EFFICIENCY OF SOLAR PANELS

Year 10

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Efficiency of Solar Panels.

Background Information:

Solar energy is undoubtedly the future trend of energy. Nowadays, many households have converted their home to be powered solely by solar power, reaping all the advantages offered by the sun. Many people use solar power because it:

1. Cuts-down electricity bills
2. It is a renewable energy source
3. Environmentally friendly

However it has become evident that many variables and factors can make a solar panel more inefficient. Such factors may involve cloud covering, light intensities, angle of elevation from the panel to the sun, dust build-up, the way in which a solar panel sits (such as north and south) all play a role in the amount of power generated. This experiment will offer a deeper analysis into the relationship between solar panel efficiency and dust build-up.

I have also found some information through the Internet about this effect of dust build-up on the efficiency of the panel. The most relevant information includes:

- Physics formula for calculating power (Power = Current x Voltage, Voltage = Current x Resistance).
- When the solar panel has more surface area, more power, voltage and current is produced. Dust build-up ultimately reduces the surface area of the panel, which in turn will decrease the power generated.
- Solar panel conversion efficiency, typically in the 20 % range, is reduced by dust, grime, pollen and other particulates. “A dirty solar panel can reduce its powers capabilities by up to 30 %” – Seamus Curran, University of Houston

Aim: To investigate if the amount of dust on a solar panel affects the power output (i.e. Watts).

Hypothesis: If the amount of dust on a solar panel increases, then the efficiency (power generated) of the solar panel will decrease. This is because the dust will decrease the surface area of the panel exposed to the light source.

Safety:

Hazard	Why is it a hazard?	How can it be minimised?
Talcum Powder	Talcum powder is made from talc, a mineral made up mainly of the elements magnesium, silicon, and oxygen. In its natural form, some talc contains asbestos, a substance known to cause cancers in and around the lungs when inhaled. Also some evidence suggests that talcum powder might cause ovarian cancer and possible to cause acute or chronic lung irritation, known as talcosis.	This hazard can be minimised by wearing appropriate clothing and by wearing a nose/mouth mask.
Incandescent Halogen Light Bulb	The 150 W (approx. 2600 lm) is very bright – because of this one could be potentially blinded by the harsh intensity of the bulb.	This hazard can be effectively minimised if one avoids looking directly at the light source.
	The halogen light bulb is a type of light bulb that is known to very hot in comparison to others. This may cause burns.	This hazard can be minimized by allocating time when dismantling or adjusting the light bulb to allow it to cool down.

Equipment:

- 1 x digital multimeter
- 1 x solar panel (16cm x 16 cm)
- 1 x 150 W (=2600) incandescent Halogen light bulb
- Talcum powder
- 1 x scale
- 1 x lamp
- 1 x seive

Method:

1. Fix 150 W bulb onto the lamp.
2. Place the clean solar panel directly underneath the lamp. Make sure the distance between the panel and the light bulb is 30 centimetres.
3. Connect the multimeter to the panel. In order to use the multimeter to measure voltage, place the red plug into the socket that has the symbol V and place the black plug into the socket that is labelled COM. In order to measure the current, place red plug in the socket labelled mA and the black plug in the socket labelled COM.
4. The clean solar panel is already under the lamp. Turn on the lamp and multimeter.
5. Set the multimeter to measure voltage. Wait 5 minutes until the reading settles and becomes stable.
6. Record the reading of the voltage.
7. Set the multimeter to measure current. Wait 5 minutes until the reading settles and becomes stable.
8. Record the reading of the current.
9. Sieve one gram of talcum powder over the panel as evenly as possible. Repeat steps 5 - 8
10. Repeat step 9 for 2 grams and 3 grams of talcum powder.
11 Once all of the voltage and current have been recorded, use the physics formula of "P=V x I" calculate the power output of each gram (Clean solar panel or 0 grams, 1 gram, 2 grams, and 3 grams) and record in tabular format.
12. Repeat steps 4-11 at least 3-5 times to ensure reliability.

Variables:

Independent Variable – The amount of dust on the solar panel

Dependent Variable – The efficiency/ power generated by the solar panel.

