UGANDA

TECHNOLOGY NEEDS ASSESSMENT REPORT

BARRIER ANALYSIS AND ENABLING FRAMEWORK FOR CLIMATE CHANGE TECHNOLOGIES – MITIGATION

NOVEMBER 2020

BARRIER ANALYSIS AND ENABLING FRAMEWORK REPORT

Abbreviations and acronyms

AC	Alternating Current
ACTADE	African Centre for Trade and Development
BA&EF	Barrier Analysis and Enabling Framework
BoU	Bank of Uganda
B2B	Business to Business
B2C	Business to Customer
CAN	Climate Action Network
CGAP	Consultative Group to Assist the Poor
CH_4	Methane
CMA	Customs Management Act
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
DCB	Deep Cycle Batteries
DC	Direct Current
EABW	East African Business Week
EAC	East African Community
FIBR	Financial Inclusion on Business Runways
GEF	Global Environment Facility
GHG	Greenhouse gas
GoU	Government of Uganda
HPPs	Hydro Power Plants
IICS	Improved Institutional Cook Stoves
IPCC	Intergovernmental Panel on Climate Change
$ktCO_2e/a$	Kilotons of carbon dioxide equivalent per annum
kWp	Kilowatt-peak
L-IFT	Low-Income Financial Transformation

LPG	Liquefied Petroleum Gas
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MEMD	Ministry of Energy and Mineral Development
MFIs	Microfinance Institutions
MGLSD	Ministry of Gender, Labour and Social Development
MoES	Ministry of Education and Sports
MoFPED	Ministry of Finance, Planning and Economic Development
MoSTI	Ministry of Science, Technology and Innovation
$MtCO_2e$	Metric tons of carbon dioxide equivalent
MW	Megawatt
MoWE	Ministry of Water and Environment
NAMAs	Nationally Appropriate Mitigation Actions
NDC	Nationally Determined Contribution
NDP	National Development Plan
NPA	National Planning Authority
O&M	Operation and Maintenance
PAYGo	Pay As You Go
PV	Photovoltaic
RE	Renewable Energy
REA	Rural Electrification Agency
RETs	Renewable Energy Technologies
R & D	Research and Development
SACCOs	Savings and Credit Cooperative Organization
SMEs	Small and Medium Enterprises
TAP	Technology Action Plans
tCO2eq	Tonnes of Carbon dioxide equivalent
TNA	Technology Needs Assessment
TW	Terawatt

UBOS	Uganda National Bureau of Statistics
UGGDS	Uganda Green Growth Development Strategy
UNBS	Uganda National Bureau of Standards
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNREEEA	Uganda National Renewable Energy and Energy Efficiency Alliance
UOMA	Uganda Off-grid Energy Market Accelerator
URA	Uganda Revenue Authority
USD	United States Dollars
USEA	Uganda Solar Energy Association

Table of Contents

List of Tables

Report II

Barrier Analysis &Enabling Framework Report

Executive Summary

Biomass contributes 88% of the total primary energy consumed in Uganda through firewood, charcoal and crop residues; electricity contributes approximately 2%; while fossil fuels (oil products) account for 10% of the national energy mix (MEMD, 2019). The Technology Needs Assessment (TNA) project is being conducted in Uganda in order to identify and prioritize technologies that need to be implemented to achieve climate and development benefits. The project comprises three (3) phases; (i) to identify and analyse through a country-driven process, climate change mitigation and adaptation technology priorities for Uganda; (ii) to identify, analyse and address the barriers hindering the deployment and diffusion of the prioritized technologies including enabling the framework for the said technologies and (iii) to prepare Technology Action Plans (TAP) to support implementation of the prioritized technologies within the country to achieve the climate and development benefits. During phase one of the TNA, three (3) technologies were prioritized, namely:

i) Solar rooftop systems,
ii) Efficient institutional cook stoves and
iii) Bio-latrines for institutions (using biogas technology).

Technologies are categorized according to the types of goods and services they belong to or contribute to because the different types of goods and services have distinct market characteristics. In this report we have considered four generic categories; *Market goods* (i) consumer goods; (ii) capital goods and *Non-market goods*: (iii) publicly provided goods; (iv) other non-market goods. All the three prioritized technologies are categorized as consumer goods which fall under a major categorization of market goods. Technologies in the 'consumer goods' category are diffused in a mass market with large supply chains and a high number of customers, including households, businesses and institutions. These Goods and products are specifically purchased by (private) consumers. The market characteristics of these technologies include;

- a high number of potential consumers
- interaction with existing markets and requiring distribution, maintenance and installer networks in the supply chain
- large and complicated supply chains with many actors, including producers, assemblers, importers, wholesalers, retailers and end consumers
- barriers may exist in all steps in the supply chain
- demand depends on consumer awareness and preferences and on commercial marketing and promotional efforts

Phase two (2) of the TNA is to analyse the barriers that hinder the deployment and diffusion of the prioritized technologies and propose an enabling framework that would ease the transfer and diffusion of the technologies. The current level of rural electrification in Uganda is significantly low; only 8% of rural residences have grid connectivity, 3% have solar home systems, 28% rely on solar lighting systems or solar lanterns and less than 1% are electrified through mini-grids (UBOS, 2018). This low level of electrification is caused by a number of barriers; some are economic and financial while others are non-financial. The Barrier identification process started with the second capacity building workshop that was attended by the consultants in Cape Town, South Africa from 22nd to 24th October 2019. Other methods for identification of barriers included: desk review of energy sectoral reports and other publications by the consultants, consultants held meetings with Ministry of Energy and Mineral Development (MEMD) officials, they visited some schools with bio-latrines and efficient institutional cook stoves, held telephone conversations with entrepreneurs engaged in the import, sale, installation and maintenance of solar systems and during the barrier Analysis and Enabling Framework Stakeholders workshop that was held from 16th to 17th March 2020.

Below are the barriers that hinder diffusion of the 3 prioritized technologies and proposed enabling framework. These were presented at two levels; first for the common barriers and then for those that are technology-specific. The entities and parties responsible for the enabling framework too were included;

Common barriers and proposed enabling framework

Barrier	Enabling framework	Responsible
High upfront cost of Renewable Energy Technologies (RETs)	• Subsidies on interest rates • Tax exemptions on RET components • Innovative risk mitigation mechanisms and credit enhancement instruments, to provide comfort to lenders. • Revolving funds • Develop the carbon financing market • Set up a renewable energy fund	MEMD, URA, REA, MoFPED
Difficulty in accessing finance		
Inadequate institutional frameworks	Proper institutional frameworks	MEMD/MoWE MoSTI
Limited information and public awareness about RETs	Consistent information and technology awareness creation on the RETs	MEMD, REA, Technology promoters, Media/ MoSTI
Capacity gaps in installation, operations and maintenance of RETs	• Develop a skilled workforce to install, operate and maintain RETs • Set up RE demonstration sites in communities	MEMD, REA, RE Associations, Universities & other tertiary institutions

Specific barriers and enabling framework for solar rooftop systems

Category	Barrier	Enabling framework	Responsible
Financial	Low disposable income especially among the rural population	• Provide grant funding to support agricultural activities • Promote solar energy for productive use	MoFPED, MEMD, MAAIF
	Unclear & inconsistent tax policy	Tax exemptions on all solar rooftop system components	MoFPED, MEMD, URA
	Poor infrastructure and the cost of setting up a distribution network	Develop financing schemes e.g. revolving funds	MoFPED, MEMD
	Difficulty in managing currency risk	Favourable forex exchange conversion terms	MoFPED

	Pay As You Go (PAYGo) solutions discourage customers due to lockouts	Provide grant funding to support agricultural activities especially for rural farmers	MoFPED, MEMD, MAAIF
Non-financial	Ineffectual quality control of products	Enhanced enforcement of quality standards Strengthen the capacity of the private sector for self-regulation under the relevant umbrella associations	UNBS, RE Associations, Police, Judiciary
	Service and maintenance are out of reach in rural communities	Develop financing schemes e.g. revolving funds	MoFPED, MEMD
	Research and Development is not a Government priority	Promote Research and Development (R&D) to promote local production	MoFPED, MEMD, MoES, Universities and other tertiary institutions

Specific barriers & enabling framework for Efficient Institutional Cook Stoves

Category	**Barrier**	**Enabling framework**	**Responsible**
Financial	Competing institution priorities	Subsidize interest rates Develop financing schemes e.g. revolving funds Proper implementation of the NAMAs	MoFPED, MEMD, MoES
	Fuel savings not recognized as a source of income	Sensitization of institutions on use of savings from fuel to cover stove instalments	MEMD, RE Associations, Promoters & Contractors
Non-financial	Poor quality and stove designs	Develop standards and regulations for biomass cooking technologies Enhanced enforcement of quality standards Strengthen the capacity of the private sector for self-regulation under the relevant umbrella associations	UNBS, RE Associations, Police, Judiciary
	Low women participation in the sector	Implement policies to ensure gender inclusiveness in the energy sector	MEMD, MGLSD

Specific barriers and enabling framework for Bio-latrines for Institutions (using biogas technology)

Category	Barrier	Enabling framework	Responsible
Financial	Competing institution priorities	Subsidize interest rates Develop financing schemes e.g. revolving funds	MoFPED, MEMD, MoES
	Fuel savings not recognized as a source of income	Sensitization of institutions on use of savings from fuel to cover bio-latrines and digester payments	MEMD, RE Associations, Promoters & Contractors
Non-financial	Limited knowledge of alterative feedstock	Train users on alternative feedstock Facilitate the establishment of linkages between institutions and communities that have alternative feedstock in abundance	MEMD, RE Associations, Promoters and Contractors
	Social biases associated with fuel from human waste	Sensitization of institutions about the benefits of the technology	MEMD, RE Associations

Problem trees each indicating the core problem and causal-effect relationship for all the prioritized technologies have been annexed to the report (see Annex IV, V and VI).

Market maps for measures of all the prioritized technologies indicating market actors, enabling framework and inputs/support services have also been annexed (see Annex I, II and III). All these were developed during the Barrier Analysis and Enabling Framework (BA&EF) stakeholders' workshop.

The list of stakeholders involved in the identification of barriers and development of the enabling framework is attached; see Annex VII.

Chapter 1: Energy Sector

Biomass contributes 88% of the total primary energy consumed in Uganda through firewood, charcoal and crop residues; electricity contributes approximately 2%; while fossil fuels (oil products) account for 10% of the national energy mix (MEMD, 2019). The rate of electricity connectivity access is 28% (MEMD 2019), with total installed generation capacity at 1,182 MW as of May 2019 and peak electricity demand approximately 650 MW. Households comprise the largest overall energy consumer group, followed by industry and transportation. Government of Uganda (GoU) plans to develop clean energy resources like hydropower systems, solar energy and biomass with a very ambitious programme to achieve 100% electrification by 2025. According to Uganda's Vision 2040, due to climate change, renewable forms of energy including; wind, solar and biogas will be harnessed and promoted. Government will invest in Research and Development (R&D) and provide incentives to encourage use of renewable energy (NPA, 2013). Over the Vision period, Government will expand the rural electrification programme to cover the whole country. In addition, alternative energy sources such as solar, natural gas and biogas will be promoted. The Vision 2040 proposed an electricity energy mix comprising hydro (4,500MW); geothermal (1500MW); nuclear (24,000MW); solar (5,000MW); biomass (1,700MW); peat (800MW) and thermal (4300MW) (NPA 2013).

According to Uganda's Green Growth Development Strategy (UGGDS), the target outcome for the energy sector is GHG emission Reduction of 18.5 Million tonnes CO_2e by supporting the promotion of renewable energy investments and sustainable use of other energy sources (NPA, 2017). This is broken down into:

- Efficient cook stoves abatement of 13.0 $MtCO_2e$;
- Solar PV abatement potential – 1.1 $MtCO_2e$;
- Expanded large HPPs – 3.8 $MtCO_2e$; and
- Small Hydro Power Plants (HPPs) – 0.6 $MtCO_2e$ by 2030.

Uganda's Nationally Determined Contribution (NDC), stipulates that energy sector (supply) measures will increase the amount of renewable energy capacity by at least 1,100 Mega Watts compared to business- as- usual by 2030, generating an estimated 4.6 - 5.2 Terawatts (TW) more than in the business-as-usual scenario case. Technologies include hydro, solar, biomass and geothermal. The mitigation impact is forecast to be between 2.7 Million tons Carbon dioxide equivalent per year ($MtCO_2e/a$) and 3.7 $MtCO_2e/a$. The mid-point is taken as 3.2 $MtCO_2e/a$. For the Energy sector (demand), the country is prepared to undertake the following additional mitigation activities (see Table 1). The table indicates only those in line with the prioritized technologies.

Table 1: Policies and measures for Uganda's additional mitigation ambition

Sector	Measure	Emissions reduction potential in 2030
Energy (Demand)	National Appropriate Mitigation Action for Integrated Sustainable Energy Solutions for Schools in off-grid areas	82 $ktCO_2e/a$ from 1,000 schools in pilot
	Promotion and wider solar uptake of solar energy systems.	Emission reduction potential of about 1.5 million tons carbon dioxide equivalent by 2030

Uganda's National Development Plan (NDP) III stipulates that over the next five years, the country needs to focus on: (i) transitioning from biomass to clean energy sources, (ii) investing in expanding the transmission network, upgrading and expanding the distribution network, (iii) planning for generation of more hydroelectric power, (iv) increasing industrial energy consumption; (v) developing and implementing a plan for integrating geothermal, nuclear, solar and wind energy in the electricity generation mix; and, vi) strengthening intra and inter-sectoral and institutional coordination (NPA, 2020). In order to address the constraint of transitioning from biomass to clean energy sources, one of the objectives is to promote utilization of energy efficient practices and technologies. The first intervention under this objective is to promote uptake of alternative and efficient cooking technologies (electric cooking, domestic and institutional biogas and LPG).

1.1 Preliminary targets for technology transfer and diffusion

In phase one of the Technology Needs Assessment (TNA), three (3) technologies were prioritized, as follows:

i. Solar rooftop systems
ii. Efficient institutional cook stoves
iii. Bio-latrines for institutions (using biogas technology)

Technology categorization

Technologies are categorized according to the types of goods and services they belong to or contribute to because the different types of goods and services have distinct market characteristics. In this report we have considered four generic categories;

Market goods:
i) consumer goods
ii) capital goods

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- barriers may exist in all steps in the supply chain
- demand depends on consumer awareness and preferences and on commercial marketing and promotional efforts

In 2019, GoU revised the National Energy Policy with the aim of consolidating the achievements of the Energy Policy 2002 (the primary guiding document for the country's energy sector), aligning the policy framework with recent international, regional and national developments and commitments, and ensuring that the Government is well positioned to address the new and emerging socio-economic challenges of the energy sector in the coming decade. The policy provides for government to facilitate provision of reliable, stable and equitable electricity services to consumers towards achieving universal access by 2030 (MEMD, 2019). The policy does not indicate actual targets per technology but gives planned interventions for each of the three (3) prioritized technologies as thus:

Solar rooftop systems;

- Formulate and enforce quality standards for components, installation, maintenance and after-sales service of standalone energy technologies.
- Develop appropriate mechanisms to mitigate the negative environmental effects of off-grid electronic waste.
- Support organizations mandated to enforce standards and link the burden of responsibility with other enforcement organizations (e.g., the police and judiciary).
- Enhance affordability of standalone solar systems by providing appropriate incentives.
- Formulate comprehensive and innovative financing mechanisms to extend credit to unserved customers and Small and Medium Enterprises (SMEs).
- Strengthen the capacity of the private sector for self-regulation under the relevant umbrella associations.
- Encourage the off-grid efficient products market by developing product quality standards for off-grid equipment.

Bio-latrines for institutions (using biogas technology)

- Promote household and institutional biogas and bio-latrine installations.
- Promote biogas production and use for small and large scale thermal and electrical applications.

Efficient institutional cook stoves

- Develop standards and regulations for energy efficiency across all sub-sectors including biomass cooking technologies.
- Implement incentives to promote uptake of energy efficient products and equipment.

