Centre for Research in Energy and Energy Conservation

Northern Uganda Energy Study

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1. Introduction

1.1. General context and aim of the study

Uganda is one of the countries in the world with the least developed access to modern energy services. More than 93% of its primary energy needs are covered by biomass (firewood and charcoal) whereas 6% are produced through the combustion of fossil fuels (transport and industry) and only 1% consists of electricity out of hydro-power and thermal power plants (burning oil and diesel). Biomass which is by far the most important energy carrier is used in a highly inefficient way primarily for cooking, leading to a considerable overuse of Uganda's forestry resources for the last 15 years. The ongoing pressure on the remaining resources, including forest reserves, is exacerbated by the strong population growth of approximately 3.5% p.a.

The region of Northern Uganda is in particular affected by underdevelopment and widespread poverty, especially in the rural areas. With a poverty level of more than 46% (2010), the North is the poorest region of Uganda, lacking access to basic services, infrastructure and income opportunities. Slowly, this region is recovering from a 20-year ravaging civil war that left many people displaced from their homes. With the region now benefitting from stability and various post-conflict development programmes, most people have returned to their homes. However this comes with increased pressure on natural resources and the environment as they start rebuilding their livelihoods that in most cases rely on forest resources for cooking and construction. Alarming degrees of forest depletion in North Uganda are the result.

With the increasing scarcity of forest resources, costs for cooking increase and people are forced to spend more time on collecting firewood. In addition, the widely popular traditional 3-stone-fire characterized by its highly inefficient combustion of firewood does not only waste a lot of energy but also causes widespread and potentially fatal lung diseases among the rural population.

Commissioned by the Wildlife Conservation Society (WCS) and its Wildlife, Landscape and Development for Conservation programme (WILD) the present study, carried out by the Centre for Research in Energy and Energy Conservation (CREEC) focuses on current technologies that are promoting renewable energies as an alternative source for conventional biofuel in Northern Uganda, with a special focus on the six districts of Adjumani, Amuru, Nwoya, Lamwo, Kaabong and Moyo. Particular attention was given to technologies that are simple, appropriate and affordable, offering an option to either replace or reduce the use of firewood and/or charcoal as the main cooking fuel source. In addition, alternatives to the costly and hazardous use of kerosene, woodfire and candles as main lighting source have been elaborated, providing a complementary and polyvalent impact to the above mentioned reduction of fuelwood use.

1.2. Content of the study

The study starts with a market technology analysis, providing a general overview on the various technologies that are of interest for the WCS/WILD programme. For this part, CREEC was in particular concerned with providing a comprehensive set of information for each technology, covering the technical features, strong and weak points as well as their current status in the renewable energy sector of Uganda.

The market analysis is followed by a socio-economic analysis which assesses the current energy needs of the institutions in the surveyed areas as well as their costs (monetary and non-monetary) and the challenges that are related to the acquisition of this energy. Moreover, the institutions' interest and ability to contribute to the acquisition of alternative energy sources were examined in order to complete this section.

Subsequently, a cost-benefit analysis was elaborated for recommended institutions and the respective technologies that were considered to be the most appropriate for the specific context. Particular attention was given to the amount of fuelwood that would be saved by using this technology and in what period of time the upfront costs would be paid back. As the usual market price of biofuels does not take into account environmental and social externalities, those factors were added to the cost-benefit-analysis in order to underscore the actual added value of the technologies to be introduced. A concluding evaluation mentioned key-aspect that were taken into account and refined the recommendations made with regards of the specific interventions.

A strategic implementation plan is the logical next step, outlining the key elements of putting in place the technologies in question. In particular focuses are funding schemes, technical site assessments, installation, training and the envisaged time frame. A particular concern is the long-term sustainability of the technology-use by the institutions, which is sought to be ensured through cost-sharing and ownership, quality products, thorough and adapted training as well as through a tight monitoring and evaluation scheme. This approach is to tackle upcoming problems and elaborate improvements – also in respect of a future roll-out of the envisioned interventions.

1.3. Methodology

For the study, on-site visits at 63 institutions and 2 SMEs in total were carried out, covering the districts of Adjumani, Amuru, Nwoya, Lamwo, Kaabong and Moyo (see Annex 1). These institutions included primary and secondary schools (both government and private), health centres, prisons, technical institutes and parishes. What institutions had in common was that they cook their own food, using firewood and /or charcoal as biofuel source. Even institutions which do not cook food were taken into account, being not in the primary focus though, as in many cases, the demand for firewood and cooking was there, only the necessary means were lacking.

In the first stage of each visit, the survey team used semi-structured questions on the amount and type of biofuel as well as on the awareness of energy efficient technologies when inspecting the site together with an institution's representative. In the second stage, a questionnaire with more specific questions was filled out together with the representative, compiling all relevant information for assessing the needs, costs and acquisition of energy used for cooking and lighting by this institution. Furthermore, information on available resources for alternative technologies was collected and the institution's interest and ability to contribute to a possible intervention assessed.

After each visit, a data assessment sheet was filled out in order to document the data collected and to be able to compare and analyze the findings later.

2. Market technology analysis

This market analysis focused on current technologies that help to reduce or replace the use of conventional cooking fuel in institutions within the surveyed area. It provides a brief overview on existing energy efficient technologies basing on improved institutional cook stoves, biogas, pico-PV, gasification and briquettes. The analysis also comprises the technologies' specific plus- and minus points as well as their general status in the Ugandan energy sector in order to provide a comprehensive picture of their appropriateness as intervention tools in the surveyed area.

2.1. Improved cook stove analysis

2.1.1. What are improved cook stoves?

Improved cook stoves belong to biomass energy efficient technologies that have been developed in order to achieve relatively efficient firewood /charcoal combustion and maximizing heat transfer to the food being cooked. Simply put, improved cook stoves consists of a combustion chamber and several insulating layers around it to guide the heat directly towards the saucepan. In addition, institutional improved cook stoves feature a chimney that channels the hazardous smoke towards the outside of the kitchen.

2.1.2. Types of improved cook stoves

There are two broad categories of improved cook stoves that are disseminated and in use in Uganda today.

Improved household cook stove

These stoves are specially designed for the household use, existing in mobile and fixed versions. Depending on the design, these stoves can be used with firewood or charcoal. Their design is kept very simple in order to enable replication in the rural areas with minimum training. Basic material comprise ant hill soil and clay for the base and grass as well as saw-dust as insulation material. The fuel-saving effect, however, is reduced by using this simple version. In contrast, semi-industrially manufactured improved stoves for households feature a higher life expectancy and increased saving potential, requiring a distribution network and higher purchase costs though.

Picture 1: Improved household cook stove

Improved institutional cook stove

This type of stove serves as a heavy-duty cooking /baking utility for larger establishments such as schools, hospitals, prisons and army barracks, existing also as mobile and fixed versions. Their design is more sophisticated than the improved household cook stoves, featuring a higher degree of insulation, stability as well as a chimney. Their production requires low-tech but quality material (bricks, plaster, pipes etc.) and skilled craftsmanship. Their costs are significantly high, however their life expectancy and fuel-saving potential is much higher than for household sized stoves.

Picture 2: Improved institutional firewood stove

Picture 3: Energy efficient baking oven

Picture 4: Energy efficient institutional stove

2.1.3. Advantages of improved cook stoves

The advantages of improved cook stoves (institutional and household size) are as follows:

- High combustion and heat transfer efficiency (40%) of improved cook stoves compared to the conventional 3-stone-fire (16%), according to laboratory water-boiling tests.

- High saving potential on firewood and charcoal of up to 50%. Therefore direct impact firstly on the household's /institution's monthly fuel expenses as well as on deforestation.

- Reduced /eliminated smoke in the kitchen. In general, the combustion within improved stoves is much more efficient which decreases the emission of hazardous gases and smoke. Depending on the design, a chimney added to the stove can actually guarantee an almost completely smoke-free kitchen.

- Increased cooking speed, releasing valuable time resources for kitchen staff.

- Easy and safe to operate and maintain. No technical skills are required to operate the improved stove. Only basic maintenance like cleaning from time to time is necessary.

2.1.4. Disadvantages of improved cook stoves

Disadvantages of improved cook stoves comprise:

- Relatively high upfront costs for semi-industrially manufactured household stoves and institutional stoves in general.

- To the benefit of insulation, the slot for inserting firewood is rather small, which requires reloading the stove with new fuel from time to time – A disadvantage compared to the 3-stone-fire that can be loaded with firewood from all sides.

- Due to its design, the use of different saucepan sizes is restricted with improved stoves.

2.1.5. Potential of improved cook stoves in Uganda

Rural Uganda features a rapid depletion of forestall resources, a high dependency on biomass as cooking energy source and a widespread ignorance of improved cook stoves. However, those stoves are low-tech, can be produced easily and require no technical training but awareness for the end-user which makes them highly appropriate for the rural Ugandan context. A well organized dissemination of improved cook stoves can therefore have a significant positive impact on the deforestation.

2.1.6. Challenges

The challenges for the sustainable dissemination of improved cook stoves are found on the production side as well as on the end-user side.

- Concerning the production, different types and qualities of improved stoves exist, with some of them being poorly constructed and of a short life expectancy. This can lead to a loss of trust in this innovation on the end-user's side, believing that improved cook stoves do not save energy nor work at all.

- With regards to the end-user side, the traditional 3-stone-fire still enjoys widespread popularity, being the predominant stove type for thousands of years. It is assumed, that cooking practice are part of each culture's core. Therefore, acceptance of another cooking utility is growing only slowly as people, despite of the obvious virtues of improved cook stoves, stick to what has been practised for many generations.

2.1.7. Costs of improved institutional cook stoves

The price of household stoves ranges from a couple of hundred UGX (if self-built) to 30.000 UGX if professionally manufactured. In some cases, the purchase price for specific stoves is subsidized through diverse livelihoods and conservation programs.

Improved institutional stoves are disseminated at a price range between 3 to 4.6 million UGX depending on cooking capacity.

2.1.8. Projects promoting improved cook stoves in Uganda

Focusing on institutional sized stoves, over 315 improved cook stoves have been disseminated countrywide since 2004 in 120 institutions.Leading projects that promote institutional improved cook stoves are Promotion of Renewable Energies and Energy Efficiency Programme (PREEEP) by GIZ (former GTZ) and the Ugandan Ministry of Energy and Mineral Development (MEMD). Otherwise, NGOs like the Agency for Cooperation and Research in Development (ACORD), the Norwegian Refugee Council, CARITAS International, the Dutch development agency SNV and others are actively promoting improved cook stoves either as proper projects or as complementary to livelihood /conservation projects.

2.2. Biogas technology analysis

2.2.1. What is biogas?

Biogas is gas produced from fermentation of organic matter, such as cow dung, crop residue or kitchen waste. In absence of oxygen, biogas is generated as a result of microorganism activity. Biogas is colourless and combustible containing approximately 60% methane, 38% carbon dioxide and 2% trace gases.

2.2.2. Types of biogas systems

There are different types of biogas systems in use in Uganda. Dr. Kariko at Makerere University carried out a survey of 212 digesters in 24 districts in 2009. According to this study 82% are fixed dome type, 9% are floating drum and 7% are tubular digesters.

Fixed dome digester

The fixed dome digester model is the most widely used type in Uganda. It consists of an underground brick masonry compartment with a dome on top for gas storage. In this design, the fermentation chamber and gas holder are combined in one unit. Biogas plants with a digester volume between 6 m^3 and 16 m^3 are commonly used for household and small institutions. Large institutions usually require digesters of volumes between 30 m^3 and 50 m^3 to fulfil their daily energy needs.

Picture 5 and 6: Fixed dome biogas digester in Buwambo during construction

Floating drum digester

The digester chamber is made out of brick masonry and cement mortar. A mild steel drum is placed on top of the digester to collect the biogas produced from the digester. Thus, there are two separate structures for gas production and gas collection. A floating drum digester can also be made out of two poly-ethylene tanks, one inverted into the other. One tank is the fermentation unit while the second tank holds the gas.


Picture 7 and 8: Examples of floating drum biogas digesters. On the left side, digester made out of poly-ethylene tanks and on the right side constructed with bricks and steel.

Tubular digester

A tubular digester consists of a digester bag made of thick gauge plastic tube of 0.5 – 1 meter diameter, which is placed in a trench. The inlet and outlet are made of PVC pipes tied at the end of the digester bag. Gas is collected in a separate reservoir consisting of a plastic tube.

Picture 9: Example of a tubular digester type

2.2.3. Advantages of biogas

The direct and indirect benefits of biogas are:

- An energy source for cooking and lighting, which reduces dependency on firewood and/or charcoal.
- Time and money being usually spent on collecting firewood is saved.
- Ensures environmental sustainability; reduces pressure on forest resources and biodiversity in protected areas and national parks. Methane is more potent as a climate change gas than CO2. Biogas use therefore combats greenhouse gas emissions. Furthermore, biogas provides environmental education and awareness through construction of e.g. school bio-latrines.
- Improved health conditions; the use of biogas reduces or eliminates indoor air pollution, reduction of diseases related to poor waste water and solid waste management, reduces ground and surface water pollution.
- Quality fertilizer; the slurry output of a biogas-digester is a high nutrient organic fertilizer that restores soil fertility.

2.2.4. Disadvantages of biogas

Biogas systems have the following disadvantages:

- They require relatively high upfront costs that are compensated through fuel savings within 2-3 years. The initial investment may deter many potential users. A co-financing by financial institutions or donors could support further implementation of the technology.

- Even though the principle is simple and low-tech, the construction of biogas systems requires special working skills, especially in respect of masonry and pipe installation.

- The well-being of the biogas-producing bacteria is the base for a proper functioning of the systems. A regular influx of appropriate feedstock is therefore important. In addition, the feeding pipes need to remain clear and water should regularly be removed from the gas-holder-stove-connection. Hence a relatively high degree of maintenance efforts are indispensable for keeping the biogas system going.

2.2.5. Potential of biogas in Uganda

Being rich of agricultural and horticultural activities, Uganda features a considerable amount of cattle dung of different origin and agricultural by-products of which at least a part can be used as biogas feedstock. In addition there are numerous institutions such as boarding schools, parishes, prisons or health institutions that have not only large central kitchens for feeding but also high amounts of human excrements in latrines that can be linked to biogas systems.

The gas can be used to supplement cooking energy needs, boil water for cleaning /hygienic purposes, avoid hazardous emissions resulting from the combustion of traditional biomass, provide sanitary human waste disposal and demonstrate fertilizer benefits in institutional gardens. In addition it can expose inmates and students to the benefits of biogas, overcome misconceptions about cooking with gas from human waste and use of the fertilizer, increase awareness about and the demand for commercialized biogas technology.

