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Evaluation of the Performance of a Mechanical Solar Tracker

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Abstract: The aim of this study was to evaluate the performance of a mechanical solar tracker. The tracker is designed to rotate basing on the rate of mass reduction on one side of the lever. A multichannel voltage logger was used to record the voltage from the terminals of a horizontally leveled pyrometer of calibration factor 5Wfor every mV measured intensity. The voltage logger also collected, read and recorded the voltage across the 5 Ω resistor connected to the output terminals of the solar panel as it rotated. A total energy of 4286.9564Wh and 3150.8132Wh, was obtained for the tracked and none tracked solar modules for twenty days of data collected. A corresponding energy fractional increase in the amount of energy of 0.2650.

Keywords: Mechanical solar tracker, Rate of mass reduction, Intensity, Voltage and Total energy output.

1. Introduction

1.1 Background

Due to the numerous technological advancements, electricity is increasingly becoming a basic need. Electricity is needed for phone charging, hair cutting, operating television sets and powering computers which have become essential for communication (ADB, 2015). Although increasingly important, only about 26.7% of Uganda's population is connected to the national grid (World Bank, 2016). A plausible reason for this low national grid coverage is the cost of generation and transmission of electricity which translate to high tariffs charged on the end users.

Consequently, over 94% of Uganda's energy demand is met by biomass in form of charcoal or fuel wood. Alternative energy sources especially the renewable sources are prospective for solving the electricity shortage. They include; solar energy, hydropower, wind energy, geothermal energy and biomass energy. These energy sources do not emit air pollutants, diversify the energy supply and reduce dependence on depreciable and expensive energy sources.

Of the renewable energy sources, solar energy provides the best alternative. This is due to the ever decreasing overhead costs and increasing efficiencies. However, the efficiency of solar photovoltaic is influenced by intrinsic and extrinsic f9875actors. Intrinsic factors include; such as cell temperature. As temperature increases, the band gap of the semiconductor shrinks and open circuit voltage decreases. The higher the energy conversion efficiency, the maximum power point tracking.

The outdoor performance of a photovoltaic module is influenced by moving factors. Some of these issues are related to the location and environment. Few of these major factors include material degradation, solar irradiation, module temperature, parasitic resistance, tilt factor, shading, soiling, tilt angle and others.

Solar photovoltaic usually degrade, the degradation process may be chemical, electronic, and thermal or mechanic in nature, it may be due to the design flaws, fair quality materials in nature or manufacturing issues.

Module temperature, the photovoltaic cell is very sensitive to temperature. The efficiency and power output of a photovoltaic cell reduces with increase in temperature. This is mainly due to the increase in internal carrier recombination rates caused by increased carrier concentration.

Shading results in mismatches in the general currents of individual cell modules. Even partial shading on a single cell can be significant in reducing the power output of the entire module as if all cells were shaded.

Potential induced degradation, due to stray currents leading to gradual loss of power.

Soiling, accumulation of dust, dirt and other contaminants of photovoltaic module. This leads to the formation of a thin screen over the module and this reduces the light falling on one or more cells.

Photovoltaic module orientation and tilt angle. It is the worst case and must be avoided inform of poor location, timing and for capturing optimum solar energy. A photovoltaic module the incident light should be perpendicular to the module.

Variation in solar radiation, it affects the photovoltaic modules under varying light conditions and affects many parameters.

Parasitic resistance, the series and short resistance of the photovoltaic cell results in increased resistance loss hence reduced module efficiency. It comprises of the resistance of metal contact, fingers impurities and resistance of semiconductor itself.

However the above tracking systems are not commonly used in Uganda as they are expensive and most Ugandans cannot afford them. They also have other associated problems such as lack of technical knowledge in their use and operation, high procurement and maintenance costs.

The proposed model of the solar tracker in this report is simple and easy to operate. It uses the locally available materials in its setup. No data algorithms are involved in its setup and operation. It's mechanically operated using the principle of reduction in changes of rates enabling the movement by addition and reduction in masses which can be determined and fixed for rotation of the solar tracker. This would be a better option and would provide the solution to the problems of other solar trackers. However, its efficiency is not known and that's why its use is still limited.

2 Materials

Materials used for the construction and performance evaluation of the solar tracker included: Metallic stands which were used for mounting and rotating the solar module, a monocrystalline silicon solar module of dimensions 76cm×66.5cm having a voltage of 18volts and maximum current of 3.61A. The module was used to evaluate the performance of the tracker, (include why we chose the 5ohm resistor) a 5 Ω resistor used to determine the potential difference. Rocks placed in a polythene bag used as fixed weights. A plastic bag clipped to allow water to drip at a chosen rate and a multichannel voltage logger used to record voltages. A straw was used for checking the shadow to detect whether the solar panel was perpendicular to the solar rays. A stop clock and measuring cylinder used to measure time and the volume of water that drips out of the bag respectively. The dripping water helps in the rotation of the solar panel.

2.1 Pyranometer model SP-110

A pyranometer is a type of instrument used for measuring solar irradiance on a planner surface and it is designed to measure the solar radiation flux density. A pyranometer is operated based on the measurement of temperature difference between a clear and dark surface. The black courting on the thermopile sensor absorbs the solar radiation, while the clear surface reflects it and hence less heat is absorbed. The thermopile is used to measure this temperature difference. The potential difference created in the thermopile owing to the temperature gradient between the two surfaces is used for measuring the amount of solar radiation. The voltage produced can be measured using a potentiometer.

Apogee SP series is made of silicon cells which are sensitive to a portion of the spectrum. The pyranometer is calibrated to estimate the total short wave radiation across the entire solar spectrum. The sensors output an analog voltage that is directly proportional to the total shortwave radiation from the sun (Apogee Instruments, 2014). SP series sensors output an analog voltage that is directly proportional to the total radiation from the sun. The sensor is connected to the data logger that is capable of measuring and displaying a millivolt signal". (Apogee Instruments, 2014)

Figure 2.1 *SP-110 PYRANOMETER (Apogee instrument 2014)*

A horizontally levelled pyranometer of sensitivity 0.2mV per Wm^{-2} that gives a calibration factor of 5 Wm^{-2} for every mV.

2.2 Multichannel voltage logger

This is an electronic device that records data over time. It consists of an in built instrument or sensor based on digital processor and has a small, battery powered portable that is equipped with microprocessor. The microprocessor has an internal memory for data storage and sensors. The data logger interface with a personal computer and uses software to activate the data logger to view and analyze the collected data. It automatically collects data on a 24hours basis. Upon activation, data logger are typically deployed and left unattended to measure and record voltage information for duration of the monitoring period.

It is an electronic device that records data over time. It has an inbuilt instrument or sensor. It's based on digital processor and has a small battery powered and equipped with microprocessor , sensors and internal memory for data storage. (T and D Corporation, 2015).

***Figure 2.2** 4-Channel Voltage Data Logger T& D Cooperation, 2015)*

2.3 Construction of solar tracker.2.3.1 Theory of operation

When multiple forces are applied on a fixed body, equilibrium is obtained when the sum of clockwise moments is equal to the sum of anticlockwise moments and the sum of parallel forces is equal to zero. Moment of a force is the product of a force and its perpendicular distance from the line of action of the fulcrum. When one force exceeds another, motion occurs in the direction of the greater force. If the moment of a force in one direction exceeds another, the rational motion occurs. This motion can be controlled varying the moment of one of the forces. This can be achieved by either changing the perpendicular distance or the force at a defined point. The tracker is designed such that equal weights are placed equidistant from the pivot. The distances m-2 and x1 (from Figure 3.2) are made equal and fixed from the pivot to allow the module to balance horizontally Using the principle of moments and volume rate change, the

Mg x2 = x1g Mr.

For x2 = x1 and having a fixed weight of Mg, when x2g reduces rotation about the pivot occurs. From

$$MgX_1 = M_r gX_2$$

As Mr reduces withMrg, X1 and X2 fixed, a constant rate of rotation is achieved.

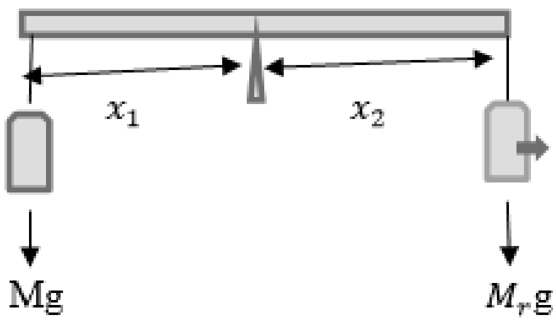

***Figure 2.3** Action of principle of moments*

2.3.3 Construction

The different parts of the stand were welded together. The mounts were prepared and lubricated to allow for easy turning. All the components are attached to one another as shown in Figure 2.4 .

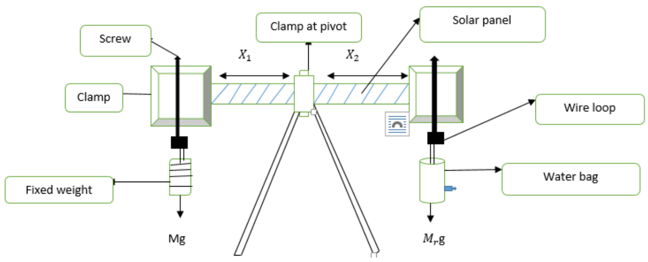

***Figure 2.4** Constructed solar tracker*

2.4 Performance evaluation

The performance of the constructed mechanical solar tracker was evaluated by assessing the difference in the module output when horizontally fixed and when mounted on the solar tracker. Data processing and analysis was done.

2.4.1 Sample Collection

A fixed solar pv and the pyranometer are leveled and connected to different channels of data logger. Measurements are taken with the panel hinged in the middle using a pair of clamps fitted with a bolt that allow rotation. The clip was adjusted to a desired level to obtain a constant rate of flow of water out of the plastic bag. The rate of flow is maintained to bring the imbalance of the loads ensuring a constant rate of rotation of the solar module about the pivot. The solar panel is first horizontally leveled and balanced at pivot using a meter rule and spirit level. A bag filled with 5 litres of water is hang on one side of the solar panel. To the oppose side of the same panel is hang a weight. Horizontal level and balance are restored about the pivot between the 5litres of water and the weights. This is achieved by adding and reducing on the weights and maintaining same distances from the pivot. The weights are reduced by removing one at a time so that the solar panel inclines facing the east. The plastic bag with a clip fitted on it is adjusted thus controlling the amount of water that dips out of it. Several adjustments on the clip are made with the use of the measuring cylinder and a stop clock to ensure that the water drips out at a rate of 10 ml per minute. This rate was arrived at using the fact that the sun sweeps out an angle of Mg in 24 hours. As the amount of water reduces on one side of the panel and maintaining same weight on its other opposite side, the solar panel rotates about the pivot at a constant rate. The pyranometer outputs were also connected to the multichannel voltage logger to collect and record the equivalent voltage the solar panel would have absorbed. The two voltage data outputs were plotted on the same graph to form a scatter graph. The line of best fit was determined from the graph that gave a cubic type of curve between the two plots. The equation was determined for the relationship between the two data sets. The data was collected between 17/05/2016 to 17/06/2016.

