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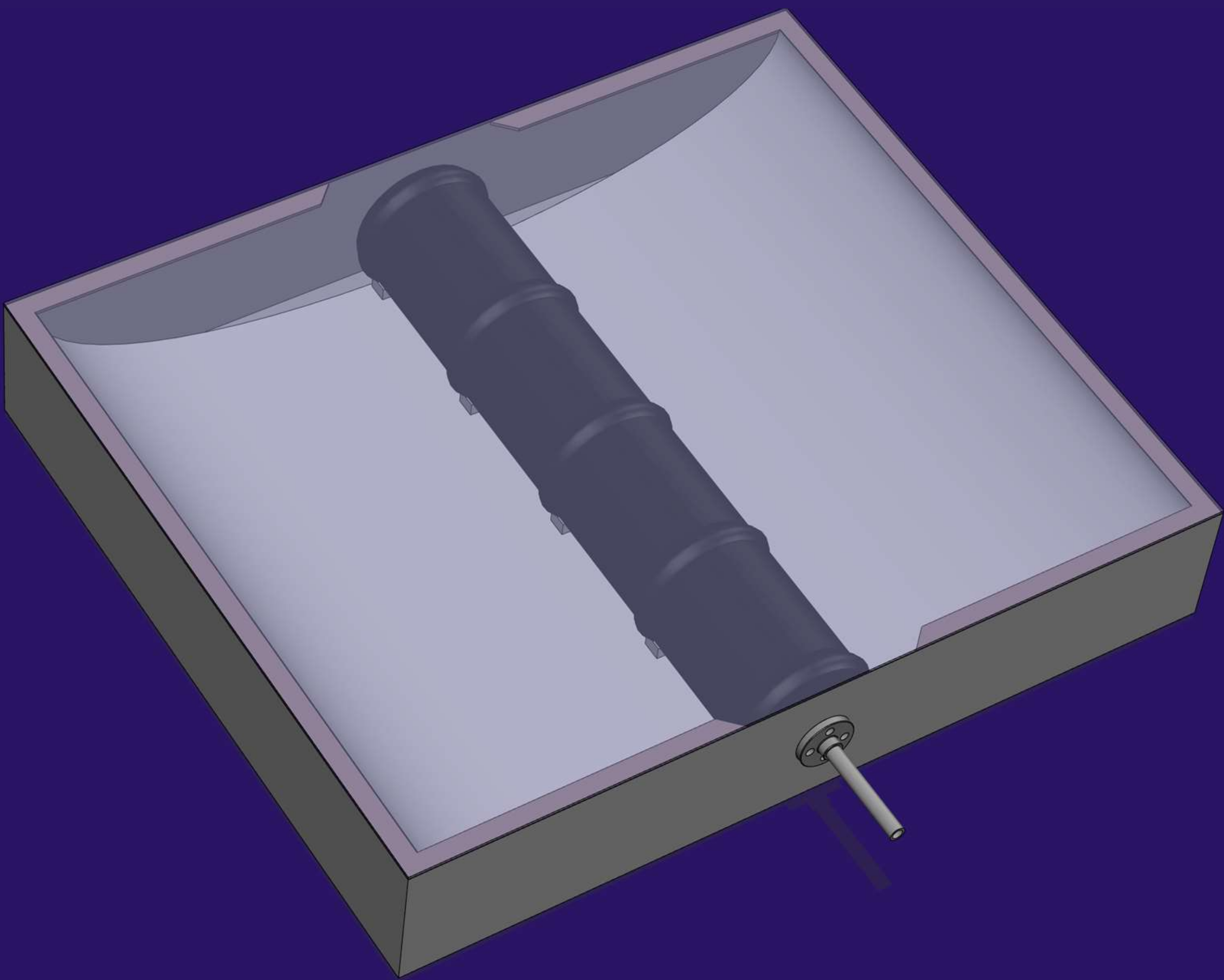
Solar-assisted heating unit

Dr Marcelo Precoppe



Construction guide delivered to **WINDWOOD MILLERS LTD.**, in fulfilment of the project 'Development of a solar-assisted heating unit to reduce firewood consumption in postharvest operations in developing countries' funded by HEIF 2020/2021

January 2021

Solar-assisted heating unit

Construction Guide: Part 2

Dr Marcelo Precoppe | Natural Resources Institute | University of Greenwich | Chatham Maritime | United Kingdom

This guide was delivered to **WINDWOOD MILLERS LTD.**, in fulfilment of the project *Development of a solar-assisted heating unit to reduce firewood consumption in postharvest operations in developing countries* funded by HEIF (2020/2021). It was prepared to instruct **Awiko Engineering Ltd.**, on how to build this novel solar-assisted heating unit. This is the Part 2 of the guide, is separate into 3 parts. Part 1 instructed the construction of the firewood-powered heating unit. Part 2 instructs the construction of the solar heater and Part 3 will instruct on how to evaluate its performance.

About the Natural Resources Institute

The Natural Resources Institute (NRI) is a specialist research, development and education organisation of the University of Greenwich, UK, with a focus on food, agriculture, environment, and sustainable livelihoods.