2.2.6. Challenges

Biogas as a source of domestic energy was introduced over 50 years ago with approximately 700 units installed in Uganda by 2008. As investigated in Dr. Kariko's report, biogas digesters did not meet the expectations in many cases: numerous plants are failing or under-performing due to poor construction works, biological reasons, lack of regular maintenance and socio-economic factors.

Therefore, to be able to run a biogas system in a successful way some requirements must be fulfilled. These include:

- Proper construction skills - The units must be built in a proper way to avoid leakages and other disturbing influences.

- Feedstock - there must be access to organic agricultural and/or (human) waste manure infrastructure like toilets or latrines; kitchen waste and food leftovers can also provide an excellent feedstock. Furthermore, certain substances may act as inhibitors to the system decreasing or completely stopping the gas production process.

- Water Supply - there should be a good constant supply of water within reach for the digester.

- Human labour - to manage the biogas plant by feeding the digester regularly and carrying out maintenance.

- Reluctance towards the use of dung/human excrements as base for the cooking gas are to be overcome by awareness-raising and demonstration.

2.2.7. Cost of biogas plants

Cost estimates for biogas plants in Uganda with different designs, fixed dome and floating drum are shown in Annex 2. The fixed dome model, which is commonly promoted in Uganda, is expensive as it requires high skilled labour to construct and a lot of building material However, digester costs can come down with larger volume installation due to economics of scale. The PE-tank based floating drum is very flexible in size; therefore it is also suitable for small households with less land space. Being in addition easier to install, costs for this type of biogas system are on a lower level than for the fixed dome model.

2.2.8. Projects promoting biogas in Uganda

Biogas energy use, dissemination and adaptation is promoted by government like Ministry of Energy and Mineral Development and non-governmental organizations such as Heifer Project International, Adventist Development Relief Agency (ADRA), Centre for Research in Energy and Energy Conservation (CREEC), The African Medical and Research Foundation (AMREF), Sustainable Sanitation Water Renewal Systems (SSWARS), AFRICA 2000 Network - Uganda, SEND A COW Uganda, Kulika Community Development and Education in Uganda, and private companies like Green Heat (U) Ltd.

The Uganda Domestic Biogas Programme (UDBP) of the Dutch development agency SNV targets to disseminate 12,000 biogas household digesters in cooperation with Heifer Project International Uganda (HPI-U) as an implementing organization. Their target is meant to be achieved by the end of 2014. In the year 2010 they have constructed 460 digesters. HPI-U is implementing family-sized digesters of 8 m^3, 9 m^3 and 12 m^3 capacity with cow dung as the feedstock for biogas production. However, Uganda has an abundance of other potential feedstock such as human excrements and various digestible agricultural by-products.

2.3. Solar (pico-PV) technology analysis

2.3.1. What is pico-PV?

Pico-PV systems are small independent appliances powered by solar energy providing light and/or other small electrical services, such as radios, mobile phone charging, mp3 player, etc.

A pico-PV system mainly consists of three components:

- Solar panel
- Rechargeable battery (inside or outside the lamp)
- Lamp

Picture 10: Example of various Pico-PV products

2.3.2. Types of pico-PV

Pico-PV systems can be characterized by their technical features, applications and quality:

- Is the pico-PV system only for lighting or does it provide additional energy services like phone charging, powering a radio, etc.?
- Is the pico-PV system designed as a task-light, lantern, fixed installed system or torch?
- Panel size and power output ranges from 0.3 Wp (Wp = peak power performance) for a solar lantern with an integrated panel up to 12 Wp for the combined system (the majority of the systems are equipped with panels from 1 to 3 Wp).
- Which technology is used in a pico-PV system (lead-acid, NiMH or Li-Ion batteries), Compact Fluorescent Lamp (CFL) or Light Emitting Diode (LED) and is the system equipped with or without a charge controller?
- How consumer friendly is the pico-PV in respect of affordability, manufacturing quality, light output, charging duration and durability.

2.3.3. Advantages of pico-PV

Pico-PV systems have the following advantages:

- High lumen output in contrast to traditional light sources like kerosene lamps and candles with low lumen output.
- Usage of pico-PV avoids the risk of respiratory diseases caused by hazardous gases and smoke that are emitted by wood fires and kerosene lamps.
- As no flammable fuels are used, the risk of indoor fires is minimised.

- Pico-PV are simple and easy-to-use-systems, thus appropriate for the rural context.
- Amortisation of initial investments is reached in 4 to 10 months if the previous light source was based on kerosene.

2.3.4. Disadvantages of pico-PV

The disadvantages of pico-PV systems are:

- They require relatively high upfront costs (about 20 to 120 USD) that are compensated through fuel savings within 4-10 months. The initial investment may deter many potential users, especially those in rural areas. A co-financing by financial institutions or donors could support further implementation of the technology.
- With the present battery technology 1-1.5 year's lifetime can be achieved. However, once the battery is used up, a replacement can impose further costs e.g. replacement of battery costs approximately 8 USD.
- Spare parts for reparation in case of damage or mal-function can be difficult to obtain and are relatively costly.

2.3.5. Potential of pico-PV in Uganda

A target analyse which is published by GIZ in 2009 "Uganda's Solar Energy Market - Target Market Analysis" shows a potential market expansion. Hence, the amount of companies, NGOs and institutions promoting pico-PVs will increase over time. This analyse reveals that up to 60% of the rural households potentially can afford micro-solar systems of 2 to 20 Wp (lanterns, phone chargers, radio systems). With their amortisation in 4 to 10 months and their capacity to sufficiently light pico-PV has the potential to reach a large proportion of low-income households in Uganda.

2.3.6. Challenges of pico-PV

As mentioned above to reach the target-group of low-income households, pico-PV must be produced at low-cost. But even for low prices the quality expectations must be fulfilled. So also the quality for pico-PV products is a key factor for a successful market.

The solar market of Uganda however exhibits many failing systems. Studies from GIZ ("Impact assessment of the solar electrification of micro enterprises, households and the development of the rural solar market" and "Impact assessment of the solar electrification of health centres" (both from 2009) show that more than 50% of installed systems are not fulfilling the expectations.

In addition Ugandans find a similar lack of quality in battery powered lamps. Due to many low-quality products which break down after a short time, many people have lost confidence in this technology.

Due to the fact that pico-PV combines solar technology with lamps the quality assurance is very important. Lighting Africa, an initiative of the World Bank, has recognized this issue and is promoting quality pico-PV products. Therefore an award was established in 2010. The winners in different categories are mentioned in Annex 4.

During the testing process for the above mentioned award a test methodology was developed which is published on the Lighting Africa homepage (www.lightingafrica.org). In addition a quality label is under development. To support and control this label several test laboratories are to be built up all over Africa.

2.3.7. Cost of pico-PV

To investigate the price challenge, GIZ has carried out an assessment in 2010 to find price-worthiness of pico-PV products available in the market today. The name of the study is: “What difference can a PicoPV system make? Early findings on small photovoltaic systems and emerging low-cost energy technology for developing countries”. The key findings of this study are summarized below:

Relatively high initial investment costs ranging from 20 to 120 USD are to be overcome by low income households. Their running costs of kerosene wick lamps are typically ranging between 2 to 5 USD per month (not taking into account their inferior lighting output.). A further obstacle that households have to overcome is a lack of access to financial services.

To be able to compare the costs of different sources of light, the lumen output has to be considered. Obviously a light is used to get lumen output. In terms of lighting service costs of 0.10 to 0.60 USD per kilolumenhour are performed by good pico-PV lamps. With these costs per lumen output LED lights are much better than all traditional lighting alternatives, except for the kerosene pressure lamps (which in turn is as expensive in monthly cost and initial investment cost as to most pico-PV products).

2.3.8. Projects promoting pico-PV in Uganda

In Uganda there are various projects around pico-PV. These are for example:

- Lighting Africa as an Initiative of the World-Bank promotes pico-PV
- GIZ PREEEP carried out studies e.g.:
  - Uganda’s Solar Energy Market - Target Market Analysis (2009)
  - What difference can a PicoPV system make? Early findings on small Photovoltaic systems and emerging low-cost energy technology for developing countries (2010)
- CREEC is implementing a solar test laboratory with support of the Presidential Initiative funding for the Faculty of Technology, Makerere University.
- In addition, there are several businesses focusing on pico-PV. This implies the establishment of local retailing and reparation networks, aiming at improving the accessibility and affordability of selling and maintenance services. Companies involved in pico-PV are for example Barefoot Power, Greenlight Planet or UltraTec Ltd.

2.4. Gasification technology analysis

2.4.1. What is gasification?

Biomass gasification means incomplete combustion of biomass under high heat and limited oxygen resulting in production of combustible gases consisting of carbon monoxide (CO), hydrogen (H_2) and traces of methane (CH_4). The generated gases can be either used in a gas engine (to generate shaft power) or directly combusted for heat application. The amount of emissions that are released to the atmosphere can be reduced in comparison to direct combustion of the biomass.

2.4.2. Types of gasification systems

Many design variations of gasification reactors (gasifiers) exist. Depending on the type of air flow conditions present in the equipment, they all fall into three general categories:

- Up-draft (air passes through the biomass from the bottom and the combustible gases come out from the top of the gasifier)
- Down draft (air enters from above and goes downwards through the biomass)
- Cross draft (air inlets are on the sides of the gasifier)

The TLUD Design:

A basic TopLit UpDraft (TLUD) gasifier consists of two canisters (concentric cylinders) forming an annular space, and a canister cover (lid). Primary air which goes through the biomass in the inner cylinder supports the process of pyrolysis that leads to the release of combustible gases. Subsequently, secondary air (through annular space) provides the oxygen for the burning of the combustible gases. Both air flows combine at the top of the inner cylinder where the combustion takes place to produce heat. A connector set (riser) is placed on top of the canister cover which guides the flame up to the cooking pot. Most of the combustion is completed within the connector.

Picture 11: A TLUD-gasifier in action

The TLUD is ideal for both households and institutions for cooking any kind of food and/or heating because it burns cleanly and is efficient on fuel. This makes it ideal for both rural and urban settings.

2.4.3. Advantages of gasification

Gasification systems have the following advantages:

- Gasifiers exist and work in various sizes and are therefore applicable to households as well as to institutions. The applications range from cooking of food through drying and heating up to driving farm machineries and electricity generators.

- The process is efficient, fast, safe, affordable, convenient and reduces fuel consumption. For example a TLUD gasifier burns biomass fuel with limited emissions, is designed to burn with limited heat loses and has been found to save up to 18% fuel compared to an ordinary 3-stone stove.

- Many non-traditional fuels, such as agricultural and forestry by-products can be used in a gasifier, for example: woody biomass, such as wood pellets, wood chips, wood stems, sawdust and papyrus reeds, seeds and shells, such as coffee and rice husks, peanut shells, pine cones, maize cobs, bean pods, jatropha seeds and leaves.

- Gasifiers burn cleanly with low emissions, little smoke or low particulate matter (PM), therefore protecting human health and the environment.

- TLUD gasifiers can be locally produced with material which is available in rural Uganda.

2.4.4. Disadvantages of gasification

Gasification systems have the following disadvantages:

- The gasification process needs careful attendance in the starting phase. Otherwise the flame goes out quickly and is followed by dense smoke.

- Refilling during burning process (10 to 30 min) is not possible. This means that if further heat is needed the gasifier has to be refilled and started again. To overcome this disadvantage research has to carry out how long a certain amount of a certain type of fuel burns. Another possibility would be to use two TLUDs which can be exchanged during the cooking process to have constant heat.

- Using gasification for cooking effects the way of using a stove (preparation of stove, heat control and cooking time) so maybe there will be some resistance of cooks and hence people might be tempted to resort to conventional stoves.

2.4.5. Potential of gasification in Uganda

In rural Uganda agricultural by-products can be found everywhere. This gives the potential of a significant number of rural households with an effective and efficient wood fuel and charcoal replacement.

In addition, the gasifier technology which is relevant for rural Uganda can be made out of scrap metal and can therefore be easy and cheap to produce and to repair.

2.4.6. Challenges

The gasifier technology is still very little known in Uganda. As most of the people are not aware of this technology and have not seen a concrete example of it in operation, this circumstance might hamper the dissemination of gasifiers.

2.4.7. Cost of gasification

In theory providing heat through gasification is cheaper than conventional burning processes because agricultural by-products can be used. For Uganda, studies have to be carried out to prove this theory.

The costs for the gasifier itself are known for household sizes. The prototypes that exist cost approximately 35,000 UGX per TLUD. In series production these costs can be reduced due to economy of scale.

2.4.8. Current projects promoting gasification in Uganda

Gasification technologies are not wide distributed, yet hence just a few projects are on the ground:

- The TopLit UpDraft (TLUD) gasifier is currently being marketed by NGOs and individuals on the Ugandan market. An example for an NGO is Pajoma Inc. which is promoting this kind of stoves for burning Jatropha seeds in Western Uganda.
- CREEC won a grant from the Word Bank program Biomass Energy Initiative for Africa (BEIA) to promote the TopLit UpDraft (TLUD) gasifier in Uganda.
- Paramount Cheese Dairies Ltd uses papyrus reeds in the gasifier to heat milk, which has lead to substantial financial savings.
- CREEC is installing a gasifier to generate 10kW electrical power as a show case at Makerere University.

2.5. Briquette technology analysis

2.5.1. What are briquettes?

A briquette is a block of compacted combustible biomass or char used as fuel. Briquettes can be used in the available stoves as a cooking fuel. When produced in an environmentally sustainable manner, this technology can significantly contribute to the reduction of deforestation.

2.5.2. Types of briquettes

Non-carbonized briquettes

Non-carbonized briquettes (also known as biomass briquettes) are made from agricultural by-products like maize cuttings, cotton stalk, baggase, saw dust, rice, coffee and groundnut husks. They are a potential replacement for firewood as fuel supply. Biomass briquettes are a renewable source of energy when they are made by recycling agricultural by-products. They can be used as cheap cooking fuel in schools, hospitals, prisons and households in most parts of Uganda.

The biomass is compressed and extruded to make a log or pellet. Under pressure, the natural lignin in the agricultural by-products binds the particles together to form a solid block. Therefore the use of binders is not necessary in this process. An advantage of briquettes is that the burning time is longer than firewood due to the higher density. Compared to firewood or loose biomass, briquettes have about 800 to 1500 kg/m^3 in average a 10 times higher density because of compression and lower moisture contains than wood.

Carbonized Briquettes

Carbonized briquettes are made from either charcoal dust or char (burned agricultural by-products under limited supply of oxygen). Charcoal fines and char are compressed or densified to form briquettes with the help of a binder. These briquettes can be produced commercially and on household level. Carbonized briquettes require no major behavioural change by users because they can be used in normal charcoal stoves.

