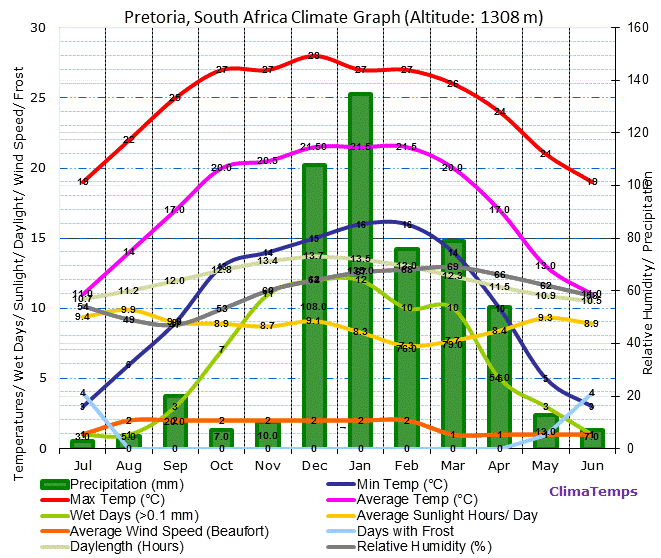
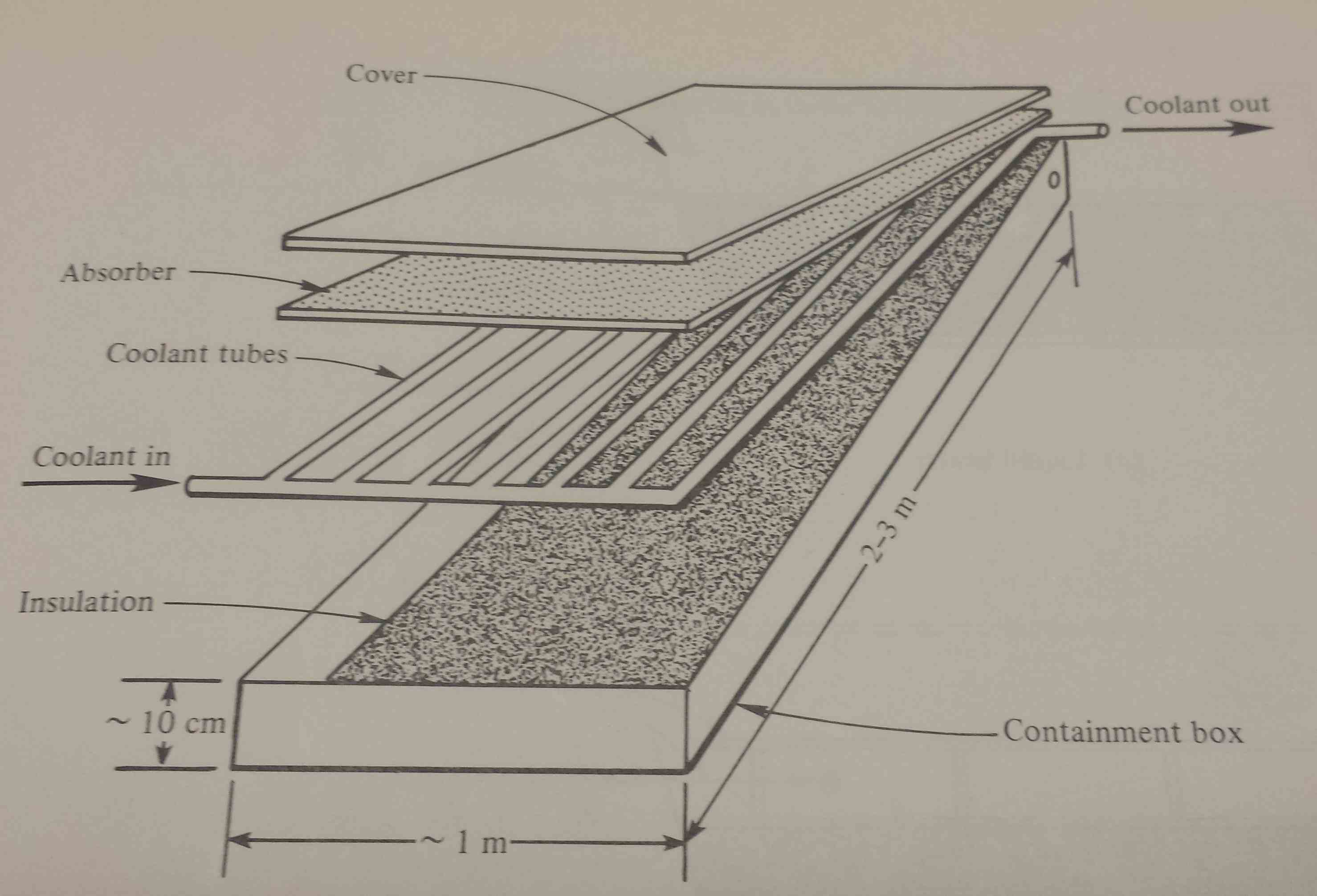
# Literature Survey