About the author

Dr Marcelo Precoppe is NRI’s Crop Postharvest Technologist. He obtained his PhD at the University of Hohenheim in Germany. His research interest lies in developing postharvest technologies for small-sized enterprises.

Disclaimer

⚠ Warning
High temperature can occur at the solar heater and its components. If handled incorrectly can result in personal injuries.

⚠ Caution
Please note that this is a design on early-stage, still under development, and not fully tested nor validated. No warranties, whether express or implied, as to the suitability or usability of the solar heater is given.

Introduction

This project aims to develop a solar-assisted, highly efficient, firewood powered heating unit to be used on postharvest drying operations. Firewood will still be used, but the efficient design, coupled with the solar heating assistance, will reduce its consumption. The objective of this guide is to provide the instructions on how to build a solar heater that assists the firewood powered heating unit. It is important to notice that this novel solar heater is still experimental, not fully tested nor validated.

Overview of the solar heater

The solar heater is composed of a water tank surrounded by a reflector, all enclosed in a box, covered with glass. A total of 16 tanks are installed in series. Water is induced by a pump, and a radiator, placed at the heating unit air inlet, pre-heats the drying air (Figure 1).

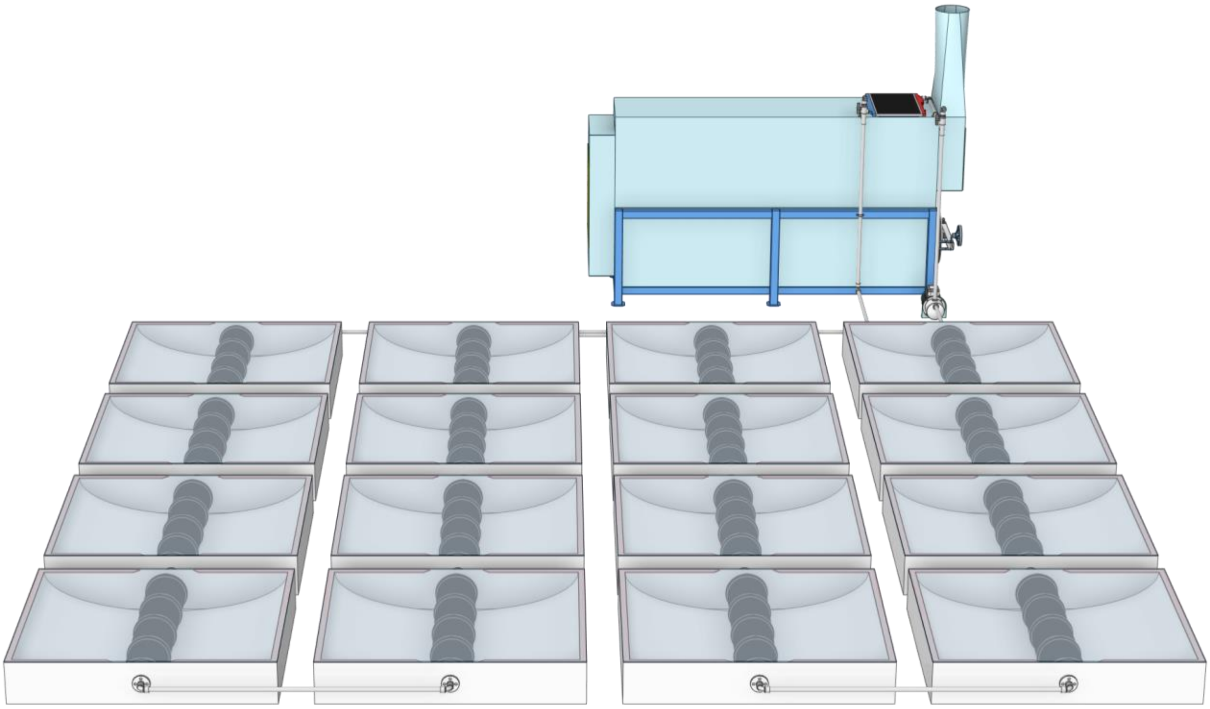


Figure 1 *Solar water heater to assist the firewood powered heating unit.*

Solar collector

The solar collector uses water as the medium. A tank surrounded by a reflector is enclosed in a case covered with a glass on top (Figure 2).

