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Cooking in the Congo

Technical assessment of cooking fuel and stoves for displaced communities in North Kivu, Democratic Republic of Congo

November 2014

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The Women's Refugee Commission works to improve the lives and protect the rights of women, children and youth displaced by conflict and crisis. We research their needs, identify solutions and advocate for programs and policies to strengthen their resilience and drive change in humanitarian practice.

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Acronyms & Abbreviations

ACF	Africa Conservation Fund
CNE	National Energy Commission (Commission Nationale de l'Energie)
CNR	National Refugee Commission (Commission Nationale pour le Refugié)
CREEC	Center for Research in Energy and Energy Conservation
CRSM	Community Disaster Rehabilitation Committee (Comité de Réhabilitation du Sinistre dans son Milieu)
DRC	Democratic Republic of Congo
FARDC	Armed Forces of DRC (Forces Armées de la République Démocratique du Congo)
FDLR	Democratic Forces for the Liberation of Rwanda (Forces Démocratiques de Libération du Rwanda)
FEC	Enterprise Federation of Congo (Fédération d'Entreprises du Congo)
FES	Fuel-efficient stoves
GACC	Global Alliance for Clean Cookstoves
IDP(s)	Internally displaced person(s)
IEA	International Energy Agency
IGA	Income-generating activities
INS	National Institute of Statistics (Institut National de Statistique)
ICCN	Congolese Institute of Nature Conservation (Institut Congolais de Conservation de la Nature)
IFDC	International Fertilizer Development Center
IRC	International Finance Corporation
IWA	International Workshop Agreement
M23	March 23rd Movement (Movement du 23 Mars)
MONUSCO	United Nations Organization Stabilization Mission in the DR Congo (Mission de l'Organisation des Nations Unies pour la stabilisation en République démocratique du Congo)
MRHE	Ministry of Water Resources and Electricity (Ministère des Ressources Hydrauliques et d'Electricité)
SGVB	Sexual and Gender-Based Violence
SNEL	National Society of Electricity (Société National d'Electricité)
TVA	Value Added Tax (Taux sur la valeur ajoutée)
UNHCR	United Nations High Commissioner for Refugees
USD	United States Dollar
WFP	World Food Programme
WWF PEVi	World Wide Fund for Nature, Environmental Program in Virunga

Executive Summary

The Democratic Republic of Congo (DRC), Africa's second largest country, has a population of 75,507,308 (July 2013 estimate) and a gross domestic product per capita of USD 400 (2013 estimate).[1] In 2012, its human development index value was 0.304 – in the low human development category – positioning the country at 186 out of 187 countries and territories.[2] Despite having extraordinary agricultural and mineral resources, the vast majority of inhabitants live below the poverty line, as nearly two decades of armed conflict have stalled and hampered socioeconomic development and progress. At the end of 2013, there were at least 2,963,700 internally displaced persons (IDPs) in the country.[3]

Following the initial major influx of refugees from the 1994 Rwandan genocide, North Kivu, a province in the eastern part of DRC, has continued to experience large-scale population increase due to conflict. The population growth has put an enormous strain on the environment and exacerbates competition over access to natural resources.

Most recently, in the fall of 2013, violent conflict between the Armed Forces of DRC (FARDC) and the M23 militia broke out in North Kivu leading to massive displacement of the local population. Many people were forced to flee their homes and wound up in IDP camps and among host communities in North Kivu, which has one of the highest numbers of IDPs in the world.

IDPs in North Kivu are facing a series of obstacles as they try to access natural resources for their household energy needs. Women and girls bear the greatest burden, often risking attack, rape, robbery, and even death to gather firewood to be able to cook a simple meal for their families. They face not only gender-based violence (GBV) while collecting firewood, but they also endure time, labor, and health burdens associated with collecting, carrying, and cooking with it. Further still, without access to safer and more sustainable income generating activities, displaced communities are heavily reliant upon the collecting and selling of firewood to earn a meager income, in spite of the associated risks.

While IDPs are especially vulnerable to energy poverty, the region has a pressing need for safe and sustainable energy resources overall. Biomass and hydropower are among the most outstanding natural resources that are available to produce energy, but yet they are underused or used unsustainably. In DRC, national parks are being depleted by the huge woodfuel demand of an increasing population, and tons of agricultural residues are burned away.

Since the beginning of this century, nongovernmental organizations (NGOs) and civil society have been trying to introduce more efficient cooking systems and technologies into the region. However, while they have helped to achieve considerable impact in urban centers, a lot of work still needs to be done to make the fuel-efficient stove sector a thriving industry. New stove designs and manufacturing methods are needed to meet market needs.

Alternative energy initiatives have been tested throughout North Kivu – mostly in IDP camps and rural zones – with low-density biomass briquettes, which are intended to alleviate urgent needs for cooking fuel. It is time, however, to for the government to create enabling conditions so that the private sector can play an important role in helping to close the energy access gap in DRC.

This report aims to provide a better understanding of the current situation of the domestic energy sector in North Kivu – with a particular focus on cooking, and how it affects the lives of communities living there. It provides an overview and analysis of the most significant energy-related interventions that have taken place (making a distinction between urban and rural/IDP-oriented) in the areas of concern. The analysis of experiences and impacts will help to identify lessons and positive practices for improved programming. Finally, this report assesses different energy resources and provides recommendations for appropriate cooking technologies in this specific context.

Key Findings

- The population of North Kivu relies almost exclusively on wood-based fuels to satisfy their energy needs. Modern energy sources such as liquid propane gas (LPG), butane, propane, kerosene and electricity, have only a minor, symbolic share of the domestic energy market.
- Displaced communities rely on firewood collection for household use and for selling. Firewood is often the only means of income generation for IDPs.
- Fuel-efficient stoves are present in North Kivu in urban centers, mainly thanks to the efforts of NGO dissemination programs. In Goma, the provincial capital, around 60 percent of the population uses some type of fuel-efficient charcoal stove. Producers and NGO programs have been largely unable expand their activities into rural areas.
- Small- and medium-scale hydropower plants, when privately managed, have proven to be successful in North Kivu with a model that is highly replicable.
- Individual and community-managed solar energy systems are widespread in the north of the province, where the national electricity service provider is not present. Small solar devices, either solar lanterns or solar-powered streetlights, can improve security and quality of life in IDP camps. However, none of the camps visited had these systems.
- NGO fuel-efficient stove dissemination programs have been consistently present in urban centers since 2008, achieving remarkable results to date. However, producers face serious challenges to generate profits from selling the models selected by the programs. Spontaneous competitors sector have gained a big share in the market with cheaper stoves that are less durability.
- Fuel-efficient stove producers are currently not under government control, meaning there is no financial mechanism to cover production, no quality and performance control, and no tax exonerations.
- Biomass briquette (the “donut” briquette) projects have been implemented by numerous humanitarian actors in North Kivu since 2008. Projects have proved to be effective in reducing acute energy crises in IDP camps and reducing environmental pressure on natural parks. However, no project has reached economic viability or has set up a self-sustaining mechanism.
- There have been several challenges regarding imported stoves distributed in IDP camps in North Kivu. Other urgent needs (e.g., lack of food) forced some IDPs to sell their stoves. The types of fuel that IDPs gather in the surroundings of the camp (leaves, corn cobs, small branches and plastics) are not appropriate for a fuel-efficient firewood stove.
- Based on the testing of new charcoal fuel-efficient stove models in Goma, there is still room for technology improvement. The new Femmes du Solei stove is a promising model, proving to be higher performing than the most popular model Jiko Nguvu Nyeusi. It has also received positive feedback from cooks.

Key Recommendations

- To ensure greater protection of IDPs in terms of fuel provision, interventions need to promote alternative livelihoods for women engaged in gathering, producing and/or selling woodfuel, in addition to fuel-efficient stoves.
- Extensive training is highly recommended to ensure increased user uptake of any new technology. It is essential to educate end-users and immediate family members on proper usage, as well as the benefits of the improved stove and negative consequences of using traditional cooking methods.
- Implementation of multi-fuel stoves is recommended to help increase user adoption. Current stoves use only one fuel type, which limits users and may force them to return to traditional

cooking methods if they do not have the fuel type required for their stove.

- Given the very low purchasing power of IDPs in North Kivu, it is recommended that stoves be provided for free as a short-term response.
- Locally produced stoves are recommended over imported options to help ensure increased user uptake and decreased sale of stoves.
- North Kivu needs alternatives to firewood and charcoal. More specifically, it is highly advisable to develop agricultural waste and other raw material into alternative fuel sources (e.g., wood chips, pellets, high-density biomass briquettes or high-density carbonized biomass briquettes). Choosing the scale of the process determines the quality and price of the end product, the number of jobs created and the investment needed, among others. For long-lasting interventions, larger scale has proven to be more successful.
- Going forward, it will be important to ensure cooperation with quality control institutions and the scientific community that support quality standards implementation. Quality standards and innovation are an important base for the holistic development of the sector.
- The most promising stove type, which should guide the evolution of design in North Kivu, is the stove produced by the "Femmes du Solei" association. This stove carries the name of the association and was developed to be more durable than other local models.

Introduction

Background

Since 2005, the Women's Refugee Commission (WRC) has been working to change the way the humanitarian system addresses energy crises and the associated risks for refugees and internally displaced persons (IDPs). In 2007, together with key partners, WRC spearheaded the Inter-Agency Standing Committee Task Force on Safe Access to Firewood and Alternative Energy in Humanitarian Settings (IASC Task Force SAFE), whose purpose was to:

> *"reduce exposure to violence, contribute to the protection of and ease the burden on those populations collecting wood in humanitarian settings worldwide, through solutions which will promote safe access to appropriate energy and reduce environmental impacts while ensuring accountability."*

WRC co-chaired the task force, along with the United Nations High Commissioner for Refugees (UNHCR) and the World Food Programme (WFP). The SAFE task force member organizations created the first-ever guidelines and tools to facilitate the implementation, coordination and decision-making processes on access to fuel-related issues in humanitarian settings, ensuring greater coherence between emergency and longer-term interventions and impacts.[4]

Since that time, the SAFE Steering Committee has been the leading body for interagency coordination on SAFE. Through a combination of partnerships and independent projects, numerous international and local organizations have been working to assess and address energy-related needs and challenges for crisis-affected people throughout the world. Systematically researching, assessing and documenting energy-related needs and challenges has been a key priority for the SAFE reference group organizations. This work has included thorough stakeholder consultations with individuals and organizations at all levels.

Where technologies are supported, it is important to do technical testing and research to ensure that the most appropriate – clean, efficient and sustainable – options are promoted and made available.

As part of its *Protecting Women and the Environment of the Great Lakes Region of Africa* project, WRC has already conducted an appraisal of the energy situation for displaced people in the eastern provinces of DRC,[5] as well as detailed assessments in several villages and IDP camps in the provinces of North and South Kivu.

This technical report, WRC's next contribution, focuses on the performance of different cooking technologies and alternative fuels. It also analyzes key factors from past experiences and provides recommendations to help ensure long-lasting impact for eastern DRC.

The SAFE Approach

More than a third of the world's population relies on traditional fuels – wood, charcoal, animal dung and agricultural waste – for their energy needs, including cooking their meals, heating their homes and lighting their communities. The challenges they face in accessing clean energy are numerous, often dangerous and unsustainable, particularly during complex emergencies and protracted crises.

Safe Access to Fuel and Energy (SAFE) promotes a holistic approach to meet the energy needs of displaced populations worldwide. Through a set of comprehensive activities that work to address the root causes of energy challenges in these contexts, SAFE helps to protect both people and the environment.

