POWERING AGRICULTURE:
AN ENERGY GRAND CHALLENGE FOR DEVELOPMENT

Feasibility Report

Insulation Materials available in Zambia and suitable for Cooling Insulation in conjunction with standardised Solar Cooling Units in Rural Areas

Prepared by:

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For the PAEGC initiative on behalf of:

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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Sweden Sverige

german cooperation DEUTSCHE ZUSAMMENARBEIT

DUKE ENERGY

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Published by:
Deutsche Gesellschaft für
internationale Zusammenarbeit (GIZ) GmbH

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Bonn and Eschborn, Germany

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Programme description:
Powering Agriculture: An Energy Grand Challenge for Development (PAEGC).

An initiative funded by the United States Agency for International Development (USAID), the Swedish International Development Cooperation Agency (SIDA), the German Federal Ministry for Economic Cooperation and Development (BMZ), Duke Energy, and the Overseas Private Investment Corporation (OPIC).

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On behalf of:

Federal Ministry for Economic Cooperation and Development (BMZ)
Division 122 - Sustainable agricultural supply chains, international agricultural policy, agriculture, innovation

53045 Bonn, Germany

GIZ is responsible for the content of this publication.

Eschborn, 2019

Summary /Abstract

This study explores the suitability of different insulation materials for the use with solar-powered cooling units for the dairy value chain in Zambia. Rapid milk cooling to storage temperatures of between 4°C and 6 °C and once cooled keeping the milk at these temperatures is important in order to preserve the quality. Good insulating materials play a major role by impeding heat transmission from the outside of the cooling cob and thereby reducing the energy required to maintain the milk at the above optimum temperature.

The work done and the criteria used to evaluate the suitability revealed that while the commercial materials with a higher insulating capacity would be the obvious choice there is need to explore other technics and concepts using natural materials for stationary cooling boxes in rural areas.

	R-Value	Availability	Durability	Cost per M2	Cost per R-Value Point
Polystyrene	avg. 5.45	good	good	~ 121 ZMW/m2	~ 22.20 ZMW
Polyurethane	avg. 9.00	endangered	very good	~ 162 ZMW/m2	~ 18.00 ZMW
Fiberglass	avg. 2.40	very good	satisfactory	~ 23 ZMW/m2	~ 9.58 ZMW
Sand	avg. 0.25	very good	difficult	~ 14 ZMW/m2	~ 56.00 ZMW
Lose Corn Cops	avg. 1.34	good	difficult	~ 30 ZMW/m2	~ 22.38 ZMW
Polyurethane & Lose Corn Cops	avg. 6.40	good	satisfactory/ difficult	~ 344 ZMW/m2	~ 53.75 ZMW
Corn Cops & Lime	avg. 0.35	good	difficult	~ 90 ZMW/m2	~257.00 ZMW
Shredded Paper / Card Board	avg. 0.56	good	difficult	~ 15 ZMW/m2	~ 26.78 ZMW

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1.0 Introduction and Background

About 72% of Zambia's population still lacks access to electricity, with many relying on expensive, unreliable or potentially harmful energy sources.

Insufficient cooling systems are a key constraint for many small-scale dairy farmers in Zambia and Africa at large. Many farmers and processors unnecessarily lose significant earning potential due to the lack of refrigerated storage and transportation. Milk collection networks are often unreliable – resulting in high microbial contamination of the milk. This results in the milk being rejected at the collection points or processing plants or worse, posing a food safety risks to consumers.

Quality low-cost, energy-efficient refrigerators customized for rural, off-grid markets can contribute to the increased uptake of solar cooling systems in rural areas for households and for agricultural value chains. The demand for refrigerators will be driven in part by their potential contribution to income-generating activities.

Nevertheless, issues around design and pricing need to be addressed in order for refrigerators to be viable for off-grid communities.
The objective of the Research presented in this report is to explore the technical feasibility and practical use of solar-powered cooling technologies in Zambia with a focus on the locally available insulation materials, with the aim of enabling dairy farmers to increase productivity and income.

The institute of Agricultural Engineering at the University of Hohenheim has been working on developing, testing and introducing solar milk cooling systems (SMCs) in different countries since 2015. The SMCs are an innovative and sustainable solution to cool milk suitable to be used both on-farm and off-farm (i.e. at a Milk Collection Centre). Based on three basic systems developed and tested by the University of Hohenheim context-specific and user-tailored adaptations can be built locally.\

As the innovative technology developed by the University of Hohenheim offers the possibility to locally assemble the units, value-addition takes place in the country of assembly and jobs can be created locally. The information gathered could provide valuable insights for other countries in Southern Africa in terms of using solar power for cooling purposes and even lay the foundation for further research to demonstrating applications for other perishable products such as fish or vegetables.

2.0 Heat Transfer

In the milk value chain it is desirable to transfer the heat from the milk that comes out of the cows udder at 35 °C, thereby lowering the temperature to between 4 °C and 6 °C. This is done by the cooling unit acting as a heat pump. Thereafter it is the role of the insulating material to impede or resist the flow of heat from the warm environment to the cooled space holding the milk. Understanding the modes of heat transfer is key to selecting appropriate insulating materials. The key determinant of how good an insulator is, is its ability to resist heat transfer. The tests done indicated this resistance.

Heat transfer is the transition of thermal energy, or simply heat, from a hotter object to a cooler object. There are three main modes of heat transfer

2.1 Thermal conduction

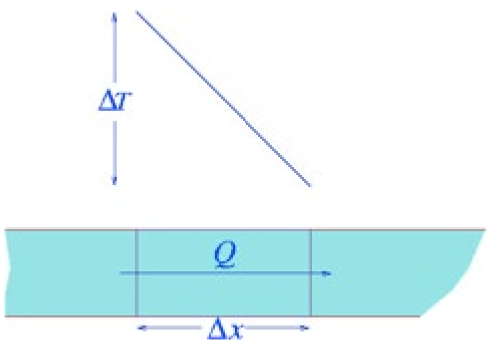
Conduction is the most significant means of heat transfer in a solid. It is also the primary means of heat transfer in cooling systems insulating materials. On a microscopic scale, conduction occurs as hot, rapidly moving or vibrating atoms and molecules interacting with neighboring atoms and molecules, transferring some of their energy (heat) to these neigh-boring atoms. The free movement of electrons also contributes to conductive heat transfer.

The law of heat conduction, also known as Fourier's law, means that the rate, in time, of heat transfer through a material is proportional to the negative gradient in the temperature and to the area at right angles, to that gradient, through which the heat is flowing:

$$\frac{\partial Q}{\partial t} = -k \oint_S \nabla T \cdot dS$$

where:

Q is the amount of heat transferred, and
t is the time taken, and
k is the material's thermal conductivity' and
S is the area through which the heat is flowing, and
T is the temperature.



Thermal conductivity usually varies with temperature, but the variation can be small, over a significant range of temperatures, for some common materials.

2.2 Thermal convection

Convection is usually the dominant form of heat transfer in liquids and gases. Convection comprises the combined effects of conduction and fluid flow. In convection, enthalpy transfer occurs by the movement of hot or cold portions of the fluid/gas together with heat transfer by conduction. So basically, Convection is the movement of heat because of the movement of warm matter.

2.3 Thermal Radiation

Radiation is the only form of heat transfer that can occur in the absence of any form of medium (i.e., in a vacuum). Thermal radiation is based on the emission of electromagnetic radiation, which carries energy away from the surface. At the same time, the surface is constantly bombarded by radiation from the surroundings, resulting in the transfer of energy to the surface.

For example a person in front of a fire can warm up because of the light of the fire, even if the air is cold. Another example of thermal radiation is the heat that comes from the Sun to the Earth.

3.0 Types of Thermal Insulation

Thermal insulation materials in milk cooling systems are specifically designed to reduce the heat flow from the warm air outside the cooling box by limiting heat conduction, convection, radiation or all three while. This reduces the energy required to use the solar cooling unit to maintain the milk at the desired temperature

There are three general material types into which thermal insulation materials can be categorized

3.1 Fibrous Insulations

Fibrous insulations are composed of small diameter fibers, which finely divide the air space. The fibers may be perpendicular or parallel to the surface being insulated, and they may or may not be bonded together. Silica, glass, rock wool, slag wool and alumina silica fibers are used. The most widely used insulations of this type are glass fiber and mineral wool

3.2 Cellular Insulations

Cellular insulations contain small individual cells separated from each other. The cellular material may be glass or foamed plastic such as polystyrene (closed cell), or polyurethane.

3.3 Granular Insulations

Granular insulations have small nodules, which contain voids or hollows. These are not considered true cellular materials since gas can be transferred between the individual spaces. This type may be produced as a loose or pourable material, or combined with a binder and fibers to make a rigid insulation. Examples of these insulations are calcium silicate, cellulose, diatomaceous earth and expanded polystyrene.

Another taxonomy distinguishes by the origin of the insulation material:

3.4 Organic insulation materials

Organic insulating materials are usually made from natural, renewable raw materials from animals or plants. For a stronger bond and increased fire protection, they are impregnated or provided with artificial fibers. As a result, organic insulating materials are not per se completely sustainable and natural - yet they are generally more environmentally friendly than mineral or synthetic solutions.

3.5 Mineral insulation materials

Mineral insulation materials consist of inorganic materials such as stone, sand or lime. These can be both of synthetic and natural origin. In addition to good thermal insulation, the insulation materials are characterized by a natural fire protection, so that no further treatment of the substance is necessary in this regard. In addition, mineral insulation materials have excellent moisture regulation.

3.6 Synthetic insulation materials

Synthetic insulation materials are inexpensive and do not rot, which is why they are more widely used in cooling systems. They consist of plastic materials refined to rigid foams. Although synthetic insulation materials are less sustainable than organic or mineral substances because of their petroleum base, synthetic insulation materials are particularly resistant and thus durable

4.0 Insulating materials and their insulation performance

In this section, the study looks at different properties of insulating materials in order to investigate their suitability for use in cooling systems in the milk value chain.

4.1 Thermal Conductivity

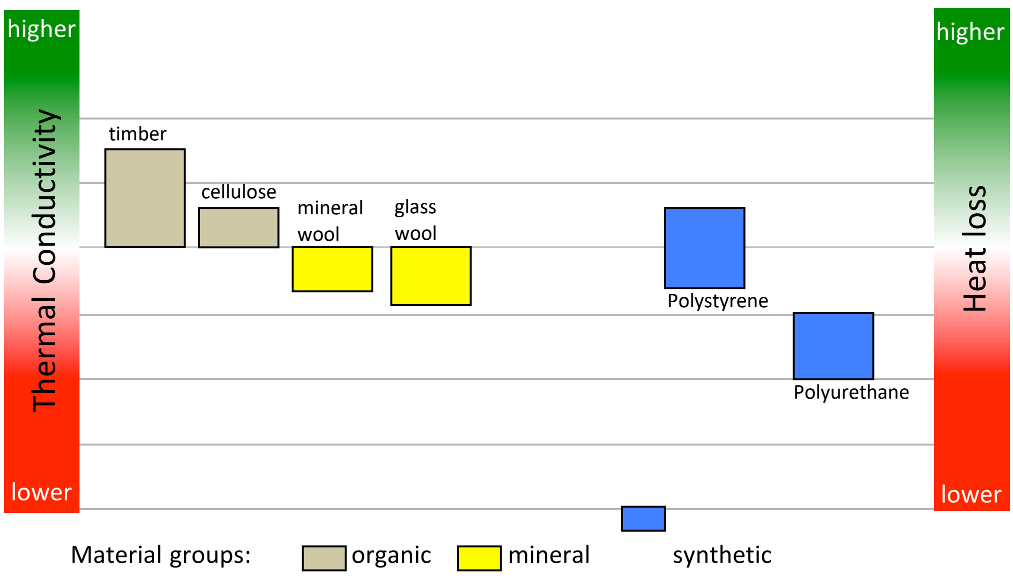
How well a material insulates is indicated by the thermal conductivity. The so-called λ-value depicts the heat flow, with which heat is distributed in a square meter of insulating material and lost to the outside. Thus, a low value indicates a low speed and thus good insulation properties.

4.2 Heat Storage Capacity

Another important property of insulating materials is the heat storage capacity. It determines how much thermal energy a material can store. Insulating materials with a high heat storage capacity can absorb temperature peaks better. The higher the capacity, the better the protection against external thermal influences

Properties	**in practice**	**Example**
Heat storage capacity low, thermal conductivity high	The space heats up quickly, but cools down quickly with the issue of heating. Heat or cold quickly penetrates the insulating material.	Mineral wool
Heat storage capacity high, thermal conductivity low	The dissipation of heat in the insulation takes longer, but also lasts longer, so that the space cools down more slowly. Heat or cold penetrate slower into the insulation material.	Polyurethane (PUR)

Insulating materials and their relative insulation performance



5.0 R-Value

Thermal Conductivity λ is a thermo-physical property that determines the ability of a material to transfer heat. The value of the thermal conductivity is characterized by the quantity of heat passing per unit of time per unit area at a temperature drop of 1°C per unit length. It depends on the medium's phase, temperature, density, molecular bonding, humidity and pressure. The R value is a measure of thermal resistance of the insulating material. The higher the number, the better the effectiveness of the insulation. R value is the reciprocal of U value.

$R = d / \lambda$ = thermal resistance

Often in heat transfer the concept of controlling resistance is used to determine how to either increase or decrease heat transfer. Heat transfer coefficients represent how much heat is able to transfer through a defined region of a heat transfer area. The inverse of these coefficients are the resistances of those areas. The heat transfer coefficient k or U value is defined as:

$k = \lambda / d$ = U value (k value)

6.0 Common types of insulation materials

6.1 Fiberglass

Fiberglass is the most common insulation used in modern times. Because of how it is made, by effectively weaving fine strands of glass into an insulation material, fiberglass is able to minimize heat transfer. The main downside of fiberglass is the danger of handling it. Since fiberglass is made out of finely woven silicon, glass powder and tiny shards of glass are formed. These can cause damage to the eyes, lungs, and even skin if the proper safety equipment isn't worn. Nevertheless, when the proper safety equipment is used, fiberglass installation can be performed relatively safely.

Fiberglass is an excellent non-flammable insulation material, with R-values from our tests ranging from 2.35 to 2.45 per inch of material thickness. Installing fiberglass insulation requires safety precautions including use eye protection, masks, and gloves.

6.2 Mineral Wool

Mineral wool actually refers to several different types of insulation. First, it may refer to glass wool which is fiberglass manufactured from recycled glass. Second, it may refer to rock wool which is a type of insulation made from basalt. Finally, it may refer to slag wool which is produced from the slag from steel mills. The majority of mineral wool in the United States is actually slag wool.

