2019

Report Activity 2019

Zero Carbon – Phase A

KUKULA

GROWING A SUSTAINABLE FUTURE

Project in collaboration with POLITECNICO MILANO 1863

Index

Intro

COLLABORATORS
Politecnico di Milano

OPERATION SECTOR	SITE OF REALIZATION	FINANCING SOURCES	COST	PROJECT STATUS	DURATION
Energy and health	Antintorona (Nosy Komba), Madagascar	Private donors	3.070 €	**Phase A** Completed **Phase B** In progress	**Phase A** 12 months (April 2019 – April 2020) **Project** 4 years (April 2019 – April 2023)

ZERO CARBON

SUSTAINABLE DEVELOPMENT GOALS (SDGs):

Context of operation

Respiratory infections, caused by traditional cooking methods that result in highly polluting emissions, are the second leading cause of mortality in Madagascar.

Furthermore, the use of firewood and vegetable charcoal as fuel by 99% of the population contributes to the phenomenon of **deforestation**, seriously threatening biodiversity and ecosystems of the entire island.
Finally, the factors above, combined with the burden of fuel collection and production (mainly affecting women and children), also have significant social impacts.

To date, the most common **cooking methods** in the north-western region of Madagascar are: *open fire* (tripod resting directly on the ground), *reshoo tole* (metal sheet brazier) and *reshoo cement* (concrete brazier). All of them are characterized by high emission rates and low energy efficiencies.

With regards to **fuels**, only firewood and vegetable charcoal are used on the island of Nosy Komba, with percentages varying according to the different villages. The wood is collected in the surrounding forests, while coal is produced in the mountains or in the nearby district of Ambanja and transported to the island for sale.

Project summary

The goal of the project is to produce and distribute **improved pyrolytic stoves**, powered by alternative fuels obtained by **biomass waste.** The advantage of the pyrolytic process is that it offers a more efficient, safer and cleaner solution compared to traditional cooking methods. The stoves are designed to be built using materials fully available on site and to meet the specific needs of rural communities in terms of usability and safety.

Given the complexity and scale of the problem addressed, the project has been divided into **four phases**:

A. Feasibility analysis and prototype development
B. Implementation of pilot solutions and study of alternative fuels
C. Small-scale production and distribution
D. Large-scale production and distribution

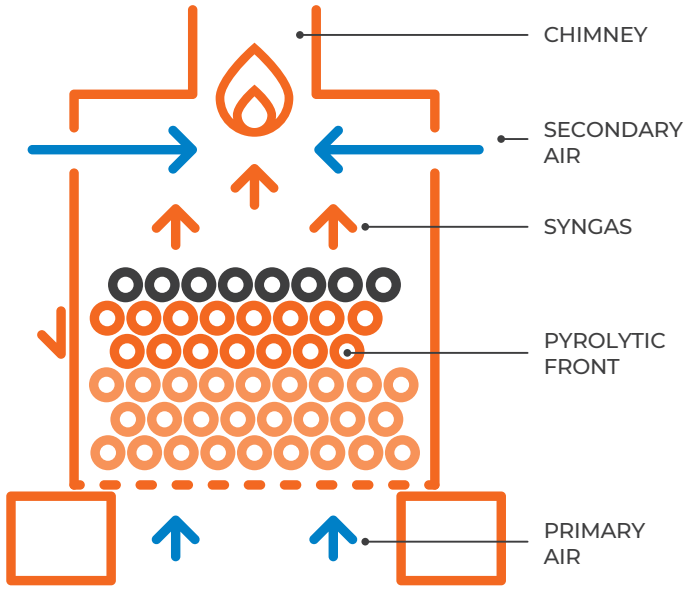
This report describes the activities carried out and the results achieved during **phase A.** The **preliminary analysis of the context** and the design and development of the first **TLUD** (Top -Lit-Up-Draft) **pyrolytic stove prototype** were carried out in collaboration with the Politecnico di Milano (Polytechnic University of Milan).

Project summary

PYROLYSIS

Pyrolysis is a **thermochemical process** that allows to separate the phases of combustion, producing a flammable gas (syngas). When mixed with the oxygen of the air, syngas results in a much cleaner and more efficient combustion process compared to traditional cooking methods, which do not allow for the separation of the different phases of combustion.

By separating the biomass from the flame, the release of CO_2 is minimized because carbon remains trapped inside the charred biomass (**biochar**), the only residue of the process.