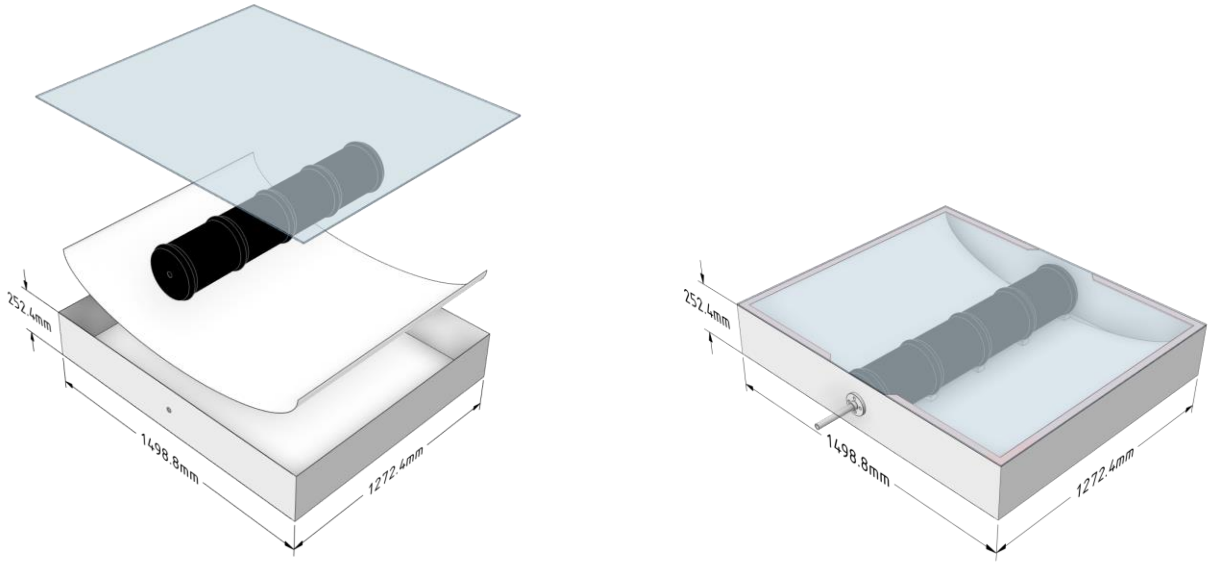


Figure 2 *The solar collector is a water tank surrounded by a reflector and enclosed in a case.*

Water tank

The water tank is built with 1.2 mm thick stainless steel. The tank dimensions are designed to optimize the use of the sheet metal panel and uses a third of it, as shown in Figure 3. The tank should be coated with a heat resistant mate-black paint.

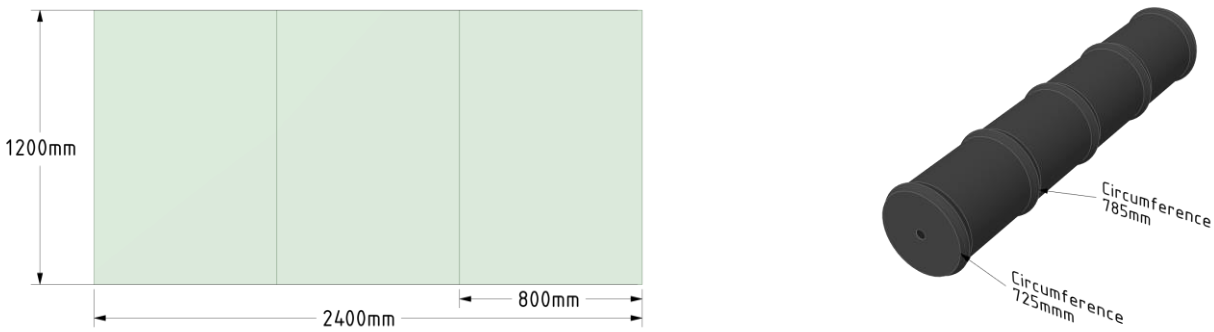


Figure 3 *Water tank can be built using a third of the stainless-steel metal panel.*

To strengthen the sheet metal and avoid the water pressure deforming the tank, structural grooved seams are added to the tank (Figure 4).

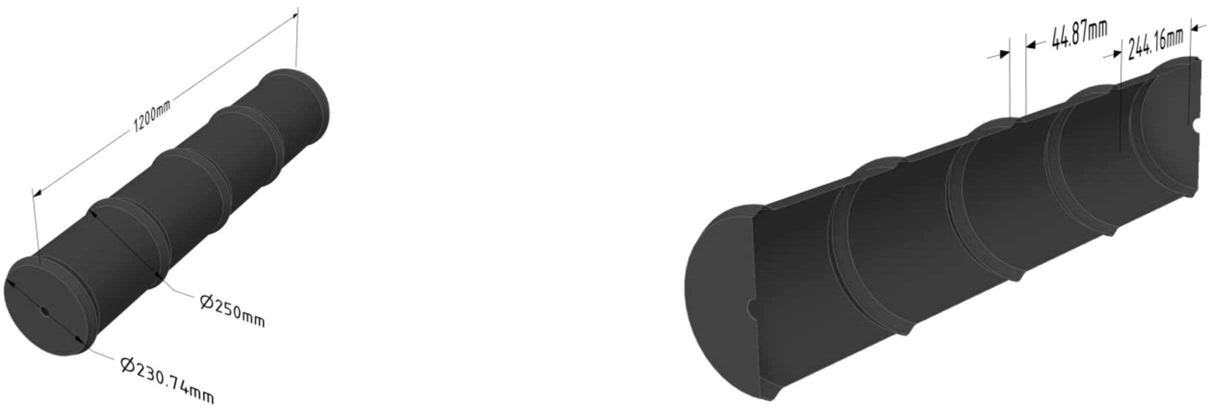


Figure 4 *Structural grooved seams are added to the tank to enhance its strength and rigidity.*

Tank holder

To keep the tank in place, wedges are placed along its length (Figure 5).