Because of the cross-cutting nature of energy use and access in humanitarian settings, the guidance developed by the IASC SAFE Task Force focuses on eight intervention sectors[6]:

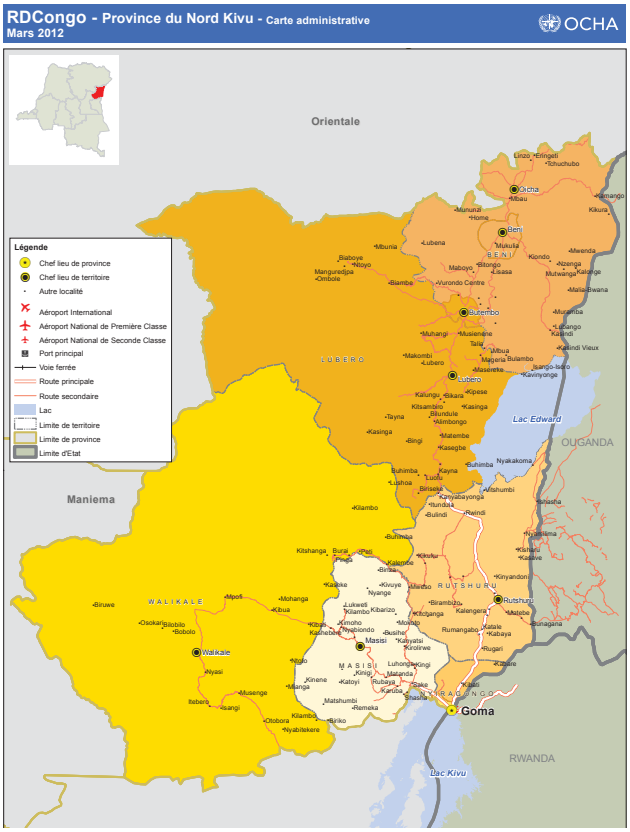
- Protection
- Livelihoods and development
- Environment and natural resource management
- Health
- Food security and nutrition
- Emergency shelter
- Information, education and communication
- Camp coordination and management

Each of these sectors has critical linkages with fuel and energy. For instance, scarcity or unsafe access to cooking fuel can lead households to adopt negative coping mechanisms such as undercooking food, skipping meals, and bartering and selling food for fuel, all of which undermine food security and nutrition.

General Context

The province of North Kivu is located in eastern DRC, to the west of Rwanda and Uganda. It covers an area of 59,631 km², of which 20 percent is made up of parks and forest reserves and 11 percent is made up of mountains and lakes. North Kivu is composed of six territories: Nyiragongo, Masisi, Rutshuru, Lubero, Beni and Walikale. In 2011, the Institut National de Statistique (INS) estimated its population to be 5,850,000. Goma, the provincial capital, is a city of 700,000 inhabitants located on the shore of Lake Kivu, next to the border with Rwanda and near the Virunga National Park. There are several other major urban centers in the province, including Rutshuru, Kiwanja and Nyamilima in "Petit Nord," and Beni, Butembo and Bulongo in "Grand Nord."

The areas surrounding the Virunga National Park and the city of Goma have for a long time accommodated the highest population density in the country other than the capital, Kinshasa. The population in Goma and around the Park has grown exponentially over the past 20 years due to numerous conflicts, including the Rwandan genocide in 1994, civil wars between 1996 and 2003, and continued instability and uncertainty. Many people have moved to Goma and the surrounding areas in search of increased security and livelihood opportunities. Goma has seen its population triple in less than 10 years, causing a high demand for fuel, especially wood-based fuels. The military surrender of the armed group M23 in November 2013 has brought more control from the Forces Armées de la République Démocratique du Congo (FARDC), the regular army,



OCHA, DRC — North Kivu Province — Administrative Map, March 2012

to Rutshuru and Nyiragongo, but the overall situation is still unstable and people are still forced to flee from their homes often.

UNHCR estimates that there are currently more than 2.9 million IDPs and nearly 500,000 refugees in DRC. The province of North Kivu is one of the most affected by this situation, accounting for more than 1.1 million displaced people in February 2014, according to UNHCR monitoring reports.[7] The energy needs of these IDPs and refugees often exacerbate their struggle to survive and are typically not sufficiently addressed. The hardship of energy poverty and its associated risks often fall on women and girls. Because food distributed by humanitarian agencies and most local food items must be cooked before they can be eaten, women must have access to cooking fuel in order to properly feed their families. They are forced to leave the relative safety of their homes and camps to travel great distances on foot to search for firewood, risking their physical safety by walking into conflict zones, wild jungles and other dangerous environments.

According to the International Energy Agency (IEA), 59 million people in DRC – 89 percent of the population – do not have access to electricity, and 62 million people –94 percent of the population – rely on traditional use of biomass for cooking. The province of North Kivu is below the national average in terms of access to electricity. According to the Commission National de l'Energie (National Energy Commission) (CNE), in 2012 3.2 percent of people had access to electricity in North Kivu province, while the national average was 9 percent.[8] This situation obliges the population to rely almost exclusively on wood-based fuels to satisfy their energy needs.

A study conducted by Action Contre la Faim (Action against Hunger) (ACF) in 2008 showed that charcoal consumption in the city of Goma alone amounted to 59.435 tons per year, equaling a total expenditure of 25 million USD by wood and charcoal consumers over a one-year period.[9] By extrapolating these figures to the entire province and by assuming that the whole supply of wood-based fuels is produced by a single company, sales would add up to, in a conservative scenario, close to 100 million USD per year.

To give a sense of this magnitude, 100 million USD per year is half of the annual turnover of some of the companies rated among the continent's top 500 income-earning enterprises.[10] This point illustrates the large demand for fuel in North Kivu and the potential for the government or private sector to meet that demand while creating a thriving fuel-related industry. Despite these important figures, however, biomass energy is still not regulated, and a vast majority of its production and trading is done informally and often illegally.

Purpose of This Report

First, this report aims to provide a better understanding of the current situation of the domestic energy sector in North Kivu and how it affects the lives of communities living there. Second, it provides a review and analysis of the most significant energy-related interventions that have been taking place (making a distinction between urban and rural/IDP oriented) in the areas of concern. The analysis of experiences and impacts will help to determine successful actions and help implementing partners to improve on those that have been insufficient or that could have been more efficient. Finally, this report assesses different energy sources and provides recommendations for appropriate cooking technologies in this specific context.

Research Methodologies

The information in this report was obtained through several different research methods:

Desk Review – Analysis of existing data was conducted through an extensive desk review on publication, reports, evaluations, documentation from workshops and Internet research. It is important to note, however, that some organizations had very few or no available reports, especially when their interventions had already finished and their staff were no longer involved in the project.

Observation – Observation was used to gather information on IDP camps, villages, small businesses, NGOs and governmental bodies related to the energy sector and humanitarian aid. For the purpose of this study, a five IDP camps were analyzed. Fuel collection practices were observed throughout each location, and cooking habits were observed through simulation. In particular, a certain amount of food, normally 5 kg of beans, was given to a group of 5 to 10 women with no other external guidance. They had to prepare that meal with whichever fuel, pots and stove they preferred or had access to at the time.

Key informant interviews – Numerous key informants were interviewed in each of the camps (e.g., for the Nzulo camp: International Organization for Migration (IOM), Commission National pour les Réfugiés (CNR), UNHCR, women's association from the camp, and International Rescue Committee (IRC) participated as key informants).

Controlled experiments – Controlled experiments were carried out to evaluate different technologies and the potential for diverse fuel sources. Experiments looked at and measured the efficiency and safety of fuel-efficient stoves, as well as the user-friendly level of the design of the stove.

Energy Access in North Kivu

Overview of the Energy Sector

The province of North Kivu, as well as the whole of DRC, has many recognized and abundant energy resources available, but they are poorly inventoried, quantified, and used. The country energy sector is characterized by a prevalence of traditional biomass resources (e.g., firewood, charcoal, animal dung and agricultural waste), underutilization of the available energy potential, and dependence on imported oil products. Moreover, there is a low energy efficiency level in terms of production, processing, and consumption of energy, including biomass energy.

The Congolese Ministry responsible for the energy sector is the Ministry of Hydraulic Resources and Electricity (MRHE). In 2012, the Congolese government, through the MRHE, made a commitment to Sustainable Energy for All (SE4All), an initiative promoted globally by the United Nations to mobilize governments, the private sector and civil society to provide sustainable energy for all people – energy that is accessible, cleaner and more efficient. The initiative strives to achieve the following three ambitious objectives by 2030:

i. Ensure universal access to modern energy services

ii. Double the global rate of improvement in energy efficiency

iii. Double the share of renewable energy in the global energy mix

Thus in 2012, the Congolese Government started a process with the support of the UN Development Program (UNDP) to develop a National Energy Strategy to achieve the objectives of the SE4All initiative by 2030.

Despite some signs of governmental willingness to improve energy access, DRC is still very far from reaching those objectives. As stated above, the rate of access to electricity in North Kivu is only 3.2 percent, a third of the national average. Moreover, non-renewable fossil fuels such as butane, propane, LPG or kerosene are considered to be modern energy sources and have a small, symbolic share on the domestic energy market. They are only available in the main urban centers of Goma and Butembo, the biggest cities of the province.

Consequently, wood-based fuel (charcoal and fire-wood) is by far the most commonly used source of energy for households in North Kivu, and are expected to remain the most commonly used for decades to come. Taking the current population growth rate of 3.5 percent per year into consideration, the population of North Kivu will increase from 5.8 million to 11.5 million inhabitants by 2030. Consequently, wood demand for

Case Study: Dap Energy

Dap Energy is a Congolese company based in Butembo that has been distributing domestic gas (butane and propane) since 2011 in the main urban centers of North Kivu: Butembo, Goma and Beni. In Goma, Dap Energy has over 3,000 clients representing 3 percent of the households of the city. Though currently this gas remains an energy for the wealthy, Dap Energy's ambition is to reach medium- and low-income households by offering affordable products with appropriate payment methods. They have three products: the 6kg, 12.5kg and 45kg gas canisters with a refill price of USD 22, USD 45 and USD 162, respectively. An average family uses a small canister in approximately one month and medium one in approximately two months. The biggest canister is appropriate for restaurants and other businesses. Using domestic gas for cooking appears to be the easiest way to achieve health and environmental benefits while cooking in urban centers of North Kivu. Cooking on an butane or propane gas stove reduces emissions of most key pollutants by over 95 percent and reduces energy uses by about 50 to 70 percent compared to biomass stoves. Butane and propane are very clean burning and have lower greenhouse gas emissions than any other fossil fuel when measured on a total fuel cycle. However, they are fossil fuels, and thus have a substantial carbon footprint. Furthermore, it is very fast to ignite, so cooks appreciate it once they are used to it. The main barrier to widespread use for this type of energy is the initial investment on the kit (gas canister + gas pipe + coupling + gas cookstove), which can amount to at least of USD 180 USD represents a huge hurdle for low- or middle-income households. DAP Energy asserts that although the gas itself is TVA exonerated, other elements are highly taxed, and the multiple and exaggerated taxes raise the price of their products. Apart from the initial investment, an average-size family would need to spend approximately USD 22 per month on gas for their cooking needs, as compared to approximately USD 30 per month for charcoal to meet the same needs.

domestic energy purposes in the province will increase from the current 1.8 million tons to 3.5 million tons of wood per year – and that is only for energy purposes.[11]

Several reasons can explain the current reliance on wood-based energy, the first of which is physical accessibility. Wood and charcoal supply chains are the only ones that are actually highly decentralized to the door of the rural end users, as well as urban end users. Second, charcoal and wood can be commercialized in small amounts. The majority of households are very poor and are only able to purchase energy in small amounts when they have enough money. Finally, both charcoal and firewood are traditional fuels – people are more familiar with them then with any other fuel.

In North Kivu, alternative energy sources are insufficiently developed. Penetration of domestic gas is limited by the initial investment price (gas cylinder and gas cooker), as well as by the physical availability of the product. Electricity is an affordable energy for cooking, but unfortunately adoption is limited due to a weak supply network and unreliable service.

Another prevailing factor as to why alternative and modern forms of energy are not available is the poor capacity of the national government to implement appropriate sector regulation, promote and engage public and private investments to improve energy access, and establish an enabling environment for doing business that would encourage new initiatives. Consequently, DRC's energy sector has seen very slow development and does not meet the needs of its population. It will certainly not meet increasing demand as the population grows.

In DRC, 92 percent of total energy consumption comes from biomass. Wood exploitation and commercialization remain informal, and illegal practices are often conducted. In some cases, such as in the Virunga National Park, where cutting trees is illegal, charcoal production is controlled by armed groups. Sometimes governmental military forces allow armed groups to partake in these activities. For these reasons, it is incredibly difficult to sustainably obtain wood-energy resources for the average household, and even more so for displaced and vulnerable populations. Moreover, the combination of over-exploitation of wood fuel and the absence of reforestation policies means an extreme pressure on protected forests.[12]

Energy Access in IDP Camps

Numerous factors determine the nature of each camp and the living conditions of its population. These factors include: the reason that the IDPs were forced to move; duration of the camp; ethnic composition of the inhabitants; natural environment and resources available; access to those resources and land; options to develop income-generating activities (IGAs) or work for host communities; status of the camp according to the government (recognized or not); and frequency and nature of humanitarian assistance. All of these factors determine the status of access to energy for the IDPs.