2.4.2 Calibrating the pyranometer

The pyranometer leveled besides the horizontal fixed solar pv and is connected to the two different channels of a data logger to record the voltage output from each simultaneously. The readings are measured, recorded and stored on the internal memory of the data logger set to take data at a 15 seconds time interval for sunshine hours. Data is then downloaded and a graph of voltage output from solar cell against voltage output from pyranometer is plotted. This gives a calibration curve whose cubic equation was chosen because it gave a best fit to the data points.

2.4.5 Energy output

As the solar panel rotates, the height of the solar panel keeps changing horizontally. A square meter ruler together with a spirit level attached to it, different heights of rotation with the horizontal at a 30 minute interval were measured and recorded as *h*.

When the solar panel is being rotated, the recorded voltage out of its terminals connected across the resistor, $R = 5\ \Omega$ is used to calculate the current. $I = 3600$ and Power is thus calculated from $P = (V)/(R)*R$. The voltage data logger is set to take data at an interval of $t = 15$seconds. The energy for each data point is calculated that is $E = P*t$.

Energy is in joules, Power is in watts, Time is converted to hours.

The voltage (*V*) of the terminals connected across a resistor (*R*) in ohms, of the tracked solar panel are recorded. The power calculate using = I2 .Since the voltage data logger is set to take data at an interval of time. Energy = (V2)/(R) is in joules when power is in watts and time converted to hours. Thus $E = P \times t$ this was done for each and every other time interval to find the energy collected for a whole day. Energy collected in a day (V2t)/(R)=ET). The same steps were repeated for each and every other day until *n* days. The collected energy amount for each day were summed up to give ∑((V2t)/(R)for a tracked solar panel.

For a horizontal solar panel the voltage is found from the intensity falling on a pyranometer with a known calibration factor of 0.2 mV per W∑ET. This voltage is read and recorded by the voltage logger as m-2 voltages for each data point and when substituted into the calibration equationgives voltage y for horizontal solar panel. Power for horizontal solar panel of each data point is calculated using the relationshipx.This power is multiplied by time t in hours to obtain the energy output for the horizontal solar panel.

The voltage data from the pyranometer for a particular intensity and the voltage across attached at the terminal output of the horizontally oriented solar panel for a single day were plotted to give a calibration curve. The cubic equation was chosen because it gave a good fit to the scatter data points plotted for a single day. The value P=(y2)/(R) represents the pyranometer voltage for a particular intensity within an interval of time as set for a multi voltage channel logger. The x value would be substituted into the selected cubic equation to give the value of voltage for a horizontal solar module. Hence x is the voltage for same solar panel when horizontally oriented for data point as recorded by a multi voltage channel logger set at that time knowing the voltage y and resistance *R*, power *P* was calculated usingy. Energy collected from the horizontally oriented solar panel = P=(y2)/(R). The same procedures for calculation of energy are followed for every other t seconds for a whole day. The energy collected in a day(y2t)/(R)and EH = ∑((y2t)/(R)) for the n days of data collection determined.

The energy collected for each day from the tracked and horizontally oriented solar panel are calculated and recorded. The difference between the two energies (∑EH is calculated and recorded. The fractional percentage energy increase for each day is calculated using the equation ;[(ET - EH) -ET] ×100

Where EH) ÷ EH = energy for rotated solar panel a day, ET= energy for horizontally oriented solar panel for each day.

The total energy collectedEH for the tracked solar panel was calculated by summing energy collected for n days. The total energy collected ((∑ET) from a horizontally oriented same solar panel was calculated by summing the energy collected for each day for n days.

Results and discussion

3.1 Constructed mechanical solar tracker

Figure 3.5 *Constructed mechanical solar tracker*

The solar tracker was set up as shown in the Figure 4.5. The tracked solar panels were connected to the multichannel voltage logger that recorded voltages throughout the day at given intervals of time. The water in the bag would drop out enabling its weight to lower and facilitate rotation.

3.2 Calibration of the Pyranometer

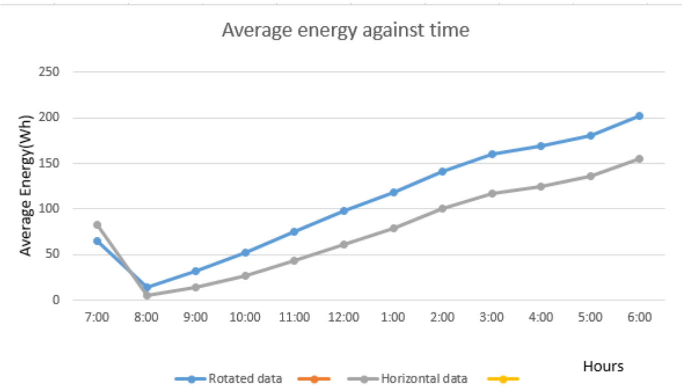

Figure 3.6 *Calibration curve*

A curve of best fit was drawn and the equation that best describes the relationship is a polynomial equation of degree three given by the equation. *y* = -1225.4∑EH)+ 258.62x3+ 76.277*x* + 0.166.

It predicts the relationship between the pyranometer voltage and what the fixed horizontal solar pv and brings about the cubic equation curve that is used to calculate the voltage y across the horizontal solar panel.

3.3.0 Diurnal variation in the tracker performance

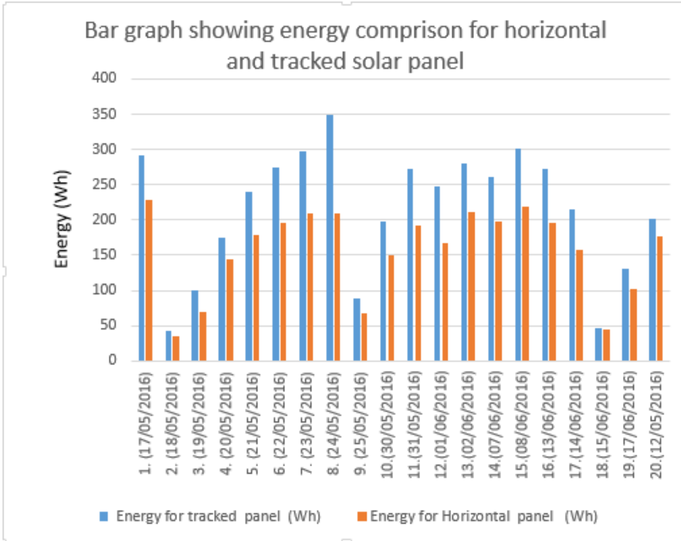

Figure 3.7 *Average energy against time*

7 shows average energy collected against time in hours for each day of data collection. In the first hour, there is a fall in the energy collected. This is the time when the solar panel is just set and has not yet accumulated more energy. In the second hour, the energy collected increases with time, but it is observed that the energy collected from tracked solar panel is always higher than that of the horizontal solar panel.

3.3.1 Daily energy output

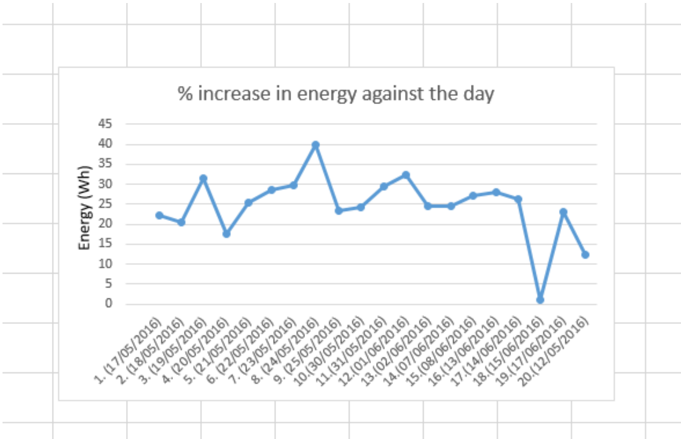

Figure 3.8 *Energy comparisons for twenty days of data collection*

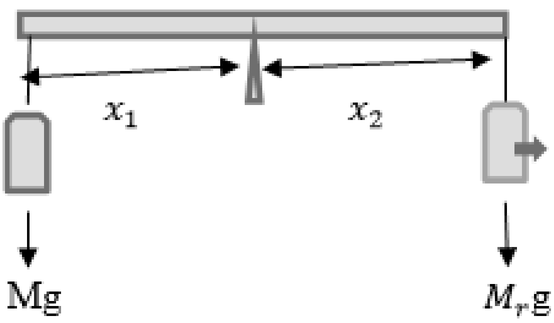

Figure 3 *Caption*

8 compares the two energies collected from the tracked and horizontal solar panel against the day. From the chart, we

observe that the total energy collected from both the tracked and horizontal solar panel is highest on 24/05/2016 but with that of the tracked solar panel higher than that of the horizontal solar panel. This is due to the fact that it was a clear day with bright sun and tracking was effective. On 18/05/2016, this was a day when the total energy collected from both panels was almost the same. The same effect is observed on 25/06/2016, but this time both panels gave equal amounts of energy collected because these were cloudy days. This is due to the fact that such days were thick cloudy days with less bright sun. On such days, tracking is not necessary as it is not effective because there is no sunlight to track because of cloudy weather. In general from the Figure 4.8 shows that one can collect more amounts of energy using the constructed solar tracker compared to using a horizontal solar panel as tracked energy is always higher than for horizontal solar panel

3.3.2 Energy output percentage variations

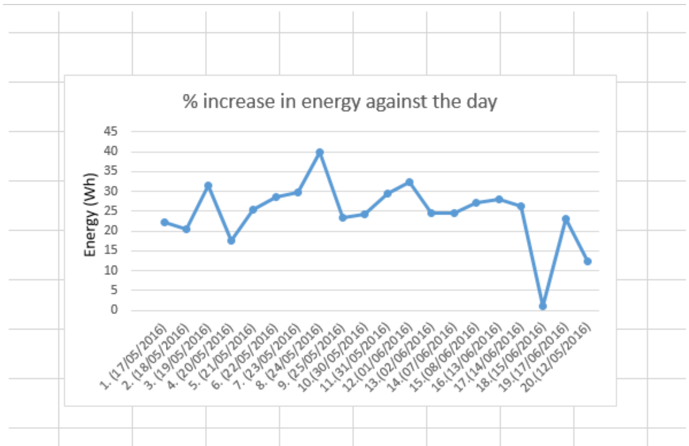

Figure 3.9 *Percentage Energy Increase Against The Day*

The graph above shows the fractional percentage increase in energy against the day for twenty days. It compares the energy collected from the tracked and horizontal solar panels.

The energy output of the tracked module was generally higher than that of the fixed module. The highest amount of energy equivalent to 348.2274 Wh was recorded for a fixed solar tracker whereas for the horizontally oriented solar tracker, 209.6784 Wh was recorded giving the highest fractional percentage increase of 39.8 %. This was a day of clear sun with the highest intensity for the bright sun.

