



EXPERIMENTAL STUDY OF FORCED CONVECTION SOLAR DRYER FOR FOOD MATERIAL

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ABSTRACT

The Solar energy is one of the huge sources of renewable energy in the world by using these energy we develop a solar food dryer. The energy we are getting in this experiment are used for the removing the moisture that results in reducing the weight of the product which we are to be dried. We are experienced on two type of dryer like Natural and Forced convection solar dryer are designed for the farmer's and the constructed material which are easily available in the local market. These types of dryer mainly used in the small scale and the home appliances. The fans were installed for the force convection and the energy obtained directly from sun through Photovoltaic-power system, we directly attached the fan with this system which worked without accumulator and load controller. When the solar radiation increases the speed of the fan also increases and vice versa. The advantages of the solar food dried are to protect in the dryer from the dust, animal, birds and vitamin losses, lots of devices available in the market to remove moisture but it is the safe, best and economical way for the farmer.

Keyword: - Force convection solar dryer, fan, photovoltaic panel.

1. INTRODUCTION

Solar energy is a great source of the renewable energy. We get it from the environment very easily and in the abounded amount. This energy is of pollution free. The solar energy helps in the drying and in the food preservation due to nature free people can use easily in the world. The sun drying is most common method in the food drying but it quite harmful and losses were found in this system. In the sun drying there are losses in the vitamins, colour and damages.[1] So to avoid these losses we provide solar food drying due to economical the industries were taking the benefits because the per capita income is low as compare to the other methods due to solar radiation all the possible cycle like photosynthesis, rain, evaporation, wind and many more which makes life possible in the world.[4] Some of the process does not possible without solar radiation because some of the location does not have same sunshine throughout the year, So we have to manage according to the availability. The solar radiation is some time also depends on the clouds of the location so to remove these problems we introduce the solar dryer for the dehydration in this process we also introduce the solar heater for the proper dehydration in the food material. The solar dryer is prevents from the rain, animals and the bird eating. So it is safe and the best way to preserve and more convenient. In the solar dryer the hygroscopic properties of the food material which have to dry were lost but in sun drying we lost the crop fertility or food vitamins.[5] The main reason is to install the dryer because it rejects more heat than the expected under the ambient condition in the solar collector. As we know that the warm air have more moisture than that of the cold air so many solar dryer were installed to improve the product quality.

2. CLASSIFICATION OF SOLAR DRYERS

According to the basic principal of the solar dryer it can be classified are as follows:-[2]

- Air base movement mode
- Insulation base
- Flow of air direction mode

2.1 According to the heating mode solar dryer can be primarily classified are as follow

- Active solar dryer
- Passive solar dryer

2.2. In active or passive solar dryer the three main sub divisions are as follows

- Integrated type solar dryer
- Distributed type solar dryer
- Mixed mode solar dryer

2.2.1. Passive solar dryer

The passive solar dryer are also known as the natural convection system. These systems are generally of normal size and normally circulation of the solar dryer so that the heat circulated by its whole product to be dried and the air is circulated by its buoyancy force and the pressure is acting all over the products which have to dry.[7] The passive dryer are generally built cheap and simple and some of the wood pieces are also provided for their proper work. There are use of insulation from the sun which is blue in colour frame are also used for the convection of air.

2.2.2. Active solar dryer

The active solar dryer are also known as the forced convection solar dryer or the hybrid solar dryer. The maximum air is allowed to flow in the collector for the proper convection throughout the process so that it



maintains the temperature and the moisture within the drying process. The total weather conditions are provided by the forced convection.[12] The forced convection is more effective than that of the natural convection in this dryer the fans may be run through the available electricity or with the help of PV- panel. The forced convection is reduced the drying process as three times and are in 50 % of natural convection dryer. Many external devices are also connected to the dryer such as electronic to indicate the drying rates In active solar dryer.

2.2.3. PV powered System

This system dc fan which is 0.18 amp and 12 volt is directly connected to the solar panel with a 50 watt and 12 volt .the solar plates are put above some distance in the collector.[3] Wood scribe is also put inside the solar collector. The solar collector are painted black inside so that it entraps more heat. The green fibre is also insulated all over the collector for proper insulation. We do not use accumulator to control the variations .Because as the intensity of the photovoltaic is increases as the speed of the fan increases. Box is covered with the transparent glass to pass the sun light [11].

