

# A Study on the use of Linear Fresnel Reflectors for Solar Cooking

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## Introduction

Solar energy provides an environmentally friendly way of meeting energy needs in a world with ever-increasing demand. The development of solar energy for cooking can help reduce demand for fossil fuels and enables cooking without the use of gas or electricity.

Whilst the concept of solar cooking dates back over centuries - with the making of sun-dried fruits as an example— it is only in the past three decades that usage and research of solar cookers has increased noticeably. Many solar technologies are relatively new. linear Fresnel reflector technology (LFR) is a concept that has not yet been applied to solar cooking in commercial means. Similar in operation to LFRs, parabolic trough collectors (PTCs) have seen various commercial applications, however, they present difficulties when subjected to wind loading and are more difficult to produce and transport due to their shape. The objective of this project is to investigate the viability of using linear Fresnel reflectors as a more compact and easy to produce alternative to cookers using parabolic trough collectors.

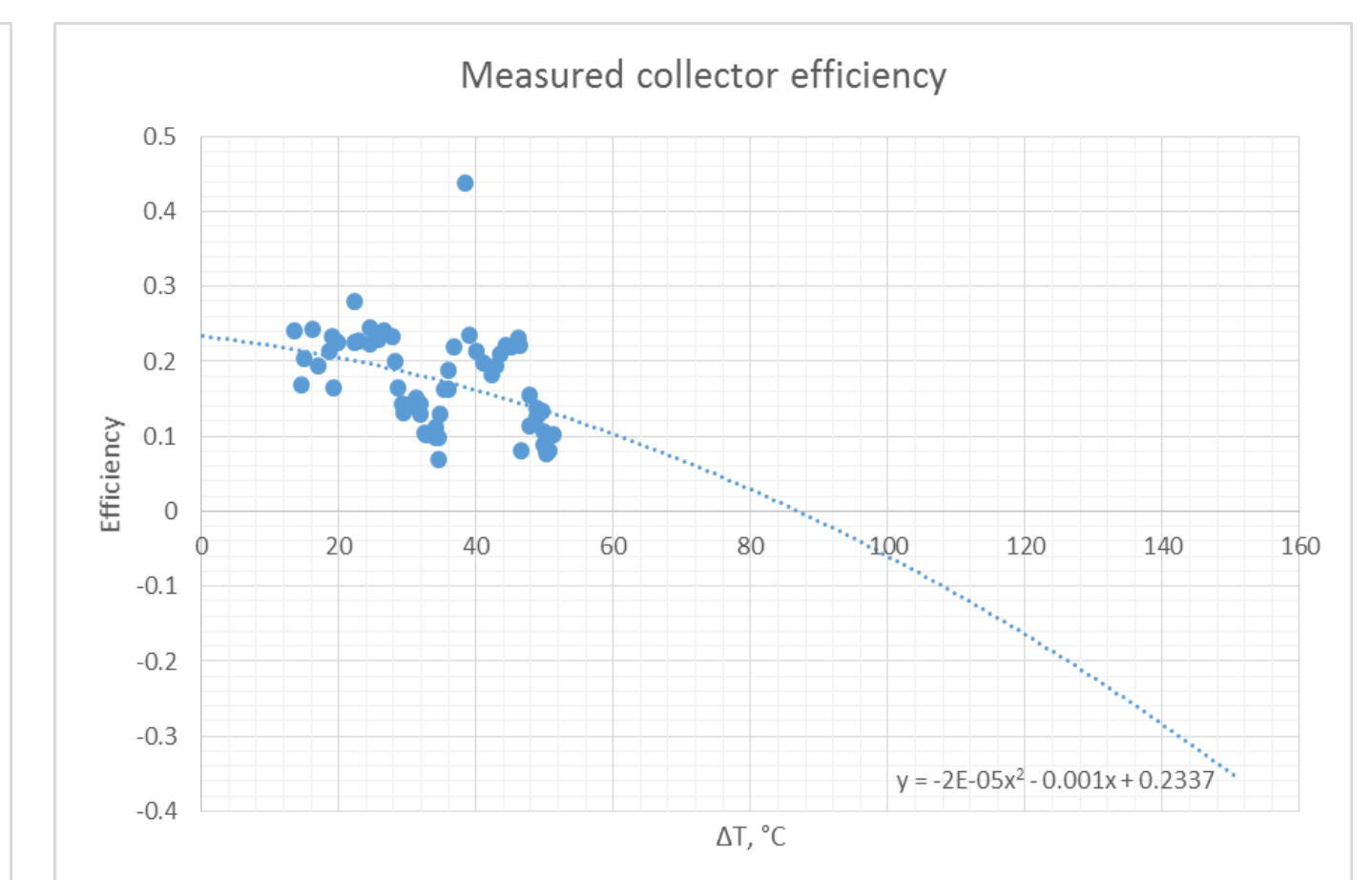
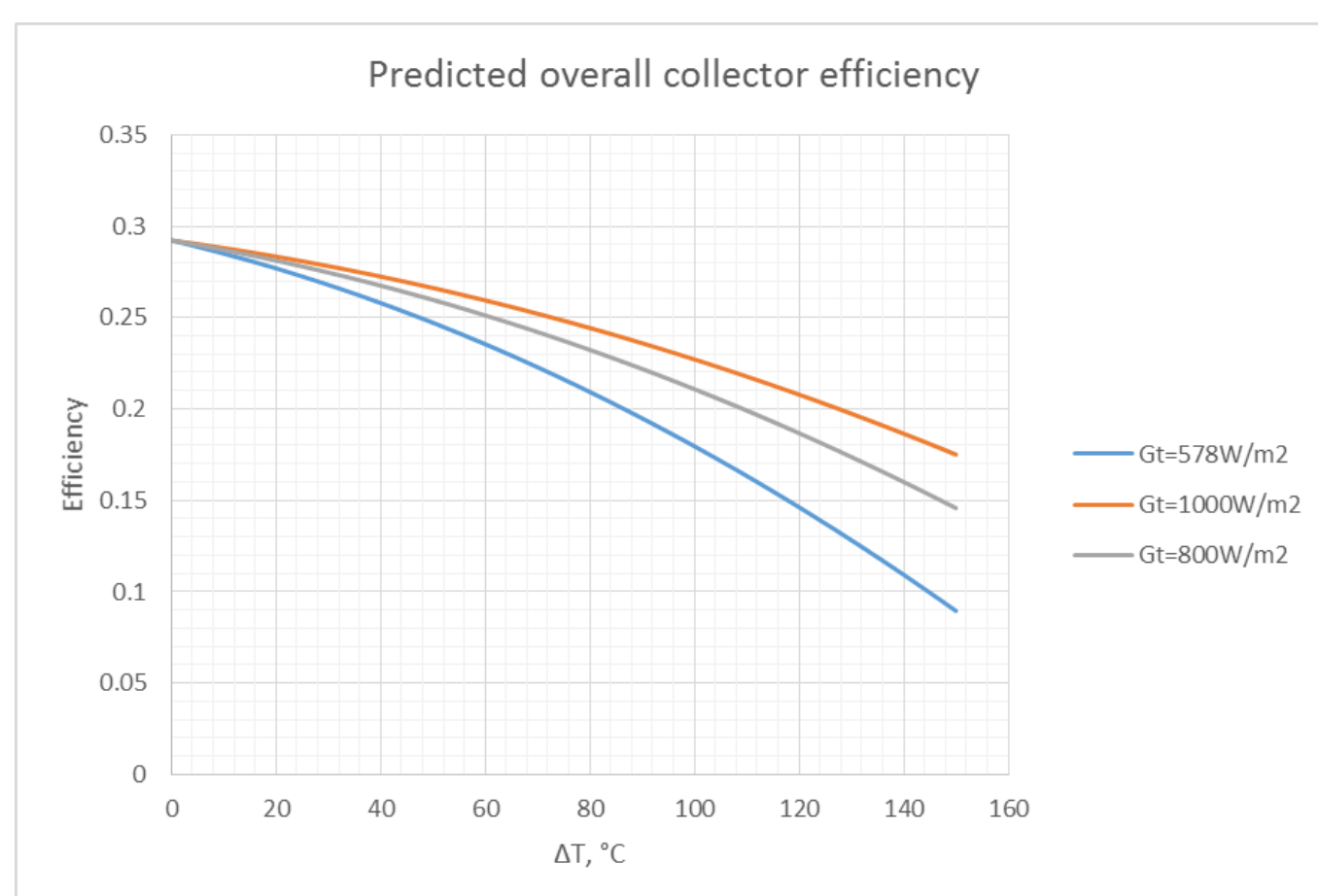
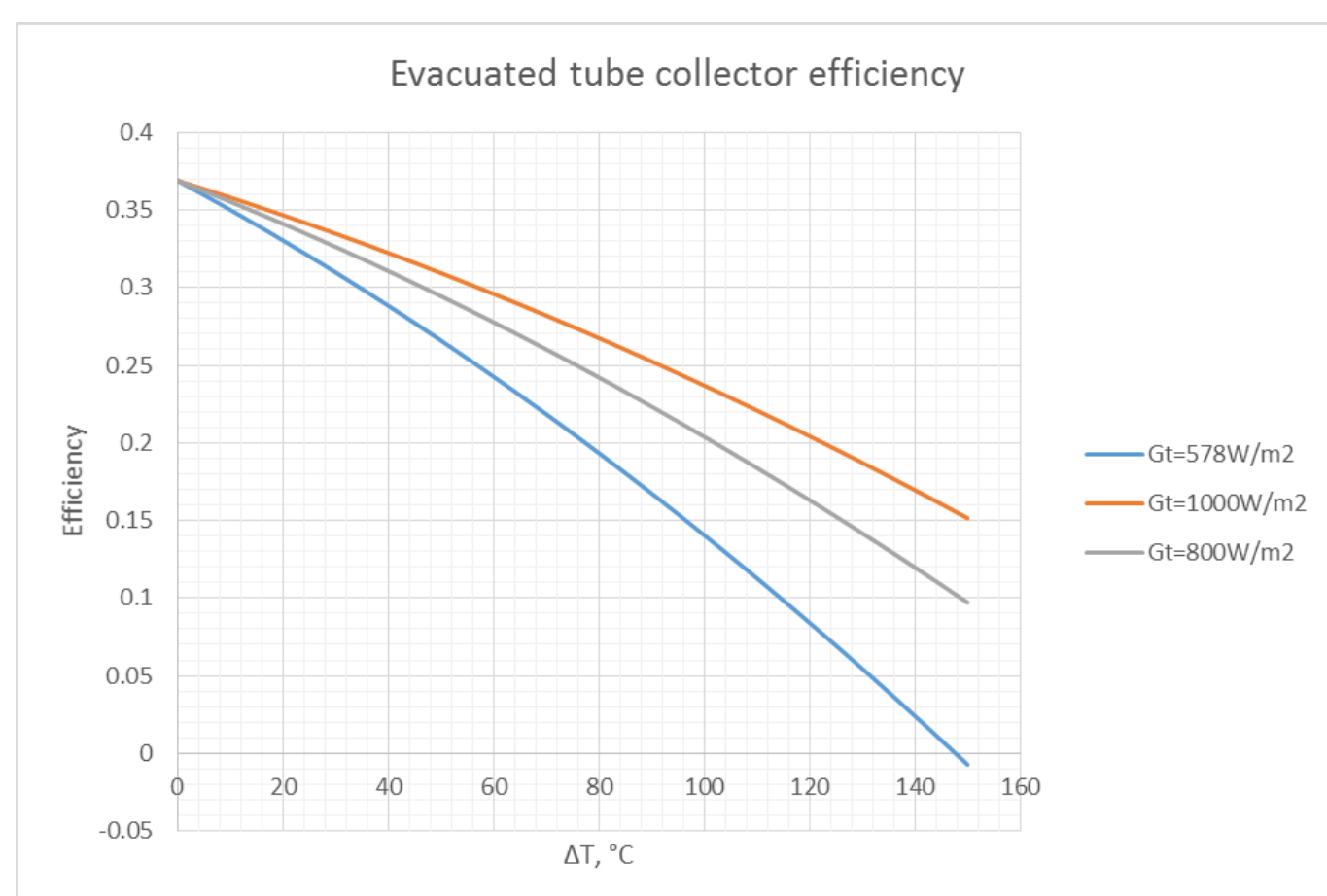
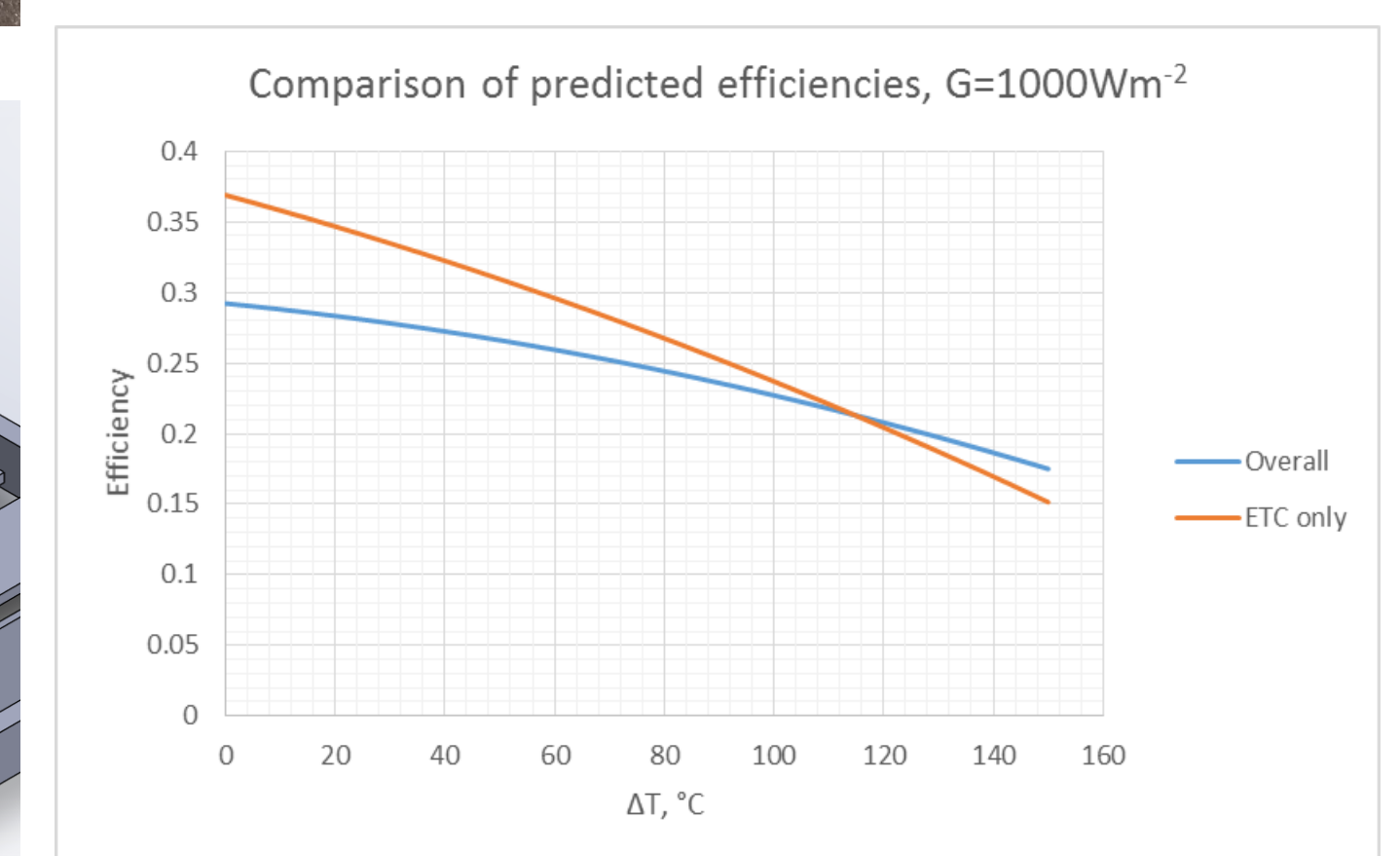
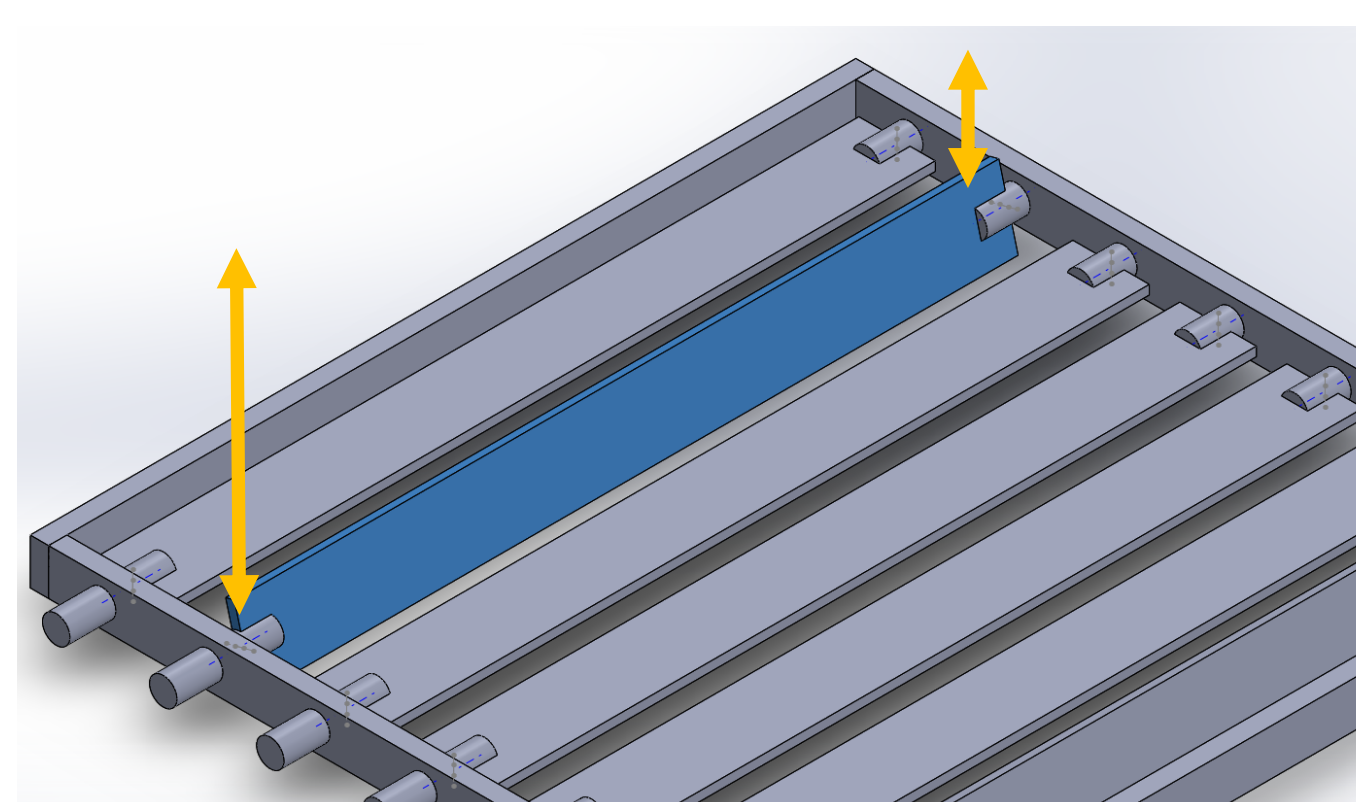
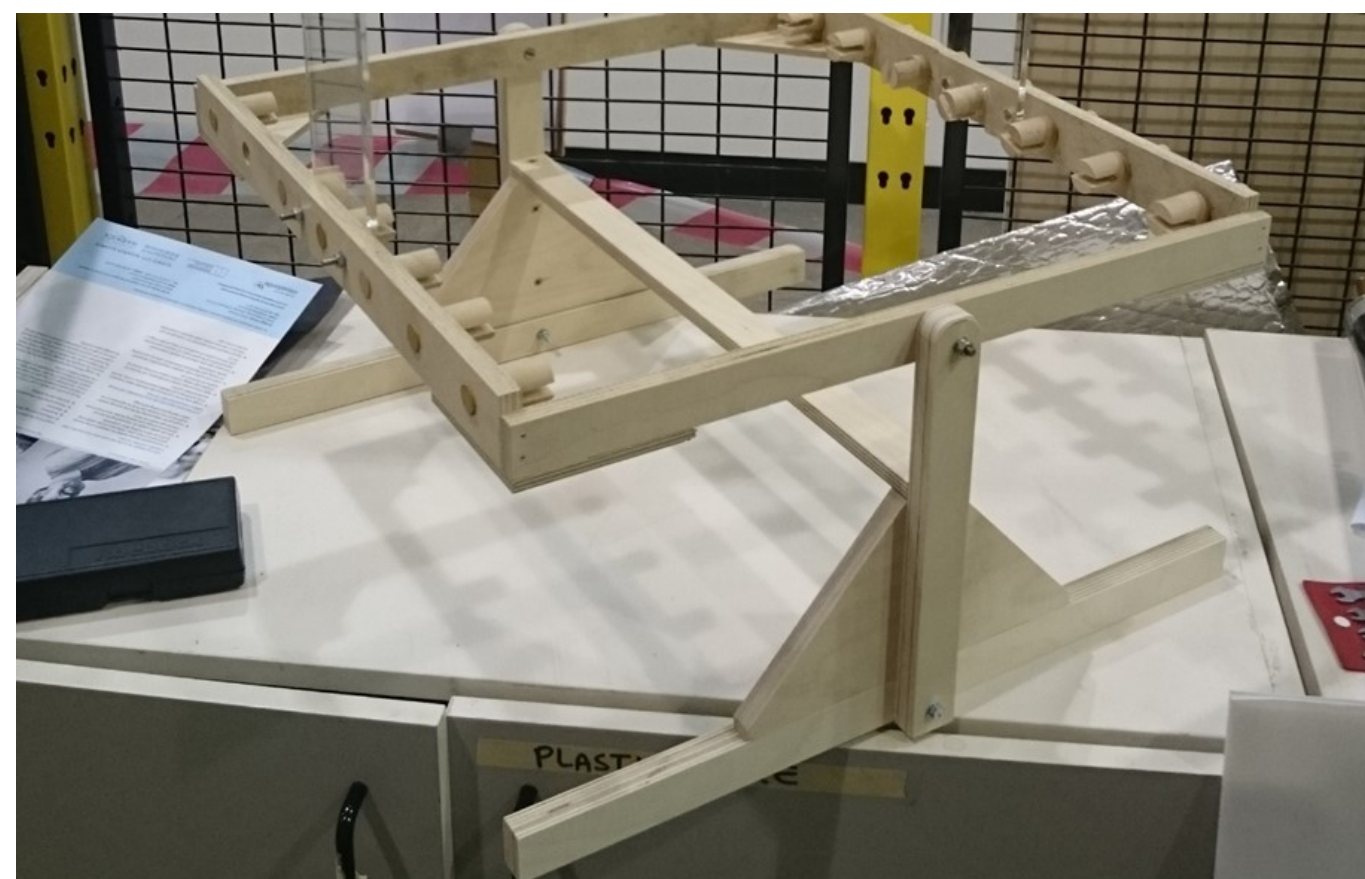