Table 2: Preliminary targets for solar rooftop systems

Target	Health Centers: 200 Education institutions :300 Households:140,000
Required Investment	Capital costs: USD 82 Million Additional O&M Costs of USD 25 million (1.5%) of capital costs per year over a period of 25 years *Assumptions:* Cost per kWp: Euro 1,400[1] (USD 1,642), (GET-Invest, 2019) Exchange rate 1 Euro = USD (1.173)[2] Investments will be made in 6 years
Economic benefits	• Attracting investments into the country • Job creation for importers, distributors and retailers
Environmental benefits	• Computation of emissions is based on IPCC 2006 and 5th Assessment Report • Household Reduction GHG emissions of 10,357 tCO_2eq • Heath Institutions Reduction GHG emissions of 143,808 tCO_2eq • Educational Institutions Reduction GHG emissions of 150,798.52 tCO_2eq • Reduced air pollution due to replacement of kerosene and diesel
Expected lifetime	25 years (average of 8 sunshine hours per day[3])

[1] https://www.get-invest.eu/wp-content/uploads/2019/06/GETinvest-Market-Insights_UGA_Captive_CS-Office-building_2019.pdf
[2] Bank of Uganda, 30th July 2020
[3] Exclude BV, (2014). *Market Assessment of Modern Off Grid Lighting Systems in Uganda*

Table 3: Preliminary targets for Efficient Institutional cook stoves

Target	1,000 efficient institutional cook stoves are built in schools saving 10,481 tons of firewood in a period of 8-10 years *Assumptions:* • 20 stoves are constructed in 50 districts; 2 stoves per school. Districts will be selected from each region in Uganda • Construction of stoves starts with 50 units in year 1 and all the 1000 are expected to be constructed by end of year 5 • Technology has been accepted and is highly demanded by the schools hence number of stoves constructed increase each year • Users are involved to inform the stove designs based on their needs • Minimum institution population is 200 people • Minimum saucepan capacity of 100 litres • Traditional stoves efficiency is about 20% , while improved institutional stove is 40%
Required Investment	• USD 3,375,000 • O&M Costs over the period of 10 years: USD 675,000 • Repair & Maintenance start in 3rd year of stove usage
Economic benefits	• Job creation for those involved in the construction of the cook stoves, suppliers of raw materials and tools; and providers of after sales services. Where the manufacturing and back-up services are local, there are jobs generated. • Increased establishment of businesses engaged in efficient institutional cook stoves construction • Savings on cooking fuel by the school administrations
Environmental benefits	• Reduced deforestation given that institutions use less firewood for more cooking. An average school of 600 children typically spends UGX 1,000,000 in firewood per term (EUROS 265) • Reduced GHG emissions of 19,094 tons CO_2 eq. in a period of 10 years
Expected lifetime	8-10 years

Table 4: Preliminary targets for Bio-latrine for institutions (using biogas technology)

Target	**500** bio-latrines constructed in schools replacing 32,130 tons of firewood over the period of the project. *Assumptions:* • 10 plants to be constructed in 50 districts. Districts will be selected from each region in Uganda • Construction of bio-latrines starts with 50 units in year 1 and to be increased progressively up to 100 units per year. Within the period of 5 years, 500 biogas digesters would have been constructed/installed • The estimated period of operation is 20 years. • Minimum student population is 600 students. • Estimated that the feedstock from 600 students will contribute about 50% of total energy of the energy need for cooking. If the school wishes to replace 100% of the fuel wood energy with biogas, then it will have to supplement with substrates / feed from other sources such as cow dung, waste food and other biomass. • Bio-latrines should be constructed in areas that have access to plenty of water

Required Investment	USD 2,945,205
Economic benefits	• Job creation for those involved in construction of bio-latrines and the suppliers of raw materials, biogas stoves and accessories • Savings on cooking fuel by the school administrations • Schools save costs that would have been spent on emptying toilets
Environmental benefits	• Reduced deforestation given that institutions will majorly use biogas for cooking • Reduced GHG emissions 58,538 tCO_2eq.
Expected lifetime	20 years

1.2 Barrier analysis and possible enabling measures for Solar rooftop systems

1.2.1 General description of solar rooftop systems

Solar rooftop systems consist of solar panels mounted on the roof of a residential or commercial building, which convert sunlight into electricity. It is the most suitable technology used in remote and rural areas, which are not served by the electricity grid. The system components include; PV panels, charge controller, inverter (to enable AC appliances or equipment to be operated), battery pack, mounting racks, Array DC Disconnect. These components, as well as the appliances operated by the solar rooftop, are interconnected by the balance-of-system components (cables, switches, plugs and installation material). In some cases, the electricity from a solar module can be used directly, in other cases the energy must be stored. In big solar rooftop systems, it is often necessary to be able to convert the direct current produced by the PV module into an alternating current. Then there is need for a DC/AC converter. In the smaller PV systems, there is usually not a DC/AC converter. Very small systems often operate without a charge regulator.

Solar technologies perform better in regions and seasons with the highest sun intensity and long sunlight hours. Prior to the installation of a large number of solar panels, it is important to ensure a roof's structure is strong enough to hold their weight. Accessibility for maintenance should also be planned for. It is recommended that preventive inspections and maintenance are carried out every 6 to 12 months. Inspection includes checking for signs of damage, dirt build-up or shade encroachment. The crucial condition of PV applications is that the locations must be exposed directly to sunlight and are not shaded. The reason is that PV modules, crystalline silicon technologies in particular, are very sensitive to shading. Taking a module consisting of 36 PV cells as an example, if one cell is shaded, the cell, instead of producing, can consume the energy produced by other cells, due to their string connectivity. Electricity production of the whole module, in this case, can be reduced by up to 50%. Therefore, shading must be avoided. Preventive measures include periodic maintenance to clean the surface of the modules (e.g., accumulated dust and/or bird droppings). In the tropical regions, especially in the regions near the equator, flat-mounted PV panels provide the best yield. However, the flat-mounted PV panels will result in poorer self-cleaning performance and tend to accumulate dust, which in times causes shading to the cells and diminishes the system's outputs. A slight inclining angle of 3 to 5 degrees, to allow for rainwater to be properly drained off and promote self-cleaning, is useful and acceptable (Climatetechwiki, 2020).

Benefits of solar rooftop systems include; *Site access:* Photovoltaic (PV) systems are at the point of consumption, thus do not require additional investment for access during construction or for operation and maintenance, *modularity*: they can be designed for easy expansion if power demand increases, solar energy is freely available, and the PV system does not entail environmental costs for conversion to electricity, *low operative and maintenance:* PV systems require little maintenance, *peak generation*: these systems offset the need for grid electricity generation to meet expensive peak demand during the day, *mature technology:* PV systems are based on proven technology that has operated for over 25 years. *Investments:* rooftop PV system costs help offset part of the investment needed for new power generation, transmission, and distribution in the power grid, *cost*: fuel savings from PV systems typically offset their relatively high initial cost, *environment*: PV systems create less pollution than traditional lighting sources and production impacts are far outweighed by environmental benefits, *longer working hours* because quality light can prolong the evening activities, *health benefits* due to reduced indoor air pollution, *improved safety* during nightfall travels, *silent energy supply* hence no noise pollution.

Limitations: *high initial costs* hence not affordable for most rural households, *limited power supply*, only small electrical appliances can be connected; cooking, heating and cooling is not possible, PV seldom increases the household income, there is often insufficient infrastructure to deal with system breakdowns, *negligible impact on emissions*: total saturation of the solar roof top market would have negligible direct impact on global carbon emissions, energy from PV cannot be used in agricultural activities, machinery which can generate income is usually not run on DC current, many of the system components are not produced locally, thus many developing countries have to rely on imports.

1.2.2 Identification of barriers for Solar rooftop systems

The current level of rural electrification in Uganda is significantly low; only 8% of rural residences have grid connectivity, 3% have solar home systems, 28% rely on solar lighting systems or solar lanterns and less than 1% are electrified through mini-grids (UBOS, 2018). This low level of electrification is caused by a number of barriers; some are economic and financial while others are non-financial. Barrier identification process started with the Technology Needs Assessment project second capacity building workshop that was attended by the consultants in Cape Town, South Africa from 22nd to 24th October 2019. The other methods for identification of barriers included: desk review of energy sectoral reports and other publications by the consultants, the consultants held meetings with Ministry of Energy and Mineral Development (MEMD) officials, held telephone conversations with entrepreneurs engaged in the import, sale, installation and maintenance of solar systems and from stakeholders during the Barrier Analysis and Enabling Framework Stakeholders workshop held from 16th – 17th March 2020.

1.2.2.1 Economic and financial barriers

High Upfront Cost

The major obstacle for wider spread uptake of solar rooftop systems is the high price of the systems. These high upfront costs result in the systems not being cost-competitive. This barrier is aggravated by lack of appropriate financing mechanisms to facilitate the development and promotion of solar rooftop systems. Most of the commercial banks are not providing long-term lending required for solar businesses since most consumers especially the rural population find them unaffordable. A study conducted in Uganda revealed that there is low interest of financial institutions in solar loan products (Enclude BV, 2014). Solar PV companies struggle to convince financial institutions that they can make credible technical partners. Majority of Microfinance Institutions (MFIs) and Savings and Credit Cooperative Organizations (SACCOs) are not interested in the provision of a solar loan product for either fixed or mobile systems. The study found that out of the 40 MFIs/SACCOs that were approached by SolarNow (a Uganda-based company selling and financing solar home systems) for example, only 2 were interested enough to follow up and make some sales. On the other hand, MFIs and SACCOs were also not able to convince solar PV companies they have the numbers that would merit additional investment in the regions served by the financial institutions. SACCOs, especially those in upcountry locations lack adequate deposits to finance the large upfront costs of solar systems and loans. This could be one of the reasons the financial institutions are reluctant to engage in providing the solar loan product as part of their portfolio.

Low disposable income especially among the rural population

About 21.4% of Ugandans are living below the poverty line (UBOS, 2018). This means there is generally low disposable income among the population. While it is a fact that rural populations are the most in need of solar PV systems, most rural households prioritize food, education and healthcare over lighting in order to fit their needs into their limited budgets. Energy cost is not a primary concern for households. Households spend on average over 50% of their disposable income on school fees (Enclude BV, 2014). Household incomes in Uganda are mainly derived from farming, businesses, salaries and wages. Sometimes, people carry-out a combination of farming, business and employment activities to supplement their incomes. In a 2014 market assessment of modern off-grid lighting systems in Uganda, eighty three percent of the people interviewed earn their incomes from a single source i.e. salary (6%), business (11%), farming (57%) and 9% wage earners (labourers) (Enclude BV, 2014). Incomes of farmers, business people and labourers are uncertain and unpredictable due to seasonal variations in weather, farm yields, buying habits and labour hiring sequences and frequencies throughout the year. These categories of people often suffer frequent income shortages and stresses, making their financial planning throughout the year difficult in contrast to salaried workers. They are more likely to have difficulty in making decisions as whether to purchase solar energy equipment or not. Whereas the country’s Energy Policy goal (MEMD, 2019) is “to meet the energy needs of Uganda’s population for social and economic development in an environmentally sustainable manner”, the greatest question and challenge is how the energy needs of all Ugandans, taking into account all social and income classes, can be met in an environmentally sustainable manner.

Difficulty in accessing finance

Difficulty in accessing credit by the suppliers creates working capital challenges especially for those who work with a business model that incorporates credit. In this model, the initial capital financing burden is with the supplier and the overall capital requirement increases as the rate of deployment grows. Some companies sell systems at 95% credit, leaving the company in a large cash deficit (Enclude BV, 2014). Companies soon run out of working capital and are unable to import more stock. In addition, most financing institutions offer loans with unfavourable terms such as high interest rates. For example, at over 20% interest, credit from financial institutions is expensive and unsupportable for most companies (Enclude BV, 2014). Instead, they resort to a cash-based business which limits the sales. Most local operators are unable to access local debt because they do not have the developed track record required to secure financing from local banks. Further, local players are typically unable to provide the type & quantity of collateral banks require. Donor guarantee programs that provide a substitute for collateral to solar system operators are rarely given to local players, in favour of the larger multi-nationals. Local entrepreneurs are typically not investment ready, lacking materials global financiers rely on when performing due diligence. Finally, many entrepreneurs are unversed in the language of impact investing & struggle to communicate their narratives for impact & growth to investors. In addition to the financing access challenge, suppliers make losses from defaulting customers/ defaulting retailers. This makes the solar business a high risk one. In a study conducted in Uganda, some suppliers reported that they had major issues with defaulting retailers (Enclude BV, 2014). This caused market penetration to slow down and suppliers to shrink their distribution networks. Defaulting also happens when products malfunction as users are reluctant to pay remaining instalments. High default rates are common in Business 2 Business (B2B), with lower rates of default by Business 2 Customer (B2C) customers.

Unclear & inconsistent tax policy on solar system components

Importers of solar rooftop system components are faced with a challenge of unclear tax policy. For instance, Deep Cycle Batteries (DCBs) are subjected to import duty, yet they are listed in the 5th schedule of the East African Community Customs Management Act (EAC CMA) 2004 as exempt goods from Import duty. Importers of DCBs as standalone have been subjected to import duty under Heading 85.07 ("Electric accumulators, including separators therefore, whether or not rectangular (including square) Lead acid, of a kind used for starting piston engines"). This classification attracts import duty. For this reason, importers of DCBs for solar as stand-alone have been paying taxes. Uganda Revenue Authority argues that the DCBs that should benefit from duty exemption (under paragraph 26 of the fifth schedule of the EAC CMA) are those used for development of solar energy, however, DCBs can be used for other purposes other than solar development and therefore not every importer should benefit from duty exemption. An importer has to provide proof from Ministry of Energy and Mineral Development (MEMD) and the Uganda Solar Energy Association (USEA) that they are members to benefit from the exemption. Solar importers who may not be members of USEA therefore find it difficult to benefit from this exemption. The bureaucracy involved in obtaining support letters from Government entities such as MEMD may lead to additional costs to the importers in the form of demurrage and storage costs. Importers who do not benefit from the exemption transfer the cost to the customers hence, highly pricing their solar systems.

Pay As You Go (PAYG) solutions discourage customers due to lockouts

Pay-as-you-go (PAYGo) solar loans are alternative forms of collateral that have far-reaching implications on how low-income households access credit. The technology links people's use of their solar systems to their loan payments. This lockout technology turns borrowers' lighting (or lack thereof) into an immediate and tangible reminder to repay their debt, making clean energy a manageable, as-you-go experience (Waldron & Swinderen, 2018). Lockout of customers when they fail to make their daily payment makes the technology counter-productive. Switching off their lights during hard times would force them to borrow or buy kerosene, making it more difficult to resume paying off a solar loan (L-IFT, 2018). Secondly this solution reaches customers at a price (by the end of the payment period) far higher than the price one would pay if they bought the solar system by cash. A research by CGAP/FIBR revealed that PAYGo customers do sometimes struggle to make payments and must cut back on consumption to make solar payments, albeit not in ways they considered severe (CGAP/FIBR, 2017). Turning off someone's lights imposes an additional expense, which may cause them to fall further behind.

Difficulty in managing currency risk

All off-grid operators face same currency challenges. Large and small operators alike import units from China and other countries, since Uganda does not manufacture solar products. Regardless of size or technology, virtually all solar products are purchased from manufacturers in foreign currencies. The terms of sale may vary, but all in all manufacturers require payment in hard currency. Much as products are imported in foreign currency, sales are made in Uganda Shillings. Operators who offer financing to consumers face much greater exposure since revenues from sales are realized over the financing period. In addition, larger, international businesses have developed in-house hedging systems; but these remain expensive, often >12%. In-house hedging also requires substantial expertise and is out of reach for smaller businesses. Accessing local currency debt from local banks remains elusive, even for established players. The most effective way to hedge currency risk is to not need to; however, the majority of local capital is unwilling to take on the risk profile offered by today's off grid businesses. In recent months, some direct investments have been made by local banks to solar system companies, suggesting that local capital may be warming to the industry; however, substantial collateral (provided via guarantees by donors or with business owned property) is required to enable the deals.