On 15/06/16, the lowest amount of energy equivalent to 45.5599 Wh from the rotated solar panel was recorded while 45.05927 Wh was recorded for a horizontally oriented solar panel. The lowest fractional percentage energy increase of 1.1 % was noticed. Both panels recorded almost the same energy outputs. This could be due to the fact that the day had a thick cloudy day with less bright sun exposed to the solar panels throughout the day. It was found out that the total energy for 20 days from a tracked solar panel was greater than that collected from the same solar panel if it were horizontally oriented. Energy collected from a rotating solar panel was added for all the 20 days and totaled to 4286.9564 Wh and that from the same solar cell when horizontally oriented was also computed for the same number of days and totaled to 3150.8132 Wh. These two when compared give a fractional energy increase equivalent to 0.2650 and when expressed in percentage gave 26.5% increase. Thus tracking is important as it increases energy output by 26.5 % using the constructed solar tracker

3.3.3 Long term data comparison

Table 1

Day of the month	Energy for tracked panel ER(Wh)	Energy for Horizontal panel EH (Wh)	Difference ER-EH(Wh)	% increase
1. (17/05/2016)	292.5345	227.5198	65.0147	22.2
2. (18/05/2016)	43.2313	34.3674	8.8639	20.5
3. (19/05/2016)	100.6491	68.939267	31.709833	31.5
4. (20/05/2016)	174.6948	143.7857	30.9091	17.7
5. (21/05/2016)	239.959125	178.855396	61.103729	25.5
6. (22/05/2016)	275.365422	196.222604	79.142818	28.7
7. (23/05/2016)	298.065394	209.338875	88.726519	29.8
8. (24/05/2016)	348.2274	209.6784	138.549	39.8
9. (25/05/2016)	88.23571	67.49549	20.74022	23.5
10.(30/05/2016)	197.0227	149.4446	47.5781	24.2
11.(31/05/2016)	271.7216	191.5369	80.1847	29.5
12.(01/06/2016)	247.7279	167.5932	80.1347	32.4
13.(02/06/2016)	280.8088	211.7758	69.033	24.6
14.(07/06/2016)	261.2917	197.3108	63.9809	24.5
15.(08/06/2016)	301.9945	219.7254	82.2691	27.2
16.(13/06/2016)	272.2452	196.3927	75.8525	27.9
17.(14/06/2016)	215.128	158.3633	56.7647	26.4
18.(15/06/2016)	45.55993	45.05927	0.50066	1.1
19.(17/06/2016)	131.4503	101.0575	30.3928	23.1
20.(12/05/2016)	201.04330	176.3508	24.6925	12.3

Day of the month	Energy for tracked panel ER(Wh)	Energy for Horizontal panel EH (Wh)	Difference ER-EH(Wh)	% increase
Total energy for 20days	∑ER=4286.9564 ∑ER2 = 1071909.3321	∑EH=3150.8132 ∑EH2= 567368.2601		Average % = 26.5

The value calculated for $t\chi 2$.Assuming a significance level of 0.05 and 38 degrees of freedom, the critical value is 2.1 and the value of t is above this critical. This reflects an increase in the amount of energy produced from a tracked solar panel compared to a horizontally oriented solar panel.

Conclusions and recommendations

4.1 Conclusions

In this study a mechanical solar tracker was designed, constructed and its performance evaluated. Comparisons of the amount of energy produced from both the tracked and horizontal solar panels on hourly, daily and over a period of 20 days were investigated. The constructed solar tracker resulted in an overall increase in the amount of energy produced compared to the horizontal panel.

4.2 Recommendations

The mechanical solar tracking system was constructed and operationalized at a small scale but the design can be applied to any solar energy system at a large scale.

The instrument needs to be tested and operated in different rural areas of Uganda to determine how well this tracking system performs compared to systems with fixed mounting methods commonly used.

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Appendix

1: Raw data

Day one: 17/05/2016

	H	I	J	K	L	M	N	O
1	time	E	calc	calc	calc	calc	5	OHMS = RESIS
2	int.		horiz	horiz	horiz	horiz		
3	s	W-hours	voltage	current	power	E (Wh)	43.231253	total energy ir
4	15	0.08371	6.4342	1.2868	8.28	0.0345	34.367368	total energy fo
5	15.0000004	0.02317	4.8851	0.977	4.773	0.0199	1.25791573	fractional incr
6	14.9999997	0.01404	4.3411	0.8682	3.769	0.0157		
7	15.0000004	0.03298	4.5212	0.9042	4.088	0.017		
8	14.9999997	0.03075	4.4404	0.8881	3.943	0.0164		
9	14.9999997	0.02772	4.3318	0.8664	3.753	0.0156	-1225.4	cubic
10	15.0000004	0.02669	4.0932	0.8186	3.351	0.014	258.62	square
11	14.9999997	0.02076	3.5822	0.7164	2.566	0.0107	76.277	linear
12	15.0000004	0.01095	3.754	0.7508	2.818	0.0117	0.1666	constant
13	14.9999997	0.0246	4.0821	0.8164	3.333	0.0139		
14	15.0000004	0.02472	4.1772	0.8354	3.49	0.0145		
15	14.9999997	0.02487	3.7375	0.7475	2.794	0.0116		
16	14.9999997	0.02213	3.7613	0.7523	2.829	0.0118		
17	15.0000004	0.00753	3.8787	0.7757	3.009	0.0125		
18	14.9999997	0.01466	3.6726	0.7345	2.698	0.0112		
19	15.0000004	0.01843	3.9448	0.789	3.112	0.013		
20	14.9999997	0.0033	3.9513	0.7903	3.123	0.013		
21	15.0000004	0.00322	3.9384	0.7877	3.102	0.0129		
22	14.9999997	0.00342	3.8062	0.7612	2.897	0.0121		

Day two: 18/05/2016

	I	J	K	L	M	N	O
1	E	calc	calc	calc	calc	5	OHMS = RESISTANCE OF FIXED RESISTOR
2		horiz	horiz	horiz	horiz		
3	W-hours	voltage	current	power	E (Wh)	85.90525	total energy in Wh
4	0.00811	3.186065	0.637213	2.030202	0.008459	66.271	total energy for fixed cell
5	0.008218	3.204094	0.640819	2.053244	0.008555	1.296272	fractional increase
6	0.008325	3.223036	0.644607	2.077592	0.008657		
7	0.008449	3.245599	0.64912	2.106783	0.008778		
8	0.008591	3.268178	0.653636	2.136198	0.008901		
9	0.008736	3.292581	0.658516	2.168218	0.009034	-1225.4	cubic
10	0.008878	3.316097	0.663219	2.1993	0.009164	258.62	square
11	0.009031	3.340535	0.668107	2.231835	0.009299	76.277	linear
12	0.00919	3.364084	0.672817	2.263412	0.009431	0.1666	constant
13	0.009378	3.391276	0.678255	2.300151	0.009584		
14	0.00962	3.423935	0.684787	2.344666	0.009769		
15	0.009767	3.444816	0.688963	2.373351	0.009889		
16	0.009864	3.459349	0.69187	2.393419	0.009973		
17	0.010075	3.480251	0.69605	2.422429	0.010093		
18	0.010164	3.498436	0.699687	2.447811	0.010199		
19	0.010132	3.501165	0.700233	2.451631	0.010215		
20	0.010177	3.510261	0.702052	2.464387	0.010268		
21	0.010234	3.51845	0.70369	2.475899	0.010316		
22	0.010318	3.529372	0.705874	2.491293	0.01038		
23	0.010415	3.541207	0.708241	2.50803	0.01045		

Day three: 19/05/2016

	E	F	G	H	I	J	K	L	M	N	
1	No.4	current	power	time	E	calc	calc	calc	calc	5	OHI
2	applied volta	calculated		int.		horiz	horiz	horiz	horiz		
3	V	A	W	s	W-hours	voltage	current	power	E (Wh)	138.557166	tota
4	2.57577	2.639728	34.8408196	15	0.14517008	10.702339	2.1404678	22.9080119	0.09545005	124.230547	tota
5	2.57576	2.616202	34.2225645	15.0000004	0.14259402	10.7635501	2.15271002	23.1708022	0.09654501	1.11532284	frac
6	2.57577	2.740182	37.542987	14.9999997	0.15642911	11.5513082	2.31026163	26.6865441	0.11119393		
7	2.57577	1.538672	11.8375576	14.9999997	0.04932316	6.0704935	1.2140987	7.37017826	0.03070908		
8	2.57576	2.225348	24.7608686	15.0000004	0.10317029	8.90247581	1.78049516	15.8508151	0.06604506		
9	2.57576	2.717478	36.9234334	14.9999997	0.15384764	11.1961907	2.23923815	25.0709374	0.10446224	-1225.4	cubi
10	2.57575	3.143386	49.4043777	15.0000004	0.20585158	13.7672871	2.75345741	37.9076386	0.1579485	258.62	squa
11	2.57576	3.190458	50.8951112	14.9999997	0.21206296	14.1471168	2.82942336	40.0281826	0.16678409	76.277	line
12	2.57576	3.195652	51.0609585	15.0000004	0.212754	14.2117459	2.84234918	40.3947443	0.16831144	0.1666	cons
13	2.57575	1.511234	11.419141	14.9999997	0.04757975	6.52295958	1.30459192	8.50980033	0.0354575		
14	2.57575	0.703792	2.4766159	14.9999997	0.01031923	2.76275321	0.55255064	1.52656106	0.00636067		
15	2.57574	0.598398	1.79040083	15.0000004	0.00746	2.35636836	0.47127367	1.11049437	0.00462706		
16	2.57575	0.582914	1.69894366	14.9999997	0.00707893	2.30396391	0.46079278	1.06164994	0.00442354		
17	2.57574	0.620898	1.92757163	15.0000004	0.00803155	2.42203654	0.48440731	1.1732522	0.00488855		
18	2.57573	1.662986	13.8276122	14.9999997	0.05761505	6.56357764	1.31271553	8.61611029	0.03590046		
19	2.57572	3.114922	48.5136953	14.9999997	0.20214039	13.6925944	2.73851888	37.4974282	0.15623928		
20	2.57573	3.209832	51.5151073	15.0000004	0.21464629	14.18736	2.83747199	40.2562365	0.16773432		
21	2.57573	3.197048	51.1055796	14.9999997	0.21293991	14.1110409	2.82220818	39.8242951	0.16593456		
22	2.57572	3.187314	50.7948527	15.0000004	0.21164522	14.0664373	2.81328746	39.5729317	0.16488722		
23	2.57571	3.17889	50.5267082	14.9999997	0.21052795	14.0382326	2.80764652	39.4143948	0.16422664		
24	2.57571	3.173618	50.359256	15.0000004	0.20983024	14.0395174	2.80790348	39.4216099	0.16425671		
25	2.57572	2.775532	38.5178894	14.9999997	0.1604912	12.1124704	2.42249408	29.3423878	0.12225995		
26	2.57571	3.176536	50.4519048	14.9999997	0.21021627	14.1458547	2.82917094	40.021041	0.16675433		

Day four: 20/05/2016

	F	G	H	I	J	K	L	M	N	O
1	current	power	time	E	calc	calc	calc	calc	5	OHMS = RESISTANCE (
2	calculated		int.		horiz	horiz	horiz	horiz		
3	A	W	s	W-hou	voltage	current	power	E (Wh)	239.781649	total energy in Wh
4	2.9187	42.59		0	10.5	2.101	22.07	0	178.763455	total energy for fixed (
5	2.9197	42.62	15	0.178	10.51	2.102	22.1	0.09209	1.34133483	fractional increase
6	2.9193	42.61	15	0.178	10.51	2.102	22.09	0.09206		
7	2.9226	42.71	15	0.178	10.56	2.112	22.3	0.09292		
8	2.9543	43.64	15	0.182	10.58	2.116	22.38	0.09324		
9	2.9855	44.57	15	0.186	10.65	2.13	22.69	0.09454	-1225.4	cubic
10	2.9804	44.41	15	0.185	10.63	2.127	22.61	0.09422	258.62	square
11	2.9724	44.17	15	0.184	10.56	2.113	22.32	0.09301	76.277	linear
12	2.9697	44.1	15	0.184	10.56	2.111	22.29	0.09287	0.1666	constant
13	2.9727	44.19	15	0.184	10.6	2.121	22.49	0.09371		
14	2.9751	44.26	15	0.184	10.62	2.124	22.55	0.09397		
15	2.9707	44.12	15	0.184	10.61	2.122	22.52	0.09384		
16	2.9721	44.17	15	0.184	10.63	2.125	22.58	0.09408		
17	2.9674	44.03	15	0.183	10.61	2.122	22.51	0.09379		
18	2.9614	43.85	15	0.183	10.58	2.117	22.4	0.09333		
19	2.9619	43.86	15	0.183	10.6	2.12	22.47	0.09361		
20	2.9652	43.96	15	0.183	10.64	2.129	22.65	0.09439		
21	2.9604	43.82	15	0.183	10.62	2.123	22.54	0.09391		
22	2.9607	43.83	15	0.183	10.62	2.123	22.54	0.09391		