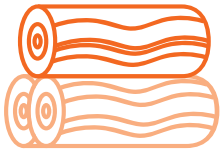


Project summary

ADVANTAGES OF A TLUD PYROLYTIC STOVE COMPARED TO TRADITIONAL COOKING METHODS

CLEANER

Complete biomass combustion allows TLUD pyrolytic stoves to reduce particulate matter (PM) emissions by 15-30% and carbon monoxide (CO) emissions by 50 to 90%.

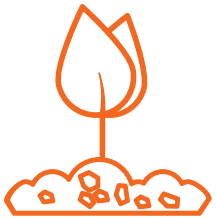


MORE EFFICIENT

Complete biomass combustion allows to save up to 75% fuel, compared to the more commonly used *open fire* method.

SAFER

Unlike traditional cooking methods, the combustion process takes place inside a chamber, thus reducing the risk of domestic accidents.



BIOCHAR PRODUCTION

Biochar is rich in nutrients and an excellent soil conditioner: it reduces soil acidity, improves water retention and allows to store CO_2 in the soil.

Objectives

GENERAL OBJECTIVE OF THE PROJECT

Countering and reducing health, environmental and social impacts caused by the **use of traditional cooking methods and fuels** through the production and distribution of improved pyrolytic stoves, using alternative fuels which are more sustainable both from an economic and an environmental point of view.

SPECIFIC OBJECTIVES OF THE PROJECT

Improvement of air quality, safety and hygiene conditions of cooking practices

Reduction of environmental and social impacts associated with wood collection and coal production

Raising awareness among local communities of the problems related to traditional cooking methods and training them towards the adoption of **virtuous behaviors**

Scalability of the project through social inclusion of vulnerable subjects

SPECIFIC OBJECTIVES OF PHASE A

- **Analysis and study of the local context** (traditional cooking methods, fuels, habits and locally available resources)
- **Development** of the first TLUD pyrolytic stove prototype.

Description of the activities

As part of **phase A** of the "Zero Carbon" project, an in-depth study of the context was first conducted. Subsequentially, the optimal layout of the TLUD pyrolytic cooker was defined and finally a preliminary assessment was completed to compare the pyrolitic stove performance against traditional cooking methods.

The on-site investigation was conducted through the use of a **questionnaire** which was administered to the local communities in their local dialect (Sakalava). Additionally, the **design and construction of the stove prototype** took place in a laboratory which was set up in the heart of the village. This approach allowed to directly involve the local population, which thus became an active stakeholder of the project.

Before the mission, Kukula started a **partnership** with the **Department of Energy Engineering of the Politecnico di Milano.** A Master Thesis was carried out under the "Zero Carbon" project with the aim of optimizing the stove's layout, conducting performance tests and evaluating the benefits of the stove compared to traditional cooking methods.

Description of the activities

The main activities of Phase A of the project have been:

- Preparation and administration of an in-depth **survey questionnaire** regarding local habits, cooking methods and commonly used fuels, together with the organization of **focus groups** [Nosy Komba]
- **Analysis of locally available materials** for the production of pyrolytic stoves [Nosy Komba]
- Preliminary study and development of the **first TLUD stove prototype** [Nosy Komba]
- **Improvement and adaptation** of the TLUD stove prototype layout with support from technical experts, in order to create a solution which could be both easily replicable on-site and scalable for serial production [Italy]
- Functional **test** and evaluation of the performance indicators (e.g. boiling time, fuel consumption, emissions, etc.) of the final prototype of the TLUD pyrolytic stove [Italy]
- **Estimation of the benefits** resulting from the introduction of alternative cooking methods: fuel savings, reduced collection time, reduced boiling time and reduced emissions (analyzed through an on-site emissions measurement campaign) [Nosy Komba].

Beneficiaries

The Zero Carbon project will benefit the following direct and indirect stakeholders:

DIRECT BENEFICIARIES

Families that will use improved pyrolytic kitchens and alternative fuels

Local staff involved in the production and distribution of improved pyrolytic kitchens and alternative fuels

Local experts involved in organizing training and awareness-raising activities for the local population

Local communities that will benefit from training and awareness-raising activities.

INDIRECT BENEFICIARIES

All individuals belonging to the **local communities** who will profit from health, environmental and social benefits brought about by the Zero Carbon project.