## Methodology

Initial research was conducted on the types of existing solar cookers in use and on the concepts of LFR technology. Following this, experiments were conducted to evaluate energy requirements and heat losses involved in boiling one litre of water. Following this, a small working LFR collector was produced to evaluate the performance of the system.

## Design and Manufacture

The LFR would be used in conjunction with an evacuated tube collector (ETC) as the receiver of solar energy. 3D models of the LFR assembly were created using Solidworks CAD software. During the design phase, refinements—such as increased structural bracings and enlarged reflector mounts—were added to improve structural strength and ease of manufacture. Efforts were made to use materials that are easily sourced from local home-improvement stores to minimise the cost and time needed to manufacture. All components were based on simple shapes so that they can be fabricated using hand tools. The frame was built using plywood, the reflectors consisted of aluminium foil glued to 6mm corrugated plastic sheet and 6mm acrylic was used for the ETC bracket. To further enhance maintenance, the reflectors are replaceable without the need for tools.



## Testing and Analysis

The LFR collector was tested in the outdoors over various conditions and test data was used to compare against the collector's predicted efficiency. The tests were varied to include direct heating of water inside the ETC and indirect heating of an aluminium block—to simulate a hot plate—by means of heat transfer using a heat pipe.

Water and block temperatures surpassed 70°C, high enough for slow cooking. A peak efficiency of 0.24 was calculated using the test data, indicating a difference of 0.05 compared to the predicted 0.29. However, the gradient of the actual efficiency graph was steeper in comparison to the predicted overall efficiency graph. The accuracy is likely to have been affected by the lack of continuous sunlight tracking on the LFR and pyranometer use to measure direct beam radiation.

## Conclusion

Linear Fresnel Reflector technology is still a rather recent development and one that has yet to see applications in solar cooking. It presents major advantages over traditional parabolic trough collectors in being easier to manufacture, transport and having increased resistance against wind.

Changing weather conditions also revealed the behaviour of temperature variations in the heat pipe and the aluminium block that was used to simulate a hotplate. Although the block increased heat up time, it acted as a thermal store, maintaining its temperature when there was cloud cover. In environments with changing sunlight conditions, heat storage would provide consistent output at lower temperatures, ideal for slow cooking as the block was able to surpass 70°C. In conditions giving long spells of direct sunlight, the LFR can also be used to cook food relatively quickly due to temperatures over 120°C being easily achievable. The efficiency of the receiver has a major influence in determining the overall efficiency, as the solar cooker's maximum efficiency is limited – in this case - by the optical efficiency of the ETC.

Further developments could include automatic tracking and implementation of a hybrid system that would be suit areas with inconsistent sunlight.