The demand of solar collectors has increased drastically in the past decade, as the world is striving to harvest cleaner and more sustainable forms of energy. The drive toward solar energy is approaching a climax at a very high rate, especially in regions of the world where there are a lot of sunny days. Public awareness campaigns are launched everywhere, and it seems that the world consumers are slowly starting to move away from electrical geysers. According to H. Aktamis (2011) the level of awareness of renewable energy sources is very among the general public, especially among second grade students in the developed countries of the world.

Solar power is readily useable in South Africa, with applications including: photovoltaic (PV) cells; domestic and swimming pool heating for the middle and upper class; industry applications; agriculture; and pumping of water in rural areas (Dept. of Energy, 2016). South Africa has an ideal climate for solar power applications with a lot of sunshine days, as well as a lot of daylight hours. Data from ClimaTemps (2016) can be seen in Figure 1.



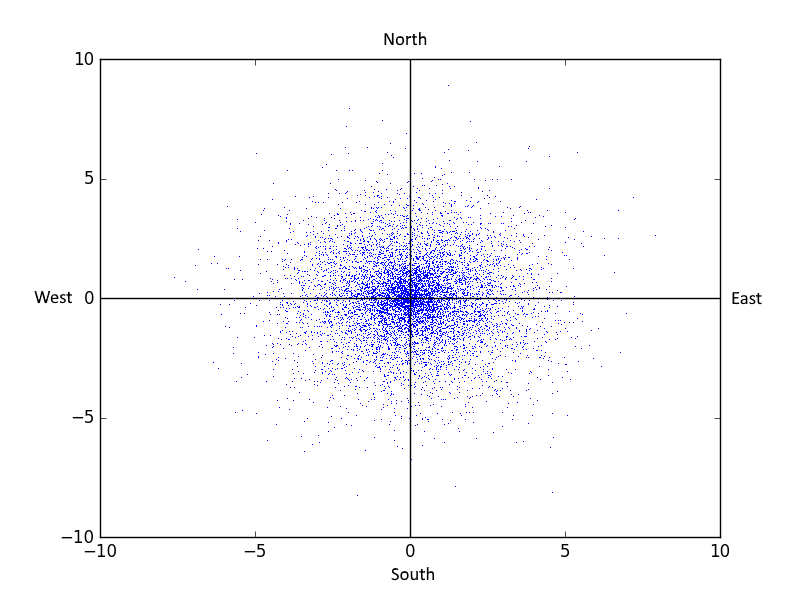
There is a wide variety of solar heat collectors. The two main types of collectors are the evacuated tube collectors and the flat plate collectors. There are also a lot of different designs for flat plate collectors. The design used in this project has copper tubing that runs through the absorber plate, and therefore heats up the fluid running through the tube. This is depicted in Figure 1.



Despite the design of the collector, there are a multitude of other conditions to consider when modelling or setting up a solar collector. A few of these conditions include: the average wind speed and direction; the effective radiation available for absorption by the collector; the materials of the collector plate, cover, and insolation; and the mean difference in angle between the normal plane of the collector and the Direct Normal Irradiance (DNI).

## Average Wind Speed and Direction

In order to minimise the heat loss through, the solar panel should preferably lie in a direction where the glass/polymer cover, gets the least amount of wind exposure. In Figure 1, the hourly wind speed and direction over the course of one year (2016) is displayed (data from SAURAN, 2016). The wind speed and direction appears to be very evenly distributed, with no obvious configuration coming to mind.



The most notable observation in Figure 1, is the low average wind velocity (a mere 2 m/s). This is very advantageous for setting up a solar farm in the Pretoria region.