Controlled Variables -

- Same multimeter
- Same light source
- Same 150 W bulb
- Same distance between the light source and the panel (30 cm)
- Same solar panel
- Same environment (such as humidity, temperature etc.)
- Same scale and measuring cup

Results:

Test 1 (conducted 13/07/15 at 5:50 pm)				
		Voltage (V)	**Current (A)**	**Power (W)**
Amount of dust on solar panel (grams)	**0 (No dust)**	6.51	0.0045	0.029295
	1	5.52	0.0026	0.014352
	2	4.48	0.0016	0.007168
	3	3.88	0.0013	0.005044

Test 2 (conducted 14/07/15 at 5:50 pm)				
		Voltage (V)	**Current (A)**	**Power (W)**
Amount of dust on solar panel (grams)	**0 (No dust)**	6.3	0.0035	0.02205
	1	4.71	0.0016	0.007536
	2	3.55	0.0009	0.003195
	3	3.15	0.0007	0.002205

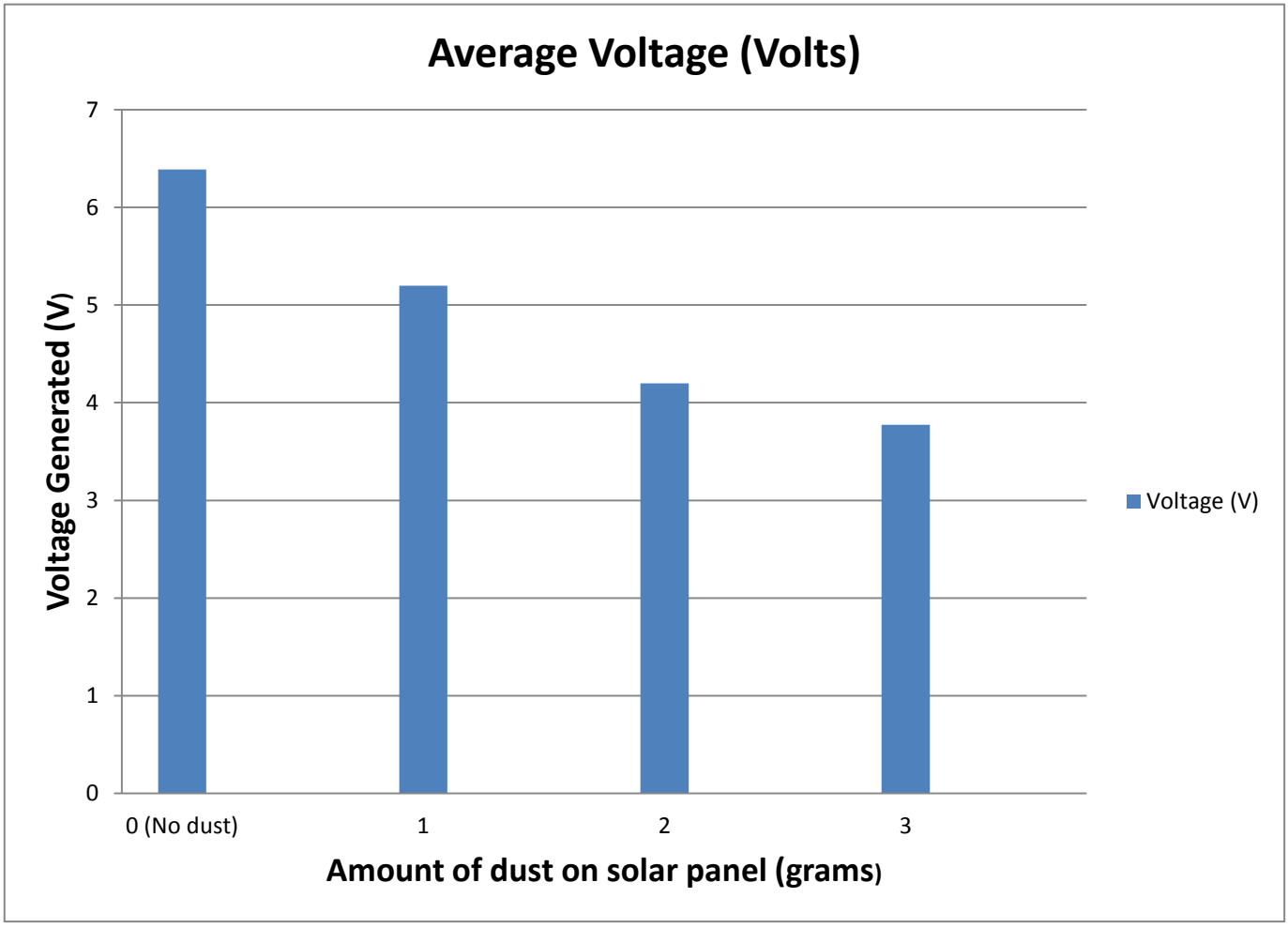
Test 3 (conducted 15/07/15 at 4.38 pm)				
		Voltage (V)	**Current (A)**	**Power (W)**
Amount of dust on solar panel (grams)	**0 (No dust)**	6.51	0.0044	0.028644
	1	5.62	0.0025	0.01405
	2	4.21	0.0014	0.005894
	3	3.97	0.0011	0.004367