Mineral wool can be purchased in batts or as a loose material. Most mineral wool does not have additives to make it fire resistant, making it poor for use in situation where extreme heat is present. However, it is not combustible. When used in conjunction with other, more fire resistant forms of insulation, mineral wool can definitely be an effective way of insulating large areas. Mineral wool has been measured by others to have R-values ranging from 2.8 to 3.5 per inch of thickness.

6.3 Cellulose

Cellulose insulation is perhaps one of the most eco-friendly forms of insulation. Cellulose is made from recycled cardboard, paper, and other similar materials and comes in loose form. Cellulose has measured by others to have R-values ranging from 3.1 to 3.7 per inch of thickness. Some recent studies on cellulose have shown that it might be an excellent product for use in minimizing fire damage. Because of the compactness of the material, cellulose contains next to no oxygen within it. Without oxygen within the material, this helps to minimize the amount of damage that a fire can cause.

So not only is cellulose perhaps one of the most eco-friendly forms of insulation, but it is also one of the most fire resistant forms of insulation. However, there are certain downsides to this material as well, such as the allergies that some people may have to newspaper dust. Also, finding individuals skilled in using this type of insulation is relatively hard compared to, say, fiberglass. Still, cellulose is a cheap and effective means of insulating.

6.4 Polyurethane Foam

While not the most abundant of insulations, polyurethane foams are an excellent form of insulation. Nowadays, polyurethane foams use non-chlorofluorocarbon (CFC) gas for use as a blowing agent. This helps to decrease the amount of damage to the ozone layer. They are relatively light, the test sample tested had R-value ranging between 8 and 10 per inch of thickness. Another advantage of this type of insulation is that it is fire resistant.

6.5 Polystyrene

Polystyrene is a thermoplastic foam which is an excellent sound and temperature insulation material. It comes in two types, expanded (EPS) and extruded (XEPS). The two types differ in performance ratings and cost with the XEPS being more costly and less permeable to moisture. The EPS measured had a R-value randing from 5.00 to 5.90 per inch of thickness. Polystyrene insulation has a uniquely smooth surface which no other type of insulation possesses.

6.6 Other Insulation Materials

The are a number of alternative insulation materials which do not play any significant role in our context as far as we can perceive the situation. These include insulating materials that are deemed not food safe, those that emit dangerous emissions in the case of a fire, and those that require considerable skills to handle and install.

7.0 Test set-up

7.1 Initial Test Design and Set up

The initial Test set-up was meant to use a climate chamber. Within that climate chamber the environment around the test box – especially in terms if temperature – can be fully controlled. The simple hot-box – or better "Cold-Box" - would then be covered with different test materials.

For each test material, we would then be able to monitor, how long a standardized ice cube (0.5kg or 1kg) would take to melt or the temperature in the test box would rise from 0 Celsius to e.g. 5 Celsius. In addition to that, a special heat flux sensor would directly measure the R-Value of the test materials.

Above: Climate Chamber – Outside and Entrance Area

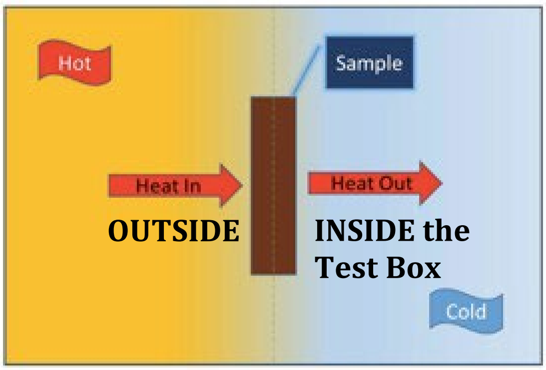
Above: Climate Control in the Climate Chamber / Test Box

Below: Test Box Stand with Temperature Sensor

Unfortunately the research team had to experience a period of very extended Load Shedding in Zambia (up to 18 hours). The unreliable power supply situation made it literally impossible to run the initial set up: Sensor data and monitoring data got lost during the power outages, calibrations had to be done over and over again and it turned out to be impossible to produce a 1 KG ice cube.

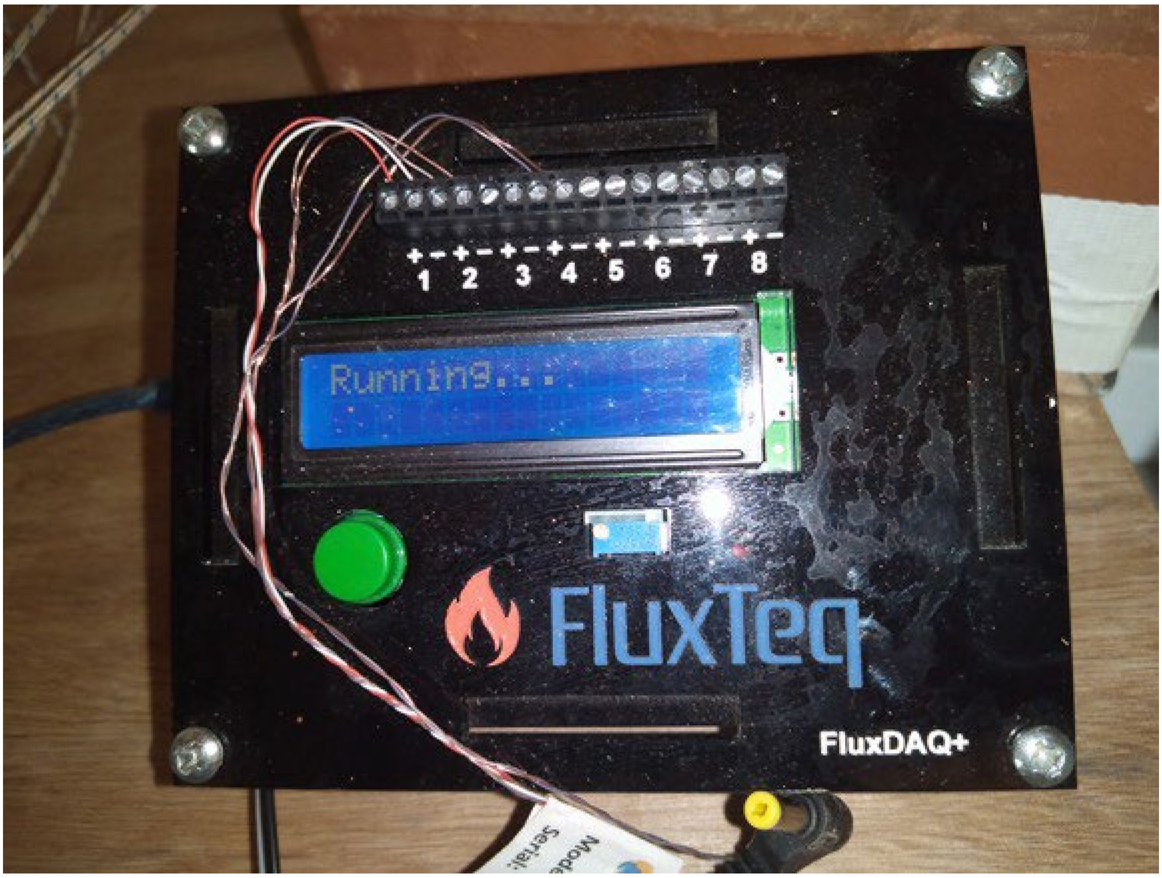
7.2 New Test Design and Set up

In respect to the time critical situation, it was decided to skip the procedure with the climate chamber, and run the heat flux measurements just with the test box in the natural environment. For that a solar system had to be set up, that would allow for reliable 24/7 power supply. As the ambient temperature was constant around 30 °C, the produced data is still valuable and valid. According to Climates to travel a World climate guide website the maximum temperatures in Zambia range between 29 °C and 33 °C.



Above: Simple Hot Box

Below: Calibrating the Heat Flux Sensor / Changing Test Material



Above: Heat Flux Sensor and Measuring Device

8.0 Test and evaluation criteria

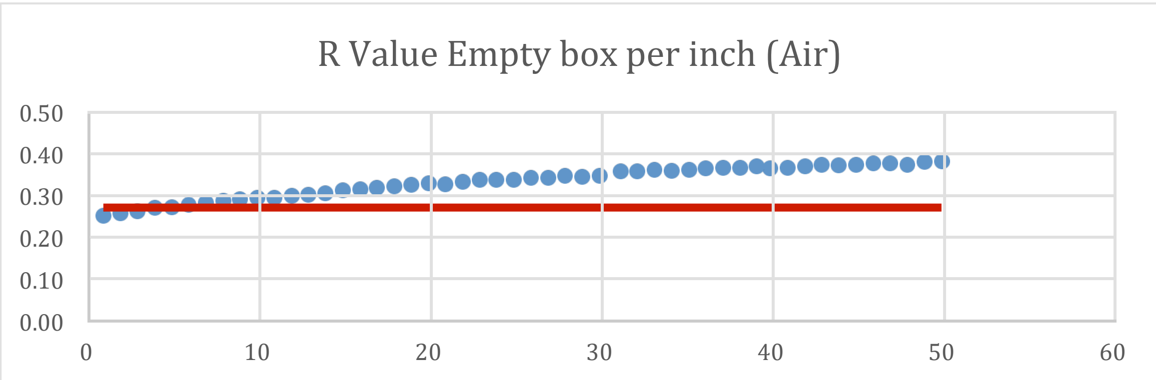
To decide if a specific material is suitable as insulation material in our context and to compare the different materials among each other, we selected 4 verification dimensions:

R-value

The R-Value - as pointed out further up – is a quite objective measurement of the insulation properties of a material.

Because all / most materials had to be put together in a frame, an empty box measurement was taken to show the material R-Value of the frame (including the air inside).

All R-Values are standardized to an R-Value for 1-inch thickness of the insulation material. The R-Value is generally linear proportional to the thickness of the material. That has an important impact on the evaluation of the materials in their respective function and physical position.



Availability

Some commercial as alternative materials may be available, but not all the time and sourcing can be a challenge – others are nowadays readily available at any time.

We rated if the materials where locally produced or needed to be imported. If they are locally imported, the question is, if all or the main ingredients need importation or if they are locally available. And finally, how many suppliers are actually stocking and selling the respective materials.

Durability

The usage of the materials in our specific situation, purpose and environment may relativizes the overall rating of a material.

We rated, if the handling of the materials is non-problematic or if special safety gear is required. We also considered the stability of the material and the requirement of special tool for working with such materials.

Cost

Cost is a very important, if not the most important aspect for an economically viable dissemination of this technology. Cost also needs to involve cost of handling and logistics. We normalized to the cost, so that the prices are comparable on an area level.

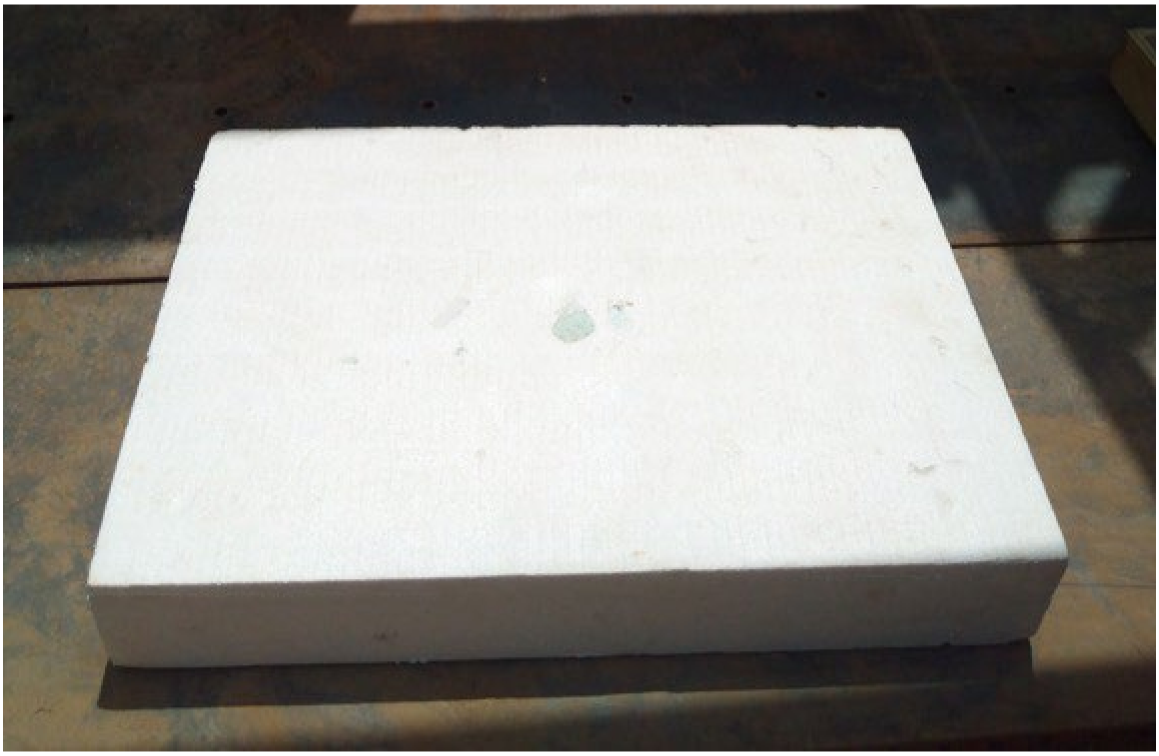
Taking into account that the R-Value is linear proportional to the thickness of the material, it is possible to calculate the cost for each material to provide a specific R-Value.