Poor infrastructure and the cost of setting up a distribution network

Setting up a distribution network is expensive. Solar companies find it difficult to get reliable franchisees, and these must be trained on the job, which is quite costly given the poor infrastructure and transport to many areas. Agents in place in a local area are a key requirement for a continuous local presence to provide aftersales service and carry out promotions. Lack of wide distribution networks, especially in rural areas, impacts the ability to offer after-sales services and limits capacity to supply products when demand peaks. Reaching unserved populations is a very costly venture for most suppliers. This barrier also contributes to high maintenance costs. Solar rooftops systems are alternatives for the supply of electricity to rural and remote areas in Uganda. However, most of the suppliers and retailers are based in urban centres, it's costly for these suppliers to offer after sales services especially for maintenance of the systems in rural communities. Despite the fact that about 76% of the Ugandan population lives in rural areas, there are only a few enterprises that are involved in the solar businesses in these communities. There are inadequate technically skilled human resources in the rural communities to provide maintenance services for the solar systems. The high maintenance costs deter potential solar system users from purchasing them hence the low uptake.

1.2.2.2 Non-financial barriers

Ineffectual quality control of products

Despite availability of national technical standards, these are not effectively implemented. The major cause for ineffectual quality control is inappropriate training and personnel (Murphy et al, 2014; Raisch, V., (2016). Uganda National Bureau of Standards (UNBS) lacks capacity to fully enforce product standards across the country. This has led to the inflow of a huge amount of substandard/poor quality solar components and systems into the country. For instance, most of the solar products are basically imported from China through various neighbouring borders into the marketplace at cheaper prices (Rotberg, I.R. (Ed.), (2008); Cicale, N.J. (2010). However, despite the fact that the sub-standard components/products are cheaper, they become more expensive over time, as the components will often be replaced and thus affect the performance and efficiency of the entire solar PV system. During a media training on renewable energy sector held by the Uganda Solar Energy Association, the Association's CEO noted that the influx of counterfeit solar equipment on the market was one of the major challenges affecting the sector (EABW, 2019).

Inappropriate quality assurance creates low consumer confidence. There are different solar technologies on the market and the general public is not aware of their effectiveness. The majority of the population learn about PV from their neighbours, which emphasizes the importance of well-functioning systems. The end users' expectations are raised, and if not met may cause public dissatisfaction with the systems. It is very important that people are aware of the limitations of the system before they invest in it. Inappropriate enforcement of product standards creates low consumer confidence by allowing low quality products and servicing to persist. As much as consumers are sensitive to unit price, cheaper systems are normally of lower quality. Low cost units are often mislabelled (e.g., advertising a 5W unit as 7W) & low quality, ceasing to function soon after purchase. Unknowingly buying low quality units erodes consumer trust. Consumers struggle to distinguish high from low quality units, and when a unit does not perform or ceases to function, market confidence is damaged. Existence of several counterfeit solar products on the market negates public confidence in the quality of the products and consequently hinders sales and uptake.

Limited information and public awareness

Limited public awareness has been documented to be a big barrier in the utilization of renewable energy (RE) technologies such as solar rooftops in many countries (Adebayo et al., 2018). The most common issues associated with this are inadequate knowledge regarding the use, importance, socio-economic and environmental benefits that are derivable from renewable energy and its technologies, and the fears in relation to the economic feasibility of RE installation projects. Most of the companies installing solar rooftop systems do not give the end user sufficient information on maintenance of the system. Information is mostly given orally to the man of the house at the time of installing the system. There is also a challenge with literacy levels where some users may not understand the information given to them. When a solar PV system fails, it is usually assumed that the solar module is faulty. However, sometimes when things go wrong with a solar PV system, it is usually the other system components or the appliances that are powered by the PV generator that are found to be the real cause of the fault. This is mainly because PV modules are highly standardized and are certified using internationally validated procedures, but by contrast, there are few equivalent standards and procedures available for balance-of-system components, component matching or installation quality, even though the quality of these components has a dramatic influence on user satisfaction and operating costs.

A major cause for disappointment lies in the under sizing of systems leading to power shortages. It is highly recommended not to be too optimistic when grading components' efficiencies and derating factors when sizing individual components. However, users tend to opt for a cheaper (undersized) system. Balancing between the realistic sizing and the users' acceptance of costs requires a high level of communication between users and suppliers or implementing institutions.

Limited talent and capacity to install and maintain solar systems

Businesses struggle to find the technical expertise required to develop requisite systems and maintain those installed (UOMA, 2018). Technical support for diffusion of renewable energy technologies (RETs), such as the solar PV systems in rural communities, requires a large workforce that has a basic technical skill rather than a few experts with high technical skills. Training such artisans and ensuring that they have ready access to spare parts requires the establishment of new infrastructure that can provide a quality training platform for technical and engineering personnel. Generally, in most of the least-developed countries such as Uganda, the lack of such an auxiliary industry usually results in higher cost of RE projects and further barriers to deployment (Murphy et al, 2014). Presently, in Uganda, there are limited trained personnel and training facilities for the installation, operation, and maintenance of RETs which make it very difficult for the country to achieve a sustainable RE market (Raisch, V. 2016). This is also coupled with lack of technical certification for services, this means customers are unaware of where to go when units malfunction. "One size fits all" solar systems require minimal servicing while larger, tailored systems require significant expertise. Expert servicers struggle to distinguish themselves from low cost, untrained technicians. Low quality servicing affects consumer trust in the market, making them and others hesitant to purchase products in the future. In the case of businesses using the PAYGo model, the technical expertise required to develop requisite systems is considerable; most local operators do not have the capacity, technical expertise, or capital necessary to build these systems. Technical assistance programs and accelerators are also unable to offer the long-term support needed to develop this expertise. Broadly, some industries have begun developing embedded talent models to facilitate training and technical development, though these remain rare.

Inadequate institutional framework

There are low institutional capacity and inadequate regulatory and investment frameworks to provide the enabling environment for RE development, uptake and transfer of technology on a larger scale in Uganda (Uganda Climate Change Policy, MoWE, 2015). Solar rooftop systems are some of the renewable energy technologies that are affected by this challenge. There are several institutions involved in RET development and the procedure is not well defined. The institutional structure of the energy sector in most developing/least-developed countries such as Uganda is still under government monopoly, with the responsibility for energy generation and distribution allocated among a number of government departments (Painuly, (2001). However, insufficient coordination due to an array of government bodies authorized to regulate energy and the limitation of institutional capacity constitute critical institutional hindrances to the production of RETs in Uganda. This in turn creates an unsteady macro-economic environment which increases risks and dampens investments. This barrier exists not only because Uganda is still a low-income/least developed country, but also as a result of the inadequate government investment in R&D, scientific activity and human resources development. In addition, there are no regional or national research centres with the required basic research facilities and infrastructures for RETs (Wilkins, 2010). There are also uncoordinated stakeholder activities among those who promote the technology, which leads to duplication of initiatives.

Service and maintenance are out of reach in rural communities

In the rural areas, service and maintenance of RE equipment are out of reach, due to inadequate number of solar PV equipment and service providers. Consumers continue to complain about lack of technical support on the ground, and this provides additional cause for financial institutions to be sceptical about the sustainability of a solar PV portfolio. Only a few retailers offer warranties and aftersales services. Poorly maintained systems and lack of trained personnel working in rural areas often cause premature damage to the systems and reduced lifetime for the storage battery (Adebayo et al, 2008). Recently graduated electricians often prefer working in the city in the computer industry rather than in remote areas. In Uganda, there is little experience with organized after sale services. It is assumed that this is very costly because of the scattered systems. This is because the distance between the retailers and end-users is very big.

Research and Development is not a Government priority

GoU has not given proper attention to research and development in the renewable energy sector. This discourages local production of solar rooftop system components hence, the country depends on imported products most especially from China. There is a lack of focus on research and development in the RE, and there are no visible plans/budgets provided to universities and institutions of higher learning to precisely conduct research on RETs (Adebayo et al., 2018). That is, there is no well pronounced RE research and development program that is supported with modest funding. Also, no working systems have been put in place for quality international research and development collaborations that can easily accelerate transferable skills and technologies. The negligence of this overall technically supportive environment has slowed down the development of most RET projects such as solar technologies. As a result, domestic technical knowledge concerning these products is inadequate and, as such, related technologies are imported at very high costs. However, with an indigenous skilled and averaged-skilled workforce, a sustainable RE industry in Uganda can be easily achieved. This implies that skilled personnel from multidisciplinary academic and research institutions are mandatory for R&D activities in Uganda.

These identified barriers that hinder deployment and diffusion of solar rooftop systems have been used to develop a problem tree (see Annex IV).

1.2.3 Identified measures

While Uganda's solar PV market shows great development potential, there are still massive barriers, both structural and fundamental, that need to be overcome before this potential demand can be translated into effective demand (Exclude BV, 2014). To prevail over the aforementioned barriers and accelerate the transfer and diffusion of solar rooftop systems in most off-grid parts of Uganda, there is a need for the Government to introduce favourable policies at its different levels. These policy frameworks are basic premises needed by the GoU to apply, extend and assess its policies and succeeding actions that may include legislation, enforcement, decision-making etc. This will effectively tackle major RE (such as solar technology) concerns that are captured in the policy framework and others which are not. The following efficient measures and policies are thereby suggested, in order to accelerate uptake of solar rooftop systems in Uganda. These are further analysed in the market map (see annex I). These economic, financial and non-financial measures were identified through desk review of energy sectoral reports and other publications by the consultants and during the barrier Analysis and Enabling Framework Stakeholders workshop.

1.2.3.1 Economic and financial measures

Favourable financing and fiscal policy

In order to establish an appropriate financing and fiscal policy to attract more investments and enable RETs such as solar rooftop systems to penetrate different markets, there is need for Government to:

i) Implement innovative financing mechanisms, including targeted subsidies to stimulate the market penetration of renewable energy technologies. Where subsidies are to be provided, they should be determined in a transparent manner and published. GoU can for example; subsidize interest rates to enable financing institutions provide cheaper and affordable loans to importers of solar rooftop system components and other players in the business value chain. This will overcome the barrier of expensive capital that results from high interest rates charged by financing institutions. Reduced interest rates will attract importers to secure loans, which will increase their capital to import more solar rooftop system components. This will in turn reduce the cost of solar rooftop systems and make them accessible to users. Subsidies on interest rates will also overcome the barrier of difficulty in accessing finances by suppliers; these will be able to sell solar system components at lower prices and is expected to increase demand and uptake for solar rooftop systems.

ii) Introduce specific regimes that favour renewable energy. These will include preferential tax treatment and tax exemptions. For example: Government of Uganda should exempt all solar rooftop system components from taxes. This will lower the capital costs required by importers to purchase and bring the components into the country. Here the major barrier of high price of the systems will be overcome. Currently some system components are exempted from taxes while others such as the deep cycle batteries which have alternative purposes are not exempt. This will overcome the barrier of the unclear and inconsistent tax policy.

iii) Implement innovative risk mitigation mechanisms and credit enhancement instruments, to provide comfort to lenders. Credit enhancement is a strategy for improving the credit risk profile of a business, usually to obtain better terms for repaying debt. The strategy reduces the credit risk/default risk of the company's debt and thus can make it eligible for a lower interest rate. For example, GoU can provide Partial Risk Guarantees to facilitate Financial Institutions on lending for Renewable Energy projects/ programmes. These guarantees reduce the real or perceived risks faced by primary lenders and financial intermediaries.

iv) Develop affordable financing schemes adapted to local needs and traditions, such as revolving funds, to enable market development for small, appropriate renewable energy technologies for rural development, such as household solar PV systems. This will help overcome the challenge of the costly setup of the distribution network in the rural communities as entrepreneurs can benefit from the revolving fund to set them up and return the funds to support other entrepreneurs involved in other activities in the value chain. This will also overcome the barrier of high maintenance costs since distributors and retailers who will offer these services will be able to reach out to most of their customers.

v) Develop the carbon financing market. GoU can be able to secure funding to offer subsidies to reduce interest rates and grants to the different players in the renewable energy sector since RE technologies directly contribute to reduction of Greenhouse Gas (GHG) emissions and would be collectively eligible for green financing. Carbon credits can also be earned by the private sector players and this will help in financing their businesses and reducing the need for loans.

vi) Set up a Renewable Energy Fund. Government of Uganda through Ministry of Energy and Mineral Development (MEMD) should set up a renewable energy fund to cater for funding challenges experienced by players in the solar rooftop systems supply chain. This funding could for example: (a) subsidize interest rates on solar loans, (b) provide low cost funding in financial institutions to attract investors in the sector to take them up and import more solar rooftop system components into the country, distributors and retailers too can take up these loans, (c) the fund can also cater for incentives to early adopters of the technology especially in rural off-grid communities.

vii) Put in place favourable forex exchange conversion terms in order to overcome the barrier of difficulty in managing currency risks faced by importers who purchase solar rooftop components in foreign currency and sell the components in Uganda Shillings.

viii) Promote solar energy for productive use such that users gain income from the solar systems. This will contribute to overcoming the barrier of low disposable income. It will also help users to earn income that will be used to pay for systems acquired on credit.

ix) Provide grant funding to support agricultural activities especially for rural farmers. Development of agricultural sector will enable the rural communities to engage in commercial farming and this will lead to increased incomes among the population hence overcoming the barrier of low disposable income. Since people will have enough food and money to cater for the education and health needs, then they will include clean energy in their budgets. This measure will also overcome the challenges people face with the Pay As You Go solutions, since some will have the money to buy solar systems by cash and those who will buy on credit will also be able to cover their daily payments to avoid lockouts.

Establish a body to manage all RE projects and activities

GoU should take into consideration the significance of RE with technologies such as solar and establish a particular body that will be responsible for the management of all the activities related to RE projects across the country (Adebayo, et al., 2018). This will be of great assistance in streamlining the urgent and important needs in the RE sector. Also enforcing reputable laws will be a necessary step to decrease the basic hindrances of the political and regulatory risk in Uganda.

1.2.3.2 Non financial measures

Develop and enhance enforcement of quality standards

Uganda National Bureau of Standards (UNBS) and other government agencies must develop and strictly enforce appropriate manufacturing standards and specifications. This can be achieved by introducing policy instruments and incentives that can encourage local assembling of solar system equipment. Likewise, for the purpose of sustainability, the government needs to also make efforts to introduce domestic manufacturing industry for RETs, thus reducing the reliance on the imported products. This is particularly applicable to solar energy technology. With the implementation of these standard production procedures, the quality and quantity of RE output will yield increase. This will be a step in the right direction that would entirely empower the RE industries. Creating a standardized certification for units would help keep customers informed of what they are buying, hence increasing trust in the market. Creating a certification process for technicians would allow service providers to distinguish themselves & improve relationship with customers. Quality control officers should be based at district level such that there is enhanced enforcement at each and every border point. Private sector players through the RE associations should be strengthened to play a role in implementation of standards.

Consistent information and technology awareness creation

The implementation of RE applications such as solar rooftop systems can only be embarked upon successfully if there is an improved understanding and support of the public. Hence, an increased awareness of the prospects and advantages associated with the development of RETs, and the fundamental advantage for climate change alleviation is quite important to swiftly and appreciably enhance the desire and interest among the Ugandan populace. Primarily, a centralized data-based information center that is both comprehensive and accessible to the public needs to be established. This center will be expected to keep records of the various field experience acquired during the installation, operation and maintenance of RE technology systems and make available information that is related to RE incentives, RETs, RE policies and the utilization of RETs systems for investors. Such information can act as an important tool for learning and thereby allowing RE sector players to expand and adapt RETs for particular environmental conditions. This center will not only serve as a means of assessing resources, but also for monitoring and evaluation. Thus, with proper management of the center, there will be increase in general awareness, reception and interest in RETs. Government should finance country wide clean energy awareness campaigns by setting up demonstration sites in communities.

