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A new vista in increasing total energy output in a fixed area by the movement of multiple solar panel arrangement

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1. Abstract:
Developmental research to increase the efficiency of solar cells has been deeply stressed while the other aspect of increasing the total energy output by simply multiplying the number of solar panels has not been given much attention. In this work, theoretical evaluation and suggestion of new method of solar energy harvesting is discussed. The rough estimates and calculations are used for energy efficiency and total energy output. It was concluded that by using multiple solar panels in a fixed area can significantly increase the solar energy output.
Keywords: Efficiency, solar panel arrangement, total energy output.

2.Introduction:
Solar energy, the energy that is generated from the constant nuclear fission and fusion reactions occurring in the core of the sun; which is then harvested by us using the photoelectric cells.
Solar energy, by definition, is the radiant light and heat that is harnessed by variety of equipment such as solar power to generate electricity, solar thermal energy etc.
But today's focus of discussion is solar power to generate electricity. It's a clean renewable source of energy that decreases the carbon footprint in a colossal amount. To many scientists, solar energy is the only way of achieving sustainability.
A study by IEA(International Energy Agency) regarding world energy consumption shows that by 2050, more than 45% of energy demand[1] will be satisfied by electricity generated by solar power, which is a good sign. People nowadays are getting more aware of the carbon footprint and thinking of harvesting the solar power for personal, domestic use.
But for other people who can't move forward to spend or hesitating to spend to get electricity from solar energy has one thing in common: it's pricey.
Solar panels, which are used to generate electricity from solar energy are expensive to install, i.e initial cost is high.

Besides the high cost, there are a couple of factors that are to resolved as soon as possible, which are:

1. Efficiency of solar cells.
2. Optimization of tilt angle for solar panel[2]
3. Total energy output

Now for the efficiency, it is found that upon immersion of solar cell in water[3] rapidly increases the efficiency of the solar panel. It is because of:

a) Cooling of PV module
b) Reduction of light reflection (due to lower refraction index)
c) Absence of thermal drift.

Another way of improving the efficiency is using heterojunction[4] with thin layer(HIT) structure(thin silicon wafer). Also the arrangement of solar cells is a way of improving the efficiency of solar panels.

The dust above the panels drastically reduces the efficiency of the panels[5].

So an auto cleaning mechanism above the panel may be incorporated.

For the total energy output, while some may stress on efficiency of solar cells, to me, it's almost a dead end now. While scientists are pushing the barrier to break 22% efficiency of solar cells, it is coming with a toll; it is getting very expensive due to use of exotic elements and making it more tough to manufacture. So till we use a whole new element or a whole new method, it is impossible to get a breakthrough from 22% efficiency.

Rather it is more fruitful to shower some light to the arrangement of solar panels. In a conventional macro use of solar panels, we see a stretch of land covered with solar panels where each solar panel covers a fixed part of land and is arranged in rows and columns. In this arrangement either the solar panels are fixed at an angle or moves based on the movement of the sun for optimum usage.

3.Experimental Methodology:

Taking inspiration from vertical farming, we can arrange the solar panels by stacking. As said earlier, a single solar panel covers a fixed part of land.

3.1 Case 1(Fixed, ideal scenario):

Let the production of energy be X. Now imagining a scenario where two more solar panels are stacked one above the other vertically using a rod. So now we have got three solar panels stacked one above another. Now let us consider the thickness of a solar panel to be around 1.4 inches or 3.56 cm(ranges between 1.25 and 1.6) and the length and breadth to be 66*40 sq. inches or 167.64*101.6 sq cm. The aforementioned scenario is like this:

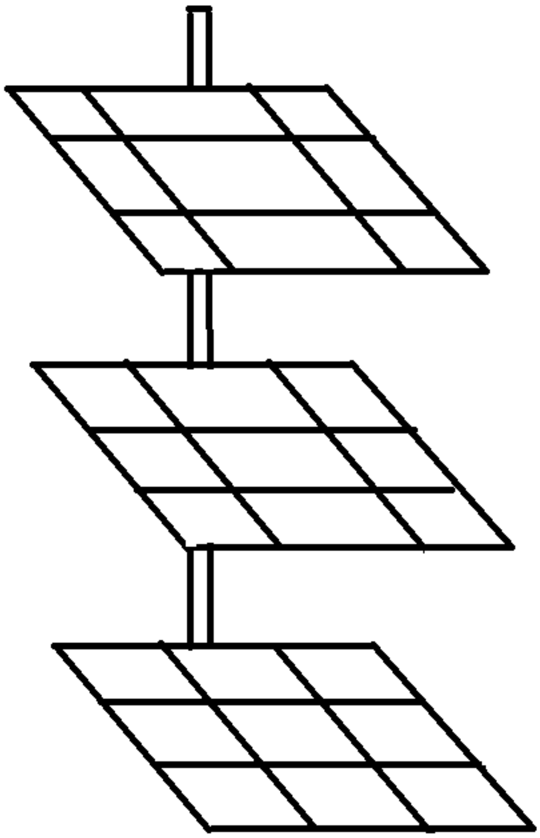


Diagram not to scale

Now if we fix the angle of the sun such that the shade of the solar panel from the top does not affect the working of the solar panel in the middle as well as the middle does not affect the bottom one, then we obtain a situation where, from a single area of land we are obtaining more energy output. As said earlier, the production of energy from this arrangement will be 3X.

Thus for a fixed, ideal scenario, we can definitively conclude that simple multiplication of solar panels in a fixed area of land significantly increase the total energy output.

3.2 Case 2(Real world scenario):

But in real world, many complications arise. So now, let us consider an almost real world scenario. Same as aforementioned scenario, let us consider three identical solar panels namely solar panel 1, solar panel 2 and solar panel 3 (Length: 66 inches, Breadth: 44 inches, Thickness: 1.4 inches) stacked one above the other with a fixed angle of 60 degrees(with some variations in different seasons such as 45 degrees for spring). Now here comes the problem. Since we are unaware of the position of the sun, we cannot solve the shade problem(which was previously solved in the fixed scenario). So to tackle that let us join two brushless motors (a) and (b) under solar panel 2 and solar panel 3 respectively. These two brushless motors will independently work to move forward to avoid shade and thus at any given position of the sun, the independent single chip computer, along with the data from the top mounted photoelectric sensor with camera, will decide to change the position of the solar panel 2 and 3.

Since the solar panel receives maximum sunlight between 45 degrees and 60 degrees, it’s better to set the distance between two solar panels for optimum use.

3.2.1 Case 3(Analogous experiment):
For that let us perform an analogous experiment using two cardboard plates(Length: 7.4 cm, Breadth: 6 cm, Thickness: 0.1 cm) and a pencil as the shaft and an incandescent light as source of solar energy.

It is found that for 45 degree angle($\theta 2$) of the light source, and 21 degree angle($\theta 1$) of tilt for each of the cardboard plate, the minimum gap between two cardboard plate to avoid shade is approximately 8.11 cm.

To confirm the data let us solve it algebraically.

3.2.2 Case 4(Algebraic Derivation) :
Let t be the required distance between the two cardboard plates.
Now,
x= given gap between two cardboard plates
$\theta 1$= tilt angle of the cardboard plate
$\theta 2$= angle of light source
l= length of the cardboard plate
z= shaded portion