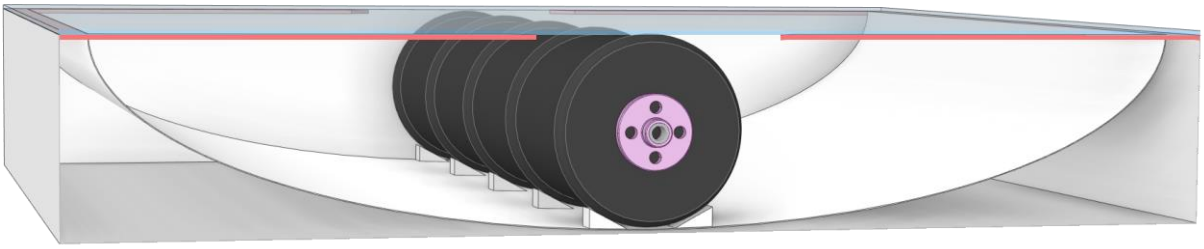


Figure 5 *Wedges are used to hold the tank in place.*

Reflector

The reflector can be build using a flexible mirror, aluminium, stainless steel, or any other highly reflective material. Here, the remaining of the stainless-steel panel is used as shown in Figure 6.

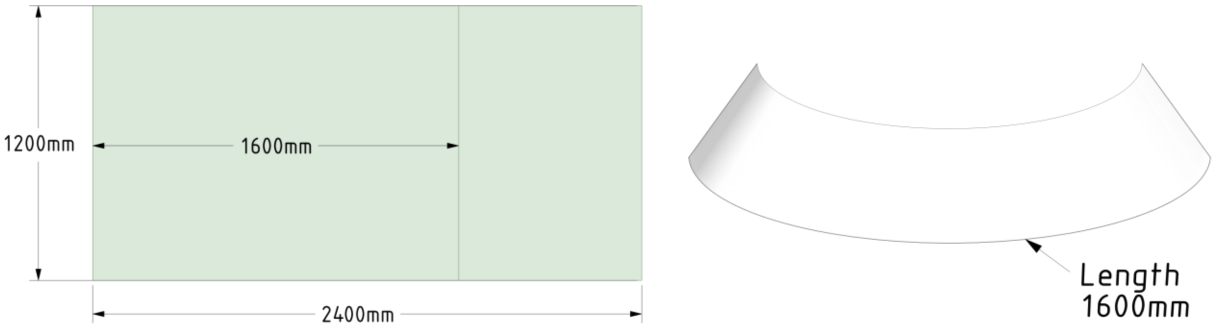


Figure 6 *Reflector can be built using the remaining of the steel panel used to build the tank.*

The reflector should be polished to maximise its reflectance. The shape of the reflector is a parabola with the tank at its focus (Figure 7).

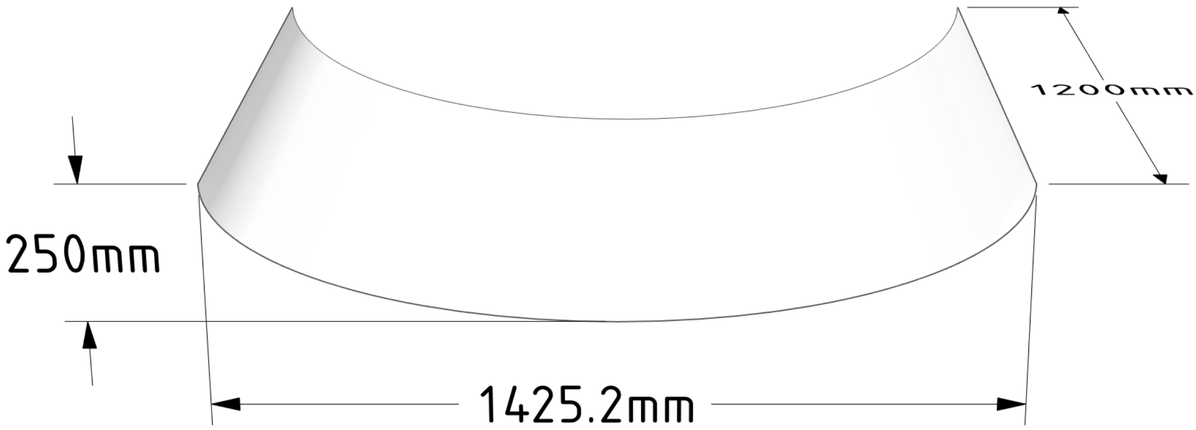


Figure 7 *The reflector has the shape of a parabola (half ellipse) with the tank at its focus.*

Enclosure

The enclosure is a sheet metal folded box. It can be galvanized or coated with corrosion-resistant paint, preferably mate black. The box has a frame at the edge for the fitting of the glass, as shown in Figure 8.