Day five: 21/05/2016

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	
1	Date/Time	No.1	No.2	No.3	No.4	current	power	time	E	calc	calc	calc	calc	5	C
2	Date/Time	accelerometer	pyronameter	fixed resistor	applied volta	calculated		int.		horiz	horiz	horiz	horiz		
3		V	V	V	V	A	W	s	W-hou	voltage	current	power	E (Wh)	275.365422	tc
4	5/22/2016 9:36	1.45525	0.11167	14.96139	2.48734	2.9923	44.77	15	0.187	10.2	2.041	20.82	0.08675	196.222604	tc
5	5/23/2016 9:36	1.45524	0.11185	14.96169	2.48736	2.9923	44.77	15	0.187	10.22	2.044	20.89	0.08702	1.40333181	fr
6	5/24/2016 9:36	1.45448	0.11215	14.97587	2.48737	2.9952	44.86	15	0.187	10.25	2.049	20.99	0.08747		
7	5/25/2016 9:36	1.45401	0.11238	14.97235	2.48739	2.9945	44.83	15	0.187	10.27	2.053	21.08	0.08782		
8	5/26/2016 9:36	1.45437	0.11265	14.98506	2.48742	2.997	44.91	15	0.187	10.29	2.058	21.17	0.08823		
9	5/27/2016 9:36	1.45269	0.11293	14.99394	2.48743	2.9988	44.96	15	0.187	10.31	2.063	21.28	0.08865	-1225.4	c
10	5/28/2016 9:36	1.44909	0.11315	15.00508	2.48745	3.001	45.03	15	0.188	10.33	2.067	21.36	0.08898	258.62	s
11	5/29/2016 9:36	1.44908	0.11331	14.99287	2.48746	2.9986	44.96	15	0.187	10.35	2.069	21.41	0.08922	76.277	li
12	5/30/2016 9:36	1.44914	0.11373	15.00515	2.48747	3.001	45.03	15	0.188	10.38	2.077	21.57	0.08986	0.1666	c
13	5/31/2016 9:36	1.44894	0.11408	15.00788	2.48749	3.0016	45.05	15	0.188	10.41	2.083	21.69	0.09039		
14	6/1/2016 9:36	1.44918	0.11408	14.99467	2.48751	2.9989	44.97	15	0.187	10.41	2.083	21.69	0.09039		
15	6/2/2016 9:36	1.449	0.11413	14.9803	2.48752	2.9961	44.88	15	0.187	10.42	2.084	21.71	0.09046		
16	6/3/2016 9:36	1.44899	0.11449	15.00108	2.48753	3.0002	45.01	15	0.188	10.45	2.09	21.84	0.09101		
17	6/4/2016 9:36	1.44926	0.11493	15.02104	2.48756	3.0042	45.13	15	0.188	10.49	2.098	22	0.09168		
18	6/5/2016 9:36	1.44901	0.11491	15.00892	2.48758	3.0018	45.05	15	0.188	10.49	2.097	22	0.09165		
19	6/6/2016 9:36	1.44922	0.11527	15.02547	2.48759	3.0051	45.15	15	0.188	10.52	2.104	22.13	0.0922		
20	6/7/2016 9:36	1.44936	0.11527	15.01366	2.48761	3.0027	45.08	15	0.188	10.52	2.104	22.13	0.0922		
21	6/8/2016 9:36	1.44907	0.11495	14.98578	2.48763	2.9972	44.91	15	0.187	10.49	2.098	22.01	0.09171		
22	6/9/2016 9:36	1.44909	0.11469	14.95832	2.48764	2.9917	44.75	15	0.186	10.47	2.094	21.92	0.09132		

Day six: 22/05/2016

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	
1	Date/Time	No.1	No.2	No.3	No.4	current	power	time	E	calc	calc	calc	calc	5	OHM
2	Date/Time	acceleromete	pyronameter	fixed resistor	applied volta	calculated		int.		horiz	horiz	horiz	horiz		
3		V	V	V	V	A	W	s	W-hou	voltage	current	power	E (Wh)	298.065394	total
4	############	1.56114	0.09075	12.8689	2.66229	2.5738	33.12	15	0.138	8.303	1.661	13.79	0.05745	209.338875	total
5	############	1.56138	0.09264	13.12311	2.66227	2.6246	34.44	15	0.144	8.478	1.696	14.38	0.0599	1.42384157	fracti
6	############	1.56402	0.09402	13.21845	2.66224	2.6437	34.95	15	0.146	8.606	1.721	14.81	0.06172		
7	############	1.56179	0.09269	13.41482	2.66223	2.683	35.99	15	0.15	8.483	1.697	14.39	0.05996		
8	############	1.56221	0.09131	13.56616	2.6622	2.7132	36.81	15	0.153	8.355	1.671	13.96	0.05817		
9	############	1.56191	0.09127	13.58806	2.66219	2.7176	36.93	15	0.154	8.351	1.67	13.95	0.05812	-1225.4	cubic
10	############	1.56187	0.09149	13.61015	2.66217	2.722	37.05	15	0.154	8.372	1.674	14.02	0.0584	258.62	squai
11	############	1.56191	0.09167	13.62114	2.66214	2.7242	37.11	15	0.155	8.388	1.678	14.07	0.05864	76.277	linea
12	############	1.56186	0.0915	13.58174	2.66213	2.7163	36.89	15	0.154	8.372	1.674	14.02	0.05841	0.1666	const
13	############	1.56077	0.09209	13.64519	2.66211	2.729	37.24	15	0.155	8.427	1.685	14.2	0.05918		
14	############	1.5574	0.09225	13.64595	2.66209	2.7292	37.24	15	0.155	8.442	1.688	14.25	0.05939		
15	############	1.55744	0.09271	13.6844	2.66208	2.7369	37.45	15	0.156	8.485	1.697	14.4	0.05999		
16	############	1.55749	0.09297	13.70057	2.66206	2.7401	37.54	15	0.156	8.509	1.702	14.48	0.06033		
17	############	1.55753	0.09296	13.70742	2.66205	2.7415	37.58	15	0.157	8.508	1.702	14.48	0.06032		
18	############	1.55763	0.09314	13.70874	2.66203	2.7417	37.59	15	0.157	8.524	1.705	14.53	0.06056		
19	############	1.55734	0.09342	13.74211	2.66202	2.7484	37.77	15	0.157	8.55	1.71	14.62	0.06092		
20	############	1.55766	0.09363	13.76154	2.66201	2.7523	37.88	15	0.158	8.57	1.714	14.69	0.0612		
21	############	1.55738	0.09366	13.71307	2.66199	2.7426	37.61	15	0.157	8.573	1.715	14.7	0.06124		
22	############	1.55867	0.09354	13.67978	2.66198	2.736	37.43	15	0.156	8.561	1.712	14.66	0.06108		

Day seven: 23/05/2016

Day eight: 24/05/2016

	C	D	E	F	G	H	I	J	K	L	M	N	O
2	pyroname	fixed resis	applied vc	calculated		int.		horiz	horiz	horiz	horiz		
3	V	V	V	A	W	s	W-hou	voltage	current	power	E (Wh)	326.7858	total energy in '
4	0.04878	4.07796	2.58322	0.81559	3.326	15	0.014	4.3605	0.8721	3.8029	0.015845	189.7071	total energy fo
5	0.04921	4.11017	2.58321	0.82203	3.3787	15	0.014	4.4004	0.8801	3.8728	0.016137	1.722581	fractional increa
6	0.04956	4.14587	2.58321	0.82917	3.4376	15	0.014	4.4329	0.8866	3.9302	0.016376		
7	0.05006	4.19377	2.58321	0.83875	3.5175	15	0.015	4.4794	0.8959	4.013	0.016721		
8	0.0507	4.26023	2.5832	0.85205	3.6299	15	0.015	4.5389	0.9078	4.1204	0.017168		
9	0.05146	4.33481	2.58319	0.86696	3.7581	15	0.016	4.6097	0.9219	4.2498	0.017708	-1225.4	cubic
10	0.05221	4.39482	2.58318	0.87896	3.8629	15	0.016	4.6796	0.9359	4.3797	0.018249	258.62	square
11	0.05266	4.41518	2.58317	0.88304	3.8988	15	0.016	4.7216	0.9443	4.4587	0.018578	76.277	linear
12	0.0527	4.39781	2.58316	0.87956	3.8681	15	0.016	4.7253	0.9451	4.4657	0.018607	0.1666	constant
13	0.05259	4.36422	2.58314	0.87284	3.8093	15	0.016	4.715	0.943	4.4463	0.018526		
14	0.05254	4.33843	2.58314	0.86769	3.7644	15	0.016	4.7104	0.9421	4.4375	0.01849		
15	0.05242	4.30973	2.58313	0.86195	3.7148	15	0.015	4.6992	0.9398	4.4165	0.018402		
16	0.05224	4.27612	2.58312	0.85522	3.657	15	0.015	4.6824	0.9365	4.385	0.018271		
17	0.05191	4.22229	2.58312	0.84446	3.5655	15	0.015	4.6516	0.9303	4.3275	0.018031		
18	0.0515	4.17156	2.5831	0.83431	3.4804	15	0.015	4.6134	0.9227	4.2567	0.017736		
19	0.05105	4.12079	2.58309	0.82416	3.3962	15	0.014	4.5715	0.9143	4.1797	0.017416		
20	0.05057	4.06339	2.58309	0.81268	3.3022	15	0.014	4.5268	0.9054	4.0984	0.017077		
21	0.05011	4.00862	2.58307	0.80172	3.2138	15	0.013	4.4841	0.8968	4.0213	0.016756		
22	0.04961	3.96284	2.58308	0.79257	3.1408	15	0.013	4.4376	0.8875	3.9384	0.01641		
23	0.0491	3.91486	2.58307	0.78297	3.0652	15	0.013	4.3902	0.878	3.8548	0.016062		
24	0.0486	3.86279	2.58306	0.77256	2.9842	15	0.012	4.3438	0.8688	3.7738	0.015724		