Picture 12 and 13: Types of briquettes: Non-carbonized (left) and carbonized briquettes (right)

2.5.3. Advantages of briquettes

The use of biomass-derived fuels brings both environmental and local economic benefits by reducing pressure on the forest resources, preserving biodiversity and providing employment opportunities. Biomass briquettes also provide more calorific value per kg and save fuel costs due to the possibility to use agricultural by-products. In addition, they have the following advantages:

- Briquettes can be cheaper compared to other biomass fuels
- Briquettes burn longer than charcoal and firewood of the same volume

- Briquette-making create employment opportunities
- Briquettes are easy to transport, store and handle
- Briquettes do not need to be chopped to fit into a stove like wood fuel
- They can be produced locally for domestic use, as long as there is access to charcoal fines

2.5.4. Disadvantages of briquettes

So far, few minus points of briquettes are known. However, commercial briquette manufacturing requires a machine for pressing the raw material to briquettes. This implies an upfront investment as well as follow-up costs that are without doubt higher than in the traditional charcoal business. Moreover, briquettes are little known as a real alternative to fuel wood and charcoal. So in general, people remain sceptic about the burning length and quality unless they have tried briquettes themselves.

2.5.5. Potential of briquettes in Uganda

Same as with biogas and gasifiers, the briquette technology can rely on considerable amounts of biomass that is accessible on farmland as well as in processing units for agricultural products. In particular rice and maize mills or wood-processing units provide a large supply of waste products (rice husks, wood pieces etc.) that are excellent raw materials for briquette making. The highly decentralized processing of agricultural products in the rural districts would allow a widespread dissemination of the technology and its products.

2.5.6. Challenges

Briquettes are new for the Ugandan market so it remains to be seen how people will accept this technology. The lack of awareness about the quality of briquettes in Uganda is predominant. On the production side for example, difficulties exist in finding reliable and sufficient supply of raw material. Furthermore, high upfront investment is opposed to relatively low biofuel-prices, especially in the rural areas. Moreover briquettes are not yet tested on a large scale. Further studies are required to examine this technology.

2.5.7. Cost of briquettes

In theory briquettes are cheaper than wood fuel because agricultural by-products (and thus free or cheap raw materials) can be used to produce briquettes. The costs for the machine necessary for compressing the briquettes (which requires low-tech though) are outweighed by revenues arising from briquette selling. However, briquettes have to compete with low firewood and charcoal prices (see above) which makes briquette making profitable rather on a large-scale base in terms of production and selling. For Uganda, further studies are required to give a better understanding of the cost aspect of briquettes.

2.5.8. Projects promoting briquettes in Uganda

The current activities are geared towards domestic or small scale briquette production. There are very few commercial companies who use agricultural waste and charcoal fines for briquette production. These companies produce and/or sell briquettes on a large scale or benefit from relatively high charcoal prices in urban centres such as Kampala. An example of a company in the briquette business is Kampala Jellitone Suppliers which makes briquettes from coffee husks and sells them to schools around Kampala. Another example is Green Heat (U) Ltd which produces briquettes from charcoal fines and sells them to restaurants and households in urban centres, where relatively high charcoal price allow a certain profit.

2.6. General summary of the market technology analysis

The findings from the market technology analysis reveal a variety of innovative and simple technologies that are energy efficient and help protect the endangered forestry resources at the same time. Being all appropriate for the rural context in general, the specific virtues but also challenges require, however, a careful assessment of the needs and possibilities in the specific institution and household. In order to prevent the emergence of a technological monoculture (which might be determined by a misled one-size-fits-all approach), it is important to identify the technologies for the specific local context that are both energy efficient and appropriate.

To conclude, a SWOT-analysis for each technology is to be found in Annex 3.

3. Socio-economic assessment

3.1. Introduction

The socio-economic assessment was conducted during the field research in the six districts Amuru, Nwoya, Adjumani, Moyo, Lamwo and Kaabong. It provides an overview of economic and social impacts associated with the use of energy in the respective areas, leading to recommendations of potential energy alternatives. On a small scale, the survey also took a look at institutions' involvement in beekeeping as an alternative financial source as well a tool for bio-diversity conservation.

First priority of this assessment was to elaborate how much wood and/or charcoal were used where the biofuel is coming from and what technology is used for cooking. Moreover, the willingness and ability of the institutions to pay for energy efficient technologies was also investigated. Second priority was given to the investigation of other energy demands of these institutions in respect to other purposes than cooking, e.g. for lighting. Based on these findings, recommendations of alternative energy solutions for cooking and lighting were evaluated, also taking into account the willingness and ability of these institutions to pay for energy efficient technologies. The results obtained through this assessment will to lead over to the subsequent sections were they are to be concretised further.

3.2. Result of survey

3.2.1. Number of institutions visited

A total of 63 institutions were visited in the districts selected as samples for the assessment study including a showcase institution in Gulu district.

Whether an institute cooks his own food or not was important because it indicated if the institute has demand for firewood, charcoal, etc. During the survey an average of 11 (both cooking and non-cooking) institutions were visited in each of these districts.

Table 1: Overview of visited institutions (cooking + non-cooking)

District	Institution cooking (total)	Institution cooking (visit)	Institution non-cooking (visit)	Institution total visited	% visited of cooking institutions
Moyo	14	13	1	14	93
Adjumani	12	11	1	12	92
Amuru	7	7	4	11	100
Nwoya	5	5	3	8	100
Gulu	not known	1	-	1	?
Kaabong	7	7	0	7	100
Lamwo	9	9	1	10	100
TOTAL	**54**	**53**	**10**	**63**	**98**

A complete list with all institutions visited, their location and the number of meals prepared per day is to be found in Annex 1.

3.2.2. Current sources of energy

The distance to the locations where institutions get fuel for their energy need depends on the energy source. Firewood is collected from distances averaging 9 km. Kerosene was available in every sub-county, the distances averaged 3 km. Charcoal is mainly delivered by producers to the institutions; which explains why just a few institutions could answer where their charcoal comes from. For the few institutions which could estimate the distance for their charcoal, sources are on average 5 km away. Diesel can be obtained at an average distance of 31 km. The biggest distance for an energy source is LPG (Liquefied Petroleum Gas). LPG is available in bigger town like Gulu and Arua that average 89 km.

It is interesting that institutions with tree-planting programs are still buying their firewood from a wood supplier. A reason could be that their own trees were planted a few years ago and cannot yet fulfill the demand. A 100% supply of firewood from their own plantation was found at Moyo Mission (catholic parish in Moyo). From 2011 St. Mary Asumpta Girl's school (Adjumani) will use wood from their own plantation. The distance for energy fuel sources were different for each district. The following maps illustrate the distance of firewood supply in the districts.

Table 2: Distances covered by institutions to acquire different energy fuels

	Distances (km) covered by Institutions to acquire Energy						
	Districts Visited	**Institution**	**Wood**	**Charcoal**	**Diesel**	**Kerosene**	**LPG**
1	**Moyo**	Laropi Secondary School	4	4	-	-	-
2		Laropi Health Centre III	-	3	-	-	-
3		Metu Secondary School	7	-	5	-	-
4		Metu catholic parish	1	-	-	5	-
5		Moyo Technical Institution	18	-	1	-	-
6		Moyo Secondary School	15	-	1	-	-
7		Uganda Govt Prison Moyo	8	-	-	4	-
8		Bishop Asili Secondary School	12	-	-	-	-
9		Erepi Teacher's College Moyo	15	-	5	-	-
10		Redeemer Children's Home	-	-	-	-	-
11		St. Andrew College	15	-	2	-	-
12		Moyo Town Secondary School	15	-	-	-	-
13		Moyo Mission	-	-	-	-	-
14		Moyo Babies Home	6	-	-	-	-
	Average Distances (km) for institutions in Moyo		**11**	**4**	**3**	**5**	**0**
15	**Adjumani**	Comboni Comprehensive College	20	-	1	-	-
16		Adjumani Secondary School	10	-	1	-	150
17		Uganda Govt Prison Farm – Adjumani	15	-	-	2	-
18		Monsignor Bala Secondary School	10	-	-	-	-
19		Pakele catholic parish	-	-	-	-	-
20		St. Mary Asumpta Girl's school	12	-	5	-	-
21		Olia Prison Adjumani	1	-	-	10	-
22		Ofua Seed Secondary School	-	-	8	-	-
23		Mungula Secondary School	5	-	5	-	-
24		Uganda Kids School e.V.	8	-	2	-	-

25		Adjumani Mission	15	-	-	-	-
26		Alere Secondary School	18	-	10	-	-
	Average Distances (km) for Institutions in Adjumani		**11**	**0**	**5**	**6**	**150**
27	**Amuru**	Alero Primary school	-	-	-	-	-
28		Reckiceke Primary School	20	-	-	-	-
29		Amuru catholic parish	10	1			
30		St. Anthony of Padua Nursery School	8	-	-	-	-
31		Otwee Public Primary School	-	-	-	-	-
32		Pabo Senior Secondary School	15	4	-	-	60
33		Atiak Health Centre IV	-	-	60	-	60
34		Atiak Technical School current site	15	15	-	-	-
35		Atiak Technical School future site	15	15	-	-	-
36		Atiak Catholic Parish	10	4	-	-	-
37		Lwaui Memorial College – Atiak	7	2	-	-	-
	Average Distances (km) for Institutions in Amuru		**13**	**7**	**60**	**0**	**60**
38	**Nwoya**	Pope Paul VI Secondary School	4	4	56	-	-
39		Anaka P.7 School	-	-	-	-	-
40		Patara Primary School	4	-	-	-	-
41		Koch Goma Secondary School	10				56
42		Alero Senior Secondary School	7	-	-	-	-
43		Anaka Hospital	-	-	-	-	-
44		Anaka catholic parish	20	20	-	-	-
45		Got Apoypo Primary School	1	1	-	1	-
	Average Distances (km) for Institutions in Nwoya		**8**	**8**	**56**	**1**	**56**
46	Gulu **(Show Case)**	Daniel Comoboni Technical Institute Gulu		-	-	-	-
47	**Lamwo**	Bana Bana Army Barracks	4	-	-	-	-
48		St. Mary College	7	-	-	-	-
49		YEP centre	-	-	-	-	-
50		Lotuturu Prison Farm	2	-	-	-	-
51		Padibe Girls Primary School	8	-	-	-	-
52		Sisters community	8	-	-	-	-
53		Padibe Girls Comprehensive School	7	-	-	-	-
54		Padibe Technical School	6	-	-	-	-
55		Childcare	2	-	-	-	-
56		Lokung Technical School	-	-	-	-	-
	Average Distances (km) for Institutions in Lamwo		**6**	**0**	**0**	**0**	**0**
57	**Kaabong**	Karenga Catholic Parish	1	**-**	**-**	**-**	**-**
58		Karenga Boy Primary School	5	-	-	-	-
59		Jubilee Secondary school	12	-	-	-	-
60		Kidepo Kalokudo Primary School	1	-	-	-	-
61		Lokori Primary School	2	-	-	-	-
62		Loyoro Napore Primary School	1	-	-	-	-
63		Karenga Girls Primary school	2	-	-	-	-
	Average Distances (km) for Institutions in Kaabong		**3**	**0**	**0**	**0**	**0**
	Average distances (km) of Institutions visited		**9**	**5**	**31**	**3**	**89**

3.2.3. Energy technologies currently in use

Cooking/boiling

Out of the 63 institutions visited 57 were cooking their own food/ boiling their drinking water therefore using wood and/ or charcoal as energy fuel for cooking/ boiling. One institution in Gulu (Daniel Comboni Technical Institute) makes briquettes and uses them for their domestic cooking and for sale. Gulu was not in the focus area of this study but this institution is recommended as a showcase in Northern Uganda for briquette making. Another institution in Moyo district (Redeemer Children's Home) was found to have completed the construction of a fixed-dome biogas digester.

The following table and chart show different energy fuels used in institutions to fulfill their cooking/ boiling demand (multiple fuels per institute possible).

Table 3: Summaries of the energy fuels used by the institutions visited

Purpose	Fuel	Moyo	Adjumani	Amuru	Nwoya	Gulu	Lamwo	Kaabong	Total per Fuel
Cooking/ Heating	Firewood	13	12	9	5	-	9	7	55
Cooking/ Heating	Charcoal	2	-	6	3	-	2	1	14
Cooking/ Heating	Maize Cobs	1	1	-	1	-	1	-	4
Cooking/ Heating	Briquettes	-	-	-	-	1	-	-	0 +1(Gulu)
Cooking/ Heating	Biogas	1	-	-	-	-	-	-	1

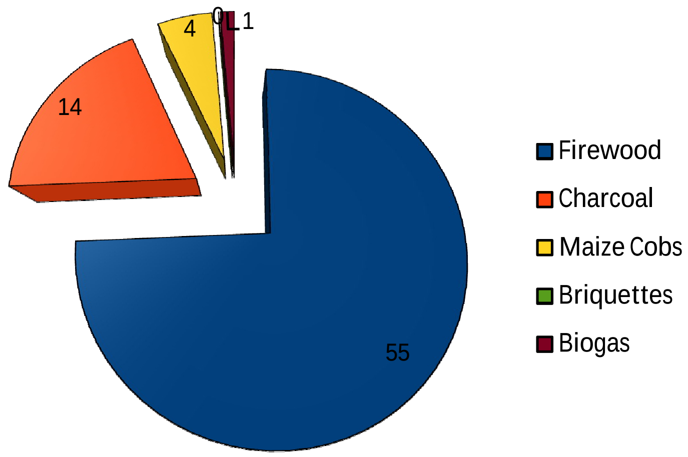


Figure 1: Types of energy fuels used for cooking/boiling by institutions

The following table and chart show the various technologies used (multiple technologies per institute possible). The order of the figures starts from inefficient (3-stone fire) to very high efficient technologies.