9.0 Tested Materials and Results

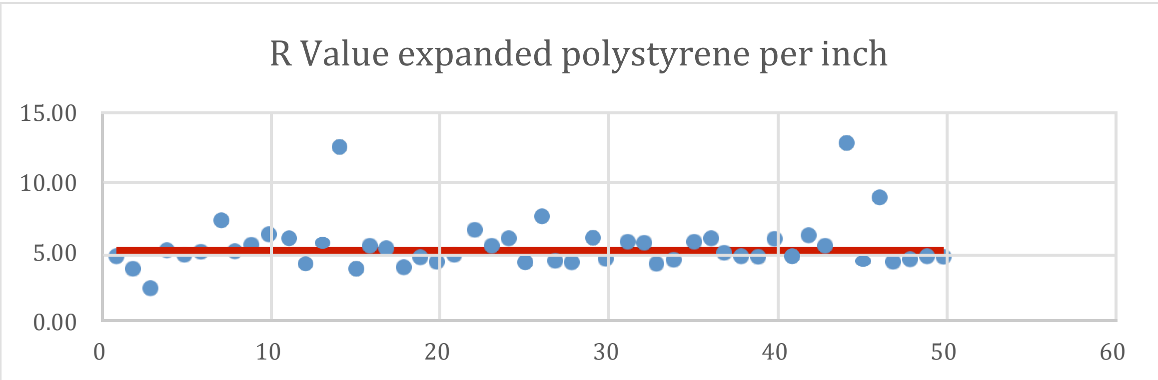
	R-Value	Availability	Durability	Cost per M2	Cost per R-Value Point
Polystyrene	avg. 5.45	good	good	~ 121 ZMW/m2	~ 22.20 ZMW
Polyurethane	avg. 9.00	endangered	very good	~ 162 ZMW/m2	~ 18.00 ZMW
Fiberglass	avg. 2.40	very good	satisfactory	~ 23 ZMW/m2	~ 9.58 ZMW
Sand	avg. 0.25	very good	difficult	~ 14 ZMW/m2	~ 56.00 ZMW
Lose Corn Cops	avg. 1.34	good	difficult	~ 30 ZMW/m2	~ 22.38 ZMW
Polyurethane & Lose Corn Cops	avg. 6.40	good	satisfactory/ difficult	~ 344 ZMW/m2	~ 53.75 ZMW
Corn Cops & Lime	avg. 0.35	good	difficult	~ 90 ZMW/m2	~257.00 ZMW
Shredded Paper / Card Board	avg. 0.56	good	difficult	~ 15 ZMW/m2	~ 26.78 ZMW

9.1 Commercially available Materials

9.1.1 Polystyrene



R-Value: 5.45



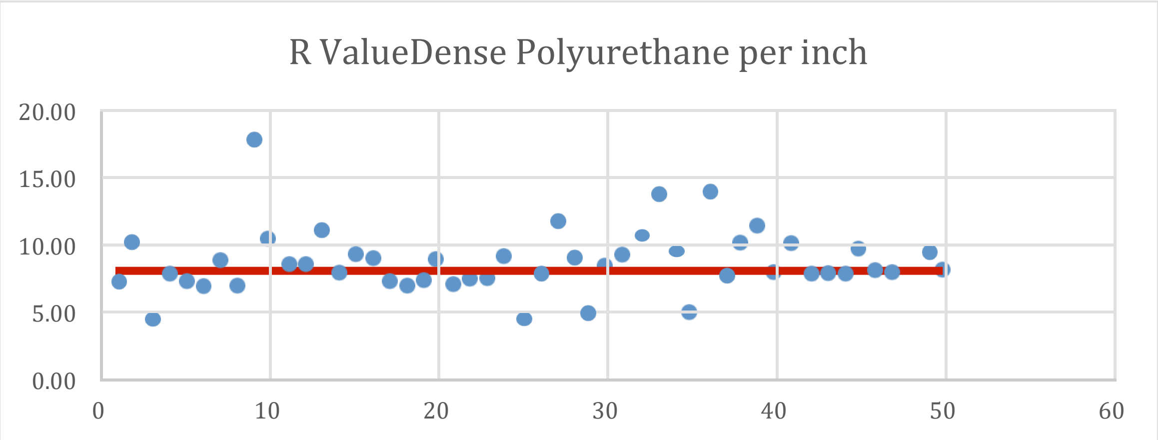
Availability: readily available on order as it is manufactured locally though lead supply time is determined by availability of stock at manufacturing plant.

Durability: needs to be handled with care as it can easily break but durable once installed, can further absorb water to some extent causing it to lose its initial properties

Cost: 121.00 ZMW/m2 22.20 ZMW per 1-R-Value Point/m2

9.1.2 Polyurethane

R-Value: 9.00



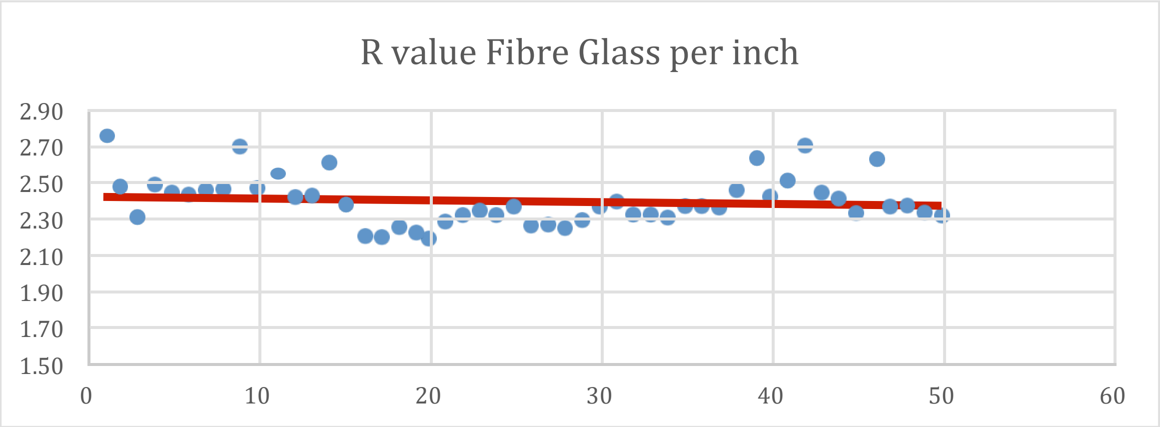
Availability: available though only through 1 local supplier hence there could be delays on lead supply time

Durability: very good material and doesn't require any protective gear when handling and causes no side effects.

Cost: 162.00 ZMW/m2 18.00 ZMW per 1-R-Value Point/m2

9.1.3 Fiberglass

R-Value: 2.40



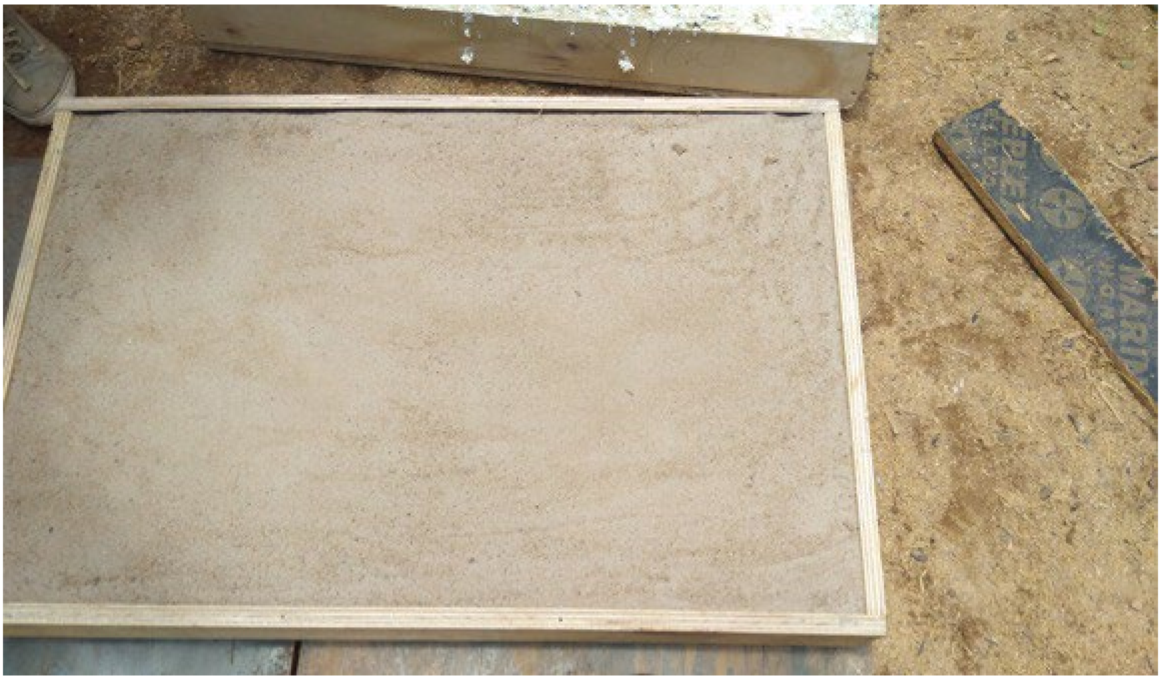
Availability: so many suppliers readily available on the Zambian local market though not locally produce but imported

Durability: very durable and can stay for a long period of time, however; needs special protective gear when handling as it cause itching once it gets in contact with the skin and can also cause possible respiratory problems if fibers are inhaled.

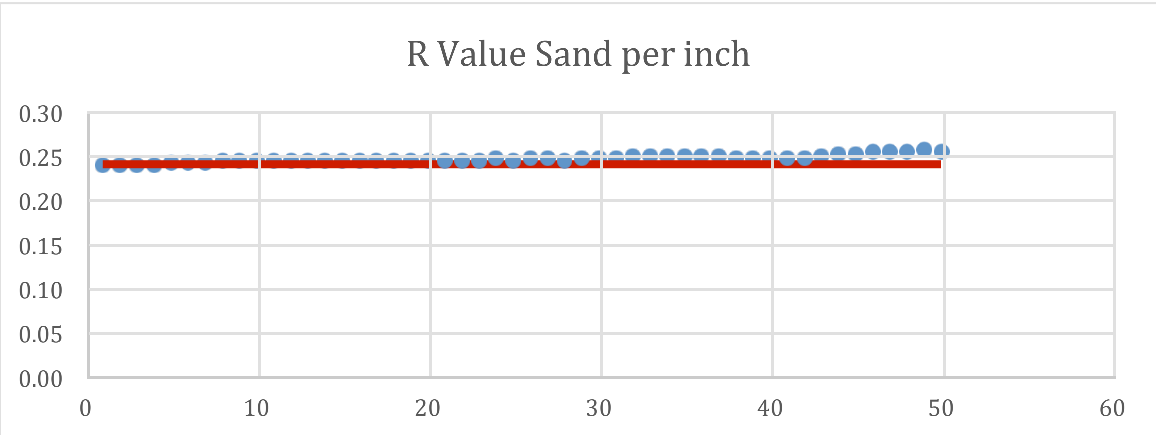
Cost: 23.00 ZMW/m2 9.58 ZMW per 1-R-Value Point/m2

9.2 Recycled / Alternative Materials

9.2.1 Sand



R-Value: 0.25



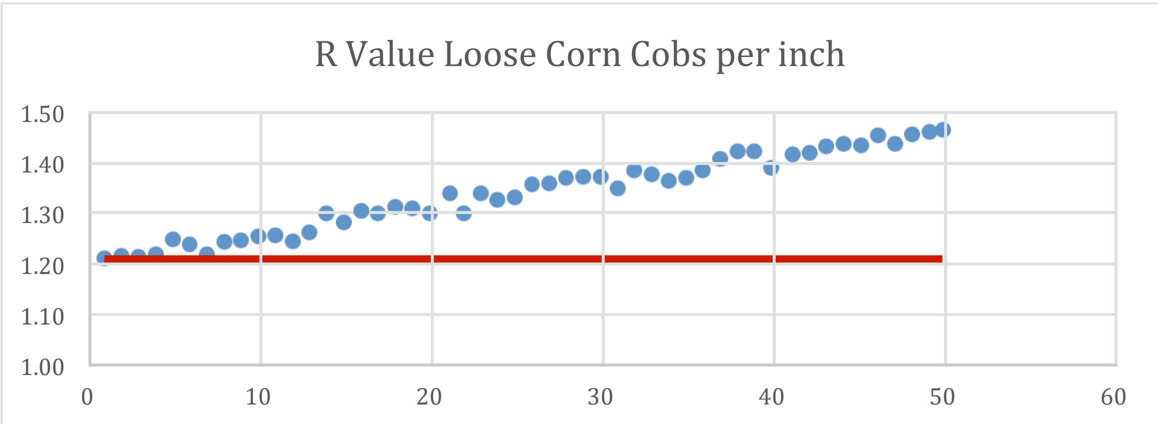
Availability: readily available in most places and can easily be sourced, no special handling required

Durability: not very durable as it can easily absorb water and takes long to dry up, could require sanitizers as-well to prevent fungal/bacteria from being formed.

Cost: 14.00 ZMW/m2 56.00 ZMW per 1-R-Value Point/m2

9.2.2 Lose Corn Cobs

R-Value: 1.34



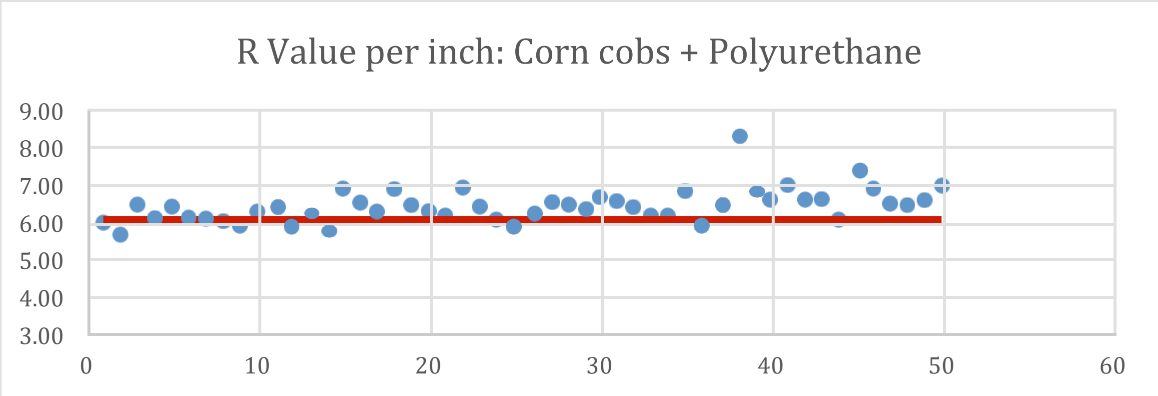
<u>Availability:</u> readily available on the local Zambian market, seasonal as have to wait in times when corn cobs are dry.

<u>Durability:</u> not very durable as it can easily absorb water causing it to lose its properties and rot.