Day nine: 25/05/2016

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Date/Time	No.1	No.2	No.3	No.4	current	power	time	E	calc	calc	calc	calc	5	OHMS = RESISTANCE
2	Date/Time	accelerom	pyroname	fixed resis	applied vc	calculated		int.		horiz	horiz	horiz	horiz		
3		V	V	V	V	A	W	s	W-hou	voltage	current	power	E (Wh)	88.23571	total energy in Wh
4	13:07	1.25224	0.06496	6.1857	2.53322	1.23714	7.6526	15	0.032	5.877	1.1754	6.9078	0.028782	67.49549	total energy for fixe
5	5/25/2016 13:08	1.25211	0.06536	6.22453	2.53323	1.24491	7.749	15	0.032	5.9147	1.1829	6.9968	0.029153	1.307283	fractional increase
6	5/25/2016 13:08	1.2521	0.06765	6.43095	2.53321	1.28619	8.2714	15	0.034	6.1309	1.2262	7.5177	0.031324		
7	5/25/2016 13:08	1.25218	0.06987	6.67739	2.53321	1.33548	8.9175	15	0.037	6.3406	1.2681	8.0407	0.033503		
8	5/25/2016 13:08	1.25225	0.06714	6.37004	2.5332	1.27401	8.1155	15	0.034	6.0828	1.2166	7.4	0.030833		
9	5/25/2016 13:09	1.2521	0.06503	6.1527	2.53319	1.23054	7.5711	15	0.032	5.8836	1.1767	6.9233	0.028847	-1225.4	cubic
10	5/25/2016 13:09	1.25196	0.06406	6.0553	2.53318	1.21106	7.3333	15	0.031	5.7921	1.1584	6.7096	0.027957	258.62	square
11	5/25/2016 13:09	1.25199	0.06316	5.97024	2.53317	1.19405	7.1288	15	0.03	5.7072	1.1414	6.5144	0.027143	76.277	linear
12	5/25/2016 13:09	1.25192	0.06976	6.64951	2.53316	1.3299	8.8432	15	0.037	6.3302	1.266	8.0144	0.033393	0.1666	constant
13	5/25/2016 13:10	1.25186	0.07386	6.96634	2.53315	1.39327	9.706	15	0.04	6.7175	1.3435	9.025	0.037604		
14	5/25/2016 13:10	1.25215	0.06017	5.7153	2.53314	1.14306	6.5329	15	0.027	5.4256	1.0851	5.8873	0.024531		
15	5/25/2016 13:10	1.25226	0.0555	5.26232	2.53313	1.05246	5.5384	15	0.023	4.9871	0.9974	4.9742	0.020726		
16	5/25/2016 13:10	1.25202	0.0556	5.29269	2.53311	1.05854	5.6025	15	0.023	4.9965	0.9993	4.9929	0.020804		
17	5/25/2016 13:11	1.25195	0.05472	5.20612	2.53311	1.04122	5.4207	15	0.023	4.9141	0.9828	4.8296	0.020123		
18	5/25/2016 13:11	1.25203	0.05465	5.20131	2.53309	1.04026	5.4107	15	0.023	4.9075	0.9815	4.8168	0.02007		
19	5/25/2016 13:11	1.25209	0.05637	5.38238	2.53308	1.07648	5.794	15	0.024	5.0686	1.0137	5.1382	0.021409		
20	5/25/2016 13:11	1.25197	0.05749	5.47778	2.53308	1.09556	6.0012	15	0.025	5.1737	1.0347	5.3534	0.022306		
21	5/25/2016 13:12	1.25195	0.0655	6.2428	2.53306	1.24856	7.7945	15	0.032	5.9279	1.1856	7.0281	0.029284		
22	5/25/2016 13:12	1.25195	0.12188	11.56839	2.53304	2.31368	26.766	15	0.112	11.086	2.2173	24.582	0.102423		
23	5/25/2016 13:12	1.25189	0.1278	12.18753	2.53303	2.43751	29.707	15	0.124	11.581	2.3162	26.824	0.111766		

25 may data set 2 with horizont

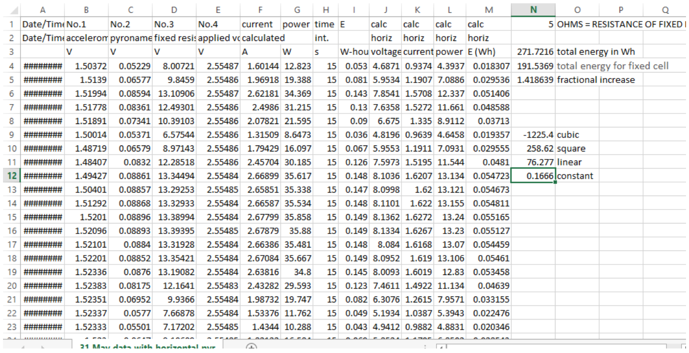
Day ten: 30/05/2016

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Date/Time	No.1	No.2	No.3	No.4	current	power	time	E	calc	calc	calc	calc	5	OHMS = RESISTANCE OF FI
2	Date/Time	accelerom	pyroname	fixed resis	applied vc	calculated		int.		horiz	horiz	horiz	horiz		
3		V	V	V	V	A	W	s	W-hou	voltage	current	power	E (Wh)	197.0227	total energy in Wh
4	5/30/2016 9:29	1.56243	0.08822	11.22989	2.6741	2.24598	25.222	15	0.105	8.0672	1.6134	13.016	0.054233	149.4446	total energy for fixed cell
5	5/31/2016 9:29	1.56182	0.08475	10.52797	2.67404	2.10559	22.168	15	0.092	7.7427	1.5485	11.99	0.049958	1.318366	fractional increase
6	6/1/2016 9:29	1.56131	0.07771	10.72946	2.67399	2.14589	23.024	15	0.096	7.0808	1.4162	10.028	0.041781		
7	6/2/2016 9:29	1.56105	0.08541	9.98512	2.67394	1.99702	19.941	15	0.083	7.8045	1.5609	12.182	0.050759		
8	6/3/2016 9:29	1.56089	0.09136	11.16375	2.67388	2.23275	24.926	15	0.104	8.3594	1.6719	13.976	0.058234		
9	6/4/2016 9:29	1.55548	0.0916	11.40432	2.67382	2.28086	26.012	15	0.108	8.3817	1.6763	14.051	0.058544	-1225.4	cubic
10	6/5/2016 9:29	1.55523	0.09207	11.47079	2.67377	2.29416	26.316	15	0.11	8.4253	1.6851	14.197	0.059155	258.62	square
11	6/6/2016 9:29	1.55518	0.09289	11.58516	2.67371	2.31703	26.843	15	0.112	8.5013	1.7003	14.454	0.060227	76.277	linear
12	6/7/2016 9:29	1.55487	0.09355	11.6856	2.67365	2.33712	27.311	15	0.114	8.5624	1.7125	14.663	0.061096	0.1666	constant
13	6/8/2016 9:29	1.55468	0.09447	11.81482	2.67359	2.36296	27.918	15	0.116	8.6474	1.7295	14.956	0.062315		
14	6/9/2016 9:29	1.55484	0.09536	11.91548	2.67354	2.3831	28.396	15	0.118	8.7295	1.7459	15.241	0.063504		
15	6/10/2016 9:29	1.55461	0.09598	12.00583	2.67348	2.40117	28.828	15	0.12	8.7866	1.7573	15.441	0.064337		
16	6/11/2016 9:29	1.55446	0.09594	12.00131	2.67343	2.40026	28.806	15	0.12	8.783	1.7566	15.428	0.064284		
17	6/12/2016 9:29	1.55424	0.0956	11.96572	2.67336	2.39314	28.636	15	0.119	8.7516	1.7503	15.318	0.063826		
18	6/13/2016 9:29	1.55377	0.09552	11.96144	2.67331	2.39229	28.615	15	0.119	8.7443	1.7489	15.292	0.063719		
19	6/14/2016 9:29	1.55339	0.09572	11.98421	2.67325	2.39684	28.724	15	0.12	8.7627	1.7525	15.357	0.063987		
20	6/15/2016 9:29	1.55241	0.09551	11.94605	2.6732	2.38921	28.542	15	0.119	8.7434	1.7487	15.289	0.063705		
21	6/16/2016 9:29	1.55175	0.09497	11.87974	2.67314	2.37595	28.226	15	0.118	8.6936	1.7387	15.116	0.062982		
22	6/17/2016 9:29	1.55044	0.0944	11.78873	2.67308	2.35775	27.795	15	0.116	8.641	1.7282	14.933	0.062222		
23	6/18/2016 9:29	1.54755	0.09411	11.74526	2.67301	2.34905	27.59	15	0.115	8.6142	1.7228	14.841	0.061837		

