The true cost of using traditional fuels in a humanitarian setting. Case study of the Nyarugusu refugee camp, Kigoma region, Tanzania

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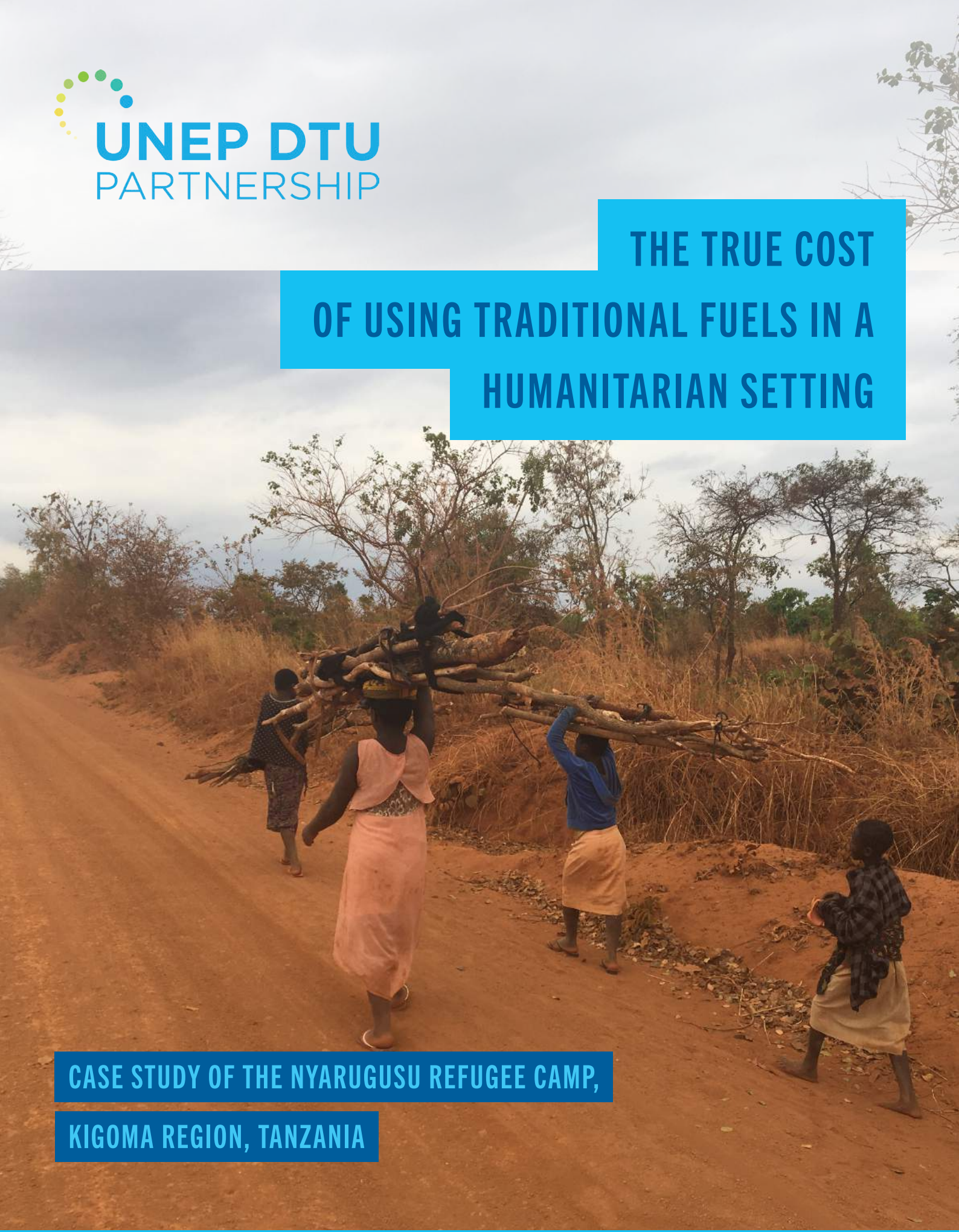
THE TRUE COST OF USING TRADITIONAL FUELS IN A HUMANITARIAN SETTING



CASE STUDY OF THE NYARUGUSU REFUGEE CAMP, KIGOMA REGION, TANZANIA

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Finally, a special thanks go to all the camp residents who agreed to respond to the survey, and to those who spent hours with us during the semi-structured interviews.

LIST OF ACRONYMS

CBA	Cost-benefit Analysis
CDM	Clean Development Mechanism
CRRF	Comprehensive Refugee Response Framework
DALY	Disabled Adjusted Life Years
DRC	Democratic Republic of Congo
GACC	Global Alliance for Clean Cookstoves
FDP	Forcibly Displaced People
***f*NRB**	Fraction of Non-Renewable Biomass
GHG	Greenhouses Gases
ICS	Improved Cookstoves
LPG	Liquefied Petroleum Gas
MEI	Moving Energy Initiative
MEM	Ministry of Energy and Minerals
MHA	Ministry of Home Affairs
NRC	Norwegian Refugee Council
PM	Particulate Matter
PoC	Persons of Concern
RSC	Refugee Studies Centre
SC-CO_2	Social Cost of Carbon
SGBV	Sexual and Gender Based Violence
TZS	Tanzanian Shillings
UDP	UNEP DTU Partnership
UNHCR	United Nations High Commissioner for Refugees
WFP	World Food Program
WHO	World Health Organization
WTP	Willingness-To-Pay
WRC	Women's Resource Centre

All dollar amounts referred to are US dollars.

The exchange rate used in this research is $1 = 2,241 TZS

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KEY MESSAGES

- This study is the first Cost Benefit Analysis carried out for a cooking intervention in a humanitarian setting, comparing LPG stoves against a baseline scenario in which families are using three-stones fires and biomass.
- Over a ten years period, this LPG intervention would cost $397 per capita and yields a benefit of $700 (using a 3% discount rate). As such, there is a clear rationale to invest in fuel switching.
- Despite conservative assumptions, a program to distribute LPG stoves to all households in Nyarugusu camp will achieve $45,358,352 in net benefits after ten years (using a 3% discount rate). The benefit-cost ratio (BCR) is 1.76. This means that for each dollar invested, the LPG program will yield a return of $1.76. The Internal Rate of Return confirms the strength of this investment, as it is significantly higher than the discount rates normally used in this type of project (at 189%). Even with a short time-frame of 5 years, the program has a Net Present Value of $19,528,809 and a BCR of 1.6.
- There is a need to expand the use of economic tools in humanitarian settings, to better understand refugee behaviour and preferences, and to guide humanitarian response and investment decision making. For example, 95% of refugees in Nyarugusu stated a willingness-to-pay for LPG gas, revealing a high value placed on cleaner, modern energy technologies and a latent market demand.
- The research revealed that households are currently bearing very high costs for fuel procurement. 53% of the households buy their fuel and they are spending on average $12 a month per family, (the capped monthly salary in the camp is $27), 19 hours per week to collect firewood in the forest, and over 6 hours per day cooking with traditional cookstoves. Household air pollution from the use of solid fuel contributes to respiratory diseases, where lower respiratory tract infections is the 3rd ranked cause of mortality in the camp.
- Switching to LPG stoves would reduce Carbon Dioxide emissions stemming from the incomplete combustion of biomass, by a factor of 10. The mitigation potential of this intervention is 111,032 t of CO_2 eq. per year, 3.70 t of CO_2 eq. per stove per year, or 0.74 t of CO_2 per capita. Additionally, the use of LPG, by removing the need to collect firewood or buy charcoal would save 2,167 ha of forest each year.
- There are various options to finance the roll out of LPG in refugee camps, including the voluntary carbon market and climate financing mechanisms such as the Green Climate Fund. Refuelling costs could be partly covered by refugees themselves.
- Investing in cleaner energy infrastructure can be seen as the first step in a paradigm shift to bridge the humanitarian/development divide. To enable the development of a sustainable solution, it is crucial to obtain the support of the Tanzanian government, which implies an acknowledgement of the protracted situation and support for the expansion of income generating activities. There appears to be some movement in this direction, since the government recently stated its ambition to enhance refugees' access to 'education and employment', when signing the Comprehensive Refugee Response Framework (CRRF) in 2017.

EXECUTIVE SUMMARY

Over the past two decades, the global number of forcibly displaced people has doubled, reaching 65.6 million in 2017. Reducing energy poverty has been identified as a priority on the international agenda since September 2015, when the UN adopted seventeen Sustainable Development Goals including Goal 7 which seeks to 'ensure access to affordable, reliable, sustainable and modern energy for all by 2030'. However, recent research sheds light on the magnitude of energy poverty in humanitarian settings. In Sub-Saharan Africa, as much as 85% of the refugee population living in camps lack access to enough energy to cover their basic needs for cooking, heating and lighting. The inefficient use of energy by displaced people emitted 14.3 million tonnes of Carbon Dioxide (tCO_2) in 2014, globally.

The topic of humanitarian energy entails three aspects: the energy services (e.g. lighting, cooking or heating), the sources (solar, LPG, kerosene) and the products (solar panels, cookstoves, electricity grids) (RSC, 2017) (Gunning, 2014). Within this field, the provision of energy for cooking is a crucial dimension for many reasons. Firstly, because the food distributed by the World Food Program needs to be cooked, access to fuel underpins food security. Secondly, as many as 3.9 million people die every year from respiratory diseases associated with Household Air Pollution from cooking with solid fuels (Smith, 2014), which makes it the second most important environmental health risk factor after childhood malnourishment in Sub-Saharan Africa in terms of years due to ill-heath (DALY) (Lim et al., 2012). This recognition even led to the creation of the UN-funded Global Alliance for Clean Cookstoves (GACC) in 2010. Finally, the encampment policy in Tanzania inevitably constrains firewood collection to small geographical areas, which often generates competition for resources and conflicts with the local communities.

Tanzania is currently hosting 358,900 refugees and faces a protracted humanitarian crisis. The government has stressed the importance of finding a rapid solution to the growing issue of woodfuel collection, stating that the environmental destruction perpetrated by the refugees will no longer be tolerated. At a humanitarian level, energy has been identified as a major failure in the UNHCR mandate to protect the Persons of Concerns (PoC)[1] due to the increase in reported cases of conflict and violence with the local communities surrounding Nyarugusu camp over access to woodfuel (UNHCR,2017). Therefore, a pilot program to distribute LPG as cooking fuel was undertaken in the camp between December 2016 and March 2017.

The aim of this research is to bring an economic rationale to the core of the humanitarian decision-making process in examining the specific issue of cooking in the Nyarugusu refugee camp. The current combination of woodfuel and inefficient cookstoves carries many hidden costs resulting in numerous negative externalities. These costs have been identified and valued using a monetary metric. In conducting this research, we pursued two objectives:

- To calculate the benefit-cost ratio of a Liquefied Petroleum Gas (LPG) stove program in the camp. The business-as-usual scenario entails the use of traditional cookstoves.

- To assess the Willingness-To-Pay (WTP), among the camp's residents, for LPG. This second question prompted an ethical and theoretical consideration about asking a WTP question in the context of a refugee camp, where the provision of basic needs is traditionally covered by the UNHCR mandate. This in turn is related to the debate on the sustainability of the camp, the 'shared but differentiated' burden of the refugees, and their inclusion into the country's economy.