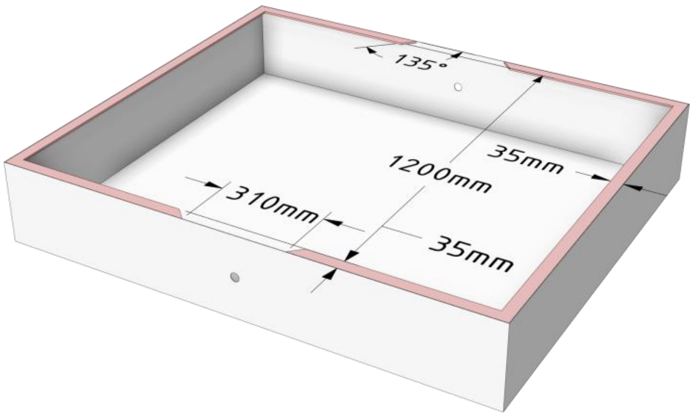


Figure 8 *The box, enclosing the water tank and the reflector, has a frame for fixing the glass.*

Glass cover

The glass is the most fragile part of the solar heater and should be installed in a way that is not subject to the contracting and expanding forces of the enclosure (Figure 9). The type of glass and its thickness can be adjusted according to local availability.

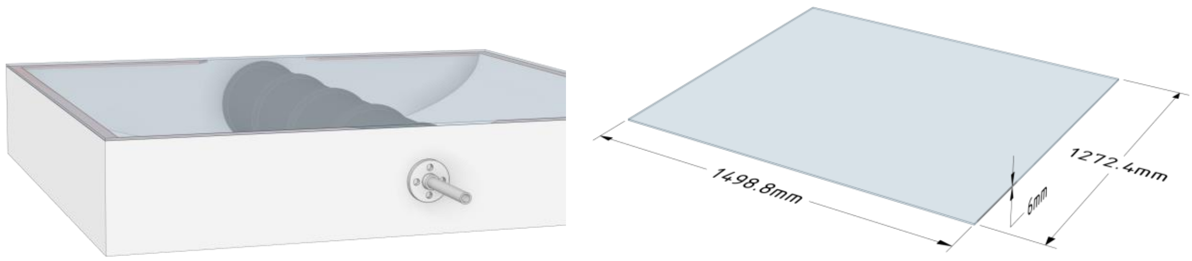


Figure 9 *Discuss with the local dealer about the best choice of glass type and available thickness.*

Radiator

A car radiator is used to transfer the heat accumulated by the water to the air. The model of the radiator depends on the local availability, but its size should match the size of the air inlet of the heating unit (Figure 10).

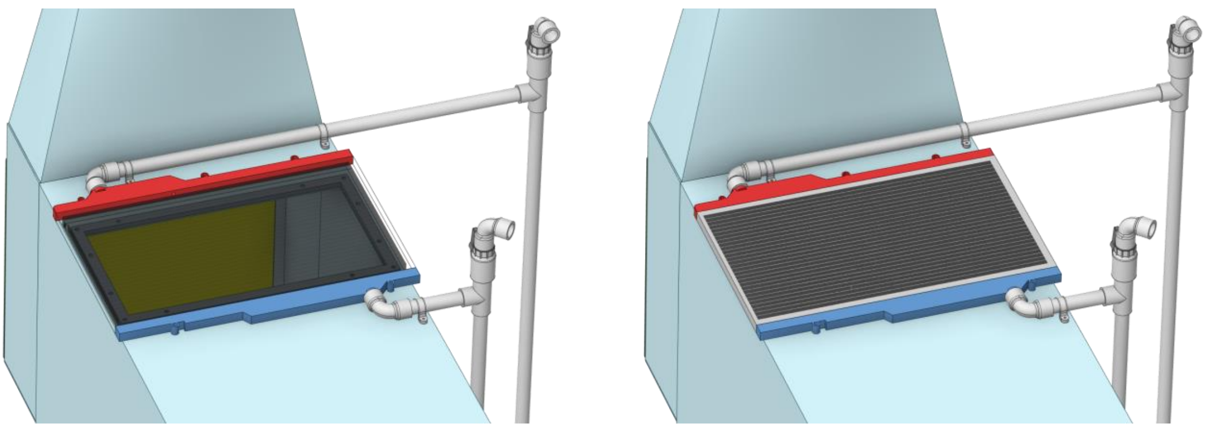


Figure 10 *A car radiator of a size that fits the heating unit air inlet should be used.*

It should be verified that the model of the radiator chosen can be operated in a horizontal position. If no model that can be operated horizontally can be found locally, a duct at the heating unit air inlet must be added, to allow the heat exchanger to be installed vertically.

Depending on the model of the radiator acquired, the air inlet of the heating unit might have to be built further from the chimney to allow space for the connecting pipes (Figure 11).