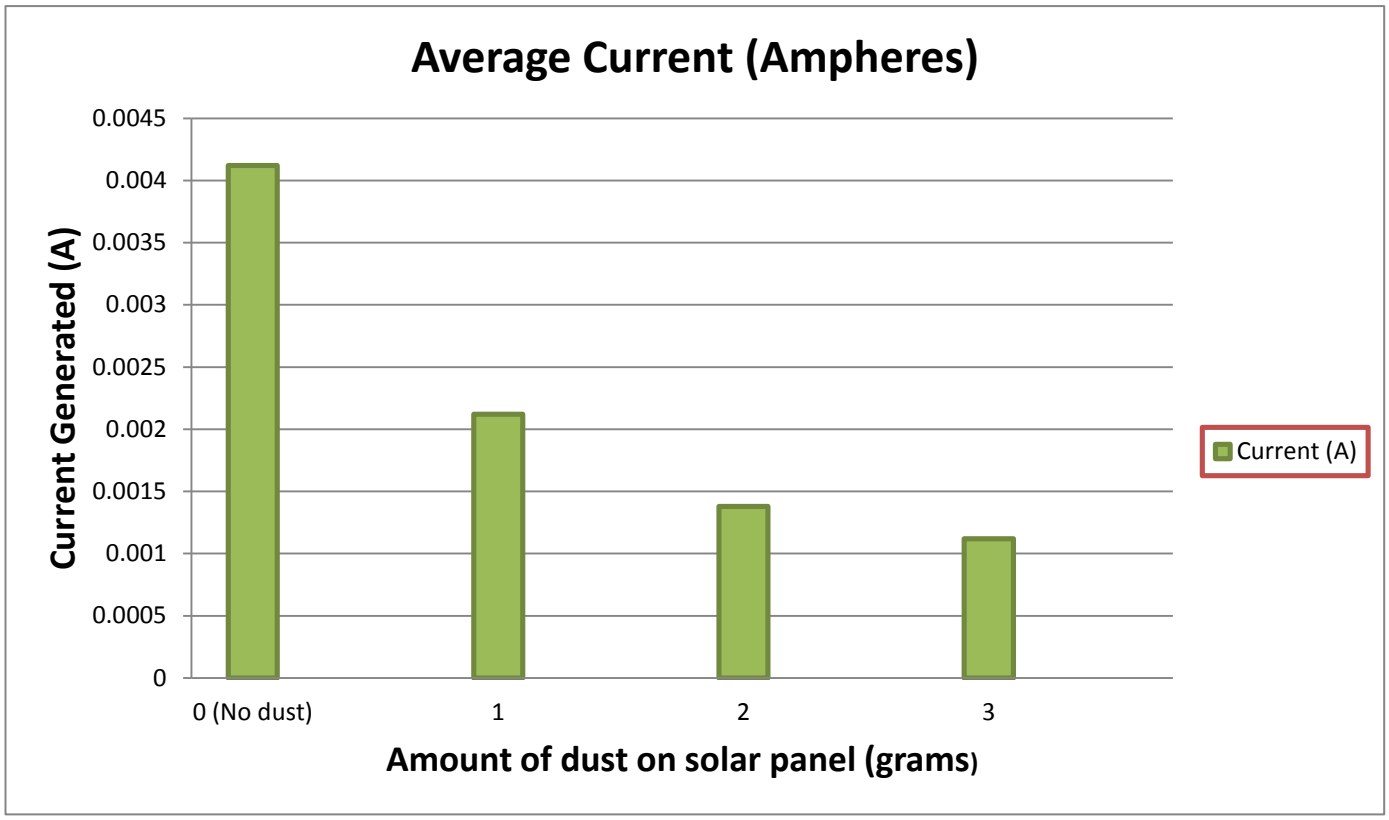
Test 4 (conducted 15/07/15 at 5.31 pm)				
		Voltage (V)	**Current (A)**	**Power (W)**
Amount of dust on solar panel (grams)	**0 (No dust)**	6.29	0.0042	0.026418
	1	5.00	0.002	0.01
	2	4.51	0.0016	0.007216
	3	4.08	0.0013	0.005304