1 *Following UNHCR nomenclature, the term Persons of Concerns (PoC) describes refugees, asylum-seekers and internally displaced people. Throughout this paper the term PoC is only employed to encompass the refugees living in the camp.*

The first phase of this research involved an extensive literature review to map the impacts of using inefficient cookstoves. They were then classified as either 'monetisable' or 'non-monetisable' impacts. Monetisable impacts include land degradation, greenhouse gas emissions and household air pollution leading to respiratory diseases, while non-monetisable impacts include human security, access to education and a reduction in the number of cases of sexual and gender based violence. The second step comprised one month of fieldwork in the Nyarugusu camp to gather primary data. In order to give an in-depth understanding of the cooking issue in the camp, a mixed method approach was employed. This involved the collection of 504 questionnaires, including a contingent valuation study, 30 semi-structured interviews and 6 focus groups. Finally, a statistical and qualitative analysis was performed in order to establish the economic indicators of the CBA.

In the business as usual scenario, the refugees report spending almost 6 hours per day cooking with traditional stoves, on average 19 hours per week collecting firewood, and over half of them have faced violence or intimidation while performing this activity. Moreover, those refugees who pay for fuel firewood or charcoal are spending an annual average of $141[2] per household. The statistical analysis indicates that, as in many other contexts, income has a significant influence on fuel consumption and expenditure. As incomes increase the residents will move up the energy ladder, from collecting firewood themselves in the forest to buying firewood and charcoal (inside the camp for 85% of them).

The dissemination of LPG stoves in Nyarugusu camp appears to be a viable economic option with a range of co-benefits. After ten year, the program would yield a Net Present Value of $45,358,352, a Benefit-Cost Ratio of 1.76 (using a 3% discount rate), and an Internal Rate of Return of 189%. This means that for every dollar invested, the benefits will yield $1.76 as 'payback'. This intervention will save 21,673 ha of forests over 10 years, almost 8 times the area of Nyarugusu camp. In term of GHG emissions, the use of a LPG cookstove is 10 times more efficient than the use of traditional stoves burning biomass. It means that the program would save 3.70 tCO_2 equivalent per stove, compared to the baseline.

For future financial mechanisms, the development of market-based solutions has been envisioned. To assess the level of financial commitment from the refugee population to help cover the costs of the cleaner technology option, a Contingent Valuation study was designed. The respondents were asked how much would they be willing to contribute to the costs of refilling the gas cylinder. 95% declared a Willingness to Pay of (on average) $25.5 annually per family, which equated to 12% of the total cost of fuel. Using Ordinary Least Squares (OLS) regression, the variables education, age and employment, and current fuel expenditure were found to be significant ($p < 0.01$) and positively influence the WTP. The results are positive as they demonstrate a strong commitment from the refugee population to get access to cleaner energy, and can been seen as an indicator of a likely high adoption rate. Therefore, this research advocates the development of an LPG market within the camp, which would increase households' well-being. The difference between the stated WTP and the revealed fuel expenditure can be explained by different factors: the inherent 'gaming aspect' of the WTP question, a general tendency in developing countries to underestimate the responses to Contingent Valuation Studies or the choice made by the head of household to spend more on other necessities, such as food.

2 *or $12 per month. The capped monthly salary in the camp is $27 monthly.*

During the interviews and focus groups, the issue of energy for cooking was highlighted as the main cause of conflict with the local community. The results of the survey also revealed a sharp increase in traditional fuel prices (multiplied by three) over the last two years, which further indicated the increasing scarcity of biomass resources in the area around the camp.

A fundamental change is needed in the way energy is provided in the camp, to better respond to the protection remit, while mitigating the negative externalities arising from the use of traditional cookstoves. However, UNHCR is currently faced with a number of barriers: the absence of an energy cluster, limited in-house expertise, a short-term funding cycle, and the effects of 'donor fatigue'. Investing in cleaner energy infrastructure, with an inherently longer payback period and the increasing involvement of private sector actors, can be seen as the first step in a paradigm shift to bridge the humanitarian/development divide. To enable the development of a sustainable solution, it is crucial to obtain the government's support, which implies an acknowledgement of the protracted situation. There appears to be some movement in this direction, since the Tanzanian government recently stated its ambition to enhance refugees' access to 'education and employment', when signing the Comprehensive Refugee Response Framework (CRRF) in 2017. Indeed, facilitating access to sustainable energy among refugees has far-reaching consequences beyond their improved well-being and security. Due to the high upfront cost of LPG, it is unlikely that UNHCR alone will be able to cover the costs of the program, hence it may require a financial contribution from the refugees. This in turn would change the way refugees are currently viewed and treated, i.e. moving from a dependency culture to a market-based set of solutions to the supply of goods and services. That would both require, and drive, a better integration of refugees into the local economy. Indeed, if camp residents are to sustain themselves and buy their own fuel, there is a need to ensure they have a stable disposal income, which depends upon employment opportunities, and in turn their legal status.

The contribution of this research to existing knowledge is manifold. Empirically it provides a comprehensive snapshot of Nyarugusu camp, using rigorous quantitative and qualitative data from a large sample to draw inferences about the energy situation. This study is also the first to apply a Cost-Benefit analytical framework for a cooking intervention in a humanitarian setting, to date. It is a first step toward enhancing the understanding of a complex situation, and is aimed to equip UNHCR with a methodology applicable in other settings. The provision of economic data and arguments will hopefully help to secure new ways of funding cooking interventions. Finally, this study sheds light on the magnitude of energy poverty experienced by most refugees living in camps, highlighting the need to 'leave no one behind' as per the Sustainable Development Goal 7.

A major limitation of this current research is the absence of an epidemiological study to assess the health impacts, to measure concentrations and exposures to pollutants, and better value the change in household air pollution. Future research is needed to value more accurately all the externalities associated with the use of traditional stoves in the camp, for instance to obtain a complete valuation of ecosystem services.

We finalise the report by offering a range of recommendations, targeted at different stakeholders. These centre around the need to commission economic valuation studies to inform decision makers and investors. This could be complimented by a dedicated cluster of energy experts within the humanitarian sector, in the pursuit of a range of SDGs. Furthermore, a prerequisite to the successful implementation of sustainable energy programs is the alignment of the humanitarian agenda with national energy plans to develop an enabling environment for the roll-out of cleaner energy technologies.

INTRODUCTION

In 2016, the number of Forcibly Displaced People (FDP) reached 65.6 million worldwide, its highest level since the Second World War (UNHCR Global Trends, 2015). Sub-Saharan Africa hosts the largest refugee population in the world, with around 30% of the 17.2 million refugees under the United Nations High Commissioner for Refugees (UNHCR)'s mandate. Most of them are in 'protracted situations' defined as ones in which 25,000 or more refugees from the same nationality have been in exile for at least five consecutive years.

Reducing energy poverty has been identified as a priority on the international agenda since September 2015, when the UN adopted seventeen Sustainable Development Goals including Goal 7 which seeks to 'ensure access to affordable, reliable, sustainable and modern energy for all by 2030'. Shortly afterwards the Moving Energy Initiative (MEI) consortium was established to analyse and advocate for the uptake of sustainable energy solutions in the humanitarian context, funded by the UK Government. In the setting of a refugee camp, energy refers to the provision of services for cooking, lighting and heating (Bellanca, 2014). However, this basic need has often been neglected because of a lack of expertise and funding, or a reluctance from host governments to authorize long-term infrastructure in 'temporary' camps (Gunning, 2014).

An additional distinction has to be made between the camp energy needs, such as the diesel generators used by the administration or for health services, and the household energy needs namely the refugees' needs. Within this new field, three main trends have been identified (RSC, 2017). First, a paradigm change in the responsibility of delivering energy: that UNHCR is no longer the only provider and market-based solutions are emerging. Secondly, there is a transition from fossil fuel technologies to renewable energy options, due to the increase in cheap and available technologies such as solar photovoltaic mini-grid (Lahn, 2015). Finally, the growing need to embed interventions in national plans leads to a broader consideration for the host communities. For instance, afforestation programs take place around Nyarugusu, and 20 villages have received over 30,000 seeds in 2016 (Philidorius, 2017). These three trends demonstrate a transition from a humanitarian to a development perspective.

It is estimated that 89% of the refugees in camps have access to electricity less than four hours a day, and 77% of them rely on traditional biomass for cooking (wood, charcoal[3] or animal waste). The inefficient use of energy by displaced people in the world emitted 14.3 million tonnes of Carbon Dioxide (tCO_2) in 2014, globally (Lehne, 2016). This number includes the inefficient burning of biomass (principally firewood or charcoal) but also the use of kerosene for lighting. The use of firewood for cooking by refugees would amount to 26,000 ha of forests burnt every year. Furthermore, it is estimated that the use of solid fuels causes the premature death of 20,000 displaced people annually (Lahn, 2015).

Since 2010, the Global Alliance for Clean Cookstoves (GACC) has brought together experts to tackle the 'Killer in the Kitchen' (Warwick, 2004). In doing so, they have made explicit the negative impacts associated with the use of solid fuels. In most refugee camps, as elsewhere, these include: respiratory diseases (Smith, 2014), greenhouses gas emissions and land degradation (SAFE, 2016), increased conflicts for scarce resources, sexual and gender based violence (SGBV) (Lyytinen, 2009), time lost for education or leisure (Vianello, 2016), etc.

3 *Charcoal is defined as 'wood carbonized by partial combustion or application of heat from an external source' by the FAO (FAO, 2010).*

