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Implementation and scale-up of a biomass pellet and improved cookstove enterprise in Rwanda

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ABSTRACT

This paper reviews the experience of a for-profit firm in Rwanda promoting biomass pellets and a fan micro-gasification improved cookstove as a clean cooking alternative to charcoal. Consumers purchase locally produced biomass pellets and receive the improved cookstove on a lease basis. The cost of the pellets and stove(s) is lower than the cost of cooking with charcoal in the urban setting where our study takes place. Inyenyeri has been piloting its business model since 2012. Using data from an ongoing quantitative impact evaluation study, focus group discussions, and a series of key informant interviews, we chronicle the firm's experience with stove choice, pellet production, and marketing, highlighting lessons for the design of private sector-led clean cooking interventions.

We find that 38% of households marketed to as part of our ongoing impact evaluation study adopted the pellet and stove system, but that approximately 45% of those who adopted suspended contracts after signing up. The firm's experience with stove choice, pellet production, pricing structures, and customer service strategies have influenced implementation, adoption rates, and scale-up. Customer preferences for specific stove attributes and willingness of stove manufacturers to modify stoves for local conditions have influenced both the firm's choice of stove and customer satisfaction. In 2015 the firm transitioned customers from the Philips stove to the Mimi Moto, a decision which created confusion among consumers, and affected adoption rates. Despite the challenge of establishing and scaling-up pellet production in central Africa, the firm increased production 400% between 2014 and 2017 to reach 800,000 kg/year. Importing and maintaining pelletizing equipment in Rwanda is costly, the supply of feedstock irregualar, and undercapitalization of the firm have affected production. With respect to marketing, after experimenting with a sign-up fee and a minimum monthly purchase of pellets, the firm has decided to transition to a pay-as-you-go system to reduce perceived risk by consumers. A high-level of customer service including in-home visits, free in-home repair, and home delivery of pellets are major innovations. The long pilot phase and the evolutionary nature of the firm's activities illustrate both the complexity of building a market for clean cooking, and the time required to understand nascent markets and consumer demand.

Introduction

Over 81% of households in sub-Saharan Africa use solid fuels (e.g., dung, crop residues, fuelwood, and charcoal) for cooking (World Bank, 2015). The use of solid fuels in inefficient traditional stoves contributes to household air pollution (HAP), the largest global environmental risk factor for disease burden (Forouzanfar et al., 2015). According to World Health Organization estimates, between 2000 and 2030, there will be 8.1 million premature deaths among children and 1.7 million premature deaths among adult women in sub-Saharan Africa attributed to exposure to HAP from cooking (World Bank, 2015).

Rwanda provides an excellent case study for the challenges that lie ahead for mitigating HAP in Africa. Lower respiratory infection is the leading cause of total years of life lost due to premature mortality (GBD, 2017). With 483 persons per square kilometer, Rwanda is Africa's most densely populated country. The total population is expected to increase from approximately 11 million in 2016 to 16.9 million in 2032. Rapid growth is coupled with a rapid urbanization; urban dwellers will double from approximately 15% to 29% by 2030 (Government of Rwanda, 2016a, 2016b; NISR, 2017). Meeting demand for energy services for this dynamic and growing population is a

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major challenge. The delivery of clean, accessible, affordable, and sustainable energy for cooking is a pressing issue.

Nearly all (99.7%) of Rwanda's household cooking energy comes from solid fuels, with firewood being the dominant cooking fuel (95.7%) in rural areas, and charcoal (50.1%) and firewood (45.4%) the major fuel sources in urban areas (Ndegwa, Breuer, & Hamhaber, 2011; World Bank, 2014). Rwanda has one of the highest rates of non-renewable biomass utilization globally; the fraction of non-renewable biomass consumed by households exceeds 50%, implying considerable pressure on remaining forest resources (Bailis, Drigo, Ghilardi, & Masera, 2015). The Rwandan government's Economic Development and Poverty Reduction Strategy II (EDPRS) prioritized reduction of woody biomass energy consumption from 94% in 2009 to 50% by 2018 (Government of Rwanda, 2016a, 2016b).

At the same time, markets for clean cooking technologies are limited. In 2013, over 50% of stoves in the Rwandan improved cookstove (ICS) market were basic (i.e. offering only modest gains in combustion efficiency) using charcoal and fuelwood as input fuels. Only 0.3% of the ICS market were stoves that could accommodate modern fuels such as liquefied petroleum gas (LPG), electricity, alcohol-based fuels or biogas (World Bank, 2014).

Rwanda has been a testing ground for several clean cooking initiatives. Between 2010 and 2012, the Government of Rwanda Energy, Water and Sanitation Authority in partnership with Dutch SNV encouraged rural households to use the locally produced clay improved fuelwood cookstove (*Canarumwe*), and urban households to use the locally produced charcoal ICS (*Canamake*). In 2014, in a major government initiative, the Ministry of Health and environmental health technology suppliers Del Agua, in formal agreement with EcoZoom freely distributed 300,000 wood rocket stoves (EcoZoom Dura) and advanced water filters to cash-constrained rural households (World Bank, 2014). This effort, financially backed through the Clean Development Mechanism, failed to generate sufficient funds through carbon finance to sustain the program. As a result, efforts to bring the program to scale failed (World Bank, 2014, 2015).