3. EXPERIMENTAL SETUP OF THE FORCE CONVECTION FOOD DRYER

Solar food dryer is design and constructed simplest and easy method. It has been more effective in food moisture removing process.

3.1. Assembly

List of the equipment and materials used in the force convection solar food dryer are as follows:-Structure of solar food dryer are made with the wooden ply box and green sheets of fiber were covered outside the walls of the box for proper insulation, absorber plates are used that is of aluminium to absorb the solar radiation for proper heat up the air for removal of moisture. The inside walls are painted black to entrap more heat than the normal box. Dc fans are used to floe the air all over the box for the force convection. Dc fans are attached to the PV- power system to get the energy produce from the solar radiation to run the fan.

3.2. Materials are using to make the solar food dryer

Table 1:- Materials are using to make the solar food dryer

| S. No | Materials | Dimension/capacity | Quantity |
|-------|-------------------|--------------------|----------|
| 1 | Ply Wood Box | 12mm thickness | 1 |
| 2 | Green fiber sheet | 4mm thickness | 1 |
| 3 | Absorber plate | 22 gauge | 1 |
| 4 | Wood scraber | 1kg | 1 |
| 5 | Glass cover | 4mm | 1 |
| 6 | Fan | 12 volt D.C | 2 |

| | | | |
|---|----------------|----------------------|---|
| 7 | PV-Solar panel | 50 Watt .12 Volt D.C | 1 |
| 8 | Black paint | | 1 |



Fig:-1. Front view Fig:-2. Side view



Fig:-3. Back view Fig:-4. Complete view

4. THE METHOD WERE USED IN THE PROCESS ARE AS FOLLOWS

1. Design calculation

According to the designing parameters the size of the drier are to be selected

R = SA/V..... (1)

SA = surface area

V = volume of the drying chambers

Table - 2: The measurements of the solar food dryer parameters

| S. No | Design parameters | Measurements |
|-------|-------------------------------|----------------------|
| 1 | Surface Area of the collector | 1.33m ² |
| 2 | Volume of the drying chamber | 2.38m ³ |
| 3 | SA/V Ration | 0.55 per m |
| 4 | Latitude of the Jaipur | 26° 55' N & 75° 58'E |
| 5 | Collector slope | South 27° to 40° |

5. Data Analysis process

1. To determine the loss of the moisture.

Moisture loss of the mint, red chillies and coriander

ML= mi - mf..... (2)

Where,

ML = moisture loss

mi = Initial mass of the sample



determine the content of moisture on wet basis

Δ t = time interval

The % of moisture by using the formula

$$\% M a b = \frac{m_i - m_f}{m_i} * 100.....(3)$$

Where,

% Ma b = % of moisture

m_i = initial mass of the sample

m_f = final mass of the sample

3. To determine the drying rate by using the formula

$$\Delta R = \frac{\Delta m}{\Delta t}$$

4. To determine the drying efficiency by using the formula

$$\eta_d = \frac{M}{IAt}.....(5)$$

IAt

Where,

M= mass of the water evaporated from the sample

L= latent heat of the vaporisation of the water

I= solar insolation

A= area to be affected in the collector [13]

Date: 26/11/2014

*South facing at 27°

*Note:- F.C(force convection),N.C(natural force),g(gram) and wt(weight).

Table 1.1:-Observation on force convection and natural convection solar food dryer sample of Mint.

| Time of day | F.C Inside absorber plate(°C) | N.C inside absorber plate(°C) | F.C (wt.loss) sample Mint (g) | N.C(wt.loss) Sample Mint (g) | F.C Inlet (°C) | F.C Outlet (°C) | N.C Inlet (°C) | N.C Outlet (°C) | Solar flux in surface (0°) (W/m ²) | Solar Flux at (27°) (W/m ²) |
|-------------|-------------------------------|-------------------------------|-------------------------------|------------------------------|----------------|-----------------|----------------|-----------------|--|---|
| 10:00 | 41.3 | 56.2 | 1000 | 1000 | 34.3 | 36.7 | 38.9 | 43.9 | 440 | 535 |
| 11:00 | 48.3 | 61.4 | 937.3 | 922.2 | 36.5 | 39.9 | 39.3 | 48.7 | 590 | 665 |
| 12:00 | 54.8 | 67.6 | 826.5 | 797.2 | 38.9 | 44.6 | 42.4 | 53.3 | 660 | 840 |
| 13:00 | 54.3 | 66.2 | 723.7 | 603.9 | 40.5 | 46.9 | 43.9 | 53.7 | 645 | 833 |
| 14:00 | 52.5 | 59.6 | 601.7 | 539.5 | 38.7 | 45.3 | 41.6 | 58.3 | 550 | 673 |
| 15:00 | 49.9 | 58.7 | 533.4 | 429.7 | 33.1 | 44.3 | 40.3 | 47.7 | 415 | 620 |
| AVG | 50 | 61 | 100 | 110 | 35 | 40 | 40 | 50 | 600 | 675 |

