud Abbas | Sudanese Industrial Chamber Association |
| Mohamed Aljak Sulaiman | Industrial Research Centre |
| Seif Eldin Abdalmageed | Ministry of Labour |
| Alam Sighayroun Mohamed | Sudanese Industrial Chamber Association |
| Yasir Abdelkarim Abdelaziz | Sudanese Industrial Chamber Association |
| Salwa Hamza Ali | Sudani Newspaper |
| Ishraga Alhilo | Sahafa Newspaper |
| Shza Alrhma | Alray Ala'am Newspaper |

Republic of Sudan

Ministry of Environment, Forestry and Physical Development

Higher Council for Environment and Natural Resources

# BARRIER ANALYSIS AND ENABLING FRAMEWORK

## PART 2

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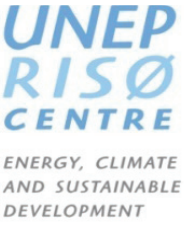



# List of Abbreviations

| | |
|---|---|
| AFOLU | Agriculture, Forestry and other Land Use |
| CFL | Compact Fluorescent Lamp |
| $CO_2$ eq | Carbon dioxide equivalent |
| $CO_2$ | Carbon dioxide |
| EB | Efficient Boilers with Dual Fuel |
| ERA | Electricity Regulatory Authority |
| FNC | Forest National Corporation |
| GHG | Greenhouse Gases |
| ICL | Incandescent Lamps |
| IS | Improved Stoves |
| LPA | logical Problem Analysis |
| LPG | Liquefied Petroleum Gas |
| MWRE | Ministry of Water Resources and Electricity |
| MWh | Megawatt hour |
| NPV | Net Present Value |
| PPP | Public- Private sector-Partnership |
| SAIC | Sudanese Association for Industrial Chambers |
| SSMO | Sudanese Standards and Metrological Organization |
| TNA | Technology Needs Assessment |
| W | Watt |

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## Executive Summary

This report represents the second part of the Technology Needs Assessment Report (TNA). The first part (TNA report) is dedicated to the identification and prioritization of technologies that can mitigate GHG emissions while contributing to Sudan's development. Those technologies are Compact Florescent Lamps (CFLs) and mass transportation (Buses 60+) in the energy sector, Improved Stoves (IS) and biogas system in the Agriculture, Forestry and other Land Use (AFLOU) sector, and Efficient Boilers (EB) using Dual Fuel in the industrial sector. This second report is concerned with the identification of barriers hindering the transfer and diffusion of these technologies, and consequently defining the measures to overcome these barriers. Ultimately, the report aims to conceptualize the enabling framework for the diffusion and deployment of the identified technologies.

The methodology adopted is the one recommended in the TNA Guidebook, namely close consultation with stakeholders representing the sectors of energy, AFOLU and industry. To improve the quality of work, a sectoral group meetings approach has been pursued. More emphasis has been given to sector group meetings and the national team discussions. Sectoral groups are composed of stakeholders that have great expertise in the selected technologies. As described in the TNA Report, the national team comprises diverse backgrounds, and each member, within a sectoral group, is responsible for one technology. The sectoral groups' outcomes and results have been validated during team meetings. The work started as the guide recommends by classifying the technologies into consumer, capital, public or non-market goods. The CFL, IS and Biogas systems fall under the category of consumer good, the EB under capital goods, and the buses under public goods. Then the process continued with listing all barriers that hinder the transfer or diffusion of each technology.

The next step is ranking and selecting the barriers according to their

importance. This has been followed by cataloguing them into financial and non-financial barriers, where the non-financial barriers have been further categorized under one of the eight categories suggested in the Barrier Guide Book. For the CFLs the financial barriers are high purchasing price as result of high tax and customs costs as well as absences of local industries. Another barrier is the lack of market availability as CFLs are not sold everywhere, especially in rural and poor areas. The non-financial barriers incorporate factors such as absences of legal and regulatory frameworks required for supporting the technology, absence of awareness and lack of information at all levels s about the benefits of CFLs. The main financial barriers for buses have been absence of investment incentives which affect the import and operation process. The non-financial barriers include, among others, inadequate urban planning and cultural barriers towards bus riding. The main financial barriers for introducing biogas systems have been high costs of the units resulting from the lofty expenditure costs of the adopted design and the prevailing project planning practices. The non-financial barriers included absences of a dedicated body to coordinate between the different stakeholders and to carry out the monitoring and evaluation plans. Absences of awareness programs for target groups about the benefits of the technology and lack of scientific backup have also been identified. For the Improved Stoves technologies the financial barriers included the absences of appropriate financing mechanism for both producers and users. The non-financial barriers included the absence of a dedicated body to coordinate the different stakeholder interventions and to implement plans and actions. The absence of awareness program for targeted groups about the benefits of the technology has also been recorded. The barriers for EB technologies identified in the industry sector have been related to high acquisition costs due to the lack of support financial mechanisms. The non-finical barriers include absence of awareness among factory owners about EB benefits

and the limited technical support available in the different stages of purchasing, operation and maintenance of EBs. Finally, a problem tree for each technology has been created in which the central problem has been identified. CFLs are a relatively available commodity in the market but it is not really diffused. Hence, the low acceptability has been identified as a main barrier. The limited use has been agreed upon to be the starter problem for buses (60+). The biogas and IS technologies' central problems are due to the limited uptake of the technology. For the industrial sector the starter problem is the limited acceptability of EB among factor owners. The next step is identifying the measures needed to overcome those barriers and classifying them into financial and non-financial measures. For CFLs, the main financial measures have been the introduction of the technology to the local industry, reduction of taxes and customs, and establishment of the financial support mechanism for users. The non-financial measures include conduct awareness programme campaigns and establish a labelling and grantee system. For the buses financial measures include providing subsides to lower ticket prices and establish investment incentives to encourage bus imports. For IS and biogas technologies financial measures included establishing financial mechanisms to increase their affordability and promote the local industry. Non-financial measures identified by stakeholders include policy reforms for articulating their roles within the respective sectoral polices, establishing of dedicated body that can patronage the technology. It has also been recommended to conduct awareness campaigns and capacity building programmes. The financial measures for EBs are encouraging and supporting factory owners to invest in EBs. The non-financial measure include conducting of training programs for workers and operators, inform the factory owners about the benefits of EB benefits, and support them in adopting such technologies, e.g. by providing consultation service and including the industrial sector

in the LPG distribution policy.

Cost benefit analysis has been done for all prioritised technologies in the different prioritised sector/ subsector. The analysis considered all incremental costs incurred and all benefits gained from technology transfer and diffusion. The findings revealed that different measures selected by the team member in consultation with the stockholders to overcome the main barriers for technology transfer and diffusion have different positive net present value. Evaluation of measures is supposed to help decision makers and stakeholders to choice between different measures and implement informed measures, regulations and policies for technology transfer and diffusion.

The barrier and measures analysis have been followed by conceptualizing the enabling framework for the diffusion of the selected technologies, where a market mapping approach has been used for all selected technologies expect the buses as they are public goods. The main enabling actions proposed include providing finance mechanisms, import of technologies and strengthening/supporting sectoral policies, specification and standard norms. The services providers include media and NGOs to carryout awareness programmes Research Institutions to conduct trainings activities and contribute to adoption of technology. Quality assurance offices are suggested to support quality assurance and grantee services. Market support associations such as consumers groups are expected to promote market and improve the affordability of the consumers.

The report is written according to the template provided by United Nations Environment Program (UNEP Risoe Centre), however as the selected technologies are considered to be affiliated to autonomous subsectors each subsector has been separately presented in the Problem Trees, Objective Trees, Market Maps and Policy Fact Sheets which are presented in the Annexes, as well as a list of the consulted stakeholders.

# Chapter 1
# Energy sector

## 1.1 Preliminary Targets for Technology Transfer and Diffusion of Compact Fluorescent Lamps (CFLs)

Electricity consumption has been identified in the TNA report Part I as an area of high mitigation potential within the Energy production and consumption subsector that is classified under the Energy sector. The stakeholders consider that this area is characterized by excess electricity consumption due to utilization of inefficient appliances. This situation implies extra electricity production. As the thermal power generation system is one of the two electricity production systems in Sudan, GHG emissions from energy industries are expected to increase. CFLs are a consumer type technology which has been prioritized as technology with high potential to generate residential energy-savings. Hence, the main deployment objectives of this technology could be pinpointed as follows:

• To reduce GHGs emission by reducing electricity consumption and so electricity production from thermal power plants, ultimately fossil fuel consumption

• To contribute to family welfare by reducing the electricity bill

• To enhance energy security issues by lowering the overall demand

Based on the stakeholder consultations, the TNA team suggests a utilization of 6,000,000 CFLs per year over the next 10 years. The expected impacts are:

• Reduction of national electricity consumption by 835,200 MWh annually, (energy saved by replacing 6,000,000 ICLs (100 W-60 W) by CFLs (20 W).

• Annual reduction of GHG emissions by 251,395 tonnes of CO2eq.

• On family economic basis, the electricity bill will be reduced by 14 per cent which is an average based on the replacement of 60 W and 100 W

(ICLs) by 20 W (CFLs) for first 200 KWh which are subsidized for all consumers.

• Increase of energy supply security level as a result of reducing the lighting demand

### 1.2 Barrier Analysis and Possible Enabling Measures for CFLs

#### 1.2.1 General Description of CFL

Compact Fluorescent Lamps (CFLs) technology provides low energy lighting services through the use of a compact fluorescent light bulb (7-20 W) that replaces the normal Tungsten Filament light bulb known as Incandescent Lamps (ICLs) (60-100 W), thus, energy saving results through lighting consumption. CFLs mitigate GHG emissions by reducing electricity consumption, and hence, energy reduction occurs through lesser power production of thermal power plants. This leads to the reduction of the amount of fossil fuel combusted and eventually less GHGs will be emitted. According to the base year of this study (2010), the grid emission factor is found to be 0.301 tCO2/ MWh. So, the total CO2 reduction from replacing CFLs (6,000,000 lamps) over 10 years is estimated to be 251,395 tCO2. This is about 50 percent reduction of the total emissions from the thermal power plants in 2010 (471,096 tCO2), which is equivalent to an annual reduction of 5 per cent (scenario as usual).

#### 1.2.2 Identification of Barriers for CFLs

Based on the logical problem analysis (LPA) approach through problem and objectives trees (Annex I), the meetings held between the stakeholders and the national team members showed that there is relatively poor acceptability for CFLs in the Sudanese communities. Individuals and institutions including governmental bodies generally avoid purchasing such technologies despite having been imported for the late ten years. This is suggested to be the result of different barriers that are summarized in Table 1 and discussed below.

**Table 1: Summary of Barriers for CFLs**

| Category of Barriers | Classification of Barriers | Description of Barriers | Impact on Technology diffusion |
|---|---|---|---|
| Financial barriers | Financially not viable | High cost of CFL<br>Absence of financial support programs | Consumers cannot afford to purchase CFLs |
| Non-financial barriers | Information and awareness | Lack of awareness | CFL benefits are not realized by the community |
| Non-financial barrier | Policy and regulatory | Absence of labelling systems<br>Absences of import restrictions | CFLs are not legally protected |
| Non-financial barrier | Policy and regulatory | Absence of specifications and standards | Consumers are not encouraged to buy CFL |
| Non-financial barrier | Market failure | Poor marketing strategies | Poor Availability of CFLs |

### 1.2.2.1 Economic and Financial Barriers

The Economic and financial barriers for CFLs technology incorporate the following:

**Financial Viability:**

The initial costs for integrated CFLs is typically 3 to 10 times greater than that of an equivalent ICL, approximately 2 USD /CFL lamp) compared to 0.3 USD for ICLs. This is mainly due to the high value of customs and taxes added to the basic costs of CFLs. In addition, in order to realise a significant reduction in electricity bill implies that more than one lamp has to be replaced at a time. Thus, it has been concluded that, in spite of the low price level of CFLs compared to other electrical appliances, the low income of the majority of household affects the purchasing process negatively. Absence of local industries also plays a role in the price structure.

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(1) Based on 2010 prices: 7 SDG for one CFL and 1SDG SDG for an ICL, on exchange rate of 2.3-2.8

### 1.2.2.2 Non-financial Barriers

The non-financial barriers for CFLs include the following:

**Information and Awareness Barriers:**

There is a remarkable absence of awareness programs that educate the consumers about the advantages of the CFLs compared with ICLs such as payback period and electricity bill reduction. Most consumers receive opaque electricity bills and cannot identify how much of the bill is accounted for lighting. The Ministry of Water Resources and Electricity (MWRE) offices(1) do not generally provide adequate information of electricity consumption on the designated device. Additionally, a service of explaining/calculating current electricity consumption for premises is not provided on official basis. Furthermore, on the institutional level energy audit is not a common practice. Parallel to this, there is an absence of accurate and complete information about the comparative merits of CFLs at the decision-makers' level. Lack of awareness extends to distributors and installers who are not adequately equipped with proper information about their attributes. This would include the quality assessment of the CFLs.

Policy, legal and regulatory barriers:

The electricity consumption sector is generally characterized by the absence of energy efficiency policies including legal and regulatory measures.

**This is reflected for CFLs in the following points:**

• Absence of a labelling system that classifies the commodities according to their energy consumption. Additionally, there are no restrictions for selling or using any extra consumption devices including ICLs, and there is a lack of encouragement/support to devices with low energy consumption. The

(1) MERW offices are area –based customer service centers responsible for new connection, selling/collecting electricity costs (electricity is charged in many areas of Sudan through prepaid system).

selection of the device is mainly based on price and personal preferences.

• There is no standard for the quality of the CFLs; as mentioned during the stakeholder consultation sessions some lamps showed unsatisfactory performance or accidents. Failure to have such standards will lead to negative perception for CFLs. Additionally, there is an absence of guarantee systems, which might be an additional barrier as consumers often look for guarantees or assurances that the products they buy will achieve the expected results (i.e., number of hours), especially when they pay high prices compared to those of the other lighting lamps.

**Market Failure:**

Low income levels among large strata of consumers usually lead to a lower demand, and hence, a limited market, especially, this can be witnessed in poor and rural areas. This barrier might also be linked to the weak marketing know-how level in Sudan and the status of marketing infrastructure.

### 1.2.3 Identified Measures for CFLs

In order to overcome the barriers some measures are recommended to be taken into consideration. It is suffice to say that the main measures should be taken by the government bodies, especially in relation to policy and regulation issues. These measures are summarized in table 2 and discussed below.

## Table 2: Summary of measures for CFLs

| Measures classification | Measure | Activity | Responsibility |
|---|---|---|---|
| Financial | Import policy reforms | Modify the import policy to decrease the tax and customs on CFLs. | Ministry of Finance; Customs authority |
| Financial | Increase affordability | stablish flexible finance mechanism<br>Establish consumer groups | MWRE officer, localities |
| Financial | Encourage local industry | Provide investment incentives | Ministry of Investment |
| Non- financial | Increase awareness | Conduct awareness programmes and education programmes among at all levels of the community | MWRE; NGOs; consumer groups |
| Non-financial | Establish legal and regulatory frameworks | Initiating labelling systems<br>Formulate quality assessment (QA) policies | SMSO, ERA |
| Non-financial | Increase availability | Improve marketing strategies | MWRE, private sector |

### 1.2.3.1 Economic and Financial Measures

**To achieve the financial viability of CFLs, the following measures need to be taken:**

• Establish import policies that decrease the tax and customs on CFLs

• Provide financial support programs to the poorer consumers who cannot afford to buy them e.g. MWRE could sell CFLs through instalment systems linked to electricity bills, or allowing extra bill reduction or free commodities for first consumers using CFL

• Encourage local committees and worker associations to include CFLs in their flexible payment commodity list, and encourage them to create small investment which can act as revolving funds. This will increase their affordability, which ultimately improves CFLs market availability

• Support the local industry for CFLs through different investment incentives, e.g. provision of loans and lowering taxes for investments on CFLs production.

### 1.2.3.2 Non-financial Measures

• Increase awareness level among consumers through the following:

- Dissemination of adequate information (energy efficient concept, CFL benefits) using different tools e.g. appropriate media programs (TV and radio), outdoor advertisements at public locations, mobile telephone messages system

- Wide distribution of consumption leaflets explaining the benefits of CFLs

- Introduction of the concepts of energy saving and energy efficiency in the basic school curriculum, i.e., within the science classes and/or out of class activities.

• Introduction of energy saving policies and establishment of legal and regulatory frameworks that support CFLs by ascertaining set of standards required for energy saving devices (labelling system) for all electric

appliances.

• Enforce laws and regulations that mandate guarantee systems, set up of administrative procedures and steps required for issuing Quality Assurance (QA) certificates for CFLs.

• Enact regulations to restrict the import of ICL lamps

• Establish effective marketing strategies and programs for CFLs

Costs of measures for CFLs technology transfer and diffusion

The incremental costs of the implementation of the financial measure vary according to the type and dimension of the measure evaluated and the size of the group targeted by the non-financial measures. Give away financial measure accompanied by awareness programs to increase the perception of consumer towards CFLs have been considered in the analysis. The following incremental costs have been considered and quantified on annual basis for ten year span program.

1. Incremental Cost of using CFLs instead of incandescent lamp.
2. Distribution Cost of CFLs.
3. Program Management Cost.
4. Awareness Programs Cost.

Benefits of CFLs technology transfer and diffusion

Different benefits have been derived from the transfer and diffusion of the CFLs technology, among them the following have been identified and quantified for a ten year span program:

1. GHGs emission reduction.
2. Energy saving.

Results of the cost-benefit analysis of the selected measures

The NPV has been calculated by discounting the annual cash flows (earnings minus costs) to the first year of the proposed project at a discount rate of 15% for ten years. The cost benefit analysis of the selected measures has revealed a positive NPV of $ 112 million. This result shows that the

transfer and diffusion of CFLs technology yield benefits that outweigh the costs incurred due the implementation of measures.

### 1.2.4 Enabling Framework for CFLs

#### 1.2.4.1 Market Chain

The current market chain starts by the importers who supply the CFLs to the wholesalers, who in turn sell them to the retailers and the chain ends at the individual consumers who buy from the retailers. The proposed CFL market chain (please see Annex I) starts either through import or local industry, hence, the import policy for either final products or productions inputs is of high importance. At the middle stage the product goes to the wholesale then to either a normal retailer or to MWRE service offices. There are two types of consumers; individual consumers who purchase CFLs for their own use, or consumer groups such as working associations or villages committees who purchase the CFLs at relatively low prices and sell them to their members at special offers (e.g., through instalments). Both consumer types could get the product from either the retailer or MWRE.

#### 1.2.4 2 Enabling Business Environment

Energy Policy: It is needed for the introduction of a green technology concept and labelling system including setting the effective, legal and regulatory measures.

Standard and specification: they are required to ascertain the set of standards and specifications needed for assigning the low energy consumption and/or green technology label to CFLs within Sudan. Their second job is to regulate the issuing of QA certificates for products. This certificate is the main element for establishing effective guarantee systems.

Financial policy: It influences the diffusion of CFLs in two ways; either

by establishing investment incentives like reduction of taxes for local industry or providing fiscal facilities such as low interest loans or subsidies to institutions such as MWRE offices and consumers groups.

Import policy: It facilitates reduction of import tax and customs on final products for importers or production inputs for local industries

MWRE regulation: It intends to support CFLs sales for consumers through MWRE offices, and set internal regulations and procedures for promoting CFLs.

### 1.2.4.3 Service Providers

Media, basic schools and NGOs: They carry out awareness activities and encourage programs about expected saving and environmental benefits

Consumers groups: They arrange and mange revolving funds that increase affordability among poor consumers. They also support awareness programs.

MWRE offices: They suppose to support the marketing and promotion activities and act as sell points

Standard and specification offices: They are set to facilitate issuance of QA certificates, e.g. lowering the certificate fees

## 1.3 Preliminary Targets for Technology Transfer and Diffusion of Mass Transport (Bus 60+)

In the TNA report Part I, the transport sector has been identified as the second subsector with high mitigation potential under the Energy sector. Transportation in Sudan is entirely dependent on petroleum which accounts to about 60 per cent of the total petroleum consumption. The road transportation makes around 84 per cent of the transportation consumption. The in-city transportation system is mainly served through private cars and public mini/micro buses with capacities ranges between 7-25 passengers.

This system consumes high amounts of fuel, thus emitting GHGs and polluting gases.

The Australian department of Sustainability, Environment, Water, Population and Communities has stated that for every litre of petrol fuel 2.3 kg of $CO_2$ is emitted. Stakeholders have mentioned that the wide utilization of Mini/micro buses, private car also leads to high congestion levels in the cities. Therefore, the major deployment objectives for bus system within the transportation subsector have been identified as follows:

• To contribute to mobility systems' improvement by increasing public transport capacity

• To lessen the road congestion level

• To lower the air pollution level

• To reduce GHG emissions

The starting target has been agreed upon to be the introduction of 400 buses per year in Khartoum State over the period of 10 years

### 1.3.1 Barrier Analysis and Possible Enabling Measures for Bus (60+)

### 1.3.2 General Description of Bus (60+)

Buses (60+), which have been classified as public goods, are vehicles that are able to transport larger numbers of passengers per trip. They lead to a reduction of vehicles moving on the roads, and hence, congestion level will be lowered and mobility be improved. Adoption of mobility system depends greatly on bus system instead of small vehicles. .

### 1.3.3 Identification of Barriers for Buses (60+)

Although the use of mass transport system is old in Sudan, the bus system is inefficient and its utilization is still limited. According to Transport Chamber statistics of 2010, in the capital Khartoum (population of around

10 million), there are around 350,000 vehicles out of which around 30,000 are mini buses (25 passenger), and 1,600 buses. However, the in –city buses are estimated to be in the range of 250-400 bus only. Therefore, major improvements are needed, especially with the quick horizontal expansion of the cities. According to stakeholder discussions, using LPA, problem and objective trees, expansion of the bus system requires encouragement of the private sector to invest in importing buses and running bus fleets. Thus, some strategies and policies are needed to be reformed to give priority to public transportation systems including buses, traffic regulations and instructions. Considering the status of transportation infrastructure, such as extension and quality of paved road network, improvement is highly required. Efforts are also needed to encourage car owners to use public transportation systems. Additionally, the stakeholders have emphasized that the lack of coordination between Ministries of Petroleum, Transport, Infrastructure and other concerned bodies such as city administration and state governments has resulted in poor management system. After lengthy discussions, the following barriers have been identified, please see Table 3. The results are summarized and discussed further in the designated section below.

**Table 3: Summary of barriers for Buses (60+)**

| Category of Barrier | Classification of Barrier | Description of Barrier | Effect on Technology |
|---|---|---|---|
| Financial barrier | Financially not viable | Lack of investment incentives<br>Unacceptable pricing policy | Low investment interest<br>Low number of buses |
| Non-financial barrier | Cultural barrier | People reluctance to ride buses | Low investment interest<br>Low number of buses |

| | | | |
|---|---|---|---|
| Non-financial barrier | Technical barrier | Inadequate Urban planning and street design<br>Absences of adequate technical setup for running bus fleets | Limited mobility for buses<br>Limited skilled drivers<br>Poor maintenance services |
| Non-financial barrier | Policy and regulatory | Absence of effective transport policy | Bus systems are not given priority in transport policy and traffic regulations |

### 1.3.3.1 Economic and Financial Barriers

• Pricing policy and transportation tariff calculation that have been set by governmental authorities are considered to be unrealistic and they are not accepted by both owners and consumers. The main point here is that the government estimates lower values for running and maintenance costs which does not satisfy bus owner's needs, especially as they are not given any subsidies in fuel or reduction in license fees. On the other hand, the consumers consider the bus ticket to be more expensive than tickets for micro buses.

• Imports of bus spare parts are not given any investment incentives (e.g. consideration with respect to custom duties and import taxes). Additionally, there is no flexible financing mechanism that encourages the investors to import buses and/or spare parts.

• The scarcity of foreign currency and fluctuation of exchange rate affect the import of the spare parts and increase the running cost. Bus spare parts are not given any priority in hard currency policy.

### 1.3.3.2 Non-financial Barriers

### Cultural Barriers

Bus riding is not preferable transportation option in Sudan, therefore Car owners perceive bus riding negatively. Non-car owners prefer to use mini/micro buses for more comfort and elegance. Generally, the

internal conditions of buses cleanliness and seat neatness are not up to the norms. Citizen's behaviour towards bus boarding does not consider the environmental and social benefits of bus riding.

Technical Barriers

The technical framework required to run bus fleets is not up to the standard. This is mainly due to two factors:

• There are limited training centres to train skilled bus drivers. Unskilled drivers often drive irresponsibly, leading to increased maintenances and in some cases to accidents. Therefore, private sector is not encouraged to get into this business.

• The maintenance services and spare parts quality presented by the commercial workshops are not well developed, this results in high maintenance costs. Hence, this has increased the private sector reluctance towards investment in buses.

The infrastructure and the urban planning mode of the cities in Sudan affect the bus system as follows:

• Buses are by definition slower than cars and there are limits for using shortcuts and bridges, so less manoeuvring room. Therefore, the trip time with a bus is much longer than with small vehicle.

• There is no well-developed system of bus stops, timetable and information signs.

• The existing urban planning systems do not support public transport. The Sudanese cities, especially Khartoum, are characterized by urban concentration of services in relatively small areas.

• The paved road network is limited and of relatively low quality.

Policy, Legal and Regulatory Barriers:

Absence of transportation policies that give priority to buses (60+) over private cars and small buses, e.g. the traffic regulation in the capital city Khartoum prohibits the public transport sector mobility in several regions

including the city centres. Regulatory barriers include also the absence of Public- Private sector- Partnership (PPP) in the public transport field. Additionally the formation of bus company is not given any consideration within the company act.