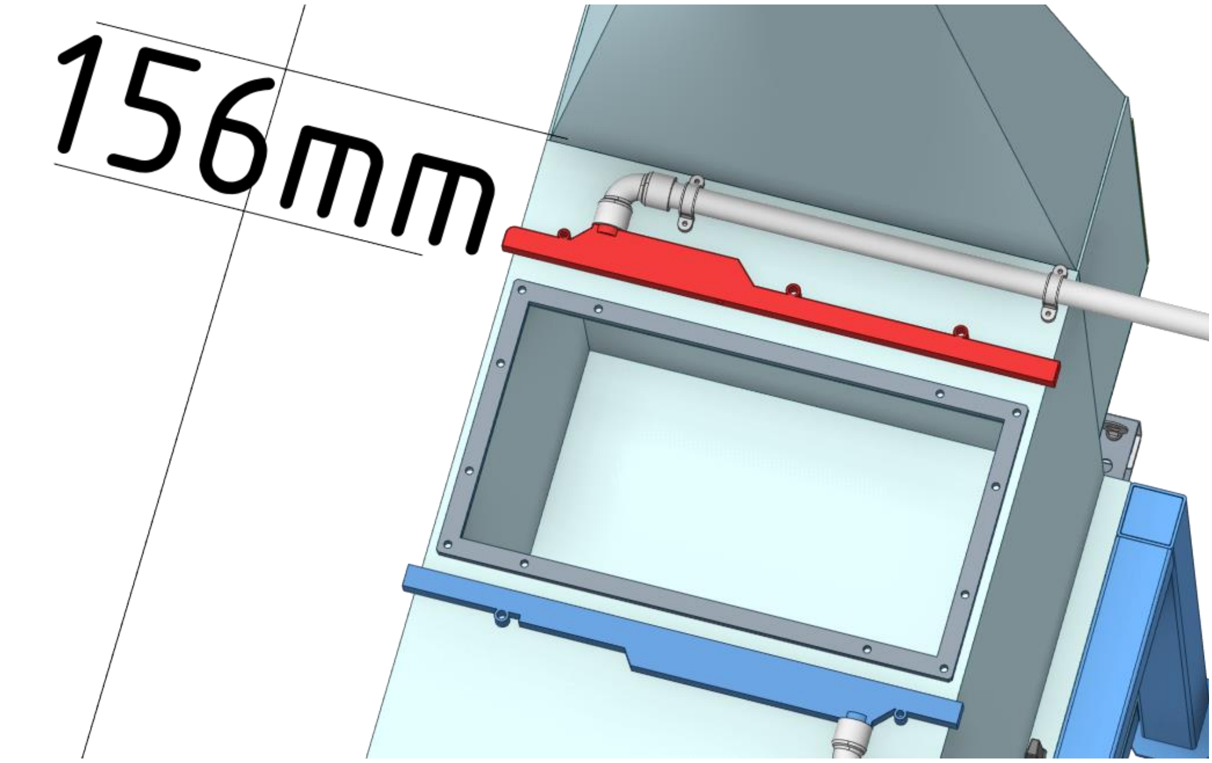


Figure 11 *Heating unit air inlet might have to be built further away from the chimney.*

Water pump

Water flow is induced by a water pump (Figure 12). The model of the pump depends on the local availability, but it must be able to withstand water at a temperature up to 85 °C. Preference should be made to a water pump designed to circulate water, instead of a pump designed to raise water. In addition, a pump with a higher head is preferable than a pump with a higher flow rate.

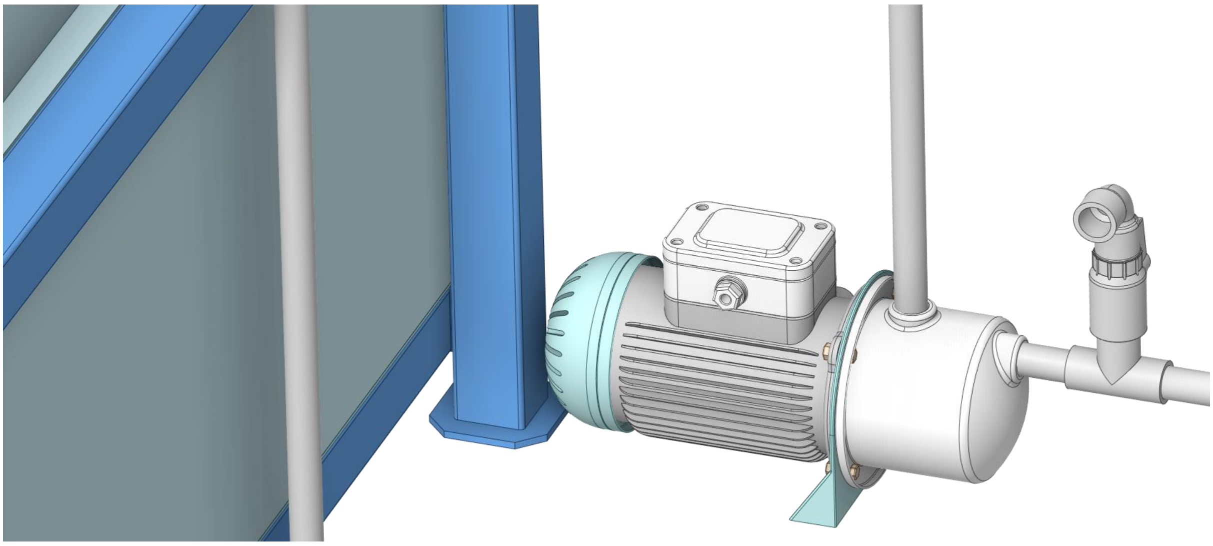


Figure 12 *Pump must be able to withstand water at 85 °C.*

Plumbing

Plumbing layout should be carefully planned in a way to minimize elbows and bends, as illustrated in Figure 12.