Achievements

CONTEXT ANALYSIS

The questionnaire, administered to a significant sample of the population (30 out of 70 families), made it possible to obtain the following information:

COOKING HABITS

- All families cook on the ground, exposing themselves to risks associated with **precarious hygiene conditions**
- 67% of the population uses the ***open fire*** technique for cooking, 47% has a ***reshoo tole***, while 40% has a r***eshoo cement.*** Most families in the village use at least **two cooking pits** simultaneously
- **The population cooks both outside and inside their houses.** 43% always cooks outside, another 43% only cooks outside during the dry season, while the remaining 14% always cooks inside

FUELS

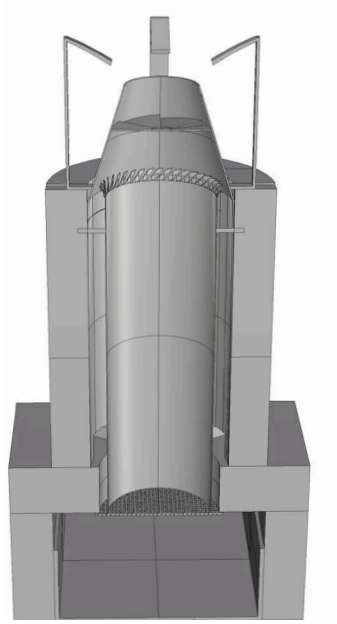
- **Vegetable coal is the most commonly used cooking fuel (37%) and it is purchased** on average **2-3 times a month** in 23 kg bags. It is perceived as a more noble fuel than timber and it can be easily stored and used during the rainy season, which makes it more advantageous compared to wood. However, its heat transfer efficiency (HTE) is lower than wood's thus increasing cooking time. Furthermore, not everyone can afford it, since it costs approximately € 3 per bag (the equivalent of a daily wage)
- **Firewood, used by 23% of the population, is collected** with an average frequency of **3-4 times a week.** It has the advantage of being free and its higher THE, compared to coal, allows to cook faster. However, it often generates smoke and blackens the bottom of the pots due to hydrocarbon condensation and unburnt tar
- **40% of the population alternates the use of the two fuels** based on the season, preferring the former during the rainy season and the latter during the rest of the year.

Achievements

PROTOTYPE DEVELOPMENT

Thanks to a thorough literature review, various field tests and the support of technical experts, Kukula's team has **designed, built and perfected a TLUD pyrolytic stove**, which can be built with **locally available materials** and best meets the **needs of the local population.**

Photo of the TLUD pyrolytic stove prototype



Front section of the TLUD pyrolytic stove prototype

BENEFITS ESTIMATION

Reduction of cooking times by up to

60%

Reduction of fuel consumption by up to

30%

Reduction of carbon monoxide (CO) emissions by up to

70%

Next steps

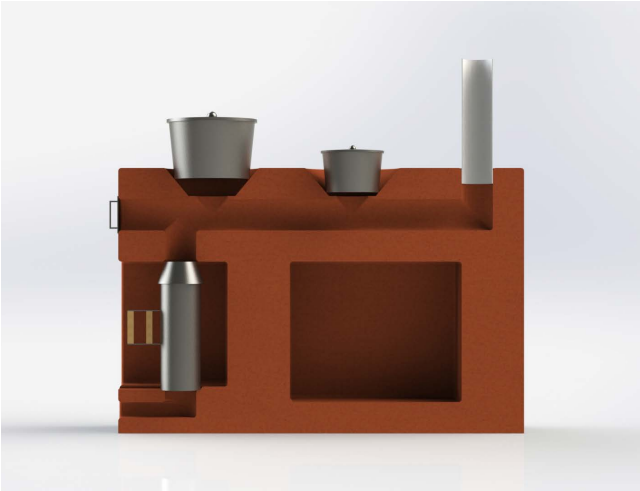
Scientific studies show that air quality inside closed environments is mainly determined by the following factors: cooking method, fuel type and ventilation of the environment.

Based on these studies, Kukula is designing an **improved pyrolytic kitchen**, which would include the TLUD pyrolytic stove, thus offering an **efficient, clean, economic and safe** cooking solution.

The kitchen is being designed so as to (1) maximize the heat produced by a **single TLUD stove**, offering the possibility to cook simultaneously on **two cooking pits and** (2) expel the exhaust fumes outside the house through a **chimney.**

The **raised cooking surface** would allow to improve safety and hygienic conditions during food preparation and to create a space, in the lower part of the structure, to store and dry fuel.

Phase B of the project will involve building and testing pilot models of **improved pyrolytic kitchens** on site and gathering users' feedback to better adapt the solution to the specific needs of the local population.
In addition, surveys and tests will be conducted to assess the quality and availability of potential **alternative fuels.**



Layout of the improved pyrolytic kitchen

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