Observed tendencies and behaviors in the visited camps allow for deduction of general trends and explanations about the energy access situation. The five camps visited were Mugunga 3 and Nzulo in Nyiragongo territory, Shasha and Kishusha (Rubaya) in Masisi territory, and Kiwanja camp (near a MONUSCO base) in Rutshuru territory.

Cooking habits and preferences of the IDPs living in camps are very similar to those of their compatriots and especially similar to those of people living in rural areas. A concise description of local habits and practices is available in the WRC publication *We have no choice, Safe Access to Firewood & alternative Energy in Eastern Democratic Republic of Congo*.[13] The report specifically documents the burden of firewood collection and associated risks, particularly for women and girls. IDPs have additional barriers compared to the rest of the population, notably, no access to land for agriculture or livestock activities and no means to be involved in productive activities such as fishing or small commerce. In addition, they are forbidden from collecting firewood in the surrounding zones of the camp.

Most IDP camps in North Kivu are located in areas that have abundant biomass resources. Some camps

Landscape around Shasha camp (Masisi)

Landscape around Nzulo camp (Nyiragongo)

are located on top of volcanic rock, making it more challenging, but IDPs are often still able to find some biomass in the surrounding areas. It is important to note, however, that the biomass in the surrounding areas is not particularly appropriate for cooking. For example, grass, small sticks, corn or banana leaves, corn cobs, small branches and parts of sugar cane are often available. It is possible to cook with these materials, even with plastic bottles or foam sandals, but the fires are very smoky and unpleasant, and need constant attention. Moreover, the air pollution can have quite negative health effects, particularly when indoors. Good quality trees and big chunks of wood tend to be less accessible due to overexploitation or because they are controlled by host families, land owners or armed groups.

For these reasons, when asked about their priority problems, IDPs consider firewood collection to be among their top concerns, together with their struggle to obtain food, the absence of health services and medicines, inaccessibility to land and the lack of means to engage in productive activity.

Collection of firewood for cooking is a common activity all over the province, which is done predominantly by women and girls. In addition to being used for cooking, firewood is critical for generating income for those who have few to no livelihood alternatives.

Collectors sell firewood to households that can pay for the fuel thanks to income generated through other activities. Local people typically have farm land, and they collect firewood from their surroundings. The efforts involved in this activity depend on the camp location, the proximity and accessibility to the park, and the physical strength of the collector.

During the site visits, WRC asked more than 20 women to quantify the effort engaged in this activity. Overall, they reported that this activity is equivalent to a full day of hard work, and sometimes the women must even sleep overnight in the park. They also reported that an average of six to seven hours is dedicated to this activity per day, including walking between 10 km and 30 km on average. The amount they can earn for

Biomass for cooking collected by local women in the surroundings of camp of Shasha (Masisi)

the selling of their wood bundles is USD 3-3.50 for bundles weighing between 15 kg and 25 kg.

Charcoal is less frequently used by IDPs, but it was observed in some camps. In Nzulo camp, some IDPs produce charcoal with branches that they collect in the parks and sell it to host communities or other IDPs. An artisanal charcoal maker was interviewed during the visits, and he mentioned that the primary purpose for making charcoal is to generate income by selling it to households with higher incomes in the nearby villages. In the Kishusha camp in Rubaya (Masisi), the displaced community buys charcoal from the host community. The IDPs have limited access to firewood, as their camp is located in a grazing zone. Firewood is tightly controlled by the land owners. Interestingly, this was the only visited camp where charcoal stoves were seen to be owned by displaced people.

Artisanal charcoal kiln in Nzulo camp

Charcoal pieces for sale in Nzulo camp. Price, 500FC each stack.

In summary, IDPs may be able to obtain fuel sources from areas surrounding the camps in North Kivu, but they face numerous associated risks and dangers. Moreover, the fuel types are often not ideal or appropriate for cooking. In fact, some displaced households with improved or fuel-efficient stoves are not able to use them regularly due to limited access to adequate firewood.

In four of the camps visited (Mugunga 3, Nzulo, Shasha and Kiwanja), firewood is most likely to be used, and so an improved firewood cookstove is more suitable for them. In Kishusha camp, however, an improved charcoal cookstove would be a better choice as charcoal is the most commonly used fuel.

Because many families in North Kivu do not have safer or more sustainable alternatives, they rely on firewood and charcoal for generating income. It is especially difficult for displaced populations who are treated as foreigners and banned from collecting firewood. Despite the risks and restrictions, they have no choice but to venture into unsafe and wild areas, like the national parks, or sneak into areas owned by host communities to collect firewood to cook meals, generate income and, ultimately, to survive.

Cooking Devices in North Kivu

Throughout the world, people use a variety of cookstoves and fuels to meet their daily cooking needs. Over 40 percent of the world's population still burns various forms of biomass – such as wood, dung, charcoal or crop residues – or coal as a cooking fuel. They cook on open fires or with rudimentary cookstoves. This traditional cooking method emits a harmful smoke that causes a range of deadly chronic and acute health effects, such as child pneumonia, lung cancer, chronic obstructive pulmonary disease, heart disease and low birth-weight.

Clean, efficient, durable, safe and affordable stoves are – along with clean fuels and other products like chimneys and heat retention cookers – central to most solutions to the health, environmental and other risks

inherent to traditional cooking methods. Cooking with clean fuels is the most common way to achieve dramatic health and climate benefits.

When describing the situation regarding cooking devices in the Province of North Kivu, it is first important to distinguish between urban and rural zones or villages. In urban areas, many households have benefited from fuel-efficient stove programs. More specifically, fuel-efficient stoves are primarily being used in Goma, the capital of the province, Butembo, the second city with approximately 200,000 habitants, and Beni, the third largest city with an estimated 110,000 inhabitants. Very similar models have been introduced by NGO-driven stove programs in the three cities.

People living in the rest of the province, particularly rural areas and villages, tend to still use traditional methods. However, it is worth noting that some of the improved stove models produced in urban areas can also occasionally be found in smaller villages far from the city. For example, in Kiwanja, 70 km from Goma, people are using the Jiko Nguvu Nyeusi stove, which is produced in Goma.

See next page for the different models or types of cooking devices that can be found in the province.

Unsurprisingly, modern fuel sources like electricity, domestic gas and kerosene are rare in rural zones. However, only three of the aforementioned stoves – traditional metal stove, traditional ceramic stove and three-stone fire – are found in rural zones. It is complicated to establish a market for stoves in these areas for several reasons. Low purchasing power, high transportation costs from the production centers and inexpensive available fuel in rural zones are all factors that make it unattractive for stove producers to expand their activities away from urban centres.

In the city of Goma, around 60 percent of the population uses some type of fuel-efficient or improved cooking stove.[14] The most popular models are the Rwandan Stove, which is inexpensive and light but not durable, and the Jiko Nguvu Nyeusi, which is expensive but sturdier.

Fuels with a Promising Future

Identifying alternative energy sources with the capacity to supply affordable and high quality energy for all the households of the province is critical for North Kivu. The province has great potential given its abundant natural resources, which could be sustainably transformed into appropriate forms to be used for lighting and cooking.

Sun for Lighting

Solar power has the potential to be widespread in North Kivu. In the far north of the province, in Beni and Butembo, domestic solar systems are currently supplying electricity to a significant percentage of the population. Solar systems are, in most cases, only used for lighting and basic electric devices, such as TV, video or music players, as well as to charge phones and back-up batteries. New enterprises offering complete equipment with installation are emerging in areas where potential consumers are concentrated. Solar power can offer reliable electricity with low maintenance if the equipment is meant for this purpose.

Small solar devices, like solar lanterns, also have a lot of potential in the region. Affordable prices, from USD 20 to USD 30 with appropriate payment methods, are important for their success. These technologies are also more likely to be disseminated in rural zones and to increase security in IDP camps. Having light at night means being able to study during hours of darkness, and less risk at night. Electricity can power refugee camps, giving schools, training centers and medical centers light and a way to power computer systems or refrigerate lifesaving medication. It can also power livelihood activities in the evening; IGAs do not have to stop at dusk, and shops can stay open longer. Public spaces, such as communal meeting areas and latrines, can also become safer in the evening.

Models or types of cooking devices that can be found in the province (prices are based for stoves available in Goma)			
			
Traditional metal stove Charcoal Rural & urban Fuel savings: baseline Price: USD 1	**Traditional ceramic** Charcoal Rural & villages Fuel savings: Not tested Price: USD 1	**3-stone fire** Firewood & all kind of biomass Rural & villages Fuel savings: baseline	**Rwandan stove** Charcoal Urban Fuel savings: 30%* Price: USD 2.50
			
Jiko Nguvu Nyeusi Charcoal Urban & villages Fuel savings: 28%* Price: USD 5	**Jiko Argus** Charcoal Urban Fuel savings: 26%* Price: USD 10	**Small Goma stove** Charcoal Urban Fuel savings: 38%* Price: USD 5	**Femmes du Solei** Charcoal Urban Fuel savings: 39%* Price: USD 10
			
Butembo stove Charcoal Urban Fuel savings: 33%** Price: USD 10	**Envirofit M-5000** Firewood NGO Distributed Fuel Savings: 45%*** Price: N/A (cost ≈ USD 45)	**Electric stove** Urban Price: USD 5	**Kerosene stove** Urban and villages Price: USD 10
			
Briquette stove CRSM Briquettes NGO distributed Price: N/A (cost ≈ USD 10)	**Briquettes stove ICCN** Briquettes NGO distributed Price: N/A (cost ≈ USD 10)	**Battery stove** Charcoal powder Urban Price: USD 15	**Gas stove** Butane/Propane/LPG Urban Price: USD 100 to 130

* Controlled Cooking Test conducted in Goma in May 2014 by consultant. See detailed results in Annex 1.
** Controlled Cooking Test conducted in Kampala in September 2012 by CREEC.
*** Emissions and Performance test protocol. Colorado State University, October 2011.

The Great Potential of Hydropower

North Kivu has great hydropower potential thanks to its abundant rivers and mountainous terrain. All hydropower projects in the province have been promoted by NGOs or religious missions, and they are generally medium- to small-scale initiatives (< 15 MW). In 2013, construction of a 12 MW hydropower plant financed by the Howard Buffet Foundation started in the village of Matebe, in the Rutshuru River. It is expected that this hydropower plant will provide electricity to 15,000 to 20,000 people in the province, which can save 85 tons of firewood per day or more than 30,000 tons per year, half of Goma's firewood consumption per year.

Hydropower is a very promising option for meeting the energy needs of communities in the region, as well as for creating jobs. However, it is important to recognize that hydropower may have negative consequences in some cases, such as downstream social impacts, forced population displacement due to construction, or loss of cultural heritage assets. These risks must be taken into consideration when considering the scale-up of hydropower projects and then continually monitored.

Learning from Experience

This chapter provides a brief overview of the main recent projects developed by NGOs in the province of North Kivu related to improved stoves or alternative fuels. The objective is to analyze interventions in order to learn about previous experiences (field of intervention and geographical area), recognize the track record of actors in the region and take advantage of their experiences to draw lessons and identify the most appropriate approach for future projects with similar objectives.

The first experience with improved stoves in the region happened between 2000 and 2002. The FIDA/GTZ project supported initiatives to promote the use of improved stoves by working with 26 women's organizations and seven craft associations. Over 6,740 improved stoves (both fixed and mobile) were constructed in Beni, Oicha Mutwanga, Bulambo and Kyondo (territory of Beni, northeast of the province). Thanks to this project, it was possible to introduce the first portable improved stoves with ceramic inserts. It was an adaptation of the Kenyan Ceramic Jiko, and this stove would later evolve into the Jiko Nguvu Nyeusi. Unfortunately, the project was suddenly interrupted due to conflict and the eruption of the Nyiragongo volcano – the most destructive eruption in modern history, which destroyed part of Goma.