**Identified Measures**

In order to overcome such barriers the following measures are suggested:

**Table 4: Summary of Measures for Buses (60+)**

| Classification of measure | Measure | Activity | Responsibility |
|---|---|---|---|
| Financial measure | Establishment of investment Incentives measures | Reduce taxes and import duties Encourage PPP | Ministry of Finance, Ministry of Transport, states and cities government, mini vehicles driver associations |
| Financial measure | Adopt fair pricing policy | Provide special subsidies for | Ministry of Finance, Ministry of Transport, states and cities governments, consumers |
| Non-financial measure | Break cultural barriers | Conduct encouragement program | NGOs, state government, media |
| Non-financial measure | Adopt effective mobility policy | Give priority to public transport | Ministry of Transport, state government, traffic police |
| Non-financial measure | Modify urban planning concept | Improve street design Reallocate service and residential areas | Ministry of Transport, Ministry of Infrastructure state government, traffic police |
| Non-financial measure | Improve technical support | Conduct training session for drivers Improve maintenance services | Ministry of Transport, Ministry of Infrastructure, state government, Ministry of Labour traffic police |

### 1.3.4 Identified Measures for Buses (60+)

### 1.3.4.1 Economic and Financial Measures

• Establish investment incentives measures such as lowering taxes and import duties for buses and their spare parts or arranging low interest loans to encourage the private sector investment

• Assign high priority for bus investment activities within the hard currency policy

• Adopt more realistic pricing policy considering the mutual interest of bus owners and consumers (e.g., fuel subsidy or reducing licenses fee).

• Establish financing mechanisms to local authorities to upgrade the road status, equip the street with bus stations and conduct training courses for bus drivers

• Simplify the establishment procedures and requirements for new companies e.g. by lowering the annual licence fees and taxes for buses

### 1.3.4.2 Non-financial Measures

• Formulate comprehensive policy for mass transport that defines their role in alleviating the mobility problem, e.g. traffic laws

• Include public transportation system in urban planning activities, e.g. specific bus lanes

• Support the efforts paid to reduce urban concentration of services and distribute it all over

• Raise awareness in collaboration with NGOs and environmental movements within the community to break down the cultural barrier and disseminate information about environmental benefits of bus riding

• Encourage more middle- and small-sized investors to enter into such type of investment by organizing them in larger partnerships or companies

## Costs of measures for Mass transit Buses technology transfer and diffusion

The analysis has been carried out for a project formulated to diffuse 400 buses annually in the transport system for a period of 10 years. The costs of the following items have been calculated to obtain the total cost of the selected measures as follows:

1. Capital cost of the bus
2. Operating and maintenance cost
3. Energy fuel cost
4. Financing cost
5. Training and capacity building

Benefits of measures for (EB) technology transfer and diffusion

To calculate the benefits derived from the financial incentives given to promote mass transport buses technology transfer and diffusion, the following benefits have been quantified over 10 year project:

- Time savings benefits
- Fuel savings benefits

Results of the cost-benefit analysis of the selected measures

The Net Present Value (NPV) has been calculated by discounting the annual cash flows (earnings minus costs) to the first year of the project for 10 years with a (15%) discount rate. Considering the two benefits quantified namely, time saving benefits and fuel saving benefits, the NPV comes to $ 465 million; considering other benefits such as conventional pollutant reduction and air quality and public health benefits result in substantial increase the NPV.

# Chapter 2
# Agriculture, Forestry and other Land Use (AFOLU) Sector

## 2.1 Preliminary Targets for Technology Transfer and Diffusion of Improved Stoves

The TNA report identified the forestry as subsector with high mitigation potential within the AFOLU sector. The main reason is the high loss of carbon sink due to deforestation. Wood constitutes the main source of energy in rural areas and to a great extent in the semi-urban and urban communities. The Forest National Cooperation (FNC) 2010 report stated that "Enhancing economic efficiency of energy use is vital to achieve the best utilization of biomass resources and to protect the environment, and should be given high priority in the FNC policy and plan" (FNC, 2010). FNC literature also shows that forests contribute to a total of 4.11million T.O.E., representing 70 – 81 per cent of energy supply in the country (FNC, 1995) estimates the average annual per capita consumption by approximately 24.3 kg and 10.1 kg of wood fuel for rural and urban households respectively. The 2010 report stated further that in rural and semi urban areas the use of non-renewable biomass or fossil fuels for cooking (LPG, solar cookers) has not gained any significant importance. Traditional cook stoves such as three stones open fire stoves are the prevailing cooking devices. Improving the efficiency of fuel wood consuming appliances is therefore crucial to combat deforestation and increase carbon sequestration in the forestry sector in Sudan. Hence, Improved Stoves (IS) have been identified as technology with highest priority in the TNA report Part I. Improved Stoves are known in Sudan and some projects have been executed to introduce and disseminate the technology, but a large-scale uptake has not yet taken place. Based on the severe consequences of forest harvest to satisfy the energy needs, the stakeholders agreed that the main deployment

objectives of the IS are as follows:

• To increase carbon sink/sequestration rate

• To decrease deforestation rate which in turn is related to land degradation, population and livelihood

• To contribute to family welfare by reducing fuel amount, and hence, fuel costs (1)

• To improve women and children's health status by reducing indoor pollution

• To support the efforts paid to maintain biodiversity by conserving its natural habitat

The stakeholders reached to the consensus that around 600,000 stoves/ year(2) should be made available to the targeted groups through different projects in Central, Eastern and North Darfur regions at both urban and rural areas(3) within a 3-5 years project. This amount is assumed to serve about 5 million people, which represents about 30 per cent of the total population in these regions (14 million) (census 2008). These targeted areas are selected because of their high deforestation rate. The expected impacts are:

• Reduction of forest degradation in terms of quantity of wood cut which will simultaneously conserve the prevailing ecosystems

• Improvement of women's and children's health by providing efficient stoves (better combustion)

(1) The CDM PIN estimated the daily charcoal costs in Kassala and Gadrif –Eastern Sudan in 2010 by 3 SDG which corresponds to1.3 USD (exchange rate 2.3-2.8) 2010.
(2) The lifetime of a stove is around one year.
(3) Generally, in Sudan the family had more than one type of stove, charcoal, wood, LPG, charcoal stoves (metal) are more prevailing in urban areas.

## 2.2 Barrier Analysis and Possible Enabling Measures

### 2.2.1 General Description of Improved Stoves

Improved Stoves (IS) are consumer technologies ranked under forestry subsector, AFLOU sector. They are built to reduce wood energy and contribute to appropriate combustion mode through optimum design and suitable material. They have a better efficiency of up to 35 per cent and reduce GHG emissions by reducing the amount of wood used. CDM PIN estimated a saving of 2.8 tonne of wood/ stove/ year. It also calculated the emission reductions of each IS compared to LPG stove is 2.3 $CO_2$ tonne / stove /year.

### 2.2.2 Identification of Barriers for IS

FNC literature reports stated that "despite research & development programs, improved stoves of the types known up to now have not gained any significant foothold in any part of the country". Hence, by using the LPA tool, the stakeholders agreed that the starter problem of the main barrier is the weak uptake of the technology. Many factors contribute to this starter problem which is summarised in Table 5

**Table 5: Summary of Barriers for IS**

| Category of Barrier | Classification of Barrier | Description of Barrier | Effect on Technology |
|---|---|---|---|
| Financial barrier | Financially not viable | Relative high cost of IS (high discount rate) | Affordability of households |
| Financial barrier | Lack of financial incentives | Absences of financial support for producers | High purchasing price |
| Non-financial barrier | Information and awareness | Lack of awareness | ISs benefits are not noted by the community |

| | | | |
|---|---|---|---|
| Non-financial barrier | Policy and regulatory | Absence of effective energy and forest policy | Ineffective / non-sustainable dissemination programme |
| Non-financial barrier | Institutional barrier | Lack of coordination between stakeholders, Low capacity for addressing adoption of IS | Ineffective/ non-sustainable dissemination programme |

### 2.2.2.1 Economic and Financial Barriers

**The financial barriers hindering the uptake of the IS are:**

**Financial viability:**

• A good quality(1) IS is a commodity of higher cost compared to traditional stoves. Stakeholders estimate double to triple value compared to metal stove (2). However, users generally do not relate the saving in fuel with stove price (high discount rate). Additionally, the limited household budget limits the possibility of purchasing new stoves.

• Lack of investment incentives for producers, against low demand, results in inadequate private sector participation. This results in higher profit margin, and thus high purchasing price.

### 2.2.2.2 Non-financial Barriers

**Information and awareness:**

There is low awareness level about IS due to the lack of appropriate awareness programs among the community and inadequate training for extension/development workers. Additionally, decision makers (local/ national), also needs to be informed about the importance of forests conservation and the role of IS in this field

(1) Good IS requires specific mixture , proper heat treatment for the mud mixture and good quality metal mesh

(2) Three stones stove have no cost.

**Institutional arrangements**

• Different institutions consider IS in their programs e.g. the FNC, the Energy Research Centre and NGOs but there is an absence of government patronage and institutional coordination. In addition, there is no clear distribution of responsibilities and smooth coordination between them.

• The mandates of these institutions limit their ability to enforce efficient dissemination and implementation plans, and support measures to promote such technologies.

**Institutional capacity:**

The dissemination of new technologies such as the improved stoves involves different aspects of social, economic and investment circumstances. Yet, there is relatively limited governmental capacity capable of addressing such issues.

**Policy legal and regulations:**

There is absence of the environmental governance concept specifically in relation to energy and forestry. In addition, there is no well-established, regulatory and legal framework for the diffusion and transfer of forest conservation/energy saving technologies in general. Therefore, IS dissemination and adoption projects are more or less dependent on “good understanding" of the governmental officers.

### 2.2.3 Identified Measures for IS

The stakeholders agreed that the following measures are necessary to ensure the deployment of IS. These measures are summarised in table 6 and are discussed further.

## Table 6 : Summary of Measures for IS:

| Measure | Activity | Responsibility |
|---|---|---|
| Increase affordability and demand | Financially support for user groups e.g. revolving fund. | Consumer groups, FNC, state government, CBOs/ NGOs |
| Increase private sector involvement | Provision of low interest loan. to private sectors | FNC, state government, craftsmen association, CBOs/NGOs |
| Increase awareness level | Conduct different awareness programmes at different levels through different tools | FNC, NERC, local media |
| Improve IS quality | Conduct extensive training programs for producers | FNC, NERC |
| Establish a specific administrative body | Coordination with different stakeholder | Relevant institutions |
| Improve policy and regulatory framework | Applying environmental governance and empower energy and forest polices | |

### 2.2.31 Economic and Financial Measures

To make IS more financially viable it has been recommended to establish a financial mechanism that provides support to users and producers, (e.g., to make revolving funds for users and loan system for producers accessible).

### 2.2.3.2 Non-financial Measures

### Non-financial barriers can be reduced through:

• Increasing awareness level among consumers by adequate information dissemination through different approaches, e.g. appropriate media programs, outdoor advertisements, mobile messages etc. Special programs about the importance of forest conservation, benefits of IS to environment should target decision makers and development workers

• Conducting extensive training programs for selected multipliers, e.g. provide extension officers, school teachers, development workers with sufficient, clear and simple information about IS

• Establishing a specific administrative body (coordinating committee) from the current relevant institutions stakeholders. It is suggested to be responsible for management of the implementing programs and coordination with other sectors. This body can act as representative when negotiating the different issues of economic support, policy, standards etc. The body should also be responsible for better project preparation that may improve the addressing of the complex relationship between different issues such as financial support and community ownership, sustainability and resource management.

• Applying environmental governance policies and empowering the energy and forest polices in addition to setting effective legal and regulatory frameworks that consider the role played by IS within the energy efficiency and forest conservation issues.

**Improved stove (IS) Technology:**

Costs of measures for Improved Stove (IS) technology transfer and diffusion

The costs of the following items have been calculated to obtain the total cost of the selected measures:

1. Subsidy per improved cook stove
2. Cost of improved cook stove
3. Repair and maintenance cost
4. Training &capacity building cost
5. Increase awareness cost
6. Program management and technical assistance

**Benefits of measures for Improved Stove (IS) technology transfer and diffusion:**

From the objective tree analysis done by the team member in consultation with stockholders the adoption of improved cook stove yield many benefits. To calculate the benefits derived from the financial incentives given to remove barriers for the technology transfer and diffusion, benefits due to fuel savings and benefits due to GHGs emission reduction have been quantified. Other benefits such as, benefits due to; fuel savings, reduced cooking time , better health, preserved forest cover and improved soil fertility have been identified but have not been yet estimated because of insufficient data and time constrains.

**Results of the cost-benefit analysis of the selected measures:**

Regarding the proposed project as an investment project with duration of 3 years, the net present value (NPV) represents the sum of all costs and benefits calculated along the project cycle and valuated at beginning of the project. The NPV has been calculated by discounting the annual cash flows (benefits minus costs) to the first year of the project.

Taking only the fuel wood savings as benefits into account, the NPV comes to $ 234 million; considering GHGs emission reduction with for $ 10 price also, the NPV amounts to $ 275 million.

### 2.2.4 Enabling Framework

#### 2.2.4.1 Market Chain

Currently there is no market for IS; they are distributed by NGOs, in a free donation mode, mainly in Darfur Region “Butana”. The stove selected in this study is made of burned earth mud and metal sheets. To ensure a better quality it is recommended to produce stoves in medium level workshops led by local trained craftsmen to follow a better mud mixture. The suggested market chain starts with the manufacturing step in the workshops. Then the IS go to distribution centres from where they are sold to either mid-

term institutions such as NGOs, government offices, or consumers groups, such as village committees or women group. The individual consumers can either get the product through the consumer groups or through the activities of the mid-term institutions.

### 2.2.4.2 Enabling Business Environment

**Energy and forest policy:** articulate the role of IS within the energy consumption/forest conservation issues and set measures needed to support/ regulate, and enforce their utilization

**Financial policy**: set fiscal measures that support producers such as tax and fees reduction, low interest loans for starting the business s. Also it facilitates support systems for consumer groups and individual consumers such as revolving funds.

**Import policy:** reduce tax and customs on imported material mainly machines needed in workshop.

**Institutional arrangements:** ease coordination between different stakeholders, especially governmental institutions, e.g. in areas of licensing workshops, distribution centres, or legal formation of consumer groups.

### 2.2.4.3 Service Providers

**Media and extension services**: provide awareness about forest conservation importance and IS benefits

**Consumers groups:** arrange and manage revolving funds, distribution of IS and contribute to awareness activities

**Educational and training institutions:** provide capacity building services for craftsmen and midterm officers in both issues of engineering and project management

**Research and education institutions:** carry the job of improving the commodity and production of best practices booklets and support awareness and training activities.

## 2.3 Preliminary Targets for Technology Transfer and Diffusion of Biogas System

Livestock is the second subsector identified with high mitigation potential in the AFOLU sector. The manure management technology "i.e., biogas" has been prioritized as the first mitigation technology. Due to open fermentation resulting from absences of adequate utilization of dung, the manure management practices in Sudan is considered to be a source of high methane emission. Biogas systems are consumer goods selected under manure management practices. The main targets for the deployment of this technology are strongly related to improving the livelihood status of the rural areas. This includes raising the service level and improving the public health situation. Hence, the following objectives have been identified as follows:

- To reduce GHG emissions
- To supply cooking fuels
- To provide electricity
- To deliver lighting service
- To improve public health by collecting livestock dung

Deployment programs are envisaged to be executed over a period of 5 years. It will be directed towards the rural areas in Sudan, mainly Gezira, White Nile and Blue Nile regions. These areas are selected based on the fact that:

- High cattle potential on semi sedentary system, estimated by 30 million heads
- Sedentary population, average household of 10 persons per household
- Availability of water, explained by their close location to the river Nile

Based on above facts, the stakeholders set the following assumption:
60 per cent of the cattle population is expected to enter such systems with

dung availability of 70 per cent as the expected amount of dung is around 1.5 tonnes fresh basis and 0.3 dry basis of dung/head/year. The dung is expected to produce 350m3 of biogas/tonne of dry matter with an average heating value of 20 MJ/ m3 biogas.

Based on needed energy for each use, the generated gas quantity is suggested to be used as follows:

- 35 per cent cooking fuel
- 50 per cent electricity production
- 15 per cent direct lighting to bypass the high cost of gen set

The expected gas is enough to cover basic services of heat and light, and partially electricity for around 100,000 households/ year.

### 2.3.1 Barrier Analysis and Possible Enabling Measures for Biogas Technology

### 2.3.2 General Description of Biogas System

Biogas Systems converts organic material to a mixture of combustible gases known as biogas that can satisfy different energy needs including electricity. The residue can be used as bio fertilizer. The biogas generation process involves anaerobic fermentation under specific conditions. The biogas system is composed of a reactor, gas holder and connecting pipes, as well as suitable end use appliances. Biogas systems reduce GHG emissions by converting methane emissions to biogenic carbon dioxide emissions thus the effective GHG emission is zero.

### 2.3.3 Identification of Barriers for Biogas

Although biogas technology for energy purposes has been introduced to Sudan in the mid-70s through some projects there is no systematic use of this technology and most executed projects had failed. Different barriers had led to this situation. One factor is the low awareness level about biogas

among the different community members, including the livestock sector. Another factor is that the government environment plans are general and relatively vague, thus they do not give specific consideration for selected technologies such as biogas within the energy, waste and livestock sectors. Other barriers are the high costs and the complexity in erecting biogas units as it requires expert builder and expensive construction materials. Table 7 summarises the main barriers that are further discussed in the section below.

**Table 7: Summary of Barriers for Biogas**

| Category of Barrier | Classification of Barrier | Description of Barrier | Effect on Technology |
|---|---|---|---|
| Financial barrier | Financially not viable | Expensive construction material | High costs of biogas system |
| Financial barrier | Financially not viable | Absence of financial policy for (low interest loans) | Low affordability among the community to adopt biogas technology |
| Non-financial barrier | Information and awareness | Lack of awareness | Community is not aware about biogas benefits |
| Non-financial barrier | Policy and regulatory | Absence of effective energy and forest policy | Low deployment level |
| Non-financial barrier | Institutional arrangement | Lack of coordination between relevant institutions<br>Absence of responsible body | Low deployment level |
| Non-financial barrier | Human skills | Limited technical know-how | Limited technical support |

### 2.3.3.1 Economic and Financial Barriers

Economic and financial barriers for biogas technology incorporate the following:

**Financial viability:**

• Biogas technology is a high-cost technology that generally cannot be afforded by individuals or even village communities. These high costs are a result of high construction materials needed for reactor (prefabricated system is generally not known) and inadequate taxes and custom fees for the appropriate appliances.

• Absence of financial policies for green technologies in general and biogas in particular. The commercial banks, community development institutions/ agricultural fund do not provide loans or any purchasing facility for the individuals or communities

### 2.3.3.2 Non-financial Barriers

**The non-financial barriers include:**

**Information and awareness barriers:**

Basic scientific information and planning for biogas technology are rarely included in university curriculum at B.Sc. level. At M.Sc. very few courses include biogas technology in their programs. This results in an acute lack of information at the different levels of society including policy making and planning. In addition, there is a complete absence of awareness packages about the conditions and the benefits of such technologies whether as direct information mode or through the media. This absence extends to rural development programs and agriculture extension services. Therefore, the livestock owners in general are not aware about biogas technologies and their benefits. This situation results in biogas being an undiscovered subject, and hence, a low demand. This low demand does not encourage allowing specific budget for biogas awareness programs.

Instead, the available fund is then directed to more common technologies and programmes such as new crop varieties or gender mainstreaming, which creates a vicious circle.

### Policy legal and regulatory barriers:

There are no well-defined policies and regulations that are issued to mainstream biogas technologies and priorities within the energy, waste and livestock sectors. This is due to inadequate awareness among decision-makers about the importance of green technologies and the benefits of biogas.

### Institutional barriers:

Although different pilot projects are executed it is believed that they are not optimally planned (e.g., there is prevalence of small scale, single purpose units using expensive designs). Furthermore, follow -up measures have not been critically considered. This results in unsustainable projects which generate negative community perceptions. Research and educational institution are relatively active in producing scientific documents including technical packages or execution instructions, however the impact of the research outcomes are very limited due to absences of transformation channels. Additionally, there is no specific body responsible for smooth systematic cooperation between the main governmental bodies and institutions that deal with biogas such as Ministry of Animal Wealth or the Ministry of Energy as well as supporting the dissemination and adoption efforts of biogas technologies.

### Human skills barriers:

Although there are some biogas professionals there is generally very limited technical know-how at the different levels including planning, scientific research, contractors, builders and operators. This can be explained by the

fact that many higher education faculties including engineering, agriculture and animal production, do not include adequate biogas related topics in their curriculum. In addition, the relatively small job market related to biogas technologies does encourage youth to anticipate a career in biogas technologies other than the jobs related to universities and research centres.

### 2.3.4 Identified Measures for Biogas

The main measures are expected to be carried out by both the community organizations such as NGOs, livestock owner association, village committees and the different governmental bodies including research centres and universities. It has been generally agreed upon that a very crucial point for establishing biogas in Sudan is the smooth coordination between the different stakeholders in addition to a strong policy and regulatory framework. For biogas technology the main measures identified are summarized in table 8 and discussed later.

**Table 8: Summary of Measures for Biogas**

| Measure | Activity | Responsibility |
|---|---|---|
| Decreasing the initial costs for biogas | Reduce the tax and customs on the biogas system inputs | Ministry of Finance , customs authorities |
| Increase affordability and demand | Financially support user groups, e.g. through revolving funds | NGO, consumer groups |
| Encourage investors to invest in local industries of Biogas | Provision of low interest loans to the private sector | Ministry of Finance |
| Increase awareness | Raise awareness through different approaches with special consideration to decision makers and development workers | Ministry of Animal Health, NERC |
| Capacity building for operators | Conduct education and training programs | NERC |
| Establish a specific administrative body | Coordinate with different stakeholder<br>Better project planning | Relevant institutions |

| | | |
|---|---|---|
| Improve policy and regulatory frame work | Empowering environmental governance, in particular energy and forest polices | Ministry of Environment |

### 2.3.4.1 Economic and Financial Measures

• Establishing finance mechanisms to decrease the tax and customs on the imported materials for biogas systems, e.g. steel sheets and biogas based appliances

• Provide subsidies and flexible payment mechanisms to the community to increase their affordability, e.g. by initiating a tariff for biogas technology products and so encourage private sector to enter such fields

• Encourage investors to invest in local industries of Biogas e.g. by establishing factories for prefabricated system that can significantly lower the erection costs

### 2.3.4.2 Non-financial Measures

• Increase awareness level among decision-makers by conducting awareness campaigns, decision-maker workshops and field visits

• Enact and enforce waste and energy policies that can accommodate legal and regulatory frameworks for the utilization of biogas technologies, including monitoring and evaluation activities. This requires the establishment of a dedicated institutional body that carries out the effort of mainstreaming the biogas technologies into Sudan's development plans. This body will be responsible for coordination between internal and external interest groups and stakeholders.

• Conduct short and long term training activities for mid-term institutions as well as on biogas unit installation and operation

• Intensify the biogas technology done in the university curriculum, and design new programs at different levels of vocational training and Masters level. Within this context special care should be given to encourage youth

to join such programs.

• Encourage exchange programs and expert visits to benefit from other countries' experience

Costs of measures for anaerobic manure digestion technology transfer and diffusion

The incremental cost of measures has been based on a proposed five year intervention anaerobic manure digestion (biogas) project targeting 20,000 households. Based on its success in elsewhere and consultation with stakeholders in the energy sector in Sudan, a fixed dome model using a prefabricated digester of 8 cubic meters has been proposed for the analysis. Accordingly the following Incremental costs identified and quantified:

1. A flat subsidy of US 200 per biogas plant
2. Cost of biogas plant (US 900)
3. Repair and maintenance cost (2%) of the capital cost
4. Training & capacity building (10%) of the capital cost
5. Installation (10%) of the capital cost.
6. Program management and technical assistance (20%).

## Benefits of measures for anaerobic manure digestion technology transfer and diffusion

Measures for uptake of (biogas) yield multiple benefits. In the analysis the following benefits has been identified and quantified.

1. Saving in alternative fuel consumption
2. Saving from chemical fertilizer consumption
3. $CO_2$ saved per HH ($tCO_2e$)
4. Annual $CH_4$ saved per HH ($tCO_2e$)

Results of the cost benefit analysis of the selected measures

Total annual costs and benefits have been discounted for 25 years taking in consideration the expected life span of the biogas plant and the time

scale of the project. The socio-economic evaluation came to the result of a positive NPV of US 33 million. In other words, the project will result in a welfare gain if it is initiated.

### 2.3.5 Enabling Framework for Biogas

#### 2.3.5.1 Market Chain

The biogas technology at the village level is expected to be acquired in two ways, namely via

• Locally prefabricated reactors according to standard sizes which require extra erection costs.

• On-site construction which can be tailored according to consumer preference and site limitation. This requires the utilization of construction material such as steel and cement which can be imported.

**The market chain goes as follows:**

• Case 1: Prefabricated system: from the factory to mid-term institutions which could be NGOs or development project administration. These mid-term institutions will arrange a financial agreement with the village committee regarding the purchasing and erection of the unit.

• Case 2: In-site systems: the midterm institutions will support the village committee by providing skilled builders and set financial arrangement for purchasing material and covering construction expenses. The construction in case 2 is expected to be carried out by independent contractors.

#### 2.3.5.2 Enabling Business Environment

Energy, waste policy: articulate the role of the biogas units within these sectors, organize the relationships with other bodies and sets the necessary measures and regulation that support its use.

Import policy: Both options depend to different extend on imported commodities. So, in both cases the import policy affects the cost and availability of biogas unit.

Financial policy: sets fiscal measures that support producers such as tax and fees reduction, low interest loans for both local contractor and prefabricated industry. Also, it facilitates support systems for mid-term institutions and village committee such as revolving funds.

Institutional arrangements: some arrangements are required for establishing a dedicated body that can liaise and coordinate between different government institutions and consumers.

Standards and specifications will produce the necessary standards and specification necessary for using the technology such as site selection, building and production codes etc.

### 2.2.2.3 Service Providers

**Media, extension offices and NGOs:** carry out awareness programs for villagers, development workers and decision makers at both regional and national level about problems associated with open dung fermentation and biogas benefits.

**Market support groups:** Community groups will arrange and manage revolving funds, contacts with government bodies, midterm institutions and contribute to activities related to raising awareness.

**Educational and training institutions**: provide capacity building services for builders, operator and midterm officers in both issues of engineering and project management.

**Research and development institutions:** improve the commodities and production of best practices advices, support awareness and training activities.

