Master's Thesis Engineering Technology

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A pilot project to introduce renewable energy and reduce environmental pollution by using a solar collector in Kenya

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Introduction

Figure 1: Technical university of Mombasa

This master's thesis is conducted in collaboration with the nonprofit organization **Students for Energy in Africa** [1]. This non-profit organization realizes annually recurring projects in function of sustainable energy in Africa.

This Master's thesis consists of two parts and includes the placement of **renewable energy sources** to reduce environmental pollution. These energy sources are placed in the **kitchen** of the **Technical University of Mombasa (TUM)** (Figure 1) in **Kenya** [2].

In this kitchen, 3 meals a day are served for the students. Because of these meals, there is a high consumption of **hot water**. This hot water is now heated 70% by wood and 30% by LPG.

Problem definition

Every kitchen of large institutions require **large amounts** of boiling water. In the Technical University of Mombasa, this water is heated in large kettles up to 50 liters. To get these amounts of **water to a boil**, large amounts of energy are needed. In the kitchen of TUM (Figure 2), this energy is provided by a combination of **firewood and LPG**. The use of these fuels poses following **problems**:

- high energy costs;
- harmful atmosphere for kitchen staff;
- wood usage leads to deforestation;
- fossil fuels emit greenhouse gasses.

The shortcomings occur not only at the **economic** level, but also at the **ecological** and **ergonomic** level.

Ultimately, the goal is to heat the water to 70°C. This temperature must be reached at the end of the day.

Figure 2: The kitchen

Methods

Based on the literature review, a **flat plate solar collector** is chosen, and it is placed at an angle. Throughout the matrix structure (Figure 3) of the collector, an **intermediate fluid** consisting of 30% glycol and 70% water flows. Due to this percentage, the boiling point is higher than the boiling point of water. The intermediate fluid heats up uniformly due to the **absorption of the sun's rays**. This heated intermediate fluid releases its heat into the **storage tank** filled with water. The cooled intermediate fluid is returned to the collectors so that the **cycle** can start again. This cycle is powered by **natural convection** (Figure 4). By repeating the cycle, the water in the tank heats up. This warm water can be used in the university's kitchen.

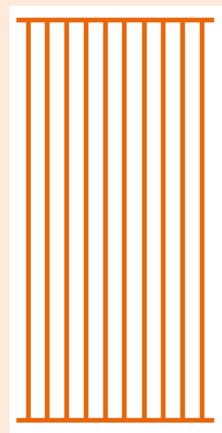

Figure 3: Matrix structure

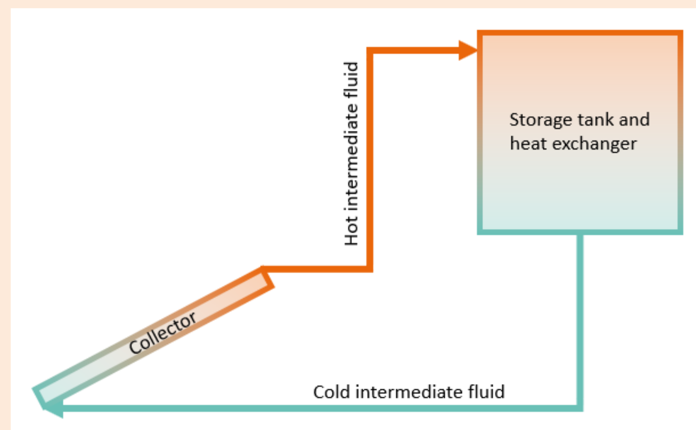

Figure 4: Schematic representation natural convection

Figure 8: The solar collector, top view

Conclusion

The main objective of this master thesis was to **reduce the energy costs** of the kitchen with a solar collector. The intended goal was to preheat the water needed for cooking to **70 °C**. This would reduce the needed energy by **65%**. From the results on figure 5, the actual situation reaches a temperature of 70 °C so this **goal** has been **achieved**.
Figure 6, 7 and 8 give the actual solar collector installed at the Technical University of Mombasa.

Figure 6: Selfie with Sollatek and the collector

Figure 7: The solar collector on the roof, side view

Results

To get a better idea of the effectivity of the installation before it is constructed, **simulations** were done in **Python**. These simulations take in account the design parameters, as well as the **environmental conditions** of the location, Mombasa. Together with the actual measurements we can see of the simulations are correct and if they gives us a qualitative result. Figure 5 gives an example of the simulations and measurements.

The temperature of the water in the storage tank reaches a **temperature of 80°C** according to the **simulations**. The **actual situation** reaches a temperature of 70°C. These are slightly different, but they **align perfectly** between **10 AM and 3 PM**.
The **deviation** from the simulation is due to **usage of hot water** for cooking around 12 PM. This is **not yet implemented** in the simulation.

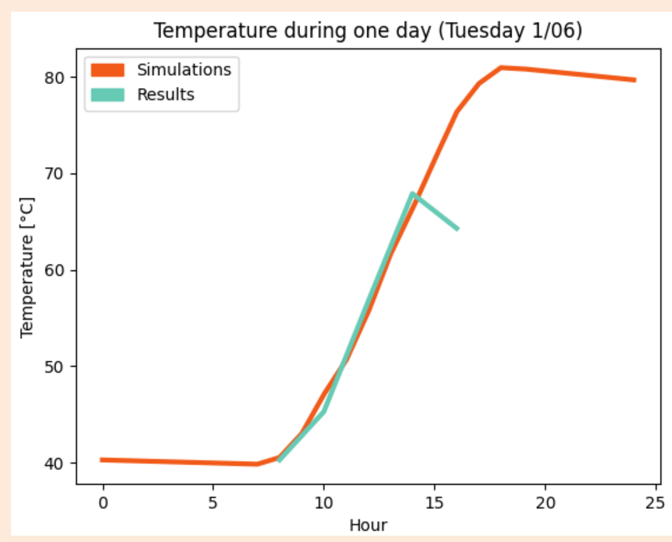

Figure 5: The temperature variation trough the day

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[1]: S. f. e. i. Afrika. [Online]. Available: https://studentsforenergyinafrica.com/nl/. [Accessed February 2021].

[2]: T. u. o. Mombasa. [Online]. Available: https://www.tum.ac.ke/. [Accessed February 2021].

[3]: G. maps. [Online]. Available: https://www.google.be/maps/. [Accessed May 2021].

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