Mercy Corps, World Wild Fund, and International Fertilizer Development Center: Projects to Change the Cooking Stove Baseline in Urban Centers

Project Description and Key Milestones

Mercy Corps in 2008, World Wide Fund (WWF) in 2008 and International Fertilizer Development Center (IFDC) in 2009 initiated their respective fuel-efficient stoves (FES) programs in the province of North Kivu. The three programs from these NGOs are described together because they have the same basic principles:

- Focus on the commercialization of domestic charcoal stoves in urban centers (the promotion of FES for IDPs or institutional use was not prioritized).
- FES production driven by small associations of local artisans trained on the production and commercialization of stoves. The long-term focus is the economic sustainability of these artisans, and they receive subsidies that allow them to start the production.
- FES models are locally developed by NGOs, prioritizing low cost and the use of locally available materials over high performance and durability.

The overall geographic scope of these projects included the principal cities of the province and some smaller villages surrounding Virunga National Park. However, they primarily focused on the cities of Goma and Butembo, recognizing the greater potential

for achieving impact in terms of commercialization in these urban areas. In the next chapter "3.1.3 lessons learned," the significant factors that hinders success in rural zones are explained.

According to the surveys conducted by WWF, the presence of FES in the households of the city of Goma increased from 7 percent in 2008 to 60 percent by the end of 2011. During this period, Mercy Corps supported the construction of 20,000 improved stoves and WWF provided around 25,000. IFDC has not provided data on the number of stoves, but it reports giving support to seven organizations of artisans to increase their production capacity from six to 100 stoves daily.

The remarkable penetration of FES in the households of Goma since the onset of these programs has several explanations. First, the NGO programs included the same activities – the creation of groups or associations of artisans, no matter whether they were previously familiar with the business of cookstoves or not, as well as training on production of different stove models and, on a smaller scale, marketing techniques.

The three programs created a total of 50 associations. These associations were equipped with the necessary raw materials to start production, as well as with assistance for commercialization thanks to access to retail sale centers, promotional material and campaigns to raise awareness among the public.

In the back, improved stoves constructed by Mercy Corps in the prison of Muzenze in 2011. In the front, a traditional stove in use. © Alvaro Trincado

It is important to note that there are also unexpected consequences of the development programs that help to explain the rise of improved stoves in Goma. The first one is the "switch" of some producers of traditional charcoal-burning metallic stoves to improved models due to their success among the population. Even without training, these producers proved capable of reproducing the same models with similar durability, effectiveness and competitive prices.

Finally, the spontaneous emergence of imported improved stoves from Rwanda has greatly contributed to reducing the consumption of charcoal in the city. The Rwandan stoves are a different model that was not previously available in Goma. They are less durable than those promoted by the NGOs and are often negatively categorized as "pirates"; however, there is no evidence to suggest that they are less efficient than the locally produced models. In fact, the Rwandan stoves have the advantage of being lighter and, therefore, easier to move. They are also cheaper (approximately USD 2), and their effectiveness, as it has been demonstrated during this technical assessment, is even superior to the models promoted by the NGOs. Furthermore, their commercialization does not need external support, because it is already a part of the market without subsidies.

The most popular improved stove model is the Jiko Nguvu Nyeusi. According to a study carried out by WWF, this model of stove is present in 40 percent of the households in Goma. Although this figure is likely exaggerated, there is surely a strong presence and standardization of this stove in the households of Goma. This model sells for USD 5 and has a varying lifespan depending on the producer and the care taken by the user. The lifespan is estimated to be between six months and two years.

Other models also emerged from producer associations and are sold, to a much smaller extent, at higher prices. The different models seek to meet the demand of restaurants or customers looking for a better quality stove.

Stove manufacturing association in Goma

Current Status of the Projects

The Mercy Corps and IFDC projects ended due to the lack of funding in 2012 and 2013, respectively. During this technical assessment, WRC met numerous artisans who were trained by these programs and who are now struggling to continue running their improved stove businesses. In fact, the stove models – Mercy, Rocket, and Goma stoves – promoted by both NGOs are not being produced anymore, and they switched to the popular FES, like Jiko Nguvu Nyeusi, or slight variations either in sizes and details. Moreover, the stoves for institutional use promoted by Mercy Corps in hospitals and prisons in 2010 are being underused or have been directly replaced by the traditional three-stone fire. The arguments provided by the cooks of the Muzenze Prison in Goma is that the opening of the combustion chamber is too small for the type of wood they use, and the height of the kitchen is too low to easily put large pots onto the fire and remove them.

The WWF program, on the other hand, continues to support a select group of producers organized under the name of REPROFCA (REseau de PROducteurs de Foyers de Cuisson Amélioré), who still receive training on the commercialization of improved stoves. These producers hope to receive future grants or loans from the WWF program in order to purchase raw materials for the production of stoves, and they are eager to look for solutions in order to make their business profitable.

In general, there is little difference between the challenges of the producers supported by the NGO programs and those who operate independently. The main barriers identified by these producers are as follows:

- The little profit they obtain from selling the most popular stove, Jiko Nguvu Nyeusi, priced at $5, is not enough to earn a decent living and to provide for their families. Competition with other producers of similar stoves, even though they are of lower quality and sell at the same price or lower, does not give them the option to raise the price. This situation has endured for the past six years, and it is possible to see desperation among producers.
- The provision of galvanized metal sheet with 28 BG thickness, which is the most common sheet metal used in improved stoves in the cities of Butembo and Goma, comes mainly from Uganda. The problem for small producers is that they do not have enough capital to buy this material on a wholesale basis in Kampala, which would be the cheapest way – and often the only way – to source the sheet metal. Consequently, the producers must often find other types of metal, such as corrugated iron used on roofs or metal debris.
- The lack of means to test the new models of improved stoves, as well as the absence of a proof of quality, such as a quality seal, does not allow them to confirm that their stoves meet certain quality requirements and efficiency. The ability to properly test stoves would allow them to more easily develop new models and improve the commercialization of their products.

Lessons Learned

Technology selection

All of these projects went through long and expensive screening periods to bring appropriate technologies

to communities, and yet, the stove models and related activities were not sustainable without the funding and support of the implementing NGOs. While this period of product development is necessary for selecting the right technology, it could be done more efficiently and more cost effectively. Recommendations for selecting technology should focus on choosing a model that is already commercially viable. The prioritization by NGOs of certain criteria, such as efficiency or aesthetics, can lead the program to promote non-sustainable models, instead of taking into consideration other criteria, such as the ease of use or cooking speed, which are often more important for the consumer. With a market approach and proven models, these risks are reduced, as is the testing and selection time.

Selecting areas of implementation

Current results from these projects demonstrate that in areas where woodfuel is abundant (often in rural zones), stove uptake and long-term usage is minimal, but in areas with limited wood supply or higher-cost combustibles, stove uptake and long-term usage can be maximized. This can be seen among urban households that generally pay for combustibles and stoves and are more likely to pay for and continue using their stove. In urban areas, people have a higher appreciation of the benefits of using a fuel-efficient stove, such as a reduction of firewood/charcoal, decreased smoke emissions and a faster cooking time.

On the other hand, people who have an abundant supply of free or easily accessible combustibles are less likely to change their behavior or adapt to new technology. People who experience fuel scarcity will be more inclined to get used to new technology that allows them to save money or time. In addition to the low demand and scarce payment facilities in rural areas, there are limited enabling factors for business, such as reliable financing and implementing capacities, which make it more challenging to develop improved stove programs in those areas.

Urban stove projects are easier to implement and monitor due to accessibility, population stability and proximity of beneficiaries, whereas rural populations are more likely to be mobile due to chronic conflict. Urban beneficiaries can often even be reached by telephone, making household visits easier to organize than rural households, which tend to be in areas outside of mobile networks and work in fields several kilometers from their houses. Accessibility is both geographically challenging and time-consuming in rural areas.

A good starting inquiry to be made by program developers who would like to explore rural areas would be to analyze what kind of products are being commercialized in those areas and how the commercialization is being done (supply chains, price policies, economic margins, type of consumers, etc.). It is also useful to consider the product from the end-user's perspective and try to understand the type of device that the end-user would like to use.

The stoves approach

The general approach for stove commercialization in these programs can be summed up as follows: basic technology with common materials, local production with small producers and subsidization of the products. This approach is the most widely used by programs to promote improved stoves around the world. It has many advantages, such as affordable products that can be easily adopted by the poorest communities, job creation and high replication potential in other regions.

However, the disadvantages of this approach are also numerous, including low product quality, limited production capacity, limited capacity to adapt to changes or market demands, lack of ability to face large upfront costs, and reduced capacity for innovation and market distortion due to selective subsidization. In analyzing the situation of the three NGO programs in Goma, it is clear that, almost six years after their inception, there has been a great adoption of certain models with relatively low cost. However, the quality of the stoves has also been low, which is not entirely negative if the projects have been able to change the baseline reference for stoves.

Certainly, the lack of a pure market approach from the beginning has put a burden on producers, making

them dependent on subsidies as their businesses are barely profitable. Unfortunately, their insignificant profit margins do not allow for growth, prosperity or self-reliance. Moreover, the implementation of subsidies selected by some programs incentivizes the rest of the producers to compromise on quality and flood the market with less efficient stoves.

To improve the development of the sector, it is recommended that more efforts are made to reach out to financial institutions, such micro-finance institutions (MFIs) or banks, to provide the necessary financing for new business development. It is also critical that there be political will to support the energy sector, which results in concrete measures, such as tax exoneration for FES, with an understand that doing so is socially and environmentally important.

Finally, it is important to ensure cooperation with quality control institutions and the scientific community that support quality standards implementation. Quality standards and innovation are an important base for the holistic development of the sector.

ICCN, ACF Virunga & UNHCR: A Project to Protect Virunga National Park

Project Description and Key Achievements

Between 2008 and 2012, the ICCN, in collaboration with the NGO ACF Virunga and UNHCR, implemented a program to reduce the use of charcoal and firewood from the Virunga National Park, which serves as cooking fuel source for indigenous populations. The project focused on the territories of Nyiragongo and Rutshuru. This project was intended to simultaneously fight against deforestation and energy poverty, while preventing the exploitation of wood and charcoal by armed groups, mainly the Mai-Mai and FDLR. Between 2008 and 2011, the project was able to establish 530 micro-enterprises in charge of producing biomass briquettes from wood waste, such as sawdust, paper and cardboard, as well as waste from coffee and peanuts. Each micro-enterprise comprised at least four workers and possessed necessary materials for production, including a special press for making briquettes. The micro-enterprises were established in towns and small villages such as Kiwanja, Rubare, Jomba, Tongo, Kibirisi and Rugari, and received support from the program for their production and commercialization of both the supply of raw materials and sale of final product.

Bread oven powered by biomass

While the project received financial support, first from the ICCN and later from UNHCR, briquettes were bought directly from producers at a price of $7 per bag of 35 kg (approximately 300 briquettes) in order to be later distributed to IDPs or vulnerable people. In addition, briquettes were sold to small bread-baking businesses that were also created by this program. The businesses were encouraged to buy the briquettes.

In 2012, the project received new funds from the UNHCR to focus on returnees and IDPs, and 110 new presses were installed.

Furthermore, in the city of Goma, the ICCN established a production center of “fireballs,” which are briquettes made from charcoal dust that can be found in markets. The production center called “Energy Center of Munigui” had a production capacity of one ton of fireballs per day. Bags of 6 kg are being sold at $3, and bags of 40 kg at $11.5. The project implemented retail centers for fireballs in the main markets of the city, and due to their low price compared to traditional charcoal

(a bag of 25 kg costs around $15), they were selling relatively well. In addition, some industries were regular buyers, like Maize King, producer of corn flour.

Current Project Status

The project ran out of funding by the end of 2012. Now, the ICCN division dedicated to energy projects is focusing on hydropower projects. In 2013, the manufacturers of biomass briquettes were ceasing their activities, and all presses have been abandoned. In villages where several presses were installed, there are still tons of stored biomass briquettes that have not been sold. The price per bag of 35 kg, which was initially sold at USD 7, is now USD 5. Despite the price reduction, the briquettes have not yet been sold and remain stored. On the other hand, the "Energy Center of Munigui" was not able to profit off of the fireballs, so when funding came to an end, the production of charcoal briquettes was also stopped.

