Improved Cook Stoves and Green House Gas Reduction in Uganda

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Abstract- Globally, around 2.6 billion people still rely on traditional biomass fuels for their cooking. This biomass burning produces green house gases and black carbon, which contributes to climate change. Uganda's low level of income as shown by a low per capita income (approx. US$300) and its heavy dependence on rain-fed agriculture make it very vulnerable to climate change. Uganda like other countries in the least developed Countries (LDC) group, through its energy policies emphasizes the importance of access to sustainable energy and affordable energy efficient technologies in order to adapt to climate change. Although climate change and it effects have taken root in most part of the country, there is limited knowledge about climate change and its impact. Mitigation and adaptive measures taken by Uganda include but are not limited to creating a mix of renewable and low carbon technologies, implementation of reduce emission from deforestation and desertification (REDD) strategy and widespread implementation of energy efficient measures such as the dissemination of improved cook stoves to households.

Index Terms- Improved cook stove (ICS), Water Boiling Test (WBT), climate change, Clean Development Mechanism (CDM) Emission Reduction (ER)

I. INTRODUCTION

Energy is arguably one of the major challenges the world faces today, touching all aspects of our lives. For those living in extreme poverty, a lack of access to modern energy services dramatically affects health and limits opportunities. The vulnerability of the poor is only worsened with recent challenges from climate change, a global financial crisis, and volatile energy prices [1]. Energy is vital to economic growth in Uganda. The majority of Ugandans are not aware of the resulting environmental problems or of the need to use modern, affordable and energy-efficient technologies [2]. Climate change is one of the most critical issues of our time. Global warming, the gradual increase in the average temperature on the earth, affects every sector of development [3]. Its predicted effects including adverse ecosystem impacts, rising sea levels, increased frequency of storms, floods, and droughts, and adverse impacts on human health and agricultural production are expected to cause potentially major environmental and economic dislocations across the globe. Many of these impacts are likely to impinge most severely on the world's poorest countries, which are least able to cope and adapt [4].

Climate change is a global issue that has brought about noticeable weather change in the past decades in Uganda. Human induced climate change is likely to increase average temperatures in Uganda by up to 1.5 ºC in the next 20 years and by up to 4.3 ºC by the 2080s [5]. Ice caps on mount Rwenzori are retreating. A recent study carried out by researchers suggests that all glaciers on Rwenzori Mountains will disappear in the next two decades. The severe drought in year 2005 contributed to the reduction of Nile river level with serious impacts on power generation leading to power rationing in the domestic and commercial sectors, floods cause pollution of drinking water leading to spread of waterborne diseases. The International Climate Risk Report identifies Uganda as one of the most unprepared and vulnerable countries in the world [6].

Fuel wood provides more than 90% of Uganda's energy needs [7]. An estimated forest surface of 115 football fields is used for cooking every day either in form of firewood or charcoal [8]. Population increase has brought about deforestation because of increase in demand for food and fuel. Increased electricity tariff lead to increased demand for firewood and charcoal leading to increased soil erosion, damage to vital water shed and flooding. By virtue of being a party to the United Nations Framework Convention on Climate Change (UNFCCC), the government of Uganda recognizes and supports the need to address climate change. Under CDM, projects that reduce greenhouse gas emissions and contribute to sustainable development can generate Certified Emission Reductions (CERs), a tradable commodity in international carbon markets. Climate change mitigation through the Clean Development Mechanism and Voluntary Carbon Markets has had a limited impact in Uganda, although it is thought that there is potential for Uganda to benefit from these in the future.

1.1 Country Background

Once known as the "pearl of Africa", Uganda lies in the heart of sub Saharan Africa. It is located in east Africa and lies across the equator about, 800 kilometres inland from the Indian Ocean. The country is land locked bothered by Kenya in the East, Sudan in the North, Democratic Republic of Congo in the West and Tanzania in the South. It has an area of 241,038sqkm [9]. In most parts of the country, mean annual temperatures range between 16^{o}C and 30^{o}C. Most of the country receives between 750 mm and 2100 mm of rainfall annually [9]. It has varying vegetation with semi arid vegetation in the North. The economy of Uganda is primarily based on the agricultural sector with over 70% of the working population being employed by the sector. Agricultural export accounts for over 45% of total export earnings with coffee, tobacco and fish being the main export.

