The Republic of Sudan

Technology Action Plan for Mitigation

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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.

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 Environmental 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 Sudan 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. Hence, Sudan is considered as one of the many vulnerable developing countries around the world due to its fragile ecosystem and its livelihood which is directly affected by the impact of climate change. 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 different views, background and experiences in climate change. Identified sectors and sub sectors for the TNA would build upon preceding studies conducted earlier such as the National Adaptation Program of Actions and National Communications.

Sudan has set many goals in its Millennium Development Goals (MDGs). Amongst the most important goals identified are eradication of extreme poverty and hunger, combating HIV/AIDS, Malaria and other diseases and ensure environmental sustainability. Conducting TNA will give Sudan a great opportunity in achieving those goals. Technologies identified through the TNA will assist remarkably in overcoming many challenges that face the country in the context of poverty, hunger, human health and environment in general.

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 improvement of the environment and alleviation of poverty. The government exerts great emphasis on the improvement and development of international relations with environmental development partners, and augmenting mechanisms for benefiting from the latest research, expertise and technologies to enable the country for achieving 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 overcome these barriers.

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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 (diesel- furnace/LPG)
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 Electricity and Water Resources
MWH	Mega Watt per Hour
NEC	National Electrical Corporation
NERC	National Energy Research Center
NG	Natural Gas
NGO	Non-Governmental 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. Five technologies have been identified in three mitigation sectors, namely Compact Fluorescent Lamps (CFL) 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_2eq 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 had 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 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 80%. 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 decrease 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. MERW 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 beniits 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 stake holders' consultations, the TNA team suggests the diffusion of 6,000,000 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_2eq 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 for 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:
    - 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.
    - 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.
    - 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.
    - 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.
    - 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 Center 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.

Table 1.1: 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	MERW, SSMO, customs authority	2	50,000	1. Laboratory established 2. 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	3. Percentage of reduced customs and tax 4. Numbers of imported CFL
Country wide awareness campaigns	To Promote public awareness about the benefits of CFL	1. Mass media (TV and Radio programs) 2. Publications 3. Workshops	Energy institutions/ Local media	Continuous	500,000	5. Number of performed campaigns 6. Number of publications prepared 7. 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 ,governmental bank and customs administration	2	150,000	8. Number of CFL imported and distributed 9.
Put in place effective energy policy and powerful institutional arrangement	To ensure utilization of high quality efficient commodities	***1.*** To ascertain specific quality Standards. ***2.*** To enact effective regulatory frame work	Energy Institutions, Sudanese Corporation for standardization and metrological measures	1		10. Testing Institutions established 11. standards, code and specifications for CFL approved 12. 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 put 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 reducing 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 standardization 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 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 (Three Hundreds thousands and Fifty US Dollars) 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 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 finance 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 (1.2) below

Table 1.2: 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	1. number of mini buses 2. 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	3. 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	4. 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	5. 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	6. Improved passenger satisfaction
Awareness programs	• To raise awareness of bus riding benefits • To tackle cultural barriers	Mass media, publications, workshops	Ministry of information, traffic authorities, Ministry of Environment, NGOs	Continuous activity	100,000	7. 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	8. Number of contradictin g 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 X175,000USD (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) mitigation 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 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 the CO_2 emitted. It is the second contributor for the aggregated GHG emissions in

CO_2 equivalent in 1995 (24%). 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 Improved Stove (IS) is mud stove type with an efficiency of about 35% to replace a 10%-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 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%. 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. Based on the severe consequences of forest harvest to satisfy the energy demand without driving desertification or disturbance of natural balances, the stakeholders agreed that the main deployment objectives should be based around the following:

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 Center (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 that cover all type of energy consumption results in absence of as general including improved stoves technology. 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 1,650,000.00 USD at 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 Institute and universities is 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.

Table2.2: Summary of action plan 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	1. Number and types of campaign designed 2. Number of materials prepared 3. Number of campaigns performed 4. 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	5. Number of people financed 6. Size of annual finance received 7. % 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	8. Number and types of training needs assessment performed 9. Number of training packages prepared 10. Number of training sessions held 11. 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	12. Number of businesses initiated 13. Number of manufactured units per year 14. 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	15. Institutions establishment 16. Conducive financial and import policy put in place 17. 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 1,650,000.00 USD
One million Six Hundred and Fifty Thousands US Dollars 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 mix 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 350m^3 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 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/m^3 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 are given to other issue. This could be referred to inadequate awareness among decision makers about green technology importance ad 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 production, 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 Institute 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 2.3: 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 disseminatio n of biogas	support producers village committees	Governmenta l Banks ,	20	1000,000	1. Number of people financed 2. Size of annual finance received 3. % 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/vocat ional training centres	5	50,000	4. Number of curriculums designed and applied 5. Number of Instructors trained Locally/Abroad 6. Number of students graduated
Country wide awareness campaigns	Raise the awareness of the population about the economical & environment al benefits of biogas	Workshops seminars brochures,	Energy institutions	10	100,000	7. Number and types of campaign designed 8. Number of materials prepared 9. Number of campaigns performed 10. Geographical coverage of campaigns
Capacity building and training programs	Training of trainees (engineer technicians)	Training programs	Energy institution/pri vate training centres/ local media	5	100,000	11. Number and types of training needs assessment performed 12. Number of training packages prepared 13. Number of training sessions held 14. 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	15. Number of businesses initiated 16. Number of built biogas plants per year 17. 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	18. Institutions establishment 19. Approved biogas standards and specifications 20. 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
(One ten million, seven hundred and sixty five thousands US Dollars) 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 in the end of 2010.The contribution of large-scale enterprises is around 82 percent and small scale companies account for 18 per cent. 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 55 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_2e, representing about 0.1 percent of total CO_2eemissions. Cement production activities account for the overwhelming majority of CO_2eq 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_2eq 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 ton/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

3.3.3 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 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

3.3.4 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 ton/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 (EB) 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/LNG and develop the regulation and standards as well as the needed infrastructure for the LNG importation.
2. Ministry of industry in association with the -Industrial Chamber Association is to formulate standards of Efficient boilers (EB) 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 NGO's, 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 3.1: 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	1. Number of people financed 2. Size of annual finance received 3. % 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	4. Number of curriculums designed and applied 5. Number of Instructors trained Locally/Abroad 6. 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	7. Number and types of campaign designed 8. Number of materials prepared 9. Number of campaigns performed 10. 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	11. Number and types of training needs assessment performed 12. Number of training packages prepared 13. Number of training sessions held 14. 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	15. Number of businesses initiated 16. Number of built biogas plants per year 17. 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	18. Institutions establishment 19. Approved biogas standards and specifications 20. 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
One ten million, seven hundred and sixty five thousands US Dollars

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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