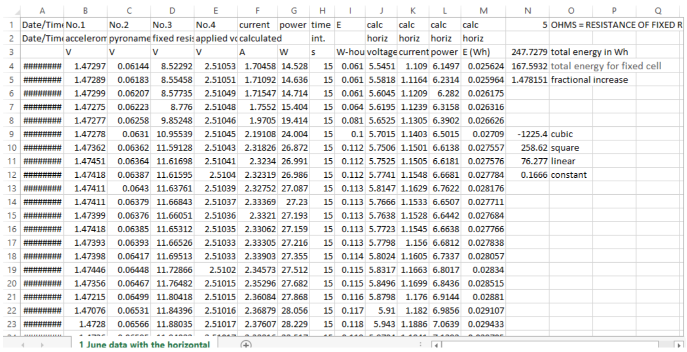
30 may data set with horizontal

READY

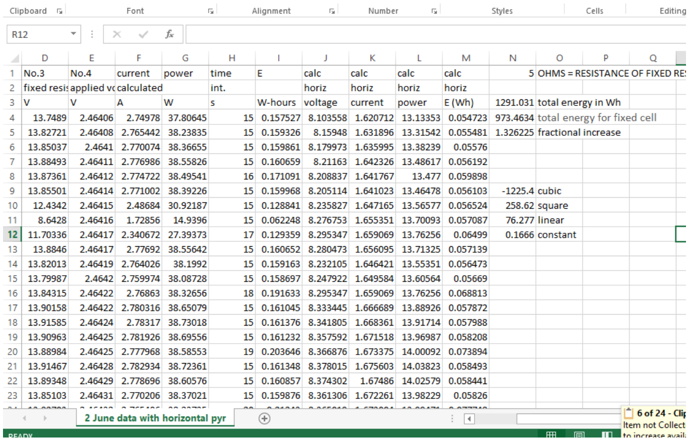
Day eleven: 31/05/2016



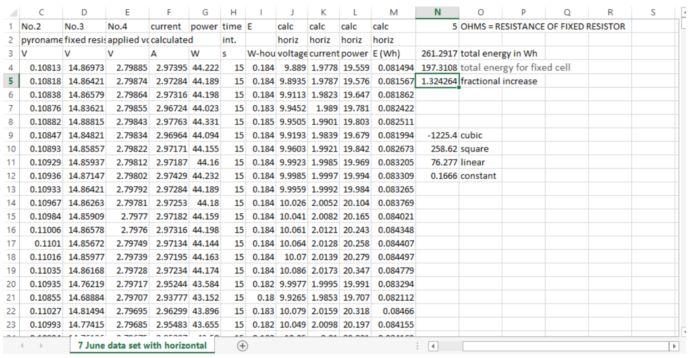
Day twelve: 01/06/2016



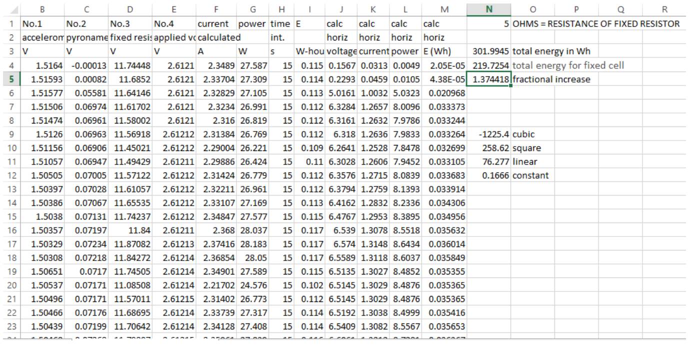
Day thirteen: 02/06/2016



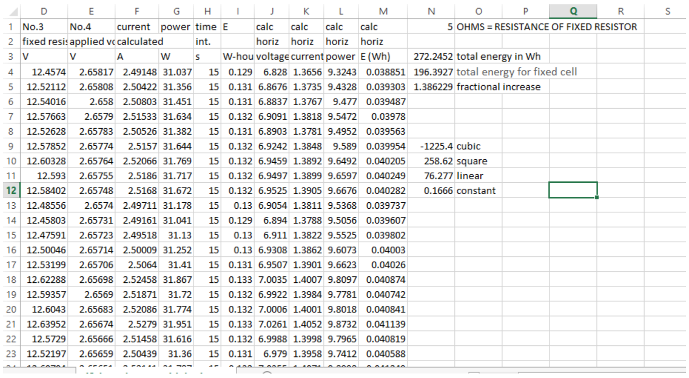
Day fourteen: 07/06/2016



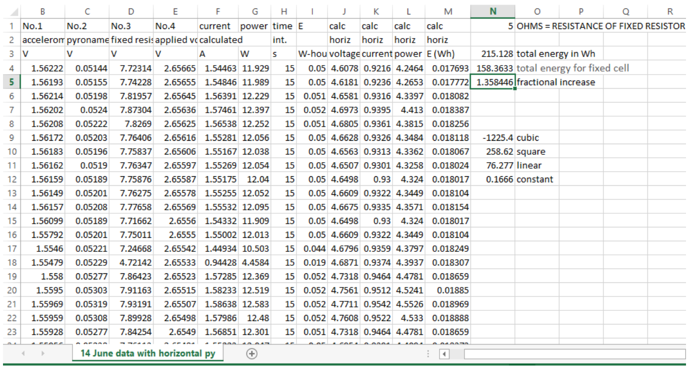
Day fifteen: 08/06/2016



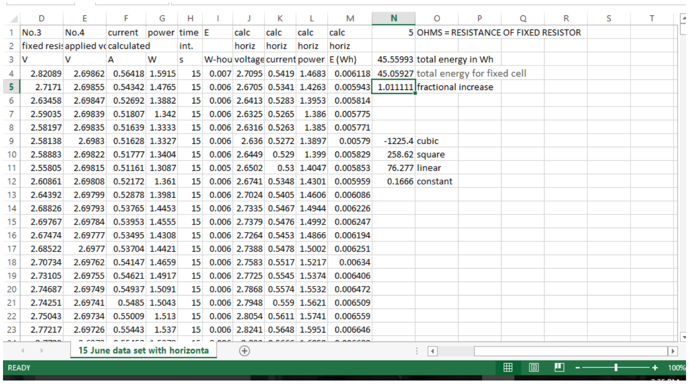
Day sixteen: 13/06/2016



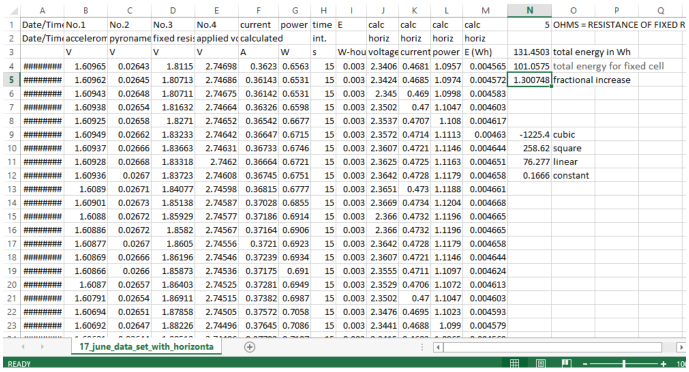
Day seventeen: 14/06/2016



Day eighteen: 15/06/2016



Day nineteen: 17/06/2016

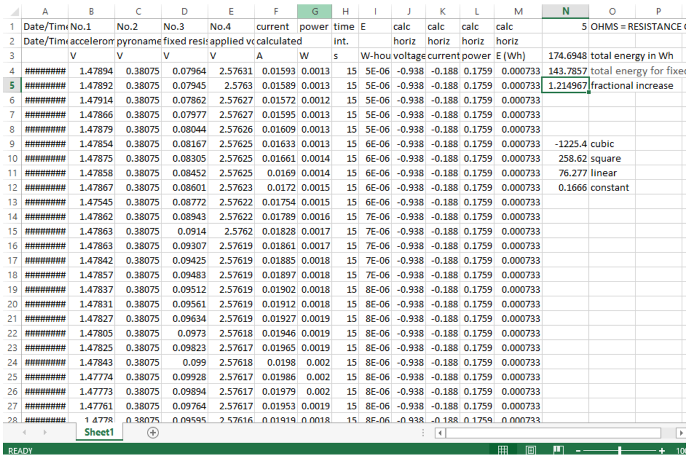


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Date/Time	No.1	No.2	No.3	No.4	current	power	time	E	calc	calc	calc	calc	5	OHMS = RESISTANCE OF FIXED R		
2	Date/Time	accelerom	pyroname	fixed resis	applied vo	calculated		int.		horiz	horiz	horiz	horiz				
3		V	V	V	V	A	W	s	W-hou	voltage	current	power	E (Wh)	131.4503	total energy in Wh		
4	########	1.60965	0.02643	1.8115	2.74698	0.3623	0.6563	15	0.003	2.3406	0.4681	1.0957	0.004565	101.0575	total energy for fixed cell		
5	########	1.60962	0.02645	1.80713	2.74686	0.36143	0.6531	15	0.003	2.3424	0.4685	1.0974	0.004572	1.300748	fractional increase		
6	########	1.60943	0.02648	1.80711	2.74675	0.36142	0.6531	15	0.003	2.345	0.469	1.0998	0.004583				
7	########	1.60938	0.02654	1.81632	2.74664	0.36326	0.6598	15	0.003	2.3502	0.47	1.1047	0.004603				
8	########	1.60925	0.02658	1.8271	2.74652	0.36542	0.6677	15	0.003	2.3537	0.4707	1.108	0.004617				
9	########	1.60949	0.02662	1.83233	2.74642	0.36647	0.6715	15	0.003	2.3572	0.4714	1.1113	0.00463	-1225.4	cubic		
10	########	1.60937	0.02666	1.83663	2.74631	0.36733	0.6746	15	0.003	2.3607	0.4721	1.1146	0.004644	258.62	square		
11	########	1.60928	0.02668	1.83318	2.7462	0.36664	0.6721	15	0.003	2.3625	0.4725	1.1163	0.004651	76.277	linear		
12	########	1.60936	0.0267	1.83723	2.74608	0.36745	0.6751	15	0.003	2.3642	0.4728	1.1179	0.004658	0.1666	constant		
13	########	1.6089	0.02671	1.84077	2.74598	0.36815	0.6777	15	0.003	2.3651	0.473	1.1188	0.004661				
14	########	1.60901	0.02673	1.85138	2.74587	0.37028	0.6855	15	0.003	2.3669	0.4734	1.1204	0.004668				
15	########	1.6088	0.02672	1.85929	2.74577	0.37186	0.6914	15	0.003	2.366	0.4732	1.1196	0.004665				
16	########	1.60886	0.02672	1.8582	2.74567	0.37164	0.6906	15	0.003	2.366	0.4732	1.1196	0.004665				
17	########	1.60877	0.0267	1.8605	2.74556	0.3721	0.6923	15	0.003	2.3642	0.4728	1.1179	0.004658				
18	########	1.60869	0.02666	1.86196	2.74546	0.37239	0.6934	15	0.003	2.3607	0.4721	1.1146	0.004644				
19	########	1.60866	0.0266	1.85873	2.74536	0.37175	0.691	15	0.003	2.3555	0.4711	1.1097	0.004624				
20	########	1.6087	0.02657	1.86403	2.74525	0.37281	0.6949	15	0.003	2.3529	0.4706	1.1072	0.004613				
21	########	1.60791	0.02654	1.86911	2.74515	0.37382	0.6987	15	0.003	2.3502	0.47	1.1047	0.004603				
22	########	1.60694	0.02651	1.87858	2.74505	0.37572	0.7058	15	0.003	2.3476	0.4695	1.1023	0.004593				
23	########	1.60692	0.02647	1.88226	2.74496	0.37645	0.7086	15	0.003	2.3441	0.4688	1.099	0.004579				

17_june_data_set_with_horizonta

READY

Day twenty:

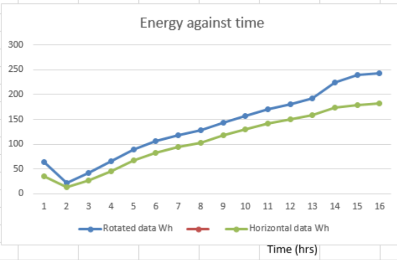


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Date/Time	No.1	No.2	No.3	No.4	current	power	time	E	calc	calc	calc	calc	5	OHMS = RESISTANCE (	
2	Date/Time	accelerom	pyroname	fixed resis	applied vo	calculated		int.		horiz	horiz	horiz	horiz			
3		V	V	V	V	A	W	s	W-hou	voltage	current	power	E (Wh)	174.6948	total energy in Wh	
4	########	1.47894	0.38075	0.07964	2.57631	0.01593	0.0013	15	5E-06	-0.938	-0.188	0.1759	0.000733	143.7857	total energy for fixed	
5	########	1.47892	0.38075	0.07945	2.5763	0.01589	0.0013	15	5E-06	-0.938	-0.188	0.1759	0.000733	1.214967	fractional increase	
6	########	1.47914	0.38075	0.07862	2.57627	0.01572	0.0012	15	5E-06	-0.938	-0.188	0.1759	0.000733			
7	########	1.47866	0.38075	0.07977	2.57627	0.01595	0.0013	15	5E-06	-0.938	-0.188	0.1759	0.000733			
8	########	1.47879	0.38075	0.08044	2.57626	0.01609	0.0013	15	5E-06	-0.938	-0.188	0.1759	0.000733			
9	########	1.47854	0.38075	0.08167	2.57625	0.01633	0.0013	15	6E-06	-0.938	-0.188	0.1759	0.000733	-1225.4	cubic	
10	########	1.47875	0.38075	0.08305	2.57625	0.01661	0.0014	15	6E-06	-0.938	-0.188	0.1759	0.000733	258.62	square	
11	########	1.47858	0.38075	0.08452	2.57625	0.0169	0.0014	15	6E-06	-0.938	-0.188	0.1759	0.000733	76.277	linear	
12	########	1.47867	0.38075	0.08601	2.57623	0.0172	0.0015	15	6E-06	-0.938	-0.188	0.1759	0.000733	0.1666	constant	
13	########	1.47545	0.38075	0.08772	2.57622	0.01754	0.0015	15	6E-06	-0.938	-0.188	0.1759	0.000733			
14	########	1.47862	0.38075	0.08943	2.57622	0.01789	0.0016	15	7E-06	-0.938	-0.188	0.1759	0.000733			
15	########	1.47863	0.38075	0.0914	2.5762	0.01828	0.0017	15	7E-06	-0.938	-0.188	0.1759	0.000733			
16	########	1.47863	0.38075	0.09307	2.57619	0.01861	0.0017	15	7E-06	-0.938	-0.188	0.1759	0.000733			
17	########	1.47842	0.38075	0.09425	2.57619	0.01885	0.0018	15	7E-06	-0.938	-0.188	0.1759	0.000733			
18	########	1.47857	0.38075	0.09483	2.57619	0.01897	0.0018	15	7E-06	-0.938	-0.188	0.1759	0.000733			
19	########	1.47837	0.38075	0.09512	2.57619	0.01902	0.0018	15	8E-06	-0.938	-0.188	0.1759	0.000733			
20	########	1.47831	0.38075	0.09561	2.57619	0.01912	0.0018	15	8E-06	-0.938	-0.188	0.1759	0.000733			
21	########	1.47827	0.38075	0.09634	2.57619	0.01927	0.0019	15	8E-06	-0.938	-0.188	0.1759	0.000733			
22	########	1.47805	0.38075	0.0973	2.57618	0.01946	0.0019	15	8E-06	-0.938	-0.188	0.1759	0.000733			
23	########	1.47825	0.38075	0.09823	2.57617	0.01965	0.0019	15	8E-06	-0.938	-0.188	0.1759	0.000733			
24	########	1.47843	0.38075	0.099	2.57618	0.0198	0.002	15	8E-06	-0.938	-0.188	0.1759	0.000733			
25	########	1.47774	0.38075	0.09928	2.57617	0.01986	0.002	15	8E-06	-0.938	-0.188	0.1759	0.000733			
26	########	1.47773	0.38075	0.09894	2.57617	0.01979	0.002	15	8E-06	-0.938	-0.188	0.1759	0.000733			
27	########	1.47761	0.38075	0.09764	2.57617	0.01953	0.0019	15	8E-06	-0.938	-0.188	0.1759	0.000733			