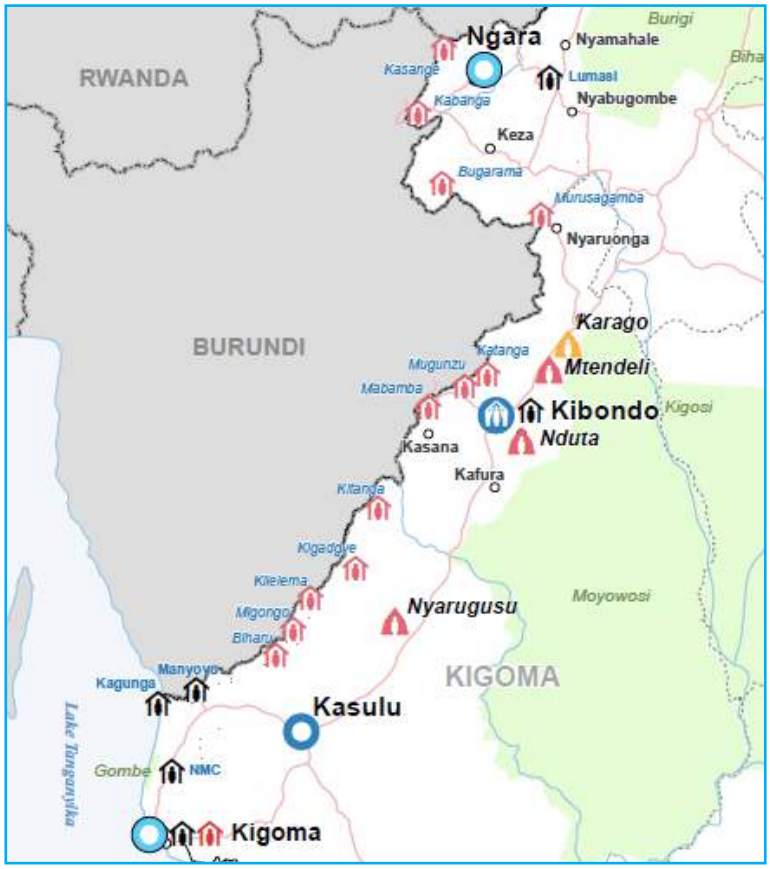
1. BACKGROUND

1.1 A BRIEF HISTORY OF REFUGEES IN TANZANIA

Following the decolonisation process started in the 1960s, ongoing civil wars, genocides and ethnic conflicts in the Great Lakes region, have forced millions of people to flee their countries. As such, Tanzania, due to its relative political stability, has received more than 2.5 million people since its independence in 1961. Refugees have come from the Democratic Republic of Congo (DRC), Rwanda, Burundi and Mozambique, mostly arriving in the north-western Kigoma, Kagera and Mwanza regions. In the name of Pan-Africanism and solidarity, the first elected president of Tanzania - Julius Nyerere - pursued an open-door refugee policy, until the mid-1980s. Since then, several factors have contributed to a shift from an open-door policy to a restrictive encampment policy. The government's change in attitude was formalised with the 1998 Refugees Act and culminated in the 2003 Tanzanian National Refugee Policy. This policy stated that 'refugees will be hosted in designated areas whereby the international community will be obliged to provide material assistance' (Chiasson, 2015). However, it seems that, once again, the refugee paradigm is set to change in the country. In 2014, the government decided to naturalize more than 162,000 Burundians who fled in 1972, making it the largest single act of naturalisation in refugee history. Moreover, Tanzania volunteered to be one of the pilot countries in the Comprehensive Refugee Response Framework (CRRF). This new approach was launched after the New-York Declaration on Refugees and Migrants in 2016. By joining the CRRF, the country commits to 'enhance refugee access to education and employment' and review its National Refugee Policy 'to ensure that it is in line with international laws'. In turn, it will receive incremental financial support from the international community.

By mid-2017, Tanzania was host to 358,900 refugees under UNHCR protection, living mostly in three camps: Nyarugusu, Ndtua and Mtendeli, situated along the border of Lake Tanganyika. Nyarugusu, the largest of the three, was opened in 1996 to accommodate those fleeing genocide in DRC.

FIGURE 1: LOCATION OF THE THREE REFUGEE CAMPS IN THE KIGOMA REGION (UNHCR, 2017).



1.2 NYARUGUSU CAMP

Nyarugusu camp, one of the largest and oldest refugee camps in Africa, is located in the Kigoma region, north-west Tanzania, just 50 km from the Burundian border, and 156 km from Kigoma city – the regional administrative capital. It covers an area of 28 km2. The camp was established in November 1996 to accommodate Congolese refugees fleeing the civil war in the former Zaire, which started in the aftermath of the Rwandan genocide. Since April 2015, the political unrest in Burundi has forced 215,000 refugees to flee to Tanzania. As a result, Nyarugusu camp received approximately 85,000 people in a six-month period (UNHCR, 2017). At present, Nyarugusu camp is home to 144,194 persons (as of 31 August 2017), approximately 30,000 families, which makes it the second largest urban settlement in the Kigoma region. 48% of the residents come from Burundi, 52% from DRC and over half of them are under 18 years old. The camp is organized into 12 zones and 142 villages (UNHCR, 2017) and a clear hierarchy governs its structure. UNHCR 's role entails the coordination of the operational partners, who are mostly NGOs, while the Ministry of Home Affairs (MHA) acts on behalf of the government, hence represents the highest authority on-site. As such, government buy-in is crucial in the pursuit of new interventions and/or ways of providing goods and services to the camp residents.

1.3 THE LPG PILOT PROGRAM

The rapid expansion of Nyarugusu since 2015 has overwhelmed the natural carrying capacity of the camp, leading to an increase in competition for scarce resources such as firewood. Soon after the influx, increasing rates of Sexual and Gender Based Violence (SGBV) were brought to the attention of UNHCR. The crimes were mostly perpetrated during firewood collection, against women and children. In 2016, an analysis of potential fuel solutions was undertaken by UNHCR headquarters in Geneva, which identified LPG as the 'cheapest and cleanest source of energy' for Nyarugusu (UNHCR, 2016). In addition, the distribution of LPG cookstoves was identified as an effective means to mitigate the conflict with locals, by eliminating the need to collect woodfuel. Because of the gravity of the situation, funding from the Safe Access to Fuel and Energy initiative (SAFE) was secured. The LPG pilot program was initiated in December 2016, supplying 3,264 households for three months (UNHCR, 2017). Supplying the entire camp with LPG stoves and fuel would cost roughly $7 million a year. Figure 2 depicts a woman using the LPG stove during the pilot program in early 2017.

FIGURE 2: COOKING WITH LPG STOVE IN NYARUGUSU CAMP (CEMDO, 2017)

Due to the complete combustion of the fuel, using LPG[4] for cooking is considered a clean technology (Larsen, 2015), producing no smoke and substantially reducing pollutants such as particulate matter. It also produces a very small amount of black carbon, and has a much higher energy content of 45 MJ/Kg compared to 15 MJ/Kg for firewood (Smith et al., 2000). As such, LPG stoves are estimated to be about four times more efficient than even the most efficient biomass stoves (Pachauri et al., 2013).

4 *LPG is a mixture of propane and butane and a by-product of the natural gas extraction or crude oil refining process (IAE, 2016)*

2. RATIONALE – RESEARCH QUESTIONS

To-date, research addressing the question of energy services in the context of humanitarian response has tended to focus on baseline studies (Bellanca, 2014) or qualitative reports, but the impacts of technology switching remain poorly understood. Moreover, most of the research conducted thus far has neglected economic considerations. By doing so, most previous studies have omitted the fact that funding for energy services has to compete against other priority issues (Vianello, 2016).

Evaluating the social and environmental impacts of improved cookstove interventions is a complicated task requiring mixed methods, drawing from different fields. Furthermore, the use of economic valuation methods can be seen as controversial due to the range of assumptions, norms and values they build upon. However, providing economic arguments allows donors and practitioners to compare and contrast alternative scenarios, technologies and financing. This in turn will drive economic efficiency in a field constantly struggling to secure more financial resources.

Drawing on a framework developed by the World Bank (2012), this research is an attempt to bring an economic rationale to the core of humanitarian decision making on energy use. Consequently, the aim of this research is twofold:

- Firstly, a cost-benefit analysis (CBA) methodology is developed to define the benefit-cost ratio of an LPG program, in comparison to a business-as-usual scenario where households use traditional cookstoves[5]. The CBA includes the estimations of direct costs as well as the monetization of the impacts on health and the environment.
- Secondly, a Willingness-To-Pay (WTP) scenario is employed to elicit the total value placed by the residents on the aforementioned technology. This provides a 'real life' indicator; if the families are ready to cover part of the costs to refill the stoves, it could be postulated that that the adoption rate will be high, and thus the intervention effective.

5 *There seems to be no general definition of a traditional cookstove thus throughout this report the term 'traditional stove' is used to refer to both three-stone fires and mud-stoves using biomass.*

3. METHODOLOGY

Cookstoves have been heavily studied from different angles, i.e. environmental 'The other energy crisis' (Eckhlom, 1975), health 'Killer in the kitchen' (Warwick, 2004) and gender the 'Rape-Stove Panacea' (Abdelnour & Saeed, 2014). This demonstrates both the significance of cookstoves in the sustainable development agenda, and the need for a holistic and quantitative assessment of these impacts.

3.1 SOCIAL COST-BENEFIT ANALYSIS (SCBA)

A SCBA is an evidence-based tool used by planners and decision-makers to assess the potential impacts of a policy or investment opportunity, to inform future resource allocations (Hanley & Barbier, 2009). While a financial analysis only considers the monetary costs and benefits assumed by a single agent, a SCBA is interested in the outcomes for 'society as a whole', by allowing for the quantification of non-market costs such as environmental degradation (Hanley & Barbier, 2009). The strength of a SCBA is that it ensures transparency and facilitates comparison between projects by using a single monetary metric. The aim is to appraise the efficiency of a specific project or proposal, based on its overall net welfare or net benefits, therefore the SCBA must be explicit and transparent about the assumptions used. To date, no quantitative assessment has been performed to estimate the impacts of the cookstove program in a refugee camp. The LPG program is a financially costly energy intervention, it is therefore necessary to question and estimate its economic efficiency, over the lifespan of the project. In this research the 'society' entails UNHCR, and the Persons of Concern (PoC) living in Nyarugusu camp.

The outputs of the SCBA give three types of ratios:

The Net Present Value (NPV): All costs and benefits over the lifespan of the project are converted to their present value, using a social discount rate[6]. The discounted stream of costs is subtracted to the discounted stream of benefits to obtain the discounted Net Benefits (or NPV). If NPV >0 the project makes a positive contribution to the society welfare.

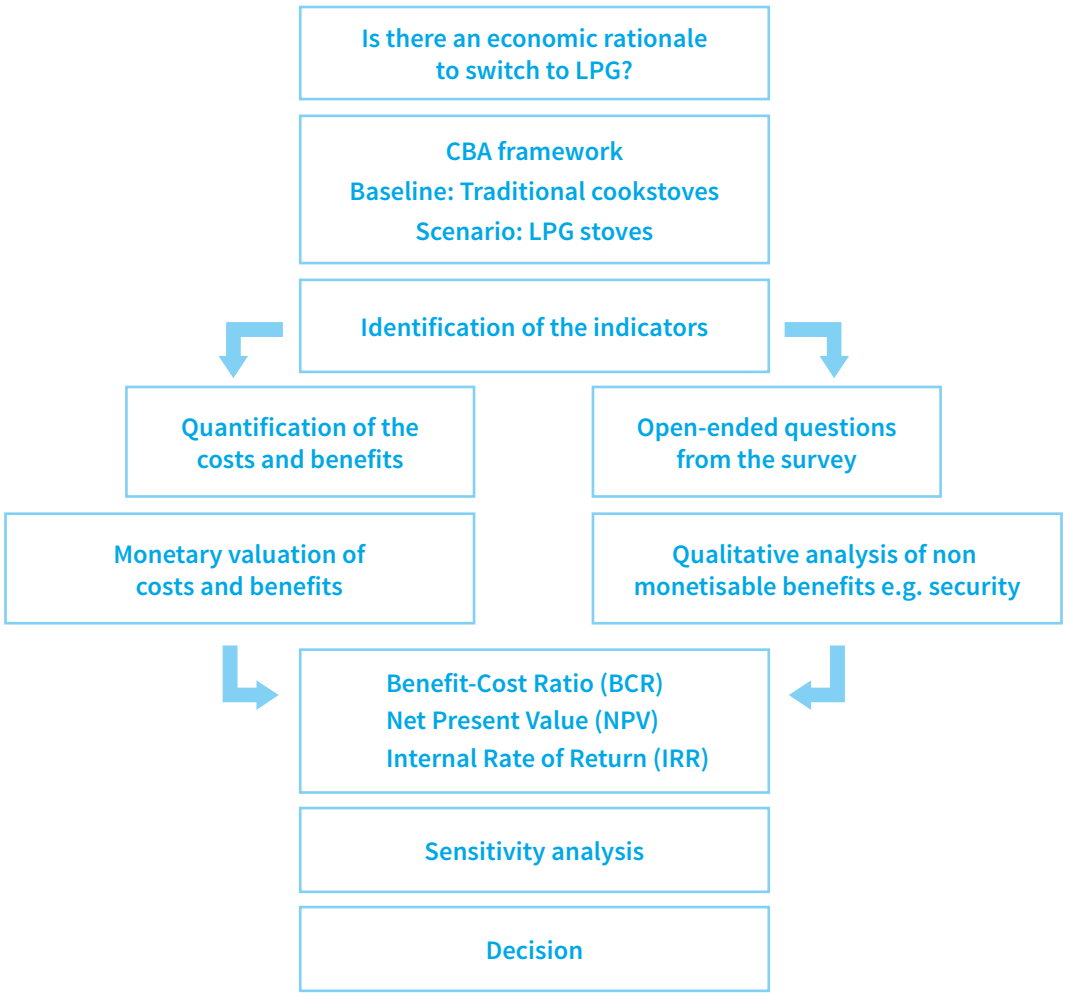
The Benefit-Cost Ratio (BCR): Discounted benefits/ Discounted costs. For one dollar invested, what is the net benefit? If the BCR > 1 it means that the discounted benefits exceed the costs. The project is cost-effective and therefore viable.