These sites will not only contribute to awareness creation but also capacity building, jobs and research and development. It is therefore clear that an increased access to RE technology-related information and technology is crucial to the successful development of RE projects in Uganda.

Training of the media and equipping them with relevant knowledge and information about the renewable energy sector is also a step in the right direction. This is because the media plays a key role in information dissemination to the public. If the media accesses the right information about the renewable energy sector, they can raise awareness among the public about the benefits of transitioning from climate-harming technologies to clean energy solutions like solar. The media will report effectively about the sector and promote the use of RE technologies among millions of people in Uganda. It is also important for RE trainings to start in schools by integration of basics of RE in the school curriculum and running awareness programmes for youth in and out of school.

Develop a skilled workforce to operate and maintain solar rooftop systems

Developing a skilled workforce to operate and maintain RETs such as solar rooftop systems is essential for successful deployment and development of the technologies in the country. The development of RE calls for skills in different fields that may include physics, materials science, chemical, mechanical, and electrical engineering, business management and social science (Wilkins, 2010). Nonetheless, the different groups need precise training, since the set of skills may vary in detail for the different technologies. It is also essential that RE technology users understand the availability and explicit operational features of RE sources. In particular, this is highly significant in the rural areas of least-developed countries such as Uganda. Technical support for diffuse of RETs, such as the solar PV systems in rural communities, requires a large workforce that has basic technical skills rather than a few experts with high technical skills. Training such artisans and ensuring that they have ready access to spare parts requires the establishment of new infrastructure that can provide a quality training platform for technical and engineering personnel.

Provide ample end user training

The user of the solar system is a key person in maintaining the system and making the system function well. It is not enough to orally train one member of the household on the system maintenance. It would be a good idea to give a maintenance and safety poster to the end user. Technicians should train end users on; advantages and limitations of solar rooftop systems and maintenance; they should listen to the end user's needs, ensure that the spare parts for the systems are available and be available to the users.

Put in place proper institutional frameworks

GoU needs to realize that, at the institutional level, the centralized energy model is becoming increasingly redundant in developed nations (Twaha et al, 2016). Instead of expanding its centralized power systems, Uganda needs to focus more on the development of a decentralized energy structure that would better match its current capital resources and management ability. This will help position the country to adapt to future energy technologies and systems. There should be proper coordination of stakeholders engaged in and supporting solar energy initiatives in order to avoid duplication of programs and initiatives.

Implement policies to ensure gender inclusiveness in the energy sector

Women need to play a special role in the provision and management of energy sources, since they are the most affected by inadequate energy supplies. The difference in interests, needs and priorities that women have compared to those of men should be recognized in planning, implementation and monitoring of renewable energy projects and activities. Energy technologies and services should be designed and disseminated in ways that take into consideration the difference in tasks and roles. Provision of modern renewable technologies in rural areas - such as solar PV for lighting and powering communication devices - contributes significantly to the well-being of women who normally perform indoor chores. Providing rural households with minimal electricity supply for lighting, addresses another burden unequally shared by women; indoor pollution from the use of traditional kerosene lamps and consequent health impacts. Access to electricity for other economic and social purposes reduces the drudgery experienced daily by women and elevates their well-being. The impact of rural electrification programs on women is well-documented, with its benefits ranging from time savings, employment and education, to safety and maternal health. It is important to greatly consider gender in all rural electrification programs and in all phases of planning and implementation: (i) at the institutional level in employment practice and human resource policies, and (ii) at the construction level through connection with social institutions and energy information campaigns targeting women; and at implementation level, by targeting both genders in a designed social intermediation process.

Promote Research and Development (R&D), International Co-operation and Technology Transfer and adoption of standards in the design and manufacturing of solar rooftop systems

To promote mechanisms for international co-operation in research and development and technology transfer, Government should promote appropriate research and development and local manufacturing capability, in renewable energy technologies like solar rooftop systems. This should be done by; (a) advocating and supporting collaboration with researchers and developers in industrialized and other developing nations, (b) allocating adequate funding towards R&D initiatives, (c) setting up an R &D Division under the Renewable Energy Department at MEMD to coordinate R&D programmes in RETs, (d) support the research initiatives in tertiary institutions, and (e) develop or adapt standards which govern the design, installation and performance of renewable energy systems and put in place certification processes, to verify that the systems meet these standards.

Stakeholder Participation

Government, development partners, importers, distributors and suppliers should foster community participation in renewable energy projects and initiatives and strive to promote knowledge of and greater acceptance by the public of prospective renewable energy solutions that are appropriate for their locations. This involvement should start at an early stage in the planning process. These developments should take into account the socioeconomic set up of the concerned community, including the needs of the poor. The development of the renewable energy resources should lead to employment creation and poverty alleviation. This will create a sense of ownership in the public and will increase acceptance and uptake of the renewable energy solutions.

The above identified measures have been used to develop a market map for solar rooftop systems, see Annex 1.

1.3 Barrier analysis and possible enabling measures for Efficient Institutional Cook stoves

1.3.1 General description of Efficient Institutional Cook stoves

Institutional stoves are used where larger amounts of food than can be accommodated on a standard kitchen stove have to be cooked. Typical examples of institutions that utilise such stoves are: schools, hospitals, prisons, barracks among others. Institutional stoves are also used in refugee camps, particularly in the early stages when large influxes of people require food urgently. Typically, these groups will use institutional stoves with a cooking capacity of 50 litres to 200 litres. Another very different group of users are entrepreneurs who own cafés or restaurants, selling street foods, or selling staple foods. In such cases, the stove is likely to be used for several hours each day (Appropedia, 2019).

What makes a good institutional stove?
Fuel efficiency: where stoves are used in refugee camps, the acute shortage of fuel may be one of the reasons for choosing to cook communally, *strength and quality*: heavy weights, such as a full container of boiling water, will regularly be placed onto the stove. If livelihoods are dependent on cooking food, the stove must be reliable, durable and strong, *low emissions*: Good institutional stoves reduce emissions and *Seasonal influences*: if a stove can use a variety of fuels such as agricultural residues, it may be possible to use lower cost fuels at certain times of the year. However, a stove that relies solely on residues can only be appropriate if the supply of these residues is assured.

When an institution or individual is considering an institutional stove, other factors need to be considered: For example: In refugee situations, the needs and preferences of those seeking help should be identified before a stove type is selected. A reliable supply chain for fuel should be assured, as the well-being of a lot of people will depend on the outcome. Considerations of whether the stove will benefit a whole community or just a single owner of the stove, distribution of benefits, the technology under consideration should reduce the total emissions to the environment, one should consider if there are possibilities to get carbon finance to support the activity. Types of institutional stoves include; Rocket stoves, Nkokonono, Libhubesi, Bellerive-type, Injera, stoves using peat, solar-powered cookers and ovens and gasifier stoves

The benefits of institutional stoves include: *cost saving*, 42% savings on fuel expenditure, on average (Ireri & Collings, (2017), *time savings* due to ease of lighting the stove and the increased speed of cooking leads to reduced cooking time, *health* – the new generation of institutional stoves provides energy which is cleaner and requires less effort to use, improved working conditions and health status of the cooks because the kitchens are less smoky, *environment* – stoves with improved combustion require much less wood, and ultimately reducing deforestation, thus benefiting the environment. Where residues can be used, two problems are solved at once – more fuel is available and the problem of waste management is resolved, *employment* – using more efficient stoves can make small enterprises very attractive to the entrepreneur as the profit margins can increase substantially, where those savings are passed onto the consumer, they pay less for the services, additional services, such as bakeries, can improve the quality of life for communities which are served, within a refugee situation, food can be provided quickly and efficiently, reducing the risks associated with fuel collection for traumatized people. Well-designed stoves provide useful services to the consumer and a good income to the provider, acquisition of new skills and knowledge, prevented declines in soil fertility due to preserved trees and woodlots, protection of water, flora and fauna and maintaining the biodiversity due to preserved forest cover.

1.3.2 Identification of barriers for Efficient Institutional Cook stoves

Efficient institutional cook stoves are not a new technology in Uganda. Most of the initiatives in the transfer and diffusion of this technology are donor funded. Much as this technology is vital in ensuring that institutions use less fuel for more cooking, it has not been widely adopted by the institutions. This is due to a number of barriers which are economic, financial and non-financial. Barriers were identified through desk review of energy sectoral reports and other publications by the consultants, the consultants held meetings with Ministry of Energy and Mineral Development (MEMD) officials, one of the consultants visited three (3) schools with bio-latrines and efficient institutional cook stoves, held telephone conversations with entrepreneurs engaged in the construction of institutional cook stoves and during the Barrier Analysis and Enabling Framework Stakeholders workshop.

1.3.2.1 Economic and financial barriers

Affordability is the main challenge for institutions and increasingly for manufacturers too (Ireri & Collings, (2017). The biggest reported barrier to Improved Institutional Cook Stoves (IICS) adoption is cost to institutions. IICS are considered expensive and unaffordable by institution owners and managers. Most institutions need assistance in financing for stoves while manufacturers want more creative payment options for institutions, which would enhance affordability and improve repayment.

Difficulty in accessing finance and collection of repayments from customers

Difficulty in accessing credit by the contractors who construct efficient institutional cook stoves creates working capital challenges and yet most of the institutions do not make full upfront payments for the stoves. Most payments for services are made in instalments and most institutions, especially schools take this option over full upfront payments. In some instances, institutional cook stoves contractors face difficulty in collecting repayments and delayed repayments, after delivering installation services. Companies soon run out of working capital and are unable to offer credit to more than a few customers at a time. The manner in which enterprises manage credit could become an issue, even where there is access to steady capital, given that delayed repayments jeopardise business operations. In addition, most financing institutions offer loans with unfavourable terms such as high interest rates. Typically, the over 20% interest credit from most financial institutions in Uganda is expensive and unsupportable for most companies. Most operators are unable to access credit because they do not have developed track record required to secure financing from financial institutions. Further, local players are typically unable to provide the type and quantity of collateral banks and other financial institutions require. In addition to the financing access challenge, contractors make losses from defaulting customers.

Competing institution priorities

Institutions will always have high and conflicting demands on limited resources. For example, in a school, IICS may not be a priority if extra classrooms or dormitories are needed. Often the IICS may have to wait until more pressing needs have been met. This greatly contributes to low uptake of IICS since institutions typically have these pressing needs all year round. In addition, normally institutions have a budget for their cooking needs at the beginning of the year hence convincing them to take up an efficient institution cook stove might not be considered pressing and may always be postponed.

Fuel savings not recognized as a source of income

The absence of explicit mentions of instalment payments may suggest that, despite targeted messaging by the practitioners, institutions owners and managers do not see a precise link between affordability of the stove and cost saving generated by the stove. The dissociation could explain the low uptake of bank supported loans by the institutions. They do not appear to see savings from fuel as a potential source of income, with which to pay off loans or instalments.

1.3.2.2 Non-financial barriers

Inadequate institutional framework

One of the key barriers to development and uptake of new and renewable energy in Uganda is low institutional capacity and inadequate regulatory and investment frameworks to provide the enabling environment for such development, uptake and transfer of technology on a larger scale (Uganda Climate Change Policy, MoWE, 2015). There has for a long time been a lack of a standard procedure and legal instruments for new renewable energy investments. There are several institutions involved in RET development and the procedure is not well defined. The institutional structure of the energy sector in most developing/least-developed countries such as Uganda is still under government monopoly. However, insufficient coordination due to an array of government bodies with energy authority and the limitation of institutional capacity constituent critical institutional hindrances to the production of RETs in Uganda. This in turn creates an unsteady macro-economic environment which increases risks and dampens investments. This barrier exists not only because Uganda is still a low-income/least-developed country, but also as a result of the inadequate attention of the government to R&D and the government's failure to facilitate science activities while improving human resources. In addition, there are no regional or national research centers with the required basic research facilities and infrastructures for RETs (Wilkins, 2010). Furthermore, there are uncoordinated stakeholder activities among those who promote the technology. This leads to duplication of initiatives.

Low levels of awareness among institution owners and managers

There are low levels of awareness about the efficient institutional cook stoves technology and its benefits among institutions owners and managers. A study conducted in 10 districts in Ugandan showed that issues around misinformation due to variety of contractors and information sources in the market could have been causing awareness gaps (Ireri & Collings, (2017). Contractors reported that sensitisation' of schools was a complex challenge and appeared to be linked with mistrust from consumers who had interactions with numerous enterprises of varying credibility.

Capacity gaps

Low skilled capacity and technical support is also one of the barriers experienced by those involved in construction of IICS. The main resource gaps are in sales and marketing, installation and fabrication. Enterprises' often desire sales and marketing staff and this reflects the challenge of acquiring institutions as customers. Capacity gaps among contractors contribute to improper stove usage as end users are not well trained on how to use and handle the stoves. This also contributes to increased mistrust and low uptake.

Decision making and timing

Decision making at institutions requires a number of stakeholders and a lot of time and visits to the institutions before reaching an agreement to purchase and make the installations. The decision to purchase IICS is not a one-person decision but often a consultative process with other institutions stakeholders. The period between visits may be the decision makers' consultative period. Many institutions such as schools may not have acquired IICS because they are waiting for or deliberating the decision among stakeholders. If some stakeholders have low awareness about the benefits of efficient institutional cook stoves, then this could lead to the abandonment or delay of the acquisition process. The solutions may be to arrange full stakeholder meetings at the time of first or second discussions with the institutions but this may not be easy since these come together normally to discuss other institutions priorities yet energy may not be one of these priorities.

Poor quality and stove designs

In a study conducted in Uganda, school administrators reported a concern over "fake stoves" and "poor designs". Some stove designs had an unforeseen disadvantage for female cooks due to the weight of saucepans and height of installation (Ireri & Collings, (2017). This led to changing gender dynamics in school kitchens where most of the work has to be handled by men who are in position to carry heavy saucepans. This barrier was also witnessed by the consultant during the visit to one of the schools in Uganda where cooks had to use steps in order to prepare posho (a meal prepared by mingling maize flour), these stoves were abandoned by the cooks due to the discomfort experienced while using them.

Low women participation in the sector

Women are the most affected by inadequate energy supplies and hence should play a special role in the provision and management of energy sources. There is a definite gender facet to IICS installation; existing stove characteristics may be introducing unfair disadvantages for women cooks. There are aspects in the use of IICS that are more challenging for women such as lifting of heavy weights and inappropriate height of the stoves. In addition to this, IICS requires splitting of firewood to small pieces, this is difficult for most women due to the manual labour required. This aspect would also unfairly disadvantage female cooks if they were expected to carry out the same tasks as their male counterparts.

The barriers to adoption of the efficient institutional cook stoves have been used to develop a problem tree (see Annex V).

1.3.3 Identified measures

1.3.3.1 Economic and financial measures

Favourable financing and fiscal policy

In order to establish an appropriate financing and fiscal policy to enable increased demand and uptake of the efficient institutional cook stoves, there is need for Government to;

i) Implement, innovative financing mechanisms, including targeted subsidies to stimulate the market penetration of renewable energy technologies such as efficient institutional cook stoves. Where subsidies are to be provided, they should be determined in a transparent manner and published. For example, GoU can subsidize interest rates to enable financing institutions provide cheaper and affordable loans to contractors and institutions (up-takers) of efficient institutional cook stoves. This will overcome the barrier of affordability experienced by institutions and difficulty in accessing finance experienced by the stove manufacturers. Reduced interest rates will attract contractors to secure loans which will increase their capital to construct more IICS as they wait for instalment payments from customers.
ii) Develop affordable financing schemes adapted to local needs and traditions, such as revolving funds, to enable market development for renewable energy technologies. This will attract contractors to take up the funds and refund them as the institutions pay up their instalments.
iii) Develop the carbon financing market. GoU can be able to secure carbon funding to offer subsidies to reduce interest rates and grants to the different players in the renewable energy sector since these directly contribute to reduction of Greenhouse Gas (GHG) emissions and would be collectively eligible for green financing. Carbon credits can also be earned by the private sector players and this will help in financing their businesses and reducing the need for loans.
iv) Setup a renewable energy fund. Government of Uganda through Ministry of Energy and Mineral Development (MEMD) should set up a renewable energy fund to cater for funding challenges experienced by players in the renewable energy sector such as those involved in the IICS business and the value chain. For example, this funding can (a) subsidize interest rates on loans, (b) cater for incentives to early adopters of the technology. These incentives can be used to cater for some of the other competing priorities of the institutions.