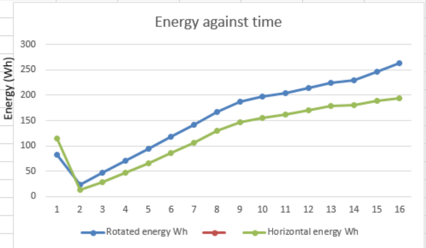
Sheet1

READY

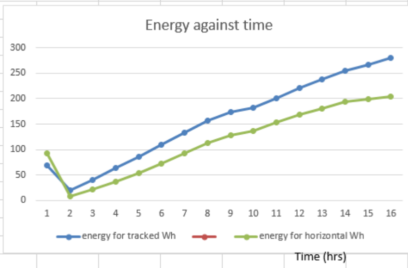
hours	Rotated data Wh	Horizontal data Wh
0.5	64.15	34.67
1	21.61	12.31
1.5	42.16	26.67
2	65.23	45.58
2.5	88.85	66.35
3	106.65	82.66
3.5	118.65	94.61
4	127.89	102.59
4.5	143.1	117.57
5	156.63	129.73
5.5	169.68	141.63
6	180.89	149.91
6.5	192.24	158.43
7	224.23	173.88
7.5	239.3	178.63



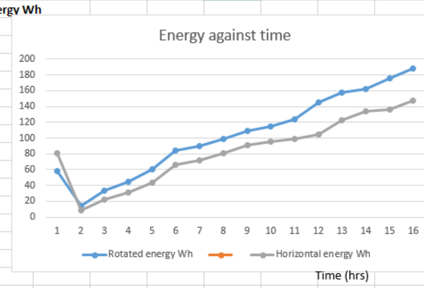
Hours	Rotated energy Wh	Horizontal energy Wh
0.5	81.78	115.02
1	22.3	12.12
1.5	45.94	27.88
2	69.91	46.75
2.5	93.67	65.51
3	118.32	85.7
3.5	141.6	106.29
4	166.22	129.12
4.5	186.87	147.14
5	196.99	155.52
5.5	204.41	161.61
6	215.15	170.89
6.5	224.78	178.06
7	229.84	181.18
7.5	246.75	188.49
8	263.45	193.48



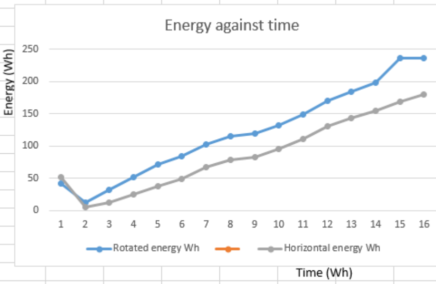
time Hrs	energy for tracked W	energy for horizontal Wh
0.5	67.87	91.77
1	18.83	8.29
1.5	40.38	20.62
2	62.84	36.59
2.5	85.75	54.11
3	109.23	71.58
3.5	133.33	92.1
4	156.88	113.03
4.5	173.58	128.78
5	182.41	137.05
5.5	201.48	153.17
6	220.71	168.61
6.5	237.71	180.77
7	255.52	193.42
7.5	267.05	199.17
8	280.3	204.37



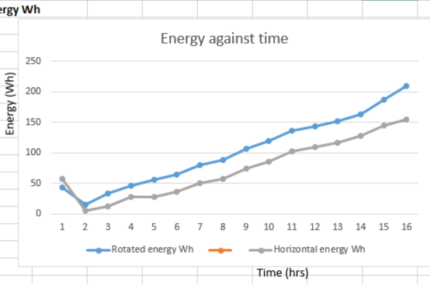
Hours	Rotated energy Wh	Horizontal energy Wh
0.5	58.02	80.82
1	14.49	8.25
1.5	33.72	22.06
2	45.06	31.45
2.5	60.27	43.79
3	83.74	66.49
3.5	89.46	71.95
4	98.58	80.5
4.5	109.43	90.5
5	114.92	95.6
5.5	123.98	98.5
6	145.12	104.03
6.5	157.86	122.14
7	161.6	133.73
7.5	175.13	136.13
8	188	147.48



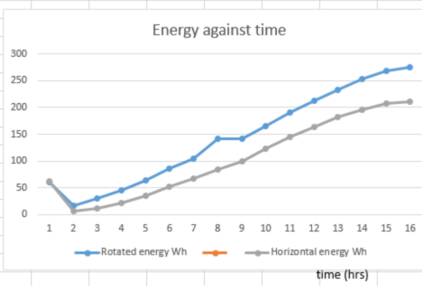
Hours	Rotated energy Wh	Horizontal energy Wh
0.5	41.54	51.61
1	11.76	4.52
1.5	31.17	12.74
2	51.89	24.34
2.5	71.22	38.18
3	83.94	48.41
3.5	102.65	67.01
4	114.57	78.25
4.5	119.08	82.43
5	132.4	94.92
5.5	149.23	111.01
6	170.3	130.74
6.5	184.53	143.89
7	198.65	154.96
7.5	236.65	169.25
8	236.66	180.66



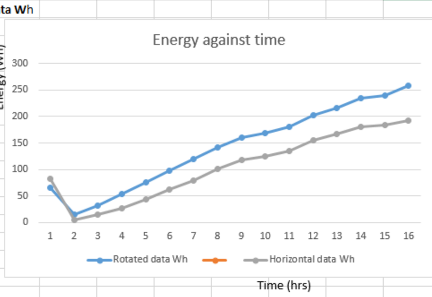
Hours	Rotated energy Wh	Horizontal energy Wh
0.5	43.8	56.66
1	15.27	4.34
1.5	33.8	12.03
2	46.05	27.26
2.5	55.29	27.78
3	63.75	35.67
3.5	80.31	50.45
4	87.85	56.74
4.5	106.51	74.47
5	118.75	86.1
5.5	135.63	101.79
6	143.86	108.98
6.5	151.93	117.09
7	162.44	127.49
7.5	187.68	144.51
8	209.62	155.07

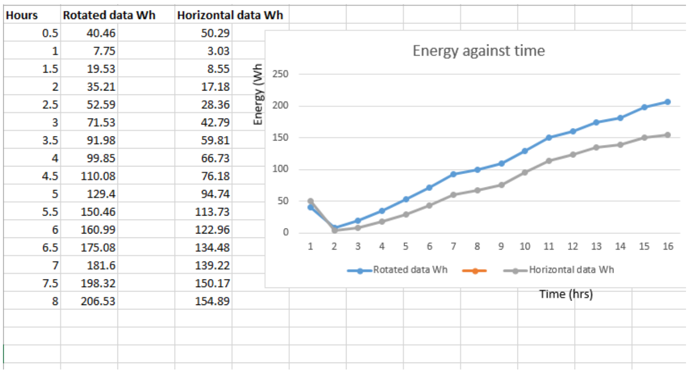


Hours	Rotated energy Wh	Horizontal energy Wh
0.5	60.8	61.11
1	15.61	5.41
1.5	29.89	11.67
2	45.16	20.58
2.5	63.92	34.16
3	86.16	51.88
3.5	104.94	66.68
4	141.99	83.82
4.5	142.2	99.4
5	166.03	122.13
5.5	190.08	144.73
6	212.03	164.06
6.5	233.52	183.02
7	252.58	196.52
7.5	268.88	207.55
8	274.67	210.19

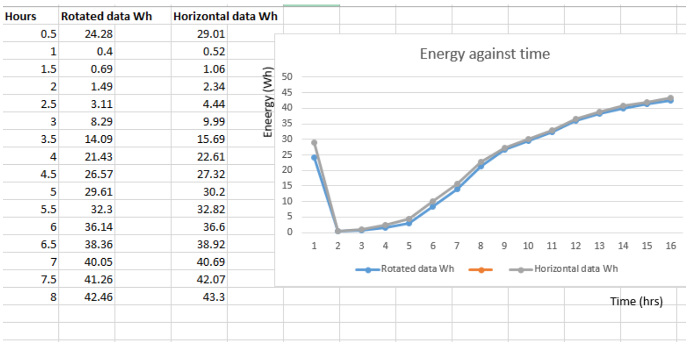


Hours	Rotated data Wh	Horizontal data Wh
0.5	65.28	82.98
1	14.01	4.87
1.5	31.89	14.53
2	52.75	27.16
2.5	74.8	42.88
3	97.63	61.45
3.5	118.84	79.44
4	141.13	100.97
4.5	159.96	117.25
5	169	125.02
5.5	180.46	135.47
6	202.04	154.56
6.5	216.8	166.4
7	234.85	180.78
7.5	240.45	184.11
8	257.88	191.83





Hours	Rotated data Wh	Horizontal data Wh
0.5	40.46	50.29
1	7.75	3.03
1.5	19.53	8.55
2	35.21	17.18
2.5	52.59	28.36
3	71.53	42.79
3.5	91.98	59.81
4	99.85	66.73
4.5	110.08	76.18
5	129.4	94.74
5.5	150.46	113.73
6	160.99	122.96
6.5	175.08	134.48
7	181.6	139.22
7.5	198.32	150.17
8	206.53	154.89



Hours	Rotated data Wh	Horizontal data Wh
0.5	24.28	29.01
1	0.4	0.52
1.5	0.69	1.06
2	1.49	2.34
2.5	3.11	4.44
3	8.29	9.99
3.5	14.09	15.69
4	21.43	22.61
4.5	26.57	27.32
5	29.61	30.2
5.5	32.3	32.82
6	36.14	36.6
6.5	38.36	38.92
7	40.05	40.69
7.5	41.26	42.07
8	42.46	43.3