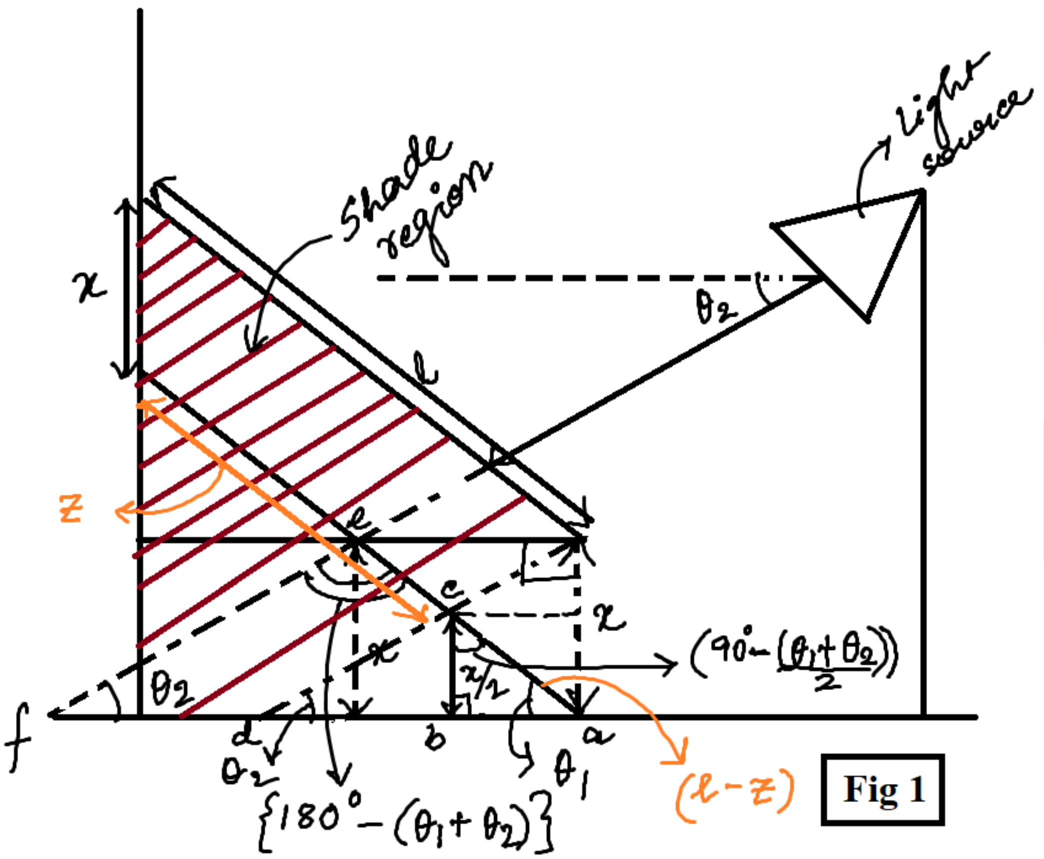


Fig 1

From Fig 1,
Since △ aef is congruent to △ acd,
∠cad=$\theta 1$
∠adc=$\theta 2$
Therefore, ∠acd=180 -(∠cad + ∠adc)   [Sum of angles of triangle=180]
= 180-($\theta 1$ + $\theta 2$)
Now, considering △ acb,

Given,
ac= (l-z)
bc=(x/2) [from diagram]

Now,
cos(∠acb)={(x/2)/(l-z)} [cosθ=(base/hypotenuse)]
=>cos[{180-(θ1 + θ2)}/2]={(x/2)/(l-z)} [Considering ∠acb=∠bcd]
=>cos[90-(θ1 + θ2)/2]={(x/2)/(l-z)}
=>sin[(θ1 + θ2)/2]={(x/2)/(l-z)}
=>(l-z)={(x/2*sin[(θ1 + θ2)/2]}

Therefore, z=l-{(x/2*sin[(θ1 + θ2)/2]}

Now to get the value of t, the shaded region has to be removed; i.e z=0.
0=l-{(t/2*sin[(θ1 + θ2)/2]}

Putting the value of length, θ1 & θ2 from **Case 3**, we get,

t=l*2*sin[(θ1 + θ2)/2]
=7.4*2*sin[(21+45)/2]
=7.4*2*0.54463
=8.0606 cm which is very similar to the practical data which is 8.11 cm.

Hence our data is true and confirmed.

Now for **Case 2**,
The optimum distance between two solar panels is approximately,
t= 167.64*2*sin[(60+45)/2] [l=66 inches=167.64cm,θ1=66 degrees, θ2=45 degrees]
= 265.99 or 266 cm or 104.724 inches.

So, the next issue is regarding the movement of solar panel arrangement.
For that, a top mounted photoelectric sensor with camera will be used. It will determine the movement of solar panels. The camera sensor will accurately determine the position of the sun which will be cross checked with the data from the photoelectric sensor. The photoelectric sensor will give direction to the camera to move by detecting the intensity of light in the surroundings.