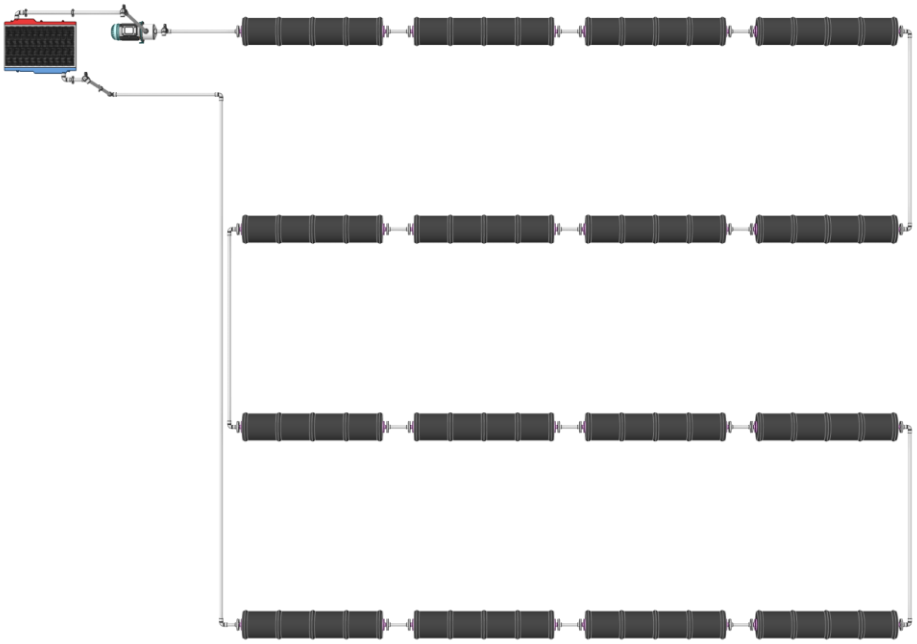


Figure 12 *Pipeline should be planned to minimize the use of bend and elbows.*

Pipe size and connection style can be chosen according to local availability, but it should be able to withstand temperatures up to 85 °C. CPVC pipes for hot water are recommended. All pipes and elbows must be covered with pipe insulation (i.e., flexible rubber foam, fibreglass, polyethene foam, etc.)

On/Off valves should be fitted in the pipeline, to facilitate filling the tanks with water, to prime the water pump, and to release the pressure built from the water expansion when heated (Figure 13). Anytime the system is not being used the valves should be left open to avoid pressure build-up and consequent damage to the pipeline and water tanks.

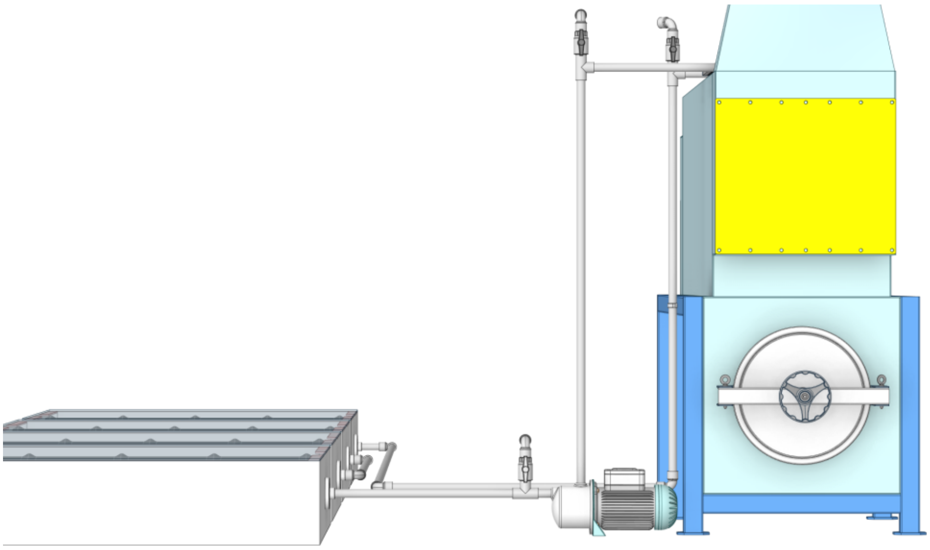


Figure 13 *Valves installed in the pipeline must remain open when the system is not in use.*

Equipment dimensions

Figure 14 is an interactive 3D drawing of the solar heater and Appendix 1 shows its main dimensions. However, exact figures should be obtained from the 3D CAD file available at https://a360.co/3ivPnTn. This link allows visualization and downloading the file in IGES, STEP and other commonly used 3D CAD formats. Please note that only the outer shell of the firewood powered heating unit is included in this drawing. For the full assembly of the heating unit, please refer to Part 1 of the construction manual.

