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Building a consumer market for ethanol-methanol cooking fuel in Lagos, Nigeria

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ABSTRACT

A recently completed randomized controlled study in Nigeria that transitioned pregnant women from traditional fuels to ethanol in their cook stoves demonstrated improved pregnancy outcomes in mothers and children. We subsequently conducted a pilot study of 30 households in Lagos, Nigeria, to determine the acceptability of blended ethanol/methanol as cooking fuel and willingness to pay for the CleanCook stove. A third of the pilot participants expressed a willingness to purchase the stove for the minimum price of 42 USD or more. Fuel sales data suggest sustained, but non-exclusive, use of the CleanCook stove. These results will influence the final design and implementation of a planned 2500 stove commercial pilot that is scheduled to start in Nigeria in August 2018.

Introduction

While research on the global burden of disease research provides a mandate for transitioning populations away from polluting cooking fuels, location-specific evidence on feasibility of alternatives and resulting health benefits is often lacking, particularly for alcohol fuels. Like liquefied petroleum gas (LPG), household alcohol fuels burn cleanly (MacCarty, Still, & Ogle, 2010; Shen et al., 2018), reducing risk factors associated with household air pollution (HAP) and cardio-respiratory diseases (Rehfuess et al., 2014). In Nigeria, birth outcomes associated with switching to ethanol were recently investigated with a randomized controlled clinical trial (RCT) with support from the Global Alliance for Clean Cookstoves. Outcomes and methods from the RCT are as follows (Alexander, Northcross, Wilson, et al., 2017; Alexander, Northcross, Karrison et al., 2017; Dutta, Brito, et al., 2017; Dutta, Khramtsova, et al., 2017; Northcross et al., 2016; Olopade et al., 2017):

The rate of adoption and use of the ethanol stoves was high. 84% of the women in the ethanol group give away their kerosene stoves before the end of the study (Northcross et al., 2016). The ethanol stove intervention improved pregnancy outcomes and reduced the risk of developing hypertension during pregnancy (Alexander, Northcross, Wilson, et al., 2017; Alexander, Northcross, Karrison, et al., 2017); HAP exposure during pregnancy was associated with chronic hypoxia in the placenta (Dutta, Brito, et al., 2017; Dutta, Khramtsova, et al., 2017).

Gas flaring represents another risk to human health and environmental quality, especially for residents of the Niger Delta in Nigeria (Giwa, Adama, & Akinyemi, 2014; Osuoha & Fakutiju, 2017). Studies show that flaring is a significant contributor of black carbon (BC) to the atmosphere and is likely responsible for greater than 42% of all BC surface deposition in the Arctic, linking it to climate change (Conrad & Johnson, 2017; Johnson, 2017). Gas flares also emit nitrogen oxides (NOx), fine particulate matter ($PM_{2.5}$), polycyclic aromatic hydrocarbons (PAH), and unburned methane (Fawole, Cai, & Mackenzie, 2016). The Niger Delta is ranked seventh in the world for flare volumes (The World Bank, 2018), and the issue of flaring has become a highly contentious and politicized one for residents of the Delta (Ajugwo, 2013). The Nigerian Government's ban on flaring has global support, and oil producers are under pressure to eliminate the practice, creating an opportunity for alternative uses such as the production of methanol for cooking fuel.

The Nigerian Government is currently developing a national energy strategy and, while it has not yet adopted a specific position on alcohol fuels, interest in this issue is growing (Kennedy, 2017; Nigerian National Petroleum Corporation, 2017). The displacement of kerosene and biomass fuel has a greater opportunity for success with policy support from the Nigerian government. For example, the recent removal of the household kerosene fuel subsidy could have a positive impact on the market for an ethanol-methanol alternative. Further, Nigerian ethanol production is expected to grow robustly over the next few years, with the addition of new producers (Kennedy, 2017; News Agency

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Fig. 1. CleanCook 2-Burner Stove (left) and model showing the adsorptive canister (right).

of Nigeria, 2017; Sapp, 2017). For example, an affiliate of UNIKEM Industries Ltd. (Africa's leading importer and local producer of ethanol) recently commissioned a distillery in Kogi State, Nigeria, designed to produce up to 240,000 l of ethanol daily from cassava, sugarcane, and other feedstock. Nigeria also possesses Africa's largest natural gas deposits, and plans exist to build several methanol plants to leverage this capacity (Gas Processing, 2017).