Sensitization on the potential use of savings from fuel to cover stove instalments

Contractors who build IICS and promoters of the efficient institutional cook stoves technology should ensure that institutions have clarity on potential savings that could accrue with the IICS as this will help them make the right decisions for the institutions to take up the technology. Examining the association of stove affordability through fuel savings may aid in designing funding structures and value messages that are better received by institutions owners and managers.

Proper implementation of the NAMAs

The introduction of the Nationally Appropriate Mitigation Actions (NAMAs) - Integrated Sustainable Energy Solutions for Schools in Uganda presents a change in government policy through introduction of a "Clean Cooking Policy "to promote dissemination of energy efficient cook stoves. This policy if well implemented, might shift school priorities in regard to energy budgets, thereby enabling better IICS penetration.

1.3.3.2 Non financial measures
Put in place proper institutional frameworks

The GoU needs to realize that, at the institutional level, the centralized energy model is becoming increasingly redundant in developed nations (Twaha et al, 2016). Instead of expanding its centralized power systems, Uganda needs to focus more on the development of a decentralized energy structure that would better match its current capital resources and management ability. This will help position the country to adapt to future energy technologies and systems. There should be proper coordination of stakeholders engaged in and supporting efficient institutional cook stoves initiatives in order to avoid duplication of programs and initiatives.

Sensitize institutions to create and increase awareness

There is need to create awareness among institutions through more regular direct contact and communication with institutional heads who should be sensitized on the economic, social and environmental benefits of efficient institutional cook stoves. Public awareness and acceptance are important elements for rapidly and significantly scaling up diffusion and uptake of IICS to help meet climate change mitigation goals. Increased uptake can only be undertaken successfully with the understanding and support of the public. There's need for stove manufacturers and promoters of IICS to do more intensive sales and marketing of the IICS. The stove benefits will attract institutions to take up the technology.

Given that decision making at institutions requires a number of stakeholders and a lot of time and visits to the institutions before reaching an agreement to purchase and make the installations, manufacturers should approach institutions at the "right" time. This can only be done by maintaining regular contact to be able to gauge when institution management meetings will take place such that the decision to purchase IICS are added to the meeting agendas as part of the other priority needs of the institutions. This will reduce on the time for decisions making.

Develop a skilled workforce to construct efficient institutional cook stoves

Developing a skilled workforce to construct efficient institutional cook stoves is essential for successful deployment and development of the technology in the country. The workforce should be trained on the good quality and designs that can be easily used by male and female users in the institutions. The users at the institutions should be trained in how to use and maintain the stoves.

Develop and enhance enforcement of quality standards

GoU should develop standards and regulations for energy efficiency across all sub-sectors including biomass cooking technologies. Uganda National Bureau of Standards (UNBS) and other government agencies must strictly enforce appropriate IICS manufacturing standards and specifications to ensure that manufacturers do quality work. Independent quality assurance and technology focused messaging from a trusted body like UNBS will increase customer trust in the technology and in turn will contribute to increased uptake of IICS by institutions. Quality assurance will also ensure that the stove designs take into consideration the gender interests and needs such that women do not face any difficulty in using the efficient institutional cook stoves. Quality control officers should be based at district level.

Implement policies to ensure gender inclusiveness in the energy sector

Women should play a special role in the provision and management of energy sources, since they are the most affected by inadequate energy supplies. The difference in interests, needs and priorities that women have compared to those of men should be recognized in planning, implementation and monitoring of renewable energy solutions such as IICS. Energy technologies and services should be designed and disseminated in ways that take into consideration the difference in tasks and roles. The current structure of energy consumption in Uganda accounts for much of the gender disparity with nearly 95% of total primary energy consumption due to cooking with biomass fuels, and, both women and men are involved in carrying out this task in the institutions. Inhalation of smoke and other emissions in indoor use increases the risks of respiratory diseases for the cooks. Promotion of more efficient stove designs that reduce fuel needs and cut down smoke and other emissions could be an effective approach to this problem. It is important to implement policies that ensure that gender is considered in all phases of planning and implementation: (i) at the institutional level in employment practice and human resource policies, and (ii) at the construction level through connection with social institutions and energy information campaigns targeting women; and at implementation level, by targeting both genders in a designed social intermediation process.

Foster stakeholder participation during planning of RE projects and activities

Government and project developers and promoters should foster community participation in renewable energy projects and strive to promote knowledge of and greater acceptance by the public of prospective renewable energy projects that are appropriate for their locations. This involvement should start at an early stage in the planning process. These developments should take into account the socioeconomic set up of the concerned community, including the needs of the poor. The development of the renewable energy resources should lead to employment creation and poverty alleviation.

The above measures expected to increase the adoption of efficient institutional cook stoves have been used to develop a market map, see Annex II.

1.4 Barrier analysis and possible enabling measures for Bio-latrines for institutions (using biogas technology)

1.4.1 General description of Bio-latrines for institutions (using biogas technology)

A Bio-latrine is a low maintenance system comprising a combination of a toilet and a bio-digester unit. It can be constructed using local materials and requires no machinery or fuel input other than human waste (Khatavkar & Matthews, 2013). Bio-latrines can vary dramatically in size, from household level to a system which serves a small community. It is suitable for schools, prisons, barracks and other institutions. It can be used to supplement firewood use in institutions. In most cases faecal matter is not enough to provide the necessary amount of feedstock to meet energy demand in an institution. The biogas generated can be used for cooking, lighting, refrigeration, heating and electricity production purposes or even as a substitute to petrol and diesel in engines. Many different types of the bio-latrines components exist but all are built to minimise the risk of gas leakage. This is most likely to occur in corners and joints; therefore, a cylindrical or half-sphere shape tends to be favoured. The three most common designs of plants are: fixed dome, floating drum and flexible bag digesters, which are often further adapted to suit local situations and requirements.

Regardless of the bio-latrine unit design, the human waste from the toilet or toilet block is fed via a pipe into the bio-digester chamber of the biogas unit which should be at least 0.3 m below the floor of the toilet to prevent flooding. Once the waste material has entered the bio-digester chamber, a number of biological processes take place, resulting in the formation of fatty acids such as acetic acid, which will be broken down further via anaerobic fermentation. This encourages the waste to decompose into a mixture of slurry and biogas, primarily comprised of methane (CH_4). The fermentation process requires the presence of a dark and air-free environment with temperatures of 30 - 40°C or 45 - 60°C which are most easily achieved in tropical or sub-tropical countries. Biogas collects in the upper part of the bio-digester chamber and passes through an outlet pipe at the top of the dome either to a storage facility or through pipes directly to the stoves and other appliances where it is required, whilst the slurry can be accessed by an outlet either directly or via one or more chambers.

For the bio-latrine system to work, a tested and proven design must be built by professionally trained and skilled individuals who must also ensure that the construction details are followed carefully. For example, the bio-digester chamber of a fixed dome digester is often lined with bricks and must contain high pressures of gas, so if the chamber is not constructed properly the gas will escape and the whole system will not work properly.

Particular care should also be taken to prevent non-biological materials other than human waste and toilet paper entering the system, otherwise blockages can occur. In cooler climates it may be necessary to heat or insulate the bio-digester chamber in order to achieve the optimum temperatures for fermentation and biogas production. The presence of antibiotics and disinfectants will inhibit the bacteria responsible for the anaerobic digestion and production of biogas. The units must be well constructed to contain the highly pressurised gas and prevent leakage into the surrounding environment.

Bio-latrines should be located in areas of firm but sloping ground to allow the slurry generated to flow through the biogas plant by gravity. Furthermore, pipe work on the chosen site should not interfere with the movement of people or school children.

Benefits: *Require little maintenance*: many of the biogas designs require little maintenance as there are no moving parts, therefore they are simple to operate and maintain. *Prestige and decency* due to cooking using biogas compared to the use of firewood and *clean environment* due to proper disposal and utilization of human waste, *health benefits* due to reduction in the water borne or respiratory diseases in the users' population. They are a good alternative to traditional pit latrines in flood prone areas or where a high water table makes the construction of pit latrines difficult or impractical. Unlike traditional pit latrines and VIP toilets, bio-latrines do not fill up hence are sustainable and suitable for areas where space is limited; *reduced deforestation* due to use of biogas as an alternative cooking fuel to wood; *reduced workload for women* since they are largely responsible for collecting firewood, the *slurry/biodegraded waste has a high nutrient content*, making it an ideal organic fertilizer, *income* from the fertiliser and biogas generated. Although the retention time for human excreta is 100 days, the fixed dome digester can be built to include an additional safety factor of an average of 120 days. This ensures that the waste is well treated and harmless by the time it leaves the system. The performance of the digester can be improved by having a steerer, pH meter and temperature sensors. The power needed for the operation of the digester can be provided by solar.

GoU through MEMD has piloted a project constructing bio latrines in 10 schools across the country for cooking purposes. Institutions such as schools are known to use significant quantities of firewood which negatively impact the forest assets of the country. Most of the schools use three truckloads of firewood per term. The estimated weight per truck is 850 kg, that is 2,550 kg per term. It translates to 7.65 tonnes per year for 1,000 students.

1.4.2 Identification of barriers for Bio-latrines for institutions (using biogas technology)

Biogas is one of the oldest technologies which has been disseminated in Uganda over the last 40 years, most of the initiatives on promoting this technology have previously focused on household biogas plants. One of the specific strategies for waste management is to promote the use of human waste for production of biogas, which can be used for cooking and lighting in institutions such as schools and hospitals, while the effluent can be used as fertiliser. Bio-latrines were only introduced in Uganda in the recent years and are mainly in schools. The transfer and diffusion of this technology is facing a number of barriers some being economic and financial and others being non-financial. Barriers were identified through desk review of energy sectoral reports and other publications by the consultants, the consultants held meetings with Ministry of Energy and Mineral Development (MEMD) officials, one of the consultants visited schools that utilize biogas technology from bio-latrines and efficient institutional cook stoves and during the barrier Analysis and Enabling Framework Stakeholders workshop.

1.4.2.1 Economic and financial barriers

Affordability is the main challenge for institutions such as schools and increasingly for contractors too. Bio-latrines are considered expensive and unaffordable by institutions owners and managers. The institution has to cover costs for construction of a toilet block, bio-digester chamber, expansion chambers, slurry retention tank, cover costs for connecting the biogas to the kitchen, metering it and purchase biogas stoves. These high costs discourage the institutions from taking up this technology especially since most of them already have toilets/latrines at the institutions.

Difficulty in accessing finance and collection of repayments from customers

The limited access to credit creates working capital challenges especially for bio-latrine contractors yet most of the institutions do not make full upfront payments for the systems. Contractors have to offer their services and receive payments in instalments and most institutions especially schools, opt for this over full upfront payments. In some instances contractors may also encounter delayed payment for their services or no payment at all. Companies may soon run out of working capital and may be unable to offer credit to more than a few customers at a time. Credit management is also a critical factor even when there is sufficient capital, given that delayed repayments jeopardise business operations. In addition, most financing institutions offer loans with unfavourable terms such as high interest rates. For example, at over 20% interest, credit from financial institutions is expensive and unsupportable for most companies. Most contractors are unable to access credit because they do not have a developed track record required to secure financing from banks. Further, most contractors are typically unable to provide the type & quantity of collateral banks and other financial institutions require.

Competing institution priorities

Institutions will always have high and conflicting demands on limited resources. For example, in a school, bio-latrines may not be a priority if extra classrooms or dormitories are needed. Often the clean energy solution may have to wait until more pressing needs have been met. This greatly contributes to low uptake of this technology since institutions always have these pressing needs all year round. In addition, normally institutions have a budget for their cooking needs at the beginning of the year hence convincing them to take up an alternative energy solution might not be considered pressing and may always be postponed.

Fuel savings not recognized as a source of income

The absence of explicit mentions of instalment payments may suggest that, despite targeted messaging by the contractors and promoters, institutions owners and managers may not see a precise link between affordability of the biogas from the bio-latrines and cost saving generated by the system. The dissociation could explain the low uptake of bank supported loans by the institutions. They do not appear to see savings from fuel as a potential source of income, with which to pay off loans or instalments.

1.4.2.2 Non-financial barriers

Limited knowledge of alternative feedstock

Cow dung is the most well-known feedstock used for the generation of biogas in Uganda. Most institutions and individuals are not aware of any other alternative feedstock used for the generation of biogas. With limited knowledge of alternative feedstock, some institutions may not consider the technology especially if they do not own cattle. Many institutions have human waste, food waste, peelings, dung from other animals and other bio-degradable materials but they are not aware that these too can be used to generate biogas.

Gaps in data, information and awareness of the technology

There is currently limited information related to design, construction, operation and maintenance of biogas latrines. This is probably responsible for low adoption of the technology (Mutai, et al, (2016). Many institution owners and managers may not be aware of the benefits of the bio-latrines. Informational and awareness barriers include deficient data about natural resources, often due to site-specificity.

Social biases associated with fuel from human waste

Using biogas and fertiliser from human waste may not be culturally acceptable in most settings in Uganda. Some people feel that the bad odour from human waste may affect the smell of their meals if cooked using biogas from human waste and may resist to take up the technology due to that social bias. Most people are not aware that the fuel from human waste is clean and not interfered with by the human waste odour.

Capacity gaps in operations and maintenance

The systems may fail to work because those who manage or use the bio-latrines technology have insufficient knowledge about the different operational and maintenance activities such as maintenance of main valves, checking leakages, draining of condensate water, cleaning of overflow, oiling of gas tap and cleaning of gas stoves. Research conducted in Uganda and Kenya by various researchers revealed that often bio-latrines units fell into disrepair due to lack of maintenance. A number of bio-latrines have in the past been abandoned due to poor feeding and irregular maintenance of the digesters (Arthur et al., 2011; Parawira, 2009). The lack of trained personnel responsible for construction of biogas latrines negatively affected their performance (Estoppey, 2010; Mwakaje, 2008). Additionally, biogas loss from latrines that were constructed by unskilled personnel in the slums of Nairobi was documented (Umande, 2014). The operation and maintenance of the biogas latrines is dependent on the motivation of users to get sanitation and energy benefits from installed latrines. The sense of ownership by users of the biogas latrines is an important motivation in ensuring that they are properly operated and maintained (Ghimire, 2013). Contrasting performance of biogas latrines have been reported in East Africa (Letema et al., 2012) varying even within the same city. In Kampala for example, biogas production is affected by the feeding and maintenance regimes (Lutaaya, 2013) whereas in Nairobi it is affected by operation and maintenance (Kithandi, 2014). Biogas leakage due to damage of biogas pipelines and improper maintenance of the biogas latrines may be a potential source of greenhouse gas emissions, hence contributing to global warming and climate change (Yu et al., 2008).

Inadequate institutional framework

One of the key barriers to development and uptake of new and renewable energy in Uganda is low institutional capacity and inadequate regulatory and investment frameworks to provide the enabling environment for such development, uptake and transfer of technology on a larger scale (Uganda Climate Change Policy, MoWE, 2015). There has for a long time been a lack of a standard procedure and legal instruments for new renewable energy investments. There are several institutions involved in RET development and the procedure is not well defined. The institutional structure of the energy sector in most developing/least-developed countries such as Uganda is still under government monopoly, with the responsibility for energy generation and distribution allocated among a number of government departments (Painuly,2001). However, insufficient coordination due to an array of government bodies with energy authority and the limitation of institutional capacity constituent critical institutional hindrances to the production of RETs in Uganda. This in turn creates an unsteady macro-economic environment which increases risks and dampens investments. This barrier exists not only because Uganda is still a low-income/less-developed country, but also as a result of the inadequate attention of the government to R&D and the government's failure to facilitate science activities while improving human resources. In addition, there are no regional or national research centers with the required basic research facilities and infrastructures for RETs (Wilkins, 2010).