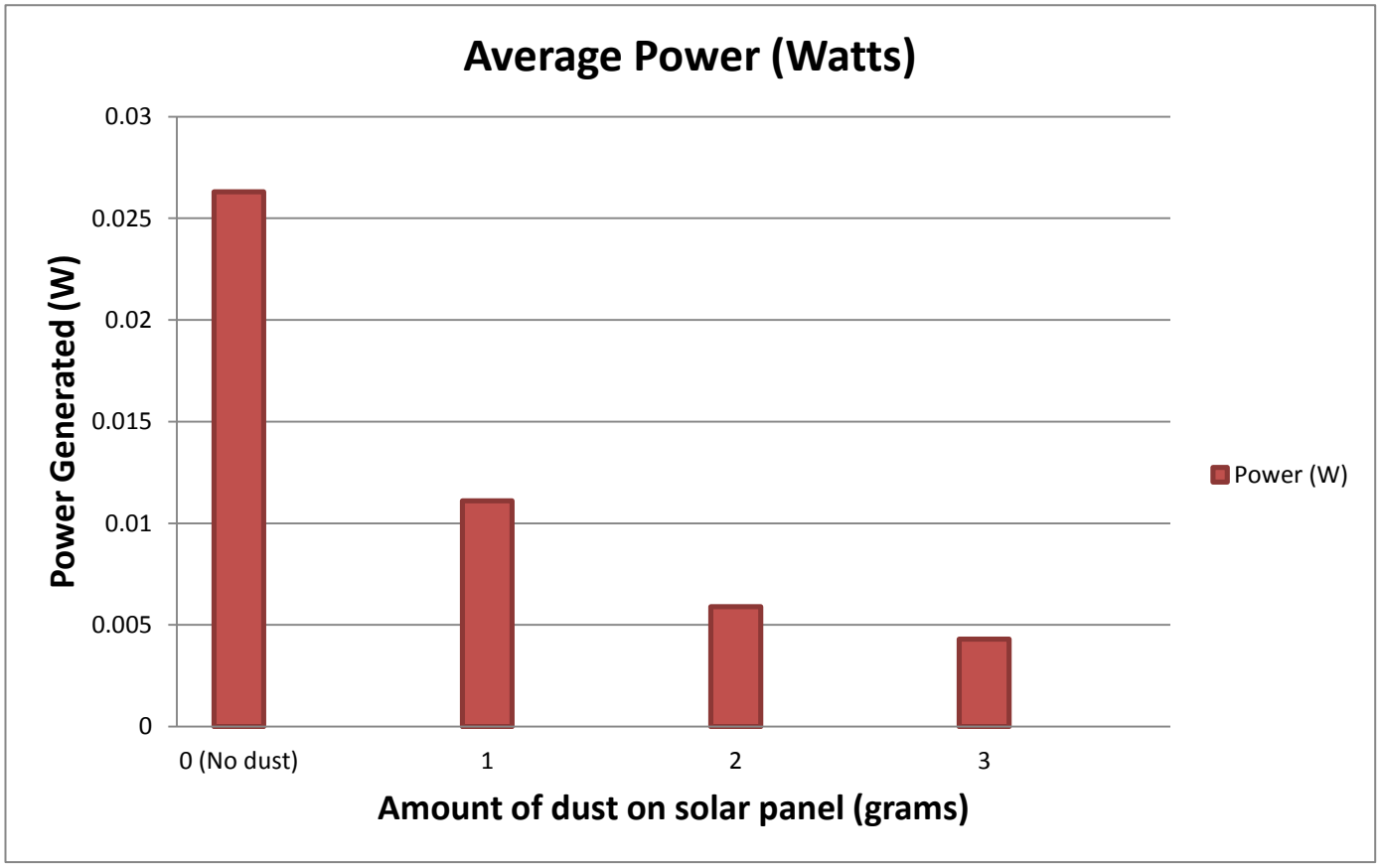
Test 5 (conducted 15/07/15 at 6.33 pm)				
		Voltage (V)	**Current (A)**	**Power (W)**
Amount of dust on solar panel (grams)	**0 (No dust)**	6.32	0.004	0.02528
	1	5.13	0.0019	0.009747
	2	4.24	0.0014	0.005936
	3	3.79	0.0012	0.004548