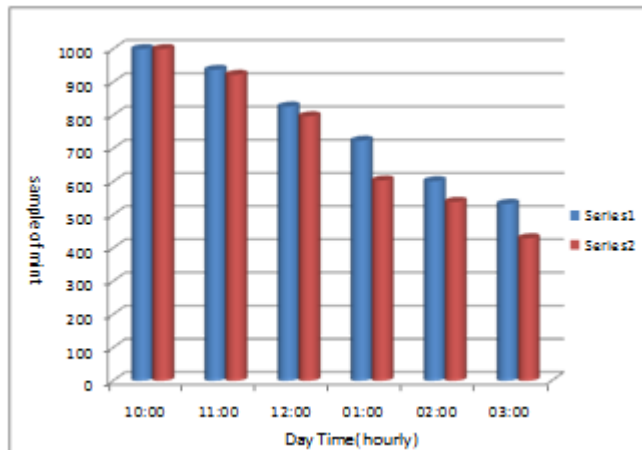
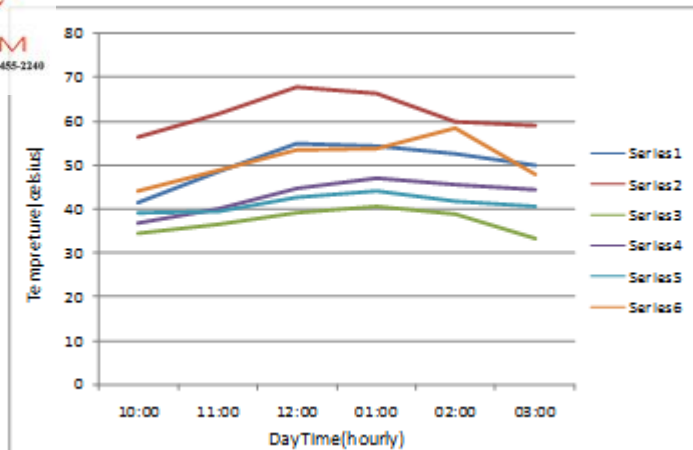


Figure1:-Graph Temperature variations of Mint sample.

Figure 2:-Graph Weight variations of Mint sample

Series 1.Absorber plate temperature in force convection dryer (Figure 1)

Series 1.Weight losses of sample mint in F.C solar food dryer (Figure 2)

Series 2.Absorber plate temperature in natural convection dryer. (Figure 1)

Series 2 Weight losses of sample mint in N.C solar food dryer (Figure 2)

Series 3 Inlet air temperature force convection dryer.

Series 4 Exit air temperature force convection dryer.

Series 5 Inlet air temperature natural convection dryer

Series 6 Exit air temperature natural convection dryer

Date: 27/11/2014

*south facing at 27°

*Note:- F.C(force convection),N.C(natural force),g(gram) and wt(weight).

Table 1.2:-Observation on force convection and natural convection solar food dryer sample of mint.

| Time of day | F.C Inside absorber plate (°C) | N.C inside absorber plate(°C) | F.C (wtloss) sample Mint (g) | N.C (wtloss) Sample Mint (g) | F.C Inlet (°C) | F.C Outlet (°C) | N.C Inlet (°C) | N.C Outlet (°C) | Solar flux in surface (0°) (W/m ²) | Solar Flux at (27°) (W/m ²) |
|-------------|--------------------------------|-------------------------------|------------------------------|------------------------------|----------------|-----------------|----------------|-----------------|--|---|
| 10:00 | 40.7 | 54.3 | 465.7 | 393.7 | 34.1 | 36.9 | 38.1 | 42.9 | 405 | 545 |
| 11:00 | 49.2 | 60.9 | 395.3 | 303.1 | 37.2 | 40.3 | 40.4 | 50.1 | 565 | 620 |
| 12:00 | 55.3 | 69.7 | 293.4 | 268.6 | 40.3 | 45.2 | 44.3 | 54.7 | 640 | 815 |
| 13:00 | 54.9 | 67.9 | 195.6 | 183.2 | 40.9 | 48.3 | 44.9 | 55.1 | 605 | 785 |
| 14:00 | 51.4 | 61.2 | 102.2 | 98.3 | 38.7 | 44.7 | 41.2 | 54.3 | 535 | 650 |
| 15:00 | 47.6 | 59.7 | 87.3 | 72.4 | 38.1 | 44.2 | 40.7 | 48.9 | 395 | 540 |
| AVG | 50 | 60 | 90 | 95 | 40 | 42 | 40 | 50 | 550 | 650 |