# Chapter 3
# Industry Sector

## 3.1 Preliminary Targets for Technology Transfer and Diffusion of Efficient Boilers

Although the industrial sector contributes to about 1 percent of Sudan's total GHG emissions, the TNA report Part I has identified it as an important sector for mitigation. This is because it has been considered to develop and grow substantially in the near future. In the Part I report, the food industry has been identified as the main area for mitigation which constitutes about 48 percent of the industries, and contributes to about 15 percent of the GDP. Literature shows that the generation of steam to the small and medium scale food industry, such as beverage and milk products, is prepared in obsolete boilers, mostly with high leakage and heat loss characteristics (50 to 60 percent efficiency) that use "dirty" fossil fuel such as residual fuel oil (furnace) or disposed lubrication oil. This situation results in high fuel consumption, pollution and GHG emissions. Hence, efficient boilers (EB) with dual fuel (diesel- furnace/LPG) have been identified as a proper technology with the high potentiality for the reduction of GHG emissions in the industrial sector. The main deployment objectives for this technology are as follows:

• To reduce fuel consumption in boilers and minimize the fuel expenses
• To increase energy efficiency in the industrial plants
• To minimize air pollution and improve work environment
• To cut down in GHG emissions

After in depth consultation, the stakeholders have agreed on the following targets:

• Installation of 100 efficient boilers (EB) with dual fuel (furnace, diesel/ LPG) in 10 years period at a rate of 10 boilers per year. The recommended

target sector is medium and small scale food factories. It is suggested that this sector has to be equipped with new boilers of 1 to 6 tonnes/hour capacity, working pressure from 5 to 12 bars and an efficiency rate of 90 percent.

Hence, the expected impacts are:

• Reduction of around 3740.5 kg $CO_2$/GJ in ten factories in a year

• Increase of profitability of the produced commodities through lowering the fuel consumption by 30 percent

## 3.2 Barrier Analysis and Possible Enabling Measures

### 3.2.1 General Description of Efficient Boilers

Efficient boilers are turn-key equipment with high Maximum Continuous Rating (MCR)(1) . This technology could be applied for replacement of existing boilers or upgrading and improvement of their efficiency. This can be achieved by adding advanced heat recovery system, controlling and upgrading the burner by suitable dual burner systems to allow for utilization of the different fuels (LPG or for diesel/furnace). Consequently, the emission reduction in boilers depends on boiler efficiency and fuel type as discussed in the technology fact sheet in TNA report.

### 3.2.2 Identification of Barriers for Efficient Boilers

The technology transfer in general and green technology in particular is a challenging process in Sudan. This is because most industries are of small and medium size nature, with limited budgets and they often have unskilful human power.

In this respect, the stakeholders have agreed that the main barriers for adopting EB in Sudan are mainly related to (i) the level of technical facilities available to the factory owners. These facilities include the selection of the appropriate system, availability of operating guide lines

(1) MCR is a measure for boiler efficiency determined as amount steam produced at specific temperature and pressure: It is defined as the maximum output in that system. It is capable of producing steam continuously under normal conditions over a year.

and proper working capacity. (ii) The financial requirements are needed to achieve the replacement/upgrading process.

The stakeholders have identified the following barriers which are summarised in Table 9 and discussed further in the text below:

**Table 9: Summary of Barriers for EB**

| Category of Barrier | Classification of Barrier | Description of Barrier | Effect on Technology |
|---|---|---|---|
| Financial | Absences of investment incentives | Limited finance resources for owners | Limited number of EBs |
| Non-financial | Policy, legal and regulatory | Lack of clear policy towards industrial development, especially in issues such as fuel provision, finance and employment | Limited number of EBs |
| Non–financial | Human skills barriers | Lack of adequate training programs | Lack of competent technical know-how<br>High maintenance and operational costs<br>Complexity in calculation of emissions |
| Non–financial | Information and awareness | Lack of effective awareness programmes | Industrial sector is not aware of EB benefits |

### 3.2.2.1 Economic and Financial Barriers

Absences of investment incentive

• There are limited financial resources available for the factory owner to support them in replacing and upgrading their old boilers. This also includes limited accessibility to foreign currency for the import process. Financial resources are also needed to establish proper gas storage and handling systems for the LPG.

• Efficient boilers are sensitive equipment. Stakeholders assume that the maintenance frequency is high in Sudan, and hence, a high maintenance cost is expected.

### 3.2.2.2 Non-financial Barriers

**Human Skills Barriers**

There is a lack of competent technical staff (operators and engineers) that can properly handle the technical operations needed at the different stages of technology adoption.

**Policy, legal and regulatory barriers**

• Changing the governmental regulations in relation to LPG distribution. The industrial sector has greatly been encouraged to utilize LPG. However, currently the household sector is given the highest priority and the Ministry of Energy restricts LPG distribution to the industrial sector.

• Insufficiency of clear industrial policies with well-defined objectives regarding issues of pollution and occupational health.

**Information and awareness barriers**

The awareness level about the benefits of EB is still limited. This includes the economic evaluation of EBs in relation to the payback period and the ability of using GHG in the carbon market.

### 3.2.3 Identified Measures for Efficient Boilers

The main measures are expected to be mainly taken by the Sudanese Association for Industrial Chamber (SAIC) in collaboration with the Ministry of Industry.

These measures are summarized in table 10 and discussed further in text below.

**Table 10: Summary of Measures for EB**

| Measure | Activity | Responsibility |
|---|---|---|
| Provision of investment and incentives for importing EBs | Loans with low profit for purchasing EBs | Ministry of Finance |
| Introduce awareness raising policy | Raise awareness among the industrial sector | SAIC, Technical consultants, NGOs |
| Strengthen human skills | Establish training programs for workers and operators in using EBs | Universities, industrial research centres, SAIC |
| Policy and regulatory | Clear industrial/ energies policy for fuel provision and fuel distribution<br>Well defined regulatory framework for air pollution and occupational health | Ministries of Energy, Industry, Health and labour, SAIC |

### 3.2.3.1 Economic and Financial Measures

**Financial Measures:**

Establishment of financing mechanisms that support the industrial sector to acquire such technologies, e.g., through low interest loans

### 3.2.3.2 Non-financial measures

• To raise awareness by informing enterprises about the merits of using EBs. This should predominantly be accomplished by the Sudanese Industrial Association Chamber through adequate number of consultants and advisers.

• To involve civil societies and local communities near industrial zones to participate in awareness campaigns, and to advocate for the corporate responsibility of existing pollution, the use of efficient boilers and support for LPG availability in the industrial sector as environmental issues.

• To organize training programs for workers and operators for skilful use of efficient boilers.

• To establish clear industrial energy policies for fuel provision and distribution

• To set well-defined regulations and by-laws for prevention of air pollution

and occupational health hazards.

Costs of measures (EB) technology transfer and diffusion

The analysis has been carried out for a project targeting the installation of 50 efficient boilers (EB) with dual fuel (furnace, diesel/ LPG) in 5 years period at a rate of 10 boilers per year. The analysis has been done on a life span basis which is 30 years. The costs of the following items have been calculated to obtain the total expenditure of the selected measures:

1. Life time cost of the (EB)
2. Capital cost of the (EB)
3. Operating and maintenance cost
4. Fuel energy cost
5. Financing expenses
6. Training and capacity building
7. Awareness programs

**Benefits of measures for (EB) technology transfer and diffusion**

As it has been illustrated in the objective tree analysis at the measures section, that the fuel saving will certainly lead to the identification of the benefits. These benefits include better work environment and GHGs emission reduction. The cost benefit analysis has only been limited to sort out the fuel saving benefits due to the lack of adequate data.

**Results of the cost-benefit analysis of the selected measures**

The NPV has been calculated by discounting the annual cash flows (earnings minus costs) to the first year of the project for 30 years at a (15%) discount rate. Taking only the fuel savings into account, the NPV totalled $ 6 million; considering other benefits this will probably hike the NPV.

### 3.2.4 Enabling Framework for Efficient Boilers

#### 3.2.4.1 Market Chain

Efficient boilers are advanced technologies that can only be acquired from abroad. Currently, EB is not adopted in Sudan, hence, the would-be-available ones will only be found in newly established factories. The proposed market chain could be established by national commercial agents for the foreign manufacturing companies. These agencies are expected to act as technical consultants to assist the final consumers (food processing factory owners) in selecting EB specifications and capacity. Additionally, they are expected to supply the final consumers with maintenance and spare part services.

#### 3.2.4.2 Enabling Business Environment

• Energy/industry policy: It supports fuel (LPG) distribution to the industrial sector and articulates the role of EBs in energy consumption, occupational health and the reduction of air pollution

• Import policy: It introduces policies that enable the import process for EBs and their spare parts

• Financial policy: It sets fiscal measures that support factory owners in acquiring the technology e.g. low interest loans

• Institutional arrangements: They make institutional arrangements to establish and adopt programs that include training courses, capacity building, coordination and liaising with committees, governmental institutions, manufacturing companies and factory owners.

• Standards and specifications: It sets the necessary standards and specifications for the application of EB technologies.

#### 3.2.4.3 Service Providers

• **Media and NGOs:** They carry out awareness programs to the village communities, development workers and decision makers about the benefits

of EBs and biogas, both at the regional and national level, and about health problems associated with open dung fermentation.

• **SAIC:** It organizes, arranges and manages the adoption programmes for EBs, (e.g. by establishing service contracts with experts and advisers and raising awareness).

• **Educational and training institutions:** They provide capacity building programs, awareness and consultation services. They act as builders, operators and midterm officers for both engineering and project management activities.

• **Research and development institutions:** They offer best operational packages and practical advices. They also improve the commodity, support awareness programs and training activities

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6. G. Legros, I. Havet, N. Bruce and S. Bonjour, The Energy Access Situation in Developing Countries – A review focusing on Least Developed Countries and Sub-Saharan Africa (UNDP, December 2009).

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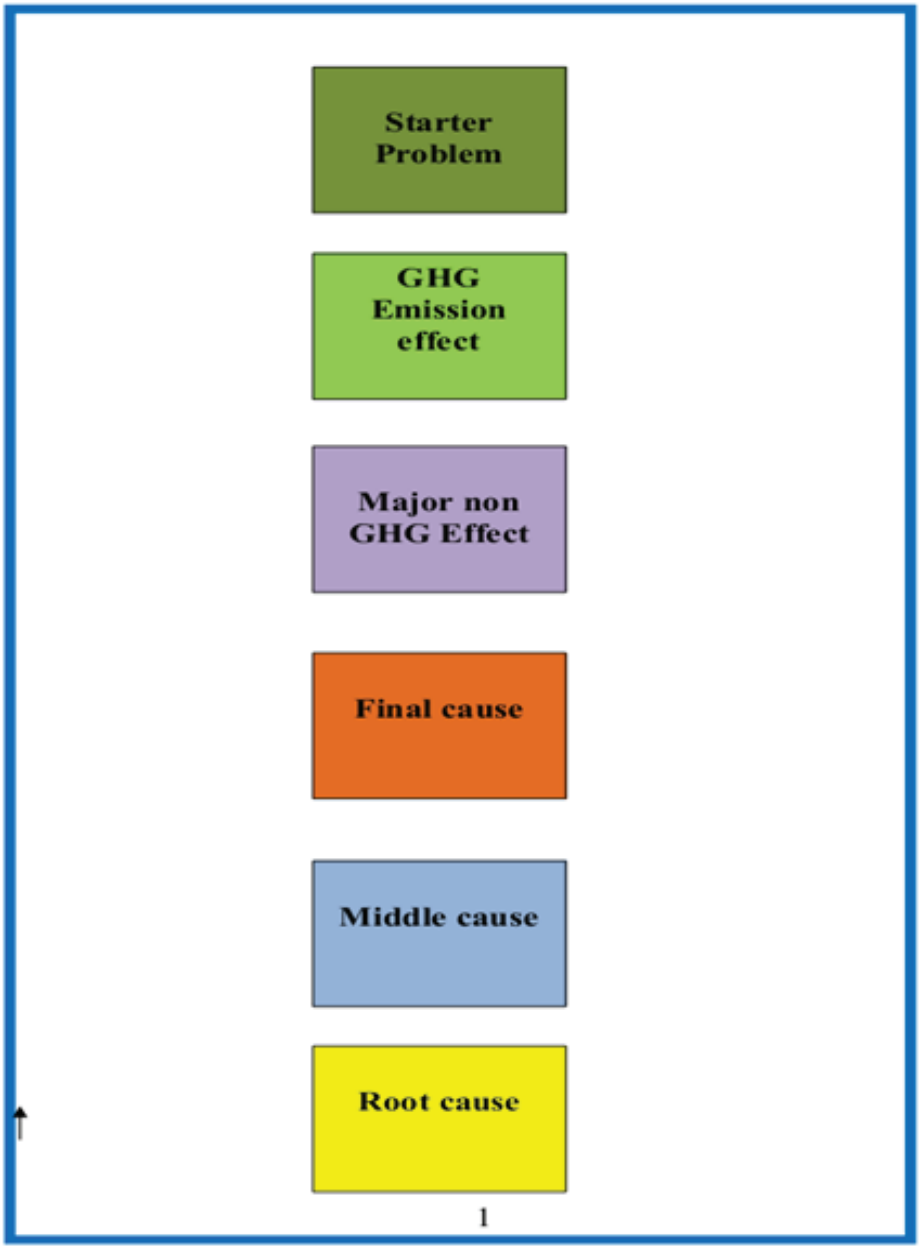
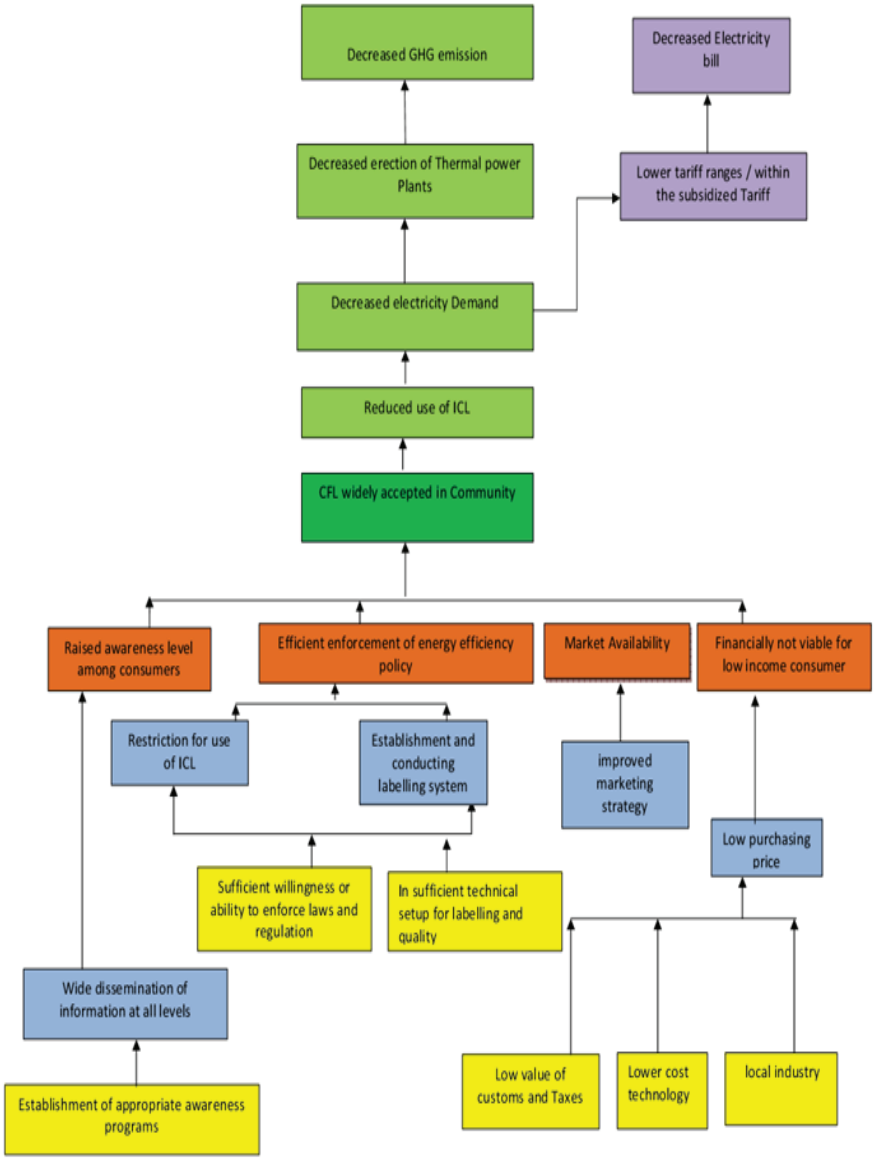
## Annex I: Problem and objectives Trees and Market Maps

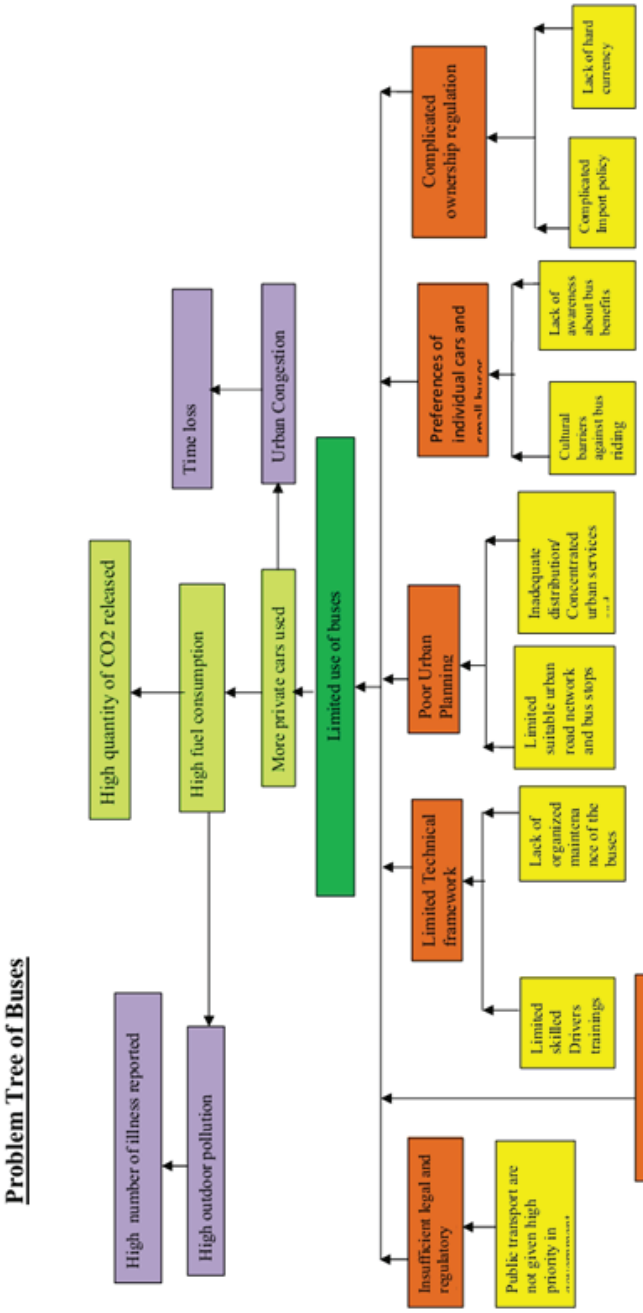
**Legend for problem and objective tree**

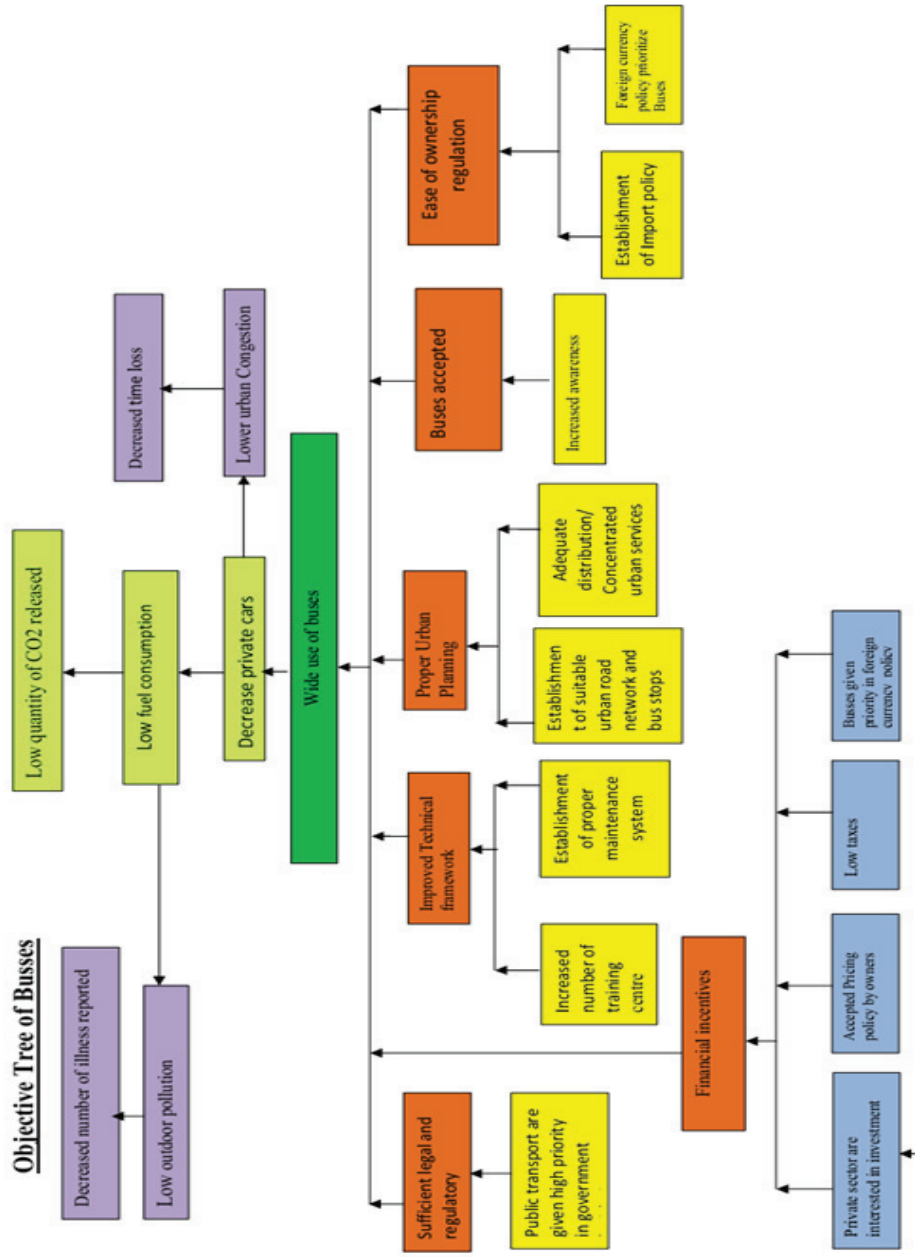


**Problem Tree of CFLs:**

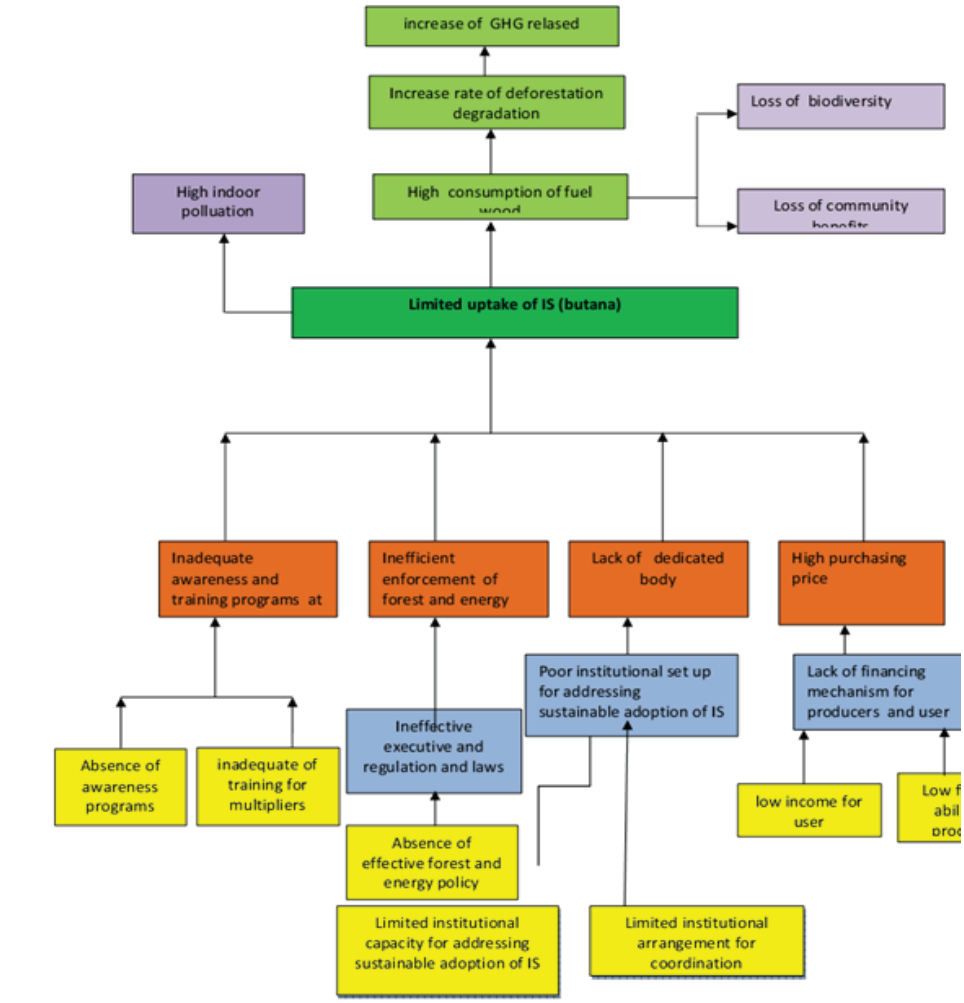
**Objective Tree of CFLs:**



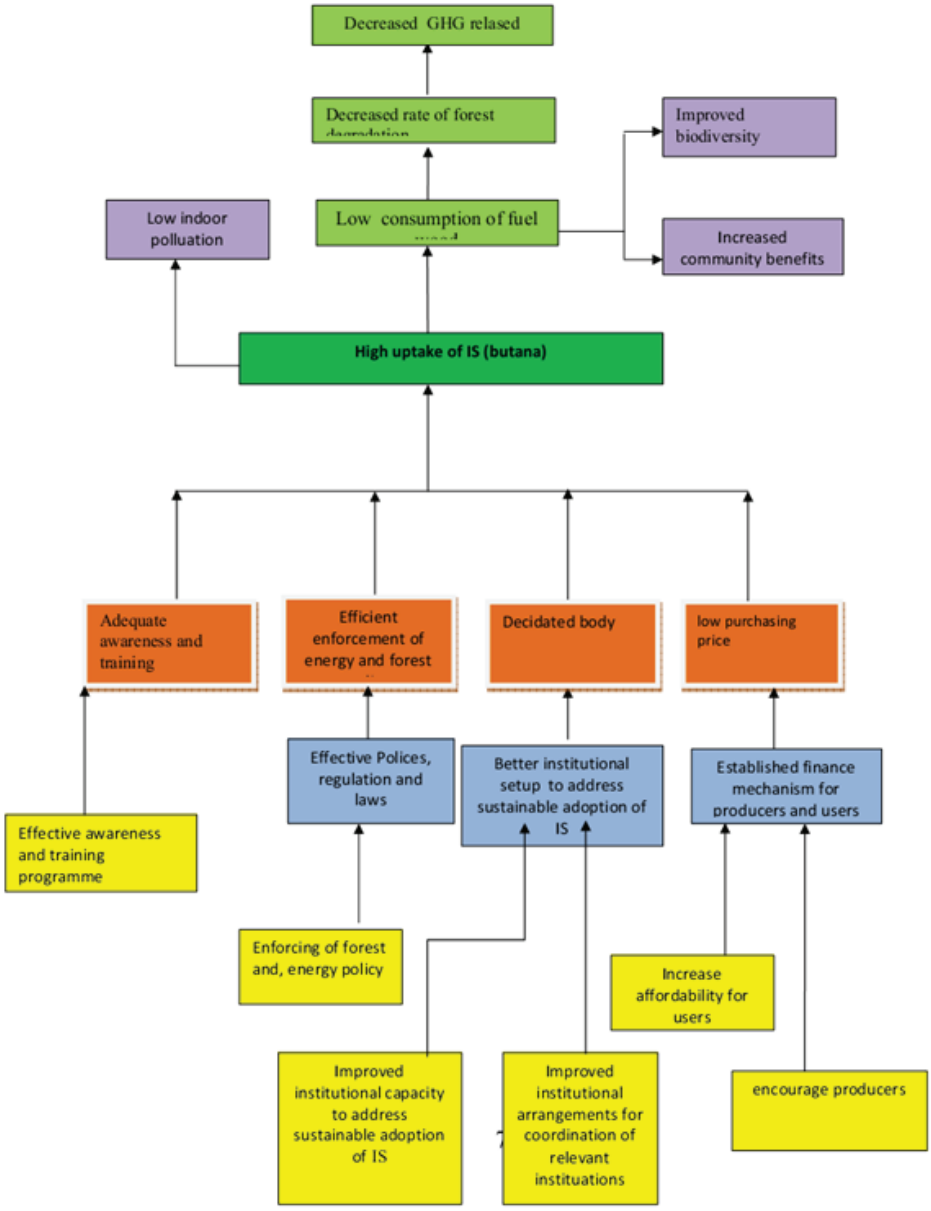

Problem Tree of Buses
High number of illness reported
High outdoor pollution
High quantity of CO2 released
High fuel consumption
More private cars used
Time loss
Urban Congestion
Limited use of buses
Insufficient legal and regulatory
Public transport are not given high priority in
Limited Technical framework
Limited skilled Drivers trainings
Lack of organized maintena nce of the buses
Poor Urban Planning
L imited suitable urban road network and bus stops
Inadequate distribution/ Concentrated urban services
Preferences of individual cars and small buses
Cultural barriers against bus riding
Lack of awareness about bus benefits
Complicated ownership regulation
Complicated Import policy
Lack of hard currency
Financial barrier
Lack of private sector investment interest
Lack of investment incentives
Pricing policy not accepted by owners
High taxes
Fluctuation of foreign currency