Averages:

Averages of tests 1-5				
		Voltage (V)	**Current (A)**	**Power (W)**
Amount of dust on solar panel (grams)	**0 (No dust)**	6.386	0.00412	0.0263374
	1	5.196	0.00212	0.011137
	2	4.198	0.00138	0.0058818
	3	3.774	0.00112	0.0042936




Average Current (Ampheres)
Current Generated (A)
0.0045
0.004
0.0035
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
0 (No dust)
1
2
3
Amount of dust on solar panel (grams)
Current (A)


Average Power (Watts)
Power Generated (W)
0.03
0.025
0.02
0.015
0.01
0.005
0
0 (No dust)
1
2
3
Amount of dust on solar panel (grams)
Power (W)

Problems that were encountered –

- Multimeter would need to be set correctly at first, trial and error was required to find the right scale.
- The distance that I originally set between the light bulb and solar panel was too big (60 cm) and the solar panel was absorbing a small, weak reading. Due to this I had to make the distance between the light bulb and panel smaller (30 cm) so that the reading of the voltage and current could become larger.
- Lamp required time for adjustment to stay at the right distance from the panel.
- When the lamps wire was stepped upon, sometimes the lamp would turn off completely. This may have interfered and destabilized the result. Due to this, the lamps wire was relocated to areas that were not walkable.
- The lamp that was used for the experiment could only hold bayonet style light bulbs and thus the experiment was limited to bayonet fitting bulbs.
- Multimeter was sometimes faulty or slow in receiving a result. Therefore more time had to be allocated to determine the results.

How I ensured the data was accurate –

- Repetition would affirm reliability – this experiment was repeated 5 times thoroughly.
- Constant checking of equipment and the experimental setup to ensure that the items were in the right positions
- All results were written on paper and typed on the spot directly after seeing the digits flash on the multimeter.

Discussion:

The amount of dust can affect solar panel efficiency by up to 84 %. This supports the hypothesis – 'If the amount of dust on a solar panel increases, then the efficiency (power generated) of the solar panel will decrease". This is also supported by studies from Dayal Singh Rajput & K. Sudhaka (2013) which demonstrated that dust considerably reduces the solar panel efficiency by up to 89 %. This reduced efficiency is caused by the fact that dust will decrease the surface area of the panel that is exposed to the light source. No dust on the panel would mean that the maximum surface area of the panel would be exposed to the light source – thus generating more energy. One important trend to note is that the power was always in between the Voltage output and the current output. This must be because the current was always below one ampere (<1 amp).

One error that may have had an impact on the experiment is that the sieving of the dust was not controlled and was only sieved to be as **evenly as possible**. This may have been the reason that the power outputs of the results varied significantly. Another error that occurred was when the lamp blew out temporarily when it was stepped on. Although this was later fixated upon and minimised, it may have impacted on the test results by slightly decreasing the voltage/current that was being measured.

An improvement that will increase the reliability of the experiment is to perform the tests using a more reliable light source. Another improvement may include the use of a mechanism that sieves the surface as evenly as possible. This will enable results to become more accurate.

Conclusion:

This experiment was able to determine if the amount of dust on a solar panel affects the power output and it did find that the amount of dust does affect the power output. The experimental data did support the hypothesis that the energy output of the panel would decrease as the amount of dust increased, as shown in each of the graphs for average voltage, current and watts. Therefore to be most efficient the solar panels should be cleaned regularly to avoid dust build up and inefficient solar power production.

Bibliography:

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ABC article, Titled “Keeping solar panels free from dust”

PDF file, Titled “Effect of dust deposition on the performance of multi-crystalline Photovoltaic Modules based on Experimental Measurements”

Academia article, Titled “Effect of Dust on the Performance of Solar PV Panel”, http://www.academia.edu/3037876/Effect_Of_Dust_On_The_Performance_Of_Solar_PV_Panel

Anand Tech, forum, http://forums.anandtech.com/showthread.php?t=1559830

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