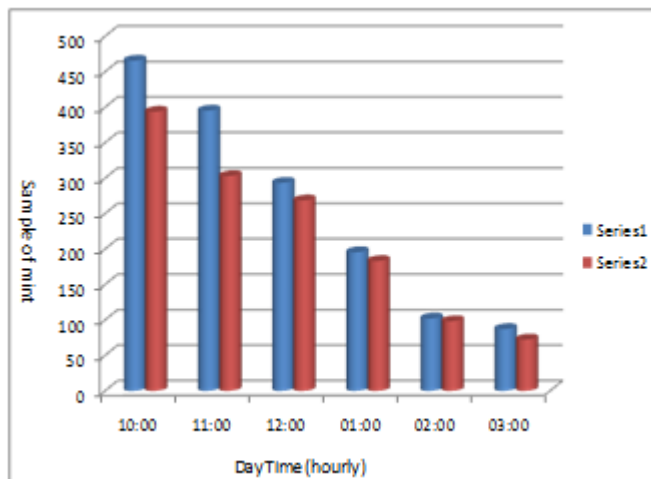
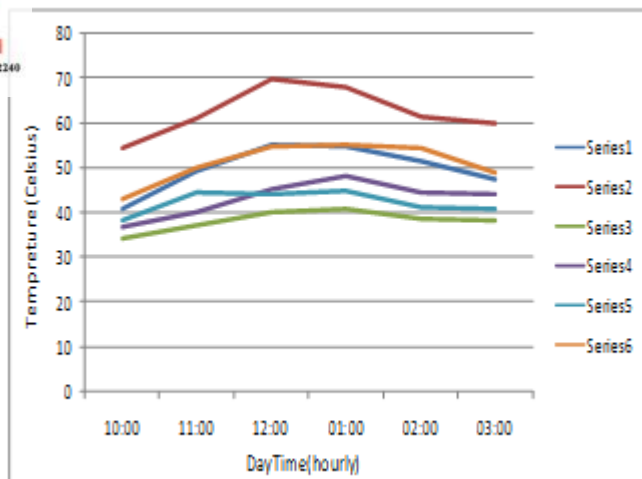


Figure 3:-Graph Temperature variations of Mint sample.

Figure 4:-Graph Weight variations of Mint sample

Series 1.Absorber plate temperature in force convection dryer. (Figure 3)

Series 1.Weight losses of mint in F.C solar food dryer (Figure 4)

Series 2.Absorber plate temperature in natural convection dryer. (Figure 3)

Series 2.Weight losses of mint in N.C solar food dryer (Figure 4)

Series 3.Inlet air temperature force convection dryer.

Series 4.Exit air temperature force convection dryer.

Series 5.Inlet air temperature natural convection dryer

Series 6.Exit air temperature natural convection dryer

Date: 28/11/2014

*south facing at 27°

*Note:- F.C(force convection),N.C(natural force),g(gram) and wt(weight).

Table 1.2:-Observation on force convection and natural convection solar food dryer sample of potato chips.