Objective Tree of Busses
Decreased number of illness reported
Low outdoor pollution
Low quantity of CO2 released
Low fuel consumption
Decrease private cars
Lower urban Congestion
Decreased time loss
Wide use of buses
Sufficient legal and regulatory
Public transport are given high priority in government
Improved Technical framework
Increased number of training centre
Establishment of proper maintenance system
Proper Urban Planning
Establishmen t of suitable urban road network and bus stops
Adequate distribution/ Concentrated urban services
Financial incentives
Private sector are interested in investment
Accepted Pricing policy by owners
Low taxes
Busses given priority in foreign currency policy
Buses accepted
Increased awareness
Ease of ownership regulation
Establishment of Import policy
Foreign currency policy prioritize Buses

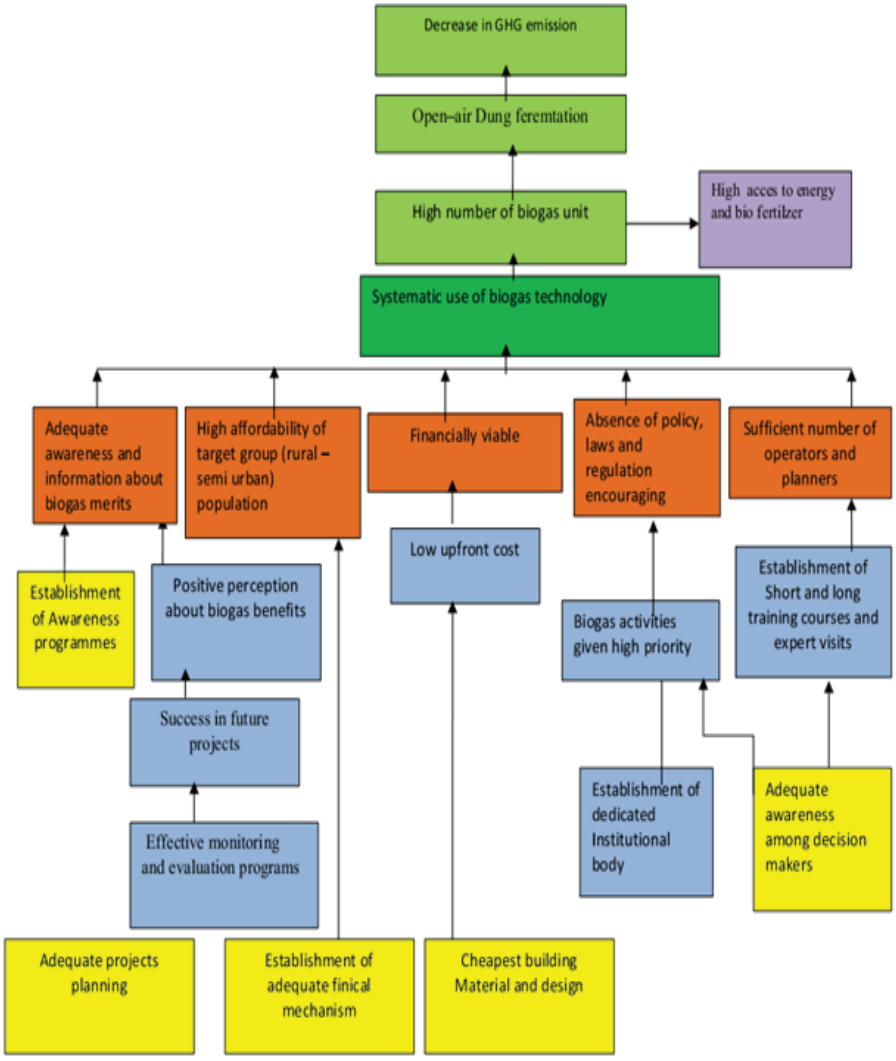
**Problems Tree of Improve Stoves**

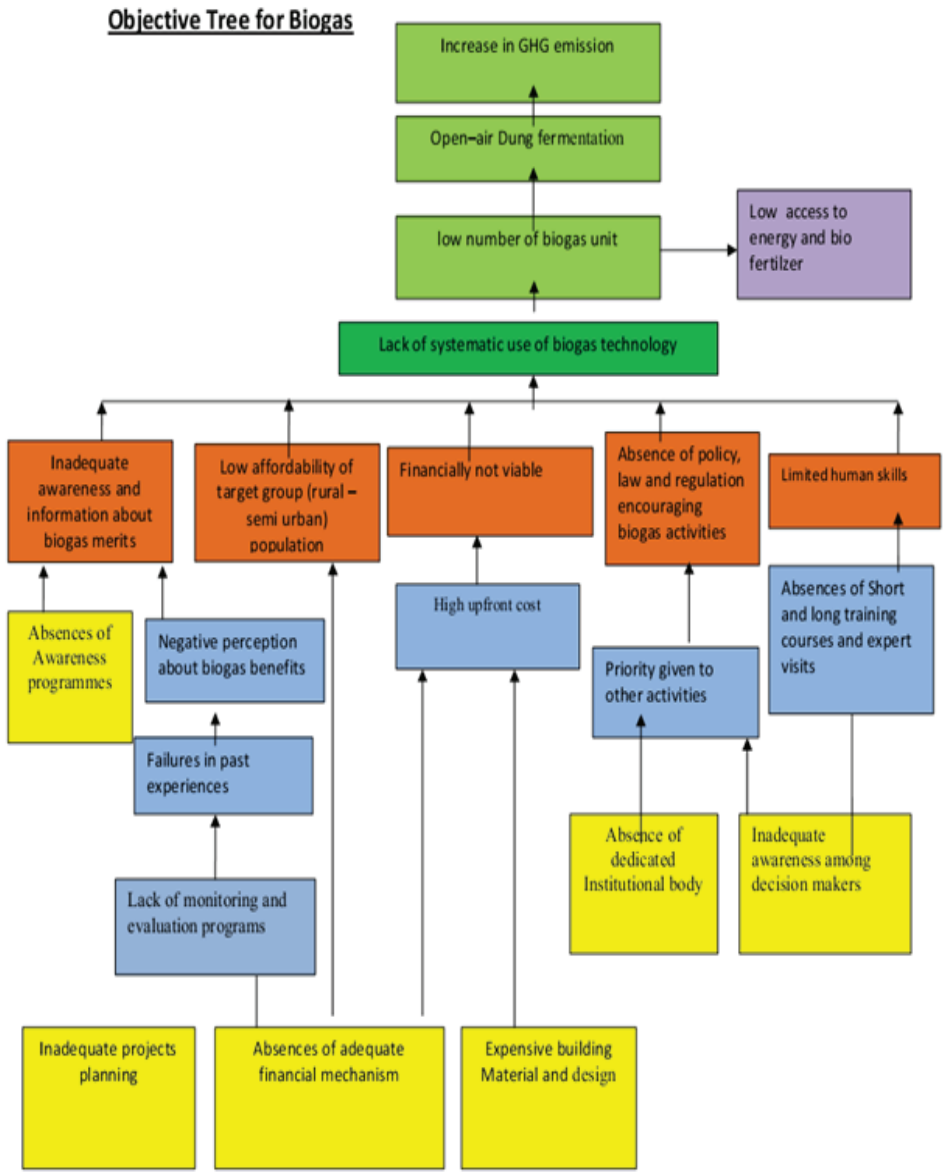


**Objective Tree of Improve Stoves:**

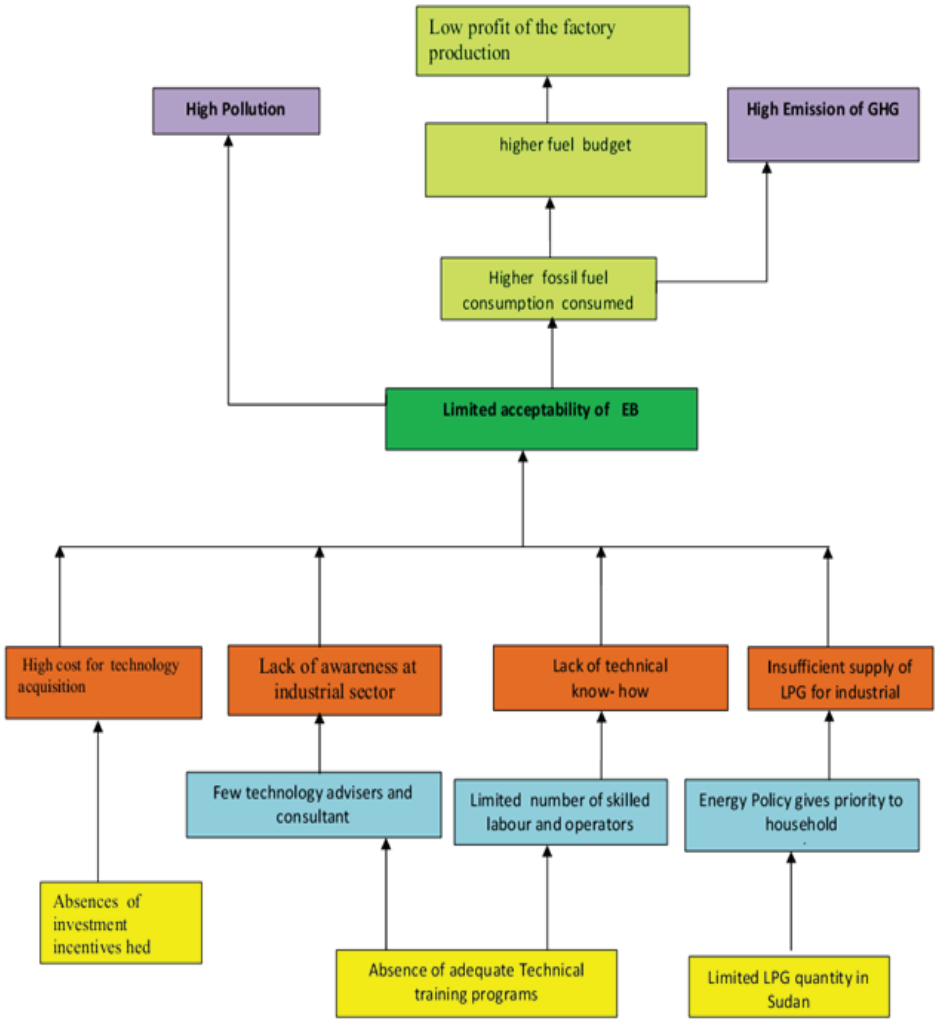


**Problem tree for Biogas**

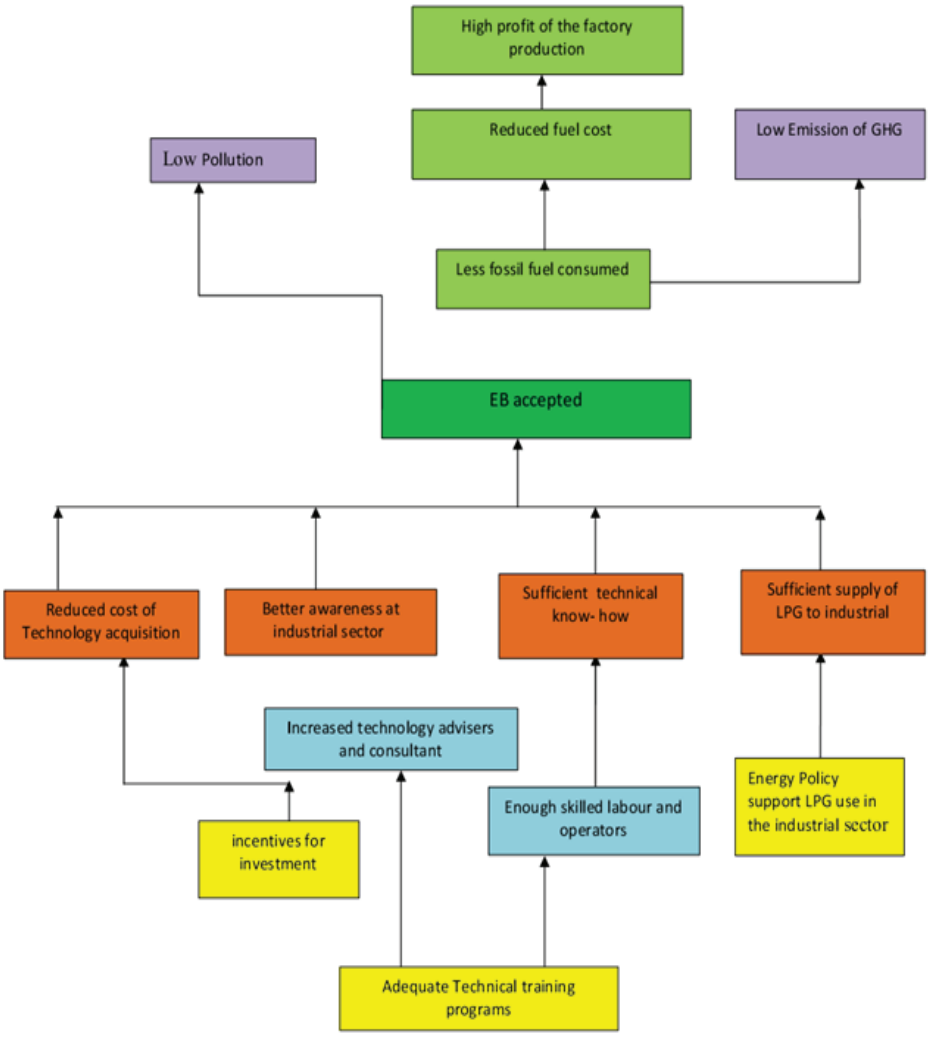



Objective Tree for Biogas
Increase in GHG emission
Open–air Dung fermentation
low number of biogas unit
Low access to energy and bio fertilzer
Lack of systematic use of biogas technology
Inadequate awareness and information about biogas merits
Low affordability of target group (rural – semi urban) population
Financially not viable
Absence of policy, law and regulation encouraging biogas activities
Limited human skills
Absences of Awareness programmes
Negative perception about biogas benefits
High upfront cost
Absences of Short and long training courses and expert visits
Priority given to other activities
Failures in past experiences
Absence of dedicated Institutional body
Inadequate awareness among decision makers
Lack of monitoring and evaluation programs
Inadequate projects planning
Absences of adequate financial mechanism
Expensive building Material and design

**Problem Tree of EB:**

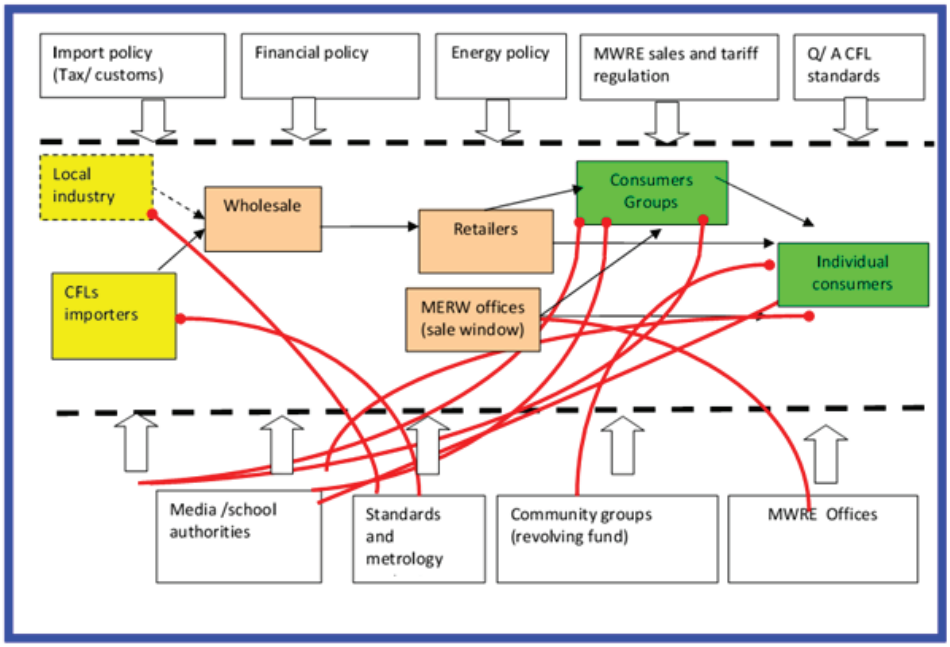


**Objective tree for EB**

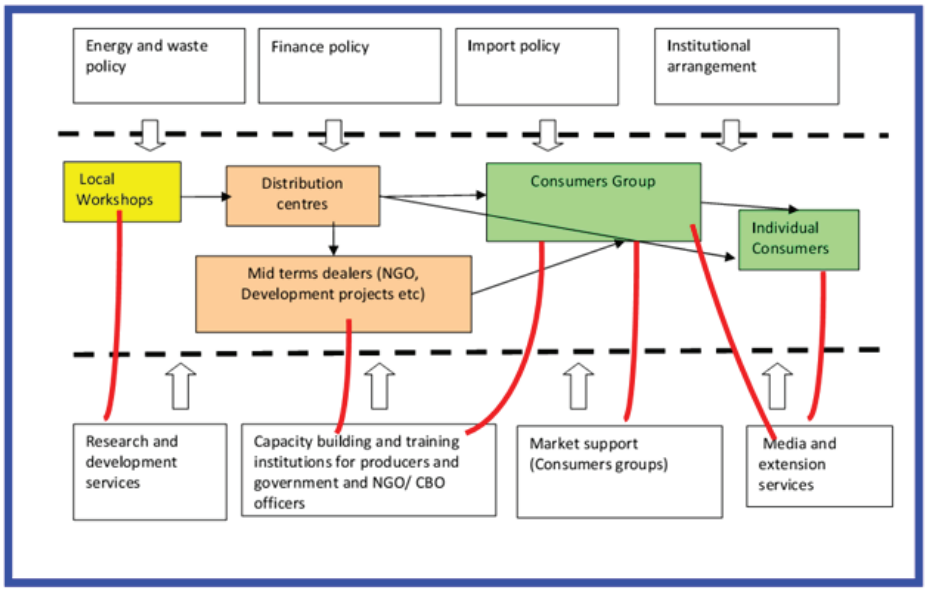


Market maps

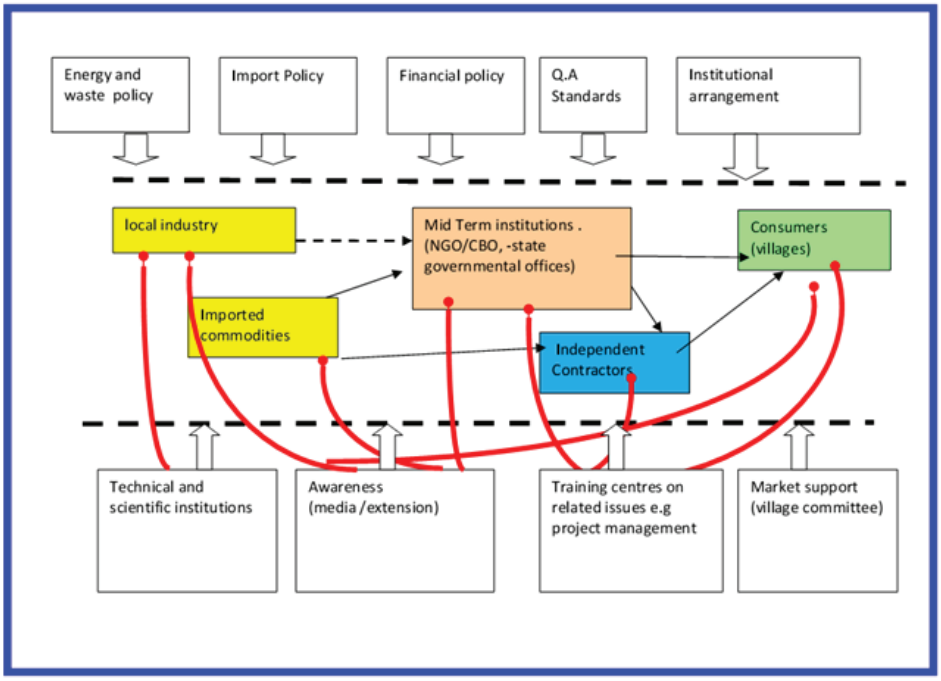
**Market map for CFLs**



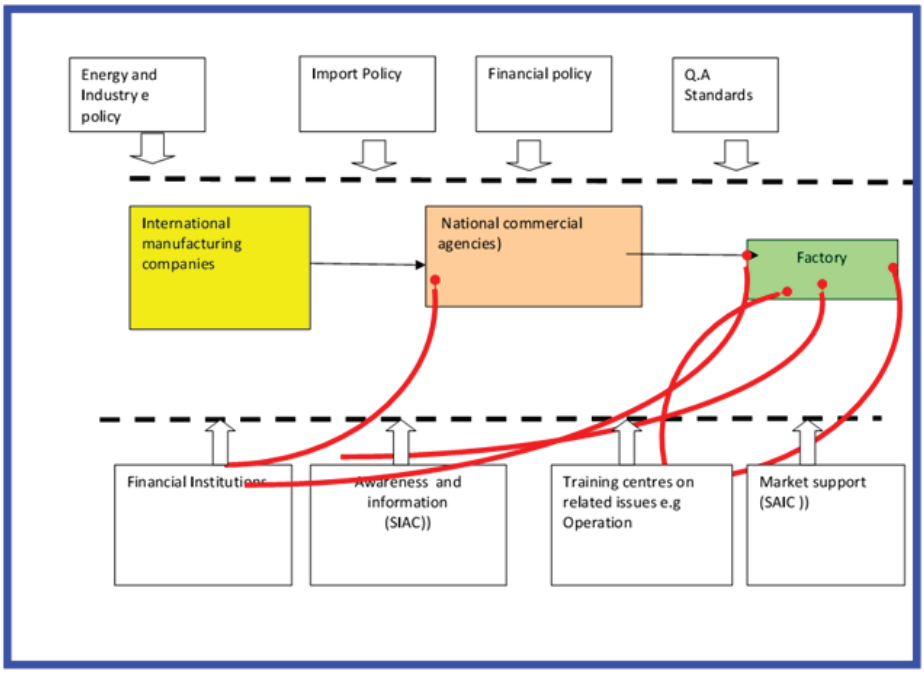
**Market map for IS technology**



**Market map for Biogas**



**Market Map for EB**



# Annex II: List of Stakeholders

| No. | Name | Institute |
|---|---|---|
| 1. | Somaya Alsayid | Ahfad University for Women |
| 2. | Nawal Hussain | Sudan Academy for Communication Sciences |
| 3. | Nazik Hassan Ali Alawad | Ministry of Water Resources and Electricity |
| 4. | Nouralla Yassin Ahmed | National Energy Research Centre |
| 5. | Sawsan Abdalla Ali | Forests National corporation |
| 6. | Haythum Kamal Aldin Abdalla | Kenana Sugar Company |
| 7. | Almothana Saad Mohamed | Kenana Sugar Company |
| 8. | Hassan Wardi Hassan | Ahlia University |
| 9. | Mona Mahjoub Mohamed Ahmed | Institute of Environmental Studies |
| 10. | Aboubaida Alboukhari Ibrahim | Sudanese Industrial Chamber Association |
| 11. | Abdelrahman Altahir Ahmed | Kenana Sugar Company |
| 12. | Salah Aldin Ali Mohamed Nour | Ministry of Petroleum |
| 13. | Abdelazim Widaa | Ministry of Petroleum |
| 14. | Alrabia Mohamed Altahir | Ministry of Petroleum |
| 15. | Mostafa Mohamed Altahir Atti | Ministry of Water Resources and Electricity |
| 16. | Ikhlas Abdelaziz | Industrial Research Centre |
| 17. | Alwalid Abas Mohamed Alsaid | National Energy Research Centre |
| 18. | Ali Omer Ahmed | National Energy Research Centre |
| 19. | Hanadi Attaalfadil Mohamed | Ministry of Industry |
| 20. | Quosay Awad Ahmed Babiker | University of Khartoum, Petroleum Department |
| 21. | Mohamed Saad Ibrahim Abdellatif | Ministry of Animal Wealth |
| 22. | Najla Mahgoub Hamadain | Forests National corporation |
| 23. | Awatif Abdalla Mohamed | Ministry of Animal Wealth |
| 24. | Naima Abedlgadir Hilal | Industrial Research Centre |
| 25. | Farough Ismail Abdeljalil | Ministry of Industry |
| 26. | Salah Yousif Mohamed Ahmed | Forests National corporation |
| 27. | Amira Hasan Alam | Salam Company for Cement Production |
| 28. | Ahmed Amer Mohamed | Shamal Company for Cement Production |
| 29. | Alyas Ahmed Alyas Ahmed | University of Khartoum, Faculty of Forestry |
| 30. | Mohamed Ali Hamed | United Nations Development Program |
| 31. | Osman Taha Alzaki | National Centre for Research |