## Effective Radiation

## Materials and Construction of a Collector

### Glass Cover

The glass cover’s (usually made of tempered or toughened glass) purpose is to protect the rest of the collector from environmental effects, while at the same time allowing radiation to strike the absorber plate. Usually the glass used is very transparent, allowing more than 90% of the incident radiation to pass through.

### Absorber Plate

Made from a thin sheet of aluminium, with a coating of a highly selective material that is very efficient at absorbing solar radiation, the absorber plate’s main purpose is to convert the incident radiation to effective heat that can be transferred to the water (or another working fluid). The welding between the copper pipes and the aluminium sheet is usually done ultrasonically, in order to weld joint with very low thermal resistance.

### Insolation

The insolation’s, usually made from ultra-light weight melamine foam, function is to minimize the heat loss through the back of the absorber plate. Newer flat plate models use a vacuum as insolation (AEE INTEC).

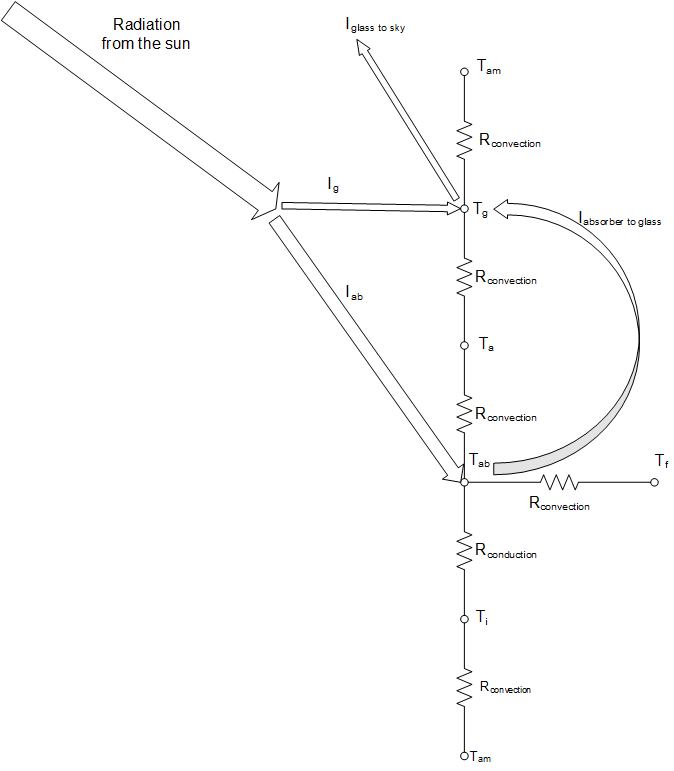
### Riser and Header Pipes

Made from copper, these tubes are welded ultrasonically in order to minimize heat loss over the weld joints. Further functions of these tubes are to transfer the stored/converted heat to the working fluid. Small riser pipe diameters contribute to turbulent flow through the pipe, maximizing the convective heat transfer within the pipes.

Further detail regarding the physical and heat transfer parameters of all the relevant materials can be found in Appendix B.

## Thermal Network of the Collector

The easiest way to conceptualize the heat transfer within a flat plate solar collector is to draw up a thermal resistance network. This can be seen in Figure 2.



While resistances were not actually used to set up the model, the resistance network still holds as a very convenient way to illustrate the system. The convective and conductive ‘resistances’, were only used to in order to calculate the heat flux, by using the common transfer function for heat transfer

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The equation describing the thermal resistance to convection is

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whereas the equation describing thermal resistance to conduction is

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(Ḉengel & Ghajar, 2011). For more information regarding the heat transfer coefficients refer to Section ?? and Appendix ??.

## Radiation heat flow

In this model, it was assumed that the emitted radiation from the glass panel and the absorber plate was substantial. The other components’ radiative effects were assumed to be negligible.

The radiative heat flux from the glass panel to the sky, can be described by

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(Ḉengel & Ghajar, 2011), where the sky temperature is given by Swinbank’s formula

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(Saleh, 2012).

Radiation from the absorber plate is toward the glass plate, and can be calculated using the formula

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(Goswami *et al*, 2000).

All of the radiation constants can be seen in Appendix ??.

## Convective heat transfer coefficients

Multiple convective heat transfer coefficients are needed for the model.