The Internal Rate of Return (IRR): represents the theoretical discount rate where the NPV equates to 0. At which discount rate do the future costs equate the future benefits? It indicates the strength of the project, irrespective of the discount rate used.

6 *The social discount rate is used to reflect the present value of future costs and benefits. The choice of the discount rate has critical implications in the final results of the SCBA. Therefore, a sensitivity analysis was performed varying the discount rate from 3 to 12%.*

The approach followed in this research draws on three comprehensive studies: Hutton's (2006) guidelines focus on health interventions, Jeuland's (2016) CBA of improved cooking solutions and the World Bank (2012) guidelines to assess the costs and impacts of forced displacement. Six steps were identified to carry out the CBA, as presented in Figure 3.

FIGURE 3: STEP-BY-STEP APPROACH TO CBA. ADAPTED FROM HUTTON (2007)



The table below provides a summary of the costs and benefits used to calculate the CBA

TABLE 1: COSTS AND BENEFITS INCLUDED IN THE CBA

Total Costs of implementing the LPG program
- Costs of capital
- Building a LPG storage facility on camp
- Refilling Costs
- Staffing Costs

Total Benefits of the LPG program
- Adverted Fuel Expenditure
- Time savings Benefits
- Time saved cooking
- Time saved collecting wood
- Positive Health Impacts
- Environmental benefits
- GHG Emission reductions
- Economic value of the local forests

3.2 DATA COLLECTION

DESK REVIEW

A review of relevant academic literature was performed at UDP, in order to identify the main impacts caused by the use of inefficient cookstoves. This also comprised an extensive search for the grey literature on energy use in the refugee camps. The Moving Energy Initiative (MEI) has produced the most comprehensive reports, to date. This research builds on their work. It also appears that there is a crucial lack of quantitative data measuring the impacts of household energy interventions in a humanitarian setting. In order to investigate the complex phenomena at play in Nyarugusu, a mixed-method approach was applied. Specifically, four methods were combined: household questionnaires, semi-structured interviews, focus groups and direct observations.

HOUSEHOLD QUESTIONNAIRES

Two household questionnaires were developed in consultation with local UNHCR and CEMDO experts, piloted and revised with the team of refugees working as survey enumerators. They were identical, the only difference being an extra set of questions for the LPG pilot households, regarding their recent use and opinion of LPG as a cooking fuel. The questionnaires focused on cooking habits, energy expenditure, fuel collection and changes in fuel use in recent years. Data was also sought to measure household income levels, through the use of proxies. Finally, the survey aimed to elicit a WTP, i.e. the total value placed on LPG through the use of a contingent valuation survey.

SEMI-STRUCTURED INTERVIEWS

Thirty semi-structured interviews were conducted with key informants, in Tanzania. Due to the multi-dimensional impacts of the cookstoves, interviews were sought with a range of actors, including government officials, UNHCR officers, NGOs operating in the camp or in the region, and academics.

FOCUS GROUPS

Six focus groups were organized: two with the seven local enumerators, two with the leaders of the local villages: Makere and Vugwe (4 persons each), and two focus groups attended with three zone leaders in the camp. Because of the prevalence of conflict between the refugees and the host community, it seemed crucial to understand the perceptions of such conflict, what they think drives it, and to characterize the nature of their economic relationships (employment, common market etc.). With the zone leaders, the benefits of using LPG was the main focus of discussion, as well as the prospects of a financial participation from the refugees for fuel refilling.

SELECTION OF THE SAMPLE POPULATION

UNHCR provided the camp profile, and the breakdown of the PoC. The population was then partitioned by nationality, namely Congolese and Burundians, and divided, following the camp administration, into 12 zones. A random-sampling approach was used in each zone, where one in every five houses was chosen for surveying. The interviewers sought to speak with the head of the household (over the age of 18), who are usually women. Data was collected by four 'incentive workers' from CEMDO and three locally-engaged translators, who accompanied the UDP researchers. The average time to complete each survey was around 35 minutes. Of the 516 surveys completed, twelve were screened out because of missing results or incomplete information; hence the final total sample size was 504 families.

ETHICS

Careful consideration was taken regarding the ethics of conducting research in a humanitarian setting. For example, care was taken to ensure that the questions were asked and framed in a manner that did not expose the interviewee to any risk of harm. Every interview started with a summary of the study and its objectives. As a fundamental principle, informed consent was required, and the participants were given time to decide if they wanted to be part of the study. They were also reminded that they could withdraw from the survey at any moment. An emphasis was placed on confidentiality and anonymity at the beginning and at the end of the survey.

4. RESULTS

4.1 SOCIO-DEMOGRAPHIC CHARACTERISTICS OF SAMPLED HOUSEHOLDS

This sample is representative of the adult camp population, enabling a generalisation of the findings with a confidence level of 95% and a confidence interval of 5%. The sample consisted of 29% men (n=145) and 71% women (n=359). Women are traditionally in charge of all activities related to cooking, thus this high proportion also appears in previous guidelines (SAFE, 2012) and other studies undertaken in refugee camps (Oxfam, 2016). Over half of respondents were Congolese (54%, n= 274) which reflects the reality in the camp, where 52% of the total PoC come from DRC. The majority (54%) of respondents were under the age of 35. This share is not in line with the camp's population, where children (less than 18 years old) comprise 53% of the population. However, for ethical reasons, all respondents were all over the age of 18. The average household size in the sample was 6.7 persons, with 1.5 children under five years old. 38% of respondents had attended primary school and 45% secondary school, while 15% stated having received no education.

TABLE 2: SOCIO-DEMOGRAPHIC CHARACTERISTICS OF THE RESPONDENTS

Gender	Nb	Freq.
Men	145	29%
Women	359	71%
Total	504	100%

Nationality	Nb	Freq.
Congolese	274	54%
Burundian	230	46%
Total	504	100%

Characteristics of households	Mean	Std. Dev	Min	Max
Age	36	12	18	76
Family size	6.7	3.6	1	42
Children U5	1.5	1.1	0	11

Age of the respondents	Nb	%
18-25	75	15
25-35	197	39
35-45	117	23
45-55	70	14
55-65	32	6
>65	13	3

Education level	Nb	%
Primary	193	38
Secondary	225	45
Postgraduate	10	2
None	76	15

4.2 LIVELIHOODS

To overcome the reluctance of PoCs to declare their income, the survey comprised a section with questions inquiring about income proxies, summarised in Table 3.

- Over a third of the sample declared receiving money from the WFP. Indeed, to improve food diversity, WFP had, since 2016, engaged in a shift from food distribution, to cash distribution: each person was receiving $8.9 a month, allowing recipients to purchase food according to their tastes. At the time of writing, this distribution had been stopped by the MHA, and it is uncertain whether the program will be resumed.

- Almost half of the respondents (44%) reported using mobile banking on their phone (such as M-Pesa), indicating the existence of a cash-economy.

- Only 51 families (10%) reported receiving remittances from family or friends living abroad (often refugees now resettled in developed countries, mostly US and Canada). The value and frequency of remittances is likely to vary greatly, though where they exist, they are likely to significantly increase household purchasing power. Of the 51 households who reported receiving money from abroad, 78% were buying their fuel as opposed to collecting or bartering for it.

- Another indicator of income is the respondents' assets. 43% of the households are using solar PV panels for which there has been no external distribution or subsidy in the camp. The capital cost of PV panels and balance of system costs (inverters, batteries and appliances), for even small units, i.e. less than 50W, is significant and reveals both an ability and willingness to pay for modern, clean, energy services among these households.

- 24% of households reported having at least one family member engaged in formal employment with income earning activities in the camp, for example working as a teacher with the International Rescue Committee. And we know that the Tanzanian government placed a maximum monthly income for refugees employed in the camp at 60,000 TZS (i.e $26.7)

- Although the encampment policy hinders their right to work, during the focus groups it became clear that most refugees are involved in some form of income generating activity inside or outside the camp, mainly to complement the food rations supplied by the WFP, which are generally insufficient.

TABLE 3: INCOME PROXIES

Income	Nb	%	Employment	Nb	%	Mean	St. Dev.
Cash from WFP	193	38.3	0	375	74		
M-Pesa	222	44	1	121	24		
Solar Panel	131	26	3 – 9	8	2		
Remittances	51	10	Total	488	100	0.3	0.7

4.3 BASELINE HOUSEHOLD ENERGY CONSUMPTION

Following the matrix provided by the World Bank's Energy Sector Management Assistance Program (ESMAP, 2016), the camp has been described as Tier 0 or Tier 1 for cooking and lighting, meaning that the sources of energy are inadequate, unhealthy and cause inconvenience. With regards to cooking, PoCs lie at the bottom of the 'energy ladder' using firewood and charcoal in traditional stoves. They use three-stone stoves *(see Figure 4)* which are simply put on the ground or mud-stoves *(see Figure 5)* defined as a semi-fixed structure made of mud with a smaller hole at the top (Barbieri, Riva & Colombo, 2017). The thermal efficiency of the latter is supposed to be slightly more efficient than the three-stone fires (19% vs 16%) (Jeuland, 2016).

FIGURE 4: THREE-STONES FIRE

FIGURE 5: MUD-STOVE

Nyarugusu appears to have experienced a transition to a market economy for fuel use, along with other basic goods - both food and non-food items. This transition is taking place partly due to a *de facto* transition to economic integration, driven by WFP's shift to cash payments in place of food rationing, a number of income-generating programs run by NGOs such as Oxfam, the 'common market' set up in 2015 and a (presumably) modest flow of remittances from friends and family living abroad. Key figures include:

- 85% of respondents report cooking indoors of which 88% are using a ventilation system such as a gap in the wall to allow smoke to leave.
- The majority of the families (79%) are cooking on a mud-stove, followed by the three-stones fire (20%).
- Only 8% of households are using two different stoves, a practice called stove-stacking. This is positive as it would ease the switch and the adoption from traditional stoves to LPG stoves.
- Firewood is the primary fuel used (88%) followed by charcoal (35%), with a quarter of the families using both fuels.
- 42% of the households have received a solar a lamp and 43% are using a solar panel. Only 2% use kerosene lamps for lighting, which should facilitate the future measurement of harmful air pollutants as it eliminates one key source of these.