Lessons Learned

Commercialization of Biomass Briquettes

Selling alternative fuel in the rural areas surrounding Virunga National Park is more or less difficult depending on the proximity of the park to the villages. In places like Rubare, where the park is very close, it is more difficult to sell alternative fuel because people are used to getting it for free. In other towns, like Kiwanja, the park is farther away, and it is common to see retail centers for firewood or charcoal.

At this point, it is clear that the micro-enterprises created by the program were not able to become self-sustainable. Once the financial support ended, so did the businesses. Why did the businesses fail in selling the alternative fuel, if the raw material used was practically free? Some possible answers include:

The Product

Biomass briquettes have low-energy density, which makes combustion slow and the power of fire low for cooking. It implies that cooking time is longer and may require more attention to keep the fire alive. In the most advantageous conditions, like in Kiwanja, where the cost to prepare a meal with briquettes is slightly less than the cost to prepare the same meal with charcoal purchased in the local market,[15] this lower price was not a reason enough to convince and to completely shift new users to using biomass briquettes. Ideally, any new fuel supply should work better (making life easier for the cook) so households can change their preference.

In addition, briquettes require a specific stove to burn properly. This stove costs approximately USD 15 and is not always available in rural areas. This creates a large obstacle for the introduction of briquettes into the market.

Finally, many comments were made regarding the smoke produced when briquettes are used. Smoke can be more abundant than when charcoal is used. It is true, though, that most of these disadvantages related to the product disappear when the briquettes are used in a larger device, such as a baking oven. The high temperature inside the oven eliminates the smoke, and briquettes ignite easily as they are fed in.

Entrepreneurial Capacity

Local people are often willing to cooperate with the activities proposed by humanitarian and development organizations; however, the willingness to cooperate can deteriorate over time. It is also possible that the objectives of the project may not be a priority for many beneficiaries, who may not see the long-term benefit. These attitudes can foster a lack of entrepreneurship among the employees of the implementing enterprises. In addition, a lack of ownership or sense of belonging largely contributes to failure.

Even though there are valid arguments for establishing complex businesses with few resources and fragile corporate structures, it is incredibly difficult to maintain their sustainability. To ensure long-lasting impact, the project must support new

business for longer periods, at least two or three years, particularly if business owners have limited management capacities and resources.

Commercialization of Fireballs

Fireballs were well received among the population and were sold like any other product in retail centers in Goma. Feedback from people who have tried this fuel has been mostly positive in terms of quality.

Fireballs are quite similar to traditional charcoal – they have a similar calorific value and burning duration; they are used in the same stove and require the same cooking techniques. The only prominent concern is that they are compacted, one above the other, thereby making it difficult to start a fire underneath. This challenge has be easily solved by giving charcoal briquettes a prism shape or by using traditional charcoal for ignition, and then switching to the use of fireballs.

There seem to be several reasons why fireballs were not produced and sold after external funding ended. First, the Production Center of Munigui did not develop an effective business model and market approach from the outset. Consequently, it was not able to cover the cost of equipment and personnel with the profits generated from sales. Even though it is not an easy task, the market for alternative fuels in Goma has the necessary conditions for profitable initiatives. The price of charcoal in Goma ranges from USD 0.55 (piecemeal) and USD 0.65/Kg (wholesale) and is objectively high. The price of charcoal on the international market for exports is USD 0.5 to USD 0.55/Kg. There are briquette production companies that do business in markets where the price of charcoal is USD 0.30/Kg. This is a sign that an appropriate approach for sustainability can obtain a profit from this business, particularly considering that raw materials are abundant and inexpensive, because the charcoal dust that is thrown away in markets is not currently used.

Fireballs placed on a Jiko Nguvu Nyeusi stove ready to be lit

WFP & CRSM: Food-for-Work and Briquettes for IDPs

Project Description and Key Achievements

Since March 2013, the World Food Programme (WFP) and the local NGO Comité de Réhabilitation du Sinistré dans son Millieu (CRSM) have been implementing a biomass briquette distribution program for vulnerable community members in the Mugunga I, Mugunga III, Lac Vert and Bulengo displacement camps near Goma.

Many displaced people walk at least five hours to find firewood, and they sometimes even spend the night in the forest. They have no choice but to venture into unsafe territory, despite the drudgery and risks, because firewood collection is critical to their survival. It is essential for household energy purposes, primarily cooking, and it is also serves as a livelihood option, as it is sold for income generation purposes.

WFP and CRSM have engaged IDPs in the production of improved metal stoves and briquettes, as a safer and more sustainable alternative to firewood. CRSM provides all of the equipment and material for manufacturing, including the raw materials, to displaced people who work in exchange for food provided by the WFP.

WFP and CRSM have distributed and installed 50 presses to produce the low-density biomass briquettes across the four camps. They have also trained 1,000

IDPs in the manufacture of improved metal stoves and briquettes from cardboard and sawdust. By the end of 2013, the trained IDPs had made 1,800,000 briquettes and 5,500 metal stoves.[16]

In an effort to mitigate firewood dependence, the stoves and briquettes are then distributed to vulnerable families. Each family receives 35 kg of briquettes per month to help shift away from the unsafe and unsustainable reliance on firewood.

In this context, the use of low-density biomass briquettes for cooking is much appreciated by the displaced persons who receive them for free. This program targets the most vulnerable population of the camp, old people or those with physical limitations, who find it hard to go to collect wood. Otherwise, their options are to spend money on fuel brought by other displaced persons from the park or to use biomass waste found in the countryside, such as dry leaves, corn cobs, or even plastic and shoes.

The project was initially meant to end in November 2013, but the Embassy of the Netherlands and MONUSCO have provided additional support to help sustain it. Moreover, the project serves to recycle paper and cardboard waste obtained at the MONUSCO base in order to transform them into alternative fuel.

Lessons Learned

These briquettes have proven to be a viable option for alleviating acute crisis in contexts where fuel can be very scarce. Implementing the production unit and building the capacity of the stove and briquette makers have proven to be relatively inexpensive, simple and fast. For these reasons, in addition to the low environmental impact and peace-building potential among communities, this approach is recommended for similar emergency contexts.

It is important to note, however, that the IDPs participating in the project still have little or no economic power. Moreover, the project requires adequate transportation for equipment, raw materials and the final products, making it difficult to achieve complete self-reliance. For example, in some cases, such as in the IDP camps of Masisi province, raw materials for manufacturing briquettes must be transported between 80 km and 100 km. Transportation costs to cover such distances are not feasible for small businesses. In these situations, the project can only survive with external support.

IRC and WRC: Imported FES Distribution in IDP Camps

Project Description and Key Achievements

In mid-2013, International Rescue Committee (IRC) and Women's Refugee Commission (WRC) piloted an emergency distribution of imported FES to two displacement sites in the province of North Kivu. Leveraging WRC's energy-specific research and assessments in North Kivu, along with IRC's extensive and well-established Women's Protection and Empowerment programming, was particularly key in this stove intervention collaboration. The distribution of the FES was intended to reduce the frequency of firewood collection – particularly by women and girls – for household use, and, therefore, reduce the exposure to risk of sexual and gender-based violence. It was also intended to provide other benefits, such as reducing respiratory illnesses caused by smoke emitted during cooking, reducing household expenditure on fuel and protecting the environment.

A total of 2,500 Envirofit M-5000 FES were distributed to displaced people in North Kivu as part of the pilot. Envirofit is an American company with a manufacturing center in Nairobi Kenya, from where these stoves were procured. The Envirofit M-5000 is one of the most commonly procured industrially produced FES models thanks to its efficiency and user uptake.

The majority of the stoves, approximately 2,200, were distributed to Congolese IDPs in Nzulo displacement site and Nzulo town, 20 km west of Goma. The remaining stoves were distributed to pygmy IDPs in Shasha displacement site, located 30 km further west. The criteria for selecting the camps were primarily

Envirofit M-5000 fuel-efficient firewood stove after 10 months of use in Nzulo camp

based on economic status of the displaced persons and the distance traveled to the fuel source. Prior to the distribution of the stoves, beneficiaries received training and awareness sessions to increase their understanding of the benefits of the new technology, as well as good practices for using and maintaining the stoves, so as to help minimize the resale or neglect of stoves.

Current Situation

The IRC and WRC stove pilot has been completed with baseline and end-line assessments to help measure impact. Overall, findings show different levels of adoption between the two sites. To start, it is clear that Nzulo displacement site inhabitants are exceptionally impoverished and vulnerable, without any other support from international organizations. The displacement site is spontaneous, meaning not officially registered, and located on volcanic rock, making it nearly impossible to partake in productive activities there. During focus group discussions with WRC, Nzulo displacement site inhabitants reported that their number one concern is a lack of food. While many beneficiaries in Nzulo either sold or traded their stoves, the community members felt that they had no other choice. Several even expressed their remorse in the focus group discussions. With next to no resources, these IDPs have few options to obtain food and water.

Given the proximity of Nzulo to Goma, almost half of the people who participated in this assessment's focus group did not have the stove anymore – they had either sold it or it had been stolen. People who still had the stoves reported appreciating the stove, but many could not use it due to a lack of appropriate firewood. The usual fuel they collect in the surroundings – leaves, small sticks, corn or sugar cane waste – does not work well with the type of distributed stove, so many continue cooking with the traditional three-stone fire. However, participants also mentioned that if they had appropriate firewood for cooking, they would consider using the stove.

In the Shasha displacement site, user uptake of the stove appeared to be higher, according to observation and focus group discussions. Most participants reported that they had kept the stoves and were using them regularly, which may be in part because finding adequate firewood is easier for Shasha inhabitants than for the Nzulo displacement site inhabitants. Shasha inhabitants also reported having some access to income generating activities, primarily through work on local farms.

Lessons Learned

Effectiveness of FES in reducing exposures during firewood collection

Ideally, recipients of FES use them consistently. In doing so, they can save up to 50 percent of fuel as compared to the traditional three-stone fire. This reduction in household consumption of cooking fuel should result in a decreased need for collecting firewood. Evidence suggests that the regular users of FES have been able to reduce their number of firewood collection trips and time spent collecting firewood per week.

In IDP camps and sites in North Kivu, IGAs are generally limited to very few options: fetching firewood to sell it in the villages or to other displaced people, working as day laborers in the fields of nationals, transporting goods or performing other small jobs. For this reason,

even when a family might consume less firewood in their home, members are often still forced to fetch firewood for other basic needs.

To ensure greater protection, interventions should combine FES with the introduction of safer and more sustainable IGAs to generate income that will allow displaced people to buy essential commodities such as food and medicine.

Adoption of given-away stoves

The IRC and WRC FES distribution in Nzulo and Shasha shows different degrees of adoption in a single project. It is clear that 100 percent adoption is almost impossible, but with the right expertise, an acceptable level of stove adoption can be achieved. If the risk of the FES being sold or stolen is very high, an ideal solution is to promote fixed FES. These are normally less efficient and harder to be adopted by population (there are many cases of fixed FES installed but not being used), but if the right model, with intense training, is introduced, it can be a good solution.

Improving Energy Access for Cooking

This chapter presents a view to the future with proposals and thoughts for the Province of North Kivu to improve its energy crisis and the negative effects of the current fuel supply. First, it focuses on how to improve the choice of the stove technology on the basis of already existing models. Second, it explores the potential of alternative fuels from biomass and a proposal to replace a certain percentage of traditional fuels with high-density briquettes. These proposals may be useful for future or current programs developed by the SAFE sector organizations, as well as government entities or private sector companies qualified to improve the current situation.

The Right Stove: Keep Improving Existing Technologies

There is no perfect improved stove option, as there is always a compromise between quality and price. Some users may prefer a lower-priced stove with minimal efficiency and durability, while others opt for a more expensive, lower fuel consumption stove with certain other value added features, e.g., aesthetics, modern materials or durability. The higher the price of a stove, the more efficient and durable it should be. Given the vulnerability of displaced communities, it is critical for long-term sustainability that an improved stove program promote technologies that have the best value for the price range of the desired end-user.

Ideally, an FES program should assess the quality of select stove models in terms of their fuel savings, production characteristics and adaptation to users in order to identify potential improvements in design and construction. For this technical assessment, some models were chosen because they are currently the most popular stoves in Goma and others were chosen because they are promising new models that are not yet widely distributed.