<u>Cost:</u> 30 ZMW/m2 22.38 ZMW per 1-R-Value Point/m2

9.2.3 Polyurethane & Corn Cobs

R-Value: 6.40



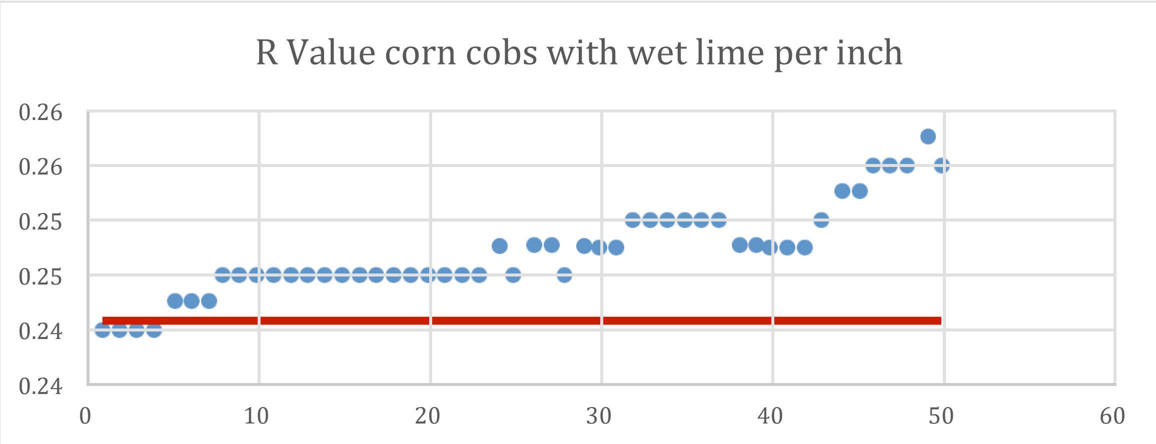
Availability: both mixed materials are readily available on the local Zambian market though the corn cobs could be seasonal when they are dry, should be noted that the polyutherane used during this test was the spray foam.

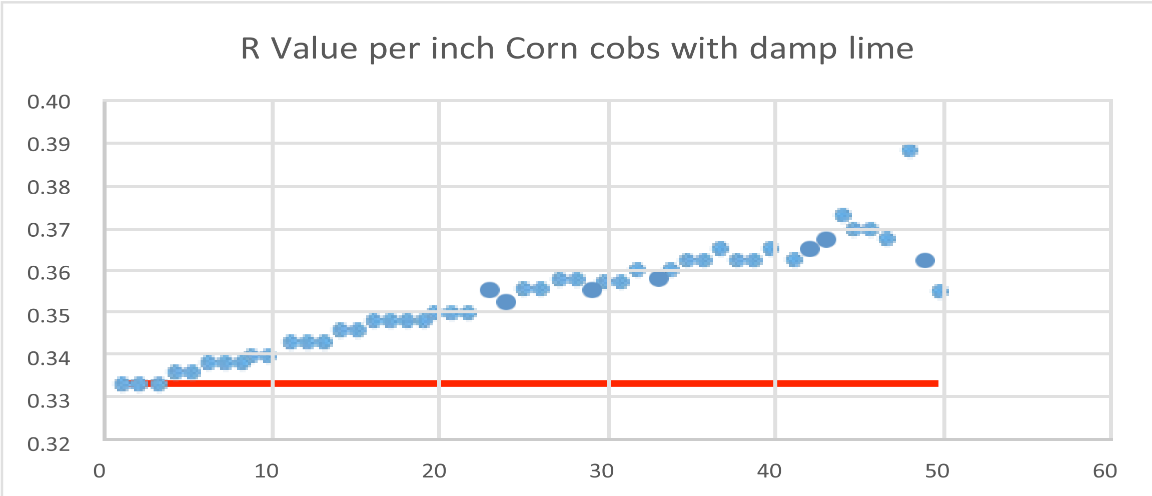
Durability: though can perform better, mostly due to the fact that the other material (polyutherane spray foam) has better properties than the corn cobs which can easily lose its properties when the absorb water or any liquid.

Cost: 344.00 ZMW/m2 53.75 ZMW per 1-R-Value Point/m2

9.2.4 Corn Cobs & Lime

R-Value: 0.25 - 0.35 (depending on the degree of humidity in the Lime)





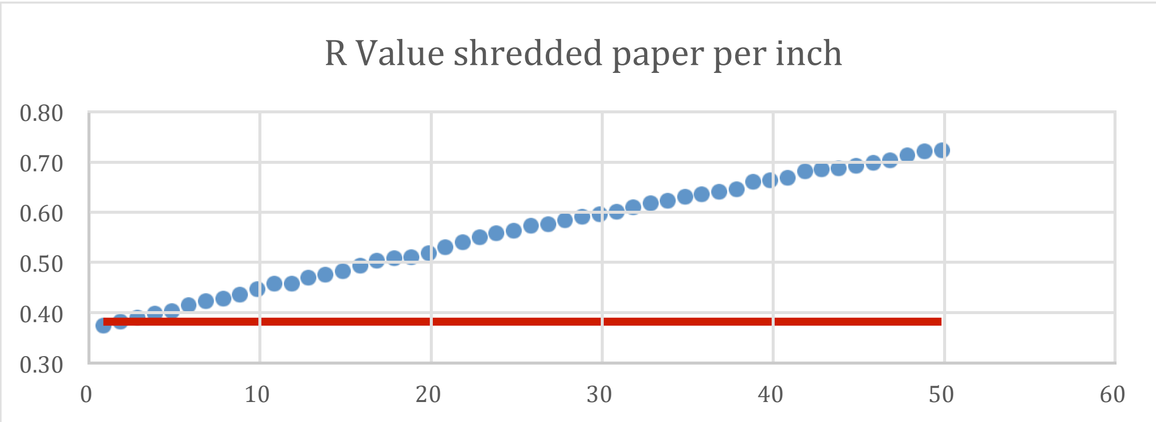
<u>Availability:</u> both mixed materials are readily available on the local Zambian market

<u>Durability:</u> not very durable as if they absorb any liquids they change properties and takes long period of time to dry up.

<u>Cost:</u> 90 ZMW/m2 257.00 ZMW per 1-R-Value Point/m2

9.2.5 Shredded Paper/Card Board

R-Value:



Availability: readily available and can be sourced locally even from waste.

Durability: not very durable as it can easily get damaged when absorbs liquids and can easily catch fire.

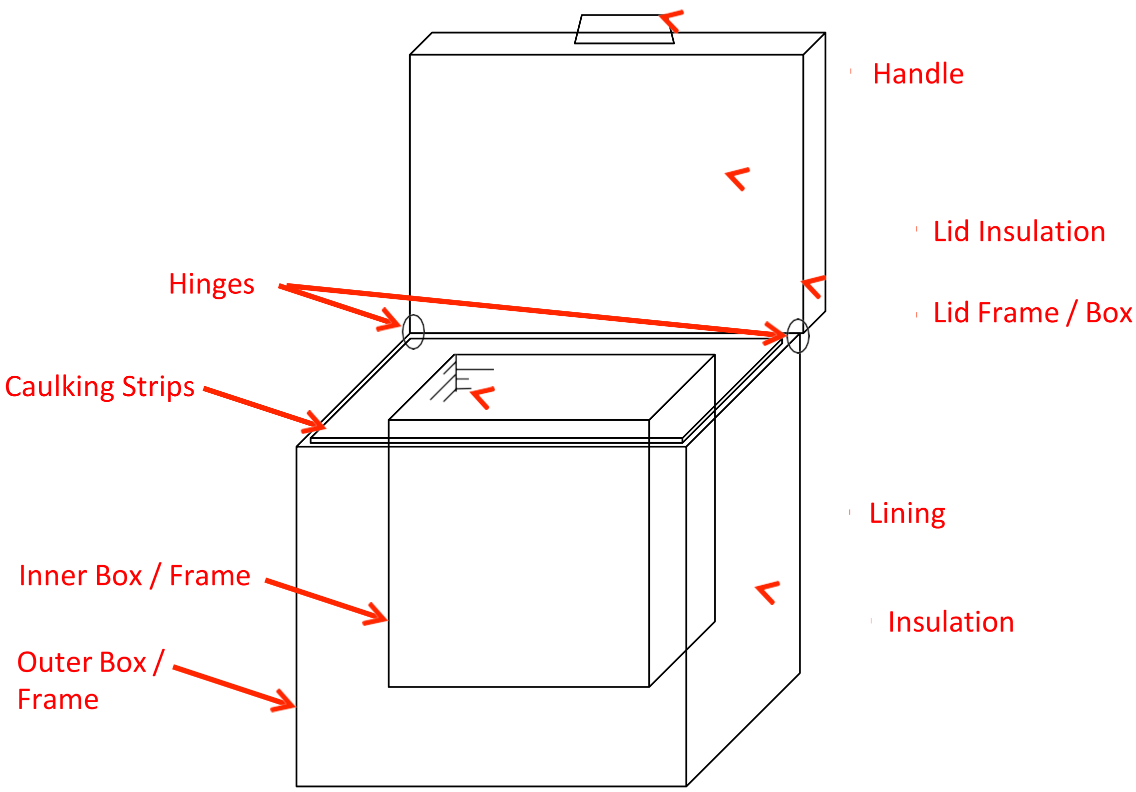
Cost: 15.00 ZMW/m2 26.78 ZMW per 1-R-Value Point/m2

10.0 Container Components Research

The main focus of the research was to determine, if and which insulation materials are available in Zambia. Nevertheless, it is important to also think about the container itself, it components and their performance under our defined test evaluation criteria, as far applicable: Availability, Durability and Cost.

To better practically grasp the object of research, it was decided to first de-construct a typical container to determine its several parts. We did not define auxiliary materials like screws, glue etc. These materials are available and have a cost implication at prototype stage, but can drastically reduce due to economies of scale when purchased for production.

10.1 Insulated Container Deconstructed



The typical design is a top loader "deep freezer" design. It consists of an outer box, which is filled with insulation material, in which then an inner box is fitted. The inner box need – depending on the actual use – a food-safe lining, and a caulking strip around the top to allow for proper closure when the lid is down.

The Lid is a separate box, which is connected to the lower outer box with hinges. The lid can't be too heavy; otherwise there will be difficult to open the container, as well as some structural challenges with the hinges. Lastly, some sort of handle should allow the user to comfortably

10.2 “Classic” Insulated Container Designs / Practical Trials

Material Cost: Approx. 2,000 ZMW / 125 EURO

Material Cost: Approx. 1,000 ZMW / 62 EURO

Material Cost: Approx. 1,000 ZMW / 62 EURO

The Box Design was executed with different materials and in different sizes. Besides several smaller challenges with the materials, e.g. timber boards being bend, metal frames uneven etc. the boxes worked, but seemed to be a bit “off” when imagining them in a rural Zambian environment.

10.3 Thinking the Insulated Container in Context

During the research phase, we conducted two side visits. One in southern province with support of the GIZ program, and one in the Chongwe area closer to Lusaka.

Especially the setting of a smallholder diary farmer clarifies, what kind of materials, cost impact and procedures are feasible.

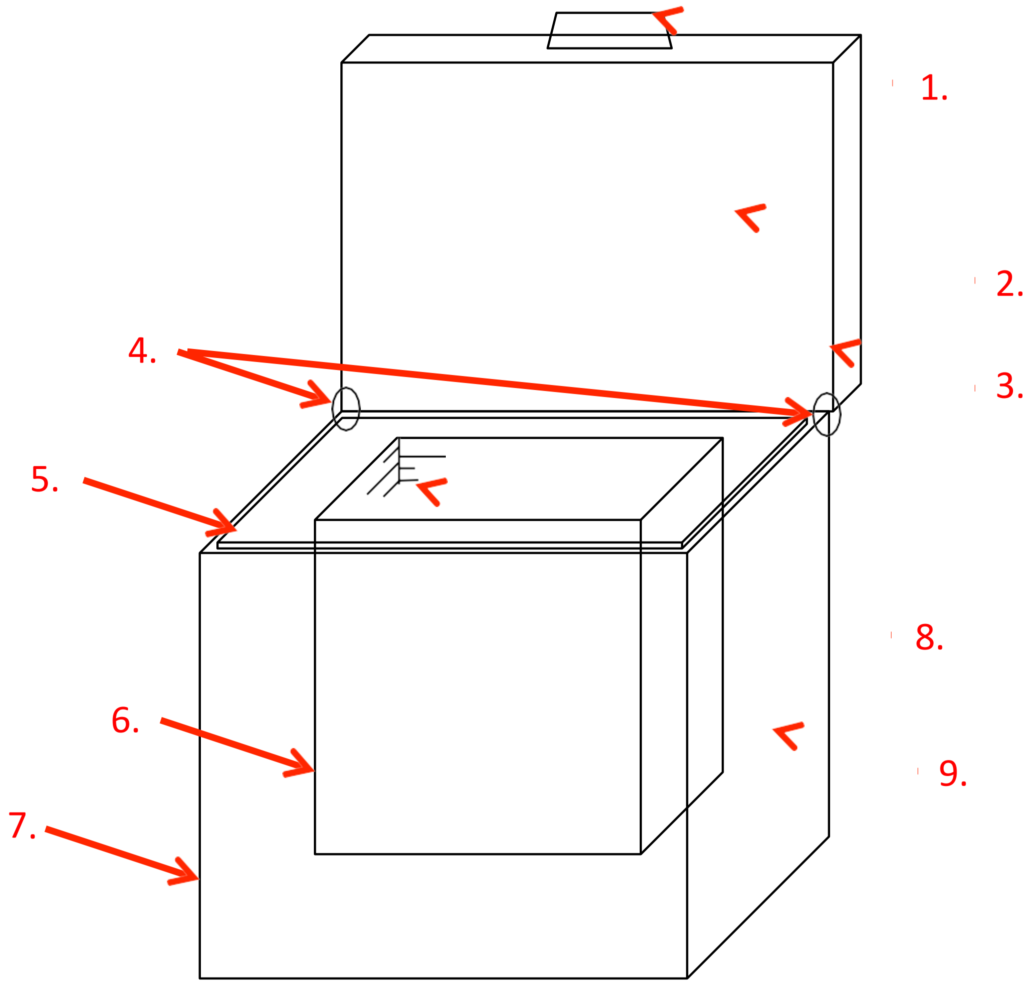
The most significant learning from our site visits and the interviews with people working the diary value chain in rural areas is, that there is not one type of smallholder farmer. Each farm is different, has different structures, space, understanding, level of education and so on. If we want to generalize, then we may summarize a rural farmer as follows:

- rather poor
- rather robust build containers needed
- rather difficult to provide a clean room (in terms of being free / minimum of germs)
- rather enough land / space available for housing and cattle
- rather smaller structures available
- rather exposed to weather / natural elements
- rather no electricity (ZESCO)
- rather no borehole
- rather simple procedure to follow
- rather keen to improve their situation

Taking these findings into account, the wood-based container designs seemed not to be adequate for the described environment, both I terms of robustness as well in terms of cost.

10.4 Results and Interpretation

All Materials, with the exception of food – safer liners for the inside of the box – are available in Zambia:



1. Handle

There are ready-made handles available as well as different materials, that can be used to create a handle for a lid, depending on the size and weight of the lid.