Table 4: Summaries of the technologies used by the institutions visited

Purpose	Technology	Moyo	Adjumani	Amuru	Nwoya	Gulu	Lamwo	Kaabong	Total per Technology
Cooking/ Heating	3-Stone	3	3	5	5	-	7	5	28
Cooking/ Heating	Mud Stove	-	-	3	1	-	2	-	6
Cooking/ Heating	Metal Stove	1	-	2	1	-	-	-	4
Cooking/ Heating	Improved mud Stove	2	5	-	-	-	-	1	8
Cooking/ Heating	Improved met-al stove	2	1	-	-	1	-	4	7 + 1 (Gulu)
Cooking/ Heating	Energy Effi-cient Oven	5	3	-	-	-	1	-	9

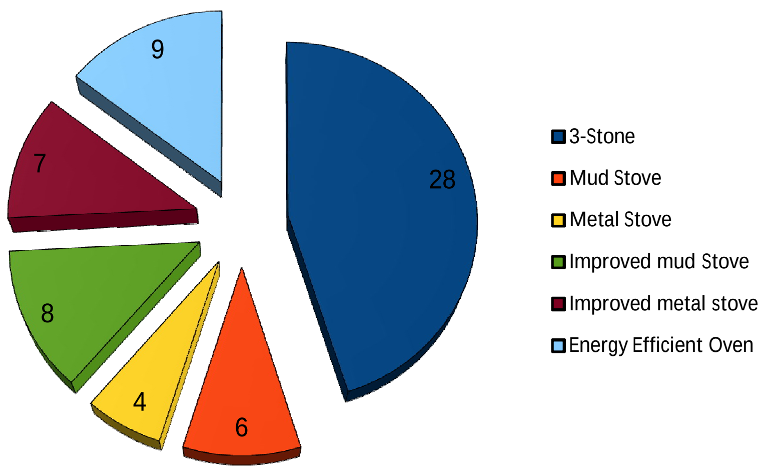


Figure 2: Types of technologies used for cooking by the institutions surveyed

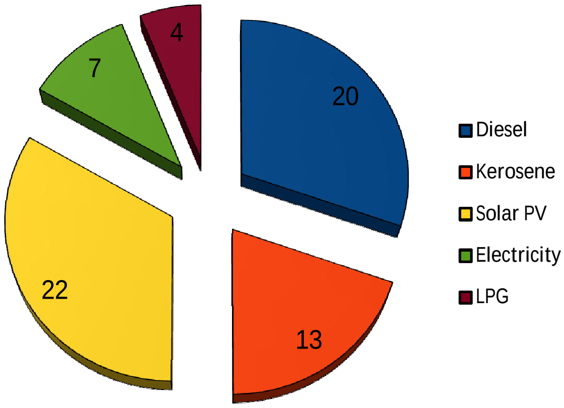
Energy of other purposes than cooking/boiling

Heat for cooking/ boiling has the biggest demand for energy. However other demands for energy were investigated too. 35% of the institutions are using solar energy while (32%) use generators mainly for lighting and running computers, 21% use kerosene lamps and 11% use electricity. LPG was found in 5 secondary schools used for laboratory experiments. In addition the health centre in Atiak uses LPG for cooling medicines. In total six institutions were interviewed about how they are using LPG (6%). Therefore, the amount if LPG used in institutions is not representative of the entire sample.

The following table and chart illustrate the various energy sources which are used in addition to the energy for cooking/ boiling (multiple entries also possible).

Table 5: Summaries of additional energy sources used by the institutions visited

Purpose	Fuel	Moyo	Adjumani	Amuru	Nwoya	Gulu	Lamwo	Kaabong	Total per Fuel
Lighting/ ICT	Diesel	5	6	2	4	-	1	2	20
Lighting	Kerosene	2	3	2	-	-	4	2	13
Lighting/ ICT	Solar PV	7	2	5	4	-	1	3	22
Lighting/ ICT	Electricity	4	3	-	-	0	-	-	7
Laboratory	LPG	-	1	2	1	-	-	-	4



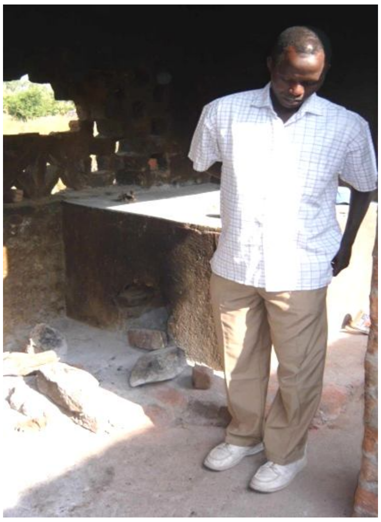
Figures 3: Types of fuel used for other purposes by the institutions surveyed

3.2.4. Energy costs

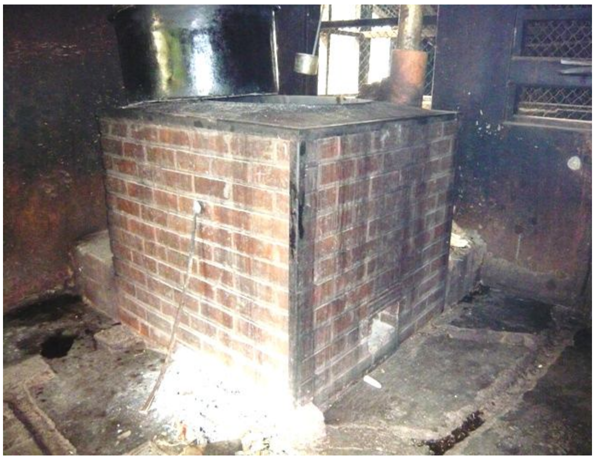
Cooking/boiling

The cost of energy depends on the type of energy source used and its usage amount. The pictures below show examples for the six different cooking technologies encountered during the site survey.

Picture 14 and 15: 3-stone fire (left) and mud stove technology (right)



Picture 16 and 17: Metal stove (left) and improved mud stove technology (right)



Picture 18 and 19: Improved metal stove technology (left) and energy efficient stove (right)

The amount of firewood and charcoal used for cooking/ boiling in institutions is difficult to establish because the interviewed representatives did not know the weight which is consumed. The costs for energy (payment for fuel) are better known and more reliable. Therefore the amount spent on firewood/charcoal is included here.

The following tables declare costs per meal (USX/ meal) that were associated with energy for cooking/ boiling in institutions. These costs include transportation (fuel and maybe rent of the vehicle), costs for loading and the wood and/ or charcoal itself. These costs are specific for each institution and separated into the technology used.

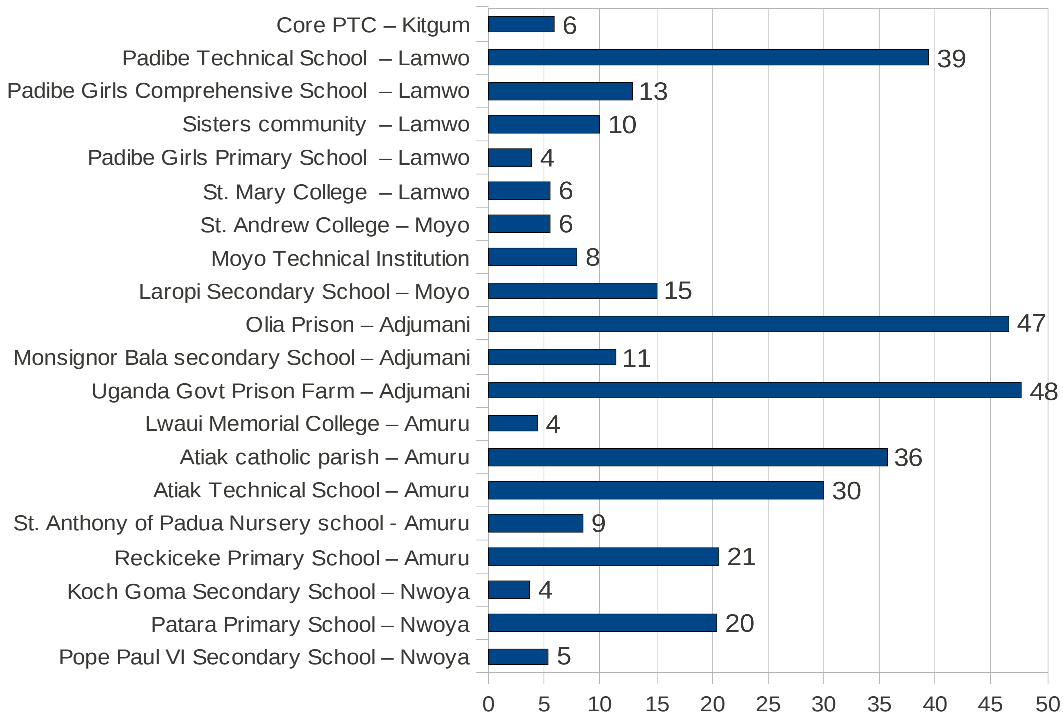


Figure 4: UGX per meal for institutions using ***3-stone fire technology*** *for cooking*

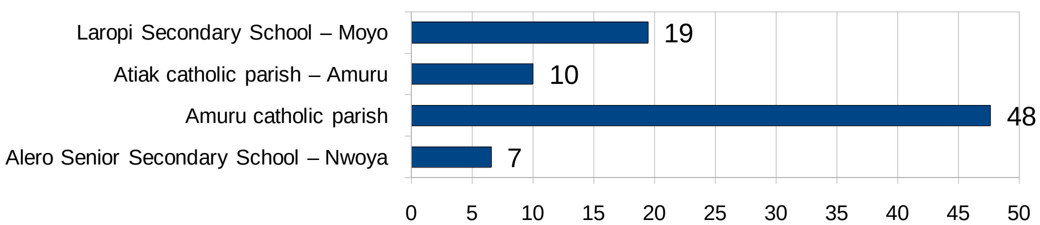


Figure 5: UGX per meal for institutions using ***metal stove technology***

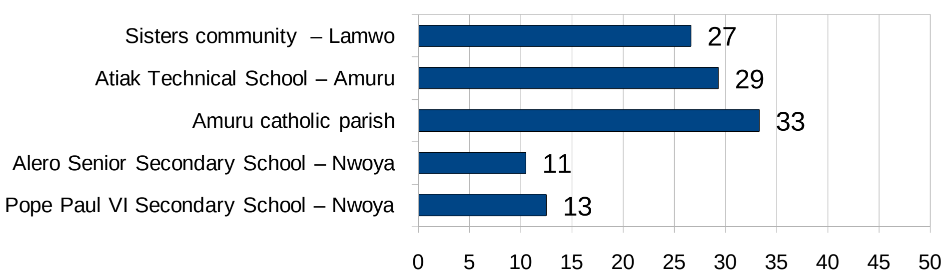


Figure 6: UGX per meal for institutions using ***mud stove technology***

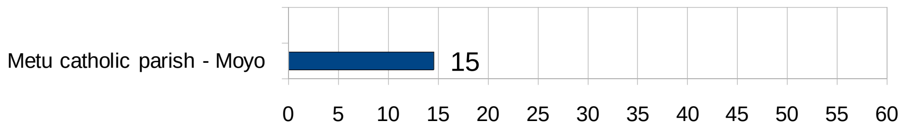


*Figure 7: UGX per meal for institutions using **improved metal stove technology***

It was only possible to analyze the daily fuel costs per meal for Metu catholic parish in Moyo. For the other institutions which are using improved metal stoves, no figure could be presented because no costs were given.

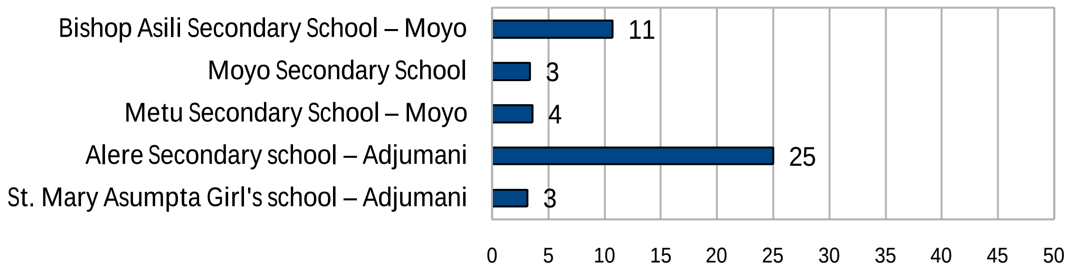


*Figure 8: UGX per meal for institutions using **energy efficient stove technology***

The big difference between the highest and lowest cost per meal for the institutions, independent of the technology, is because of the following reasons:

- Many institutions have their own tree-planting program and some are already using the trees for their own energy demand hence has reduced the energy costs.
- Some institutions have their own truck while others have to hire for getting their wood.
- Fuel expenses for collecting depend on the distance to drive.
- Some institutions incurred extra costs like loading and off-loading.
- Figures for wood could be over or under estimated by the interviewees because they never referred to documents when giving information.
- Some institutions boil their drinking water. The amount of water was nowhere known so it was not possible to consider this impact into the cost per meal.

The data of the following chart is not considered for calculation of the average values (average costs per meal per technology) as their particular circumstances because disproportional deviations from the general baseline survey results. The specific reasons for each of the five institutions are:

- Karenga Catholic Parish use free firewood, and a lot of charcoal at the same time despite preparing meals for mainly five people (15 meals a day); they have an unusually high cost per meal.

- Moyo Babies Home gave data for their firewood from the hill next door (about 150m) costs but the interviewee was not sure about the exact figure. After analysis the data seems to be highly over-estimated for such sophisticated stoves.

- Both Uganda Government Prisons in Moyo and Adjumani have one energy efficient stove installed, but they also use 3-stone fire which consumes a lot of wood and therefore produces high energy costs. The costs per meal represent both (energy efficient stove and 3-stone fire) and thus they are not specific for one technology.

- Anaka Catholic Parish has very low costs because they have a big tree-planting program and use many trees for their own demand. Only when they cook for many people (during workshops) they buy some additional firewood.

- Adjumani Mission has given their energy costs of one quarter based on seven persons. But in each quarter the mission holds a big 2-weeks workshop where the parish cooks for many more people (200+) hence increasing energy demand. In the costs per meal only 21 meals a day are calculated therefore the figure is unrealistically high.

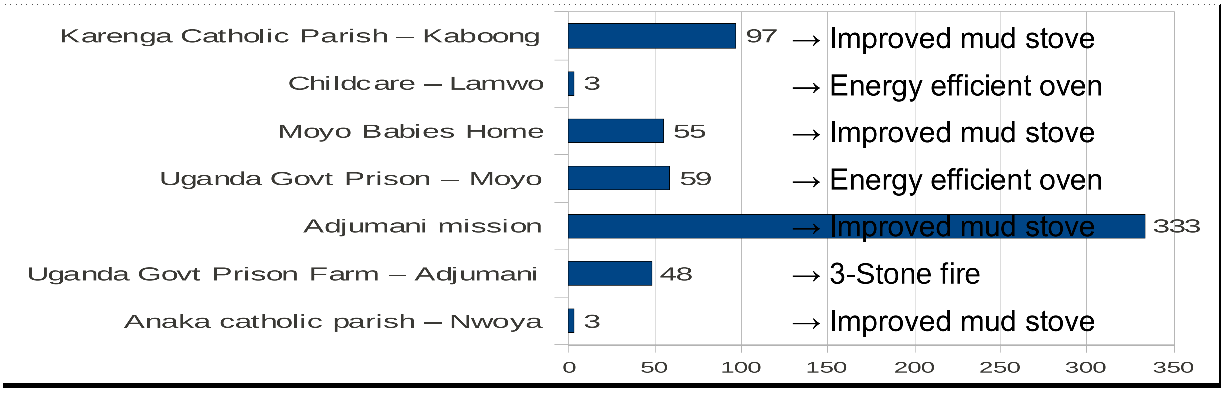


Figure 9: UGX per meal for institutions not considered for the average cost calculation

Comparison of costs for cooking/boiling

The survey revealed that energy demands were higher in institutions that were using traditional methods for cooking like the 3-stone fire, mud and metal stoves compared to the ones that were using improved technologies

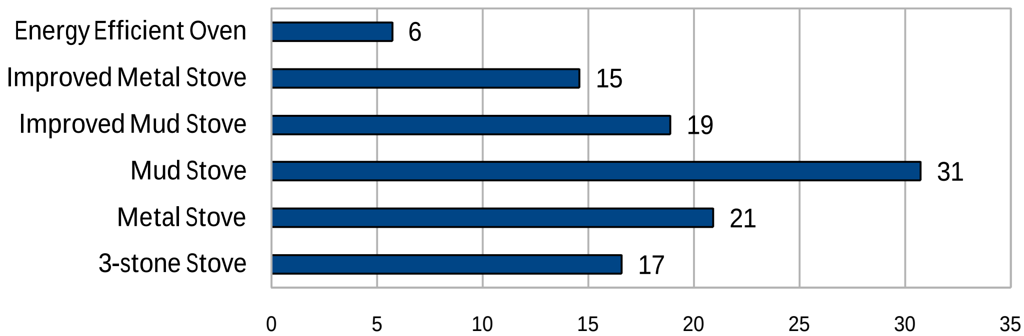


Figure 10: Average costs per meal (USX/meal) for the different stove technologies

The average cost for each technology is not representing the exact amount of energy per meal due to the accuracy of the data. But the trend that energy efficient technologies reduce the costs/ amount of firewood is also found in a further Wildlife Conservation Society study on household level by Richard Kisakye in 2010. Comments of interviewees during the fieldwork have underlined the finding that improved technologies save money and reduce the amount of trees for energy use.