While alcohol fuels have been used for household cooking in Sub-Saharan Africa (SSA) for many years on a small scale, there is very little reporting on outcomes in the literature (Pope, Bruce, Dherani, Jagoe, & Rehfuess, 2017). Now a more extensive commercial pilot study will explore the potential of an ethanol-methanol fuel and stove system as a mainstream clean cooking option in Lagos. This Short Communication provides a brief description of the commercialization plans, but focuses primarily on an aligned, in-progress assessment called, Pilot Evaluation of Diffusion and Usage of Ethanol Clean Cooking Technology (PEDUCCT). The summary of the commercial pilot study is based on review of documentation supplied by Project Gaia and from interviews of key informants. The description of the PEDUCCT assessment methodology was drawn directly from the study protocol. Some preliminary assessment results are included, but the commercial pilot itself and the full assessment analysis are not expected to conclude until 2019. This work was supported in part through the Clean Cooking Implementation Science Network (ISN) with funds from the United States National Institutes of Health Common Fund program for Global Health as well as by the African Development Bank.

Commercial pilot of ethanol-methanol fuel in Lagos

A consortium of Nigerian private sector partners, anchored by Project Gaia Partners Limited (PGPL) and Shell Nigeria Exploration and Production Company (SNEPCo), is exploring how to promote ethanol-methanol fuel for cooking in West Africa, with a pilot project designed to roll out as a commercial start-up. Beginning in the third quarter of 2018, an initial 2500 CleanCook stoves and 15,000 alcohol-fuel canisters will be sold in selected neighborhoods of Lagos. The consortium also includes Forte Oil, a leading fuel sales and distribution company with over 500 retail outlets, and UNIKEM Industries Ltd.

The commercial pilot study is motivated by an overarching social responsibility goal to “promote a safer cooking system in Nigeria as part of efforts to encourage access to a better source of energy” (SNEPCo, 2015). Specifically, the pilot aims to introduce the CleanCook stove into the Nigerian market and facilitate commercial scale-up of stoves and alcohol fuel. To enable this commercialization, the consortium focused on developing a commercial supply chain that could safely and profitably blend methanol into the ethanol fuel and deliver it to the customer in a secure and user-friendly canister. It sought to establish a system that enabled consumers to visit designated retailers to return empty fuel canisters and purchase newly refilled replacements. Finally, it also aimed to identify and characterize the target market for the new cooking system, establish effective promotional activities, and determine the correct price for the stove and fuel.

The two-burner stove has a stainless-steel body and an expected lifespan of 8 to 10 years. The factory cost is about 24,000 Naira (N).[1] The CleanCook stove has a unique, fiber-filled adsorptive fuel canister that retains the ethanol-methanol mix inside the canister (see Fig. 1). Because ethanol and methanol have extremely low surface tension, they spread out on and cling to the surface of the fiber in the canister. This is a process of adsorption, as distinct from absorption. As it does not adhere to itself, the alcohol will not form droplets and leak out of the canister, even when the canister is put upside down, struck or shaken, or the fiber is depressed. The canister was designed to exploit this unique physical property of the simple alcohols. The mouth of the canister, which is protected by a rigid stainless-steel wire mesh, and from which the alcohol will evaporate when the mouth is open, is sealed by a sliding plate on a control arm when inside the stove. The stove operator adjusts this arm. When the plate is closed, the stove is turned off. Neither alcohol gas nor vapor evaporates from the mouth of the canister when the stove is turned off. When the plate is slid to open the mouth of the canister, alcohol fuel evaporates into the stove's combustion chimney and may be lit with a match or spark igniter. If the plate is only partially slid from the mouth of the canister, less gas is released into the combustion chimney, which will produce a smaller flame. As the alcohol vapor burns in the combustion chimney, the fuel mixes with air drawn in from the sides by natural convection, which is important for obtaining complete combustion.

The unique adsorptive fuel canister and combustion chimney with sliding regulator plate ensure safe containment of the alcohols and a fuel delivery system that will not leak or spill fuel and is not pressurized and cannot be made to pressurize. The adsorptive alcohol fuel canister is somewhat analogous to an LPG cylinder, but without need for a high-pressure containment vessel. When outside of the stove, the canister is closed by use of a pliable elastomer lid, which is snapped on, or, alternatively, a peel off seal. The lid or seal is removed when the canister is placed in the stove. The lid, seal and sliding plate all work on a simple principle to contain alcohol within the canister. They form a vapor barrier in the void between the fiber and the cover. When this vapor barrier is equalized in saturation or vapor pressure with the vapor in the fiber, all evaporation ceases and the alcohol remain in place. This vapor pressure is very low and is safely contained by the lid, seal or plate. If the canister were to become heated to the boiling point of alcohol and sufficient pressure were to build in the canister, the lid or seal is designed to release this pressure harmlessly, as will the sliding plate, which is on a flexible spring steel arm. When alcohol evaporates from the canister, it cools the alcohol remaining in the canister because heat is

[1] At the time of the WTP exercise, the exchange rate of Naira to USD was around 360 Naira/USD.