2. Lid Insulation

As pointed out in part one of this research, there are several insulation materials available. In the case of the insulation materials for a lid, it is necessary to consider the R-Value and the weight of the materials to prevent them becoming too heavy. In the following table the possible lid insulation materials are marked green.

	R-Value	Availability	Durability	Cost per M2	Cost per R-Value Point
Polystyrene	avg. 5.45	good	good	~ 121 ZMW/m2	~ 22.20 ZMW
Polyurethane	avg. 9.00	endangered	very good	~ 162 ZMW/m2	~ 18.00 ZMW
Fiberglass	avg. 2.40	very good	satisfactory	~ 23 ZMW/m2	~ 9.58 ZMW
Sand	avg. 0.25	very good	difficult	~ 14 ZMW/m2	~ 56.00 ZMW
Lose Corn Cops	avg. 1.34	good	difficult	~ 30 ZMW/m2	~ 22.38 ZMW
Polyurethane & Lose Corn Cops	avg. 6.40	good	satisfactory/ difficult	~ 344 ZMW/m2	~ 53.75 ZMW
Corn Cops & Lime	avg. 0.35	good	difficult	~ 90 ZMW/m2	~257.00 ZMW
Shredded Paper / Card Board	avg. 0.56	good	difficult	~ 15 ZMW/m2	~ 26.78 ZMW

3. Lid Frame / Box

Depending on the insulation materials, this structure need to be stronger or is just an outside lining / weatherproofing. As for the insulation material, the overall weight of the lid box comes into consideration when determining the durability of the lid.

4. Hinges

Hinges are readily available in all forms and sizes as well as other materials with which hinge functionalities can be created like fabrics, round metals etc.

5. Caulking Strips

There are various materials available with which caulking strips and alike functionalities can be created.

6. Inner Box / Frame

Timber boards and / or Shutter boards are available and easy to handle, but for a high price. Ideally the inner box is “swimming” or “Floating” within the insulation material which is in the outer box. That scenario would allow for the best insulation properties because it prevents thermal bridges due to a lag of connecting materials between the inner and the outer box.

7. Outer Box / Frame

Timber boards and / or Shutter boards are available and easy to handle, but for a high price

8. Lining

It was not possible during the research period to source locally food safe lining. Both acrylic glass as well as stainless steel plates where not available.

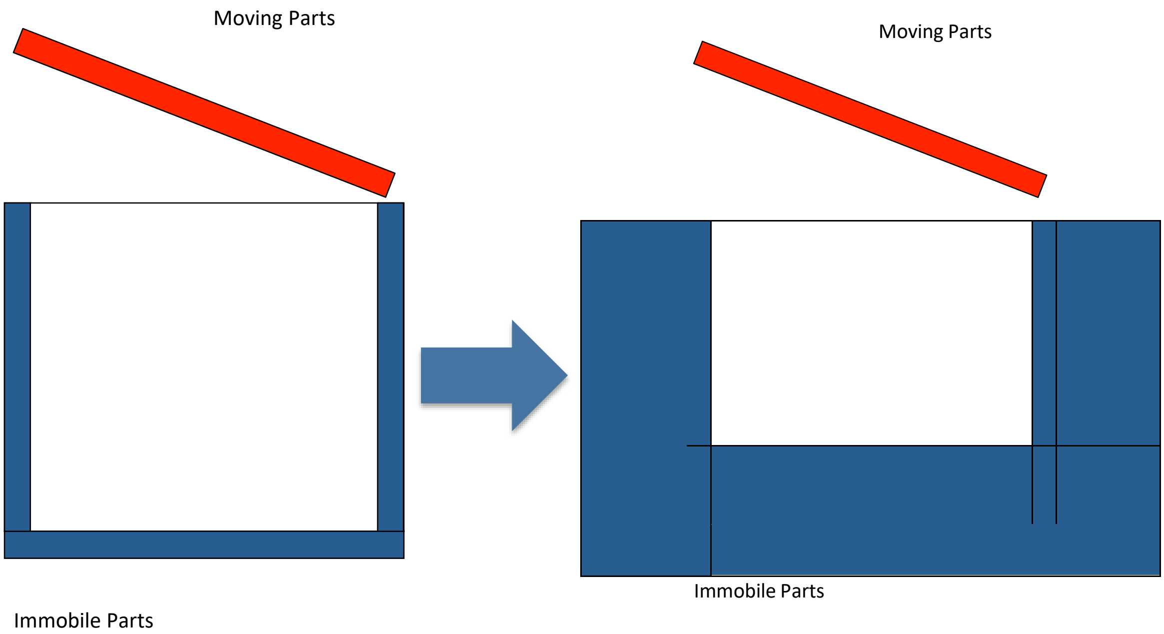
9. Insulation
As pointed out in part one of this research, there are several insulation materials available. In the case of the insulation materials for the base container, it depends on the container concept, which materials are appropriate. If we consider the possibility of a stationary cooler box, a good R-Value can also be achieved with high weight and bigger volume.

10.5 Way forward / Thinking out-and-aside the box

So far the research has sown, that technically it is possible to build containers in Zambia and to find the adequate insulation materials. Unfortunately, it also shows, that the prices of the materials lead to an prohibitive high price point for the finished product.

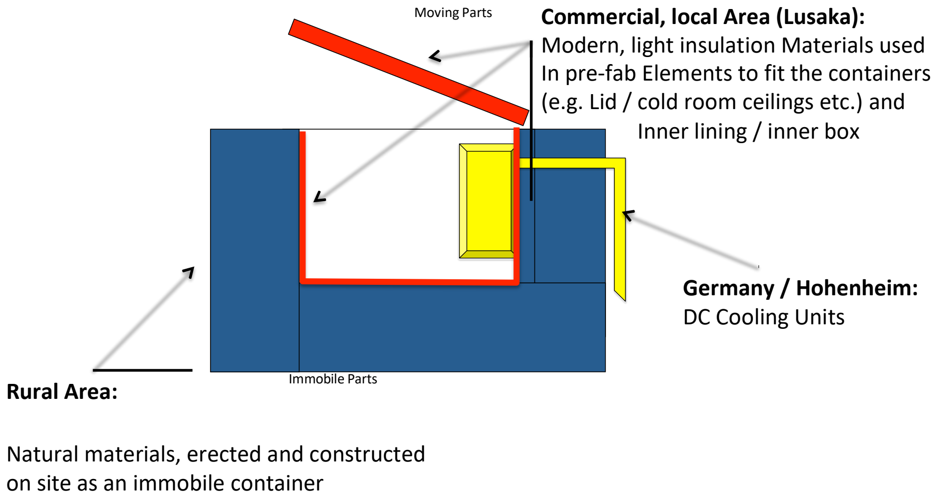
For that reason the research team looked into alternative approaches by considering the overall circumstances, prices of input materials and the necessary features – and the not important features – of the finished product.

The main feature that is considered as not important is the overall weight of the base container and it being mobile. Given the situation of the smallholder farms, there should be enough space in a shaded area to place an immobile cooling container. That approach allows much cheaper, alternative and local approaches. In that scenario, the only moving part is the lid. As such, it requires a lighter insulation material and a certain extend of mechanical sophistication.



The approach of using stationary, immobile storage containers is a known and proven concept in the African context and may be important in terms of acceptance.

Such an approach would also allow to stretch the value chain into the rural areas:



Appendix:

List of suppliers and available materials

Supplier Details	Material
Kaylite Zambia Limited Plot 222 of 288A, Blue Boar Road, Makeni +260963 412687 kaylite.zam@gmail.com	Polystyrene Board Comes in bead form then through production process it's expanded to make a board as per request dimensions. 150mm thickness x 1.2m x 3m board costs k 813. Durable and readily available on Zambian local market
Insulated Systems Plot 13951 Lumumba Road, Light Industrial Area Lusaka +260953 415068 insuslatedsystems@gmail.com	Polyurethane board Is cut as per request dimensions ranging from 50mm to about 250mm thickness. Board with dimensions of 1.2m width,3m length and 100mm thickness costs k 1, 080 Available on local market
MICMAR Arcades Shopping mall Great east road	Polyurethane spray Comes in different packaged sizes e.g 750 ml cover between 25-30 liters which is 0.5m length, 0.3m width and 20mm thickness costs k Available on Zambian local market
Phoenix Limited Kafue Road+260968840765	Fiberglass butt Comes rolled in dimensionsof 10m length, 1.2m width and 50mm thickness and costs k 278 per roll.
Ansultech Fire Systems Limited	Mineral wool Comes in slug and ceramic

10580 Chandwe Musonda Road, Lusaka, Zambia +260 964 959641, +260 966 923500	form but not readily available only through special order.
Most bigger hardware stores like Builders Warehouse, Handyman's Paradise etc.	Fiberglass / Glass wool

Raw data

Polystyrene

Date	Time	Raw CH1 Signal (uV)	q1 (W/m^2)	Tinside (degC)	Toutside (degC)	R-Value	dT	Expanded Polystyrene	R Value expanded polystyrene per inch	dT: Expanded Polystyrene
11/11/19	11:36:24	6.56	6.19	2.99	30.63	-27.78	27.64	27.78	4.63	27.64
11/11/19	11:37:08	7.75	7.31	2.93	30.59	-22.27	27.66	22.27	3.71	27.66
11/11/19	11:37:51	6.08	5.74	2.91	30.61	14.08	27.7	14.08	2.35	27.7
11/11/19	11:38:35	7.16	6.76	2.91	30.59	-30.14	27.68	30.14	5.02	27.68
11/11/19	11:39:19	6.53	6.16	2.91	30.6	-28.33	27.69	28.33	4.72	27.69
11/11/19	11:40:02	6.26	5.91	2.95	30.6	-29.77	27.65	29.77	4.96	27.65
11/11/19	11:40:46	6.31	5.95	2.9	30.54	-42.91	27.64	42.91	7.15	27.64
11/11/19	11:41:30	6.64	6.26	2.87	30.46	-29.87	27.59	29.87	4.98	27.59
11/11/19	11:42:13	6.29	5.93	2.85	30.42	-32.83	27.57	32.83	5.47	27.57
11/11/19	11:42:57	5.7	5.38	2.87	30.42	-37.17	27.55	37.17	6.20	27.55
11/11/19	11:43:40	5.82	5.49	2.89	30.47	-35.63	27.58	35.63	5.94	27.58
11/11/19	11:44:24	7.01	6.61	2.91	30.53	-24.85	27.62	24.85	4.14	27.62
11/11/19	11:45:08	5.75	5.42	2.96	30.55	-32.33	27.59	32.33	5.39	27.59
11/11/19	11:45:51	5.6	5.29	3	30.58	-74.63	27.58	74.63	12.44	27.58
11/11/19	11:46:35	6.45	6.08	2.95	30.54	-21.71	27.59	21.71	3.62	27.59
11/11/19	11:47:18	5.7	5.37	2.94	30.55	-32.29	27.61	32.29	5.38	27.61
11/11/19	11:48:02	5.88	5.55	3.01	30.52	-31.16	27.51	31.16	5.19	27.51
11/11/19	11:48:46	7.47	7.04	2.96	30.52	-23.22	27.56	23.22	3.87	27.56
11/11/19	11:49:29	5.9	5.56	2.96	30.56	-27.28	27.6	27.28	4.55	27.6
11/11/19	11:50:13	6.93	6.54	2.96	30.56	-25.2	27.6	25.2	4.20	27.6
11/11/19	11:50:57	6.32	5.96	2.87	30.56	-28.43	27.69	28.43	4.74	27.69
11/11/19	11:51:40	6.34	5.98	2.9	30.6	-39.94	27.7	39.94	6.66	27.7
11/11/19	11:52:24	6.32	5.97	2.93	30.62	-32.95	27.69	32.95	5.49	27.69
11/11/19	11:53:07	6.08	5.74	2.94	30.65	-36.09	27.71	36.09	6.02	27.71
11/11/19	11:53:51	7.26	6.84	2.95	30.65	-24.36	27.7	24.36	4.06	27.7
11/11/19	11:54:35	5.52	5.21	3.01	30.69	-45.41	27.68	45.41	7.57	27.68
11/11/19	11:55:18	7.01	6.62	3.02	30.69	-25.88	27.67	25.88	4.31	27.67
11/11/19	11:56:02	6.96	6.57	2.91	30.68	-25.15	27.77	25.15	4.19	27.77
11/11/19	11:56:45	6.33	5.97	2.93	30.71	-36.48	27.78	36.48	6.08	27.78
11/11/19	11:57:29	6.6	6.23	2.93	30.73	-26.63	27.8	26.63	4.44	27.8
11/11/19	11:58:13	5.95	5.62	2.97	30.76	-33.71	27.79	33.71	5.62	27.79
11/11/19	11:58:56	5.83	5.5	2.98	30.73	-33.31	27.75	33.31	5.55	27.75
11/11/19	11:59:40	7.15	6.75	2.96	30.74	-24.44	27.78	24.44	4.07	27.78
11/11/19	12:00:23	6.95	6.56	2.86	30.67	-26.06	27.81	26.06	4.34	27.81
11/11/19	12:01:07	6.05	5.71	2.86	30.69	-33.58	27.83	33.58	5.60	27.83
11/11/19	12:01:51	5.94	5.6	2.89	30.69	-34.85	27.8	34.85	5.81	27.8
11/11/19	12:02:34	6.42	6.06	2.97	30.7	-29.04	27.73	29.04	4.84	27.73
11/11/19	12:03:18	6.43	6.07	2.96	30.73	-27.69	27.77	27.69	4.62	27.77
11/11/19	12:04:02	6.88	6.49	2.93	30.73	-27.55	27.8	27.55	4.59	27.8
11/11/19	12:04:45	5.58	5.26	2.93	30.71	-35.12	27.78	35.12	5.85	27.78
11/11/19	12:05:29	6.59	6.22	2.99	30.73	-27.87	27.74	27.87	4.65	27.74
11/11/19	12:06:12	5.67	5.35	3.03	30.77	-36.83	27.74	36.83	6.14	27.74
11/11/19	12:06:56	6.24	5.89	2.98	30.77	-32.27	27.79	32.27	5.38	27.79
11/11/19	12:07:40	5.78	5.45	2.97	30.75	-76.35	27.78	76.35	12.73	27.78
11/11/19	12:08:23	6.83	6.44	3.03	30.79	-26.47	27.76	26.47	4.41	27.76
11/11/19	12:09:07	6.58	6.21	3.09	30.81	-52.79	27.72	52.79	8.80	27.72
11/11/19	12:09:50	7.04	6.64	2.99	30.8	-25.4	27.81	25.4	4.23	27.81
11/11/19	12:10:34	6.77	6.39	2.99	30.84	-26.43	27.85	26.43	4.41	27.85
11/11/19	12:11:18	6.56	6.19	2.95	30.8	-27.89	27.85	27.89	4.65	27.85
11/11/19	12:12:01	6.58	6.21	2.95	30.8	-27.46	27.85	27.46	4.58	27.85