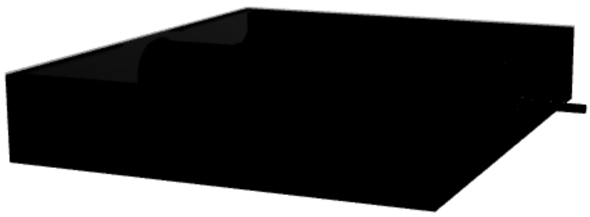


Figure 14 *Interactive 3D drawing of the solar heater (visualization requires activating 3D tools).*

Finances

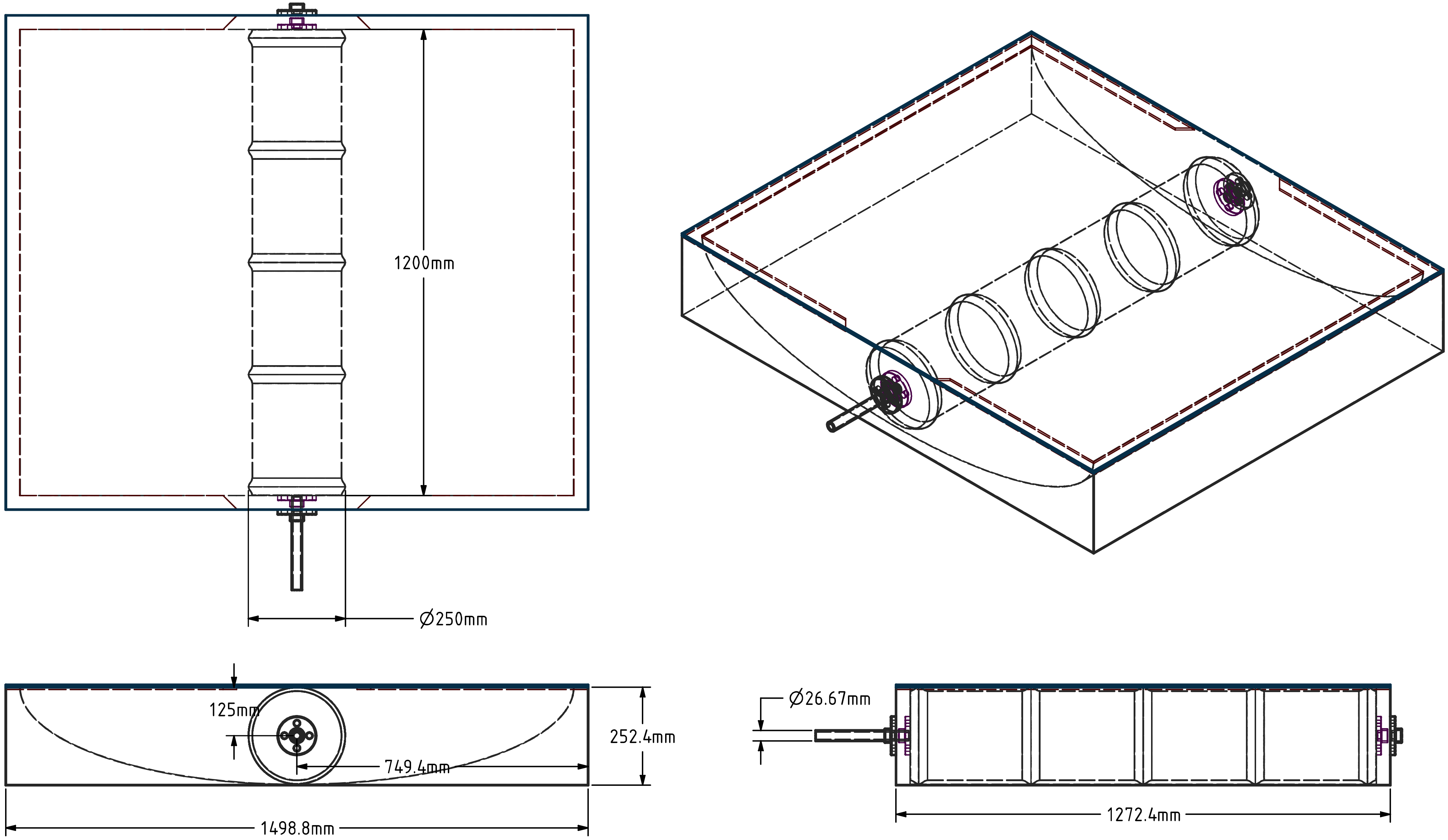
The construction of this equipment will be funded by HEIF 2020/2021. Payments will be made via international bank transfer, in two instalments, one at the start and one at completion. Once authorized, payments might take up to 28 days to be processed.

Follow-up activities

The heating unit must be built and installed at Windwood Millers' processing centre latest by the end of February, so it can be tested and troubleshot in March. Table 1 shows the work schedule.

Table 1 *Work schedule of the follow-up activities.*

Tasks	**Responsible**	**Jan**	**Feb**	**Mar**
Obtain a quote for construction and installation	Windwood Millers			
Construction and installation	Awiko Engineering			
Test and troubleshooting	University of Greenwich			



Appendix 1

Natural Resources Institute

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