For this assessment, several visits to manufacturers and stove users were required to detect improvements and weak points in construction methods. Then, a Controlled Cooking Test[17] was conducted to assess real fuel savings and cooks' preferences with regards to the stove. All the stoves tested were charcoal stoves, using similar construction materials and methods. As mentioned earlier, most of the stoves programs have focused on urban centers where charcoal is the preferred fuel, so the technologies introduced use charcoal. No firewood FES are being produced locally.

Test results (see next page) showed significant variations across the different stoves, including the most significant parameters: fuel savings and cooking duration. One of the main concerns of stoves craftsmen is that they have no information and capacity to test the efficiency of their products. They are not able to improve the efficiency of their products with new

models and designs, based on reliable evidence.

The tests conducted show that some of the stoves considered low quality or less efficient, such as the Rwandan stove, actually perform better than the flagships of the local FES, including the Jiko Nguvu Nyeusi or Argus. The test results are calculated as an average of the data collected during 12 days of cooking with six different cooks. Each stove was represented by three samples to avoid bias from small differences between stoves of the same model. Each sample was tested four times by different cooks. The same procedure for cooking was followed every day.

Construction Materials

The main components are ceramic and metal. In all cases, the combustion chamber is made of clay from Rwanda or the provinces of Rutshuru or Masisi. The stove has a metal housing of different qualities, depending on whether it is new metal sheet or recovered scrap metal. Between the metal housing and the combustion chamber, a sealing material is used to properly join both parts. The sealing material combines black sand, volcanic gravel and cement. This sealing mixture is also used to isolate other parts of the stove. Finally, stoves are normally painted with water-resistant paint on the outside and red dye in the combustion chamber.

The bulk price for clay is about USD 5 for a 25 kg bag or USD 200 for a 6 square meter truck. There is no problem with clay availability, although the price has

Controlled Cooking Test to assess real fuel savings and cooks' preferences with regards to the stove

gone slightly up in recent years. Its quality is supplier-dependent, but is generally very good, since it is very pure clay containing minimal pebbles and sand.

As for the metal sheet, when the real estate sector activity plummeted, the retail sale of BG 28 metal sheets dropped in Goma and Butembo. As small manufacturers lack the capacity to order from Kampala, they are meeting their needs with rippled metal sheet used for roofs, or recovered metal. The quality of the metal sheet as raw material is not as critical as is the quality of the ceramic insert (inserted piece of material – see the photos below), but a very low metal sheet quality would compromise the stability of the ceramic insert inside because it could be too thin or rust quickly.

Manufacturing Methods

In Goma, all stoves are handmade by specialized craftsmen. Metal and ceramic parts are produced separately, often in different shops.

The ceramic bowl is the most critical part of a stove and is difficult to manufacture; this is where more breakages have been noted. The most usual problems are the uncoupling of the metal part due to wear of the sealing material, and the breakage of the grate as a result of cracks.

In Goma the ceramic bowl is not baked at high temperatures in a kiln before piecing it together with the rest of the stove, as it is by producers of similar stoves in other locations. Although it will subsequently be naturally fired during its initial use in a stove at 400 or 500° C, the risk of cracks or deformation during transportation and use is high. The most relevant factor in crack formation, which may then result in breakage of the grate, is the drying process of the clay prior to manufacturing the bowl. It is mostly dried under the sun, given the lack of space in craftsmen's shops. However, this fast drying in the sun is not advisable, since the rapid loss of water from the surface creates stress in the ceramic, which in turn results in deep cracks. The drying process should be slow, in the shade, and indoors protected from draughts. It could take one to two weeks, after which the piece is ready for baking or assembly.

To improve the assembly of metal and ceramic parts, it is advisable that the sealing material is as thin as possible on the upper surface of the stove, preferably hidden from view. The sealing material, which also acts as an insulator, should grow progressively thicker under the surface; if it is left on the surface, it will soon detach, causing the bowl to move and rapidly damaging the stove.

Currently, all stoves are produced by small shops and are handmade; centralizing some of the production processes could contribute towards higher quality and reduced production costs. Such has been the case with projects that were able to scale up, such



On the left, crack on the ceramic wall of the combustion chamber. In the center, a broken grate of the combustion chamber. On the right, displacement between the ceramic inlet and the sealing.

as the International Lifeline Fund (ILF) or Ugastove, in Uganda, where the low-density bricks and ceramic bowls are mass-produced in one facility. This should also be considered an option for Goma producers who face difficulties due to low profitability.

Keep Innovating with the "Femmes du Solei" Stove in Mind

Given the results of the tests performed, there is a clear indication that current mass produced and largely adopted models of FES in urban centers of North Kivu – Jiko Nguvu Nyeusi and Rwandan stove, could improve from their actual performance on fuel savings (28 to 30 percent) to a higher performance rate close to 40 percent by just modifying their shape. Tests showed that this improvement is possible using the same materials and the same manufacturers. While the price may be higher, this should be seen as an opportunity for manufacturers to increase their profits through new marketing strategies.

The most promising stove type, which should guide the evolution of design in North Kivu, is the stove produced by the "Femmes du Solei" association. This stove carries the name of the association and was developed to be more durable than other local models. Unintentionally, in fact, Femmes du Solei produced a stove that saves more fuel as well. This stove, besides saving more fuel than any other, is preferred by many users, because it is easy to ignite, cooks fast enough, is powerful when required, has good stability for the pots and is easy to handle when it is hot. These characteristics are critical for large-scale adoption and clearly more important to end-users than the fuel savings performance.

For instance, the Jiko Nguvu Nyeusi stove has very good user adaptation characteristics, which have permitted its mass adoption. While the Small Goma stove is much more efficient than Jiko Nguvu Nyeusi, cooks do not like that it requires a lot of fanning to have a powerful fire, and it takes more time to ignite. It seems unlikely that the Small Goma stove will achieve widespread adoption. As for the Femmes du Solei stove, although it performs

Top performing FES "Femmes du Solei"

very well, it still needs some improvements, mostly in the manufacturing process, to avoid cracks and to improve the sealing material stability.

Below are the size and shape parameters that improve the stove's performance and which can help to guide further innovation:

- Smaller combustion chamber; keep it under 1,500 cm^3
- Wide combustion chamber top diameter; no smaller than 18.5 cm
- Thick isolation; better 5 cm than 4 cm
- Keep the air holes area no smaller than 60 sq. cm.

The smart design of the Femmes du Solei stove includes all the above mentioned parameters. Its characteristic combustion chamber design with three "noses" allows for volume reduction while keeping a wide diameter top opening. This avoids the typical fuel overloading of the stove that most cooks do. Smaller combustion chambers have systematically been noted to reduce fuel consumption, as in other models. At the same time, this stove still offers the necessary high power and consequently faster cooking because of its wide top diameter and appropriate air entrance area. With the thickest insulation of all the stoves tested, its outer temperature is the lowest, which makes it safer

than the others and ensures that more heat produced by the charcoal gets to the pot.

Alternative Fuels: Bringing Briquettes to the Next Level

The people of North Kivu have very few options when it comes to fuel for cooking: charcoal or wood. However, this contrasts with the vast amount of biomass resources available in the region. Unlike many refugee camps in Africa, refugee camps in North Kivu are surrounded by green landscape and are fertile. They also get abundant rainfall. Although the use of machinery is practically non-existent, the land not occupied by national parks or used for grazing is devoted to agriculture: potatoes, beans, corn, rice, peanuts, coffee, sugar cane, carrots and many other vegetables and fruits. Every year this results in many tons of agricultural refuse that is wasted, often burned, since it is inefficient for cooking, as it is in small pieces, is damp or contains ash. However, if processed with the right technology, it could be transformed and used as a stable energy source.

The main obstacle for a project that manages agricultural waste is the cost involved in the transport of raw material, which has a very low economic value per ton, and may be distributed over a very large area. Therefore, a strategic site for the transformation plant is essential in order to minimize transportation costs.

When using agricultural waste for energy supply, the needs of the community are the primary drivers in choosing the most appropriate technology. In the case of North Kivu, there is no centralized need, but rather a scattered need over large areas. For this reason, turbines and gas systems for electricity production should be ruled out. This does not mean that production with large-scale combustion systems (> 5 MW) is not a good option for cooking purposes, but it requires electric grids, and thus becomes a larger project. In North Kivu, the best options are technologies that involve the physical transformation of biomass into cooking fuel, inter alia: wood chips, pellets, high-density biomass briquettes or high-density carbonized biomass briquettes. This section describes the production of the latter, made from agricultural waste, as an option to supply high quality and inexpensive fuel to both the local population and displaced persons.

Charcoal briquettes: A New But Common Fuel

As seen in previous chapters, the weak point of low-density biomass briquettes produced by previous programs was the lack of adoption by communities, due to poor combustion features and the need for special stoves. In the case of high-density charcoal briquettes, users adopted those more easily than

Charcoal briquettes in Cambodia

Charcoal powder briquette extruding

low-density biomass briquettes, and even wood-chips or pellets, since they behave like traditional charcoal. Moreover, the charcoal briquettes use the same type of stoves. This means that all the progress made through FES promotion and distribution programs will continue to be valuable.

Charcoal briquettes are made by compressing charcoal dust or paste and mixing them with a binder at high pressure (200 MPa) and high temperature (100 to 150° C). A briquetting press consists of a feeding hopper, a variable-speed, simple or multiple dosing system, a compaction or densification chamber, a cooling channel and a cutting system. The press is the key component in briquette production. There are four types of briquetting presses, used according to their industrial application and the type of material to compress: (a) impact press; (b) extrusion press; (c) hydraulic or pneumatic briquetting press; and (d) double-roller press. The common feature of briquettes is their high density (1,000-1,300 kg/sq.mt.), and a calorific value similar or higher than traditional charcoal. The shape is normally prismatic with diameters ranging from 3 to 20 cm and lengths between 15 and 50 cm.

Another advantage of high-density charcoal briquettes is that they can be produced from practically every agricultural raw material. The waste must be charred in special furnaces and turned into coal dust. Different raw materials ideal for charring and producing briquettes have been successfully tested in various projects, for example, coconut shells and husks, corn cobs, sawdust, peanut shells, bamboo, sugar cane and coffee husks. It is also ideal to use the charcoal dust collected in charcoal markets.

The Appropriate Approach for Long-term Success

Given its vital role in social and economic development, improved access to energy has typically been the responsibility of state-owned power utilities, rural energy agencies, international development and non-govern-

Case study: Sustainable Green Fuels Enterprise (SGFE), Pnomh Penh, Cambodia

SGFE was created in 2008 with the aim of alleviating poverty and reducing deforestation in Cambodia, as well as improving waste management in urban areas, by developing a local economic activity. Combining modern processing with innovative technology, SGFE is manufacturing a high quality and sustainable alternative to wood charcoal: charbriquettes, made of organic waste. As a real social business, SGFE profits are reinvested into the company's assets and fairly distributed among the employees to maximize the social impact. SGFE's current production capacity is 50 tons of charcoal briquettes a month, and it is planning to upgrade its facility to produce another 50 tons/month. SGFE is now a profitable company, supplying alternative fuels in a country with scarce resources; a success case in a competitive environment. Translating this experience to North Kivu, an estimated USD 60,000 investment for two production lines with a capacity of 25 tons of charcoal briquettes a month each, including a crusher, a mixer, an extruder press, driers and carbonizing kilns, could replace in one year 1 percent of the charcoal used in Goma, a small but significant amount.

See http://www.sgfe-cambodia.com/ for more information about SGFE Cambodia.

mental organizations, and other public entities. However, with a growing recognition of the potential for "base of the pyramid" (BOP) consumers to become fast-growing markets for goods and services on the one hand, and the emergence of innovative models for serving them on the other hand, the energy access gap is increasingly being recognized as a commercial opportunity as well. A study conducted by International Finance Corporation (IFC) in over 100 enterprises shows that with the right business models and enabling conditions, the private sector can play an important role in helping to close the energy access gap.[18]

Moreover, the development of the private sector in terms of energy will both directly and indirectly affect stability. The creation of durable jobs and the reduction of risk in fuel collection and extraction must be priorities for development in long-standing crisis-stricken areas such as North Kivu.