| | | |
|---|---|---|
| **32.** | Ali Mohamed Korak | Sudanese Association for Rural Afforestation |
| **33.** | Mirghani Abnauf | Freelance |
| **34.** | Dawoud Abas Osman | Sudanese Industrial Union |
| **35.** | Alfadil Biryma Hamed | National Energy Research Centre |
| **36.** | Salahaldin Hasab Elgabo | Ministry of Water Resources and Electricity |
| **37.** | Adam Musa Mohamed | University of Neelain |
| **38.** | Adel Abdalla Rabih | Ministry of Water Resources and Electricity |
| **39.** | Osama Salah Mohamed Ibrahim | Ministry of Water Resources and Electricity |
| **40.** | Zuhair Mohamed Alsheikh Dafalla | Ministry of Water Resources and Electricity |
| **41.** | Samya Yousif Idris Habani | National Council |
| **42.** | Amira Elnour | Ministry of Industry |
| **43.** | Abdelrahman Altahir Ahmed | Kenana Sugar Company |
| **44.** | Mustafa Mohamed Salih Agha | Ministry of Water Resources and Electricity |
| **45.** | Nadir Mohamed | Sudanese Environmental Conservation Society |
| **46.** | Taysir Ismail Idris | Ministry of Agriculture |
| **47.** | Howida Mirghani Almrdi | Ministry of Agriculture |
| **48.** | Wigdan Mohamed Ibrahim | Higher Council for Environment & Natural Resources |
| **49.** | KhadijaYounis Abdelmawla | University of Bahri |
| **50.** | Hasan Bashir Nimir | University of Khartoum, Petroleum Department |
| **51.** | Nagmaldin Goutbi Alhassan | Higher Council for Environment & Natural Resources |
| **52.** | Ahmed Mohamed Abdelkarim | Meteorological Authority |
| **53.** | Hiba Mahjoub Hasan | Higher Council for Environment & Natural Resources |
| **54.** | Mohamed Altahir Mohamed | Higher Council for Environment & Natural Resources |
| **55.** | Dinan Babiker Elkhalil | Higher Council for Environment & Natural Resources |
| **56.** | Mahjoub Hasan | Ministry of Environment, Forestry &Physical Development |
| **57.** | Ahmed Ibrahim Ahmed | Ministry of Transportation |
| **58.** | Abdelrahmen Elamin | EWASCO Company |
| **59.** | Hana Hamadalla Hamad | Higher Council for Environment & Natural Resources |
| **60.** | Fathalrahman Ahmed Mohamed | Ministry of Agriculture |

| | | |
|---|---|---|
| **61.** | Daoud Abbas | Sudanese Industrial Chamber Association |
| **62.** | Mohamed Aljak Sulaiman | Industrial Research Centre |
| **63.** | Seif Eldin Abdalmageed | Ministry of Labour |
| **64.** | Alam Sighayroun Mohamed | Sudanese Industrial Chamber Association |
| **65.** | Yasir Abdelkarim Abdelaziz | Sudanese Industrial Chamber Association |
| **66.** | El Yemen Fadlalla Mohame | Freelance Energy Consultant |
| **67.** | Shommo Shaeldin | Freelance Energy Consultant |
| **68.** | Yahoub Aldoum Hamid | National Energy Research Centre |

# Annex III: Policy Factsheets

| Minimum requirements | **Policy for Energy Sector** |
|---|---|
| Recommended/ good to have | |
| POLICY: Name of Policy | Sudan Energy Policy 1992 |
| Name of field: | Content |
| Date Effective: | 1992 |
| Date Announced: | 1992 |
| Date Promulgated: | Refers to date a legal text/ruling was established |
| Date Ended: | The date the policy ended if no longer in force or superseded; sometimes the planned end date for a policy |
| Unit: | EEPM: Energy Efficiency. Normally, all entries in RE and EE are also visible in Climate Change. |
| Country: | Sudan |
| Year: | 1992 |
| Policy Status: | Options are: policy is still in force aiming towards full privatization of energy sector. Gradual removal of subsidies on oil fuel is implemented the last was in 2011 when prices of LPG, Diesel and petrol were raised by 22%, 50% and 85% respectively.<br>Electricity tariff remains unchanged, maintaining the previous subsidy of the first 200 kWh for households. While other consuming sectors tariff is kept higher than the households by about 140%. |
| Agency: | Name of relevant agency or agencies; please note any name changes.<br>1. Ministry of Water Resources and Electricity (previously Ministry of Electricity and Dams)<br>2. Ministry of Petroleum (previously Ministry of Energy and Miming) |
| Funding: | N/A |
| Further Information: | 1. National Compréhensive Strategy (1992-2002)<br>2. Quarter-Century Strategy (2007-2032) |
| Enforcement: | |
| Penalty: | N/A |

| | |
|---|---|
| Related Policies: | Presidential Decree 32 (2011) which defines roles and responsibilities of the different institutions active in the energy sectors including:<br>- Ministry of Water Resources and Electricity<br>- Ministry of Petroleum<br>- Ministry of Sciences and Communication<br>Ministry of Minerals |
| Policy Superseded by: | Ministry of Oil |
| Policy Supersedes: | |
| Stated Objective: | Since 1992, the energy policy is designed to be consistent with the general economic liberalization and encourage private investment in the energy sector development. The policies objectives of the energy sector were stated as follows:<br>1. Ending state control over energy supply (The privatization of oil products and gas was adopted in 1996).<br>2. Encouraging the private sector through concessions including tax exemptions for periods ranging from 5 to 10 years, depending on the size and type of energy investment.<br>3. Exemptions for oil companies from taxes and duties on the import of equipment.<br>4. Removal of subsidies on all types of hydrocarbon fuels.<br>5. Ending the monopoly of the NEC on electricity generation, transmission and distribution beyond the national grid.<br>6. Priorities in electricity supply are for the productive export sectors of agriculture and industry.<br>7. Encouraging the use of renewable energy through the exemption from taxes and duties of all renewable energy equipment. |
| Evaluation: | |
| Policy Type: | Privatization and deregulation of energy sector policy |
| Policy Target: | 1. To direct the electrical supply to the productive sectors: agriculture and industry<br>2. Increase the coverage of the grid to 80%<br>3. Full privatization of oil sector<br>4. Rational use of natural resources and protection of the environment. |
| URL: | http://med.gov.sd/ |
| Legal References: | Water Resources Act 1995<br>Sudan Petroleum Corporation ACT 1998<br>Electricity Act 2001<br>National Petroleum Commission Act 2005 |

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|---|---|
| Description: | The energy organization structures developed during the 1980s continued to operate until 1992, when the GPC and the NEA were dissolved and the MEM was restructured to act as a coordinator with the private sector which now had full responsibility for petroleum products. The current energy sector structures, which were formed in 1992, are dominated by the Ministry of Energy and Mining which supervises local and international companies involved in the exploration, production, export and local distribution of oil products. Other organizations, including NEC, ERI and NFC, remain relatively autonomous from the authority of MEM and outside its structures. Unlike with the oil resources, all attempts to involve the private sector in electrical power generation and distribution have failed, and the NEC remains the main actor in electrical power generation and distribution. The main reasons for the lack of private sector investment in electrical power are summarized in the following two points.<br>Electric power generation: The electricity sector is the responsibility of the National Electricity Corporation (NEC). The NEC, which is a federal public sector body, is responsible for the National Grid. The NEC is also responsible for large thermal power generation plants in the states with a capacity of more than 2 MW. Thermal generation less than 2 MW is the responsibility of the state level bodies, or private individuals who have established their own facilities. This regulation of the electricity sector began in 1995 with ministerial decree No. 519, which defines the boundaries between the state and NEC responsibilities (as the federal body) concerning the administration of the electric power sector.<br>In 1996, the responsibilities for state electrical power plants were handed over to the state level Ministry of Physical Affairs. This was in response to demands from the state governments. The 1998 constitution defines the responsibilities between the state and the federal agencies in all energy affairs. |

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|---|---|
| Minimum requirements | **Policy for Forestry Sector** |
| Recommended/ good to have | |
| POLICY: Name of Policy | Forest Resource Strategy 2011: Post South Sudan Separation Scenario |
| Name of field: | Forestry and Renewable Natural Resources Act |
| Date Effective: | 2011 |
| Date Announced: | 2011 |
| Date Promulgated: | |
| Date Ended: | |
| Unit: | CC\|RE\|EE : RE: Renewable Energy, EEPM: Energy Efficiency |
| Country: | Sudan |
| Year: | 2011 |
| Policy Status: | Superseded by the forest policy 2006 |
| Agency: | Forest National Corporation (FNC) |
| Funding: | FNC depends to a larger extent on resources and revenues for financing its programs. In 2009 the FNC budget is SDG 26.4 million of which the own revenues account for 62%. The budget is disbursed according to the following three chapters:<br>- Chapter one (salary and allowances) 57%<br>- Chapter two (operation and maintenance) 22%<br>- Chapter three (development) 21%<br>However, in 2011 the FNC budget showed a deficit of SDG 758,000 |
| Further Information: | |
| Enforcement: | |
| Penalty: | |
| Related Policies: | - The Wildlife Conservation and National Parks Act 1986<br>- Water Resources Act, 1995<br>- Petroleum and Mining Resource Legislation 1998<br>- The Investment (Encouragement) Act, 1999<br>- Environment Protection Act, 2000<br>- Local Government Act, 2003<br>- The Public Corporations Act, 2003<br>- Desertification Combat Act 2009 |
| Policy Superseded by: | Sudan Forests Policy 2006 |
| Policy Supersedes: | Sudan Forests Policy 2006 |

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| Stated Objective: | - Aiming at covering 25% of the area of the country with forests together with the sustainable management of the natural resources<br>- Encouraging the local population, to participate in the preparation of projects and their execution.<br>- Realization of agriculture and forest integration through the introduction of the tree in the agricultural cycle by 5% in the irrigated agricultural schemes and by 10% in the rain fed sector. |
| Evaluation: | N/A |
| Policy Type: | Conservation of Sudan natural forests |
| Policy Target: | - Plantation of forest<br>- Dissemination of improved and efficient charcoal making kilns<br>- Dissemination of improved and efficient fuel wood stoves |
| URL: | http://www.forest.sd/ |
| Legal References: | - Forests and Renewable Natural Resources Act 2002<br>- The Sudan Constitution 2005. |

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|---|---|
| Description: | The first phase in the development of Northern Sudan's forest policy culminated in the Forest Sector Review (FSR) in 1986 – the equivalent of a national forest program. Often noted as a 6-year project, the FSR focused on strengthening central and regional public institutions, introducing incentives to engage the private sector in the conservation of wood energy and wood fuels. Resource constraints during the eighties resulted in the prioritization of activities which involved less capital and yielded maximum benefits in the short-term.<br>Later interventions would concentrate on longer term development.<br>Using the FSR as a basis for national policy development, the Minister of Agriculture and Natural Resources approved the Statement of Forest Policy (1986). In accordance with this statement and because of the need to restructure the forestry administration to carry out new responsibilities, the government passed the Forests Act in1989, the same year it established the Forests National Corporation (FNC) – a service-oriented parastatal body which reports to the Minister of Agriculture and Forestry. The Act provides for private forest ownership, community ownership, and forest reserves to be managed by institutions, in addition to national and regional reserves. All forest reserves are under the technical supervision of the FNC.<br>In 2002, the Forests and Renewable Natural Resources Act replaced the forestry laws of 1989, providing a framework for the management and protection of forests and renewable natural resources, including pastures, rangelands and aspects of agricultural land use. It also serves as the basis for governing the forest sector as a whole. The Act calls for the creation of the National Forests and Renewable Natural Resources Corporation to manage natural resources, other than wildlife and water. However, it has not yet been established. In the interim, the FNC is performing the functions stipulated in the legislation, including the management of federal forest reserves. States manage reserves, in accordance with FNC policies and technical plans.<br>Weak capacity and lack of resources, among other difficulties, have hindered enforcement of both the 1989 and 2002 Acts. Forestry offences registered with the police versus those still pending investigation are indicative of the problem, as is the low number of cases brought to trial.<br>Significant changes have taken place since the Forest Sector Review was developed 20 years ago and current events are shaping future direction. The Forests National Corporation (FNC) is proposing to draft a new Forestry Policy (FNC, 2005a), amend the Forest Act (FNC, 2006), update the Forest Sector Review (FNC, 2004, draft) and review the functions of the FNC with a view to adjusting to the changing institutional landscape. |

# Policy Factsheets -A

| | |
|---|---|
| Minimum requirements | **General Policies for the Industry Sector** |
| Recommended/ good to have | |
| POLICY: Name of Policy | General policies & Strategies for the manufacturing industries sector |
| Name of field: | The application of environment friendly measures in the industrial sector and anti-pollution legislation |
| Date Effective: | 2001 |
| Date Announced: | 2002 |
| Date Promulgated: | 2001 |
| Date Ended: | in force |
| Unit: | Normally, all entries in RE and EE are also visible in Climate Change. |
| Country: | Sudan |
| Year: | 2002 |
| Policy Status: | In force |
| Agency: | Ministry of Industry. |
| Funding: | N/A. |
| Further Information: | Ministry of Industry Resolution No.(12) for the year 2001 |
| Enforcement: | Ministry of Industry |
| Penalty: | there are no penalties for non-compliance with the policy |
| Related Policies: | National Environmental Policies, Legislation and Standards derived from the Environmental act |
| Policy Superseded by: | Policy in force |
| Policy Supersedes: | the policy not has superseded another one |
| Stated Objective: | The application of environment friendly measures in the industrial sector and adopt industrial pollution legislation<br>- Issuance of laws and regulations governing industrial pollutants<br>- Transfer and resettle of technologies for the use of national industries, Utilization of appropriate technologies that suit Sudan conditions.<br>- Dissemination of environmental awareness.<br>- Planning and adoption of environmental regulations<br>Encourage transfer of modern technologies in the area of micro and artisan manufacturing activities. |
| Evaluation: | No Evaluation has been made yet |

| | |
|---|---|
| Policy Type: | General policies & Strategies of Manufacturing Industries Sector derived from the Resolution No. (12) For the year 2001 in line with the programs of the second terms of the President of the Republic and the executive programs of the economic strategy and in confrontation to the development of the industry sector. |
| Policy Target: | The policy Target is The application of environment friendly measures in the industrial sector and anti industrial pollution legislations<br>Which encourage the utilisation of any type of technology or fuel that lead to minimize air pollution /emissions. |
| URL: | www.ministry of industry-Sudan |
| Legal References: | In accordance to terms of reference to Ministry of Industry as stated in the Publican Resolution No. (12) |
| Description: | The Ministry of Industry is responsible for formulating industrial policies, strategies and programmes in conso¬nance within the overall national objectives. To achieve this, the Ministry has an environmental unit that performs promotional and regulatory functions that include:<br>Industrial planning<br>- Issuing licenses and following up investment projects<br>- Controlling all industrial enterprises including import licenses and the allocation of some domestic raw materials for factories<br>- Controlling quality and determining standard specifications for industrial products<br>- Collecting and analyzing data on industry<br>- Facilitating and organizing the flow of technical assistance to the industrial sector<br>- Undertaking and, in part, assessing environmen¬tal impacts of projects.<br>- Following The application of environment friendly measures in the industrial sector and adopt industrial -pollution legislations |

Republic of Sudan

Ministry of Environment, Forestry and Physical Development

Higher Council for Environment and Natural Resources

# TECHNOLOGY ACTION PLAN

## PART 3

**Supported by:**

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## List of Abbreviations

| | |
|---|---|
| AFOLU | Agriculture, Forestry and Other Land Use |
| CDM | Clean Development Mechanism |
| CFL | Compact Fluorescent Lamp |
| EB | Efficient Boilers with Dual Fuel |
| FNC | Forest National Corporation |
| FRA | Forests Resources Assessment |
| GDP | Gross Domestic Products |
| GWH | Giga Watt per Hour |
| ICLs | Incandescent Lamps |
| IS | Improved Stoves |
| LPG | Liquefied Petroleum Gas |
| MWRE | Ministry of Water Resources and Electricity |
| MWH | Mega Watt per Hour |
| NEC | National Electrical Corporation |
| NERC | National Energy Research Centre |
| NG | Natural Gas |
| NGO | Non-Governmental Organization |
| SSMO | Sudanese Standards and Metrological Organization |
| TNA | Technology Needs Assessment |
| USD | United States Dollar |

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## Executive Summary

This report presents the Technology Action Plan (TAP) for the mitigation technologies identified by the TNA Report, Part I. Five technologies have been identified in three mitigation sectors, namely Compact Fluorescent Lamps (CFLs) and mass transportation (buses 60+) in the energy sector, improved stoves and biogas in the agriculture, forestry and other land use (AFOLU) sector, and efficient boilers using dual fuel in the industrial sector.

Technologies within the energy sectors have been selected from two sub-sectors, namely electricity production and consumption and transportation. As for electricity generation the main source for GHG emissions results from the burning of fossil fuel in thermal power plants. Lighting is generally provided by using incandescent lamps (60-100 watt). On average, the total demand for lighting is about 2460 GWh per year. Therefore, the CFL technology is selected for lighting to save about 80 percent of electricity consumption. This calculation is based on households' consumption assuming that Incandescent Lamps (ICL, 100 W) are replaced by CFL (200 W). The action plan for the technology of CFL target proposes to diffuse 600,000 CFL per year for a period of 10 years. This is expected to save 835,200MWh annually, reduce greenhouse gases (GHG) by 251,395 tonnes of $CO_2$eq per year, and reduce electricity bill for consumers by 14 percent. This requires an investment of USD 950,000 for five years. The main barriers for the diffusion of CFL technology are identified as financial, absences of local industry, lack of incentives, and insufficiency of awareness about the economic benefits of CFL.

Regarding the transportation sub-sector, mass transport, in particular buses 60+ have been set as first priority for Sudan. The expansion of mass transport bus +60 systems requires encouraging private sector investments, and running fleets of buses 60+. Furthermore, some strategies and policies need to be reformed to give priority to mass transportation buses such as traffic law, taxes exemptions for investors or fuel subsidies. The Proposed action plan for the deployment of mass transport buses 60+ in Sudan proposes to start with the introduction of 400 buses per year in greater Khartoum State. The implementation of the proposed action plan faces many barriers which are mainly lack of legislation and laws addressing the transport or the reduction of GHG emissions in the transport sector. Therefore, specific standards and regulations are needed

to enhance public mass transport. These measures are divided into three types, namely technological, regulatory such as standards and legislation and their enforcement, and awareness raise. Suggested actions to meet the targets include establishing financing mechanisms within the banking system to encourage the private sector to import buses 60+ such as loans systems with low or free interest. It also involves assigning high priority for bus investment activities within the hard currency policy, establishing financing mechanisms to local authorities to upgrade the road status, equip the streets with bus stations, and conduct training courses for bus drivers, engineers and technicians for maintenance services by establishing training centres.

Mitigation technologies selected in the AFOLU sector are improved stoves (IS) and biogas. Improved stove is a type of mud stoves built to reduce wood consumption and contribute to appropriate combustion modes through optimum design and suitable material. They have an efficiency of up to 35 percent and mitigate GHG emissions through reducing the amount of wood used, hence reducing forest degradation by allowing more carbon sequestration. Emission reductions for each adopted stove range from 1 to 3 tons of $CO_2$ equivalent per year ($tCO_2e$/ year). As a first step, the proposed action targets a number of around 600,000 stoves per year to be distributed in Central, Eastern and North Darfur regions.

Barriers facing IS include financial viability which is mainly due to the lack of investment incentives resulting from low consumer demands, since investors need to ensure a certain level of distribution in order to attain specific revenues. To address this problem, the report proposes to arrange fiscal support measures such as low interest loans.

The proposed action plan for the dissemination of IS technology is based on awareness raising campaigns and conducting extensive training programs for selected multiplayer by providing them with sufficient, clear and simple information about IS. It also involves the establishment of specific administrative bodies responsible for the management and implementation of IS programs as well as the coordination with other sectors. Another important aspect is providing measures of economic support and setting adequate policies and regulations to facilitate the establishment and maintenance of IS. Additionally acts as representative when negotiating the different issues of economic support, policy, standards establishing of environmental governance policies and activation of the energy and forest polices in addition to setting effective legal and regulatory framework that

consider the role of IS within the energy efficiency and forest conservation issues.

A biogas plant consists of a pit, which serves as a digester for organic waste and a gas holder. Generally, cow dung is the most suitable material for biogas. The main targets for the deployment of the biogas technology, selected under manure management option within the livestock subsector are strongly related to improving the livelihood status of the rural areas, improving public health, reducing GHG emissions, supplying cooking fuel and providing electricity and lighting services. The programs will be primarily directed at first steps towards the rural areas, mainly Gezira, White Nile and Blue Nile region. These areas have been selected based on the following characteristics: Large numbers of livestock (cattle) and potential on the semi sedentary system. Biogas technology is a high cost technology that is generally unaffordable to individuals or even village communities. There are no financial measures to support the deployment of biogas technology. In addition, commercial banks, community development institutions or agricultural funds do not provide loans or any purchasing facility for the individuals or communities.

The proposed action plan for the diffusion of biogas technology will start by initiating awareness raising programs through campaigns, workshops, and field visits. A second step requires establishing and enforcing waste and energy policies that can accommodate legal and regulatory frameworks for the utilization of biogas technologies including monitoring and evaluation mechanisms. In addition, steps of actions include conducting short and long term training activities for midterm's institutions, as well as the erection of biogas units and an effective coordination with all the relevant institutions.

With respect to the industry sector efficient boiler technologies are selected as priority mitigation technologies. In Sudan industrial activities are mainly agro-based, and focused on sugar, flour milling, confectionary biscuits, textiles, edible oils, ethanol and leather products as well as dairy products, animal fodder, and packing/canning activities. Future agro-industrial expansion is expected to focus on fertilizers, pesticides and agricultural appliances. GHG emissions in the industrial sector can be resorted to two main sources; firstly, energy for electricity heat or steam/hot water for the industrial processes, and secondly, process emissions.

The analysis of Sudan's development priorities for the industrial sector focuses on food industries, mineral and non-mineral industries, and the cement industry. Since this sector is continuously growing, and expected

to continue growing as result of population increase, the majority of boilers in the food industry are old in design and inefficient. About 60 percent of them use fuel oil which leads to pollution and GHG emissions. The food industry in particular plays an important role in Sudan's economy as it provides food commodities, supports employment activities and encourages exports. Efficient dual fuel boilers are used internationally and have the advantages of using different types of fuel .This will lead to substantial reductions in GHG emissions when using LPG/NGs.

The main barriers facing the implementation of EBs in Sudan are lack of technical know-how, scarcity of awareness among the owners of the industries about the long term economic and environmental benefits, shortage of finance as most of the industries are small and medium sizes with limited financial resources for importing new EBs or modifying existing boilers. The diffusion and deployment of efficient boilers in Sudan are becoming an urgent necessity for the continuation of local industries and the survival of owners and their families. Due to the high prices of the imported fuels and the other processing raw materials, some imported finished products are cheaper than locally produced goods which affect the continuation of local industries.

An action plan is proposed to target the medium and small scale food industries, beverage and textile by the erection of 100 efficient boilers with dual fuel (furnace, diesel/ LPG) in 10 years' time at a rate of 10 boilers per year. This will give rise to an estimated reduction of 3740.5 kg $CO_2$/mmbtu in ten factories per year, and a further reduction in production costs by 30 percent due to fuel saving.

The practical diffusion of EB in Sudan needs to overcome many barriers, such as financial barriers, through the establishment of Investment Portfolio, incentive and credits from banks. At the same time policies and regulations are needed to define and implement of fiscal policy for environmentally sound technologies, and encourage investments in clean fuel and EB. In addition, technical support for smooth technology transfer is needed through training capacity building strategies for the relevant institutions. For the implementation of this action plan, it is very important to make use of the significant economic and environmental benefits of EB such as fuel saving, GHG emissions reduction and the CDM projects.

# Chapter1:
# Technology Action Plan for Energy Sector

## 1.1 Actions at sector level

### 1.1.1 Short sector description

Two sub-sectors within the energy sector are considered for the mitigation options. These two sub-sectors are electricity generation/consumption and fossil fuel consumption in transportation. In the following sections general descriptions of the energy sector in Sudan are briefly described in terms of energy supply and consumption in different sectors, and the general barriers and measures.

**Electricity generation and consumption**

The electricity sub-sector is composed of the National Grid which consists of large hydro power plants and large thermal units. It has a relatively low emission factor of 0.31 due to the significant hydropower contribution. The other component is the Off Grid part which is composed of isolated small scale thermal power plants, thus, contributing to higher GHGs emissions. The strategy of the Ministry of Electricity and Water Resources (MWRE) is to provide access to electricity to over 83 percent of the population (at a level of 200 kWh/month/household), to increase the power usage by 50 percent in the industrial sector and by 100 percent in the agricultural sector by 2030.