4.4 FUEL PROCUREMENT

WOOD COLLECTION

Venturing outside the boundaries of the camp is dangerous and officially prohibited by the MHA; however:

- The respondents devote an average of 19.7 hours per week to woodfuel collection, per household. Therefore, the LPG program led to 1,014 hours in time savings from not collecting firewood, per year, per stove (i.e. per family).[7]
- In 53% of the families, one person is solely in charge of the wood collection, while for 37% of them two family members are actively participating. Only 7% of households reported having three or more persons collecting fuel at any one time.
- The burden of fuel collection falls mostly on women (85%), although a significant number of men are taking part in this activity (35%). The prevalence of cases of violence perpetrated in the forest, and the fact that collecting wood has become an income-generating activity, may help explain why more men participate in this task than is reported in non-camp settings.
- One critical observation emerging from the data collection is the prevalence (20%) of families bartering for their fuel. This finding was complemented by the question 'if fuel is bartered, in exchange of what?' The results shed light on the relationships between locals and refugees: to be granted the right to collect wood on their farms/ lands, refugees are often obliged to provide the villagers with soap, food rations or salt. Respondents reported that a failure to pay for these goods had resulted in violence or intimidation.
- When asked 'have you experienced any problems with woodfuel collection over the past week?' 52% of respondents stated having experienced cases of violence (intimidation, fights, rape). 23% reported a growing competition for wood, forcing them further afield, and 9% reported having problems with the police. This finding stressed the increasing scarcity of wood and the conflicts stemming from this shortage.
- 78% of the respondents declared that their experience of woodfuel collection has changed over the years, predominantly noting an increase in the distance travelled to gather wood. Furthermore, the situation appears to be changing rapidly, where 86% of Burundians who have arrived since 2015 reported that they're already having to travel further to collect fuel.

FUEL EXPENDITURE

- The mean fuel expenditure of households who never used LPG was reported to be 26,393.9 TZS per month, which equates to $11.8 monthly or $141.3 annually. This amount is extremely high, compared to the average wage of $26.7 per month, i.e more than 50% of income. This finding corroborates previous studies, reporting that food and fuel are the main expenses incurred by refugees.
- Of the households who pay for fuel, 47% reported that the prices for wood or charcoal have changed since they arrived in the camp, with steep price increases from 7,000 to 12,000 TZS (3 to 5 US$ for a bag). This is a notable trend, especially as access to fuel underpins food security.

7 *To improve the accuracy of the answers, the question was not left open-ended, respondents were asked the frequency of their trip, followed by the average length of it.*

- Households pursue different strategies to obtain fuelwood. The majority collect firewood, when others buy firewood or charcoal, and 23% do both. Although the production of charcoal is forbidden in and around the camp, 84% of them buy it in or around the camp. The charcoal is produced in the neighbouring villages.
- The regression analysis indicates that the M-Pesa users ($p < 0.00$) and the owners of Solar Panels have a significantly ($p < 0.00$) higher fuel expenditure than the rest of the sample. Accordingly, households who reported a higher WTP for gas currently spend more on wood and charcoal fuel. Finally, the number of family members ($p < 0.024$) currently working positively has a positive influence on fuel expenditure.

The mean fuel expenditure was inputted in the CBA as a benefit of adverted costs. Because only 53% of the households buy fuel in the camp, this ratio was applied. Therefore, the cost savings equated $2,238,296 for the entire camp.

The data tells us how many households are paying for fuel, and how much they spend. However, this actual spend shouldn't, in all cases, be equated as the ability to pay. Indeed, some households (20%) reported bartering food rations, in combination with cash payments, to secure fuel. Furthermore, when more than 50% of incomes are being spent on fuel there is clearly an implication for spending on other essential items, including food and clothes - supplementary to rations provided by UNHCR.

4.5 TIME SPENT COOKING

It was observed that women and girls are principally the ones responsible for cooking. While performing this activity, young children are often around the fire and therefore exposed to smoke from fire. This matches the results from the survey performed by CEMDO, indicating that in 90% of the households, women are responsible for cooking.

TABLE 4: COOKING TIME SAVINGS

Cooking time per 24h	Nb	Mean	Std. Dev	Min	Max
Cooking with biomass	233	5.93	2.06	2	8
Cooking with LPG	271	2.06	1.25	0.5	8

- Respondents spend approximately 6 hours a day cooking with traditional cookstoves, using biomass. In contrast, the households in the LPG pilot program reported spending on average 2 hours a day. Therefore, the mean reduction in cooking times using LPG (i.e. time saved) is 3.9 hours per day, compared to traditional stoves or 1,416 hours saved per year per households.
- This time saving benefit of using LPG was further reinforced in the qualitative part of the questionnaire, where 66% of respondents reported 'fast' as its main benefit.
- 26% of respondents declared that, with the time saved, they were pursuing income-generating activities. For half of them, this involved selling basic food items such as tomatoes, beans, bread or chapattis. In most cases vegetables are bought in the common market for re-sale in the smaller markets, within the camp.
- Other households reported using the extra time to earn money from trades such as carpentry, hairdressing, tailoring but also working as M-Pesa agents or bike mechanics.

4.6 MONETIZING TIME USING THE SHADOW VALUE OF TIME

Time savings from cooking and collecting wood play a significant role in determining the total benefits associated with the use of LPG. These costs come in the form of opportunity costs defined as 'the value of the marginal output foregone elsewhere in the economy' (Varian, 2010), also called the shadow value of time. To estimate the opportunity cost of time, we assumed that the shadow value is a proportion of the prevailing wage rate. In this research, it was assumed that the beneficiaries would convert 40%[8] of their extra hour of free time into an income-generating activity. This is a conservative measure, intended to reflect the difficulty of accessing the labour market for a refugee. From there, two labour wages were derived and inputted to the model during the sensitivity analysis. First, the average salary in the camp, assuming the refugees will be hired by one of the operational partners, is capped at 60,000 TZS (i.e. $26.7 per month). Meanwhile the minimum wage for low-skilled labour in the country is 100,000 TZS (i.e. $44.6 per month) assuming the refugees could work as a labour outside the camp.

The time savings (both Time Saved Cooking and Time Saved Wood Collection) were valued using this opportunity cost of time. Because only 82% of the total sample reported collecting firewood, this ratio was applied to the total population of the camp, when estimating the total time savings. Using the maximum salary of the camp, the cost of labour was therefore priced at $0.19 per hour (assuming a 7-hour working day). We assume that for every hour saved, 40% is transformed to an income-generating activity.

Using the aforementioned methodology, the LPG program led respectively to $3,249,191 in time savings for cooking and $1,909,175 in time savings from collecting firewood, annually, for the entire camp.

4.7 HEALTH BENEFITS

The health benefits of LPG can be captured through randomized control trials, measuring PM concentrations and/or exposure over the years. Within the limited scope of the present research, existing data provided by UNHCR was deemed as adequate. Three semi-structured interviews were conducted with doctors in order to investigate their understanding of respiratory diseases from smoke inhalation (Miombo, 2017). In 2016, the Lower Respiratory Tract Infections (LRTI), consisting of pneumonia and bronchiolitis, were the third cause[9] of all deaths in the camp, accounting for 11% (n=58) of the total morbidity of the PoC, increasing to 16% for children under five years old. Additionally, Upper Respiratory Tract Infections (URTI) including coughs, running nose with low-grade fever, and laryngitis, constituted 22% of the camp morbidity (n=99,736) of the total number of cases annually, 25% (n=46,109) for children under five years old.

This proxy figure takes into consideration the total health budget for health services in Nyarugusu camp (including doctors' salaries) and the cost of essential drugs and supplies used for treating all respiratory tract infections in 2016. However, we do not consider the opportunity foregone because of morbidity e.g. the time lost due to the disease because of an inability to work, or the duty of care from the parents toward their child. Therefore, this number is highly conservative.

The cost of treating both LRTI and URTI, derived from figures provided by the head of medical services at UNHCR, amounts to $970,000 per year for the whole camp.

8 *This fraction of time was used following the average reported by Jeuland (2016).*

9 *The largest single cause is malaria (18%) followed by neonatal deaths (16%).*

4.8 ENVIRONMENTAL IMPACTS

GHG EMISSION REDUCTIONS

We estimated the carbon savings associated with the dissemination of 30,000 LPG stoves. The emissions reduction calculation is based on the comparison of a baseline with a daily firewood consumption per family of 4.1 kg and 2.3 kg of charcoal, and a scenario of a monthly LPG consumption of 12 kg per family. The emissions associated with the production of charcoal have also been included using a conservative value of 2.55 t of CO_2 equivalent emitted per tonne of charcoal.

The Fraction of Non-Renewable Biomass (*f*NRB) plays a significant role in the determination of total emissions reductions associated with the combustion of firewood. The default value given by the UNFCCC is 96% for Tanzania, meaning that 96% of the woody biomass removed by the fuel collectors is deemed non-renewable. Disagreements exist about the accuracy of this value; however, we deem this *f*NRB plausible for the following reasons. Between 1990 and 2010, a sharp decrease of the carbon stock in Tanzanian forest has been reported: from 2,505 to 2,019 million tonnes (FAO). Additionally, the Gold Standard methodology under the Clean Development Mechanism (CDM) requires project developers to do a 'credibility check' (GACC, 2017) to consolidate their estimation of the *f*NRB. The results of the survey have clearly demonstrated the presence of these indicators. 78% of the respondents declared that their experience regarding woodfuel has changed over the years, noting an increase in the distance travel to gather wood and reporting an increase in the price of firewood and charcoal over the last two years of over 70%. The population density, which doubled after the Burundian influx, exerts an excessive pressure on the surrounding forests. Therefore, this high value (96%) for the *f*NRB appears to be an accurate reflection of reality in the camp and was thus adopted in the calculation.

The incomplete combustion of biomass in traditional stoves emits on average 4.1 t CO_2 equivalent per stove annually, compared to an LPG stove emitting 0.44 t CO_2 equivalent . Therefore, applying the Global Warming Potential (GWP) of Methane, using LPG for cooking will save 3.7 t CO_2 equivalent per year, per household per stove.

The total emission savings of scaling up the LPG program, i.e. shifting 30,000 traditional stoves to LPG, will result in savings of 81,627 tonnes of CO_2 and 1,278 tonnes of CH_4. To be included in the CBA, the emissions savings have been valued using the Social Cost of Carbon (SC-CO_2) from the US Environment Protection Agency (USEPA, 2017) at a price of $36 and $1,000 per tonne respectively for one tonne of CO_2 and CH_4. As a result, the damage avoided trough these emissions savings would be valued at $4,217,072 of benefits annually.