Energy costs of other purposes than cooking/boiling

Other costs that were associated with energy in institutions for fuels like diesel, kerosene, and LPG are illustrated in the figure below.

Solar energy is not for free, but due to the fact that none of the interviewees could tell the initial price of his/ her system, the energy costs for solar are not presented. However, 16 institutions were found using solar energy.

The next chart shows the costs per day for each institution for using diesel. The big difference depends on power amount, efficiency of engine and time (how long the generator runs per day/week). Also the uncertainty of the figures which the interviewees provided is affecting the costs per day because these are just estimates.
Diesel generators in institutes are mainly used for powering light, ICT laboratories and office equipment. Five more institutions were found to use diesel for their energy needs but could not give costs for usage.

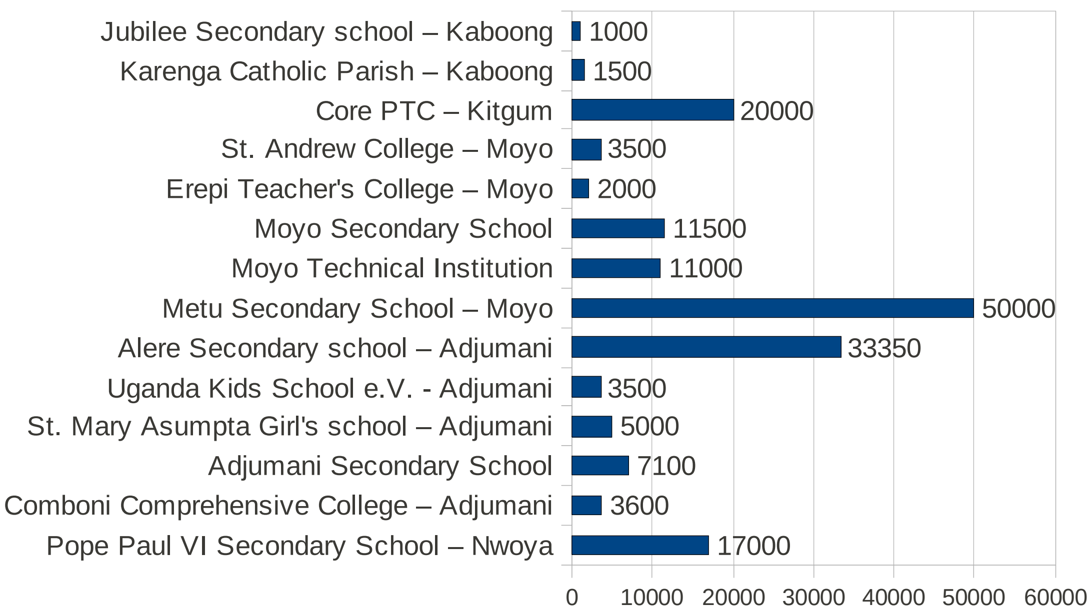


Figure 11: UGX per day for institutions using diesel

Figure 12 gives costs for kerosene per institution per day. Kerosene is mainly used for lighting and garbage burning. Three additional institutions were found which use kerosene but could not give costs for usage of the fuel.

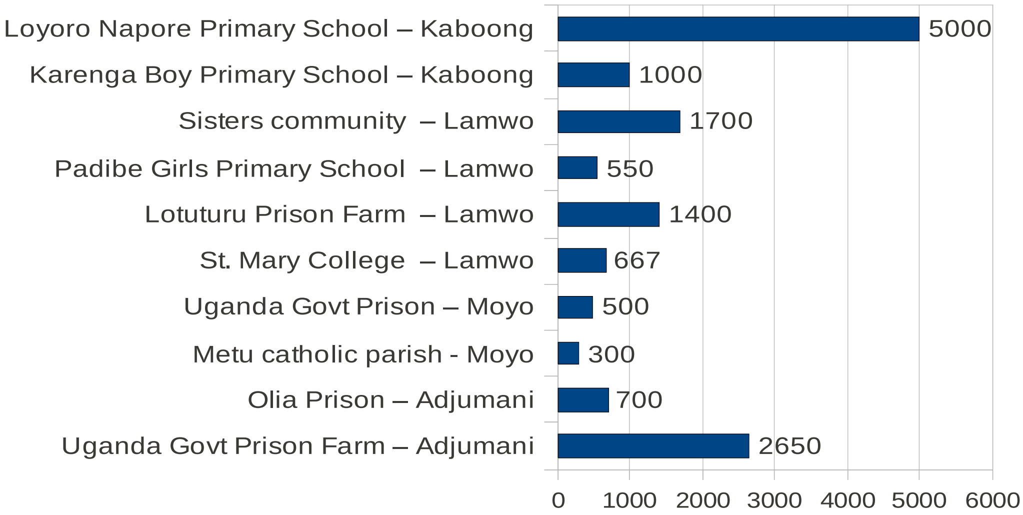


Figure 12: Costs per day for institutions using kerosene

Also, 16 institutions were found using solar energy, but nobody could tell how much they use. Therefore, daily costs for solar usage could not be estimated.

As already mentioned above seven institutions were found using electricity for lighting, office equipment and ICT laboratories. Some reasons why the amount of grid-connected institutions is small are because most of institutions are far from the national grid and if a grid is available it operates mainly during night when most of the schools are closed. Nevertheless, four additional institutions are using electricity but could not give costs for usage.

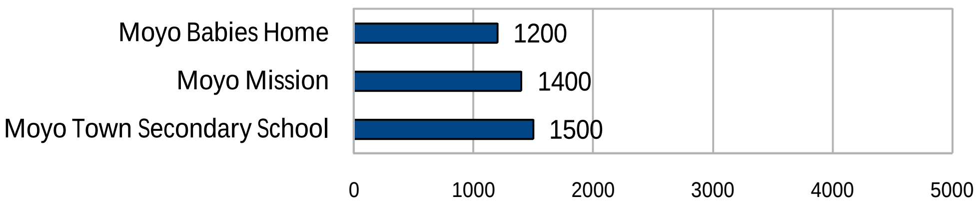


Figure 13: Costs per day for institutions using electricity

LPG was found in four institutions. One institution could not give costs for usage of LPG because the Ministry of Health covers the costs for LPG usage including refilling and transportation.

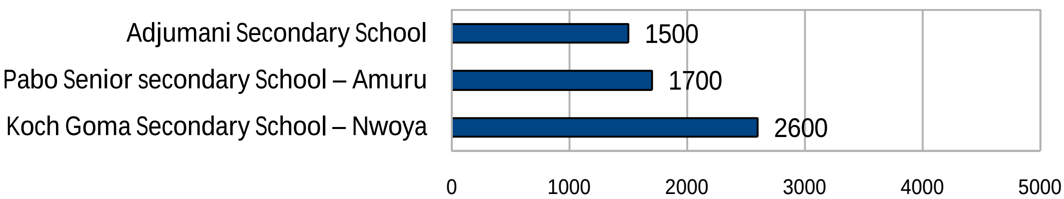


Figure 14: Costs per day for institutions using LPG

3.2. Technical assessment

After the interview with a representative of the institution an evaluation was done to determine which energy technologies could be implemented especially to reduce on the amount of wood fuel currently used. From a technical point of view the following questions must be answered to be able to implement modern types of energy:

- Which energy use is demanded (heat for cooking/boiling, electricity, shaft-power, etc.)?
- How high is the energy demand?
- Is the fuel for the modern type(s) of energy available?
- Which energy technology can be used?
- Are institutions able and willing to use the technology?

3.3. Economical assessment

The willingness of each institution to pay for modern types of energy was analyzed based on the institution's current energy demands and costs. This is related to their ability to pay for improved energy efficient technologies because it would in-turn save on energy costs in the longer term.
The assumption is that, if the institution can meet their current energy demands (wood and/or charcoal), then it can also afford the new technologies if they have any advantage over their current one. On the other side it is assumed that no institution is able or willing to pay more in the future for energy than in their current situation.

The challenge of using energy efficient technologies would be to overcome initial installation costs. Perhaps some institutions are willing and able to pay initial costs if it is clear that they will save money in the long run. Another possibility could be accessing loans and grants for these specific projects. It has to be considered that training and after-sales support must be provided for the institutions to overcome their lack of knowhow to use these technologies.

3.4. Social assessment

The social impacts of energy efficient technologies directly influence daily activities of institutions. For example, improved energy efficient stoves improve cooking conditions in the kitchen, through reduced emissions (soot). Use of other energy efficient technologies for example biogas, and briquettes also influence how energy fuels are viewed and used. While technologies like biogas and improved energy stoves improve the cooking conditions, they require preparation for biomass e.g. chopping wood into smaller pieces and feeding the digester consistently. Such efforts require extra labor and therefore affect how institutions operate.

Biogas and gasification technologies also change the way people view agricultural by-products. For example maize cobs or human excrements will no longer be viewed as waste streams and that affects the way of handling them.

3.5. Evaluation of assessments

The most appropriate institutions for improved stoves, biogas, pico-PV, gasification and briquette technologies are mentioned in the following paragraphs. The priority (0 (zero), low, medium or high) in the tables of the appendix show CREEC's opinion on how well the modern types of energy fit into the institution. In this opinion the technical, economical and social assessment are considered.

3.5.1. Improved stoves

Almost each institution which is not using an efficient technology for their cooking demand is recommended to use an improved stove. These institutions are prioritized with medium. Another priority is given due to the low cooking demand (priority 0 or low) or the institution is already interested in putting a energy efficient stove in place but does not know where to get it (priority high).

Table 6: Potential institutions for improved stove installation

Priority	District	Sub- County	Name of Institutions	Number of pupils / prisoners / patients
medium	Nwoya	Koch Goma	Koch Goma Secondary School	777; 35 teachers
medium	Nwoya	Alero	Alero Senior Secondary School	250; 76 Eaters
high	Nwoya	Anaka	Anaka catholic parish	85 on nursery school
high	Amuru	Amuru TC	St. Anthony of Padua Nursery School	203
medium	Amuru	Pabo	Pabo Senior Secondary School	700
high	Amuru	Atiak	Atiak Catholic Parish	100 tailor, 60 nursery & 10 parish
medium	Amuru	Atiak	Lwaui Memorial College – Atiak	500 students
medium	Adjumani	Adjumani TC	Comboni Comprehensive College	460 students
medium	Adjumani	Ciforo	Adjumani Secondary School	391 students
medium	Adjumani	Pakele	Monsignor Bala Secondary School	300 – 500 students
medium	Adjumani	Pakele	St. Mary Asumpta Girl's school	450 students
low	Adjumani	Pakele	Olia Prison Adjumani	30 prisoner
low	Adjumani	Ofua	Ofua Seed Secondary School	280 students
low	Moyo	Dufile	Laropi Secondary School	213 students
medium	Moyo	Moyo TC	St. Andrew College	300 + students
0	Lamwo	Madi Pei	Bana Bana Army Barracks	Soldier + their families
medium	Lamwo	Madi Pei	St. Mary College	300
medium	Lamwo	Agoro	Lotuturu Prison Farm	27 prisoner
medium	Lamwo	Padibe East	Padibe Girls Primary School	1237
medium	Lamwo	Padibe East	Sisters community	10 people
medium	Lamwo	Padibe East	Padibe Girls Comprehensive School	485
medium	Lamwo	Padibe West	Childcare	1360
medium	Kaabong	Karenga	Jubilee Secondary school	800
medium	Kaabong	Karenga	Kidepo Kalokudo Primary School	350
medium	Kaabong	Karenga	Lokori Primary School	767

3.5.2. Biogas

During the study questions were asked about the availability and number of livestock so as to estimate the amount of biomass the potentially accessible feedstock. The other important feature that was to be investigated was a constant supply of water. Biogas systems are water dependent; therefore a constant supply of clean water is necessary. Also labor to feed the digester and access to farm fields where the slurry from the digester can be utilized as fertilizer were considered.

Table 7: Potential institutions for biogas installation

Priority	District	Sub- County	Name of Institutions	Number of pupils / prisoners / patients
low	Nwoya	Anaka	Pope Paul VI Secondary School	1136; 600 eater
0	Nwoya	Anaka	Anaka P.7 School	1068; 16 teachers
low	Nwoya	Anaka	Patara Primary School	778; 49 eaters
low	Nwoya	Koch Goma	Koch Goma Secondary School	777; 35 teachers
medium	Nwoya	Anaka	Anaka catholic parish	85 on nursery school
low	Amuru	Amuru TC	Reckiceke Primary School	955 students, 16 teacher
low	Amuru	Pabo	Pabo Senior Secondary School	700
high	Amuru	Atiak	Atiak Technical School future site	up to 350
low	Amuru	Atiak	Atiak Catholic Parish	100 tailor, 60 nursery & 10 parish
high	Adjumani	Adropi	Uganda Govt Prison Farm – Adjumani	233 prisoner
low	Adjumani	Pakele	Pakele catholic parish	5 People
low	Adjumani	Pakele	St. Mary Asumpta Girl's school	450 students
low	Kaabong	Karenga	Karenga Catholic Parish	5 People

3.5.3. Pico-PV

The study explored the potential of pico-PV for institutions and households. The focus was on investigating how much money was being spent on light and/or phone charging and analyzing how acquiring pico-PV systems would save money for institutions and households while reducing indoor pollution. The amount of money spent on lighting was directly related to the number of rooms lit every day and the durations for lighting.