MWRE statistics revealed that the total consumed power increased from 5,044.7 GWh in 2009 to 6,026.0 GWh in 2010 (19.5 percent). The major groups that consume electricity in Sudan are residential and services consumers which account for 80 percent of the total electricity consumption. This is mainly utilized to satisfy the lighting and cooling demands. According to MWRE statistics, the number of consumers is estimated at 1.5 million. Considering the use of about 10 lamps per premise for 4.5 hours a day, a total of 2460 GWh per year is demanded. In the electricity production area the total $CO_2$ emissions decreased from 1,027 Tt in 1995 to 471.096 Tt in 2010 due to the introduction of Meroi Dam (1250MW). As the hydroelectric option is limited by seasonality factors more thermals are expected to be built, thereby increasing of GHG emissions in the coming years.

**Transportation**

Fossil fuel consumption incorporates two main consuming sub-sectors, namely transportation and households. Statistics from the Ministry of Oil (MO) show that fossil fuel consumption in the transportation sector represents about 65 percent of the total fossil fuel consumption in Sudan (Ministry of Oil 2010). The biggest consuming transport mode is road transportation with a share of more than 84 percent of the total consumption in the transport sector.

Due to the increase of economic activities which enhance mobility, improving infrastructure (paved roads) and the reduction of other modes of transportation like railways, the road transport sector is expected to expand further. Hence, it has been given higher attention during the consultation process of the TNA. Additionally, considering the status of infrastructure like roads and the horizontal expansion of city, the limited use of buses leads to high air pollution levels and high congestion rates in the roads.

### 1.1.2 General Barriers and proposed measures in the Energy sector

The general energy policy is designed to be consistent with the general economic liberalization which has been followed since 1992. There are some policies adopted to support implementation of plans for the development of the energy sector. Specific policy objectives for oil, electricity and renewable sub-sectors have been formulated as follows:

• Ending the state control over the energy services. The privatization of oil products and gas has been adopted since 1996.

• Encouraging the private sector through concessions including exemption from taxes for periods ranging from 5 to 10 years depending on size and type of energy investment.

• Exemption of oil companies from taxes and duties on importation of equipment.

• Removal of subsidies on all types hydrocarbon of fuels.

• Ending the monopolization of National Electrical Corporation (NEC) on electricity generation, transmission and distribution outside the national grid.

• Priorities of electrical supply are given to the productive sectors agricultural and industrial.

• Encourage the use of renewable energy through exemption from taxes and duties on all renewable energy equipment.

Furthermore, the energy sector which falls under the umbrella of one ministry (the Ministry of Energy and Mining) since 1970 is split in 2010 into three ministries these are: the Ministry of Petroleum, the Ministry for Water Resources and Electricity and the Ministry of Minerals. However, this situation holds strength in some of its parts; it also presents a barrier for diffusion of energy technologies. On one side, it encourage the private sector which is the main agent of technology diffusion and on the other side, it fragment the sources of decision making and policy formulation. Thus, the needed measures should concentrate on exerting efforts to facilitate the coordination of opposing objectives by all institutions of the different ministries and to enhance policy effectiveness. Specifically, they should also benefit from the opportunities available to the private sector and encourage their involvement in technology diffusion.

**The technologies selected in the energy sector are the following:**

1. Compact Fluorescent Lamp (CFL) is a low energy-consuming lamp (7-20 W) for saving energy by about 80percent. CFL mitigate GHG emission by reducing electricity consumption produced from thermal power plant.
2. Public transport (Bus 60+) for reducing energy consumption and decrease GHG emissions compared to private vehicles.
3. Technology of efficient dual fuel boilers (EB) for the industry sector to reduce fuel consumption and the GHG emission

There are a lot of barriers, for the implementation of the above technologies in the energy sectors, In order to overcome the barriers some measures are recommended to be taken for each selected technology, these measures are described below

### 1.1.2.1 The specific measures for the dissemination of technology of the CFL

1. Establish import policy that decreases the tax and customs on CFL.
2. Provide subsidies and flexible payment mechanism to the poorer consumers who cannot afford to buy them e.g. MWRE selling CFL through instalment system linked to electricity bill or allowing extra bill reduction

or free commodity for first consumers using CFL.
3. Support the local industry for CFL through provision of loans and lowering taxes for investments on production of CFL
4. Increase awareness level among consumers through more dissemination of adequate information (energy efficient devices, CFL benefits) using different tools e.g. appropriate media program (TV and Radio), Outdoor advertise at public locations, Mobile telephone messages system.
5. Establish effective marketing strategies and programs for CFL.

### 1.1.2.2 The specific measures for the dissemination of technology public transport bus 60+

1. Initiate Incentive measures such as lowering taxes and import duties for buses and their spare parts.
2. Establish a financing mechanism within the banking system to encourage the private sector to import buses such as low interest loans systems
3. Assign high priority for bus investment activities within the hard currency policy
4. Set financing mechanism to local authorities to upgrade the road status, equip the street with bus stations and conduct training courses for bus drivers
5. Formulate well assigned policy for mass transport that defines their role in alleviating the mobility problem.
6. Raise awareness in collaboration with NGOs and environmental movements within the community to break down the cultural barrier and disseminate information about environmental benefits of bus riding

### 1.1.2.3 The specific measures for the dissemination of Technology of efficient dual fuel boilers (EB)

1. Establishment of Investment Portfolio to finance the importation of EB
2. Finance of demonstration projects by international donors/agencies / CDM projects
3. Awareness raising (dissemination of Information) by the Sudanese Industrial Association Chamber to its members) through adequate number of consultants and advisers to inform the enterprises about the merits of using EB.
4. Training programs for labourers and operators in using efficient boilers,
5. Establish support to LPG use for industrial sector in the Energy policy

## 1.2 Action Plan for Compact Fluorescent Lamps (CFL)

### 1.2.1 About the technology

Compact Fluorescent Lamp (CFL) is a low energy-consuming lighting lamp (7-20 W). It provides an alternative to relatively high incandescent lamps (ICLs) (60W-100 W), thus saving energy consumed in lighting service by about 80 per cent. CFL mitigate GHG emissions by reducing electricity consumption, ultimately production from thermal power plant. Energy-efficient CFL are consumer type technologies with high potential to generate residential energy-savings. Within this context the main deployment objectives are:

• To reduce GHG emissions by reducing electricity consumption and so electricity generation from thermal power plants, ultimately reducing fossil fuel consumption

• To contribute to family welfare by reducing the electricity bill

• To contribute to energy security issues by lowering the overall demand

On analyzing the situation regarding CFL in Sudan, it has been realized that there is poor acceptability within the community. Individuals and institutions including governmental bodies generally do not purchase such technology and the ICLs are still prevailing although the import of CFL has started 10 years ago.

### 1.2.2 Target for technology transfer and diffusion

Based on the stakeholders' consultations, the TNA team suggests the diffusion of 600,000 CFL per year over a total period of 10 years. Replacing 6,000,000 ICLs (100W-60W) by CFL (20W) is expected to reduce the national electricity consumption to 835,200 MWh annually.

**The mitigation potential and other economic and environmental benefits of CFL include the following:**

• Reduce GHGs by 251,395 tonnes of $CO_2$eq annually

• Reduce electricity bill for the consumers by 14 per cent, as a result of replacing ICLs (60W—100W) by CFL (15W) for first 200 kWh. These are subsidized for all consumers.

• Increase energy supply security level

### 1.2.3 Barriers to the diffusion of CFL

To achieve the above set targets, several barriers have to be dealt with at sectoral level. These barriers can be grouped into financial and non-financial barriers.

## Financial barriers

The financial barriers for CFL technologies incorporate the relatively high initial cost of CFL and the high value of customs and taxes. A CFL lamp costs approximately 2 USD which is typically 3 to 10 times greater than its equivalent incandescent lamp. Additionally, the CFL price is relatively high, for consumers, compared to currently used incandescent lamps. The absence of local industries and lack of incentives that can encourage potential investors contribute to the high costs.

## Non-financial barriers

• Lack of information and awareness among households presents major barriers facing the diffusion of CFL. There is remarkable absence of awareness programs that inform the consumers about the advantages of the CFL such as short payback periods, savings of electricity and reductions in the electricity bill.

• Lack of awareness extends to distributors and installers who lack proper information about their attributes, including quality. There is wide consumer scepticism towards the packaging claims of long life and energy savings characteristics of CFL has to be addressed through well designed awareness programs.

• The electricity consumption sector is characterized by absences of enforcements for legal and regulatory measures within the energy efficiency policy. This is reflected for CFL in the following points:

o Absences of labelling system that classify the commodities according to their energy consumption, for example, there is no restriction on importation of high energy consuming devices. Hence there is a lack of support to devices with low energy consumption. Rather, the selection of the devices is mainly based on price and personal preferences.

o Absence of quality standards for the use of CFL. For example, some lamps showed unsatisfactory performance which had sometimes lead to accidents. Failure to have such quality standards leads to negative

perceptions of CFL.

o Absence of guarantee system. Consumers often look for guarantees or assurances that the products they buy will achieve the promised results (number of hours), especially when paying high prices for similar products.

o Limited market availability of CFL, especially in poor, remote and rural areas. The import process for all imported goods requires bureaucratic steps which results in limited supply for all goods in general. Additionally, logistic measures (transportation, handling etc.) are a complicated process due to internal trade regulations, e.g. local taxes and permissions. Furthermore, obstacles of accessing the rural areas such as roads status or non-suitable trucks result in high transportation cost.

o Low income levels among large strata of consumers leads to low demand and hence limited market availability in poor and rural areas. These factors are intensified by the absence of the local industry for CFL and the lack of sound marketing strategies for CFL.

### 1.2.4 Proposed Action Plan for CFL

The following table provides a summary for the actions proposed to facilitate the diffusion of CFL. The summary includes, for each action, types of responsible institutes, time frame within which action is to be implemented, and the indicators for the outcomes of the proposed action.

The CFL technology is a mature technology available in the market and so actions concentrate on its commercial application. It is a short-term action plan (2-5 years) in which deployment and diffusion activities are considered. These activities include:

• Ascertain the necessary standards and specifications needed to establish effective energy –saving labelling systems, and ensure utilization of high quality standards.

• Establish of favourable customs, duties and tax policies

• Initiate country wide awareness campaigns

• Develop smooth market chains

• Put in place effective energy policies and powerful institutional arrangement

In order to implement these activities, different institutions are to be involved including, but not limited to, financial institutions (Ministry of Finance and National Economy, Chamber of taxes, Chamber of customs and

duties), energy institutions (Ministry of Water Resources and Electricity, Ministry of Oil, National Energy Research Centre and universities) and public awareness institutions (local media, radio, TVs, newspapers).
The proposed funds needed to implement these actions are envisaged to be obtained from different national and international institutions.

## Table1: Summary of Action Plan for CFL

| The measure | Why it is needed | Action needed | Responsible Institution | Time (years) | Cost (USD) / funding | Indicators of success |
|---|---|---|---|---|---|---|
| Ascertain National standards and specifications | To establish effective energy –saving labelling systems and ensure utilization of high quality commodity | Establishment of standard construction of quality assurance laboratory | MWRE, SSMO, customs authority | 2 | 50,000 | Laboratory established Specifications set |
| Establishment of favourable customs, duties and tax policy | To attract traders and investors to import and invest in CFL manufacturing | Tax exemption of the imported CFL and the machineries for their production locally | Ministry of finance and Customs tax chambers | 1 | 250,000 | Percentage of reduced customs and tax Numbers of imported CFL |
| Country wide awareness campaigns | To Promote public awareness about the benefits of CFL | Mass media ( TV and Radio programs) Publications Workshops | Energy institutions/ Local media | Continuous | 500.000 | Number of performed campaigns Number of publications prepared Percentage of geographical coverage |
| Develop smooth market chains | To sustain availability of CFL in the market | Incentives and encouraging finance mechanisms to facilitate the importation and distribution of CFL | Private sectors ,gover-nmental bank and customs administration | 2 | 150,000 | Number of CFL imported and distributed |

| | | | | | | |
|---|---|---|---|---|---|---|
| Put in place effective energy policy and powerful institutional arrangement | To ensure utilization of high quality efficient commodities | To ascertain specific quality Standards. To enact effective regulatory frame work | Energy Institutions, Sudanese Corporation for standardization and metrological measures | 1 | | Testing Institutions established standards, code and specifications for CFL approved Laws and regulations formulated and approved by the government |
| **Total budget** | | | | | **950,000** | |

## Budget:

The total budget needed for the implementation of the action plan is 950,000 USD (Nine hundred and fifty thousand US dollars

To be financed by industry owners, governmental banks and international donors

## 1.3 Action Plan for the mass transport (Buses 60+)

### 1.3.1 About the technology

Buses 60+ are vehicles that are able to transport larger numbers of passengers per trip, thereby reducing the number of vehicles moving on roads and traffic congestions. What is more, buses 60+ mitigate GHGs through the reduction of the GHG emissions produced per person. Hence, the total GHG will be far less compared to small cars. Mass transport (buses 60+) has been the first priority within the transportation sector for Sudan.

### 1.3.2 Target for transfer and diffusion of Buses 60+

The starting target has been agreed upon to be introduction of 400 buses per year over a period of ten years in greater Khartoum State. The expected impact of using buses 60+ can be summarized as follows:

• Reducing energy consumption and therefore decrease GHG emissions compared to private vehicles
• Reducing road congestion
• Lowering the air pollution level

### 1.3.3 Barriers to the diffusion of Buses 60+

The bus system in Sudan is inefficient, and its utilization is still limited. To achieve the set target objective for the diffusion of buses 60+ the following barriers have been identified and classified.

Financial barriers

• Pricing policy is not acceptable by bus owners since government authorities fix transportation tariffs without consulting bus owners.
• Ticket prices are equal or sometimes higher than the small minibus tickets
• High taxes are imposed on the importation of buses and lack of flexible financing mechanisms that encourage importing buses
• The fluctuation of foreign currency affects the import of the spare parts and increases the running cost

Non-financial barriers

• Lack of awareness about environmental benefits of busses 60+ among the citizens
• Absences of transport policies that give priority to public transport system over private cars and small buses, e.g. bus company formation law, traffic law, road priority
• No standards or regulations for the bus mobility, quality and comfort
• No laws or regulations for traffic pollution
• Limited and low quality paved roads network
• Cultural aspects that do not favour bus riding over private cars and mini buses

### 1.3.4 Summary of action plan for the diffusion of Buses 60+

The large-scale introduction of a bus system, as a means to reduce GHGs is targeting the reduction of numbers of cars, motorcycles, and low-occupancy public transport modes that lead to reduce energy consumption and congestion. In order to achieve this objective a 10 year action plan is suggested. The plan will mainly focus on improving the transport policy, generating required regulatory frameworks such as laws and regulations, and raising awareness through these steps:

The Successful implantation of this action plan need the proper coordination and cooperation between all the government ministries and relevant institutions, private companies as well as the NGOs, civil societies in Sudan

The main governmental authorities that should be involved in the implementation of the action plan are the followings:-

1- Ministry of Finance to contribute in the budget of the action plan
2- Traffic Administration, to design with Ministry of Justice the laws and regulations to facilitate the circulation of the buses 60+ and to follow their implementation
3- Sudanese Standards and Metrological Organization (SSMO) with the Ministry of Transport, the General Corporation for Roads and Bridges and the Ministry of Environment should coordinate together to specify the type and the quality standards for the buses 60+ to be imported so that the buses should become comfortable for the public and with standards of low emissions and to design the roads, parking according to the selected types of buses.
4- The role of the Ministry of Investment is very important to encourage investors , small and medium companies to invest in the buses 60+
5- Ministry of Information as well as the NGOs, civil societies, will take care of the public awareness during the action plan , about the advantages, the economic and environmental benefits of the buses 60+:
• Setting well assigned policies for mass transport that define their role in tackling the mobility issue
• Improving the reliability and quality of public transportation with clear timetables, comfort, punctuality and route maps.
• Inclusion of public transportation system in urban planning activities, e.g. by widening roads, developing separated lanes, prohibiting private cars from travelling on the public transport lanes, etc..
• Raise awareness in collaboration with the media, NGOs and environmental movements within the community to break down cultural barriers and disseminate information about environmental benefits of bus riding
• Encourage more middle and small size investments, e.g. by establishing low interest loan systems
• The needed cost for the implantation of the buses 60+ action plan is only 350,000 USD beside the investment cost of the buses which is estimated to be 175,000 USD per buses, the number of buses for the first year are 400 buses which need an investment of 700,000 USD for the first year and a total investment of 7000, 000USD (Seven million USD) for the 10 years of the action plan life time.

• The first 350,000 USD is to be financed by international donors and organization but the investment for the importation of the buses will be funded by the private companies through bank finance as an output of the awareness and other activities of the action plan.

• More details about the action such as the needed action, the responsible institute / authority as well as the time and budget are presented in table (2) below

**Table 2: Action Plan for Mass Transportation Technology**

| The measure | Why is needed | Action needed | Responsible Institution | Time (years) | Cost USD | Indicators of success |
|---|---|---|---|---|---|---|
| Formulate Standard | To reduce import of mini buses To ensure the quality of imported buses (60+) | Tax exemption for buses (60+) Set standard for the quality of (60+) | SSMO, traffic authorities, Ministry of Finance, Customs authority | 1 | 50,000 | Number of mini buses number of buses 60+ |
| Investment laws for mass transport 60+ | To attract investors to invest in mass transport buses 60+ | Investment incentives, bank loans with zero / minimum interest rate | Ministry of finance and ministry of investment, Customs authority | Continuous activity | 50,000 | Number of new investors in mass transport buses 60+ |
| Legislation, regulations and laws for quality of mobility for buses 60+ | To attract the public to shift from minibus to mass transportation buses | Reform the bus system (clear timetables, comfort,) Quality & standards for the companies (punctuality and route maps and improving its reliability) | Ministry of transport & traffic administration, NGOs, civil societies | 2 | 50,000 | Increased number of people ride buses 60+ |
| Urban planning measures (Road infra-structure) | Facilitate buses circulations | Widening roads and improving major intersections to accommodate mass transport Developing separated bus lanes | Ministries of finance, transport, road and construction | 5 | N/A | Reduced travel time |
| Traffic laws and regulations for buses 60+ | To improve bus mobility and comfort | Traffic Priority Special lane | Ministry of Justice , Traffic authorities | 5 | 50,000 | Improved passenger satisfaction |

| | | | | | | |
|---|---|---|---|---|---|---|
| Awareness programs | To raise awareness of bus riding benefits<br>To tackle cultural barriers | Mass media, publications, workshops | Ministry of information, traffic authorities, Ministry of Environment, NGOs | Continuous activity | 100,000 | Increased number of passengers |
| institutional arrangements | Coordination between different stakeholders, especially governmental institutions | Harmonizing governmental regulations | Government ministries and relevant institutions, private companies | 1 | 50,000 | Number of contradi-cting regulations |
| **Total budget** | | | | | **350,000** | |

## Budget:

Cost of implementation of the action plan = 350,000 USD
Investment cost of 400 buses per year for 10 years 400 buses X175,000 USD (cost of one bus) is 70,000,000.USD
Total Budget for ten years = 70,350,000.00 USD
(Seventy Million Three Hundred and Fifty Thousands US Dollars)
To be financed by industry owners, governmental banks and international donors

# Chapter 2
# Technology Action Plan for (AFOLU) sector

## 2.1 Actions at sectoral level

### 2.1.1 Short sector description

In the agriculture, forestry and other land use (AFOLU) sector, the subsectors of livestock and forest management are identified to compose areas of high mitigation potential.

### Livestock

In the agricultural sector the largest source of methane (CH4) is enteric fermentation and manure management. Sudan is famous for its livestock wealth which is estimated at more than 130 million, of which 30 million is cattle. The dung production is estimated to be 4-5 kg/day/animal in open husbandry, and 10 kg/day/animal fresh weight in a closed system. Main challenges facing the livestock sector are their mobile nature and the continuous conflicts between pastors and farmers. Conflicts are mostly initiated by the dryness of the normal pasture, due to many reasons including low fertility of land. Other dimensions of pastoral life are the very low access to basic services such as potable water and electricity.
The main mitigation action within this subsector lies within manure management.

### Manure Management

Manure is a large source of methane emission, thus contribute to GHG emission, and is also a source of pollution and health hazards. Currently, in Sudan manure is mainly used as:
• Building material which requires dung fermentation in specific processes, thereby adding to GHG emissions.
• Energy provider through combustion in a very inefficient mode. This process contributes additionally to air pollution.
The suggested solution must inhibit open fermentation and minimize side effects on human beings and environment. This could be met by technologies such as anaerobic fermentation (biogas units) which produce heat/electricity, or through compost technology that produce fertilizer. These technologies could reduce GHG emissions and also provide energy, or contribute to improvements of soil characteristics. Both benefits will positively affect the rural welfare level.

## Forestry

Forests in Sudan are seen as a multifunction system. Forests products and their revenues contribute to food security. Forest revenues make up about 15 percent of Sudan's hard currency, and the forestry sector provides about 15 percent of employment opportunities in rural areas. Sudan's forests provide all requirements of hardwood and about 70 percent of the national energy consumption. Additionally, forests play an important role in encouraging ecotourism, sustaining biodiversity and soil fixation. The forest situation in Sudan has witnessed high deterioration especially after separation of South Sudan in 2011, when about 60 percent of the forest areas became part of South Sudan. The forest covers have declined from 46.5 percent in 1958 to 29.4 percent in 2005, and finally reached 11.6 percent in 2010. The annual removable rate has risen from 0.74 percent to 2.2 percent and the forest density is 200-500 tree/feddan (1feddan = 0.42 hectare. Forests in Sudan face serious challenges in two areas namely, forest management and forest conservation.

• Forest management is concerned with offsetting issues of excessive cutting/destroying forests to satisfy wood need such as energy, furniture etc. as well as to offset activities which affect forest situations such as over-grazing, forests fires etc.

• Forest conservation includes offsetting the encroachment of local communities into forest areas causing soil erosion, land degradation, destruction of habitats, and contributes to desertification and biodiversity loss. This encroachment is catalyzed by extension of mechanized agriculture area, traditional shifting cultivation and erection of infrastructure projects. Agriculture is the dominant sector in $CH_4$ emissions. It is estimated to contribute 1,713 Gg, or more than 86 percent of total $CH_4$ emissions in Sudan. Its share in the aggregated GHG emissions in $CO_2$ equivalent in 1995 is 56 per cent, and it is the largest contributor of all other sectors. Although, forestry and other land-use should constitute as a $CO_2$ sink, they have been found to be the main emitter of $CO_2$, and have mounted to 15,577 Gg or more than 75 percent of total $CO_2$ emitted. It is the second contributor for the aggregated GHG emissions in $CO_2$ equivalent in 1995 (24percent). Emission of $CO_2$ in the AFOLU sector is attributed to the burning of large amounts of fire wood for cooking in low efficient stoves. So, improved stove is selected to reduce consumption of firewood for

cooking and consequently contribute to reduction of $CO_2$ emission. The selected technology for the forestry sector is the Improved Stove (IS), mud stove type with an efficiency of about 35 percent to replace a 10 percent-efficiency traditional three-stone stove, can easily be built, used and maintained.

### 2.1.2 General Barriers and Proposed Measures for AFOLU Sector

Literature review shows that the first forest law and regulation has been established in 1901 and developed over time to the present forest Policy. However, UNEP (2006) observed that in spite of the existing good laws and regulation at the implementation level is very weak. Many reasons are responsible for this. Firstly, nearly all forests are located in areas that witnessed long periods of unrest and civil conflicts which lead to weak enforcement of laws and regulations. Secondly, the subsistent fuel wood producers lack appropriate skills in charcoal and wood production which increases rate of deforestation caused by excessive exploitation of forest resources for energy, using very low efficient traditional conversion technologies and practices. Finally, lack of financial resources to invest in forest plantation and rehabilitation of forest presents additional obstacles towards implementing sustainable management of forests. In a poor society this will make the shift to improved technology unattainable to the majority of the population.

The general barriers for livestock include low priority assigned to it compared to other sector such as mining. This is reflected in low level of services provided to both the stocks and owners. Traditional open husbandry systems are prevailing and hence best management practices are not known to most of the pastors. This includes waste/dung utilization for different purposes such as energy, both for direct use and for electricity production, and fertilizers.

The proposed measures involve strengthening both subsectors by implementing strong energy, forest and waste policies and by giving more consideration to rural areas.

## 2.2 Action Plan for Improved Stove Technology

### 2.2.1 About the technology

The Improved Stove (IS) is a type of mud stove built to reduce wood consumption and contribute to appropriate combustion modes through optimum design and suitable materials. They have efficiency rate of up to 35 percent which is much better than the commonly used three-stone stove with an efficiency rate of about 10 percent. Thus mitigate GHG emissions by reducing the amount of wood used. This can facilitate reducing forest degradation by allowing for more carbon sequestration. Emission reductions for each adopted stove range from 1 to 3 tons of $CO_2$ equivalent per year ($tCO_2e$/ yr). Improving the efficiency of fuel wood consuming appliances is therefore crucial to combat deforestation and tackle GHG emission in Sudan. Although, IS are known in Sudan and some projects have been executed to introduce and disseminate the technology, a large-scale uptake has not yet taken place.

### 2.2.2 Target for technology transfer and diffusion

As a first step the action targeted a number of around 600,000 stoves/ year to be distributed to groups in Central, Eastern and North Darfur regions. The projects of improved stoves should be firstly targeted to households as they are highly affected by the cooking fuel provisions. The mitigation potential and the other benefits of using IS can be summarized as follows:

• Reduce forest degradation in terms of quantity of wood cut which will simultaneously conserve the prevailing ecosystems. The Forest National Corporation (FNC, 2010) estimated the loss of forest to 0.542 million hectares over the period 2005-2009 to meet the energy requirements which account for 62 percent of the energy balance. The annual removal of woody biomass for energy is estimated as 21 million $m^3$. This is double the natural annual rate of forest regeneration in Sudan which is fairly put at 11million $m^3$. Thus annual rate of deforestation range is put between 0.4 and 0.7 million hectares (FAO 2005).

• Improve health, particularly for women and children by providing efficient stoves (better combustions).