10 *Because the timeframe of this research is restricted to ten years, it was assumed that the SC-CO_2 and CH_4 stay constant, whereas in the aforementioned methodology they reach $50 US$ and $1,600 in 2030. (US EPA, 2017)*

LOCAL ENVIRONMENTAL BENEFITS

To derive the economic value of forests preserved, we used the costs of afforestation in an area whose above-ground biomass stock is equivalent to the fuelwood savings during the entire lifespan of the program. Based on an average firewood consumption of 4.1kg/ family per day and 2.3 kg of charcoal, we calculated that the LPG program will save 2,167 ha of forest per year. The cost of afforestation per hectare amounts to $171 or $0.007 per kg of wood, in the area around Nyarugusu camp (CEMDO, 2017). The figure for this research is lower, mainly due to low labour costs.

This number is conservative and only reflects 'the market price' and does not include the economic value of the ecosystem services provided by the forest such as the soil erosion control, habitat for wildlife, and the aesthetic values.

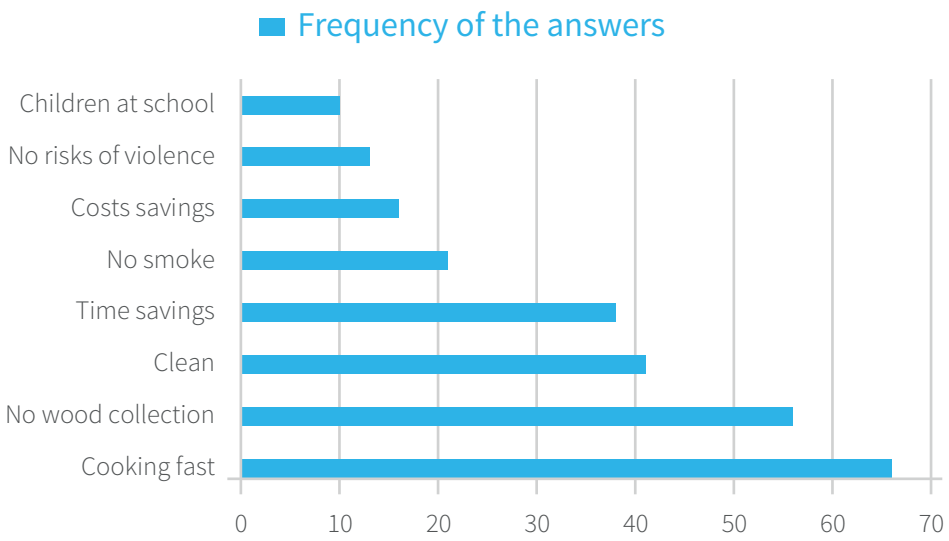
Based on these result, the economic benefits of avoided forest degradation amount to $371,178 per year, for the whole camp.

4.9 QUALITATIVE INTERVIEWS

Finally, the focus groups and a qualitative component to the survey shed light on a range of benefits associated with the use of LPG, which are difficult or problematic to monetise. It is worth noting that the reluctance or anxiety of using LPG for new users was not a focus of these interviews, as the topic has already been discussed during the post pilot focus groups conducted by UNHCR in April 2017.[11]

11 *The report suggested that the reluctance was overcome quickly, and the number of safety incidents fell from 10% of the households to less than 1% after the 3 months pilot. Additionally, several trainings were conducted prior to the distribution in order to show the beneficiaries how to safely use the LPG stoves, and answer any doubts/ questions that may arise.*

FIGURE 6: BENEFITS ASSOCIATED WITH THE USE OF AN LPG STOVE



- The main reported benefits of LPG revolved around the theme of time saved: cooking takes less time (-3.9 hours) and time is saved because they are no longer required to collect fuel. Interestingly, time savings in cooking allow 'children to be at school on time after eating porridge', or they get to 'eat before going to bed.' Removing the need to gather wood was the second most-quoted benefit, respondents reported 'I am happy because I don't have to look for firewood in the forest.'
- The 'clean' benefit is associated with the absence of dusts and ash 'There is no more dust in the pot.' Smoke was mentioned as a cause of 'eye irritation, and for 'smoke to get into the food.'
- Regarding issues of violence 'No more conflicts or threat from the host community' was the main response. The focus-group revealed stories such as 'gas brings peace to the family' or 'my husband is not angry with me anymore'.
- Additionally, 10% of respondents found it gave them the freedom to 'rest' and 'take care of myself'. Cooking with biomass requires the cook to be constantly tending the fire, taking on average 5.9 hours per day. Hence the users of LPG appreciate the flexibility of 'cooking when I want, even at night' and 'If I have a neighbour coming to visit, I can prepare the tea in ten minutes.'
- A few respondents also declared that the 'food was delicious'. This last point is valuable because it conveys the idea that the users are willing to accept LPG as their main source of energy for cooking. User uptake has always been a main barrier to the development of successful ICS, because certain types of food are cooked on the embers, to give a smoky flavour.
- The zone leaders were very enthusiastic about the LPG pilot program, but they stressed the importance of developing a camp economy in order for the residents to pay for gas, adding that a shortage of financial capital is currently a major barrier to entrepreneurship. They highlighted the prevalence of conflicts with the host communities, over firewood resources. Finally, it seems that men were more involved in cooking tasks through the LPG intervention, for reasons not fully understood, but most likely to be because it takes less time.

5. COST-BENEFIT ANALYSIS – KEY FINDINGS

This section discusses a scenario whereby 30,000 LPG stoves are distributed throughout the camp, i.e. one to each household, referred to as 'the program'. The CBA of the program was conducted for a period of five years and ten years. This relatively short time frame was chosen because of the political uncertainty around the camp and the status of refugees in Tanzania, more broadly. A discount rate of 3% is applied. This value, though quite low, is in line with previous studies evaluating stove programs, as such interventions have high social and environmental co-benefits (Habermehl, 2008; García-Frapolli et al., 2010). However, alternative scenarios, varying the discount rate to 6 % (Jeuland, 2016) and 12% (Alam, 2012) were also carried out, and presented in the sensitivity analysis (see Appendix).

5.1 ASSESSMENT OF COSTS

The costs indicated in Table 5 correspond to the annual expenses reported by the UNHCR for the implementation of the LPG program. The initial investment to purchase an LPG stove was $26.8, including all the accessories. The monthly refilling cost was estimated at $17.9 per month for a family of five persons, including two gas cylinders of 6kgs each. This quantity was judged satisfactory by the beneficiaries in a post-pilot survey (UNHCR, 2016). The fuel costs are indicated using the current marketprice of a gas cylinders provided by Oryx, the gas distribution company.[12]

The cost of building a second LPG storage facility on site to facilitate the distribution of the stoves and the refilling was included, up front. The staffing costs include paying for approximately 15 persons working full time: national staff or incentive workers (refugees). It entails activities such as community mobilisation, securing the LPG storage, cost of loading and offloading LPG cylinders. It's crucial to note that fuel expenditure which is traditionally a cost paid by refugees (in terms of money, lost time and other impacts) is now passed on to the UNHCR and its partners as a financial cost.

TABLE 5: TOTAL ECONOMIC COSTS OF THE PROGRAM FOR ONE YEAR

Economic costs $	$per cookstove	Camp/$/Year[13]	Comments
Capital Cost	$27	$803,213	Year 0 & Year 5
Fuel	$214 (per year)	$6,425,703	Yearly
Storage station		$12,450	Once
Staffing National		$48,668	Yearly
Staffing Contractual Services		$132,672	Yearly
Total costs	**$247**	**$7,422,706**	

12 *The extent to which UNHCR will entirely fund the project was under discussion and they may request a financial contribution from the refugees, which explains the further WTP question. However, the CBA has been calculated 'as if' UNHCR were supporting the full costs of the project. Moreover, reducing the costs for UNHCR and increasing the costs for the refugees does not make sense under the economic analysis performed in this CBA. In fact, it is not an analysis from the UNHCR point of view e.g. aiming to calculate the 'private net benefits', rather this research is interested in the impacts of the project for the societal welfare as a whole, therefore it measures the 'social net benefits'. We assumed an adoption rate of 100% reflected in the survey conducted after the first pilot (UNHCR, 2017).*

13 *The cost for the program is simply the cost per stove multiplied by 30,000 stoves.*

5.2 ASSESSMENT OF BENEFITS

It is important to note that during the first year of the project (Year 0), the environmental and health benefits were not accounted for, as they don't appear immediately. Similarly, the economic benefits were only considered for six months. Indeed, the households are expected to need an adaptation period before modifying their behaviour in relation to time and income-generating activities. To conclude, Table 6 illustrates the total benefits of LPG use.

TABLE 6: TOTAL BENEFITS OF THE PROGRAM PER YEAR

Economic benefits US$	Per stove/ h	% of the camp	$Value
Cooking time savings	1,416 h	100%	$3,249,191
Collection time savings	1,014 h	82%	$1,909,175
Fuel expenditure savings	$141	53%	$2,238,296
Health benefits US$		100%	$970,000[14]
Environmental benefits US$	tonnes	SC-CO_2	$Value
Emission reductions CO2	81,627	$36	$2,938,570
Emission reductions CH_4	1,278	$1,000	$1,278,501
Preservation of forests			$371,178
Total benefits			**$12,954,911**

14 *This number was provided by UNHCR medical services in Tanzania.*

5.3 CONCLUDING FINDINGS

After one year, the program yields net benefits of $6,347,868. The NPV of this energy intervention, after ten years generates $45,358,352 of benefits (at 3% discount rate). Even with a shorter time-frame of 5 years, the NPV gives positive results, with benefits ranging from $15,417,040 (12% discount rate) to $19,528,809 (at 3% discount rate).

TABLE 7: THE PROJECT WILL LAST 10 YEARS

Discount Rate	$NPV	BCR	IRR
3 %	$45,358,352	1.76	189%
12 %	$29,959,374	1.69	
Total (at 3%)	Discounted Costs	Discounted Benefits	
	$59,579,509	**$92,184,830**	

TABLE 8: THE PROJECT WILL LAST 5 YEARS

Discount Rate	$NPV	BCR	IRR
3 %	$19,528,809	1.6	186%
12 %	$15,417,040	1.55	
Total (at 3%)	Discounted Costs	Discounted Benefits	
	$32,695,380	**$52,224,190**	

In this study, irrespective of the discount rate, the Benefit-Cost-Ratio is positive, indicating that the total benefits outweigh the total costs. Considering a 3% discount rate, the BCR of 1.76 showed that for each dollar invested; society can expect $1.76 of benefits. This finding substantiates previous research from Larsen (2014) who discloses a BCR of 2, and Patel (2016) found a BCR of 1.67 for an ICS program in India.

Here, the IRR confirms that the project is viable. Indeed, the discount rate would have to yield 189% for the costs to equate the benefits. This high IRR correlates favourably with Alam (2012) who found an IRR of 173% for an ICS program in Bangladesh.

The analysis shows that the environmental benefits, global and local, contribute to a third of the total benefits, resulting in an average of 3.7 tCO_2 equivalent saved per stove per year, and 2,167 ha of forests saved. This concurs with García-Frapolli et al. (2010) who found a 3.9 tCO_2 savings for a biomass ICS program. The total economic costs concurred with the idea formulated in the literature review that the use of traditional fuelwood is not free of charge, it is not a free commodity, and costs on average $138 per family each year, based on the opportunity cost of time of collecting wood and the fuel expenditure.