II. Energy Use Pattern

Uganda has a population of about 30.7 million people who mostly depend on biomass energy for cooking with 85% of its population living in the rural area. It has 6.2 million households with an average household size of 5 [10]. The household sector represents over 85% of the national energy consumption [11]. 70% and 15% of urban households use charcoal and firewood respectively while in the rural areas, 86% use firewood and 10% use charcoal [12]. Over 80% of households use firewood as the main source of fuel for cooking and about 15% use charcoal. The implication is that more than 95% of households in Uganda depend on fuel from wood for their cooking [13]. Emissions from burning solid fuels in open and traditional stoves have significant global warming effects, due to incomplete combustion of fuel carbon. Interventions that improve combustion efficiency and reduce emissions can also mitigate climate change. The Ministry of Energy initially set (ICS) adoption targets of 2.45 million households, but technology limitations and a lack of resources prevented the government from achieving this target but the bulk of the population (91%) is still using traditional biomass [14]. The German cooperation in Uganda has distributed 220,000 ICS to households with the objective of improving access to modern energy [15].

III. Methodology

This report is based mainly on current, publicly accessible documents, as well as energy access data made available by Uganda Bureau of statistics (UBOS), Aprovecho Research Centre and United Nations Framework Convention for Climate Change (UNFCCC). WBT protocol version 4.2.2 [16] was used to determine the efficiency of the ICS. Data from baseline study on energy use carried out by the centre for integrated research and community development unit (CIRCODU) were used in the analysis.

IV. Result of Analysis

Emission reduction that can be achieved by using an improved cook stove (e.g Okelo Kuc Stove). The ER can be calculated from equation (1) [17]

$$ER_Y = B_{Y,savings} \times f_{RNB,y} \times NCV_{Biomass} \times EF_{projectedfossilfuel} \quad (1)$$

Where:

ER_y Is emission reduction during the year in tonnes of carbon dioxide equivalent (tCO_2e)

$B_{y,savings}$ Is the quantity of woody biomass saved in tonnes

$f_{RNB,y}$ Is the fraction of woody biomass saved during the year that can be established as non-renewable biomass

$NCV_{Biomass}$ Is the net calorific value of the non-renewable biomass

$EF_{projectedfossilfuel}$ Is the emission factor for the substitution of non-renewable biomass

The quantity of woody biomass saved can be taken as the difference between the quantity of wood consumed while using the three stone fire and the quantity of wood used while employing the improved cook stove.

$$B_{y,savings} = B_{old} - B_{y,new} \quad (2)$$

Biomass saved can also be calculated from

$$B_{y,savings} = B_{old} \times \left(1 - \frac{\eta_{old}}{\eta_{new}}\right) \quad (3)$$

Where

B_{old} Is the biomass consumed while using the three stone fire (Baseline situation)

$B_{y,new}$ Is the biomass consumed with the use of ICS

η_{old} Is the efficiency of the three stone fire

η_{new} Is the efficiency of the improved cook stove

For the ICS (Okelo Kuc Stove), the efficiency was found to be 0.35 (WBT protocol) and 0.1 is the efficiency of the three stone fire (UNFCCC default values). (Spreadsheet for WBT is available on request). There are 6.2 million households in Uganda (95% rely on biomass) with the households using either an open fire or a segiri (local charcoal stove). For the three stone fire, annual fire wood consumption is 3.285 tonnes/stove and 0.87 tonnes/stove for charcoal consumption [18]

The baseline biomass consumption is

B_{old} = 3.2 x 5.9 x10^6

= 18.9 million tonnes of biomass

Biomass saved from the use of ICS is

$B_{y,savings}$ = 3.2 x 5.9 x10^6 (1- $\frac{0.1}{0.35}$)

= 13.5 million tonnes of biomass

Emission reduction that can be achieved is calculated from:

$ER_Y = B_{Y,savings} \times f_{RNB,y} \times NCV_{Biomass} \times EF_{projectedfossilfuel}$

$f_{RNB,y}$ = 0.82 [19]

$NCV_{Biomass}$ = 0.015TJ/tonne (15MJ/kg) [19]

$EF_{proctedfosilfuel} = 81.6 tCO_2TJ$ [19]

ER_y = 3.2 x 5.9 x10^6 (1- $\frac{0.1}{0.35}$) x 0.82 x 0.015 x 81.6

= 13.54 x 10^6 tCO_2e

This achievable ER of about 13.5 million tonnes of carbon dioxide equivalent is estimated as being equal to offsetting the

emissions of approximately 2.85 million passenger cars in the United States.

V. Conclusion

Climate change is an emerging issue of enormous magnitude that needs to be adequately addressed as it affects the economy of Uganda. There is an opportunity for Uganda to build on the strength of its government actions through the climate change unit to drive up the adoption of high quality ICS. This is possible through comprehensive market research into consumer attitude towards ICS, build demand through cross sector awareness and campaign and supporting businesses in testing, developing and producing at scale to drive up the quality of ICS in the market. These possible ERs can be traded in the carbon markets (provided approved methodologies, monitoring and verification procedures have been adopted) thereby achieving sustainable development through carbon finance whilst mitigating climate change.

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