Table 8: Potential institutions for pico-PV installation

Priority	District	Sub- County	Name of Institutions
low	Amuru	Atiak	Lwaui Memorial College – Atiak
high	Adjumani	Adropi	Uganda Govt Prison Farm – Adjumani
0	Adjumani	Pakele	Olia Prison Adjumani
0	Adjumani	Ofua	Ofua Seed Secondary School
0	Adjumani	Ofua	Mungula Secondary School
0	Adjumani	Adjumani TC	Adjumani Mission
0	Moyo	Dufile	Laropi Secondary School
medium	Moyo	Dufile	Laropi Health Centre III

0	Moyo	Metu	Metu Secondary school
low	Moyo	Metu	Metu catholic parish
medium	Moyo	Moyo TC	Uganda Govt Prison Moyo
low	Lamwo	Madi Pei	St. Mary College
low	Lamwo	Agoro	Lotuturu Prison Farm
low	Lamwo	Padibe East	Padibe Girls Primary School
low	Lamwo	Padibe East	Sisters community
low	Kaabong	Karenga	Loyoro Napore Primary School

3.5.4. Gasification

Gasification is a relatively new technology in Uganda with potential to reduce pressure on forest products based on the fact that it mainly uses agricultural by-products, which are in most cases viewed as waste. The study investigated how much farm by-products could be assessed by institutions. An analysis was then done on the willingness of institutions to use such products for cooking. Institutions without farms would not easily assess the appropriate by-products and therefore could not use gasification technology. Those with farms had to be assessed for the type of farming in order to determine if the by-products were appropriate for gasification. In the six districts only one institution with a low priority was found where gasification could replace their current cooking application, mainly due to the lack of an agricultural farm.

Table 9: Potential institutions for gasification installation

Priority	District	Sub- County	Name of Institutions	Number of pupils / prisoners / patients
low	Nwoya	Koch Goma	Koch Goma Secondary School	777; 35 teachers
0	Lamwo	Madi Pei	Bana Bana Army Barracks	95 soldiers
low	Kaabong	Karenga	Karenga Catholic Parish	5 People

3.5.5. Briquettes

By-products which could be used include rice husks, ground nut husks and wood chips. Institutions that have access to these by-products were recommended to use briquettes after further investigating their willingness and ability to use this technology.

Table 10: Potential institutions for briquette making

Priority	District	Sub- County	Name of Institutions
high	Nwoya	Anaka	Anaka catholic parish
low	Amuru	Amuru TC	Amuru catholic parish
high	Moyo	Moyo TC	Moyo Mission
low	Kitgum	Kitgum TC	Uganda Govt Prison Kitgum
medium	Kaabong	Karenga	Karenga Catholic Parish

3.5.6. Beekeeping

Because WILD/Tree Talk has been carrying out a massive tree planting campaign in the selected areas, beekeeping was considered as another alternative to protecting trees/ forests from over exploitation due to the added financial advantage from honey. Beekeeping would enhance the tree planting campaign in that institutions would advocate for maintaining the trees while they raise money from honey. Therefore CREEC analyzed the potential linkages for institutions that have tree planting programs to beekeeping in the selected areas.

Table 11: Potential institutions for beekeeping

Priority	District	Sub- County	Name of Institutions
high	Nwoya	Anaka	Anaka catholic parish
high	Amuru	Amuru TC	Amuru catholic parish
medium	Amuru	Atiak	Atiak Catholic Parish
low	Adjumani	Adjumani TC	Comboni Comprehensive College
medium	Adjumani	Pakele	Pakele catholic parish
low	Adjumani	Adjumani TC	Uganda Kids School e.V.
low	Adjumani	Adjumani TC	Adjumani Mission
low	Moyo	Moyo TC	Moyo Technical Institution
medium	Moyo	Moyo TC	Uganda Govt Prison Moyo
high	Moyo	Moyo TC	Moyo Mission
high	Kaabong	Karenga	Karenga Catholic Parish

3.6. General summary of the socio-economic assessment

63 institutions were visited, including primary and secondary schools (both government and privately owned), technical institutes, parishes, health centres and prisons. The main focus was on investigating improved cook stoves, biogas, pico-PV, gasification, briquettes and beekeeping as alternative technologies for conserving forests in Northern Uganda.

The assessment analysed how institutions surrounding protected areas are using different technologies for cooking/boiling and lighting. It also investigated which energy efficient technologies can be used by institutions to reduce their demands for energy mainly for cooking/boiling. These demands are directly related and linked to wood use.

The assessment survey documented the energy demands for each institution including sources of energy fuels, the distances of the fuels, technologies currently being used for burning the fuels and cost for acquiring the energy fuels. On-site observations were also made to determine possible sites where improved technologies can be used successfully in the future.

The findings of possible sites were categorized according to the possibility of each improved technology being implemented in a given institution. The priorities range from zero, low, medium and high.

4. Cost-Benefit Analysis

4.1. Introduction

Following the market analysis and the socio-economic assessment, the cost-benefit analysis gives an evaluation of the cost and benefits of specific energy technologies that have been considered as appropriate alternatives earlier. It covers the institutions that were considered to have high and medium priority for implementing improved energy technologies and takes their current energy expenses as a baseline. The aim is to provide an overview on investments, savings and pay back periods by installing energy efficient technologies as a replacement for the ones that are currently in use. To enhance comprehensiveness this analysis also integrates the environmental and social benefits for the improved energy systems. These findings are relevant for a refined selection of technological interventions as well as their implementation which is subject of the following section.

4.2. Cost-Benefit Analysis of interventions at the recommended sites

4.2.1. Improved stoves

The cost-benefit analysis for improved cook stoves focused on the fixed institutional stoves due to their ability to achieve efficient firewood combustion and maximize heat transfer to the food being cooked. This would increase efficiency in firewood use, hence reduce environmental degradation and improves the working conditions of the kitchen staff that are usually exposed to the risk of lung diseases and burns related to the 3-stone-fire. The institutional stoves are able to achieve a better heat transfer towards at least 90% of the saucepan surface area and have insulation around the combustion chamber and fire passages. Being manufactured in sizes between 100 and 300 litre, improved institutional stoves can serve individually or in combination with several stoves for a large group of food consumers in institutions such as schools, parishes, temple kitchens, barracks, and hospitals to name a few examples.

The Ministry of Energy and Mineral Development in cooperation with GIZ (PREEEP) has developed a Construction Manual for Firewood Saving Institutional Stoves in 2008. The manual was used to estimate investment costs, expected costs saved, and life expectancy for the improved cook stoves. This report mentioned a payback period of 0.5 years for this kind of stove based on an average fuel amount and costs per firewood trip of 400,000 UGX. The survey team adjusted this calculation to the context of North Uganda, where the number of supply trips as well as the current energy costs for the institutions differs. Therefore in the payback period shown below those variables are considered. With this adjustment the improved stoves have a payback period between 2 to 5 years, depending on the amount currently spend on firewood.

Table 12: Saving potential and payback period for institutional improved cook stoves

Average costs per institutional stove	4,600,000 UGX
Fuel savings	50%
Expected life time	5 years
Payback Period	2 to 5 years

Environmental and social benefits

The environmental benefits of improved cooking stoves arise from the saving potential of up to 50% of firewood and/or charcoal. So it is part of energy saving technologies hence helping to fight against deforestation in Uganda.

Another important benefit is the reduction of emissions through more efficient combustion of the fuel, hence decreasing pollution of the environment as well as of the risk of kitchen staff of contracting dangerous lung and eye diseases. This effect is further increased through chimneys that are usually associated with institutional improved cook stoves.

In terms of health protection, the improved cooking stoves are designed to minimize the risks of burns for the kitchen staff and other persons. They are insulated, more stable than conventional fireplaces and burn the fuel continuously, thus making it obsolete to blow into the flame in order to keep the fire going.

The social sphere is additionally touched by the speed-up of the cooking process, as the majority (90%) of the heat is directed towards the saucepan, thus releasing valuable time for the kitchen staff that can be spent for other works.

Evaluation

Improved stoves have a proven fuel-cost saving value of 50%. With a minimum life span of 5 years, institutions would therefore be able to save a considerable amount of money throughout the years. However, with the relatively high upfront costs of a quality improved institutional cook stove, 24 institutions were recommended for installation of improved stoves, of which all feature high fuel costs per month and would thus profit of a shorter payback period.

4.2.2. Biogas

The cost-benefit analysis for biogas focused on the institutional size fixed dome reactor that is deemed to be the most appropriate technology for the surveyed region. The advantages of this type of reactor are that it has no moving parts and it is easier to maintain. The fact that it is underground makes temperature fluctuations lower, which provided stable temperatures for bacteria in the reactor. Also, stable temperatures help support a long life span of the reactor. Therefore, this is a considerable long-term cost saving investment which can reduce energy costs. Two parishes, one in Nwoya and another one in Amuru, were found where biogas is recommendable due to available feedstock. In addition the government prison farm in Adjumani is also recommended because it has over 100 cows kept in an enclosure at night which makes it easy to collect enough cow dung (feedstock). Furthermore, the prison has enough labor to feed and maintain the reactor.

The feedstock/biomass considered from these institutions includes cow and pig dung as well as human excrements. However, not only the type but also the amount of feedstock determines the volume of gas that will be produced by the system. Therefore, it is key to consistently work with the exact number of livestock or humans that produce the feedstock. The size of the reactor is not only determined by the potential gas volume it can produce but also by the actual need of cooking gas, depending on the number of meals that are prepared each day.

Initial costs which are considered in this study include: materials and equipment, construction labor and transportation. Money for buying energy fuels is not required because the planned feedstock is already available at each institution. Therefore the running costs of a biogas system is reduced to operational and maintenance costs which are relatively low for this technology. The consultancy fee for supervision and managing of the implementation is not included in the initial costs.

If the system is large enough and feedstock is available biogas can cover the up to 100% of the energy demand of the institution. The table below indicates how much biogas can replace the current cooking demand in percentage. This input is considered for the direct annual savings and therefore in the payback period.

Table 13: Cost of technology per institution for Biogas for medium and high priorities

Priority	Medium	High	High
District	Nwoya	Amuru	Adjumani
Name of institution	Anaka Catholic Parish + attached nursery school	Atiak Technical School future site	Uganda Government Prison
Number of people hosted	85	Up to 350	233
Number of meals per day	255	1050	699
Current energy costs based on charcoal and firewood	60,000 UGX /month	400,000 UGX /month	700,000 UGX /month
Feedstock	Organic by-products from farm	Human excrement and farm byproducts	Cow dung from more than 100 cows
Conversion factor of different feedstock to biogas	0.38	0.26	0.17
Feedstock input per day which is converted into Volatile Solids	86 kg (10 kg)	167 kg (33 kg)	1100 kg (125 kg)
Proposed type of digester	Fixed Dome	Fixed Dome	Fixed Dome
Proposed size of digester	10 m³	20 m³	130 m³
Biogas output per day	5.5 m³	12.4 m³	30.0 m³
Manure output per day	0.26 m³	0.50 m³	3.23 m³
Initial installation costs	5,000,000 UGX	9,500,000 UGX	26,000,000 UGX
Operation and Maintenance costs per year	150,000 UGX	300,000 UGX	600,000 UGX
Percent of cooking demand fulfilled	50%	50%	100%
Direct Savings per year	210,000 UGX	2,100,000 UGX	7,800,000 UGX
Payback Period (years)	26	4.5	3.5

Environmental and social benefits

The use of biogas as a cooking energy source goes along with several environmental benefits. First of all, the burning of biogas is almost a carbon neutral fuel because it does not add extra CO_2 into the environment. The CO_2 gas released during combustion is what was absorbed during plant growth. The technology also burns methane gas that would in any case be produced and released into the atmosphere during the natural decomposition process of dung and green wastes. The CO_2 produced by burning the methane is much less harmful as a greenhouse gas than methane itself. Moreover, the use of biogas substitutes the consumption of conventional biomass such as firewood and charcoal whose production is the main driver for the ongoing deforestation in Uganda. Therefore it contributes to the protection of the forests and their capacity of absorbing the greenhouse-gas CO_2.

Another environmental advantage of using biogas is the secondary output from a biogas reactor, the slurry, which is a good fertilizer that can be applied in gardens and plantations.

In addition, the use of biogas implies an effective waste management, as animal and human excrements are collected in the reactor, otherwise facilitating the spread of insects and diseases.

Evaluation

Biogas was recommended after field assessment in three institutions from of the six districts that were considered from the study: Anaka Catholic Parish in Nwoya, Atiak Technical School (future site) in Amuru and Uganda Government Prison farm in Adjumani.

The success of these three biogas projects will depend on how well the leaders in each institution are trained and motivated to ensure that the projects remain running after installation. They should be able to operate the system properly and, if needed, ask for technical support from the implementation team as well as have the motivation to cook with biogas.

Biogas requires big investment therefore projects must live long enough in order to pay off the initial investment. However, institutions should also understand that biogas may not be available during maintenance periods and in case of Atiak Technical School after schools holidays when the digester is not fed. They should be flexible to use other fuel sources and return to biogas when it is available again. It is hoped that by then, users will be accustomed to cooking with biogas, thus perpetuating the usage and maintenance of the system.

After the biogas reactor is installed the payback periods for the institutions would be; Anaka Catholic Parish at 26 years, Atiak Technical School (future site) 4.5 years and Adjumani Uganda Government Prison Farm at 3.5 years. The analysis for implementing biogas at Anaka Catholic Parish showed that it may not work because of two reasons: 86 kg feedstock per day is required to fulfill their cooking needs. That amount is not available. The other reason is that the payback period is close to the expected lifespan of a fixed dome reactor (30 years) and therefore seen as too long.

Hence, the sites in Atiak and Adjumani seem to be the most favorable for a biogas project.

4.2.3. Pico-PV

Being simply and relatively affordable, pico-PV lighting systems are part of a solution for electrification in the areas visited for this study. The production of electricity out of sunlight by pico-PV does not pollute the environment, deplete natural resources, or endanger animal or human health. For lighting purposes, pico-PV systems usually replace conventional light sources such as petroleum lamps, candles and dry-cell torches that all cause pollution (toxic gases and battery waste) and monthly costs to a household/institution. Apart from lighting, they offer an option of phone charging and would therefore save additional costs for households.

The on-site assessment found out that nearly everybody is willing to use solar energy. However, lack of funds and information about the technology, are the main reasons why it is not used on a large scale.

Pico-PV is much cheaper than normal solar home systems because they are significantly smaller, with the main purpose of lighting. Moreover, the systems can be easily extended by purchasing more pico-PV products depending on the current demand and availability of funds. Pico-PV systems are cost beneficial as the investment costs are relatively low while there are no other operating costs like installation, labor and maintenance.

