Design and Performance Analysis of the Candela Model 1 A Novel Electricity Generating Biomass Cook-stove

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Specific Aims:

Rwanda is among countries with a high rate of households who over an open fire jeopardizing their health, causing widespread deforestation, and burdening women and girls with hours of unpaid labor. The biomass energy strategic plan by MININFRA 2019-2030 reported that 87% of Rwandans use biomass as their primary energy for cooking whereas the EICV 5 reports that 49% of all Rwandans still rely on unclean sources of lighting energy sources like firewood and lantern kerosene lamps. This prevailing reliance on open fire cooking in rural Rwanda can be attributedto the slow adoption linked to the affordability of existing improved cook-stoves and their functioning features while the reliance on unclean sources of lighting energy is associated with the high costs of available clean energy sources. Several attempts to disseminate improved cook-stoves in rural areas have been made, but this one present the bottleneck to being dependent on other source of energy such as DC battery that facilitates the complete combustion of biomass fuels. CANDELA Tech Ltd has formed a consortium with the University of Rwanda, and renown experts. The purpose of the project is carrying out an extensive research and developmenton Candela Model 1-Anovel Electricity Generating Biomass Cook-stove. The project aims to conduct research on electricity generation by Candela model 1, thermal efficiency, emissions, affordability, as alternatives to traditional wood and charcoal-based stoves. The team will re-design and analyze the performance of Candela Model 1 expected to meetthe energy trilemma - Energy Security, Energy Equity & Environmental Sustainability and remove the barriers identified for other improved cook-stoves. **The Specific objectives are**:

- **i.** To design and develop a cook-stove that completely burns biomass independently on any other source of energy;
- **ii.** To equip Candela Model 1 with a 10W thermoelectric generator recycling heat inside the stove into electricityallowing the user to light their homes in off-grid areas.
- **iii.** To develop a cook stove with complete combustion, reducing 90% of indoor air pollution caused by uncleancooking and kerosene lamps.
- **iv.** To minimize the heat losses from the biomass cook stove by 40% hence increase the thermal efficiency of thecook stove to 40%.
- **v.** To reduce the time women and children especially girls spend preparing the meals of their families from 6 hoursto 1 hour and enable them to participate in other income generating activities of their families.

The approach of this project will start by testing and documenting the performance of the developed prototype of Candela model 1 and comparing it with existing improved cook-stove. During the whole process of the research will comprise: the electricity generation by candela model 1- Water Boiling Test (WBT) - Controlled Cooking Test (CCT)-Kitchen Performance Test (KPT)- Stove Use Monitors (SUMs) and testing of the different fuels. The consortium will involve farmers' cooperation to facilitate the supply of raw materials for the feedstock and womenas the end-users of cook-stoves to ensure that the end product resonates with their needs and requirements. The stoveswill be fabricated at CANDELA TECH Ltd premises and experiments conducted in UR labs. Confirmed prototypes by Rwanda Standards Board (RSB) will be patented, then showcased to the large audience for marketing and mass production.

The outcomes of this project are **production Candela Model 1, novel electricity generating Biomass Cook-stoves**burning biomass fuels with full combustion and producing electricity to replace kerosene lamps in rural off grid areas.**The expected impacts** are, shift from the open fire stoves to improved cook-stoves, reduction in indoor air related diseases, reduction in deforestation, reduction in greenhouse gas emission, substitution of fossil fuels, increase in revenues from spending more time on income generating activities and savings by using improved cook-stoves, job creation and substituting kerosene lamps for lighting in households in off grid areas as well. Total Project Budget is 86,800,000 rwf for duration **of 12 months**.

Additional information

Investigators/Institutions

Celine Umurenzi, M. Eng - Principal Investigator and Co-founder of Candela Tech Ltd
Holder of a Master's degree in Renewable Energy and Energy Efficiency, and a Bachelor's degree in Physics, Celineis passionate about clean energy, now working as a solar energy engineer and energy access expert.

Paul Simon Anderson Ph.D - Co.Principal Investigator
Prof. Anderson also known as Dr. TLUD is a board member of Candela Tech and a world expert in biomass energy and T-LUD micro-gasification technology. He is a consultant in gasification cookstoves, furnaces and a retired university professor with 54 publications and reviews.

Ezechiel Maniragaba, M. Eng - Co. Principal Investigator and Lecturer at University of Rwanda, School of Engineering
A lecturer since 2008 in different universities such as INES Ruhengeri, Catholic University of Goma la Sapientia andUniversité Libre des Grands Lacs (ULPGL), Mr. Ezechiel is an expert in power systems and machine construction.

Charles Ndagije, Ph.D - Investigator and Lecturer at Univeristy of Rwanda, School of Engineering
Lectuer at University of Rwanda and other universities in the region, Mr. Ndagije has been involved in different research activities especially in numerical method for solving differential equation for high frequency electromagnetic.

Musabyimana Josee – Research coordinator and an Assistant Lecturer at University of Rwanda
Mrs. Josée, has completed a Master's of Science with specialization in Renewable Energy from the University of Agder (UiA) in Norway. She has also a Bachelor of Science in Electrical Engineering from University of Rwanda former Kigali Institute of Science and Technology.

In Partnership with:

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