5.4 LIMITATIONS AND ASSUMPTIONS

The results of the CBA are in complete agreement with previous economics analyses of ICS programs, all of which show strong evidence of the environmental and social benefits. However, the results should be cautiously interpreted because they are highly conservative. It is not rare to obtain a benefit-cost ratio of between 3 and 10 for an ICS program (Habermehl, 2008). It is indeed plausible that the specificity of the case study and a number of limitations have influenced the results.

- The sample is only representative of the adult population of the camp, however in Nyarugusu 51% of the residents are under the age of 18 years old.
- First, the shadow value price of time saved is deliberately low: $0.19/ hour, in line with the regulated wages paid by NGO's to refugees in the camp. Nevertheless, direct observations during the data collection allowed the authors to suppose that the black market is generating a larger source of income.
- In this scenario, the respondents are only transforming 40% of their free time into income-generating activities while Larsen (2014) assumes a 100% conversion rate.
- The CBA accounts for the time of one person collecting firewood, but this activity is often carried out by several individuals in the families.
- The health benefits are highly conservative. Indeed, the health impacts of indoor air pollution are multidimensional and require epidemiological studies, in order to be accurate. A doctor from the Red Cross in the camp explained that smoke inhalation is a major cause of wakened immune systems, rendering patients more prone to all type of diseases which are then the ones officially recorded in the hospital records (Miombo, 2017).
- A CBA is always highly dependent on the assumptions used by the researcher. Therefore, it is crucial to estimate the magnitude of the variation when the parameters vary. Therefore, a sensitivity analysis is presented in Appendix along with six scenarios.

6. FINANCIAL MECHANISMS

6.1 WILLINGNESS TO PAY– KEY FINDINGS

Continued dependency on international donors is not sustainable amidst the current humanitarian crisis, therefore new financial solutions are emerging. Widely discussed among humanitarian aid agencies, donors, and the private sector is the transition towards a greater use of so-called 'market mechanisms'. The intrinsic nature of market mechanisms envisions a transformation in the way refugees are viewed and treated. It implies, and depends upon, households having a disposable income combined with the existence of a marketplace where they are encouraged to consume.

Contingent Valuation (CV) is a method often used by environmental economists to place a value on environmental services when prices are not available in the market place (Carson, 2000). It is a stated-preference technique, in contrast to revealed preference whereby values are derived by market behaviour. The WTP allows us to elicit how the refugees would respond to a hypothetical scenario for future initiatives and thus inform UNHCR with evidence-based results. Therefore, WTP is a tool for policy and decision makers to obtain an insight into target group behaviour, in response to the implementation of future policy and actions. Our research also sought to elicit the 'total economic value' (including both direct-use and passive-use) placed by individuals on the activity of cooking with LPG stoves.

In order to gather WTP data, a scenario was designed and presented to the heads of household during the survey, in the following manner: firstly, a hypothetical - but plausible - scenario was described whereby UNHCR would build an LPG refilling station inside the camp, and then supply the LPG stoves with filled cylinders to all families for a month, for free. It was made clear that UNHCR would not be able to cover the total costs of fuel for all families, after this month trial. It was also decided to include photos in the written scenario, to help respondent's understanding. With this scenario in mind, the households were then asked to state their WTP to refill the LPG cylinders.

- There is a significant gap between the value of the WTP and actual stated expenditure where the average WTP is just 36% of the monthly spend on fuel. It is worthwhile noting that in developing countries CV often predict low results, unlike in Europe where the values are often overstated. This tendency to understate WTP is caused by different factors. Because many economic activities are rarely monetized (for instance wood collection), it is harder for the respondents translate their preferences into monetary terms (Alam, 2015). Another argument is higher levels of distrust from the consumers toward the government.
- The mean WTP for the refill of an LPG cylinder is 4,753 TZS ($2.1 monthly and $25.5 annually) per family, which equated 12% total cost of fuel.
- There were numerous cases (n=48 or 10%) where respondents supported the proposal but gave a zero WTP. Under 'normal' circumstances, this is usually explained by either a rejection of the logic of the scenario, or a form of gaming or strategic behaviour. In the context of a refugee camp, this may be accounted for by a widespread welfare or 'dependency' logic. However, as a second step, respondents were asked open questions to identify their reasons for a zero WTP. In many cases respondents were simply unable to pay anything, offering statements such as 'I am in great poverty', 'I have no money and I am not allowed to work'. This demonstrates that those respondents were not 'protesters', but simply had no means to pay. Therefore, they were kept in the sample, thus reducing the average WTP.

- In numerous cases it was apparent that respondents thought that the price they stated is what they would end up having to pay, i.e. that the WTP question was akin to an offer or 'contribution' to the real cost of LPG, as opposed to a purely hypothetical scenario. This theory was queried, discussed and confirmed as likely with the translators, all of whom were from the camp and thus have an insight to the cultural mind-sets and institutional logics within the camp. If this is true, then it seems reasonable to assume that that 'real' WTP is higher that the reported WTP.

To ascertain the relationships between the WTP and the individual characteristics (e.g. socio demographic variables and other independent variables which potentially affect an individual WTP), an Ordinary Least Squares (OLS) regression was employed using Stata Data Analysis.

- The variables Employment and M-Pesa appear to increase significantly ($p < 0.01$) the resident's WTP. This supports the concept of the 'energy ladder', whereby an increase in disposable income correlates positively with a shift to cleaner fuels. Holding all other independent variables constant, one extra member of the family working results in an increase of 1,235 TZS in the WTP. As regards to M-Pesa , a user will have an extra WTP of 1,950 TZS compared to a non-user.

- Higher education significantly ($p < 0.01$) affects the WTP for gas. For each extra 'unit of education', the WTP increased by 1,487 TZS. Similarly, the age of the respondent is a significant ($p< 0.035$) predictor of their WTP. This is most likely explained by the physical burden placed on the activity of collecting firewood, requiring up to seven hours per trip.

- Curiously, the variable Pilot is not significant, which means that the households who have tried gas for 3 months are not willing to pay more than their non-trialled counterparts. This can be explained by the 'handouts' or 'welfare' culture predominant in the camp, i.e. once a service has been provided for free, it is unlikely that the families would be willing to pay for it. As discussed above, this relates to explanations put forward regarding gaming behaviour, to explain lower WTP.

- Perhaps surprisingly, gender doesn't appear to be a significant variable in the WTP regression model. However, the t-test revealed a statistical difference in the mean WTP between men (5,913.8 TZS) and women (4,284.7 TZS). These findings correlate favourably with previous studies supporting the idea that women have a lower WTP for improved cookstoves (ICS) (Beltramo, Levine & Blalock, 2014), (Miller & Mobarak, 2013). They explain this by pointing to the fact that women tend to lack financial authority even though they disproportionally bear the costs of collecting firewood and cooking. Another explanation could be that the higher WTP among men simply reflects their concern over the impact on their wives and daughters when conducting activities related to cooking, though this theory tends not to gain much traction among humanitarian professionals and is something that merits further research. Either way, an implication of this conclusion is the need to target both heads of households when promoting cleaner technologies. This finding is positive as it demonstrated a higher awareness about the benefits of using cleaner fuel - hence WTP from men - than expected.

In summary, the results of the WTP are extremely encouraging. It indicates a strong desire to switch to 'clean', 'fast' and 'safe' stoves. It further demonstrates that despite living for two decades in a humanitarian camp, rendering them dependent on welfare provision, the residents possess a small disposable income which they are willing to spend on clean fuel. Thirdly, user's adoption is the ultimate guarantee of a successful program and in Nyarugusu it is obvious that a switch to LPG stoves will be strongly welcomed by the community. Finally, although the values seemed relatively low, they are higher than the previous figures gathered by the UNHCR where they found that only 5% (vs 90% in this scenario) of the respondents were willing to pay for gas (UNHCR, 2017).

However, involving the private sector in a humanitarian setting isn't straight forward, and can present a few risks. Firstly, how does UNHCR's mission 'to ensure protection' fit with market-mechanisms? Will opening the camp to private enterprises remove their duty of care and role as 'the father' of the residents? Secondly, there is a question of equity. Promoting self-reliance, and access to markets seem justified in the context of protracted situations, however some residents (single parents for example) are extremely vulnerable and may not have an ability to pay. A market-based system is unlikely to cater to the most vulnerable households, and some welfare provision will be necessary, through the use of subsidies or vouchers. Finally, there is a striking market distortion. Indeed, if the camp residents ought to sustain themselves and buy fuel; where is this income supposed to come from given that they have limited permission to work, and do not have access to land for agricultural production?

Bearing in mind the risks presented above, financial contributions would be more realistic with better access to the labour market. For those who can't afford fuel some practitioners have proposed to add a 'Willingness to contribute with Time' aspect in the CV studies. This concept echoes the proposals made by the Zone Leaders, who mentioned a 'Willingness-To- Contribute' from the population unable to pay for fuel. They could help with the training, and help with the refilling of the gas cylinders, for example.

6.2 VOLUNTARY CARBON MARKET

In the Voluntary Carbon Market, companies, individuals or NGOs seek to offset emissions from their activities by buying carbon credits with high sustainable development values. The main certification body is the Gold Standard. The dissemination of LPG stoves in Nyarugusu would be eligible under the Gold Standard methodology to claim emission reductions for energy efficiency improvement, therefore the LPG program could be partially funded by carbon finance. In addition to verified GHG emission reductions, the Gold Standard has recently developed a range of 'Certified SDG Impacts' namely SDG3 related to 'adverted DALYs' (health impacts) associated with household air pollution, and SDG5 related to 'gender impacts'. Because of the numerous co-benefits delivered by the use of LPG stoves in humanitarian setting, and the strong legitimacy of UNHCR, a clean cookstove intervention appear as the prime candidate for this type of certifications. Moreover, the stringent monitoring and verification process would ensure a rigorous follow-up conducted by an external body. For instance, Carbon Clear has set-up the first registered carbon-credit project in Darfur and disseminated 10,000 LPG stoves to the rural population. We recommend implementing the LPG intervention in line with the Gold Standard Methodology in order to claim carbon credits, thus opening the door to a 'green money' over the years. Doing so would cost $50,000 in the first year, and approximately $15,000 in every additional every year. This represents less than 7% of the annual costs.

6.3 GREEN CLIMATE FUND

The Tanzanian government is eligible for applying to the Green Climate Fund (GCF), in support of its Nationally Determined Contribution (NDC) to the Paris Agreement on climate change mitigation and adaption. The GCF is open to project proposals that have a verifiable mitigation effect, and can support related national strategies and targets, including specific Sustainable Development Goals. As such, the Tanzanian government and UNHCR could work with an accredited agency, such as UN Environment, to develop a concept note for financing fuel switching in refugee camps. To this end, Tanzanian government officials and other stakeholders received training in GCF concept note development in early 2017, paid for by the Climate Technology Centre and Network (CTCN), implemented by UNEP DTU Partnership.

7. RECOMMENDATIONS

This section lists a number of organizational and behavioural changes that need to be addressed, if refugee camps are to become more sustainable with regards to energy use, and to secure all the benefits that follow from that. They have been divided by target audience.