Table 2 Collected energy data for 20 days

Day of the month	Energy for tracked panel ER(Wh)	Energy for Horizontal panel EH (Wh)	Difference ER-EH(Wh)	% increase
1. (17/05/2016)	292.5345	227.5198	65.0147	22.2
2. (18/05/2016)	43.2313	34.3674	8.8639	20.5
3. (19/05/2016)	100.6491	68.939267	31.709833	31.5
4. (20/05/2016)	174.6948	143.7857	30.9091	17.7
5. (21/05/2016)	239.959125	178.855396	61.103729	25.5
6. (22/05/2016)	275.365422	196.222604	79.142818	28.7
7. (23/05/2016)	298.065394	209.338875	88.726519	29.8
8. (24/05/2016)	348.2274	209.6784	138.549	39.8
9. (25/05/2016)	88.23571	67.49549	20.74022	23.5
10.(30/05/2016)	197.0227	149.4446	47.5781	24.2
11.(31/05/2016)	271.7216	191.5369	80.1847	29.5
12.(01/06/2016)	247.7279	167.5932	80.1347	32.4
13.(02/06/2016)	280.8088	211.7758	69.033	24.6
14.(07/06/2016)	261.2917	197.3108	63.9809	24.5
15.(08/06/2016)	301.9945	219.7254	82.2691	27.2
16.(13/06/2016)	272.2452	196.3927	75.8525	27.9
17.(14/06/2016)	215.128	158.3633	56.7647	26.4
18.(15/06/2016)	45.55993	45.05927	0.50066	1.1
19.(17/06/2016)	131.4503	101.0575	30.3928	23.1
20.(12/05/2016)	201.04330	176.3508	24.6925	12.3
Total energy for 20days	∑ER=4286.9564 ∑ER2 = 1071909.3321	∑EH=3150.8132 ∑EH2= 567368.2601		Average % = 26.5

Measurement of voltage applied, voltage along *z* axis and calculation of the tracking angle

Table shows records of the measured rotational heights at opposite sides of a rotating solar panel. These were used to calculate rotational angle at different times as panel rotates.

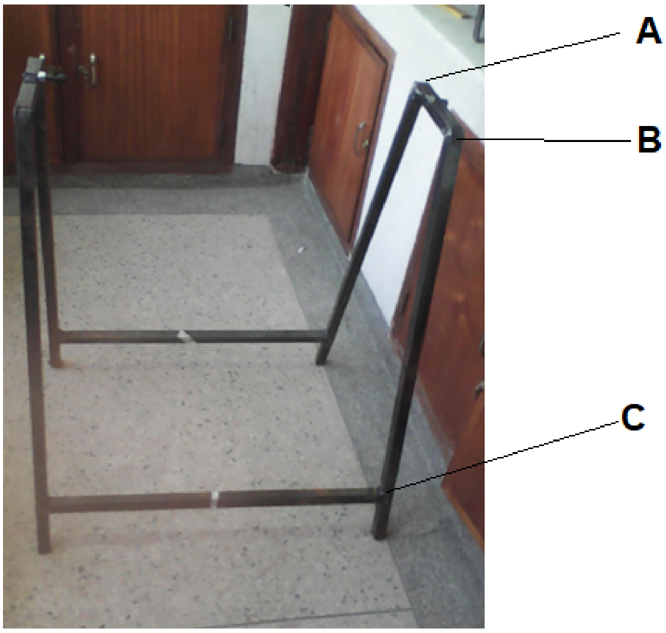
Table 3 Records for rotational height and calculation of rotational angle

Time	V battery	Vx	Vy	Vz	Height	Angle	Height	angle
Level	2.664	1.655	1.293	1.34				
solar noon	2.664	1.625	1.168	1.34			23.1	20.33
9:15 AM	2.663	1.492	1.155	1.601	57	51.658		
9:27 AM	2.662	1.526	1.156	1.571	49.5	42.932		
10:02 AM	2.66	1.544	1.156	1.545	45	38.258		
10:33 AM	2.659	1.575	1.158	1.502	36	29.694		
10:56 AM	2.658	1.584	1.158	1.477	30.9	25.162		
11:27 AM	2.656	1.597	1.159	1.45	24	19.283		
11:54 AM	2.655	1.602	1.158	1.429	19.5	15.564		
11:57 AM	2.654	1.608	1.16	1.41	14	11.107		
12:30 PM	2.652	1.616	1.162	1.346	3	2.3659		
12:57 PM	2.651	1.615	1.16	1.337	0	0		
1:29 PM	2.647	1.615	1.164	1.303	-5	-3.9451		
2:50 PM	2.642	1.582	1.171	1.179	-32	-26.124		
3:21 PM	2.641	1.561	1.172	1.135	-41	-34.344		
4:45 PM	2.633	1.483	1.176	1.057	-58.5	-53.607		
5:23 PM	2.631	1.428	1.178	1.019	-66	-65.253		
solar noon	2.628	1.603	1.154	1.324				
Level	2.628	1.632	1.276	1.328				

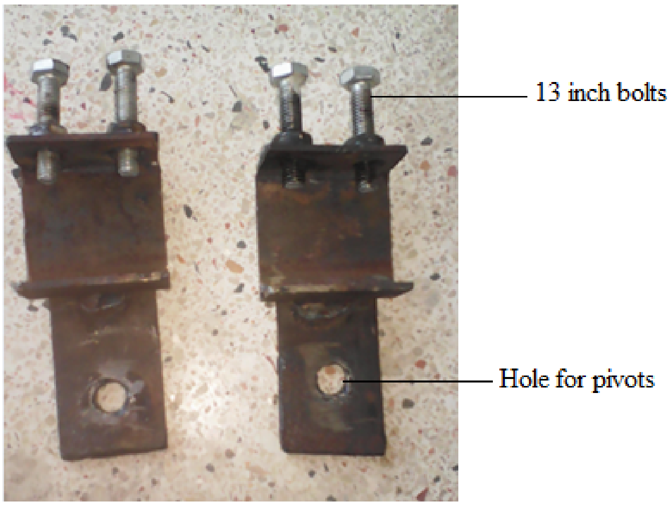
Time	V battery	Vx	Vy	Vz	Height	Angle	Height	angle
Ch1 = Vz, Ch2 = pyranometer, Ch3 = solar cell, Ch4 = applied voltage								
The rotation angle is measured by holding thebar horizontal and touching the higher corner of the PV cell.								

2: Design diagrams

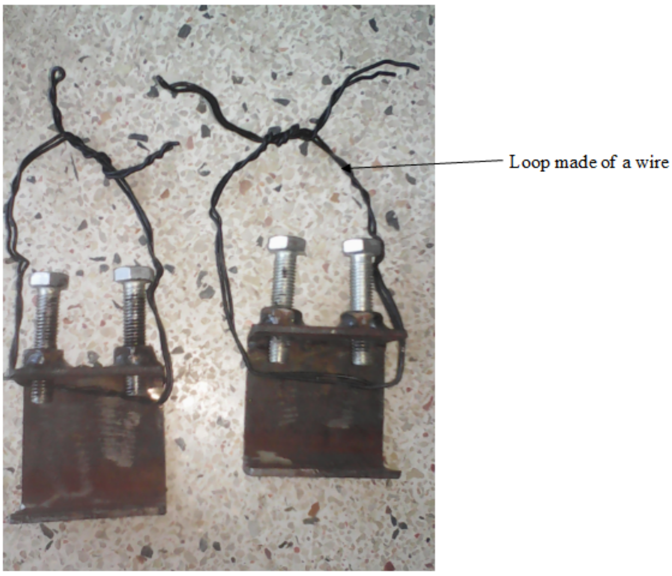
3.3.1 A metallic frame stand is welded and assembled as shown below**.**



3.3.2 A set of clamps was made by welding and attaching 13 inch bolts.

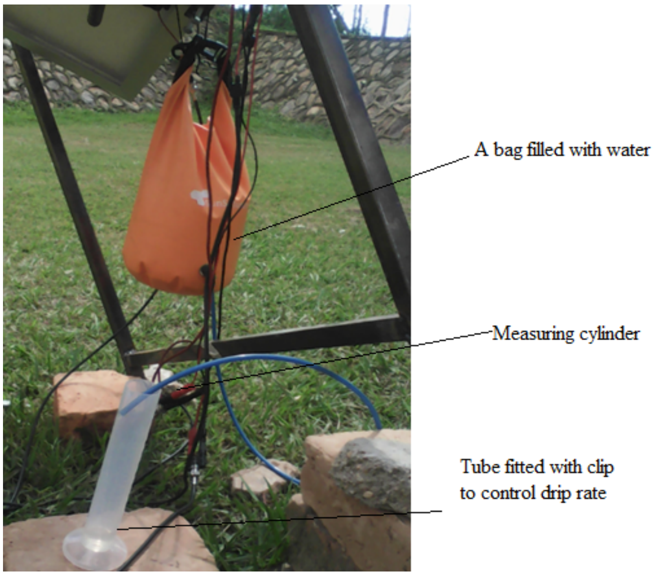


3.3.3 Set of clamps with loop of wire

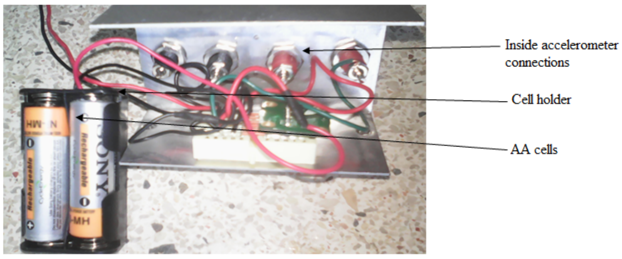


3.3.4 The top of the stand with a bolt.

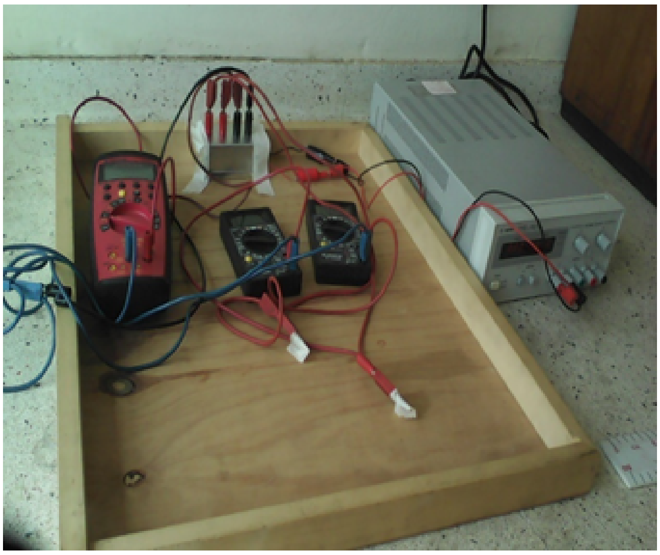
3.3.5 Part of the apparatus that shows attachment of container filled with water together with measuring cylinder.



3.3.6 Assembling of the accelerometer



3.3.7 Experiment used to test the assembled accelerometer before mounting it on solar panel



3.3.8 Attaching a 5 Ω resistor onto the terminals of a solar cell