Polyurethane

Date	Time	Raw CH1 Signal (uV)	q1 (W/m^2)	Tinside (degC)	Toutside (degC)	R-Value	Dense Polyurethane	R ValueDense Polyurethane per inch	dT: Dense Polyurethane
16/10/19	15:15:36	5.29	4.99	3.9	28.33	-29.28	29.28	7.32	24.43
16/10/19	15:16:19	4.79	4.52	3.89	28.31	-40.87	40.87	10.22	24.42
16/10/19	15:17:03	4.94	4.66	3.9	28.29	-17.55	17.55	4.39	24.39
16/10/19	15:17:47	5.03	4.74	3.87	28.3	-31.51	31.51	7.88	24.43
16/10/19	15:18:30	5.39	5.08	3.85	28.39	-29.16	29.16	7.29	24.54
16/10/19	15:19:14	5.98	5.64	3.81	28.45	-27.63	27.63	6.91	24.64
16/10/19	15:19:58	5.1	4.81	3.83	28.41	-35.49	35.49	8.87	24.58
16/10/19	15:20:42	4.73	4.46	3.86	28.38	-27.89	27.89	6.97	24.52
16/10/19	15:21:25	4.87	4.59	3.91	28.36	-70.93	70.93	17.73	24.45
16/10/19	15:22:09	4.39	4.15	3.92	28.34	-41.69	41.69	10.42	24.42
16/10/19	15:22:52	3.84	3.62	3.96	28.32	-34.79	34.79	8.70	24.36
16/10/19	15:23:36	4.75	4.48	3.93	28.28	-34.69	34.69	8.67	24.35
16/10/19	15:24:20	4.26	4.02	3.93	28.28	-43.93	43.93	10.98	24.35
16/10/19	15:25:03	5.24	4.94	3.9	28.28	-32.05	32.05	8.01	24.38
16/10/19	15:25:47	5.4	5.09	3.84	28.27	-37.65	37.65	9.41	24.43
16/10/19	15:26:31	4.69	4.43	3.86	28.27	-36.41	36.41	9.10	24.41
16/10/19	15:27:14	5.36	5.06	3.79	28.26	-29.52	29.52	7.38	24.47
16/10/19	15:27:58	5.49	5.17	3.76	28.25	-28.33	28.33	7.08	24.49
16/10/19	15:28:41	5.24	4.94	3.77	28.27	-29.7	29.7	7.43	24.5
16/10/19	15:29:25	4.76	4.49	3.8	28.28	-35.6	35.6	8.90	24.48
16/10/19	15:30:09	5.61	5.29	3.84	28.25	-28.24	28.24	7.06	24.41
16/10/19	15:30:52	5.42	5.12	3.83	28.26	-29.96	29.96	7.49	24.43
16/10/19	15:31:36	5.2	4.9	3.86	28.29	-30.1	30.1	7.53	24.43
16/10/19	15:32:19	4.71	4.44	3.86	28.29	-36.68	36.68	9.17	24.43
16/10/19	15:33:03	5.34	5.04	3.85	28.27	-17.84	17.84	4.46	24.42
16/10/19	15:33:47	5.37	5.07	3.82	28.25	-30.2	30.2	7.55	24.43
16/10/19	15:34:30	4.4	4.15	3.87	28.22	-46.58	46.58	11.65	24.35
16/10/19	15:35:14	4.77	4.5	3.88	28.23	-35.64	35.64	8.91	24.35
16/10/19	15:35:58	4.79	4.52	3.87	28.23	-19.69	19.69	4.92	24.36
16/10/19	15:36:41	4.87	4.6	3.88	28.24	-33.77	33.77	8.44	24.36
16/10/19	15:37:25	4.52	4.26	3.93	28.26	-36.96	36.96	9.24	24.33
16/10/19	15:38:08	4.19	3.95	3.92	28.23	-41.88	41.88	10.47	24.31
16/10/19	15:38:52	4.92	4.64	3.96	28.21	-54.61	54.61	13.65	24.25
16/10/19	15:39:36	4.09	3.86	3.98	28.26	-38.56	38.56	9.64	24.28
16/10/19	15:40:20	5.1	4.81	4.01	28.29	-20.11	20.11	5.03	24.28
16/10/19	15:41:03	4.77	4.5	3.96	28.32	-55.84	55.84	13.96	24.36
16/10/19	15:41:47	5.72	5.4	3.94	28.28	-30.39	30.39	7.60	24.34
16/10/19	15:42:31	4.81	4.54	3.92	28.23	-40.54	40.54	10.14	24.31
16/10/19	15:43:15	4.37	4.12	3.96	28.21	-45.83	45.83	11.46	24.25
16/10/19	15:43:58	4.22	3.98	3.99	28.19	-31.97	31.97	7.99	24.2
16/10/19	15:44:42	4.87	4.59	3.97	28.18	-40.38	40.38	10.10	24.21
16/10/19	15:45:26	5.51	5.19	3.98	28.22	-30.55	30.55	7.64	24.24
16/10/19	15:46:09	5.29	4.99	3.97	28.22	-30.65	30.65	7.66	24.25
16/10/19	15:46:53	5.05	4.76	3.97	28.11	-30.49	30.49	7.62	24.14
16/10/19	15:47:37	4.42	4.17	4	28.12	-38.86	38.86	9.72	24.12
16/10/19	15:48:20	4.99	4.71	3.99	28.19	-32.5	32.5	8.13	24.2
16/10/19	15:49:04	5.23	4.94	3.98	28.21	-31.83	31.83	7.96	24.23
16/10/19	15:49:48	4	3.78	3.96	28.22	-81.08	81.08	20.27	24.26
16/10/19	15:50:31	4.68	4.41	3.99	28.22	-36.55	36.55	9.14	24.23
16/10/19	15:51:15	4.92	4.64	4	28.21	-32.61	32.61	8.15	24.21

Fiberglass

Date	Time	Raw CH1 Signal (uV)	q1 (W/m^2)	Tinside (degC)	Toutside (degC)	R-Value	Fibre Glass	R value Fibre Glass per inch	dT: Fibreglass
19/11/19	14:44:39	11.95	11.27	7.93	29.43	-10.99	10.99	2.75	21.5
19/11/19	14:45:23	13.14	12.4	7.93	29.42	-9.92	9.92	2.48	21.49
19/11/19	14:46:07	14.13	13.33	7.91	29.43	-9.24	9.24	2.31	21.52
19/11/19	14:46:50	13.05	12.31	7.9	29.41	-9.96	9.96	2.49	21.51
19/11/19	14:47:34	13.37	12.61	7.9	29.41	-9.78	9.78	2.45	21.51
19/11/19	14:48:18	13.38	12.62	7.9	29.4	-9.74	9.74	2.44	21.5
19/11/19	14:49:01	13.29	12.54	7.9	29.41	-9.84	9.84	2.46	21.51
19/11/19	14:49:45	13.3	12.55	7.9	29.41	-9.86	9.86	2.47	21.51
19/11/19	14:50:28	12.19	11.5	7.93	29.42	-10.79	10.79	2.70	21.49
19/11/19	14:51:12	13.22	12.48	7.91	29.4	-9.88	9.88	2.47	21.49
19/11/19	14:51:56	12.9	12.17	7.9	29.39	-10.14	10.14	2.54	21.49
19/11/19	14:52:39	13.51	12.75	7.9	29.39	-9.65	9.65	2.41	21.49
19/11/19	14:53:23	13.42	12.66	7.9	29.38	-9.69	9.69	2.42	21.48
19/11/19	14:54:06	12.48	11.78	7.93	29.39	-10.46	10.46	2.62	21.46
19/11/19	14:54:50	13.74	12.96	7.93	29.38	-9.5	9.5	2.38	21.45
19/11/19	14:55:34	14.73	13.9	7.9	29.35	-8.81	8.81	2.20	21.45
19/11/19	14:56:17	14.8	13.97	7.94	29.41	-8.78	8.78	2.20	21.47
19/11/19	14:57:01	14.42	13.6	7.93	29.4	-9.01	9.01	2.25	21.47
19/11/19	14:57:45	14.65	13.82	7.96	29.41	-8.88	8.88	2.22	21.45
19/11/19	14:58:28	14.83	13.99	7.98	29.42	-8.76	8.76	2.19	21.44
19/11/19	14:59:12	14.17	13.37	7.97	29.4	-9.15	9.15	2.29	21.43
19/11/19	14:59:55	13.97	13.18	7.97	29.42	-9.29	9.29	2.32	21.45
19/11/19	15:00:39	13.9	13.11	7.96	29.39	-9.38	9.38	2.35	21.43
19/11/19	15:01:23	13.99	13.2	7.98	29.39	-9.29	9.29	2.32	21.41
19/11/19	15:02:06	13.69	12.92	7.95	29.35	-9.47	9.47	2.37	21.4
19/11/19	15:02:50	14.28	13.47	7.95	29.35	-9.06	9.06	2.27	21.4
19/11/19	15:03:33	14.34	13.52	7.92	29.35	-9.07	9.07	2.27	21.43
19/11/19	15:04:17	14.41	13.6	7.91	29.35	-9.01	9.01	2.25	21.44
19/11/19	15:05:01	14.14	13.34	7.92	29.35	-9.17	9.17	2.29	21.43
19/11/19	15:05:44	13.73	12.95	7.94	29.38	-9.47	9.47	2.37	21.44
19/11/19	15:06:28	13.58	12.81	7.93	29.36	-9.58	9.58	2.40	21.43
19/11/19	15:07:12	13.99	13.2	7.95	29.39	-9.3	9.3	2.33	21.44
19/11/19	15:07:55	13.98	13.19	7.94	29.38	-9.3	9.3	2.33	21.44
19/11/19	15:08:39	14.06	13.26	8	29.43	-9.23	9.23	2.31	21.43
19/11/19	15:09:22	13.66	12.89	7.98	29.41	-9.48	9.48	2.37	21.43
19/11/19	15:10:06	13.68	12.9	7.98	29.41	-9.49	9.49	2.37	21.43
19/11/19	15:10:50	13.83	13.05	7.98	29.4	-9.45	9.45	2.36	21.42
19/11/19	15:11:33	13.18	12.44	8	29.4	-9.84	9.84	2.46	21.4
19/11/19	15:12:17	12.7	11.98	8.01	29.38	-10.52	10.52	2.63	21.37
19/11/19	15:13:00	13.4	12.64	8.02	29.39	-9.69	9.69	2.42	21.37
19/11/19	15:13:44	12.94	12.2	8.08	29.46	-10.05	10.05	2.51	21.38
19/11/19	15:14:28	12.15	11.46	8.08	29.44	-10.82	10.82	2.71	21.36
19/11/19	15:15:11	13.26	12.51	8.11	29.49	-9.78	9.78	2.45	21.38
19/11/19	15:15:55	13.46	12.69	8.14	29.49	-9.65	9.65	2.41	21.35
19/11/19	15:16:39	13.91	13.12	8.1	29.47	-9.33	9.33	2.33	21.37
19/11/19	15:17:22	12.4	11.7	8.17	29.51	-10.48	10.48	2.62	21.34
19/11/19	15:18:06	13.64	12.87	8.13	29.47	-9.47	9.47	2.37	21.34
19/11/19	15:18:49	13.64	12.86	8.12	29.46	-9.5	9.5	2.38	21.34
19/11/19	15:19:33	13.8	13.02	8.13	29.45	-9.35	9.35	2.34	21.32
19/11/19	15:20:17	13.95	13.16	8.13	29.47	-9.28	9.28	2.32	21.34

Sand

Date	Time	Raw CH1 Signal (uV)	q1 (W/m^2)	Tinside (degC)	Toutside (degC)	R-Value	R Value Sand	R Value Sand per inch	dT: Sand
20/11/19	16:22:34	61.39	57.92	22.46	32.25	-0.96	0.96	0.24	9.79
20/11/19	16:23:18	61.46	57.98	22.48	32.27	-0.96	0.96	0.24	9.79
20/11/19	16:24:02	61.32	57.85	22.47	32.26	-0.96	0.96	0.24	9.79
20/11/19	16:24:45	61.4	57.93	22.45	32.27	-0.96	0.96	0.24	9.82
20/11/19	16:25:29	61.08	57.63	22.44	32.28	-0.97	0.97	0.24	9.84
20/11/19	16:26:13	61.06	57.6	22.42	32.25	-0.97	0.97	0.24	9.83
20/11/19	16:26:56	61.39	57.91	22.39	32.26	-0.97	0.97	0.24	9.87
20/11/19	16:27:40	61.13	57.67	22.38	32.29	-0.98	0.98	0.25	9.91
20/11/19	16:28:23	60.87	57.43	22.38	32.29	-0.98	0.98	0.25	9.91
20/11/19	16:29:07	61.17	57.7	22.36	32.27	-0.98	0.98	0.25	9.91
20/11/19	16:29:51	61.19	57.72	22.34	32.27	-0.98	0.98	0.25	9.93
20/11/19	16:30:34	60.8	57.36	22.34	32.26	-0.98	0.98	0.25	9.92
20/11/19	16:31:18	60.95	57.5	22.35	32.24	-0.98	0.98	0.25	9.89
20/11/19	16:32:01	60.87	57.43	22.33	32.21	-0.98	0.98	0.25	9.88
20/11/19	16:32:45	60.95	57.5	22.34	32.24	-0.98	0.98	0.25	9.9
20/11/19	16:33:29	60.68	57.25	22.36	32.25	-0.98	0.98	0.25	9.89
20/11/19	16:34:12	60.65	57.22	22.31	32.21	-0.98	0.98	0.25	9.9
20/11/19	16:34:56	60.53	57.1	22.29	32.18	-0.98	0.98	0.25	9.89
20/11/19	16:35:40	60.75	57.31	22.3	32.18	-0.98	0.98	0.25	9.88
20/11/19	16:36:23	60.47	57.05	22.33	32.18	-0.98	0.98	0.25	9.85
20/11/19	16:37:07	60.36	56.95	22.39	32.19	-0.98	0.98	0.25	9.8
20/11/19	16:37:50	60.56	57.13	22.35	32.18	-0.98	0.98	0.25	9.83
20/11/19	16:38:34	60.45	57.02	22.34	32.21	-0.98	0.98	0.25	9.87
20/11/19	16:39:18	59.94	56.55	22.31	32.19	-0.99	0.99	0.25	9.88
20/11/19	16:40:01	60.51	57.08	22.32	32.21	-0.98	0.98	0.25	9.89
20/11/19	16:40:45	60.28	56.87	22.3	32.19	-0.99	0.99	0.25	9.89
20/11/19	16:41:29	60.15	56.75	22.28	32.17	-0.99	0.99	0.25	9.89
20/11/19	16:42:12	60.46	57.04	22.28	32.12	-0.98	0.98	0.25	9.84
20/11/19	16:42:56	60.05	56.65	22.28	32.13	-0.99	0.99	0.25	9.85
20/11/19	16:43:39	60.01	56.62	22.27	32.13	-0.99	0.99	0.25	9.86
20/11/19	16:44:23	60.23	56.82	22.26	32.13	-0.99	0.99	0.25	9.87
20/11/19	16:45:07	59.75	56.37	22.25	32.13	-1	1	0.25	9.88
20/11/19	16:45:50	59.86	56.47	22.24	32.16	-1	1	0.25	9.92
20/11/19	16:46:34	59.85	56.46	22.24	32.16	-1	1	0.25	9.92
20/11/19	16:47:17	59.88	56.49	22.22	32.14	-1	1	0.25	9.92
20/11/19	16:48:01	59.64	56.26	22.21	32.12	-1	1	0.25	9.91
20/11/19	16:48:45	59.55	56.18	22.21	32.08	-1	1	0.25	9.87
20/11/19	16:49:28	59.86	56.47	22.2	32.04	-0.99	0.99	0.25	9.84
20/11/19	16:50:12	59.43	56.07	22.23	32.04	-0.99	0.99	0.25	9.81
20/11/19	16:50:56	59.43	56.07	22.21	32.02	-0.99	0.99	0.25	9.81
20/11/19	16:51:39	59.6	56.23	22.22	32.03	-0.99	0.99	0.25	9.81
20/11/19	16:52:23	59.54	56.17	22.21	32.04	-0.99	0.99	0.25	9.83
20/11/19	16:53:06	59.36	56	22.21	32.08	-1	1	0.25	9.87
20/11/19	16:53:50	59.22	55.87	22.21	32.12	-1.01	1.01	0.25	9.91
20/11/19	16:54:34	59.42	56.06	22.19	32.13	-1.01	1.01	0.25	9.94
20/11/19	16:55:17	58.92	55.58	22.16	32.14	-1.02	1.02	0.26	9.98
20/11/19	16:56:01	59.11	55.77	22.15	32.16	-1.02	1.02	0.26	10.01
20/11/19	16:56:44	59.19	55.84	22.15	32.17	-1.02	1.02	0.26	10.02
20/11/19	16:57:28	58.91	55.57	22.16	32.19	-1.03	1.03	0.26	10.03
20/11/19	16:58:12	59.18	55.83	22.16	32.16	-1.02	1.02	0.26	10