Decision making and timing

Decision making at institutions requires a number of stakeholders and a lot of time and visits to the institutions before reaching an agreement to purchase and make the biogas construction and installations. The decision to purchase bio-latrine units is often a consultative process with other institutions stakeholders. The period between visits may be the decision makers' consultative period. Many institutions such as schools may not have taken up the bio-latrine technology because they are waiting for or deliberating the decision among stakeholders. If some stakeholders have low awareness about the benefits of the technology, then this could lead to the abandonment or delay of the acquisition process.

A problem tree with the above barriers to uptake of institutional bio-latrines has been developed, see Annex VI.

1.4.3 Identified measures

1.4.3.1 Economic and financial measures

Favourable financing and fiscal policy

In order to establish an appropriate financing and fiscal policy to enable increased demand and uptake of the institutional bio-latrines, there is need for Government to;

i) Implement, innovative financing mechanisms, including targeted subsidies to stimulate the market penetration and uptake of this biogas technology by institutions. Where subsidies are to be provided, they should be determined in a transparent manner and published. For example, GoU can subsidize interest rates to enable financing institutions provide cheaper and affordable loans to contractors and institutions as consumers of institutional bio-latrines. This will overcome the barrier of affordability experienced by institutions and difficulty in accessing finance experienced by the contractors who construct bio-latrines that use biogas technology. Reduced interest rates will attract contractors to secure loans which will increase their capital to construct more bio-latrines and bio-digesters as they await for instalment payments from customers/institutions.
ii) Develop affordable financing schemes adapted to local needs and traditions, such as revolving funds, to enable market development for renewable energy technologies. This will attract constructors to take up the funds and refund them as the institutions pay up their instalments.
iii) Develop the carbon financing market. GoU can be able to secure carbon funding to offer subsidies to reduce interest rates and grants to the different players in the renewable energy sector since these directly contribute to reduction of Greenhouse Gas (GHG) emissions and would be collectively eligible for green financing. Carbon credits can also be earned by the private sector players and this will help in financing their businesses and reducing the need for loans.
iv) Setup a renewable energy fund. Government of Uganda through Ministry of Energy and Mineral Development (MEMD) should set up a renewable energy fund to cater for funding challenges experienced by players in the renewable energy sector such as those involved in the business of constructing bio-latrines and biogas-digesters and the value chain. For example, this funding can (a) subsidize interest rates on loans, (b) cater for incentives to early adopters of the technology. These incentives can be used to cater for some of the other competing priorities of the institutions.

Sensitization on use of savings from fuel to cover bio-latrines and digester instalments

Contractors and promoters of the institutional bio-latrines using biogas technology should ensure that institutions have clarity on potential savings that could accrue with the use of biogas as opposed to firewood as this will help them make the right decisions for the institutions. Examining the association of bio-latrines and digesters affordability through fuel savings may aid in designing funding structures and value messages that are better received by institutions owners and managers.

1.4.3.2 Non financial measures

Sensitise users on alternative forms of feedstock

Operators of bio-latrines should be exposed to alternative feedstock such as food waste, peelings, animal dung and any other bio-degradable materials. They should also be sensitized on how to sort non-biodegradable waste materials and remove them from bio-degradable materials during feedstock preparation before it is poured into the digesters. Operators should be given knowledge on quantities of sufficient feedstock that will generate enough gas based on their cooking needs. Operators should be trained on preparation of feedstock before and as it is input into the digester. This will mitigate the barrier of limited knowledge on feedstock that is faced by many users and deters other institutions from taking up the technology.

There is also a need to create win-win linkages between farmers and institutions with bio-latrines such that farmers provide additional feedstock for biogas production and get slurry in return to fertilize their gardens. In addition, users need to set up collection points in communities for bio-degradable waste to save the time that would be spent in sorting the waste.

Sensitize institutions about the benefits of the technology

The social acceptance of bio-latrines is a major hurdle to implementation and uptake of the technology. Bio-latrines require a cultural shift in how people think about the proper way to manage their wastes. They also require a reconfiguration of mindsets so that people understand that the fuel from human waste cannot contaminate their food. An additional measure would involve getting people to think more about the collective benefit of an improved waste management system. There is need to sensitize institutions to create and increase awareness through more regular direct contact and communication with institutions owners and managers. These should be sensitized on the economic, social and environmental benefits of biogas from human waste. Government should finance country wide biogas technology awareness campaigns by setting up demonstration sites in communities. These sites will not only contribute to awareness creation but also capacity building, jobs and research and development. Public awareness and acceptance are important elements in the need to rapidly and significantly scale up diffusion and uptake of the bio-latrines using biogas technology. Increased uptake can only be undertaken successfully with the understanding and support of the public.

Provide ample skills to masons

A study conducted in Uganda and Kenya showed that skills of masons responsible for construction of biogas latrines affected the performance of biogas latrines as the number of hours of burning were proportionate to the level of skills of masons, (Mutai et al, 2016). Masons need to be trained on how to effectively and efficiently construct biogas plants to the rightful shapes, sizes and texture for ultimate quality and quantity. They should also be trained on the consideration of feedstock quantities while sizing biogas systems for the institutions.

Training of users on operation and maintenance aspects of the biogas latrines

A study conducted on biogas latrines in Uganda and Kenya, revealed that training of users was an important factor that influenced biogas latrine performance, (Mutai et al, 2016). The users were trained on proper feeding of the digester, optimal use of biogas, avoidance of use of non-biodegradable matter, regular maintenance of biogas latrine components and effective application of slurry. The biogas latrines where users had comprehensive training recorded the highest number of burning hours in a day. Bio-latrine owners and operators should be trained on how to keep records of whatever operations they do on the plant such as the feeding dates and quantities, the emptying dates and stirring dates and durations for efficient monitoring and maintenance.

Put in place proper institutional frameworks

Furthermore, the GoU needs to realize that, at the institutional level, the centralized energy model is becoming increasingly redundant in developed nations (Twaha et al, 2016). Instead of expanding its centralized energy systems, Uganda needs to focus more on the development of a decentralized energy structure that would better match its current capital resources and management ability. This will help position the country to adapt to future energy technologies and systems. There should be proper coordination of stakeholders engaged in and supporting institutional bio-latrines (using biogas technology) in order to avoid duplication of programs and initiatives.

Approach institutions at the right time

Given that decision making at institutions requires a number of stakeholders and a lot of time and visits to the institutions before reaching an agreement to contract companies of individuals to construct bio-latrines and install biogas systems, contractors should approach institutions at the "right" time. This can only be done by maintaining regular contact to be able to gauge when institution management meetings will take place such that the decision to contract bio-latrine and biogas contractors are added to the meeting agendas as part of the other priority needs of the institutions. This will reduce on the time for decisions making.

Measures to overcome the barriers to the uptake of institutional bio-latrines (using biogas technology) have been developed into a market map, see Annex III.

1.5 Linkages of the barriers identified

Solar rooftop systems as one of the prioritized technologies will be majorly for lighting and powering small appliances both at the household and institutional levels such as in schools, health centres, prisons, barracks and any other institutions. Efficient institutional cook stoves will be used for cleaner cooking in institutions as they will use less firewood for more cooking. The biogas generated from institutional bio-latrines can be used for cooking, lighting, refrigeration, heating and electricity production purposes or even as a substitute to petrol and diesel in engines. Although the technologies are different from one another; they have some linked common barriers and measurers as highlighted;

High upfront cost and difficulty in accessing finance

Importers of solar rooftop systems, manufacturers of improved cook stoves and contractors who construct bio-latrines that use biogas technology are faced with a barrier of difficulty in accessing finances from banks and other financial institutions majorly due to high interest rates. These high costs of acquiring finances are incorporated in the costs of renewable energy technologies and this greatly leads to high upfront costs of acquiring these technologies which is a major barrier in the uptake of the prioritized technologies by the potential users. The other factors that contribute to high upfront costs include; taxes on importation of renewable energy components and lack of appropriate financing mechanisms to facilitate the development and promotion of renewable energy technologies.

These two barriers can be overcome by putting in place and properly implementing favourable financing and fiscal policies. In order to establish appropriate financing and fiscal policies to attract more investments and enable RETs such as solar rooftop systems, efficient institutional cook stoves and bio-latrines (using biogas technology) to penetrate different markets, there is need for Government to;

i) Implement innovative financing mechanisms, including targeted subsidies to stimulate the market penetration of renewable energy technologies. Where subsidies are to be provided, they will be determined in a transparent manner and published. For example, GoU can subsidize interest rates to enable financing institutions provide cheaper and affordable loans to importers of solar rooftop system components, manufacturers of efficient institutional cook stoves and those involved in the construction of bio-latrines that use biogas technology. Reduced interest rates will attract importers, manufacturers and contractors to secure loans which will increase their capital to provide the prioritized RETs in various parts of the country. Subsidies on interest rates will also overcome the barrier of difficulty in accessing finances by suppliers and contractors as they will be able to provide the prioritized RETs at lower prices and is expected to increase demand and uptake of these technologies.
ii) Introduce specific regimes that favour renewable energy. These will include preferential tax treatment and tax exemptions.
iii) Develop financing schemes adapted to local needs and traditions, such as revolving funds, to enable market development for small, appropriate renewable energy technologies for rural

development, such as household solar PV systems, and provision of the other two prioritized technologies.

iv) Develop the carbon financing market. GoU can be able to secure carbon funding to offer subsidies to reduce interest rates and grants to the different players in the renewable energy sector since these directly contribute to reduction of Greenhouse Gas (GHG) emissions and would be collectively eligible for green financing. Carbon credits can also be earned by the private sector players and this will help in financing their businesses and reducing the need for loans.

v) Setup a renewable energy fund. Government of Uganda through Ministry of Energy and Mineral Development (MEMD) should set up a renewable energy fund to cater for funding challenges experienced by players in the businesses value chains of the prioritized technologies. For example, this funding can (a) subsidize interest rates on RE loans, (b) provide low cost funding in financial institutions to attract investors in the RE sector, and to (c) cater for incentives to early adopters of the technologies in the communities

Inadequate institutional framework

One of the key barriers to development and uptake of new and renewable energy in Uganda is low institutional capacity and inadequate regulatory and investment frameworks to provide the enabling environment for such development, uptake and transfer of technology on a larger scale (Uganda Climate Change Policy, MoWE, 2015). There has for a long time been a lack of a standard procedure and legal instruments for new renewable energy investments. There are several institutions involved in RET development and the procedure is not well defined. The institutional structure of the energy sector in most developing/least-developed countries such as Uganda is still under government monopoly, with the responsibility for energy generation and distribution allocated among a number of government departments (Painuly, 2001). However, insufficient coordination due to an array of government bodies with energy authority and the limitation of institutional capacity constituent critical institutional hindrances to the production of RETs in Uganda. This in turn creates an unsteady macro-economic environment which increases risks and dampens investments. This barrier exists not only because Uganda is still a low-income/least developed country, but also as a result of the inadequate attention of the government to R&D and the government's failure to facilitate science activities while improving human resources. In addition, there are no regional or national research centers with the required basic research facilities and infrastructures for RETs (Wilkins, 2010). There is also a barrier of uncoordinated stakeholder activities among those who promote the technology. This leads to duplication of initiatives.

To overcome the above barrier, GoU needs to realize that, at the institutional level, the centralized energy model is becoming increasingly redundant in developed nations (Twaha et al, 2016). Instead of expanding its centralized power systems, Uganda needs to focus more on the development of a decentralized energy structure that would better match its current capital resources and management ability. This will help position the country to adapt to future energy technologies and systems. There should also be proper coordination of stakeholders engaged in and supporting RE programs in order to avoid duplication of programs and initiatives.

Limited information and public awareness about RETs

Limited public awareness has been known to be one of the main barriers in the utilization of renewable energy (RE) technologies (Adebayo et al., 2018). The most common issues associated with this are inadequate knowledge regarding the use, importance, socio-economic and environmental benefits that are derivable from renewable energy and its technologies, and the fears in relation to the economic feasibility of RE installation projects. Most of the providers of RE technologies do not give the end users sufficient information on use and maintenance of the systems and setups. Information is mostly given orally at the time of installing or constructing the systems to the head of the household or operator of the RE technology at the institutions. When an installation or system fails to operate the users may not be able to remember the one-time information to handle the maintenance.

The above-mentioned barrier can be overcome by consistent information and technology awareness creation on the RETs by Government, technology promoters, entrepreneurs and other interested parties. The implementation of RE applications such as the three prioritized technologies can only be embarked upon successfully if there is an improved understanding and support of the public. Hence, an increased awareness of the prospect and advantages associated with the development of RETs, and the fundamental advantage for climate change alleviation is quite important to swiftly and appreciably enhance the desire and interest among the Ugandan populace. Primarily, a centralized data-based information center that is both comprehensive and accessible to the public needs to be established. This center will be expected to keep records of the various field experience acquired during the installation, operation and maintenance of RE technology systems and make available information that is related to RE incentives, RETs, RE policies and the utilization of RETs systems to investors, promoters, users and all those players in the business value chains of the different RETs. Such information can act as an important tool for learning and thereby allowing RE sector players to expand and adapt RETs for particular environmental conditions. This center will not only serve a means of assessing resources, but also as a monitoring and evaluation means. Thus, with proper management of the center, there will be increase in general awareness, reception and interest in RETs. Government should finance country wide clean energy awareness campaigns. Government should finance country wide clean energy awareness campaigns by setting up demonstration sites in communities. These sites will not only contribute to awareness creation but also capacity building, jobs and research and development. It is therefore clear that an increased access to RE technology-related information and technology is crucial to the successful development of RETs in Uganda.

Training of the media and equipping them with relevant knowledge and information about the renewable energy sector is also a step in the right direction. This is because the media plays a key role in information dissemination to the public.

Capacity gaps in installation, operations and maintenance of RETs

Technical support for diffusion of renewable energy technologies (RETs) in communities requires a large workforce that has a basic technical skill rather than a few experts with high technical skills. Training such artisans and ensuring that they have ready access to spare parts requires the establishment of new infrastructure that can provide a quality training platform for technical and engineering personnel. Generally, in most of the least-developed countries such as Uganda, the lack of such an auxiliary industry usually results in higher cost of RE projects and further barriers to deployment (Murphy et al, 2014). Presently, in Uganda, there are limited trained personnel and training facilities for the installation, operation, and maintenance of RETs which make it very difficult for the country to achieve a sustainable RE market (Raisch, V. 2016). This is also coupled with lack of technical certification for servicers, this means customers are unaware of where to go when RETs break down.

The barrier of capacity gaps can be overcome by developing a skilled workforce to install, operate and maintain RETs most especially at the community level. Developing a skilled workforce to operate and maintain RETs is essential for a successful deployment and development of technologies in the country. The development of RE calls for skills in different fields that may include physics, materials science, chemical, mechanical, and electrical engineering, business management and social science (Wilkins, 2010). Nonetheless, the different groups need precise training, since the set of skills may vary in detail for the different technologies. It is also essential that RE technology users understand the availability and explicit operational features of RE sources. In particular, this is highly significant in the rural areas of least-developed countries such as Uganda. In addition to training technicians, RET users too should be provided with ample training. The users of RETs are key persons in maintaining the systems and making them function well. It is not enough to orally train one member of the household or one staff of the institution on the RETs maintenance. It would be a good idea to give a maintenance and safety poster to the end user. Technicians should train end users on; advantages and limitations of solar rooftop systems and maintenance; they should listen to the end user’s needs, ensure that the spare parts for the systems are available, be available to the users.