FOR THE DONORS

- Integrate environmental stewardship at the core of investment decision making in humanitarian settings. The donors should embark on a systematic assessment of the environmental impacts of their programs.
- Increase accountability. The objective of a donor program is not the distribution of services but rather their impacts on people's lives. Yet they are rarely measured against a set of economic criteria, which can limit their success.
- Increase the number of livelihoods programs. Access to sustainable energy sources is concomitant to questions of income, and improved access to employment would help PoC move up the energy ladder.

FOR UNHCR IN GENEVA

- Create an energy cluster. This has been repeatedly mentioned in the reports from the Moving Energy Initiative. Without the existence of a dedicated silo, energy interventions are constrained by a lack of funding and expertise.
- Design an online database which maps the current energy interventions in humanitarian settings. This tool should be made accessible to practitioners and researchers, to clarify what work has been done, where, and what the technology and policy gaps are.
- Think long-term in the case of protracted situations and engage with a systemic use of the Cost-Benefit Analysis methodology to appraise and select a program of rolling out alternative / cleaner energy technologies.
- Seek diverse sources of funding from health donors to climate funds such as the Green Climate Fund, for investment in cleaner energy.
- Unlock access to carbon finance. Assess the potential of funding through the Voluntary Carbon Market. Mitigating emissions from the inefficient burning of biomass appears as a cost-effective option with a range of co-benefits, and therefore would be as an attractive project under the new SDG methodology developed by the Gold Standard.
- Ensure that the LPG program is implemented with the help of a carbon-developer body, so as to claim emission reductions during the following years.
- Resist to the temptation of generalizing these results. This research calls for a systemic use of the CBA methodology, however the results are highly context specific meaning that individual studies should be conducted for each camp in a protracted situation.

FOR UNHCR IN TANZANIA

- Improve the coordination between energy programs. At the time of this study four energy efficiency programs were taking place in Nyarugusu. Using a CBA methodology will reduce overlaps and direct the focus toward the most cost-efficient intervention.
- Align interventions with wider Tanzanian energy development plans. Doing so will ease their acceptance by the government. A collaboration with the MEM who endorsed the SE4ALL strategy would facilitate knowledge transfer, ensure ownership. MEM has defined 'access to clean cooking fuel' as one of its priority and as a result since 2008, the use of LPG has risen 5-fold (MEM, 2015).
- Engage in a health campaign to educate the PoC of the adverse effects of inhaling toxic smoke during the activity of cooking, as an interim approach before the implementation of more durable solutions.
- Advocate for the return of the WFP cash-based program. This would act as a springboard to the development of market-based energy solutions in the camp.
- Propose and/or advocate for the development of a legal and stringent framework to enable the presence of private enterprises operating in the camp, while maintaining a degree of control over the prices of the cylinders.
- Engage with NGOs such as the Jane Goodall Institute (JGI), who have strong knowledge and capacities with regard to local environmental issues, data and management. A strong partnership with JGI will foster the uptake of environmental conservation practices in and around Nyarugusu. Notably, the JGI advocates the refugee naturalisation, and a better inclusion of refugees in the Tanzanian economy. Therefore, their advocacy work may help to remove institutional barriers such as the encampment policy.
- Continue to actively engage with the intended beneficiaries of the program, to ensure that the intervention is in line with their needs.
- Continue to evaluate, monitor and measure the impacts of all energy interventions. It is crucial to include in the M&E process more data such as land degradation, or health impacts.

FURTHER RESEARCH

- To critically explore the widespread view that refugees constitute only a burden for host countries. For example, rather than impoverish the Kigoma region, their presence has promoted business and the common market at Nyarugusu is a prime example of successful economic integration.
- Collaborate with scientists and academics to better understand the cause and effect relationship between refugees and land degradation in the region. Indeed, agriculture is widely regarded as the main driver of deforestation in Kigoma, though the political discourse and popular belief is that refugees are the main driver of local degradation and deforestation.
- Value more accurately all the externalities associated with the use of biomass in the camp. This entails performing studies to measure the concentrations and exposures to air pollutants from biomass combustion, and obtaining a complete valuation of ecosystem services.
- Expand the use of economic tools in humanitarian settings to better understand refugee behaviour and preferences. Contingent valuation studies allow for valuable insights which should guide the humanitarian response and investment decision making. For instance, in this research 95% of respondents have stated a willingness-to-pay which contradicts the general financial vulnerability of the refugees in Nyarugusu, revealing a high value placed on cleaner, modern energy technologies.

8. CONCLUSIONS

Returning to the question posed at the beginning of this report, the results of the CBA suggest that the dissemination of LPG stoves will make economic sense, while providing a myriad of co-benefits. Despite using conservative assumptions for each parameter, a program to distribute LPG stoves to all households in Nyarugusu camp will achieve $45,358,352 in benefits after ten years, and $19,528,809 after 5 years (using a 3% discount rate). The benefit-cost ratio appears systematically positive irrespective of the discount rate applied, between 1.69 and 1.76, with discount rates ranging from 3-12%. 40% of the benefits would be achieved through the time savings from cooking and collecting firewood, followed by the reduction of carbon emissions and land degradation (35%). The findings support previous studies in showing that wood collection is a significant economic burden for the households who spend on average $141 per family per year and 19 hours per week for firewood collection.

If donors or UNHCR were unable to cover the total costs of the LPG program, 90% ` of the households were found to be willing to pay on average two dollars per month for LPG, which corresponds to 12% of the refilling cost. Despite the small numeric value of its number, it has two positive implications. Firstly, it denotes a strong desire to switch to 'clean', 'fast' and 'safe' stoves. It further demonstrates that despite living for two decades in a refugee camp, with limited freedoms and largely dependent on welfare provision, the residents possess a small disposable income which they are willing to spend on gas. That is significant in and of itself.

The roll-out of LPG and its associated time savings have the potential to unlock the entrepreneurial skills of the camp residents, while stimulating the local economy. A prime example of this is the 'Common Market', which within 18 months became the largest market in the Kigoma region. The market has been a successful first step to the wider integration of refugees into the local economy and society, driving the local economy and allowing refugees and locals to meet, interact. This further reinforces the concept of 'refugee economies' outlined by Betts (2016) who calls for a holistic understanding of the economic system in and around protracted situations. Treating Nyarugusu camp as a discrete community with no economic, social, or environmental interaction is an imperfect representation of the reality.

The ability of the UNHCR to finance the roll-out of LPG will depend on the government's willingness to acknowledge the semi-permanent status of the camp, which presents political challenges. Additionally, moving 30,000 families currently dependent of international aid to consumers fostering the local economy, seems an attractive proposition (Refugees Studies Centre, 2017). Additionally, one could argue that the UNHCR is currently 'free-riding' the natural resources in the Kigoma region and in this case, LPG appears as an adequate technology to mitigate these environmental impacts. Indeed, removing all wood collection would remove the last aspect of what can be said to make refugees a 'burden' for the country, to becoming a clear source of net 'benefit'.

The research summarised in this report calls for a 'common but differentiated responsibility' for financing the cost of cleaner energy technology, to be shared between the UNHCR and its donors, and the people they are working to serve. As long as the food provided to refugees requires cooking, they will continue to bear considerable financial and health burdens of fuelwood procurement. Investment in the roll-out of LPG would facilitate UNHCR's remit to ensure protection of the PoC while removing the burden and impacts of woodfuel collection and use.

This study is the first CBA carried out for a cooking intervention in a humanitarian setting, to date. It is a first step toward enhancing our understanding of a complex situation, and is aimed to equip UNHCR with a methodology applicable in other settings. The use of economic efficiency arguments will hopefully help to secure new ways of funding energy interventions, in a context of ever-tightening aid budgets and ever-increasing needs.

9. APPENDIX

SENSITIVITY ANALYSIS

In each scenario, all other parameters have been kept constant, using a 3% discount rate and a 10 years project.

- The participation of the country to the CRRF may indicate a move towards a better economic inclusion of the refugees. Thus, scenario (1) presents the NPV with a value of time using the local market wage (TZS 100,00 or $44.6), yielding a higher BCR of 2.24.
- Because of the controversy around the *f*NRB, a 50% rate of non-renewability (2) was employed using Bailis' (2015) estimation of the rate in 'African hotspots' and the BCR is still positive although the NPV reaches $37 million, compared to over $45 million in the baseline.
- LPG is a by-product of oil, as such it is subject to price fluctuations. Hence scenarios (3) and (3bis) have assessed the changes following an increase or a decrease in the price of LPG. In both scenarios, the BCR and the IRR are still significantly positive.
- Access to the employment market may be subject to restrictions in the future. Therefore scenario (4) assesses the case of the transformation of 20% of an hour saved into an income-generating activity.
- Scenario (5) used the lowest price of a tonne of CO2 as traded in the Voluntary Carbon market for energy efficient projects.
- Scenario (6) takes into account a situation in which prices of fuel (biomass and charcoal) keep increasing, as has been the case since the Burundian Influx.

This sensitivity analysis corroborates the findings described in this research that this program is economically viable.

Sensitivity Analysis with different assumptions			
Discount Rate at 3% after 10 years	$NPV	BCR	IRR
Baseline	*$45,358,352*	*1.76*	*189%*
1. Shadow value of time: 0.38$	$73,853,539	2.24	599%
2. *f*NRB 50%	$36,654,903	1.62	155%
3. LPG Cylinder Refill +10%	$39,712,659	1.61	142%
3bis. LPG Cylinder Refill - 10%	$51,004,044	1.95	257%
4. Only 20% of time in IGA	$23,986,961	1.40	79%
5. T of CO2 Eq = $8.20	$17,816,962	1.30	82%
6. Prices of firewood & Charcoal x2	$63,905,116	2.07	384%

KEY BARRIERS TO THE IMPLEMENTATION OF AN LPG PROGRAM

Stakeholders	Barriers	How to overcome?
Tanzania Government	Refusal approve investment in long-term infrastructure in a nominally 'temporary' setting	Enable a collaborating framework under a common objective, including clarity of the CRRF strategy and links to SDG / NDC targets.
	A moratorium / reduction in cash-based interventions	Further application of CBA methods to demonstrate the benefits of money flow to the region.
Donors	Reluctance to finance LPG	Provide them with BAU scenarios and emissions projections.
	Donor Fatigue. Great Lakes region crisis is not new.	Environmental Stewardship is new. Advocate for better accountability in the name of cost efficiency.
UNHCR	Short-term funding cycle	Creation of an energy cluster, to lobby for greater investment in sustainable energy in humanitarian settings.
	Structural limitation to funding cleaner energy solutions	Tap others source of funding, including environment and health sector funds: VCM, GCF, WHO.
Refugees	Reluctance to use LPG	Education on the benefits. Include all member of the family. Facilitate bottom-up information transfer.
	Reluctance to financially contribute to LPG	Raise awareness of the cost comparisons, i.e. LPG vs. status quo energy use.
	The collection and sale of firewood continues, as a form of income generation.	Expand livelihoods programs raise awareness about the multi-dimensional benefits of LPG use.
Host Community	Resentments / grievances emerge from a discrepancy in treatment between refugees and locals.	Provide training and education to the host communities on LPG use.
	Removal of a highly profitable activity (selling charcoal)	Education about the environmental risks / impacts of charcoal production. Sticker enforcement of rules regarding charcoal production.

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UNEP DTU PARTNERSHIP

THE TRUE COST OF USING TRADITIONAL FUELS IN A HUMANITARIAN SETTING

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