However, Uganda and specially the North lacks showcases from which people can pick the idea and use pico-PV on their own. Two government prisons in Moyo and Adjumani districts are recommended to implement pico-PV in the prisoners' dormitories. They have leadership structures in place which will ensure good monitoring and charging of the systems daily. These two institutions can then be used as showcases as mentioned above for future up scaling. The systems will also act as sensitization/education for prisoners before they return to their homes. The health centre III in Moyo is also recommended to use pico-PV because it would replace the privately owned torches used at night and hence contribute a more reliable lighting source in emergencies at night.

Table 14: Cost of technology per institution for pico-PV

District	Adjumani	Moyo	Moyo
Sub- country	Adropi	Dufile	Moyo TC
Name of Institution	Uganda Government Prison	Laropi Health Centre III	Uganda Government Prison
Number of prisoners/patients	233 prisoners	50 patients per day	54 prisoners
Cost of pico-PV with phone charging possibility	2x 100,000 UGX	1x 100,000 UGX	2x 100,000 UGX
Cost of pico-PV without phone charging	6x 50,000 UGX	1x 50,000 UGX	3x 50,000 UGX
Total pico-PV costs	500,000 UGX	150,000 UGX	350,000 UGX
Savings per month	80,000 UGX	Unknown	13,000 UGX
Payback Period	7 months	Unknown	12 months

Environmental and social benefits

The main environmental benefit of pico-PV includes the significant reduction of hazardous gases that are emitted by the burning of petroleum or biomass for lighting. Those gases such as carbon monoxide and carbon dioxide are considered to contribute considerably to potentially fatal lung infections among people who rely on biomass or petroleum for lighting in the long run.

Also, burning risks especially among babies, children and women are significantly reduced by the solar lights that are clean, not burnable and cold.

Moreover, pico-PV systems contribute to the reduced consumption of low-quality dry-cells for torches. With its rechargeable battery remaining to be disposed properly after some years, the environmental impact of pico-PV systems stands in no relation to the masses of cheap dry-cells that are used up after short time and thrown away usually without proper disposal.

Evaluation

It is recommended that each institution starts with a few pico-PV lanterns in order to gain experience and subsequently decide whether they would invest in more solar lights. The lanterns have a payback period of 7-12 month for the institutions so after that time the institution is able to afford more lamps if required.

Being affordable and simple to use and operate, this technology is considered to be easy to introduce and eventually rolled out on all three sites recommended.

4.2.4. Gasification

As hydrocarbon resources are not finite and unevenly distributed, gasification technology offers another innovative alternative to conventional and dwindling energy sources. In terms of feedstock flexibility, gasification offers a cost-effective solution for the rural context in general, where there is usually an abundance of green/agricultural waste. It also reduces the costs associated with emissions as it is a low-emission technology. Gasification is highly recommended for household and institutional cooking, as low-tech gasifiers can be manufactured in small and large sizes at affordable rates.

However, the small amount of farmland at schools in the surveyed regions makes it difficult to use gasification on an institutional scale. Therefore no institution was recommended for this technology. Another disadvantage is that the costs for institutional gasifiers (for cooking) are not known yet in Uganda. After the World Bank program BEIA is implemented more data in cooking on gasification will be known. Within the project, CREEC will promote the TLUD gasifier through creating awareness about its use and benefits, training of tinsmiths in manufacturing, training of entrepreneurs in marketing/selling and creating other business opportunities. The output of the project might eventually lead to a higher popularity of this technology even for the institutions in the area of study.

Evaluation

The evaluation is not considered in the cost benefit analysis because no institution could be recommended for the technology.

4.2.5. Briquettes

With the possibility to be produced out of almost any organic by-product, briquettes state another alternative to firewood and charcoal. Briquettes are relatively easy to produce, store, transport and do not require chopping like firewood before being used. In households and institutions, briquettes can be used in conventional stoves and save on fuel costs as their raw material is available for free or at negligible costs.

In the surveyed region, biomass (rice husks and wood chips) for briquette production in the recommended institutions was readily available. Institutions must however overcome the high initial investment costs especially with the briquette making machine and also create a market for the briquettes. Three parishes were found where briquette making could be implemented. These are in Nwoya, Moyo and Kaabong districts. The amount of raw material on those three spots was estimated to be 10 tons per year which could effectively decrease the use of forestry resources in the region. Once installed, it is expected that the institutions will benefit from briquettes for their own use and selling them to neighboring homes or other institutions. For the briquette cost-benefit analysis, the following assumptions have been made:

- The price for firewood is estimated at 50 UGX/kg. This estimation is based on the average costs spent on a trip of firewood (100,000 UGX) with is approximately 5,000 kg of wood loaded.

- The price for charcoal is estimated at 125 UGX/kg. This estimation is based on the average costs spent on a sack of charcoal (10,000 UGX) with approximately 80 kg charcoal per sack.

To check economic viability of briquettes three scenarios where considered:

1. Briquette price of 50 UGX/kg and human powered briquette machine

2. Briquette price of 50 UGX/kg and engine driven briquette machine

3. Briquette price of 100 UGX/kg and human powered briquette machine

Table 15: Economical calculation of briquettes making for three different scenarios

Scenario	**1.**	**2.**	**3.**
Energy	Human power	Engine (generator)	Human power
Briquette price per kg	50 UGX	50 UGX	100 UGX
Possible fuel	Rice husks and wood chips	Rice husks and wood chips	Rice husks and wood chips
Initial costs	10,000,000 UGX	13,000,000 UGX	10,000,000 UGX
Operating Costs per year	400,000 UGX (40,000 UGX/month) 10 month /year	680,000 UGX (80,000 UGX/month) 1 month /year 2 labor	400,000 UGX (40,000 UGX/month) 10 month /year

		+ 600,000 UGX (diesel)	
Briquettes in kg /year	7,200 (30 kg /day)	10,000 (300 kg /day)	7,200 (30 kg /day)
Gross Income Year	360,000 UGX	500,000 UGX	720,000 UGX
Net profit per year	-40,000 UGX	-180,000 UGX	320,000 UGX
Payback period	Not economical	Not economical	32 years

Operating costs include the labor for running the briquette making machine, transport to get the rice husks/wood chips (no costs for fuel), maintenance costs and if needed as in scenario 2 the fuel costs for the generator. Not include are Value Added Tax (VAT) expenses, depreciation, development of the briquette market, consultancy fee for supervision and managing of the implementation.

Environmental and social benefits

As with biogas, the production and use of briquettes does not go along with deforestation but with the innovative use of organic waste such as agricultural by-products (rice husks and wood chips). Therefore, the protection of forestry resources is one of the key virtues of this technology.

In combination with an energy-efficient stove, this technology has the potential to make an impact among the various efforts to decrease deforestation, fight climate change and enable the poor to save money.

Evaluation

The raw material for briquette production will be rice husks and saw dust collected from local rice hullers and wood mills for the three recommended institutions in Nwoya, Moyo and Kaabong. In each of these institutions a quantity of approximately 10 tons per year is already available for conversion into briquettes. If required and economically feasible additional raw material can be collected in the surrounding of the respective sites for increasing the amount of briquettes.

The cost-benefit analysis, however, revealed that the pay-back period for briquette making exceeds 30 years, and this in the only scenario out of three that was considered to be profitable. The main impediment for the large-scale promotion of briquette making is the low local retail prices for firewood and charcoal, standing in no relation to the environmental and economic externalities.

Nevertheless if briquettes are well promoted through marketing and sensitization campaigns, being possibly very effective in parishes, people could be encouraged to test the briquettes. Using in addition a subsidy-scheme that takes off some of the costs, briquettes can be produced and sold up to a threshold amount that makes the technology profitable. Furthermore, retail price development of biomass fuel has to be closely observed, as higher prices might one day economically justify briquette making.

A manpowered briquette making machine is from his concept similar to a clay brick machine. Therefore an idea is to enhance the economical feasibility by combining both production processes without significant extra costs. This approach should be further investigated through research on pilot systems to understand if the compaction of the row-material for the briquettes is enough in a brig making machine.

4.2.6. Beekeeping

Apart from conservation of trees and the financial benefits from the sale of honey, beekeeping is used for pollination of flowers, crops, and fruits. Bees can fly around their hives within a radius of 3 km collecting nectar for their colonies. Beekeeping is also a good tool for education for households and communities for environmental awareness.

Institutions would benefit financially from the sales of honey, with minimum investment costs and very moderate operation and maintenance costs. They would also venture into other wax-based products like candle making. Modern beehives can produce between 10 - 20 kg of honey per harvest. The cost for these hives is between UGX 60,000 and 160,000 respectively. But it is advisable to start a beekeeping business with local produced hives. These hives do not require so much experience and they are much cheaper but also have less honey output.

Table 16: Initial costs involved for beekeeping with 1 bee hive

4 beehive (locally made)	60,000 UGX
Bee veil (for a simple type)	15,000 UGX
Smoker	50,000 UGX
Gloves	15,000 UGX
Air tight bucket	20,000 UGX
Sum of above beekeeping equipment with 1 hive	160,000 UGX
Honey output per year	20 kg
Retail price for Honey per kg	2,500 UGX
Income generated per year	50,000 UGX
Payback Period	3 years

Environmental and social benefits

The major environmental benefit of bees is their role as pollinator for all sorts of plants and trees. Beekeeping thus significantly contributes to the biodiversity. In that sense, beekeeping can actually have a pro-active impact on the reforestation efforts in the surroundings.

On the product side, honey is a valuable food that besides its energy content and sweetness also has medical properties especially in rural regions with a restricted nutritional awareness; a bit of honey can be a rich complement to the daily nutrition.

It is important to note that consultancy fee for supervision, managing and monitoring the implementation of these projects is not included in the initial costs.

Evaluation

Six institutions are recommendable to carry out beekeeping as a way of conserving trees but also as an income generating project. This includes Anaka Catholic Parish (Nwoya), Amuru Catholic Parish, Atiak Catholic Parish (Amuru), Pakele Catholic Parish (Adjumani), Moyo Mission and Uganda Government farm - Adjumani. Schools were given a low priority mainly because many school heads see a possible negative interfering between bees and the students.

The cost-benefit analysis shows that depending on the number and type of hives, beekeeping can become profitable. With four locally produced bee hive, the institutions could generate an income of 50,000 UGX per year. This would result in a payback period of 3 years with an investment of 160,000 UGX. The amount of money earned would increase with increase in the number of bee hives. That means that after an institution has experience in beekeeping it could invest in more hives or acquire modern types of bee hives to get more income.

In that sense, beekeeping is considered to be appropriate and feasible as a complementary measure at all recommended sites.

4.3. Summary

In summary, this report covers the six districts that were considered for the study. It focuses on the analysis of energy costs for institutions which include the type of recommended technology, costs for installations, costs saved/income generated from the technology and the payback period. These aspects help to justify the economic viability of the recommended system. Environmental and social benefits were also mentioned as their weight might be considered in the decision making process. Each technology and institution was analyzed individually in terms of appropriateness and favorable factors for the study.

The first technology considered was improved institutional cook stoves that are able to save up to 50% of the bio fuel used for cooking. Improved stoves feature a large variety of virtues, contributing to the halt of deforestation, helping institutions and individuals to save money and time, as well as significantly reducing health risks. Improved institutional cook stoves have relatively high upfront costs between 2 and 4.5 million UGX and a payback period of 2-5 years. However, the good cost-benefit balance requires quality material and artisanal work in the beginning, when the cook stove is designed and installed. Afterwards, operation and maintenance costs are reduced to a negligible minimum.

While biogas offers a high potential for providing a clean and cheap cooking energy source, the availability of sufficient volumes of feedstock each day is key. With sufficient feedstock the relatively high upfront costs are going to pay off after 3.5 to 4.5 years. However, the biogas systems require good artisan skills and thorough training on operation, maintenance and troubleshooting. If this is given, biogas can be a profitable and smart alternative to conventional biomass.

Solar pico-PV systems are quite promising in Northern Uganda, meeting a high interest and being considered to be highly appropriate for their local rural setting. With relatively low up-front costs, pico-PV pays off after a short period (less than 1 year). Their promotion is appropriate as a measure to reduce the use of conventional fuels.

Gasification will not be implemented in any of the institutions because none of them was found with the right amount of organic by-products to support cooking with this technology. Also it is a relatively new technology in Uganda that is still under investigation. It would only be recommended for institutions after further testing. At this point however, small scale gasification is highly recommendable for household cooking.

Briquettes will provide a challenge for implementation because of the costs associated with the technology. The initial and operational costs result in the payback periods up to 32 years. The reason which makes it an economically complicated is because the briquettes must be sold at a competitive price in relation to the current fuels like wood and charcoal. From an environmental point of view the usage of briquettes is a good alternative to wood and charcoal. So perhaps pilot projects could create awareness and become economical if energy costs are increasing.

Beekeeping is another technology considered for income generating for the institutions. With a relatively low investment, beekeepers would be able to raise extra income due to the financial benefit from honey. It would also help conserve the trees that are planted near the institutions because pollination of the crops and fruits improves yields.

5. Strategic Implementation Plan

5.1. Introduction

For the present strategic implementation plan, information has been drawn from the preliminary field-study as well as from CREEC's expertise and experience. Relevant for the choice of technology to be implemented were the conditions of the assessed site (environmentally and economically), the local beneficiaries' demand for technology and training as well as their ability to contribute financially. Therefore not only the individual implementation steps but also cost-sharing aspects are outlined as they are relevant for the long-term sustainability. Technical aspects of the installation and training were drawn from the experience of CREEC. As the present plan provides an overview on the different implementation aspects and challenges, a more specific plan, listing the exact need of material, personnel, funding and logistics, should be elaborated during further site visits and is not part of the scope of this study. A monitoring and evaluation scheme is recommended for the implementation phase.

5.2. Implementation plan

The technologies that are recommended to be implemented in northern Uganda are:

1. Improved stoves for each institution that is still using 3-stone-fire cooking technology
2. Biogas for two institutions: Atiak Technical School future site in Amuru and Uganda Government prison farm in Adjumani
3. Pico-PV systems for three institutions: Uganda Government prison farm in Adjumani, Laropi Health Centre in Moyo and Uganda Government Prison in Moyo.
4. Briquette making should be established in three parishes: Nwoya, Moyo and Kaabong
5. Beekeeping for six institutions: Anaka Catholic Parish in Nwoya, Catholic parish in Amuru, Atiak Catholic Parish in Amuru, Pekele Catholic Parish in Adjumani, Moyo Mission in Moyo and Uganda Government Prison in Moyo.

5.2.1. Improved Stoves

Improved institutional stoves should be installed at all institutions that cook with the conventional 3-stone-fire, which is the vast majority among cooking institutions. Therefore potential saving of firewood is as high as the interest, expressed from the institutions' side.