1.6 Enabling framework for overcoming the barriers in the Energy Sector

The transfer and diffusion of consumer goods such as solar rooftop systems, efficient institutional cook stoves and bio-latrines (using biogas technology) is predominantly influenced indirectly by politically changed market conditions. This means that the scope for government interventions to promote particular consumer goods technologies is related to the broad enabling framework conditions as highlighted below;

Table 5: Enabling framework to overcome common barriers in the RETs sector

<table>
<tr><th>Barrier</th><th>Enabling framework</th><th>Responsible</th></tr>
<tr><td>High upfront cost of RETs</td><td rowspan="2">Implement innovative financing mechanisms, including targeted subsidies to stimulate the market penetration of renewable energy technologies

Introduce specific regimes that favour renewable energy. These will include preferential tax treatment and tax exemptions

Implement innovative risk mitigation mechanisms and credit enhancement instruments to provide comfort to lenders

Develop financing schemes adapted to local needs and traditions, such as revolving funds

Develop the carbon financing market. GoU can be able to secure funding to offer subsidies to reduce interest rates and grants.

Setup a renewable energy fund. Government of Uganda through Ministry of Energy and Mineral Development (MEMD) should set up a renewable energy fund to cater for funding challenges experienced by players in the businesses value chains of the prioritized technologies. For example, this funding can (a) subsidize interest rates on RE loans, (b) provide low cost funding in financial institutions to attract investors in the RE sector, and to (c) cater for incentives to early adopters of the technologies in the communities</td><td rowspan="2">MEMD, URA, REA, MoFPED</td></tr>
<tr><td>Difficulty in accessing finance</td></tr>
<tr><td>Inadequate legal and institutional framework</td><td>GoU should put in place proper institutional frameworks</td><td>MEMD, MoWE MoSTI</td></tr>
<tr><td>Limited information and public awareness about RETs</td><td>Consistent information and technology awareness creation on the RETs by Government, technology promoters, entrepreneurs and other interested parties</td><td>MEMD, REA, Technology promoters, Media</td></tr>
</table>

Capacity gaps in installation, operations and maintenance of RETs	Develop a skilled workforce to install, operate and maintain RETs most especially at local community level Government should finance country wide clean energy awareness campaigns by setting up demonstration sites in communities for capacity building, research and job creation	MEMD, REA, RE Associations, Universities & other tertiary institutions

Table 6: Enabling framework for Solar rooftop systems

Category	Barrier	Enabling framework	Responsible
Financial	Low disposable income especially among the rural population	Provide grant funding to support agricultural activities especially for rural farmers. Development of agricultural sector will enable the rural communities to engage in commercial farming and this will lead to increased incomes among the population hence overcoming the barrier of low disposable income Promote solar energy for productive use such that users gain income from the solar systems. This will contribute to overcoming the barrier of low disposable income	MoFPED, MEMD, MAAIF
	Unclear & inconsistent tax policy on solar rooftop system components imports hurts business case, prevents operators from planning pricing & orders.	Government of Uganda should exempt all solar rooftop system components from taxes and this should be clearly communicated to all importers and other players in the sector	MoFPED, MEMD, URA
	Poor infrastructure and the cost of setting up a distribution network. This also contributes to high maintenance costs since most of the retailers are based in urban centres with customers in hard to reach rural areas	Develop financing schemes adapted to local needs and traditions, such as revolving funds which can be accessed by distributors and retailers	MoFPED, MEMD
	Difficulty in managing currency risk	Favourable forex exchange conversion terms in order to overcome the barrier of difficulty	MoFPED

		in managing currency risk faced by importers who purchase solar rooftop components in foreign currency and sell the components in Uganda Shillings	
	Pay As You Go (PAYG) solutions discourage customers due to lockouts	Provide grant funding to support agricultural activities especially for rural farmers. Development of agricultural sector will enable the rural communities to engage in commercial farming and this will lead to increased incomes among the population. Some will have the money to buy solar systems by cash and those who will buy on credit will also be able to cover their daily payments to avoid lockouts.	MoFPED, MEMD, MAAIF
Non-financial	Ineffectual quality control of products	Enhanced enforcement of quality standards Strengthen the capacity of the private sector for self-regulation under the relevant umbrella associations	UNBS, RE Associations, Police, Judiciary
	Service and maintenance are out of reach in rural communities	Develop financing schemes adapted to local needs and traditions, such as revolving funds which can be accessed by distributors and retailers	MoFPED, MEMD
	Research and Development is not a Government priority	Government should fund and promote Research and Development (R&D), International Co-operation and Technology Transfer and adoption of standards in the design and manufacturing of solar rooftop systems to promote local production	MoFPED, MEMD, MoES, Universities and other tertiary institutions

Table 7: Enabling framework for Efficient Institutional Cook Stoves

Category	Barrier	Enabling framework	Responsible
Financial	Competing institution priorities	Subsidize interest rates Develop financing schemes adapted to local needs and traditions, such as revolving funds, to enable market development for renewable energy technologies.	MoFPED, MEMD, MoES

		Proper implementation of the NAMAs	
	Fuel savings not recognized as a source of income	Sensitization on use of savings from fuel to cover stove installation costs	MEMD, Promoters & Contractors
Non-financial	Poor quality and stove designs	Develop standards and regulations for biomass cooking technologies Enhanced enforcement of quality standards Strengthen the capacity of the private sector for self-regulation under the relevant umbrella associations	UNBS, RE Associations, Police, Judiciary
	Low women participation in the sector	Implement policies to ensure gender inclusiveness in the energy sector	MEMD, MGLSD

Table 8: Enabling framework for Bio-latrines for Institutions (using biogas technology)

Category	Barrier	Enabling framework	Responsible
Financial	Competing institution priorities	Subsidize interest rates Develop financing schemes adapted to local needs and traditions, such as revolving funds, to enable market development and uptake of renewable energy technologies.	MoFPED, MEMD, MoES
	Fuel savings not recognized as a source of income	Sensitization on use of savings from fuel to cover bio-latrines and digester installation costs	MEMD, Promoters & Contractors
Non-financial	Limited knowledge of alterative feedstock	Train users on alternative feedstock Facilitate the establishment of linkages between institutions and communities that have alternative feedstock in abundance	MEMD, RE Associations, Promoters and Contractors
	Social biases associated with fuel from human waste	Sensitization of institutions about the benefits of the technology	MEMD, RE Associations

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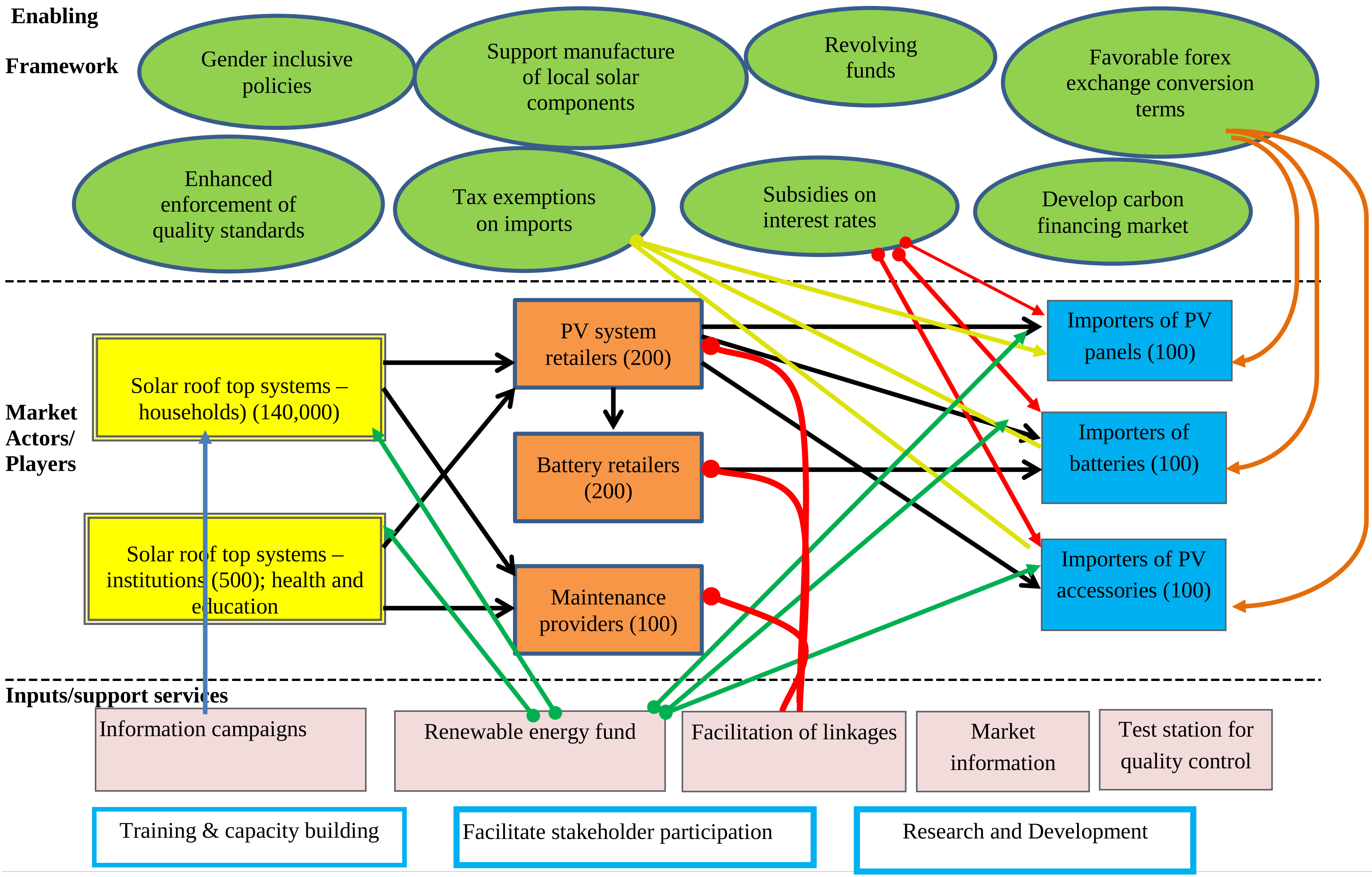
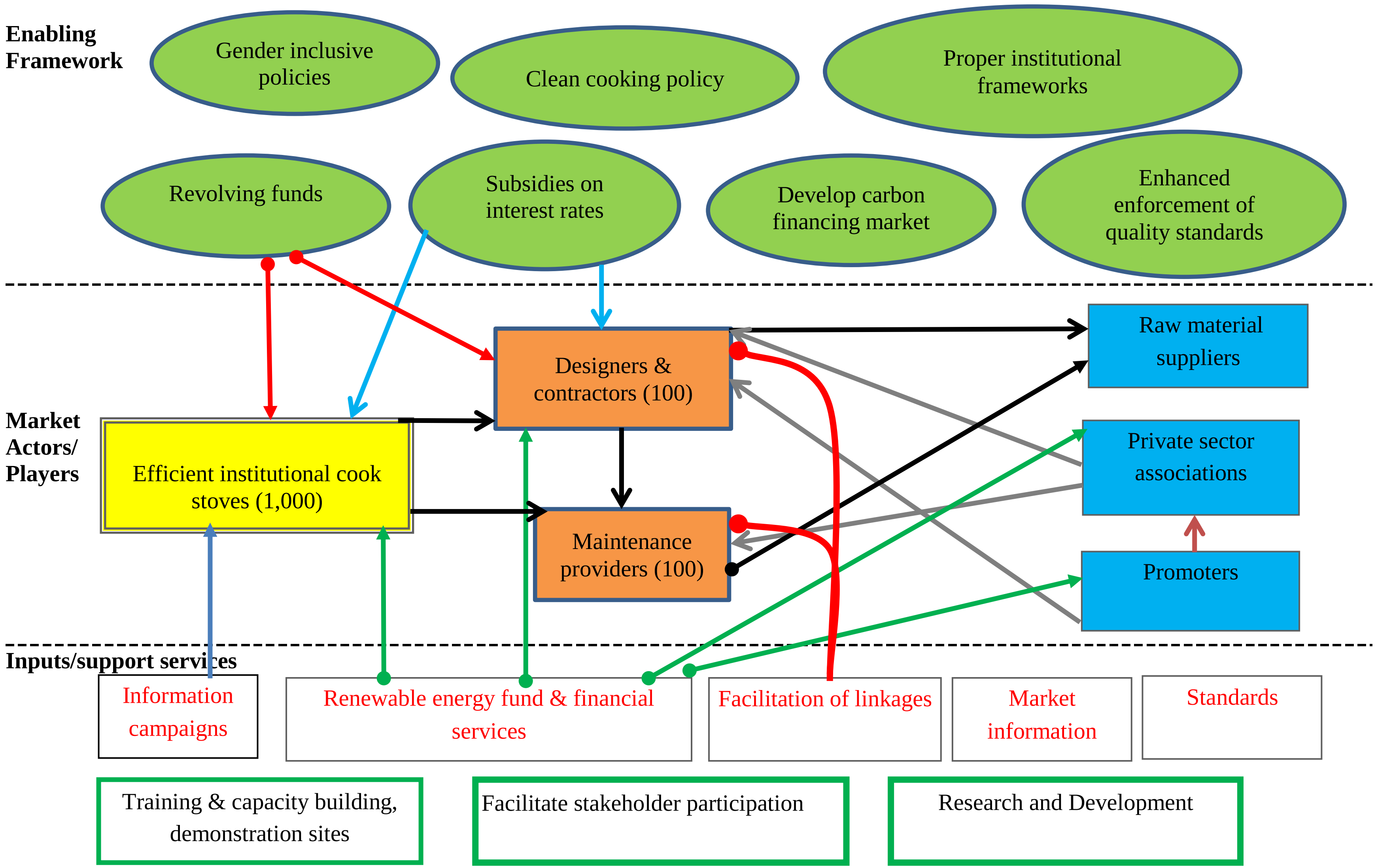
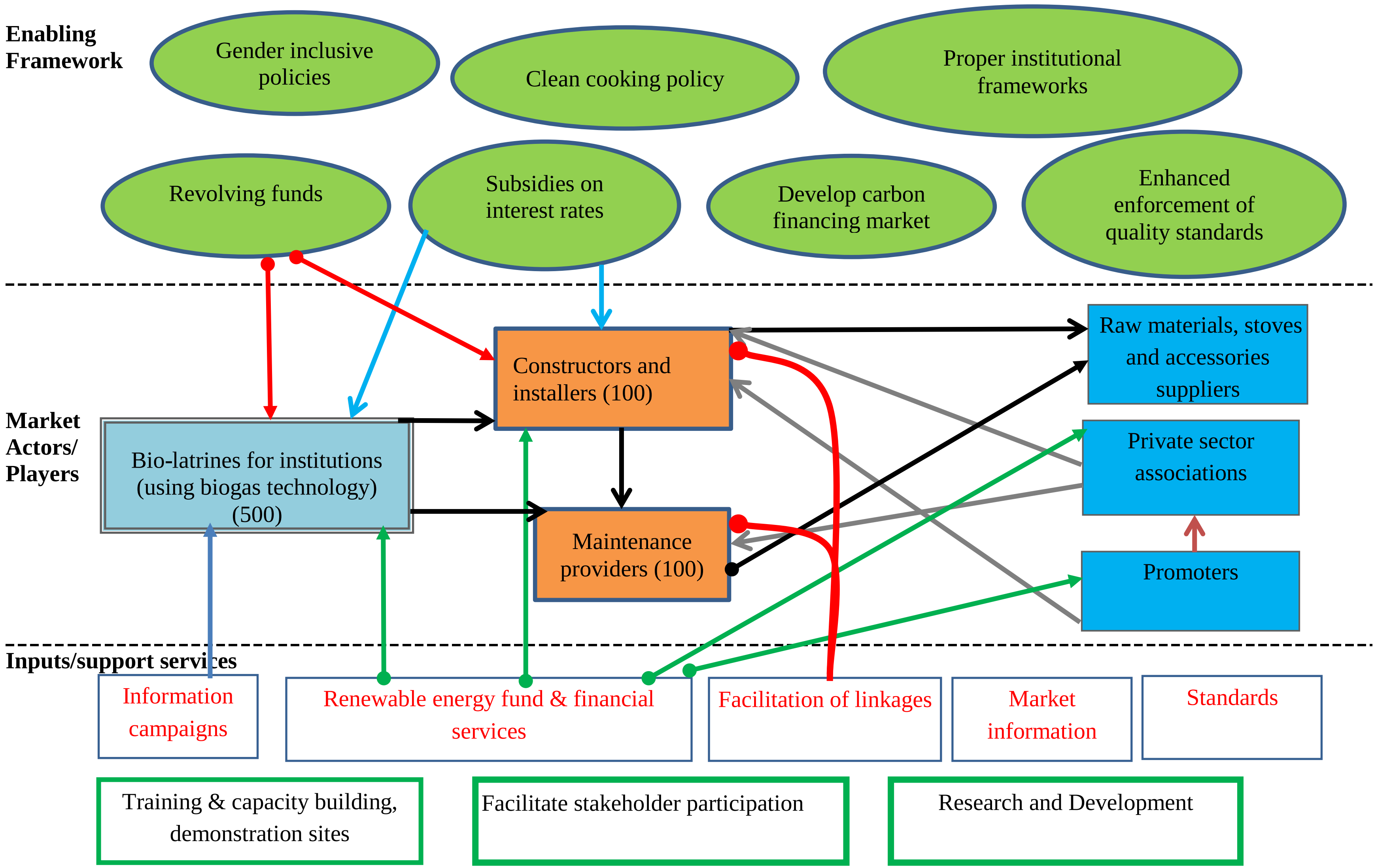
Annex I: Market map for solar rooftop systems (Measures)