### 2.2.3 Barriers to the diffusion of IS

The IS technology is not widely used in Sudan. Although, several trials have been made in the past decades to disseminate IS and scale-up its applications, the uptake of the technology is still weak. Many factors contribute to hinder the widespread of IS within Sudan, of which the following barriers are most significant ones:

### Economic and financial barriers

Improved Stoves (IS) is not a financially viable technology compared to other biomass stoves, stakeholders suggest the following reasons for this situation:

• Lack of investment incentives against low demand results in inadequate private sector participation in technology investments. Investors need to ensure certain levels of distribution in order to attain specific revenues.

• Lack of finance mechanisms for both producers and users that can arrange for fiscal support measures such as low interest loans or options creating community shops or consumer groups. This situation also affects the consumer ability to carry out the required maintenance.

• High material cost, high value of customs and taxes for steel sheets or equipment needed to produce high quality stoves.

Non-financial barriers

• Low level of information about IS in general due to the lack of appropriate awareness programs and inadequate training for extension officers and development workers, and lack of awareness among decision makers (local/national), private sectors and communities about forests conservation

• Absence of government patronage and institutional coordination, and lack of distribution of their responsibilities although different institutions consider IS in their programs, e.g. FNC, NERC and NGOs

• Absence of effective energy policy that cover all type of energy consumption and absence of laws that mandate standards related to quality assurance

There is low level of information about IS in general due to the lack of appropriate awareness programs and inadequate training for extension officers and development workers. Additionally, there is lack of awareness among decision makers (local/national), private sector and communities about forests conservation importance as general and the merits of IS

compared to the traditional stove. As there is relatively enough know – how and information in some institutions such as Forest National Corporation (FNC) and National Energy Research Centre (NERC) then these factors could be related to the limited budget assigned for such activities.

Different institutions consider IS in their programs e.g. FNC, NERC and NGOs, but there is absence of government patronage and institutional coordination. There is no clear distribution of responsibilities and smooth coordination between them. Additionally the dissemination of new technology such as the improved stoves involve different aspects of social, economic and investment circumstances and there is relatively limited capacity with the governmental institutions capable of addressing such issues. Extra the mandates of these institutions limit its ability to enforce dissemination plans and support measures set to promote such technologies.

Absences of effective energy policy results in week adoption of energy efficient technologies as general including improved stoves technology, in addotion to absence of laws that mandates standards and specification related to quality assurance.

### 2.2.4 Proposed action plan for Improved Stove

The following table provides a summary for the actions proposed towards increasing the uptake of IS.

The IS technology is a developing technology therefore its uptake is limited. Hence short-medium term plans of action (5-20 years) in which deployment and diffusion activities are considered include:

• Establishment of well-equipped workshops that can fabricate high quality IS
• Country wide awareness campaigns
• Develop smooth market chains and empower consumers groups
• Formulate conducive energy policy and strong institutional arrangements

Different institutions are to be involved in this action including the following:

### 1. The financial institutions:

• Ministry of Finance and National Economy is responsible for the provision of financial resources needed for the implementation of the

action. As indicated in the table the total budget for the action is estimated to be 1,650,000 USD which should be provided by the Ministry of Finance and National Economy.

• Chamber of taxes is responsible for the tax reduction and exemption from income taxes for dealers in an assembly and promotion of the Improved Stove.

• Banks are responsible for the provision of low interest loans and inclusion of IS workshops within the microfinance system already operating in Sudan for small business creation.

• Customs authorities are responsible for the exemption from customs and duties for the tools and equipment and imported materials used by the IS workshops.

## 2. The energy institutions:

• Ministry of Water Resources and Electricity is responsible for contribution of the general energy policies that promote efficient energy technologies.

• Ministry of oil is responsible for the contribution to general energy policies beside pricing policies for alternative energy sources.

• National Energy Research Centre and universities are responsible for IS R&D, testing and provides certification for the improved design of the IS manufactured by the local workshops.

• Forest National Corporation is responsible for the approval of the recommended IS design, establishment of well-equipped workshops for the production of IS. It is also responsible for the dissemination and follow-up of the implementation of the action plan.

**3. Public awareness institutions:** (local media, radio, TVs, newspapers) responsible awareness and promotional campaigns to facilitate the flow of information about the proposed technology.

## Table 3: Summary of Action Pan for Improved Stove

| The measure | Why it is needed | Action needed | Responsible Institution | Time frame (years) | Cost of action | Indicators of success |
|---|---|---|---|---|---|---|
| Country wide awareness campaigns | Forest conservation & (IS) benefits | Multi - media, TV and Radio programs, publicity, brochures, workshops | FNC & NERC Ministry of culture & information | 5 | 250,000 | Number and types of campaign designed Number of materials prepared Number of campaigns performed Geographical coverage of campaigns |
| Establish Financial mechanism and provision of soft loans to investors | This action is aiming to introducing the efficient Improved Stoves (IS) | Tax reduction, low interest loans for the raw materials of (IS). | Ministry of finance, governmental banks Customs administration | 10-20 | 500,000 | Number of people financed Size of annual finance received percent of loan re-payment of loans |
| Capacity building and training programs | Produce good quality of (IS) | Train craftsmen & midterm officers in engineering & project management | FNC, NERC, NGOs | 10 | 500,000 | Number and types of training needs assessment performed Number of training packages prepared Number of training sessions held Number of trained beneficiaries (persons/ institutions) |
| Develop market chain | Distribution of (IS) at reasonable price to the user | Establish link between ,manufacturers (IS) distribution centres & user | Private sector | 5 | 250,000 | Number of businesses initiated Number of manufactured units per year Number of sold units per year |
| Put in place a conducive policy mechanism &institutional arrangement | coordination between different stakeholder especially government institutions | Institutional arrangements | Government Ministries | 3 | 150,000 | Institutions establishment Conducive financial and import policy put in place Laws and regulations formulated and approved by the government. |
| **Total budget** | | | | | **1,650,000** | |

## Budget:

Total Budget needed for the implementation of the action plan is 1,650,000 USD

This budget is to be provided by industry owners, governmental banks and international donors

## 2.3 Action Plan for Biogas Technology

### 2.3.1 About the technology

A biogas plant consists of a pit which serves as a digester for organic waste and gas holder. The digester is either built of brick and cement inside the pit or prefabricated and mounted inside the pit. The tank is either made of a metal container floating on the slurry or a fixed dome built on the digester. Different types of organic materials can be fermented to produce the biogas such as animal dung, agricultural waste and industrial waste. The organic material is mixed thoroughly with the same amount of water and fed into the digester to decompose by the act of anaerobic bacteria to produce the biogas. Generally, cow dung is the most suitable; it is homogenous, not fibrous, requires less amount of water to be mixed than other materials and already contains methane producing bacteria. The biogas is a flammable gas that consists mainly of methane (60 per cent), $CO_2$ (30 percent) and water vapour (10 per cent). It is odourless, burns without soot and leaves no dirt on utensils.

### 2.3.2 Target for biogas transfer and diffusion

As a first step, the programs will be directed towards the rural areas in Sudan, mainly Gezira, White Nile and Blue Nile regions. These areas have been selected based on the following characteristics:

- Large numbers of livestock (cattle) potential on semi-sedentary system, about 30 million
- Sedentary population with an average of 10 person/household
- Availability of water as located near the river Nile

In particular, 60 percent of the cattle population is expected to enter such system with dung availability of 70 per cent. As the expected amount of dung is around 1.5 ton (fresh basis) (0.3 dry basis) /head/ year. The dung are expected to produce 350m3 of biogas/ ton dry matter with average heating value of 20 MJ / m3 biogas

The expected impacts are:

- Reduction of GHG emission
- Supply of cooking fuel
- Provision of electricity
- Delivery of lighting service
- Improve public health by collecting dung

### 2.3.3 Barriers for biogas technology diffusion

Biogas technology for energy purposes has been introduced in the mid-1970s through some projects but there is no systematic use of this technology and most executed projects have failed. Different barriers result from poor adoption of biogas technologies of which the following are identified to be the most significant:

Economic and financial barriers

Biogas technology is a high cost technology that is generally unaffordable for individuals or village communities. In particular these high costs are based around the following aspects:

• Prevalence of small scale units with single purpose mainly cooking fuel neglecting electricity, lighting and fertilizers. Hence the revenue will only be calculated upon the cooking fuel cost which increases the cost/m3 of gas. Ultimately, the payback period is very high

• The available design - building in site Indian design – requires the use of expensive construction material such as cement and iron bars.

• Absence of financial policies for green technologies and biogas, lack of funding opportunities by commercial banks, community development institutions, agricultural funds, or tax and custom authorities

• Absence of commercial technology suppliers like companies and lack of local market incentives. Hence the profit margin is low for any component therefore the purchasing of any commodity or services related to biogas technology will be against higher value.

Non-financial barriers

The non-financial barriers facing the diffusion of biomass include:

• Lack of information at different levels of society including policy makers and planners,

• Lack of awareness about the conditions and benefits of biogas technologies, especially in rural areas. Therefore the livestock owners as general is not aware about why and how biogas technology could be adopted .This situation results in biogas being undiscovered subject hence in absences of demand. This low demand does not encourage the allocation of specific budget for awareness programs as they are generally directed to the more important issues such as new varieties or gender mainstreaming consequently a vicious circle is created.

• Absence of well-defined policies and regulations to mainstream biogas technologies and priorities within the energy, waste and livestock sectors
• Absence of specific bodies responsible for the patronage of biogas technologies and supporting the dissemination and adaptation efforts and lack of cooperation between governmental bodies and institutions related to biogas.
• Lack of research on the performance of biogas technologies
• Limited technical know-how related to biogas technologies as a result of inadequate university curricula and lack of experts exchange programs

Generally there is lack of information at the different levels of the society including policy maker and planner level. Extra there is complete absence of awareness packages about the conditions and the benefits of such technology whether as direct information mode or through media. This absence extends to rural development programs and agriculture extension services. Therefore the livestock owners as general are not aware about why and how biogas technology could be adopted .This situation results in biogas being undiscovered subject hence in absences of demand. This low demand does not encourage the allocation of specific budget for awareness programs as they are generally directed to the more important issues such as new varieties or gender mainstreaming consequently a vicious circle is created.

There is no well-defined policy and regulations that are issued to mainstream the Biogas technology and priority within the energy, waste and livestock sectors. This could be referred to inadequate awareness among decision makers about green technology importance as biogas benefits.

There is no specific body responsible for patronage the biogas technology and support the dissemination and adoption efforts. Follow-up measures have not been critically considered as this requires dedicated body. This gives rise to unsustainable projects, as a result, negative community perception has been generated. Research and educational institution are relatively active in producing scientific documents including technical packages or execution instructions however the impact of the research outcomes are very limited due to absences of transformation channels. Additionally, there is no smooth systematic cooperation between the main governmental bodies / institutions that are related to biogas e.g. Ministry of Animal Wealth, Ministry of Energy etc. Although there are some biogas professionals, technical know-how is generally very limited at all levels;

planning, scientific research, contractors, builders, operators etc. This could be referred to the fact that the curriculum for many engineering, agriculture, animal production, etc. faculties does not include adequate biogas related topics in their curriculum. There are no expert visit programs through which the experience of the other countries could be exchanged. The relative small job market does not encourage young people to anticipate career in biogas beyond the university level and research centres.

### 2.3.4 Proposed action plan for the Biogas technology

The following table provides a summary for the actions proposed above to facilitate the diffusion of biogas. The summary includes for each action, types of responsible institute, time frame within which action is implemented and the verifiable indicators for the outcomes of the proposed action.

The biogas technology is not well developed in Sudan and so actions need to concentrate on developing cheap and acceptable designs of biogas plants that fit the socio-economic context of rural Sudan. So actions are based on short- and medium term measures for sustainable implementation of biogas technologies that contribute effectively in GHG reduction.

Different institutions are to be involved in this action to diffuse the biogas technology which includes:

### 1. The financial institutions:

• Ministry of Finance and National Economy is responsible for the provision of financial resources needed for the implementation of the action for the biogas technology. The estimated budget should be provided by the Ministry of Finance and National Economy.

• Chamber of taxes is responsible for the tax reduction and exemption from income taxes for constructors of the biogas plants.

• Banks are responsible for the provision support to builder of the biogas plants and support to the users in villages.

• Customs authorities are responsible for the exemption from customs and duties for imported building and prefabrication materials used in the building of the biogas plants.

### 2. The energy institutions:

• Ministry of Water Resources and Electricity is responsible for contribution

of the general energy policies that promote efficient energy technologies.
• Ministry of Oil is responsible for the contribution to general energy policies beside pricing policies for alternative energy sources.
• National Energy Research Centre and universities is responsible for R&D on biogas technologies and assess the availability and accessibility of waste resources (animal dung) in different parts of Sudan which have high potential for biogas applications.
• Forest National Corporation is responsible for the approval of the recommended biogas design, provides training on biogas plant building, operation and maintenance.

**3. Public awareness institutions** (local media, radio, TVs, newspapers) responsible awareness and promotional campaigns to facilitate the flow of information about the proposed technology.

**Table 4: Summary of action plan for biogas technology**

| The measure | Why is needed | Action needed | Responsible Institution | Time frame (years) | Cost of action | Indicators of success |
|---|---|---|---|---|---|---|
| Establish Financial mechanism and provision of soft loans to investors | To encourage the dissemination of biogas | Support producers village committees | Governme-ntal Banks | 20 | 1000,000 | Number of people financed<br>Size of annual finance received<br>percent of loan re-payment of loans |
| Qualify engineers technicians & skilful labourers | Technology transfer ,operation & maintenance of the biogas | Establish educational programs for university and vocational training centres | Universities/ Research centres/ vocational training centres | 5 | 50,000 | Number of curriculums designed and applied<br>Number of Instructors trained Locally/Abroad<br>Number of students graduated |
| Country wide awareness campaigns | Raise the awareness of the population about the economical & environmental benefits of biogas | Workshops seminars brochures | Energy institutions | 10 | 100,000 | Number and types of campaign designed<br>Number of materials prepared<br>Number of campaigns performed<br>Geographical coverage of campaigns |
| Capacity building and training programs | Training of trainees (engineer technicians) | Training programs | Energy institution/ private training centres/ local media | 5 | 100,000 | Number and types of training needs assessment performed<br>Number of training packages prepared<br>Number of training sessions held<br>Number of trained beneficiaries (persons/ institutions) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Develop market chain | Distribution of biogas construction material at reasonable price | Establish link between material suppliers manufacturer The biogas user/users | Private sector | 5 | 500,000 | Number of businesses initiated Number of built biogas plants per year Number of prefabricated units sold |
| Put in place energy and waste policy mechanism &institutional arrangement | Coordination between different stakeholder especially government institutions | Institutional arrangements | Energy Institutions | 3 | 15,000 | Institutions establishment Approved biogas standards and specifications Laws and regulations formulated and approved by the government. |
| **Total budget** | | | | | **1,765,000** | |

## Budget:

Total Budget needed for the implementation of the action plan is 1,765,000 USD

To be financed by industry owners, governmental banks and international donors

# Chapter 3
# Technology Action Plan for Industry sector

## 3.1 Actions at sectoral level

### 3.1.1 Short sector description

Industry is an important economic sector in Sudan due to its contribution to food security, GDP and comprehensives of national production in local, regional and international markets. Additionally, industry plays an important social role by creating employment opportunities.

The rate of development of the industrial sector in Sudan has grown from 7.9 percent in 2009 to 8 percent at the end of 2010.The contribution of large-scale enterprises is around 82 percent and small scale companies account for 18 percent. Generally, the food industries are considered to be the strategic goal for Sudan. The survey conducted by the Ministry of Industry in 2005 shows that the food industries constitute 70 percent of the industries in Sudan, and 50 percent of the work force are working in food industries. Also, it provides a considerable contribution to GDP, namely 5.5 percent compared with the other industries.

With respect to energy utilization, the (food) industrial sector is generally characterized by inefficient production systems, such as old boilers and high losses throughout the different processes of non-insulated pipes and very poor housekeeping. Currently, many industries are considering the use of LPGs as an alternative energy source, since it does not require major modifications to the existing plants. This alternative is especially attractive when combined with more efficient boilers that use dual fuel. The dual characteristic will minimize the risk of LPG scarcity. GHG emissions associated with industrial processes in 2000 is 93Gg $CO_2$eq, representing about 0.1 percent of total $CO_2$eq emissions. Cement production activities account for the overwhelming majority of $CO_2$eq emissions, corresponding to about 95 percent. Lime production accounts for about 5 percent followed by soda ash uses, which account for less than 0.5 percent of industrial $CO_2$eq emissions.

### 3.1.2 General barriers and proposed measures for the industry sector

Most of the industries in Sudan are of small and medium size with obsolete technologies. They are facing different types of problems which can be summarized as follows:

• Fuel scarcity: fuel availability is not sustainable due to fluctuating national and international political circumstances which govern fossil fuel exploration and import. Additionally, fluctuation of hard currency policies is a crucial factor in fuel pricing.

• Relative absence of long term appropriate storage facilities for all fossil fuel as general and LPG specifically

• Low rehabilitation budges; most of the industries are of small to medium size with relatively limited scope of work. The assigned budget for maintenance and rehabilitation is low thus explaining reluctance of factory owners to purchase new technologies including efficient boilers.

• Absences of local industry protections and policies that can restrict imports of similar products, thus resulting in low profit for produced commodities

Therefore general proposed activities include:

• Setting an effective policy to insure the availability of fuels to the industrial sector at suitable prices

• Improving storage facilities and distribution system to accommodate for fuel crises

• Enforcing local production policies to allow better profits for produced commodities

## 3.2 Action plans for the Technology of Efficient boiler (EB) for the Industry Sector

### 3.2.1 About the technology

Efficient boilers with dual fuel (Furnace –diesel/ LPG) are industrial boilers that are characterized by

• Improved combustion processes through different technical measures such air/fuel ratios, reducing heat losses to surrounding through better insulation. This leads to lower fuel consumption hence lower GHG emissions.

• Allowing the use of two fuels at same technical efficiency. This criterion

accommodates for more fuel flexibility that can result in higher profit for produced commodities.

### 3.2.2 Targets for diffusion and deployment of EB

The action targeted is the erection of 100 efficient boilers within a period of 10 years, at a rate of 10 boilers per year. The target sector covers medium and small scale factories of food, beverage and textile by introducing new boilers of capacity ranging between 1 -6 tonn/hour with working pressures of 5-12 bar and 90 percent efficiency, specifically fire-tube boiler with dual burner. A special criterion for the food sector is its relative high need for steam and hot water which calls for a reformation on the energy side. Hence the expected impact will be:

- Reduction of 3740.5 kg $CO_2$/mmbtu in ten factories a year
- Reducing the production costs by 30 percent due to fuel savings
- Lowering GHG emissions
- Increasing the degree of the energy security in the industrial plants
- Improving the occupational health and the environmental measures
- Reducing the quantity of fuel imported and hence save hard currency

### 3.2.3 Barriers to the diffusion of Efficient Boilers

**Economic financial barriers**

- Absence of investment incentives for importing EBs as banks and credit institutions do not support such projects

Small and medium industries have limited budget for rehabilitating or maintaining old systems and spare parts. Also LPG need additional infrastructure, storage facilities, connections and safety requirement, therefore the owners will not be able to buy new boilers/ dual burner system

### Non-financial barriers

- Lack of training programs for skilled operators and engineers for the total steam generation and distribution: new efficient steam generation system need well trained workers to control the whole system starting from using the dual burner system to steam distribution
- Unstable governmental regulations in fuel distribution to different sector
- Lack of clear policies towards industrial development, especially in issues such as finance and employment, initiating smart partnerships between the

industrial sector and related research institution
• Lack of awareness and ignorance about the benefits of EBs

### 3.2.4 Proposed action plan for the Efficient Boilers

The action plan target is to replace the old inefficient boilers in the medium and small scale factories of food, beverage and textile by new efficient boilers with dual burner of capacity ranging between 1 -6 tonnes/hour with working pressure 5-12 bar and 90 percent efficiency.
The plan is to start by the erection of 100 efficient boilers with dual fuel (furnace, diesel/ LPG) over a period of10 years at a rate of 10 boilers per year.
The implementation of the proposed action plan for Efficient Boilers (EBs) in the industry sector need a close coordination and cooperation between the different actors in the industry field those actors are the government ministries and relevant institutions, private companies as well as the NGOs, civil societies in Sudan
The main governmental authorities that should be involved in the implementation of the action plan are the following:-
1. Ministry of Petroleum is to facilitate the importation of LPG/NG and develop the regulation and standards as well as the needed infrastructure for the NG importation.
2. Ministry of Industry in association with the -Industrial Chamber Association is to formulate standards of Efficient Boilers (EBs) and facilitate their importation in coordination with the Ministry of Finance and the administration of the customs
3. Ministry of industry in association with the Industrial Chamber Association and the national banks is to facilitate loans that encourage the small and medium food industries to install EB
4. Close liaison and coordination for the implantation of this action plan should be maintained between Industrial Chamber Association and the Ministries of Environment, Information and other concerned bodies including NGOs, international donors and agencies that sponsor CDM projects.
More details about the action plan activities, the responsible body for each activity as well as with the estimated cost are presented in Table (3.1) below.

## Table 5: Proposed 10 Years Action Plan for Implementation of Efficient Boilers Technology in Sudan

| The measure | Why is needed | Action needed | Responsible Institution | Time frame (years) | Cost of action | Indicators |
|---|---|---|---|---|---|---|
| Establish financial mechanism and provision of soft loans to investors | To encourage the dissemination of biogas | Support producers village committees | Governmental Banks | 20 | 1000,000 | Number of people financed<br>Size of annual finance received<br>Percent of loan re-payment of loans |
| Qualify engineers technicians & skilled workers | Technology transfer ,operation & maintenance of the biogas | Establish educational programs for university and vocational training centres | Universities/ Research centres/ vocational training centres | 5 | 50,000 | Number of curriculums designed and applied<br>Number of instructors trained Locally/ Abroad<br>Number of students graduated |
| Country wide awareness campaigns | Raise the awareness of the population about the economical & environmental benefits of biogas | Workshops seminars brochures | Energy institutions | 10 | 100,000 | Number and types of campaign designed<br>Number of materials prepared<br>Number of campaigns performed<br>Geographical coverage of campaigns |
| Capacity building and training programs | Training of trainees (engineer technicians) | Training programs | Energy institution/ private training centres/ local media | 5 | 100,000 | Number and types of training needs assessment performed<br>Number of training packages prepared<br>Number of training sessions held<br>Number of trained beneficiaries (persons/ institutions) |
| Develop market chain | Distribution of biogas construction material at reasonable price | Establish link between material suppliers manufacturer The biogas user/users | Private sector | 5 | 500,000 | Number of businesses initiated<br>Number of built biogas plants per year<br>Number of prefabricated units sold |
| Put in place energy and waste policy mechanism & institutional arrangement | Coordination between different stakeholder especially government institutions | Institutional arrange-ments | Energy Institutions | 3 | 15,000 | Institutions establishment<br>Approved biogas standards and specifications<br>Laws and regulations formulated and approved by the government. |
| **Total budget** | | | | | **1,765,000** | |

## Budget:

Total Budget needed for the implementation of the action plan = 1,765,000 USD
To be financed by industry owners, governmental banks and international donors

# Chapter 4
# Cross-cutting Issues

Three main sectors have been selected for the mitigation actions in Sudan. These are; the energy sector, the agriculture, forestry and other land use (AFOLU) sector and the industrial sector. All proposed actions, for selected mitigation technologies cross-cut through these sectors and so there many common issues which can be identified at various stages. In the case of improved stove and the biogas technologies any policy formulation in either the energy sector or AFOLU sector directly affects the diffusion and adoption of both technologies. For example pricing policies of oil products such as kerosene and LPGs, which are alternatives to fuel woods and charcoal, used in the improved stove is having direct impacts on the uptake of the improved stove and the same impacts on uptake of biogas technology.

For example in the AFOLU sector the trends of wood fuel consumption in Sudan projected a continuous increase through time due to increased fuel wood consumption as a result of increases in population, lack of readily alternative fuels, and the prevailing poverty. According to population data, with an annual growth rate of 2.7 per cent, the population is expected to reach 50 million by 2030 (CBS 2010). Given the current per capital wood fuel consumption (0.7 m3/capita), fuel consumption will increase systematically from 21 million $m^3$ in 2010 to 35 million $m^3$ by 2030. At the same time the lack of alternative fuel types and escalating prices of oil products (LPG and kerosene), coupled with prevailing rates of poverty (48 percent of the population live below poverty line) make alternative fuel types unaffordable to the majority of the population. As a result the demand on fuel wood will continue to rise.

On the other hand, trends of forest cover in Sudan show continuous declining from 40 percent in 1901 to 34.36 percent in 1958 to 28.6 percent in 2005 of the total country area. FNC has estimated the loss of forest during the period 2005-2009 has fairly reached up to 0.54 million hectares deforested to meet the energy requirements. Currently, the removal of woody biomass for energy is estimated at 21 million $m^3$. This is twice as much the natural annual rate of forest regeneration in Sudan which is estimated at 11 million $m^3$. Recent assessments of forest resources show the annual rate of deforestation at 0.7 percent (FRA 2005).

This excessive use of biomass can also be attributed to low efficiency of biomass energy conversion technologies. The conversion to heat energy is taking place in low efficient stove types (fire wood stove and charcoal stove) with efficiency ranging between 10-15 per cent. So, larger quantities of energy are wasted in low efficient conversion technologies.

Forest management practices present additional challenges to sustainable supply of wood fuel. UNEP (2006) observed that despite the existence of good laws and regulations their implementation at the ground is very weak. The first forest law and regulation has been established in 1901 and developed over time to the present Forest Law 2002. Many reasons are responsible for the weak law enforcement. Firstly, nearly all forests resources are located in areas that witnessed long periods of unrest and civil conflicts. Secondly, the segments of the society involved in charcoal and wood production are subsistence producers who lack appropriate skills and technologies. Finally, lack of financial resources to invest in forest plantation and rehabilitation of forests presents another source of weakness towards implementing sustainable management of forests resources in Sudan. Thus solutions to reduce emissions from burning wood fuel and increase sequestration of $CO_2$ in forests lies in the ability of the energy sector to provide alternative fuel or improve the efficiency of existing technologies such as improved stoves.