The challenges of high burden of disease from HAP, population growth rates and associated pressure on resources, and latent demand for modern energy services requires considerable innovation in marketing models and public policy to support the clean cooking sector. Specifically, innovation is required in the supply of sustainable clean fuels, and in access to affordable clean cooking technologies. The household energy sector is guided by the Rwanda Energy Policy, Energy Sector Strategic Plan, and Rwanda specific targets under the rubric of the global Sustainable Energy for All (SEforALL). Ensuring the consistent supply and sustainable use of woody biomass for fuel is one of the major challenges Rwanda faces in achieving SEforALL goals. Together, these programs have the following objectives: (a) bridge the 20% gap in biomass energy production and consumption towards a sustainable solution; (b) by 2030, all Rwandan households should use more efficient cookstoves than currently in use; (c) charcoal losses should be reduced by 30% in 2018 from the 2009 baseline through use of improved technologies and enhancements in its value chain; and (d) advancement of substitute cooking fuels including biomass pellets, biogas digesters, and LPG (Government of Rwanda, 2016a, 2016b). Quick analysis of the scope of the problem and proposed timelines and progress to date suggests that the Government of Rwanda will not meet the stated targets. Innovative business models supporting development of the clean cooking sector are urgently needed.

Inyenyeri a Rwandan Social Benefit Company, Ltd.

Inyenyeri describes itself as a 'social benefit company'. This type of private sector entity combines the qualities of traditional for-profit company and non-profit/NGO charters to create a hybrid entity ideally suited to social enterprises. Inyenyeri has been operating in Rwanda since 2011. The Inyenyeri model couples the sale of locally produced biomass pellets with the lease of one of the cleanest burning biomass cookstoves. Inyenyeri currently leases a fan micro-gasification cookstove called the Mimi Moto™ which has been evaluated in a laboratory setting as an International Workshop Agreement (IWA) Tier 4 stove (CSU, 2015).[1] At present, the Inyenyeri model involves having customers sign a contract to purchase a supply of biomass pellets and receive the stove or stoves, on a lease basis. Pellets are produced in a pelletizing factory on the shores of Lake Kivu from sustainably sourced biomass feedstock (e.g., eucalyptus trees and branches). Inyenyeri focuses on marketing the pellets because fan micro-gasification stoves are far too expensive for almost all Rwandan households.[2] By pricing pellets competitively with charcoal, households can adopt cleaner fuels and technologies at a cost on par or below the cost of their baseline household cooking system. As part of their business model Inyenyeri offers free delivery, training, repairs, and replacement of stoves.

Inyenyeri is located in Gisenyi, Rubavu District (Fig. 1) in northwestern Rwanda. Gisenyi is Rwanda's fifth largest city with a population of over 83,000 people (World Population Review, 2018). Inyenyeri chose Rwanda for its operations due to the pressing need for clean cookstoves and more efficient biomass fuels in-country, and due to the relative ease of doing business.

During the past 5 years Inyenyeri has continuously updated its business model, has used different improved cookstoves, experienced challenges with sustaining the quantity and quality of pellets needed to grow its customer base, and experimented with its' marketing model. The aim of this article is to highlight what Inyenyeri has learned, the constraints it has faced, and how it has evolved and innovated. Inyenyeri's experience is critical to understanding the potential for a sustainable biomass solution to be brought to scale in the region.

Methods, sources and approach

Several data sources were used for this study including data from an ongoing impact evaluation, a series of focus group discussions, and interviews with Inyenyeri staff.

Impact evaluation

To provide data on rates of adoption and sustained use, and to provide contextual information on drivers and barriers to adoption we use data from baseline (2015), first midline (2016), and second midline (2017) data collections of a large household-level ($N = 1462$) randomized controlled trial in Gisenyi, Rwanda (Jagger, Das, Handa, Nylander-French, & Yeatts, 2018 *In review*; Das, Pedit, Handa, & Jagger, 2018). For this study, 1500 households were randomly selected from the total population of households in 22 neighborhoods in Gisenyi where Inyenyeri planned to expand its operations. Households were then randomly assigned to treatment ($N = 1000$) or a delayed entry control group ($N = 500$). The 'treatment' was being marketed to by Inyenyeri at neighborhood-level cooking demonstrations and through leafleting. Some households were visited by an Inyenyeri customer service representative who provided an in-home demonstration of cooking with pellets and an improved cookstove and explained and answered questions about the Inyenyeri contracting and payment plan. Baseline (2015) and endline (2018) surveys include the full sample of 1462 households and involve a structured household survey and 24-h monitoring of carbon monoxide (CO) exposure of the primary cook in the household. Greater than 90% of households use charcoal as their primary fuel at baseline.

[1] The IWA framework rates cookstoves on four indicators (efficiency, indoor emissions, total emissions, safety), each along 5 Tiers (0: lowest performing to 4: highest performing). For each indicator, the Tiers boundaries are defined by quantitative values determined by laboratory testing. The WHO Guidelines for Indoor Air Quality stipulate that only Tier 4 stoves are have low enough emissions to mitigate burden of disease associated with household air pollution (GACC, 2018).

[2] The Mimi Moto stove is sold in Zambia by Emerging Cooking solutions for US$140.

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