| Time of day | F.C Inside absorber plate (°C) | N.C inside absorber plate(°C) | F.C (wt.loss) sample potato chips (g) | N.C (wt.loss) Sample potato chips (g) | F.C Inlet (°C) | F.C Outlet (°C) | N.C Inlet (°C) | N.C Outlet (°C) | Solar flux in surface (0°) (W/m ²) | Solar Flux at (27°) (W/m ²) |
|-------------|--------------------------------|-------------------------------|---------------------------------------|---------------------------------------|----------------|-----------------|----------------|-----------------|--|---|
| 10:00 | 44.7 | 57.3 | 1000 | 1000 | 33.2 | 37.3 | 36.1 | 47.1 | 410 | 565 |
| 11:00 | 47.2 | 59.9 | 893.2 | 877.6 | 34.1 | 38.9 | 37.2 | 48.9 | 570 | 705 |
| 12:00 | 49.3 | 65.7 | 740.4 | 713.8 | 35.3 | 40.2 | 36.9 | 51.7 | 642 | 815 |
| 13:00 | 49.9 | 67.3 | 523.2 | 497.2 | 35.9 | 40.9 | 38.2 | 53.6 | 622 | 790 |
| 14:00 | 46.4 | 61.5 | 485.3 | 455.2 | 36.7 | 39.7 | 37.1 | 50.2 | 540 | 690 |
| 15:00 | 44.9 | 58.2 | 395.7 | 373.5 | 34.1 | 37.9 | 36.7 | 48.7 | 380 | 510 |
| AVG | 46 | 60 | 125 | 145 | 35 | 40 | 36 | 50 | 600 | 750 |

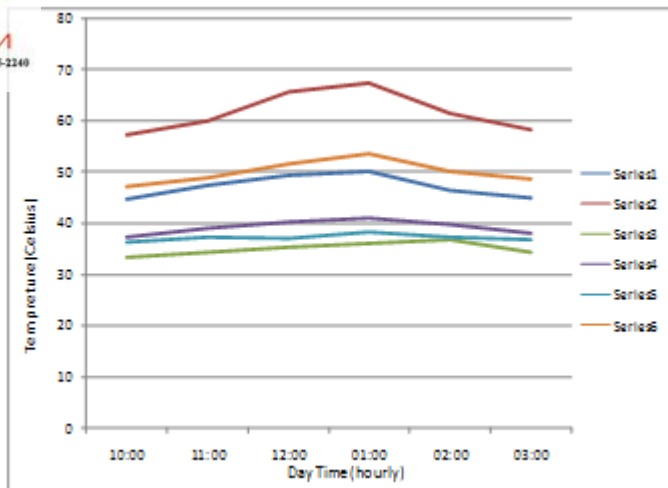


Figure 5:-Graph Temperature variations of potato chips sample.

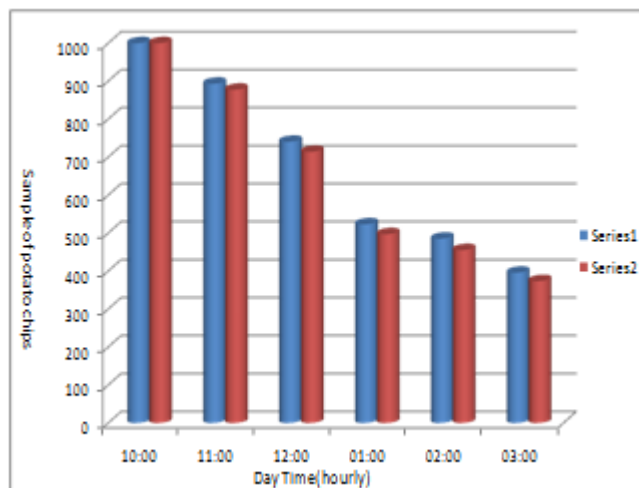


Figure 6:-Graph Weight variations of potato chips sample.

Series 1.Absorber plate temperature in force convection dryer. (Figure 5)

Series 1.Weight losses of potato in F.C solar food dryer (Figure 6)

Series 2.Absorber plate temperature in natural convection dryer. (Figure 5)

Series 2.Weight losses of potato in N.C solar food dryer (Figure 6)

Series 3.Inlet air temperature force convection dryer.

Series 4.Exit air temperature force convection dryer.

Series 5.Inlet air temperature natural convection dryer

Series 6.Exit air temperature natural convection dryer



Date: 29/11/2014

*south facing at 27°

*Note:- F.C(force convection),N.C(natural force),g(gram) and wt(weight).