Humanitarian impact is defined as lasting or significant, positive or negative, intended or unintended changes. In a region where humanitarian interventions have been taking place for over 20 years, not enough has been done in terms of creating and implementing durable solutions. Displacement will continue to be a challenge in eastern DRC as conflict and displacement ebb and flow. However, market-driven and self-empowerment approaches can help to foster security and prosperity, which is so desperately needed there.

Finally, North Kivu is endowed with ideal conditions to pursue the alternative fuels business. As described in Chapter 2, the residential fuels market annual volume is close to USD 100 million. Because large scale very low- or zero-cost raw materials are available in North Kivu, the size of the alternative fuel capacity could be large enough to be profitable, considering the factors involved in economies of scale. Furthermore, the current charcoal price in North Kivu's major consumption centers is USD 0.55 - USD 0.60 /kg, much higher than in other countries, such as in Cambodia where the price is USD 0.30 /kg. It is even higher than the price of charcoal in export markets, which is USD 0.50 - 0.55 /kg on average.

Conclusion

The inhabitants of North Kivu do not have access to sufficient energy; this is particularly pronounced for the internally displaced people in the region. Cooking fuel is generally too costly to purchase. Women and girls must collect firewood in unsafe areas, risking rape, attack and even death. Moreover, firewood and other available solid fuel sources are dirty and toxic when burned, and they pose significant health and safety risks.

The lack of sustainable fuel and energy sources represents an enormous threat for forest conservation and animal species protection, despite the natural wealth of the region. Without the development of more modern energy sources, the current fuel will become more expensive and deforestation will advance more rapidly.

Improving the overall energy situation with affordable, clean, safe and sustainable access to energy resources will benefit all people living in North Kivu, and it will reduce the need for firewood collection, thereby helping to protect both people and the environment. Ideally, better sources of fuel will be accompanied by new income generating activities that will have a multiplying effect on increasing the security of vulnerable women and girls.

In the meantime, FES manufacturers should be supported to innovate and develop better models. They should also draw on existing efficient models such as the "Femmes du Solei" stove, which are not yet widespread and may have better user uptake. Stove manufacturers need management capacity support, as well as accessible and efficient mechanisms for financing and testing their products. The government should play a key role in supporting manufacturers and encouraging fuel-efficient stove adoption throughout the province and the country.

FES are especially critical for rural and displaced populations. Given that the purchasing power of IDPs is especially low, short-term interventions should consider distribution of FES, but recognize that there

is a risk that communities will sell or abandon them if their other basic needs are not being met. Supporting local production of fixed and multiple-fuel stove types and prioritizing thorough training for both producers and end-users is more likely to increase user uptake and contribute to long-term sustainability.

Notes

1 CIA Fact Book: https://www.cia.gov/library/publications/the-world-factbook/geos/countrytemplate_cg.html
2 http://hdr.undp.org/en/countries/profiles/COD
3 Democratic Republic of Congo: Internal displacement in brief (31 December 2013). http://www.internal-displacement.org/sub-saharan-africa/democratic-republic-of-the-congo/summary/
4 See references [1], [2] and [3] for tools and guidelines on SAFE.
5 Women's Refugee Commission (E. Patrick). *We have no choice, Safe Access to Firewood and Alternative Energy in Eastern Democratic Republic of Congo*. April, 2011.
6 For an overview of these linkages, please refer to the Matrix on Agency Roles and Responsibilities for Ensuring a Coordinated, Multi-Sectoral Fuel Strategy in Humanitarian Settings developed by the IASC SAFE Task Force.
7 See http://www.unhcr.org/cgi-bin/texis/vtx/page?page=49e45c366&submit=GO for more information from UNHCR on the humanitarian situation in DRC.
8 International Energy Agency. World Energy Outlook (WEO) 2011. http://www.worldenergyoutlook.org/publications/weo-2011/.
9 Jean-Claude Balole-Bwami and Ephrem Balole-Bwami. *Study on the consumption of charcoal in Goma, Democratic Republic of Congo and Gisenyi in Rwanda*. Unpublished, February 2008.
10 *Jeune Afrique*. "Les 500 premieres entreprises africaines (The Top 500 Businesses in Africa)." 2 December 2011. http://economie.jeuneafrique.com/les-classements/classement-top-500/les-500-premieres-entreprises-africaines.html.
11 See data used for calculations in Annex 3.
12 CIFOR (J.Schure, V.Ingram, C.Akalakou-Mayimba). *Bois énergie en RDC: Analyse de la filière des villes de Kinshasa et de Kisangani.* Kinshasa, December 2011.
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14 WWF (T. Bodson). *Report: Virunga Environmental Program; Energy Saving Department.* Goma, November 2012.
15 A fuel-use test was conducted during the consultancy, which consisted of bringing four liters of water to the boil and letting it simmer for 20 minutes, using different types of fuel. To complete the test, it required 1,300 g of biomass briquettes and 630 g of wood charcoal. Considering the price in Kiwanja of biomass briquettes is USD 0.14/Kg, and the price of charcoal is USD 0.33/Kg, the cost of the fuel involved on the test (which is equivalent to prepare a short meal) was USD 0.18 with biomass briquettes and USD 0.21 with wood charcoal.
16 CRSM (V.Kagamba, M.Bizimungu). *Rapport Narrative période 1er Mars au 30 Novembre*. Unpublished, January 2014.
17 See Annex 1 for Controlled Cooking Test details.
18 International Finance Corporation. *From Gap to Opportunity: Business Models for Scaling Up Energy Access*. 2012.

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[3] WFP (M. Bizzarri, C. Bellamy, V. Barbelet). WFP Handbook on Safe Access to Firewood and alternative Energy (SAFE). 2012. http://documents.wfp.org/stellent/groups/public/documents/newsroom/wfp252989.pdf

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[10] International Finance Corporation. From Gap to Opportunity: Business Models for Scaling Up Energy Access. 2012. http://www.scribd.com/doc/94692230/From-Gap-to-Opportunity-Business-Models-for-Scaling-Up-Energy-Access

Annex 1: Controlled Cooking Testing

The Controlled Cooking Test (CCT) is designed to assess the performance of the improved stove relative to the common or traditional stoves that the improved model is meant to replace. Stoves are compared as they perform a standard cooking task that is similar to the actual cooking that local people do every day. However, the tests are designed in a way that minimizes the influence of other factors and allows for the test conditions to be reproduced.

Objectives of the test

The objectives of the test were to:

1. evaluate fuel savings compared to the three-stone fire (for wood stoves) and traditional metal stove (for charcoal stoves);
2. evaluate stoves' cooking speed;
3. identify opportunities to improve the stoves.

Location

The tests were done in the city of Goma, in a space facilitated by the local NGO CRSM in the borough of Deux Lampes. The altitude is about 1,551 meters above sea level and the local boiling point is 95°C.

Stoves tested

1. TRADITIONAL STOVE (BASELINE)

	*General information* This stove has existed for decades all over Africa. It is a simple device that is used as a hot charcoal container and as a support for the cooking pot over the fire. It is made of scrap metal with a price of approximately USD 1. There are different models available in the market, but all of which have similar performance, because the design does not allow for control of air entrance and air isolation within the device.	
Mass (Kg)		1.1
Outer body dimensions	Height (cm) Diameter (cm)	16.5 27
Combustion chamber dimensions	Height (cm) Diameter (cm) Volume (cm^3) Average diameter of Air hole (cm) Number of air holes Total area of air holes (cm^2)	5 25.5 2552 1.5 to 2.5 53 ≈160
Air/Ash Opening	Length (cm) Height (cm) Controllable	13 7 No
Insulation	Average thickness (cm) Other insulated areas	- No
Construction materials	This stove is made of scrap metal recovered from cans, barrels or other metal parts.	
Popularity	Very common. It is possible to find this model in every market.	
Lifespan	3 to 6 months	
Other observations	The grate is the part of the stove that always rusts first, and users normally extend the stove's life by placing stones or wires on the grate.	

2. RWANDAN STOVE

	*General information* This stove is produced in Rwanda. Its retail price in Goma is USD 2.50. Its design has its origins on the Kenyan Ceramic Jiko. Although this stove has not been introduced by any cooperation program, it is much appreciated by the population and it is likely to be considered as an improved cookstove if it can prove to save on fuel consumption.	
Mass (Kg)		2
Outer body dimensions	Height (cm) Diameter (cm)	16 24.5
Combustion chamber dimensions	Height (cm) Diameter (top/bottom) (cm) Volume (cm^3) Average diameter of Air hole (cm) Number of air holes Total area of air holes (cm^2) Grate thickness	6.5 20/18.5 1892 1.5 17 30 1
Air/Ash Opening	Length (cm) Height (cm) Controllable	11 5 No
Insulation	Average thickness (cm) Other insulated areas	2 No
Construction materials	The metal part of this stove is made of scrap metal and the inner ceramic part from low-density ceramic	
Popularity	Very common, it is possible to find it in every market, even in the poorest places.	
Lifespan	4 to 8 months	
Other observations	It is lightweight so one person can transport it walking, even12 or 14 of them.	

3. JIKO NGUVU NYEUSI

	*General information* This stove has its origins on the Kenyan Ceramic Jiko. It was conceived in Goma around year 2000 by the GTZ/FIDA programs and improved by WWF in 2008. It is currently produced by many artisans in Goma and Butembo, whether or not they were trained by international NGOs. Its retail price in the market is USD 5.	
Mass (Kg)		7.5
Outer body dimensions	Height (cm) Diameter (cm)	21 29
Combustion chamber dimensions	Height (cm) Diameter (cm) Volume (cm3) Average diameter of Air hole (cm) Number of air holes Total area of air holes (cm^2) Grate thickness	6.5 20 2042 2 21 65.9 2.5
Air/Ash Opening	Length (cm) Height (cm) Controllable	13 7 No
Insulation	Average thickness (cm) Other insulated areas	4.3 No
Construction materials	The metal part of this stove is made of metal sheet BG 28 and the inner ceramic part from red clay	
Popularity	Since 2008, the popularity of this stove has greatly increased and it is now one of the commonly used stoves in Goma and Butembo.	
Lifespan	6 to 24 months	
Other observations	It is the simplest design of the improved cooking stoves promoted by international NGOs. Its quality, though, varies greatly from producer to producer. When the grates breaks, customers replace it with a new ceramic bowl.	

4. FEMMES DU SOLEI

	*General information* This stove is a modification of the Nguvu Nyeusi stove. It was designed by a local women's producers association called Femmes du Solei. The most significant difference from the prior version is the form in the combustion chamber, which it is not cylindrical. In this case, the pot supports protrude towards the center of the grate, thereby creating a clover shape at the bottom. Its retail price is USD 10.	
Mass (Kg)		12
Outer body dimensions	Height (cm) Diameter (cm)	26.5 27.5
Combustion chamber dimensions	Height (cm) Diameter (top/bottom) (cm) Volume (cm3) Average diameter of Air hole (cm) Number of air holes Total area of air holes (cm^2) Grate thickness	6.5 18.5/16.5 1212 2 19 59.7 3
Air/Ash Opening	Length (cm) Height (cm) Controllable	11.5 8 Yes / Door
Insulation	Average thickness (cm) Other insulated areas	5 Yes
Construction materials	The metal part of this stove is made of metal sheet BG 28 and the inner ceramic part is made of red clay. Between the red clay and the metal housing, the space is filled with a seal made of black sand, volcanic gravel and cement.	
Popularity	This stove is only commercialized by one association, so very few have been sold until now.	
Lifespan	6 to 24 months	
Other observations	Despite having a robust combustion chamber, the presence of cracks and the bad quality joint between the ceramic insert and the metal housing makes it unlikely that it will last for more than two years.	