Lose Corn Cops

Date	Time	Raw CH1 Signal (uV)	q1 (W/m^2)	Tinside (degC)	Toutside (degC)	R-Value loose corn cobs	Loose Corn Cobs	R Value Loose Corn Cobs per inch
22/11/19	10:58:27	24.84	23.43	8.51	28.44	-4.84	4.84	1.21
22/11/19	10:59:11	24.75	23.35	8.51	28.44	-4.86	4.86	1.22
22/11/19	10:59:54	24.82	23.41	8.44	28.4	-4.85	4.85	1.21
22/11/19	11:00:38	24.67	23.27	8.46	28.41	-4.87	4.87	1.22
22/11/19	11:01:21	24.08	22.72	8.48	28.42	-4.99	4.99	1.25
22/11/19	11:02:05	24.32	22.94	8.44	28.41	-4.95	4.95	1.24
22/11/19	11:02:49	24.73	23.33	8.44	28.41	-4.87	4.87	1.22
22/11/19	11:03:32	24.23	22.86	8.4	28.4	-4.97	4.97	1.24
22/11/19	11:04:16	24.27	22.89	8.41	28.44	-4.98	4.98	1.25
22/11/19	11:04:59	24.06	22.69	8.37	28.43	-5.02	5.02	1.26
22/11/19	11:05:43	24.1	22.74	8.35	28.44	-5.03	5.03	1.26
22/11/19	11:06:27	24.34	22.96	8.35	28.45	-4.98	4.98	1.25
22/11/19	11:07:10	24.06	22.69	8.32	28.45	-5.05	5.05	1.26
22/11/19	11:07:54	23.35	22.03	8.32	28.48	-5.2	5.2	1.30
22/11/19	11:08:38	23.77	22.42	8.23	28.46	-5.13	5.13	1.28
22/11/19	11:09:21	23.39	22.07	8.12	28.37	-5.22	5.22	1.31
22/11/19	11:10:05	23.51	22.18	8.04	28.31	-5.2	5.2	1.30
22/11/19	11:10:48	23.32	22	8	28.3	-5.25	5.25	1.31
22/11/19	11:11:32	23.37	22.05	7.93	28.25	-5.24	5.24	1.31
22/11/19	11:12:16	23.58	22.25	7.87	28.22	-5.2	5.2	1.30
22/11/19	11:12:59	23.01	21.7	7.88	28.24	-5.34	5.34	1.34
22/11/19	11:13:43	23.6	22.26	7.88	28.25	-5.2	5.2	1.30
22/11/19	11:14:26	22.98	21.68	7.83	28.23	-5.36	5.36	1.34
22/11/19	11:15:10	23.15	21.84	7.8	28.2	-5.31	5.31	1.33
22/11/19	11:15:54	23.09	21.78	7.76	28.19	-5.33	5.33	1.33
22/11/19	11:16:37	22.71	21.42	7.72	28.19	-5.43	5.43	1.36
22/11/19	11:17:21	22.73	21.44	7.69	28.2	-5.44	5.44	1.36
22/11/19	11:18:05	22.57	21.3	7.65	28.18	-5.48	5.48	1.37
22/11/19	11:18:48	22.54	21.27	7.64	28.19	-5.49	5.49	1.37
22/11/19	11:19:32	22.59	21.31	7.63	28.18	-5.49	5.49	1.37
22/11/19	11:20:15	22.9	21.6	7.72	28.25	-5.4	5.4	1.35
22/11/19	11:20:59	22.29	21.02	7.79	28.29	-5.54	5.54	1.39
22/11/19	11:21:43	22.43	21.16	7.77	28.26	-5.51	5.51	1.38
22/11/19	11:22:26	22.67	21.39	7.76	28.3	-5.46	5.46	1.37
22/11/19	11:23:10	22.62	21.34	7.81	28.36	-5.48	5.48	1.37
22/11/19	11:23:53	22.36	21.09	7.79	28.34	-5.54	5.54	1.39
22/11/19	11:24:37	22.02	20.77	7.84	28.4	-5.63	5.63	1.41
22/11/19	11:25:21	21.78	20.54	7.88	28.44	-5.69	5.69	1.42
22/11/19	11:26:04	21.79	20.55	7.86	28.43	-5.69	5.69	1.42
22/11/19	11:26:48	22.29	21.03	7.9	28.47	-5.56	5.56	1.39
22/11/19	11:27:32	21.87	20.63	7.94	28.5	-5.67	5.67	1.42
22/11/19	11:28:15	21.83	20.59	8	28.56	-5.68	5.68	1.42
22/11/19	11:28:59	21.62	20.39	8.02	28.58	-5.73	5.73	1.43
22/11/19	11:29:42	21.65	20.42	8	28.59	-5.75	5.75	1.44
22/11/19	11:30:26	21.66	20.43	7.99	28.61	-5.74	5.74	1.44
22/11/19	11:31:10	21.4	20.19	7.99	28.67	-5.82	5.82	1.46
22/11/19	11:31:53	21.66	20.43	8.04	28.7	-5.75	5.75	1.44
22/11/19	11:32:37	21.39	20.18	8.02	28.71	-5.83	5.83	1.46
22/11/19	11:33:20	21.38	20.17	7.96	28.7	-5.85	5.85	1.46
22/11/19	11:34:04	21.34	20.13	7.99	28.72	-5.86	5.86	1.47

Polyurethane & Lose Corn Cops

Date	Time	Raw CH1 Signal (uV)	q1 (W/m^2)	Tinside (degC)	Toutside (degC)	R-Value	corn cobs and polyutherane	R Value per inch: Corn cobs + Polyutherane
22/11/19	7:26:06	3.92	3.7	12.04	26.99	-23.95	23.95	5.99
22/11/19	7:26:50	4.28	4.03	12.02	26.99	-22.66	22.66	5.67
22/11/19	7:27:33	3.87	3.65	12.02	27	-25.85	25.85	6.46
22/11/19	7:28:17	3.8	3.59	12.02	27.01	-24.45	24.45	6.11
22/11/19	7:29:00	3.83	3.61	12.04	27	-25.62	25.62	6.41
22/11/19	7:29:44	4	3.77	12.04	27.02	-24.48	24.48	6.12
22/11/19	7:30:28	3.96	3.73	12.04	27.03	-24.38	24.38	6.10
22/11/19	7:31:11	4.03	3.8	12.04	27.03	-24.06	24.06	6.02
22/11/19	7:31:55	3.99	3.76	12.04	27.03	-23.6	23.6	5.90
22/11/19	7:32:38	3.77	3.55	12.04	27.03	-25.09	25.09	6.27
22/11/19	7:33:22	4.02	3.8	12.05	27.05	-25.56	25.56	6.39
22/11/19	7:34:06	4.11	3.87	12.05	27.04	-23.5	23.5	5.88
22/11/19	7:34:49	3.87	3.65	12.07	27.05	-24.56	24.56	6.14
22/11/19	7:35:33	4.08	3.85	12.06	27.06	-23.1	23.1	5.78
22/11/19	7:36:17	3.65	3.44	12.08	27.06	-27.54	27.54	6.89
22/11/19	7:37:00	3.79	3.58	12.07	27.05	-26.06	26.06	6.52
22/11/19	7:37:44	3.81	3.59	12.07	27.06	-25.13	25.13	6.28
22/11/19	7:38:27	3.68	3.47	12.07	27.08	-27.47	27.47	6.87
22/11/19	7:39:11	3.74	3.52	12.09	27.07	-25.78	25.78	6.45
22/11/19	7:39:55	3.9	3.68	12.09	27.07	-25.14	25.14	6.29
22/11/19	7:40:38	4.01	3.78	12.11	27.09	-24.71	24.71	6.18
22/11/19	7:41:22	4.1	3.87	12.1	27.09	-27.69	27.69	6.92
22/11/19	7:42:05	3.75	3.54	12.1	27.08	-25.66	25.66	6.42
22/11/19	7:42:49	3.96	3.73	12.12	27.1	-24.25	24.25	6.06
22/11/19	7:43:33	4.07	3.84	12.11	27.1	-23.5	23.5	5.88
22/11/19	7:44:16	3.96	3.73	12.11	27.11	-24.76	24.76	6.19
22/11/19	7:45:00	3.71	3.5	12.13	27.12	-25.97	25.97	6.49
22/11/19	7:45:44	3.8	3.59	12.13	27.12	-25.7	25.7	6.43
22/11/19	7:46:27	3.79	3.58	12.11	27.12	-25.22	25.22	6.31
22/11/19	7:47:11	3.71	3.5	12.12	27.13	-26.65	26.65	6.66
22/11/19	7:47:54	3.7	3.49	12.12	27.14	-26.28	26.28	6.57
22/11/19	7:48:38	3.88	3.66	12.13	27.15	-25.58	25.58	6.40
22/11/19	7:49:22	3.87	3.65	12.14	27.16	-24.72	24.72	6.18
22/11/19	7:50:05	3.92	3.7	12.14	27.15	-24.66	24.66	6.17
22/11/19	7:50:49	3.61	3.41	12.16	27.17	-27.3	27.3	6.83
22/11/19	7:51:33	3.98	3.76	12.15	27.17	-23.66	23.66	5.92
22/11/19	7:52:16	3.84	3.62	12.14	27.16	-25.56	25.56	6.39
22/11/19	7:53:00	3.34	3.16	12.12	27.17	-32.97	32.97	8.24
22/11/19	7:53:43	3.61	3.41	12.13	27.17	-27.36	27.36	6.84
22/11/19	7:54:27	3.67	3.47	12.14	27.17	-26.4	26.4	6.60
22/11/19	7:55:11	3.45	3.26	12.15	27.18	-27.96	27.96	6.99
22/11/19	7:55:54	3.63	3.43	12.15	27.19	-26.41	26.41	6.60
22/11/19	7:56:38	3.72	3.51	12.15	27.21	-26.44	26.44	6.61
22/11/19	7:57:21	3.93	3.71	12.16	27.22	-24.26	24.26	6.07
22/11/19	7:58:05	3.43	3.24	12.15	27.21	-29.35	29.35	7.34
22/11/19	7:58:49	3.61	3.41	12.16	27.22	-27.54	27.54	6.89
22/11/19	7:59:32	3.66	3.45	12.17	27.24	-26.02	26.02	6.51
22/11/19	8:00:16	3.72	3.51	12.16	27.25	-25.78	25.78	6.45
22/11/19	8:01:00	3.72	3.51	12.17	27.26	-26.31	26.31	6.58
22/11/19	8:01:43	3.5	3.3	12.16	27.25	-27.91	27.91	6.98