Table 1.2:-Observation on force convection and natural convection solar food dryer sample of potato chips.



| Time of day | F.C Inside absorber plate (°C) | N.C inside absorber plate (°C) | F.C (wt.loss) sample potato chips (g) | N.C (wt.loss) Sample potato chips (g) | F.C Inlet (°C) | F.C Outlet (°C) | N.C Inlet (°C) | N.C Outlet (°C) | Solar flux in surface (0°) (W/m ²) | Solar Flux at (27°) (W/m ²) |
|-------------|--------------------------------|--------------------------------|---------------------------------------|---------------------------------------|----------------|-----------------|----------------|-----------------|--|---|
| 10:00 | 46.6 | 59.3 | 304.3 | 292.7 | 34.5 | 38.9 | 39.5 | 48.8 | 425 | 590 |
| 11:00 | 48.5 | 67.8 | 210 | 203.1 | 36.4 | 41.3 | 45.2 | 52.2 | 540 | 710 |
| 12:00 | 51.9 | 75.3 | 138.2 | 127 | 35.3 | 43.8 | 41.7 | 58.1 | 652 | 890 |
| 13:00 | 54.2 | 76.2 | 110.3 | 101.2 | 39.4 | 41.5 | 39.4 | 53.3 | 630 | 815 |
| 14:00 | 51.8 | 66.5 | 102.2 | 96.3 | 36.4 | 40.1 | 37.2 | 49.5 | 510 | 685 |
| 15:00 | 48.7 | 59.7 | 92.2 | 87.2 | 35.7 | 39.2 | 36.3 | 48.2 | 430 | 515 |
| AVG | 50 | 65 | 80 | 65 | 35 | 40 | 38 | 50 | 575 | 650 |

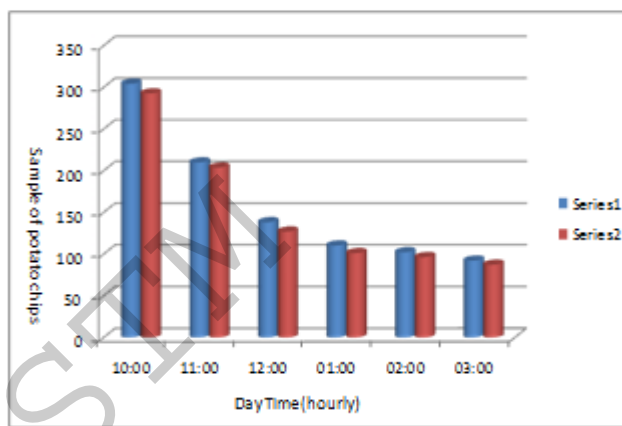
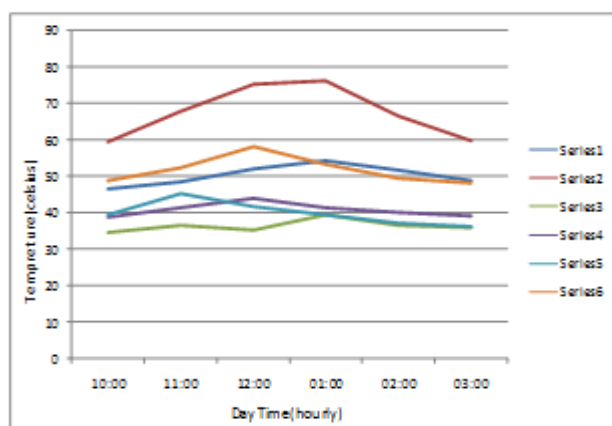


Figure 7:-Graph Temperature variations of potato chips sample. Figure 8:-Graph Weight variations of potato chips sample

Series 1.Absorber plate temperature in force convection dryer. (Figure 7)

Series 1.Weight losses of potato in F.C solar food dryer (Figure 8)

Series 2.Absorber plate temperature in natural convection dryer. (Figure 7)

Series 2.Weight losses of potato in N.C solar food dryer (Figure 8)

Series 3.Inlet air temperature force convection dryer.

Series 4.Exit air temperature force convection dryer.

Series 5.Inlet air temperature natural convection dryer

Series 6.Exit air temperature natural convection dryer

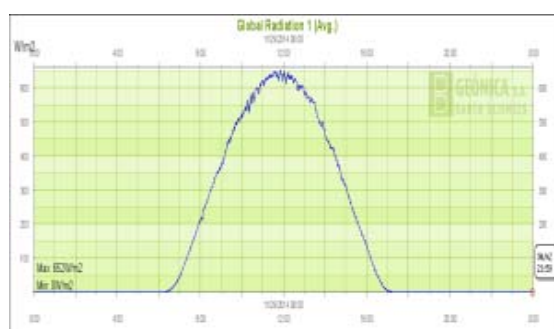


Figure 9:-Graph of solar flux radiation



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