5. JIKO ARGUS

	*General information* This stove is a variation of Jiko Nguvu Nyeusi, with improved pot supports that increase durability, and better construction, such as the molded border, which provides more resistance on the metal housing and better air isolation. Its retail price is USD 10.	
Mass (Kg)		9.6
Outer body dimensions	Height (cm) Diameter (cm)	25 28
Combustion chamber dimensions	Height (cm) Diameter (cm) Volume (cm3) Average diameter of Air hole (cm) Number of air holes Total area of air holes (cm^2) Grate thickness	7.5 20 2356 2 19 59.7 2.5
Air/Ash Opening	Length (cm) Height (cm) Controllable	12 7 Yes / Door
Insulation	Average thickness (cm) Other insulated areas	4 Yes
Construction materials	The metal part of this stove is made of metal sheet BG 28 and the inner ceramic part is made of red clay. Between the red clay and the metal housing, the space is filled with a seal made of black sand, volcanic gravel and cement.	
Popularity	This stove is not widespread because only a few artisans are producing it and it has not been widely promoted. Also the higher price makes it less competitive.	
Lifespan	12 to 30 months	

6. SMALL GOMA STOVE

General information

This stove is the small version of the Goma stove which was promoted by IFDC between 2011 and 2013. It is similar to the Jiko Nguvu Nyeusi, but with improvements on the pot supports. It also has an added metal ring, better air isolation, and solid construction. Its retail price is USD 5.

Mass (Kg)		6.8
Outer body dimensions	Height (cm) Diameter (cm)	21 29
Combustion chamber dimensions	Height (cm) Diameter (cm) Volume (cm3) Average diameter of Air hole (cm) Number of air holes Total area of air holes (cm^2) Grate thickness	7.5 16 1507 2 18 56.5 3.5
Air/Ash Opening	Length (cm) Height (cm) Controllable	10 7 Yes/Door
Insulation	Average thickness (cm) Other insulated areas	3 Yes
Construction materials	The metal part of this stove is made of metal sheet BG 28 and the inner ceramic part is made of red clay. Between the red clay and the metal housing, the space is filled with a seal made of black sand, volcanic gravel and cement.	
Popularity	This stove is not widespread, because only a few artisans are producing it and it has not been widely promoted.	
Lifespan	12 to 30 months	

Fuel Used

Dry charcoal with an estimated net calorific value of 29,800 kJ/kg was used.

Procedure for the CCT

Version 2 of the University of California Berkeley Controlled Cooking Test protocol was followed to conduct this test.* For each type of stove, three samples were tested, with each of the samples tested four times; in total, each model was thus tested 12 times. All stoves were tested by the same cooks to avoid deviations on cooking behavior.

* Find full CCT V2 testing protocol at http://www.aprovecho.org/lab/pubs/testing.

Meal Selection & Cooking Procedure

A traditional dish was chosen to conduct this CCT series. The criteria applied were:

1. People in the region should eat the chosen meals very commonly cooked, at least 2 or 3 times per week.
2. Fresh ingredients have to be available in the market during all the period of the tests.
3. The total duration of 1 single test has to be more than 1.5 hours and less than 4 hours.
4. The stove should be required to perform at high and low power during the test.
5. The quantity of the meal prepared should nourish an average family at lunch or dinner time.
6. The cost of the ingredients should be reasonable, according to the available budget for the tests.
7. The cooking task has to remain as simple as possible, avoiding as much as possible preparation of the ingredients and cooking tasks not related to the stove.

Following those criteria, the chosen dishes were: (a) fried beans, (b) rice, and (c) fried *sambaza*.*

Ingredients:

1,000 g of fresh beans
750 g of rice
400 g of *sambaza*
200 g of onions
350 g of vegetable oil
20 g of salt
10 g of garlic
4 g of bouillon cube
1.5 g of nutmeg
Water

Cooking procedure:

1) Boiling beans
2) Frying *sambaza*
3) Boiling rice
4) Frying beans

Analysis of Results

The first step was to check the data for outliers, with a confidence level of 95 percent. The method used was the Grubb's method. Then, an ANOVA test was conducted to check that all three samples of each model of stove were performing the same way. After this, an Analysis Of Variance (ANOVA) test was conducted to discard any significant variation in the results due to the cook's behavior. Finally, a T-test was conducted to see if there was significant difference between the FES and the baseline stove.

* *Sambaza* is a local tiny fish from Lake Kivu, which is available all year, but especially during the rainy season. It is very popular because of its cheap price.

Results and Discussion

The results presented below are an average of the 12 tests done on each stove model. Fuel savings are calculated with the following formula:

Fuel savings of stove A (%)= (fuel consumed by baseline stove-fuel consumed by stove A)/(fuel consumed by baseline stove)*100

Stove model	Average charcoal consumption per test (g)	Average cooking duration per test (hh:mm)	Average fuel savings compared to baseline
1. Traditional stove (BASELINE)	1,696	3:07	--
2. Rwandan stove	1,190	3:20	29.9%
3. Jiko Nguvu Nyeusi	1,214	3:03	28.4%
4. Femmes du Solei	1,034	3:19	39.1%
5. Jiko Argus	1,261	3:00	25.7%
6. Small Goma Stove	1,045	3:29	38.4%

Comments from the Cooks

While the tests were being conducted, the cooks' behavior was observed to see how they dealt with the stove if any unexpected problem or frustration occurred while they were cooking. Also, after the completion of all tests, the cooks were asked to give their general feedback.

Name of the Cook	Favorite Stove	Cook's perception
1. Orthense	Femmes du Solei	Saves a lot of charcoal. Lighting is easy.
2. Chance	Femmes du Solei	The most efficient. The inside form helps not wasting the charcoal.
3. Adidja	Jiko Argus	It is very powerful. It doesn't require much attention.
4. Viviane	Nguvu Nyeusi	Lightning is very easy. Saves some fuel.
5. Wany	Jiko Argus	Lighting is very fast. Doesn't require much attention. Saves fuel.
6. Mamy	Femmes du Solei	It is the most efficient.

Annex 2: Cookstove Safety Evaluation Test 1.0

A safety evaluation was conducted to assess the level of risk that the stove has towards injuring the cook or other people in the kitchen with burns or cuts caused directly or indirectly by the stove.

Tests and Rating

There were 10 types of test to evaluate safety. The ones that are not described below do not apply to charcoal stoves, and are scored at the highest rating.

Test 1: Sharp Edges and Points (Metric)

Sharp edges and points on a cookstove can cut flesh or entangle clothes and overturn the stove. Consequently, exterior surfaces of a cookstove should not catch or tear any article of clothing or cut hands during normal use. Sharp edges and points are measured by the number of catches or tears that occur when a piece of cloth is rubbed gently over the exterior of the stove.

Rating	Number of catches or tears in the cloth
Poor	Four or more
Fair	Three
Good	One or two
Best	None

Test 2: Cookstove Tipping

It is important that a cookstove be stable enough to maintain an upright orientation when in operation. Otherwise, burning or boiling contents could spill onto surrounding persons or materials. Therefore, cookstoves should come back to rest upright after being slightly tipped from their regular resting position.

The quality of tipping is measured by the ratio of the height of the tipped stove and the actual height of the stove when it is flat on the ground.

Rating	Ratio
Poor	$R \geq 0.978$
Fair	$0.961 \leq R < 0.978$
Good	$0.940 \leq R < 0.961$
Best	$R < 0.940$

Test 3: Containment of Fuel

Flaming fuel should rarely fall from the cookstove when it is overturned and embers/burning fuel should have little chance of being expelled from the combustion chamber. Containment of fuel is measured by the area of exposed fuel (often around the sides of the pot or through the fuel loading chamber).

Rating	Area of exposed fuel (cm^2)
Poor	$A \geq 250$
Fair	$150 \leq A < 250$
Good	$50 \leq A < 150$
Best	$A < 50$

Test 4: Obstruction Near Cooking Surface

Areas surrounding the cooking surface should be flat so that pots being moved from the stove do not collide with protruding components and overturn boiling contents onto hands or nearby people.

Typically, these obstructions include handles perpendicular to the griddle that are used for removing the cooking surface during cookstove maintenance. A ruler or tape measure is used to find the difference in height of the cooking surface to the height of any protrusions closely surrounding it.

Rating	Difference (cm)
Poor	$D \geq 4$
Fair	$2.5 \leq D < 4$
Good	$1 \leq D < 2.5$
Best	$D < 1$

Test 5: Surface Temperature

The surface temperature test measures the temperature of the surface of the stove. Δ Temperature = Temperature of stove surface – Temperature of air. Temperatures are measured in degrees Celsius. It is measured at a height below the child line (< 0.9m).

Rating	Metallic	Nonmetallic
Poor	$\Delta T \geq 50$	$\Delta T \geq 58$
Fair	$44 \leq \Delta T < 50$	$52 \leq \Delta T < 58$
Good	$38 \leq \Delta T < 44$	$46 \leq \Delta T < 52$
Best	$\Delta T < 38$	$\Delta T < 46$

Test 6: Heat Transmission to Surroundings

The heat transmission test is for determining if the stove's surface (floor or wall) will cause something touching it or nearby to catch fire.

Δ Temperature = Temperature of stove surface – Temperature of air. Temperatures are measured in degrees Celsius.

Rating	Floor	Wall
Poor	$\Delta T \geq 65$	$\Delta T \geq 80$
Fair	$55 \leq \Delta T < 65$	$70 \leq \Delta T < 80$
Good	$45 \leq \Delta T < 55$	$60 \leq \Delta T < 70$
Best	$\Delta T < 45$	$\Delta T < 60$

Test 7: Handle Temperature

This test measures the ease for cooks to handle the stove. Besides burning fingers, very hot handles can cause accidents like pot tipping. Δ Temperature = Temperature of stove handles – Temperature of air. Temperatures are measured in degrees Celsius.

Rating	Metallic	Nonmetallic
Poor	$\Delta T \geq 32$	$\Delta T \geq 44$
Fair	$26 \leq \Delta T < 32$	$38 \leq \Delta T < 44$
Good	$20 \leq \Delta T < 26$	$32 \leq \Delta T < 38$
Best	$\Delta T < 20$	$\Delta T < 32$

Results and Discussion

Air temperature the day of the test is 25°C.

Stove model	Sharp Edges & Points		Cookstove Tipping		Containment of Fuel	
	Result	Rating	Result	Rating	Result	Rating
Traditional	> 25	Poor	0.42	Best	127	Good
Rwandan stove	5	Poor	0.66	Best	77	Good
Jiko Nguvu Nyeusi	3	Fair	0.74	Best	63	Good
Femmes du Solei	6	Poor	0.58	Best	87	Good
Argus	6	Poor	0.6	Best	94	Good
Petit Goma stove	2	Good	0.67	Best	25	Best

Stove model	Surface Temperature		Heat Transmission to Surroundings		Handle Temperature	
	Result	Rating	Result	Rating	Result	Rating
Traditional	394	Poor	62	Good	0	Best*
Rwandan stove	249	Poor	37	Best	85	Poor
Jiko Nguvu Nyeusi	184	Poor	22	Best	80	Poor
Femmes du Solei	130	Poor	15	Best	28	Fair
Argus	149	Poor	23	Best	53	Poor
Petit Goma stove	189	Poor	25	Best	95	Poor

** The traditional stove rated BEST the handle temperature test, as the temperature of the handle was the same as the air temperature. This result is largely due to the fact that the handle is mostly separated from the cook-stove (see the photo in Annex 1. The wire handles comes out from both sides of the stove.*

NB: Regarding "Obstruction near Cooking Surface" Test 4, none of the tested stoves had any protrusions or obstructions over the cooking surface.

The testing protocol guidelines indicate how to obtain a global safety rating per stove. Each individual test rating has a different weight for the global result, depending on the importance given. The score for each rating is: Poor=1, Fair=2, Good=3 and Best=4.

Overall Safety Rating (Maximum score is 100 points. International Workshop Agreement (IWA) tiers range from 0 to 4, with 4 the highest):

Stove model	Overall Score	Overall Rating	IWA Tier
Traditional	84.5	Good	Tier 2
Rwandan stove	81	Fair	Tier 2
Jiko Nguvu Nyeusi	82.5	Fair	Tier 2
Femmes du Solei	83	Fair	Tier 2
Argus	81	Fair	Tier 2
Petit Goma stove	84	Good	Tier 2

Annex 3: Wood Demand Calculations in the Province of North Kivu

Data used for the calculation:

- Population of the province: 5.850.000 (data INS).
- Average size per household: 5.8 persons (data INS).
- Average wood consumed per day: 4.9 kg/hh. This is estimated by measures done in field both in rural and urban zones.
- Average time of cooking per family: 3 hours per day.
- Average charcoal consumption per meal: 1.5 kg (equivalent to 10.5 kg of wood) or 3 kg of wood.
- It is assumed that 25 percent of the population cooks with charcoal and 75 percent cooks with firewood.

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