Corn Cops & Lime

Date	Time	Raw CH1 Signal (uV)	q1 (W/m^2)	Tinside (degC)	Toutside (degC)	R-Value	corn cobs with lime	R Value corn cobs with lime per inch
20/11/19	16:22:34	61.39	57.92	22.46	32.25	-0.96	0.96	0.24
20/11/19	16:23:18	61.46	57.98	22.48	32.27	-0.96	0.96	0.24
20/11/19	16:24:02	61.32	57.85	22.47	32.26	-0.96	0.96	0.24
20/11/19	16:24:45	61.4	57.93	22.45	32.27	-0.96	0.96	0.24
20/11/19	16:25:29	61.08	57.63	22.44	32.28	-0.97	0.97	0.24
20/11/19	16:26:13	61.06	57.6	22.42	32.25	-0.97	0.97	0.24
20/11/19	16:26:56	61.39	57.91	22.39	32.26	-0.97	0.97	0.24
20/11/19	16:27:40	61.13	57.67	22.38	32.29	-0.98	0.98	0.25
20/11/19	16:28:23	60.87	57.43	22.38	32.29	-0.98	0.98	0.25
20/11/19	16:29:07	61.17	57.7	22.36	32.27	-0.98	0.98	0.25
20/11/19	16:29:51	61.19	57.72	22.34	32.27	-0.98	0.98	0.25
20/11/19	16:30:34	60.8	57.36	22.34	32.26	-0.98	0.98	0.25
20/11/19	16:31:18	60.95	57.5	22.35	32.24	-0.98	0.98	0.25
20/11/19	16:32:01	60.87	57.43	22.33	32.21	-0.98	0.98	0.25
20/11/19	16:32:45	60.95	57.5	22.34	32.24	-0.98	0.98	0.25
20/11/19	16:33:29	60.68	57.25	22.36	32.25	-0.98	0.98	0.25
20/11/19	16:34:12	60.65	57.22	22.31	32.21	-0.98	0.98	0.25
20/11/19	16:34:56	60.53	57.1	22.29	32.18	-0.98	0.98	0.25
20/11/19	16:35:40	60.75	57.31	22.3	32.18	-0.98	0.98	0.25
20/11/19	16:36:23	60.47	57.05	22.33	32.18	-0.98	0.98	0.25
20/11/19	16:37:07	60.36	56.95	22.39	32.19	-0.98	0.98	0.25
20/11/19	16:37:50	60.56	57.13	22.35	32.18	-0.98	0.98	0.25
20/11/19	16:38:34	60.45	57.02	22.34	32.21	-0.98	0.98	0.25
20/11/19	16:39:18	59.94	56.55	22.31	32.19	-0.99	0.99	0.25
20/11/19	16:40:01	60.51	57.08	22.32	32.21	-0.98	0.98	0.25
20/11/19	16:40:45	60.28	56.87	22.3	32.19	-0.99	0.99	0.25
20/11/19	16:41:29	60.15	56.75	22.28	32.17	-0.99	0.99	0.25
20/11/19	16:42:12	60.46	57.04	22.28	32.12	-0.98	0.98	0.25
20/11/19	16:42:56	60.05	56.65	22.28	32.13	-0.99	0.99	0.25
20/11/19	16:43:39	60.01	56.62	22.27	32.13	-0.99	0.99	0.25
20/11/19	16:44:23	60.23	56.82	22.26	32.13	-0.99	0.99	0.25
20/11/19	16:45:07	59.75	56.37	22.25	32.13	-1	1	0.25
20/11/19	16:45:50	59.86	56.47	22.24	32.16	-1	1	0.25
20/11/19	16:46:34	59.85	56.46	22.24	32.16	-1	1	0.25
20/11/19	16:47:17	59.88	56.49	22.22	32.14	-1	1	0.25
20/11/19	16:48:01	59.64	56.26	22.21	32.12	-1	1	0.25
20/11/19	16:48:45	59.55	56.18	22.21	32.08	-1	1	0.25
20/11/19	16:49:28	59.86	56.47	22.2	32.04	-0.99	0.99	0.25
20/11/19	16:50:12	59.43	56.07	22.23	32.04	-0.99	0.99	0.25
20/11/19	16:50:56	59.43	56.07	22.21	32.02	-0.99	0.99	0.25
20/11/19	16:51:39	59.6	56.23	22.22	32.03	-0.99	0.99	0.25
20/11/19	16:52:23	59.54	56.17	22.21	32.04	-0.99	0.99	0.25
20/11/19	16:53:06	59.36	56	22.21	32.08	-1	1	0.25
20/11/19	16:53:50	59.22	55.87	22.21	32.12	-1.01	1.01	0.25
20/11/19	16:54:34	59.42	56.06	22.19	32.13	-1.01	1.01	0.25
20/11/19	16:55:17	58.92	55.58	22.16	32.14	-1.02	1.02	0.26
20/11/19	16:56:01	59.11	55.77	22.15	32.16	-1.02	1.02	0.26
20/11/19	16:56:44	59.19	55.84	22.15	32.17	-1.02	1.02	0.26
20/11/19	16:57:28	58.91	55.57	22.16	32.19	-1.03	1.03	0.26
20/11/19	16:58:12	59.18	55.83	22.16	32.16	-1.02	1.02	0.26

Date	Time	Raw CH1 Signal (uV)	q1 (W/m^2)	Tinside (degC)	Toutside (degC)	R-Value	R Value per inch Corn cobs with damp lime	dT: Corn cobs with lime
12/12/19	10:07:09	53.86	50.81	16.27	28.16	-1.33	0.33	11.89
12/12/19	10:07:52	53.88	50.83	16.26	28.17	-1.33	0.33	11.91
12/12/19	10:08:36	53.94	50.89	16.25	28.19	-1.33	0.33	11.94
12/12/19	10:09:20	53.89	50.84	16.26	28.21	-1.34	0.34	11.95
12/12/19	10:10:03	53.93	50.87	16.18	28.16	-1.34	0.34	11.98
12/12/19	10:10:47	53.56	50.53	16.15	28.16	-1.35	0.34	12.01
12/12/19	10:11:31	53.7	50.66	16.12	28.17	-1.35	0.34	12.05
12/12/19	10:12:14	53.72	50.68	16.1	28.17	-1.35	0.34	12.07
12/12/19	10:12:58	53.63	50.59	16.1	28.18	-1.36	0.34	12.08
12/12/19	10:13:41	53.48	50.46	16.08	28.19	-1.36	0.34	12.11
12/12/19	10:14:25	53.19	50.18	16.06	28.2	-1.37	0.34	12.14
12/12/19	10:15:09	53.32	50.3	16.05	28.2	-1.37	0.34	12.15
12/12/19	10:15:52	53.39	50.37	16.04	28.21	-1.37	0.34	12.17
12/12/19	10:16:36	53.34	50.33	16.02	28.22	-1.38	0.35	12.2
12/12/19	10:17:20	53.19	50.18	16.01	28.24	-1.38	0.35	12.23
12/12/19	10:18:03	53.02	50.01	16	28.23	-1.39	0.35	12.23
12/12/19	10:18:47	53.08	50.08	16	28.25	-1.39	0.35	12.25
12/12/19	10:19:31	53.19	50.18	15.97	28.25	-1.39	0.35	12.28
12/12/19	10:20:14	53.32	50.31	15.95	28.26	-1.39	0.35	12.31
12/12/19	10:20:58	52.89	49.9	15.95	28.27	-1.4	0.35	12.32
12/12/19	10:21:41	53	50	15.96	28.27	-1.4	0.35	12.31
12/12/19	10:22:25	52.96	49.96	15.93	28.28	-1.4	0.35	12.35
12/12/19	10:23:09	52.61	49.63	15.91	28.29	-1.42	0.36	12.38
12/12/19	10:23:52	52.86	49.86	15.89	28.3	-1.41	0.35	12.41
12/12/19	10:24:36	52.78	49.79	15.89	28.3	-1.42	0.36	12.41
12/12/19	10:25:20	52.8	49.81	15.88	28.3	-1.42	0.36	12.42
12/12/19	10:26:03	52.58	49.6	15.84	28.3	-1.43	0.36	12.46
12/12/19	10:26:47	52.61	49.63	15.85	28.32	-1.43	0.36	12.47
12/12/19	10:27:30	52.93	49.93	15.84	28.32	-1.42	0.36	12.48
12/12/19	10:28:14	52.45	49.48	15.82	28.32	-1.43	0.36	12.5
12/12/19	10:28:58	52.62	49.64	15.81	28.32	-1.43	0.36	12.51
12/12/19	10:29:41	52.47	49.5	15.8	28.34	-1.44	0.36	12.54
12/12/19	10:30:25	52.81	49.82	15.79	28.33	-1.43	0.36	12.54
12/12/19	10:31:09	52.72	49.73	15.78	28.35	-1.44	0.36	12.57
12/12/19	10:31:52	52.38	49.41	15.76	28.34	-1.45	0.36	12.58
12/12/19	10:32:36	52.24	49.28	15.76	28.35	-1.45	0.36	12.59
12/12/19	10:33:20	52.03	49.09	15.75	28.35	-1.46	0.37	12.6
12/12/19	10:34:03	52.47	49.5	15.72	28.36	-1.45	0.36	12.64
12/12/19	10:34:47	52.43	49.46	15.71	28.36	-1.45	0.36	12.65
12/12/19	10:35:30	52.14	49.19	15.7	28.37	-1.46	0.37	12.67
12/12/19	10:36:14	52.51	49.54	15.69	28.37	-1.45	0.36	12.68
12/12/19	10:36:58	52.26	49.3	15.7	28.39	-1.46	0.37	12.69
12/12/19	10:37:41	52.16	49.2	15.68	28.38	-1.47	0.37	12.7
12/12/19	10:38:25	51.66	48.73	15.66	28.4	-1.49	0.37	12.74
12/12/19	10:39:09	51.86	48.92	15.67	28.4	-1.48	0.37	12.73
12/12/19	10:39:52	51.8	48.87	15.67	28.41	-1.48	0.37	12.74
12/12/19	10:40:36	51.84	48.91	15.67	28.35	-1.47	0.37	12.68
12/12/19	10:41:20	51.75	48.82	15.64	28.95	-1.55	0.39	13.31
12/12/19	10:42:04	52.08	49.14	15.59	28.15	-1.45	0.36	12.56
12/12/19	10:42:47	51.82	48.89	15.54	27.76	-1.42	0.36	12.22

Shredded Paper / Card Board

Date	Time	Raw CH1 Signal (uV)	q1 (W/m^2)	Tinside (degC)	Toutside (degC)	R-Value	shredded Card board paper	R Value shredded paper per inch	dT Shredded Paper
22/11/19	12:09:09	53.99	50.93	16.71	30.14	-1.5	1.5	0.38	13.43
22/11/19	12:09:53	53.3	50.29	16.57	30.1	-1.53	1.53	0.38	13.53
22/11/19	12:10:37	52.83	49.84	16.43	30.13	-1.56	1.56	0.39	13.7
22/11/19	12:11:20	52.23	49.27	16.3	30.13	-1.59	1.59	0.40	13.83
22/11/19	12:12:04	52.15	49.2	16.14	30.11	-1.61	1.61	0.40	13.97
22/11/19	12:12:48	51.23	48.33	16.02	30.11	-1.66	1.66	0.42	14.09
22/11/19	12:13:31	50.65	47.78	15.89	30.09	-1.69	1.69	0.42	14.2
22/11/19	12:14:15	50.37	47.52	15.75	30.1	-1.71	1.71	0.43	14.35
22/11/19	12:14:58	49.97	47.14	15.63	30.09	-1.74	1.74	0.44	14.46
22/11/19	12:15:42	48.97	46.2	15.52	30.08	-1.79	1.79	0.45	14.56
22/11/19	12:16:26	48.16	45.43	15.41	30.05	-1.83	1.83	0.46	14.64
22/11/19	12:17:09	48.59	45.84	15.3	30.06	-1.83	1.83	0.46	14.76
22/11/19	12:17:53	47.68	44.99	15.19	30.05	-1.88	1.88	0.47	14.86
22/11/19	12:18:36	47.34	44.66	15.09	30.05	-1.9	1.9	0.48	14.96
22/11/19	12:19:20	47.08	44.41	14.97	30.06	-1.93	1.93	0.48	15.09
22/11/19	12:20:04	46.45	43.82	14.86	30.04	-1.97	1.97	0.49	15.18
22/11/19	12:20:47	45.92	43.32	14.75	30.04	-2.01	2.01	0.50	15.29
22/11/19	12:21:31	45.76	43.17	14.66	30.06	-2.03	2.03	0.51	15.4
22/11/19	12:22:15	45.58	43	14.57	30.05	-2.04	2.04	0.51	15.48
22/11/19	12:22:58	45.04	42.49	14.48	30	-2.07	2.07	0.52	15.52
22/11/19	12:23:42	44.43	41.91	14.4	30.01	-2.12	2.12	0.53	15.61
22/11/19	12:24:25	43.97	41.48	14.3	30.09	-2.16	2.16	0.54	15.79
22/11/19	12:25:09	43.52	41.05	14.19	30.1	-2.2	2.2	0.55	15.91
22/11/19	12:25:53	43.25	40.8	14.09	30.08	-2.23	2.23	0.56	15.99
22/11/19	12:26:36	43.15	40.71	13.96	30.06	-2.25	2.25	0.56	16.1
22/11/19	12:27:20	42.45	40.05	13.85	30.01	-2.29	2.29	0.57	16.16
22/11/19	12:28:03	42.37	39.97	13.75	29.96	-2.3	2.3	0.58	16.21
22/11/19	12:28:47	42.13	39.74	13.66	29.95	-2.33	2.33	0.58	16.29
22/11/19	12:29:31	41.69	39.33	13.58	29.93	-2.36	2.36	0.59	16.35
22/11/19	12:30:14	41.59	39.24	13.49	29.9	-2.38	2.38	0.60	16.41
22/11/19	12:30:58	41.28	38.94	13.4	29.87	-2.4	2.4	0.60	16.47
22/11/19	12:31:41	40.83	38.52	13.32	29.88	-2.44	2.44	0.61	16.56
22/11/19	12:32:25	40.6	38.3	13.25	29.87	-2.47	2.47	0.62	16.62
22/11/19	12:33:09	40.26	37.98	13.21	29.86	-2.49	2.49	0.62	16.65
22/11/19	12:33:52	40.04	37.78	13.13	29.85	-2.52	2.52	0.63	16.72
22/11/19	12:34:36	39.75	37.5	13.08	29.86	-2.54	2.54	0.64	16.78
22/11/19	12:35:20	39.6	37.36	13.02	29.87	-2.56	2.56	0.64	16.85
22/11/19	12:36:03	39.52	37.29	12.96	29.9	-2.58	2.58	0.65	16.94
22/11/19	12:36:47	38.82	36.62	12.89	29.93	-2.64	2.64	0.66	17.04
22/11/19	12:37:30	38.79	36.59	12.84	29.92	-2.65	2.65	0.66	17.08
22/11/19	12:38:14	38.59	36.41	12.78	29.91	-2.67	2.67	0.67	17.13
22/11/19	12:38:58	38.13	35.97	12.7	29.93	-2.72	2.72	0.68	17.23
22/11/19	12:39:41	37.92	35.77	12.64	29.9	-2.74	2.74	0.69	17.26
22/11/19	12:40:25	37.87	35.72	12.57	29.87	-2.75	2.75	0.69	17.3
22/11/19	12:41:09	37.77	35.63	12.5	29.86	-2.77	2.77	0.69	17.36
22/11/19	12:41:52	37.58	35.45	12.45	29.86	-2.79	2.79	0.70	17.41
22/11/19	12:42:36	37.46	35.34	12.37	29.87	-2.81	2.81	0.70	17.5
22/11/19	12:43:19	37.15	35.05	12.32	29.89	-2.85	2.85	0.71	17.57
22/11/19	12:44:03	36.81	34.73	12.26	29.88	-2.88	2.88	0.72	17.62
22/11/19	12:44:47	36.76	34.68	12.21	29.87	-2.89	2.89	0.72	17.66

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