Funding

A 50% cost-sharing scheme is envisioned to purchase and deliver the improved institutional stoves to the respective institution. To ensure that the system remains sustainable, it is suggested that 20% of the institution's share is paid at the beginning. The next 30% share of the installation costs will be provided as a loan to the institution that will be paid back in a period of 2 years. This should serve as an incentive to keep the system running for a minimum period of time in order to establish a usage routine to enhance sustainability. With a payback period of less than three year the institutions have a financial interest in the subsidised purchase of improved stoves.

Technical Site Assessment

The preliminary work will consist of choosing the proper placement for the improved stoves. Therefore, criteria such as room layout, safety and accessibility have been taken into account as well as the possible locations of chimneys and fuel stock.

Installation

In order to achieve a heavy-duty product that is appropriate for institutional cooking, quality material as well as special skills and experience are key for ensuring durability. As long as there is no established stove-builder in the North, the main components as well as the craftsmanship have to be brought from Kampala. All construction steps would be effectuated on the spot, comprising the brick-laying and plastering of the combustion chamber as well as the construction of a chimney that channels the smoke out of the kitchen. In some cases, new, more robust saucepans are to be bought, being able to fit on the new stoves and withstand their more intense heat.

Training

One training session has to be carried out for each institution, targeting the cooks and other kitchen staff. The training would feature a cooking test with an improved and a conventional stove, demonstrating the proper use as well as the virtues of the improved stoves in terms of fuel saving and decreased risks of burning and lung diseases. Consisting of low-tech components, improved stoves require, however, basic maintenance/cleaning that would be integral part of the training.

Time frame

The actual installation would take 4-7 days per institution, excluding travel and depending on the number and size of improved stoves required. For the training, 1-2 days are foreseen, equally depending on the size of the institution.

5.2.2. Biogas

Two biogas systems can be installed in the surveyed area, having a volume of 20 m³ (Atiak Technical School) and 130 m³ (Ugandan Government Prison Adjumani) respectively.

Funding

For the installation of each biogas system, the respective institutions in Atiak and Adjumani are expected to contribute 50% of the total costs whereas the other 50% would be provided by an external funding body. To ensure that the system remains sustainable, it is suggested that 20% of the institution's share is paid at the beginning. The next 30% share of the installation costs will be provided as a loan to the institution that will be paid back in a period of 2 years (figures specific for the biogas sites are mentioned in table 17). This should serve as an incentive to keep the system running for a minimum period of time in order to establish a usage routine to enhance sustainability. When projects are implemented and institutions feel they are obliged to keep them running, it ensures their survival even beyond the payback period. In addition, each institute would be required to appoint an individual who will oversee and monitor the biogas reactor and do the basic trouble shooting.

Table 17: Outline of the funding scheme for biogas systems

	Atiak Technical School	Adjumani Prison
Cost of installation	9,500,000	26,000,000
External funding (50%)	4,750,000	13,000,000
Contribution of institution (20%)	1,900,000	7,800,000
Loan to institution (30%)	2,850,000	5,200,000
Monthly loan repayment	118,750	216,667
Loan repayment period in months	24	24
Expected monthly saving	200,000	700,000

Technical site Assessment

Potential sites for the biogas reactors have to be assessed for flooding, rocks and other hindrances to the construction and survival of the reactor. This implies also the appropriate proximity to the gas end-user (kitchen) and the feedstock.

Installation

For the reactors of 20 m³ (Atiak Technical School) and the 130 m³ (Government Prison Adjumani), the same installation steps are foreseen. Preliminary works will consist of excavation of the expansion chambers, excavation of the main digester unit and neck fabrication. The actual installation comprises the construction and plastering of the digestion and expansion chambers, drainage channel construction, piping and charging with biogas slurry. Moreover, test runs are to be conducted and the system eventually connected to the end-user.

Training

Experience has shown that the operation and maintenance of a biogas system always requires a concise but thorough training on different aspects such as the qualitative and quantitative choice of feedstock, feeding procedures, use of overflow slurry, maintenance steps and trouble shooting.
Such training would target one or two focal persons provided by each institution, who would be responsible for overseeing and operating the system.

Time frame

Preliminary site assessment, installation, training and monitoring are roughly estimated to take 2 month for the small system (Atiak) and 4 month for the large system (Adjumani), excluding logistics of material and travel. Also time for getting the permit from the institution and formalities for contracts must be considered. Due to the fact that this lies within the responsibility of the institution itself and probably its ministry, an estimation of this extra time cannot given.

5.2.3. Pico-PV

The pico-PV systems can be implemented at the three selected institutions in Adjumani (Uganda Government Prison) and Moyo (Ugandan Government Prison) and in Laropi (Health Centre III). Two different pico-PV products would apply in these projects. One which is purely for lighting and an extended, larger one that provides a charging option of mobile phones. For the prison the lamps with phone-charging opportunity could be given to the guards and the lamps which are purely for lighting to the prisoners. At the health centre the phone charging option is supposed to enjoy high popularity, what might, however, lead to discharged batteries at many moments. Therefore, also a lamp without phone-charging function is recommended in order to guarantee a stable light source in case of emergencies.

Funding

Institutions are expected to contribute 50% of the total cost for every unit. The reasoning behind that suggestion stems from the short payback period as well as the idea of ownership that is implied by a beneficiary contribution.

Technical Site Assessment

Technical site assessment is not necessary for pico-PV products. The reason is that the locations where the solar panels will be positioned are not important because they are portable. Furthermore, aspects of safety and security of the systems are part of the training that is hold after delivery.

Installation

Uganda Government Prison Adjumani is recommended for 8 units, 2 with phone-charging device and 6 pico-PV units without charging possibility. The Uganda Government Prison Moyo is recommended for 5 units, 2 with phone-charging and 3 without charging possibility. On the other hand, the Laropi Health Centre III is recommended for only 2 units, a smaller one and a larger one because it’s meant for emergency only.

The systems will be purchased and delivered to the respective institution. Installation is not needed so installation is finished after handing over the products.

Training

Pico-PV systems do not have serviceable parts, but they require the respect of some rules of operation as well as simple maintenance to keep them operating smoothly. Therefore a short training is necessary on the “do's and don'ts” of the solar light, including charging and de-charging recommendations. This training would target the focal persons in the respective institutions that would be responsible for the pico-PV system. The training will be less than one day and should be held on the same day when the systems are handed over to the institutions.

Time Frame

It will take half a day for each institution for handing over the solar lights, demonstrate how the pico-PV systems work and do the training. Further time is going to be spent on monitoring activities in order to provide technical assistance in case of need.

5.2.4. Briquettes

In total, three man powered briquette making machines can be installed in the parishes with access to raw material (in this case rice husks and saw dust). These parishes are located in Nwoya, Moyo and Kaabong.

Funding

At the current price level (see cost-benefit analysis), the payback period of briquettes is considered to be too long for motivating local producers to adopt the technology in the short run. Being nevertheless considered as one of the most promising future solutions, it is suggested to pilot briquette making so it is established at some places before conventional biomass prices go up, which is considered to be probable. Hence, a subsidy scheme is foreseen, covering the purchase of the machine (see cost-benefit analysis, scenario 3) as well as training whereas labour, transport of raw material and other operating costs are borne by the briquette producer.

A cost sharing scheme for the machine might also be possible. However, it should be considered that briquettes are still unknown among rural Ugandans and would therefore need strong marketing as well as free samples distributed to households for some time, thus leaving the briquette maker with minimal income. Hence his own financial risk for promoting a pilot technology should be limited as much as possible.

Technical Site Assessment

The technical assessment of the site would assess the amount of suitable biomass that can be pressed into briquettes. Furthermore, appropriate locations for operating and storing the machine as well as for stocking the biomass are to be identified.

Installation

The machines can be purchased from Kampala and subsequently transported to the three sites. Machines are ready-made to be operational on the spot, installation would only involve getting it fixed on a concrete base.

Training

Training on the correct operation and cleaning/maintenance of the machine would be provided during one full day per project site. Another training day would concentrate on the right raw material, its virtues and correct stocking, which is crucial especially during the wet seasons. Two more training days would treat basic marketing strategies, including promotion, conditioning, pricing and target groups.

Time Frame

The time frame for the distribution of all three briquette making machines and training would be around 18 days, with one day installation/introduction, four training days and one travel day to the next destination. More time-consuming is the “after-implementation support”. As mentioned above market developing and technology adaptation are crucial and it is recommended that the project team also offers support over a period of at least one year. It this period it should be planned to make minimum 4 visits to provide individual support wherever it is needed.

5.2.5. Beekeeping

The study found possible sites for beekeeping implementation in six parishes and one prison, being located in Anaka, Nwoya, Amuru, Atiak, Adjumani, Kaabong and Moyo. Currently, some sub counties in the mentioned districts pursue beekeeping under their Strategic Environmental Action Plans (with support of WILD), and as such adding more beekeeping site could be linked to this process.

Funding

The bee hives and the beekeeping tools would be purchased by the institutions themselves due to the small investment costs. However training and consultancy is needed which would be provided by a third party.

Technical Site Assessment

The preliminary work focuses on the analysis of the area and surroundings with regard to the local flora and potential bee hives installation sites. With the results obtained, the type and number of beehives as well as their location would be defined.

Installation

Bee hives and beekeeping tools would be purchased and delivered to the respective institution. Depending on the type of bee hive chosen, they could be produced locally or purchased from agricultural stores in Kampala. The bee hives are going to be installed in relatively short term, being usually fixed on appropriate trees that are strong enough to hold them. After the installation of the hives, the hives are to be baited to attract bees to colonize the hive.

Training

Beekeeping requires a relatively low effort in terms of operation and maintenance, compared to the output of valuable honey. However, the know-how on how to start a bee colony, multiply it and protect it from diseases and predators is key for effective beekeeping. Besides that, the proper and sustainable harvest of honey, its conditioning, marketing and further processing requires skills that are to be transferred through a series of trainings. In addition it is recommended to provide two after-implementation visits to make sure that all questions can be answered and ensure that the bees produce honey for a long time. The first visit should be two months after installation, which is before the expected first harvest and again about five months later which is before the second harvest

Time Frame

Technical site assessment and bee hive installation would take two days each, followed by a five days training period. Without transfer, the total time for all six sites would therefore amount to 7 weeks plus the after-installation consultancy and site visits.

5.3. Monitoring and evaluation scheme

Although not being an integral part of the implementation plan, this section outlines the necessary steps that have to follow this phase in order to ensure sustainability.

In order to promote the long-term functionality of the technologies after the implementation phase, a monitoring scheme will be established. The scheme foresees that every single installation is checked regularly through on-site visits during a period of one year (improved stoves, biogas and briquettes) and half a year (pico-PV and beekeeping) respectively. The main goal is to assist institutions to continue using the technology, hence saving wood and money and therewith reaching a payback of their investment.

Concerning the intervals, improved stoves, biogas and beekeeping will be monitored during two site visits after the installation whereas pico-PV will be monitored at one site visit. However, constant communication with the relevant focal persons about the performance of the systems is envisaged. Beyond the early days support, the after-installation phase is supposed to confine for two years in total, providing occasional support if needed.

Briquette making would take off after the appropriate machinery in installed. Nevertheless to implement a new technology of this calibre, one needs a good understanding in terms of record keeping, product marketing, constant monitoring and flexibility in production in order to generate income.

Mid and final evaluation reports should be written after the respective site visits, outlining the impact on the environment and institutions in terms of saving of firewood and charcoal. Moreover, the evaluation should take the lessons learnt as a base to evaluate the perspectives of a further roll-out of these technologies.

5.4. Summary

The present plan has outlined the necessary implementation steps for five technologies designated to replace or reduce the use of biomass or kerosene as cooking and/or lighting sources. Being very different in terms of technology, complexity and application, their implementation, however, requires some special attention on particular challenges that are summarized as follows.

Some of the proposed solutions necessitate only a short time and simple technical site assessment defining the placement (improved cook stoves, pico-PV) while others like biogas systems, briquette making and beekeeping require a thorough and more complex site assessment. Those complexities consist of local soil conditions (biogas), as well as environmental features (beekeeping) and economic features (briquettes) in the surroundings. This explains the differences in respect of time and expertise for the preliminary work to be done before installing the various technologies.

In terms of installation, “instant usage” solutions such as pico-PV and briquette-machines are relatively easy to set up, thus putting the focus on training. Other technologies such as biogas and improved stoves require not only material of sufficient quantity and quality but also skilled and experienced professionals to set up these systems with the necessary accuracy.

The base, however, for a long-term impact of the installation is a thorough and well-conceived training that puts the focus on different aspects. While the training on pico-PV would be limited mainly to “do’s and don'ts” and general aspects of the technology, the focus on improved stove training would be put on its purpose and virtues as its acceptance is still challenged by conservative and widespread cooking habits. Biogas and beekeeping training revolves mostly around technical aspects of operation, maintenance and troubleshooting as experience shows that these are the key aspects of a sustainable usage in rural Africa. In contrast, briquette training, although covering technical aspects of the production, would focus on business training and marketing as this is a more critical pre-condition for a successful promotion of this technology.

6. Concluding remarks and the way forward

The preliminary work has revealed that renewable energy solutions to combat deforestation and help people saving money actually are on the market, in demand and profitable. Some solutions are more complex and technology-loaded than others. However, for every single site-context, the most appropriate technology has been carefully chosen and weighted against other options. In any case, there is no “one-size-fits-all” approach, and a set of various technologies proved to be more successful in the long run, being adaptable to different needs and capabilities on the spot. Every technology recommended for the specific site effectively helps in its own way to meet the needs of the environment and humans in terms of resource protection and livelihood improvement.

Amongst the presented technologies, there are some such as briquettes and gasification that enjoy more popularity in other developing countries than here in Uganda. However, these solutions proved to work perfectly in similar contexts as parts of comprehensive strategies to provide rural and urban areas with renewable energies. Piloting such projects in Northern Uganda would therefore be a big step forward for the introduction of new, innovative technologies in a country that desperately need to consider every energy alternative that is within reach.

The implementation strategy has revealed that the more complex or unconventional a technology is the more emphasis is put on the training and subsequent monitoring in order to ensure a long-term operation of this technology. Many stranded energy projects by other organisations have been discovered by the survey team during its research, where the handover of the new technology directly followed after installation, without a proper training and trouble-shooting assistance. Therefore, people need to be assisted with hands-on knowledge and know-how as far as possible as they are also forerunners of energy-change in the North of Uganda.

For the actual implementation, a follow-up visit at each selected site is envisaged. During these visits, further site details are to be collected, the funding scheme and the implementation procedure of the planned intervention are suggested to the beneficiaries. After approval, all necessary material, human and time resources for the respective intervention are to be assessed and listed in detail, being part of a detailed practical implementation plan.

If the funding is approved, the projects suggested by CREEC bear the potential of having an immediate impact on the environment, institutions’ and households’ pockets as well as a long-term impact as they could be the pre-cursers for a possible future roll-out with an eye-opening effect in the Ugandan renewable energies sector.