Likewise, there are many common issues between energy and industrial sectors. The diffusion of the proposed technologies in the industrial sector, namely Efficient Boilers, is also affected largely by the policies and strategies adopted by the energy sector. The dual nature of the boilers, however, makes it flexible to use different fuel types. Its uptake by the industrial sector depends on the policy advantages set by the energy sector. The GHG emissions in the industrial sector are dominated by the use of heavy fuel to obtain energy to run the boilers. So the policies to achieve shifting from high emission fuel types to low emission types rely on both energy and industrial sectors policies. The import policies in the energy sector can determine what types of fuel are allowed for importation and what types are prohibited since the diffusion of technology depends on what fuel types are available.

This placed the energy sector at the centre for common policies to address barriers in the other two sectors (AFOLU and Industrial sectors). Conducive fuel pricing policies, taxes and subsidies of oil and electricity sources can

address all barriers which hinder the diffusion of the proposed mitigation technologies in the other two sectors (AFOLU and industrial sectors). Therefore, building linkages and coordinated efforts between these sectors during policy analysis, formulation and implementation are critical issues for the three sectors in pursuing their GHG mitigation objectives.

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Republic of Sudan

Ministry of Environment, Forestry and Physical Development

Higher Council for Environment and Natural Resources

# PROJECT IDEAS

## PART 4

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## List of Abbreviations

| | |
|---|---|
| AFOLU | Agriculture, Forestry and Other Land-uses |
| CBOs | Community Based Organizations |
| CFL | Compact Fluorescent Lamps |
| EB | Efficient Boiler System |
| ERA | Electricity Regulatory Authority |
| FNC | Forest National Corporation |
| GHGs | Greenhouse Gases |
| ICLs | Incandescent lamps |
| IS | Improved Stoves |
| NGOs | Non-Governmental Organizations |
| SSMO | Sudanese Standards and Metrological Organization |
| TOR | Terms of Reference |

## Table of Contents

## Executive Summary

This report offers suggestions of some project ideas that could be adopted by the different stakeholders to mitigate GHG emissions while contributing to sustainable development. These ideas were developed in close consultation with the project stakeholders and reflect governmental plans and Sudan's development priorities.

The project ideas were conceptualized to address some of the barriers for the diffusion and deployment of the respective technology as identified in the barrier report (Part 2). The barrier report of the TNA project forms the basis for discussion, and ultimately the development of the project idea. Throughout the consultation sessions it emerged clearly that the specific projects are to be executed in strong collaboration with governmental institutions, the private sector and civil societies as lessons learned from previous projects showed that concentrating the support efforts on implementing body did not achieve positive impacts on the sustainability of the project.

The project ideas identified are: `Establishment of quality control Laboratory of Compact Fluorescent Lamps (CFL) for the energy demand subsector, Establishment of cooperative for bus owners in Khartoum for the transportation subsector, Enhancing the diffusion of Improved Stoves (IS) through establishing of centre points)`. For the forestry subsector, construction of a factory for production of prefabricated biogas unit accompanied with support program for the livestock subsector, and Promotion of high efficient boilers with dual system (90% efficiency) furnace diesel/LPG for the industry sector. The report is written in a concise style, after the brief introduction of each project idea, a table summarises, among others, objectives, challenges, outputs, relationship to developing priorities, implementing agencies is provided. A list of stakeholders who had participated in preparing these ideas is annexed.

# Chapter 1
# Project Ideas for the Energy Sector; Electricity consumption Subsector

## 1.1Brief Summary of the Project Idea

This project idea is suggested to support the deployment of the Compact Fluorescent Lamps (CFL) among the consumers of the domestic sector. It is expected to realize significant reduction in electricity consumption (lighting) thus reducing GHG emissions. The project titled 'Establishment of quality control Laboratory of Compact Fluorescent Lamps (CFL)' aims to fill the gap in regulatory framework found due to absence of local setup for issuing quality assurance certificates for CFL.

## 1.2 Specific Project Idea

Establishment of quality control laboratory of Compact Fluorescent Lamps (CFL).

The establishment of a laboratory for quality assurance for CFL will encourage consumers to use them thus it enhances technology diffusion and eliminates the use of incandescent lamps (ICLs). The main performance parameters such as lifetime, lighting efficiency, power factor and harmonic disturbance are to be tested and verified before issuing a quality assurance (QA) certificate. The project incorporates two components, firstly, the physical establishment of lab with 3 testing lines capable of test 20 lamp/ month thus around 600 lamp/ year: 0.001 % of the targeted quantity of CFL 600,000 lamp/ year. This phase includes provision of the testing equipment. The establishment process is expected to be in three phase, (i) tender document (ii) construction of the buildings and setting the equipment (iii) commissioning phase where by a kind of intensive training for the local staff is expected to take place. The second phase which is expected in take place simultaneously with establishment process involves setting the optimum standards and specifications including threshold values. The project is seen as a first step in the introduction of the labelling system for electrical appliances in Sudan.

## 1.3 Project overview

| Name of Project Idea | Establishment of Quality Control Laboratory of Compact Fluorescent Lamps (CFLs12). |
|---|---|
| Introduction | An absence of an assigned laboratory for testing and quality assurances of CFL is one of the major barriers against the diffusion of this technology. This project ensures consumer confidence in the energy efficient label and protects the consumer investment in CFL. The issuing of QA certificate or energy efficiency label requires product testing in a certified laboratory that meets international standards for quality and competency. Additionally, the suitable set of standards and specification should be ascertained considering the local circumstances in Sudan. |
| Objectives | To ensure the quality of the CFL in local markets<br>To enhance diffusion and deployment of CFL<br>To contribute to efforts paid in establishing labelling systems for electrical appliances. |
| Outputs | Support quality control efforts for CFL<br>Support the establishment of the labelling system for electrical appliances |
| Relationship to the country's sustainable development priorities | The project is in line with the declared objectives of MWRE namely:<br>Execute energy labelling system for electric appliances<br>Reduce electricity consumption on the domestic sector and in government buildings The Demand reduction will provide more capacity in the grid; hence more consumers could be connected to the grid, thus increasing a coverage level for electricity service,<br>The project will also contribute also to development objectives of poverty alleviation by reducing the electricity bill to consumers<br>Reduce GHG from electricity sector; replacement of 6,000,000 ICLs by CFL will reduce GHG by 251,395 tCO2 |
| Project Deliverables | Establishing a well-developed laboratory for testing of CFL quality (20 lamp/ month; lab established<br>Setting standards and specifications for lighting lamps particularly CFL; booklet of standards produced<br>Setting conditions for QA certificates (specific instructions and steps ) |
| Project Scope | Construction of the laboratory including providing the testing equipment<br>Support the ascertaining process required to identify the suitable set of standards and specifications under Sudanese conditions<br>Support during the first work phase(commissioning) |

| | |
|---|---|
| Project activities | Establishment of standard and labelling system for CFL<br>Setting terms of reference (TOR) for importing the laboratory construction and equipment provision<br>Preparation of the tender document for lab construction and equipment supply<br>Execution phase: construct the building and Import the laboratory equipment<br>Support during first work phase (commissioning phase). |
| Timeline | The estimated timeline for the project is about 2 years: setting standards and preparing tender documents (one year), construction (six months), commissioning (six months) |
| Budget | The estimated costs for laboratory equipment for quality testing of CFL will be about 750,000 USD, excluding costs of laboratory land, construction and management The land cost and the construction expenses are approximately 150,000 USD |
| Measurement/evaluation | Construction of laboratory<br>Number of QA certificate issued |
| Possible complications/ challenges | The process of preparing standards and specifications will require some compromises between the stakeholders, which should be carefully tackled<br>Importing the lab equipment may conflict with the economic sanctions imposed on Sudan.<br>The current importers of the low quality CFL may set obstacles against quality control effort |
| Assumptions | The project implementation is expected to increase the confidence among consumers in using CFL |
| Responsibilities | Electricity-Regulatory Authority (ERA):Executing body<br>Sudanese Standards and Metrology Organization (SSMO): Setting standards and specifications<br>Importers Chambers: contribute to setting of standards, market regulation<br>Custom authority_ Control for import<br>Society of consumer protection (NGO): Awareness raising |

# Chapter 2:
# Project Ideas for the Energy sector; Transport Subsector

## 2.1 Brief summary of the Project Idea for Transport subsector:

Mass transport vehicles (buses 60+) are vehicles that are able to transport a larger numbers of passengers per trip. Replacing light duty vehicles (7-25 passengers), standard efficiency, with heavy vehicle fleets (buses 60+), higher efficiency, is suggested as an option to reduce GHG emissions in the transportation sector. This replacement leads to the reduction of vehicles moving on roads, thus reducing congestion and pollution. The suggested project is targeting the owners of small public transport vehicles. The project aims to support them in shifting to buses by organizing and creating an attractive package to purchase and run a bus. The project is seen as a win-win approach. The small vehicles owners will keep their business, less fuel will be used so saved fuel could be used by the state for other issues, citizen will benefit from better mobility and the micro climate will be less polluted on international level, less GHG will be emitted to the atmosphere

## 2.2 Specific Project Idea:

The project titled 'Establishment of a cooperative for bus owners in Khartoum' is suggested as one way to encourage adoption of bus systems in Sudan. The project aims to encourage small vehicle drivers to come together in a cooperative that will represent them in front of the authorities. Simultaneously a scrapping program should be encouraged, the scrapped vehicles could be used as stationary shops or offices or used on special conditions e.g. tourism. The suggested project activities comprise of two components, firstly, easing and supporting the bus import process. Secondly, it entails establishing mechanical workshop to carry out the required proper maintenance of busses. The project incorporate different activities such as establishing legal and regulatory frame work for the cooperative, cooperation with state government and traffic police to arrange for optimum routes and conducting awareness and promotion campaign to encourage bus riding

## 2.3 Project overview

| Name of Project Idea | Establishment of a cooperative for bus owners in Khartoum |
|---|---|
| Introduction | The capital city Khartoum is suffering from chronic problems in transporting passengers. One of the main issues linked to this problem is the prevalence of small vehicles for public transport. The large numbers of small vehicles are creating different problems such as limiting the mobility of the citizens, pollution and GHG emissions. |
| Objectives | Establishing cooperative for bus owners that can act as representative body<br>Formulating a framework for importing buses<br>Establishing mechanical workshops that can carry proper maintenance for buses |
| Outputs | Reduced congestion and thus contribute to better mobility in streets<br>Improved air quality levels and reduce GHG emissions<br>Support public transport system |
| Relationship to the country's sustainable development priorities | The replacement of small vehicles with large buses is aligned with the government initiatives to provide adequate transportation services. Simultaneously it contribute to improving air quality in cities and reduce pollution |
| Project Deliverables | Cooperative formation<br>Replacement programmes of small vehicles with large buses is formulated<br>Import 400 buses per year<br>Establish maintenance and repair workshop. |
| Project Scope | Provide technical support in cooperative formation and other issues<br>Provide financial support to start the cooperative work (import and workshop) |
| Project activities | Establish the legal and regulatory frame work for the cooperative<br>Cooperate with state government and traffic police to arrange for optimum routes<br>Conduct awareness and promotion campaign to encourage bus riding |
| Timeline | Establishing cooperative (six months)<br>Import of buses (six months).<br>One year is needed to establish the mechanical workshop |
| Budget | Cooperative formation 20,000 $<br>Monetary cushion for bus import :500,000$ (value for about 4 buses (10 % of quantity (bus value at about 120, 000 $ including import taxes and customs)<br>Mechanical workshop (including civil work and land ) 300,000 $ -400,000$<br>Promotion program: 50,000 $ |
| Measurement/evaluation | Number of cooperative members<br>Number of buses imported<br>Degree of pollution and GHG reduction |

| | |
|---|---|
| Possible complications/ challenges : | Proper cooperative and workshop management system<br>High local taxes on buses income<br>Insufficient hard currency to import buses<br>Failed promotion programmes |
| Assumptions | Cooperative suggestion is positively accepted and Governmental authorities will support the project |
| Responsibilities | Khartoum State government: general support and facilities allocation<br>Small vehicles owners: cooperative formation<br>Custom authorities: import regulation<br>Bank and donors: finance |

# Chapter 3:
# Project Ideas for the Agriculture Forestry and Other Land Use Sector/Forestry subsector

## 3.1 Brief Summary of the Project Idea for Forestry

Forest harvest for energy supply was mentioned in the technology and the barrier reports, 1st and 2nd parts of the TNA Reports , as one factor leading to loss of forest, thus increasing net GHG emissions in Sudan. Improving the efficiency of fuel wood consuming appliances is thus an important element to combat deforestation and increase the sink. Improved stoves was identified as technology with high potential to fuel wood consumption, ultimately increasing the sink, an amount of 1-3 tonne of CO2 is expected be saved/year/stove. Although the introduction of IS started in the eighties, a large-scale adoption of IS has not yet taken place. Extensive and well-organized efforts are needed to address this issue, therefore the project aims to target the different problems mentioned in the barrier report by using a holistic approach. That can tackle the multi face of the IS issue, energy provision, deforestation reduction, indoor health and safety, gender...etc. Extra the holistic approach will respond to the lesson learned from past projects that had concentrate on one activity e.g. awareness or production.

## 3.2 Specific Project Idea

This project titled 'Enhancing the diffusion of improved stoves through establishing of centre points ' can play a vital role in the sustainable supply of cooking energy for local communities in addition to conserving forests and reducing GHG emissions. The project involves establishing centre points for the production of improved stoves. These centre points are planned to include production and training workshops and carry out awareness activities. A finance mechanism that can provide low interest loans for producers and small revolving fund for that allow poor households to purchase the stoves will be established. In addition, the project involves strengthening different institutions interrelationship through formation of a coordination committee which is responsible for development and management of the diffusion plans. The coordination committee is suggested to include all the relevant institutions such as FNC, Environment and energy government bodies, research, NGO/CBOs etc. Moreover, the project contributes in developing marketing and outreach

resources for other green technologies to the targeted areas. It is suggested that each centre point will serve about 100,000 households. The project is planned to take place for about 3-5 years, as pilot project mode. After the project period the centre points are expected to continue working without external support

## 3.3 Project over view

| Project Name | Construction of a factory for production of prefabricated biogas units accompanied with support program |
|---|---|
| Introduction | Over-reliance of biomass-based fuels and inefficient technologies such as traditional stoves has placed great pressure on local forests. According to FNC the annual clearance of forest areas in Sudan has led to a tangible deficit between the annual consumption of forest products and the growth rate of tree species. Improving the efficiency of fuel wood consuming appliances such as IS, is therefore crucial to combat deforestation and tackle greenhouse gas emissions in Sudan. As a large-scale adoption of IS has not yet taken place, the project aims to increase the diffusion rate of IS by establishing local IS centre points that host the different activities and services that are needed for IS adoption. |
| Objectives | Building capacities in different aspects of IS (fabricating, using, financing etc.)<br>Improving the availability and affordability of IS<br>Developing local marketing and outreach resources<br>Sustainable supply of cooking energy for local communities in addition<br>Reducing greenhouse gas emissions |
| Outputs | Increased efficiency of wood and charcoal stoves<br>Decreased deforestation in the area<br>Reduction of poverty |
| Relationship to the country's sustainable development priorities | The project is in line with preserving forests<br>More efficient use of energy technologies<br>Poverty eradication<br>Reduction of fuel costs |
| Project Deliverables | Establishment of 6 centre points<br>Awareness and capacities among local partners (communities, institutions artisans) raised and developed<br>Distribution channels are settled<br>Strengthened coordination mechanism between/among relevant stakeholders and institutions<br>Developed financial mechanisms and provision of loans to producers<br>Reduction of 1-3 ton of CO/stove/year |

| | |
|---|---|
| Project Scope | Project limits itself to the Central, Eastern and North Darfur regions at household and small institutional level. Expected project duration is about 3- 5 years) |
| Project activities | Establish coordination committees in the study areas<br>Establish finance mechanisms<br>Identify and form centre points |
| Timeline | The estimated timeline for supporting the project at the beginning is 3-5 years |
| Budget | Main budget lines are:<br>Costs for formation and continuation of coordination committees 120 ,000 $/year<br>Costs for finance mechanisms 30,000$<br>Costs for establishing Centre points 100,000$ |
| Measurement/evaluation | No. of production centre points (6 points)<br>Continuation of the coordination committees formed<br>No. of improved stoves distributed<br>Amount of fuel wood consumption regarding the actual use of improved stoves |
| Possible complications/ challenges | Integrating private utilities to carry out the fabrication and selling activities<br>Contradictions between local partners responsibilities<br>Local ownership |
| Assumptions | Active participation from government agencies<br>IS socially acceptable |
| Responsibilities | FNC: Executing body<br>Financing Sources, private sector: finance mechanism<br>local committees, NGOs, CBOs: beneficiaries<br>Energy Research Centre for scientific backup |

# Chapter 4
# Project Ideas for Agriculture, Forestry and Other Land Use sector/Livestock subsector

## 4.1 Brief Summary of the Project Idea

This project idea is suggested to support the deployment of biogas technologies to reduce GHG emissions from dung fermentation. The project entitled 'Construction of a factory for production of prefabricated biogas unit accompanied with support program' aims to ease the erection process of the biogas units. Moreover, the project will support rural communities to purchase such technologies by initiating appropriate finance mechanism and suitable technical packages to ensure efficient operation of the erected units.

## 4.2 Specific Project Idea

This project is suggested to be implemented by the National Energy Research Centre with the collaboration of the Ministry of Animal Wealth and Ministry of Social Affairs. The construction of the factory is based on importing raw material and extruding it to the agreed size. A project component is responsible for importing the suitable biogas appliances such as cookers and lamps. The project also collaborates with the private sector and civil societies, including localities, to carry out jobs such as unit construction and operation as well as conducting awareness raising activities. As the unit costs are relatively high, a financial mechanism is recommended e.g. revolving fund or instalment system. Additionally, a technical package that allows accurate sizing and providing proper operation instruction is to be produced. Construction of such factory is seen to reflect on the welfare of rural communities by increasing the level of services provided. The project is seen as a first step in the introduction of holistic concepts in waste management and also enhance the idea of consider non-traditional product in animal husbandry.

## 4.3 Project overview

| Project Name | Construction of a factory for production of prefabricated biogas units accompanied with support program |
|---|---|
| Introduction | The majority of the industrial boilers in Sudan are characterized by low thermal efficiency and utilization of so called dirty fuels. This situation necessitates replacement of these old boilers with new efficient boilers that have better thermal efficiency, thus reducing fuel and GHG emissions. Different barriers hinder the diffusion of this technology as discussed in the barrier report, such as convincing factory owners and other stakeholder to support the deployment activities of this technology. |
| Objectives | Contribute to better performance of biogas units by reducing the possibility of technical mistakes<br>Ease the erection process of biogas system to a normal labour level<br>Lower the costs of biogas units<br>Increase the availability of biogas units in the community |
| Outputs | Support adoption of biogas technology<br>Contribute to rural development<br>Technical package, promotion booklets and manual training |
| Relationship to development priority | Biogas system contributes to<br>Waste management, thus- reducing health hazards<br>Provision of services through cooking fuel, lighting and electricity<br>Soil improvement by using bio fertilizers<br>Livestock economy by selling of biogas |
| Project deliverables | Specific number of biogas units<br>Sound technical package for sizing and operation<br>Awareness program plot<br>Manual training<br>Promotion booklet<br>Financial mechanism |
| Scope | Two production lines of 30 and 10 m3 biogas units<br>ability to produce 5000 units per year each |
| Activities | Construction of factory<br>Production of sizing and operation manuals<br>Production of Training and awareness manuals<br>Establishment of finance mechanism |
| Time line | 6 month for preparing tender document<br>one year for construction<br>6 month for commissioning |

| | |
|---|---|
| Budget | Accurate budget was not possible, however the main budget lines include:<br>Land cost and Factory construction 200,000$<br>Production lines (no cost is available )<br>Support package including lab equipment 100,000 $<br>Monetary cushion to start finance mechanism 15 % of expected value of 3000 $ and 5000 unit /year (100, 000 $ |
| Evaluation | No. of biogas units produced<br>No. of biogas systems erected |
| Challenges | Proper management and administration<br>Import of raw material<br>Hard currency fluctuation |
| Assumption | Availability of dung<br>Continuation of service needed in rural areas |
| Responsibilities | Energy Research Centre: Implementing body<br>Localities / CBOs: Beneficiaries<br>Family bank: Finance mechanism<br>Private sector: Erection and promotion<br>Ministry of Animal Wealth: Stakeholder<br>Ministry of Social Affairs: Stakeholder<br>Ministry of Environment: Stakeholder |

# Chapter 5:
# Project Ideas for the Industry Sector

## 5.1 Brief Summary of the Project Ideas

The majority of boilers used in the food industry are old and inefficient, which results in higher fuel consumption and causes air pollution and GHG emissions. This project idea is suggested to support the deployment of the High Efficient Boilers in food factories in Khartoum State. It is expected to realize significant reduction in energy loss and support clean fuel utilization, thus reducing GHG emissions. The project entitled 'Promotion of High Efficient Boilers (90% efficiency) using dual fuel (Diesel/LPG) in food factories in Khartoum State' aims to support the factory owners replacing their old boilers with high emission by new boilers that reduce emissions.

## 5.2 Specific Project Ideas

The establishment of the project aims to support factory owners to invest in erecting new efficient boilers. As a pilot project type the project seeks to create an encouraging environment to overcome the set of barriers discussed in the barrier report. The project is composed of three elements:(i) facilitating financial mechanisms and technical support for factory owners to purchase efficient boilers, (ii) raising awareness in the industrial sector for technology utilization, (iii) improving the technical setup in installation and use of efficient boilers. The project is proposed to target the medium and small-scale food industries by erecting 50 efficient boilers with dual fuel in 5 years at a rate of 10 boilers per year. This replacement lead to reductions of the production cost by 30 per cent due to fuel saving.

## 5.3 Project overview

| Name of Project Idea | Promotion of High Efficient boilers with dual system 90% efficiency: Diesel/LPG |
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| Introduction | The majority of the industrial boilers in Sudan are characterized by low thermal efficiency and utilization of so called dirty fuels. This situation necessitates replacement of these old boilers with new efficient boilers that have better thermal efficiency, thus reducing fuel and GHG emissions. Different barriers hinder the diffusion of this technology as discussed in the barrier report, such as convincing factory owners and other stakeholder to support the deployment activities of this technology. |
| Objectives | Raise awareness within the industrial sector and decision makers<br>Encourage the factories owners for purchasing efficient boilers through establishing appropriate financial mechanism<br>Improve the capacity of workers in dealing with EB working conditions<br>Provide technical support on EB retrofitting, installation and monitoring. |
| Outputs | Reduction of GHG<br>Contribute to reduce air pollution<br>Contribute to reduce fuel cost at industry |
| Relationship to the country's sustainable development priorities | The project goes in line with plans set to reduce costs of production by reducing fuel quantity and hence fuel price. This will increase profitability of produced commodities. |
| Project Deliverables | Make 50 factories aware of the benefits of using efficient boilers<br>At least 30 factories get benefits from financial facilities<br>Support all interested factories to purchase efficient boilers by providing technical support.<br>Train 80 per cent of workers in dealing with EB working conditions |
| Project Scope | The target is to replace 10 low efficient boilers in 10 factories by high efficient ones every year for a total of five years for medium and small food industries in Khartoum State. |
| Project activities | Project activities could be briefed as follows:<br>Studying the current situation of 50 old boilers in 50 factories<br>Design awareness programs for using EBs<br>Establish investment portfolio to finance the importation of EB<br>Conducting training programs for labours and operators<br>Providing technical support for factories owners. |
| Timeline | The estimated timeline for the project is 5 years |
| Budget | Importation of EBs (1million USD)<br>Awareness raising, training and technical support:$300,000<br>Management costs: 200,000 USD<br>Total budget 1.5 million USD |
| Measurement/evaluation | Drop in fuel bill<br>Reduction present in air pollution<br>GHG reduction |

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| Possible complications/ challenges | Smooth coordination between the project stakeholders, Ministry of Industry and Ministry of Energy, banks and Sudanese Industrial Association chamber<br>The coordination between these different institutions and distributions of roles in establishing financial mechanism will need well organizational system.<br>Challenging Advocacy work is needed towards fuel distribution policy.<br>Support programs like awareness, capacity building and providing technical support requires relatively high level managerial skill |
| Assumptions | The first two factories are expected to achieve the desired results and then function as a demonstration unit |
| Responsibilities | The project will be developed and managed by the Sudanese Industrial Association Chamber with coordination with Ministry of Industry and Ministry of Energy and financial support of the Industrial Development Bank. |

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# Annex 1:
# list of stakeholders

| Name | Affiliation |
|---|---|
| Abd Elhafith Fadallah Babiker | Electricity Regulatory Authority |
| Ibrahim Amin Ahamed | Electricity Regulatory Authority |
| Mustafa Mohamed Salih Agha | Electricity Regulatory Authority |
| Nazik Hassan Ali Alawad | Ministry of Water Resources and Electricity |
| Mohamed Salih Farah, | General Directorate of Energy Affairs, Ministry of Petroleum |
| Abdelazim Widaa, | General Directorate of Energy Affairs, Ministry of Petroleum |
| Hanadi Awadalla | Forests National Corporation |
| Sawsan Abdalla | Forests National Corporation |
| Salah Yousif | Forests National Corporation |
| Nagla Mahagub | Forests National Corporation |
| Elyamen Fadalla | Freelance consultant |
| Elwalid Abbas | National Energy Research Centre |
| Muna khidir | National Energy Research Centre |
| Yagoub Eldum Hamid | National Energy Research Centre |
| Elfadil Barima | National Energy Research Centre |
| Abuobida Bukary | Sudanese Chambers of Industries Association |
| Alfaith Gorhsi | Sudanese Chambers of Industries Association |
| Yassir Abd karim | Sudanese Chambers of Industries Association |
| Osman Taha Alzaki | Technology research Institute |
| Handi Atta Elfadiel | Industrial Research and Consultancy Centre |
| Amira Alnour | Industrial Research and Consultancy Centre |
| Naima Abd Algader | Industrial Research Centre |
| IKhlas Abd Alaziz | Industrial research Centre |
| Abdrahman Altahir | Kenana Sugar Company |
| Amir Hassan Alam | Salam Cement Company |
| Farouk Ismail Abd Elgalil | Ministry of Industry |
| Abdrahman Alamin | EWASCO Company |
| Nouralla Yassin | National Energy Research Centre |
| Daoud Abbass | Food Industry Chamber |
| alam saigron | Food Industry Chamber |
| Mohammed Algak Silman | Industrial Research and Consultancy Centre |
| Siefdin Abdalmagid | Ministry of Labour |