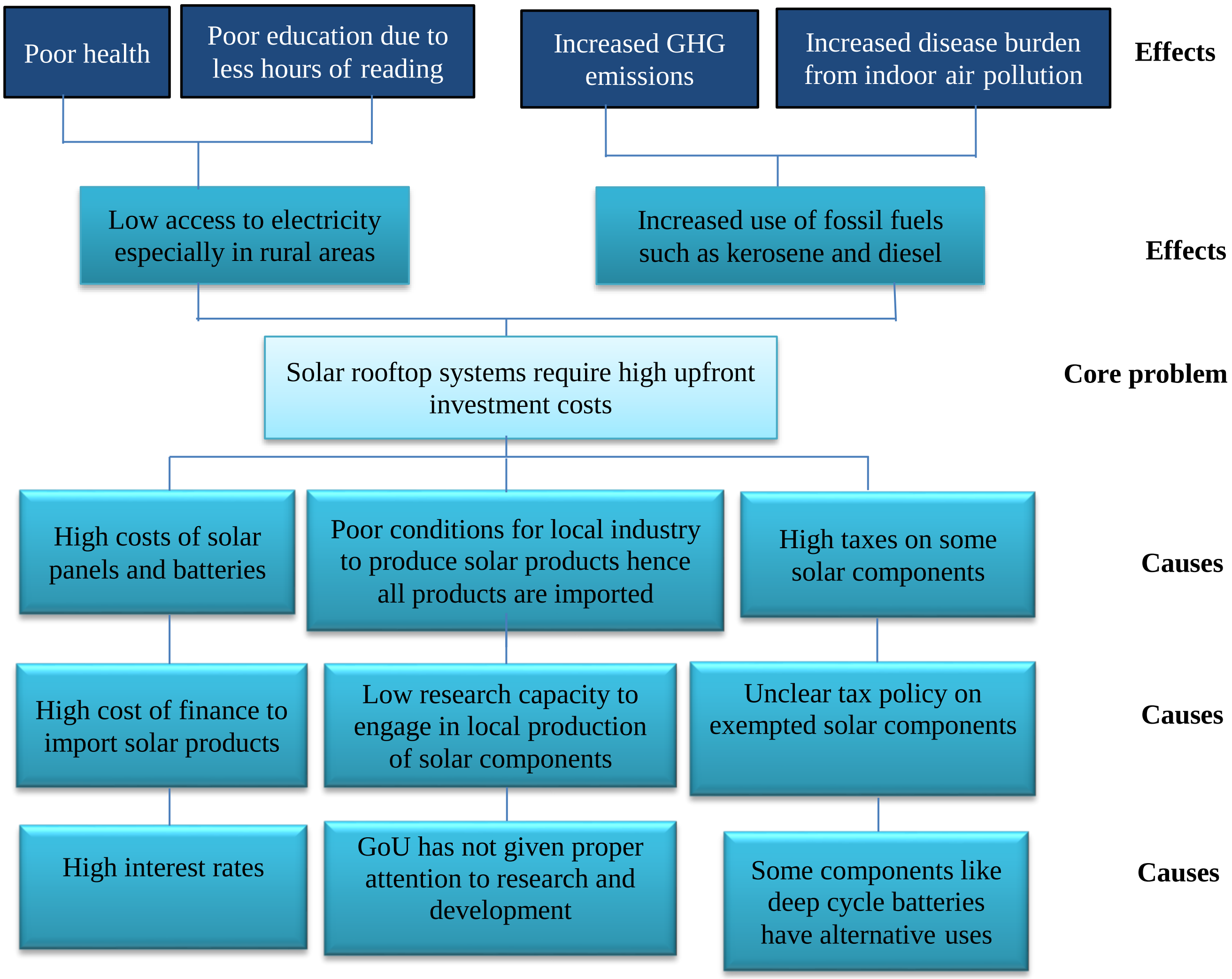
Annex II: Market map for efficient institutional cook stoves (Measures)



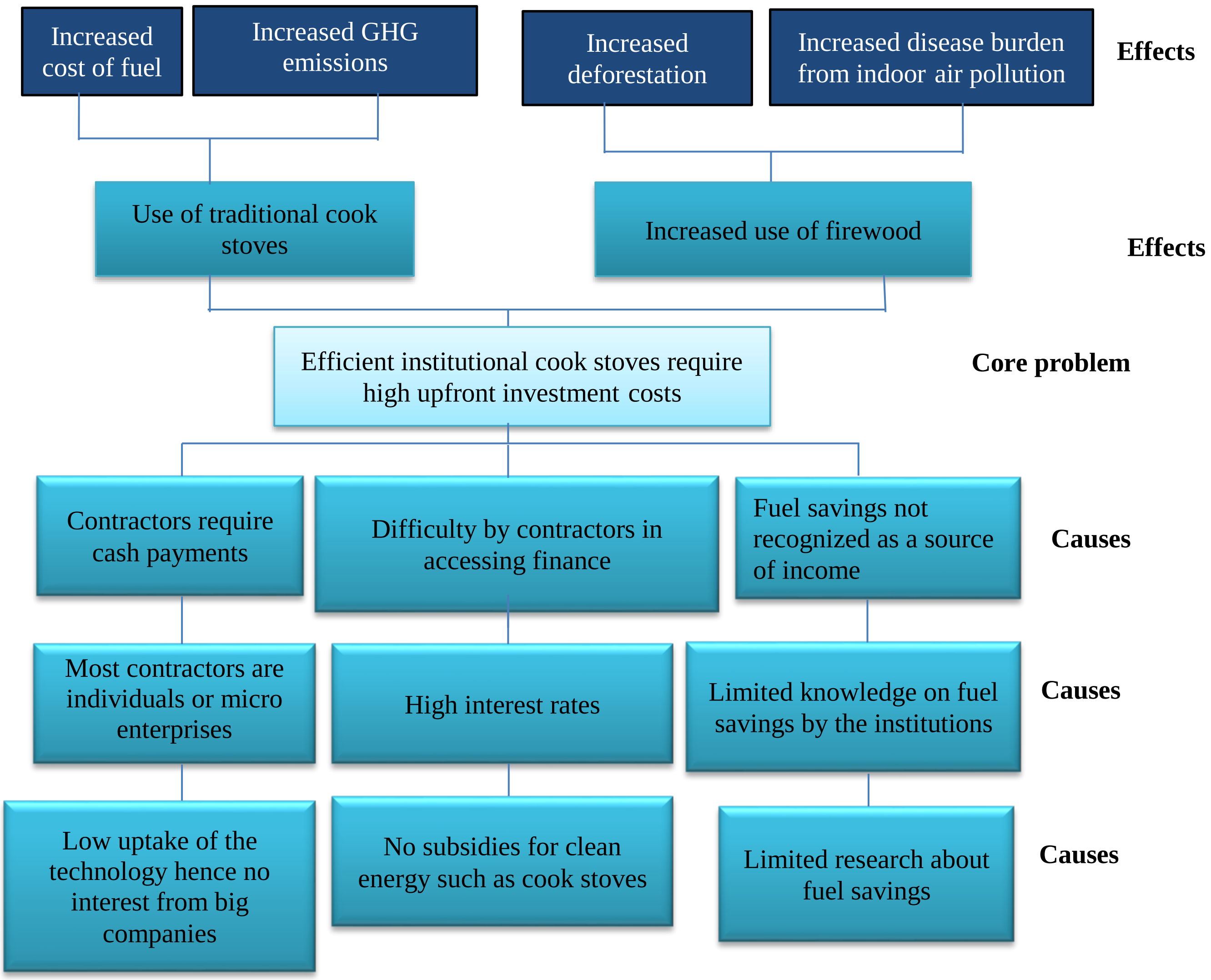
Annex III: Market map for bio-latrines (using biogas technology) - Measures



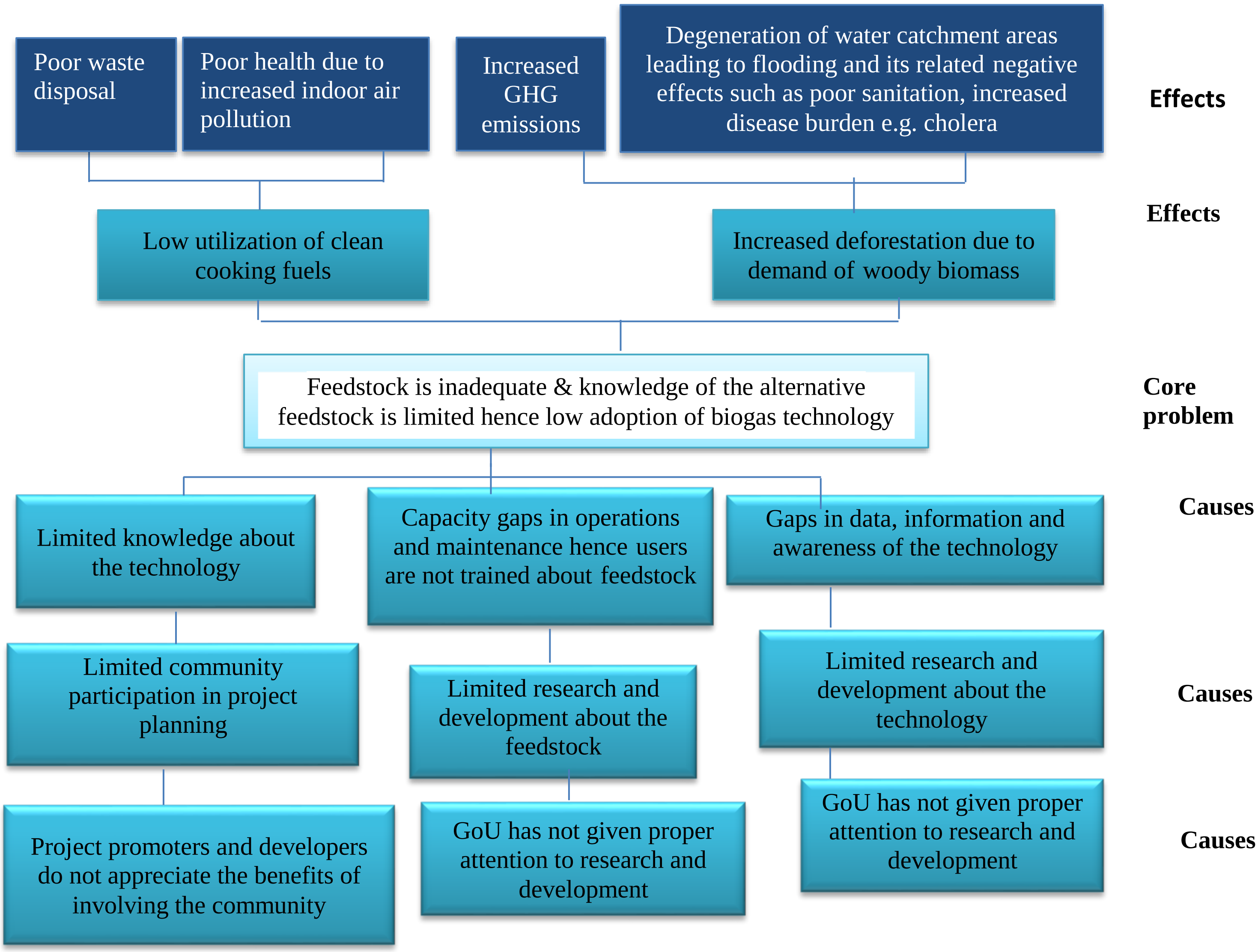
Annex IV: Problem tree for solar rooftop systems



Annex V: Problem tree for efficient institutional cook stoves



Annex VI: Problem tree for institutional bio-latrines (using biogas technology)



Annex VII: List of stakeholders involved and their contacts

List of stakeholders involved in the identification of barriers and development of enabling framework.

NO	NAME	INSTITUTION	CONSULTATION APPROACH
National Coordinator			
1.	Dr. Maxwell Otim Onapa	Ministry of Science Technology and Innovation (MOSTI)	Barrier Analysis and Enabling Framework workshop
2.	Mrs. Deborah Kasule	Uganda National Council for Science and Technology	Barrier Analysis and Enabling Framework workshop
Consultants			
3.	Prof. Adam M. Sebbit	Makerere University	Barrier Analysis and Enabling Framework workshop
4.	Ms. Claire Kagga	Renewable Energy Business Incubator Limited	Barrier Analysis and Enabling Framework workshop
Other stakeholders			
5.	Mr. Ayub Mukisa	Makerere University	Barrier Analysis and Enabling Framework workshop
6.	Mr. Wilson Wafula	Ministry of Energy and Mineral Development	Meeting discussion at the Ministry
7.	Ms. Christine Kaaya	Parliamentary Forum on Climate Change	Barrier Analysis and Enabling Framework workshop
8.	Mr. Emmy S. Kimbowa	Uganda Solar Energy Association (USEA)	Barrier Analysis and Enabling Framework workshop
9.	Ms. Esther Nyanzi,	UNREEEA	Barrier Analysis and Enabling Framework workshop
10.	Mr. Hatimu Muyanja	Ministry of Energy and Mineral Development	Meeting at the Ministry and field visits to three (3) schools with bio-latrines and efficient institutional cook stoves
11.	Head Teacher and Staff	St. Theresa Girls Primary School Kisubi	Field visit and interview at the school premises
12.	Head Teacher and Staff	Bombo Army Secondary School	Field visit and interview at the school premises

13.	Ms. Loi Namugenyi	Uganda National Council for Science and Technology	Barrier Analysis and Enabling Framework workshop
14.	Mr. Abdu Kalema	Powercon Limited	Barrier Analysis and Enabling Framework workshop
15.	Ms. Miriam Talwisa	Climate Action Network (CAN) Uganda	Barrier Analysis and Enabling Framework workshop
16.	Dr. Peter Ndemere	Uganda National Council for Science and Technology	Barrier Analysis and Enabling Framework workshop
17.	Ms. Prossy M. Namulindwa	Ndejje University	Barrier Analysis and Enabling Framework workshop
18.	Ms. Saana Ahonen	UNFCCC Regional Coordination Centre	Barrier Analysis and Enabling Framework workshop
19.	Ms. Rita Rukundo	UNFCCC Regional Coordination Centre	Barrier Analysis and Enabling Framework workshop
20.	Mr. Joseph Epitu	Ministry of Water and Environment (MoWE)	Barrier Analysis and Enabling Framework workshop
21.	Mr. Jacobs Johannes	ACTADE	Barrier Analysis and Enabling Framework workshop
22.	Mr. Yusuf Ssebuuma	Victron Solar Co. Limited	Barrier Analysis and Enabling Framework workshop
23.	Dr. Sara Namirembe	Step-up Standard Limited	Barrier Analysis and Enabling Framework workshop
24.	Deputy Head Teacher and staff	Bishop's East Primary School Mukono	Field visit and interview at the school premises