For the arrangement to move, a centrally mounted single shaft induction motor will rotate the carbon fiber rod with steel core which grips the three solar panels. The reason for using the single shaft induction motor is:
a) Cheap to manufacture
b) Has no cogging torque like permanent synchronous magnet motor

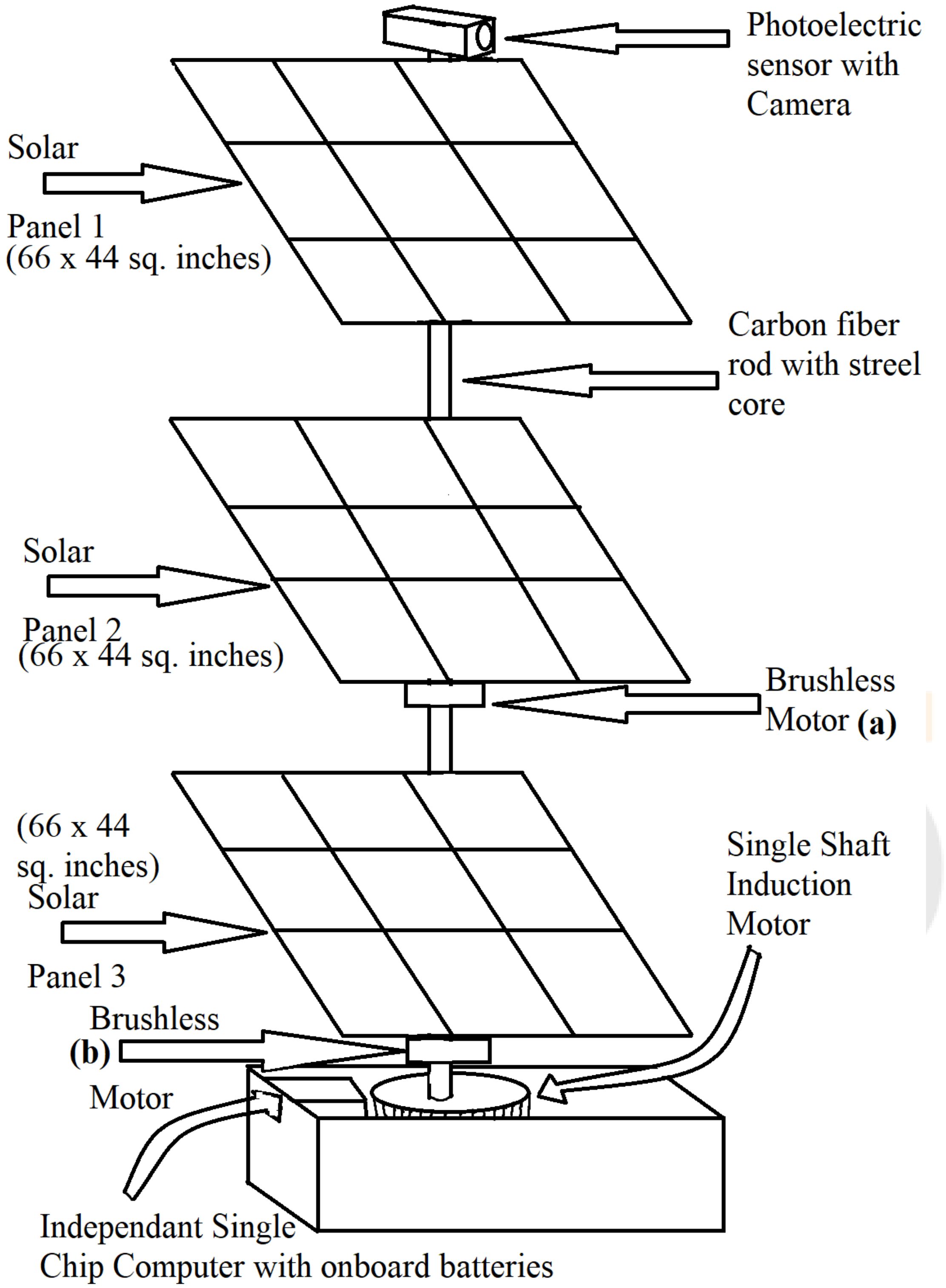
To explain the reason for using carbon fiber rod, let us take an example of a car. Say the car has 50 horsepower and weight of 800 kilos of which 250 kilos is of the outer body which is made up of sheet metal and tubular steel frame. The power to weight ratio is (50/800)= 0.0625 hp for every kilo. Now let us remove the outer body and replace it with a carbon fiber one having a curb weight of around 100 kilos. Therefore, the improved power to weight ratio is (50/650)=

0.0769 hp for every kilo. The car will feel much agile and will have improved driving dynamics.

Just like that if we use carbon fiber rod instead of metal rod, we will improve the power to weight ratio thus decreasing the consumption of electricity of the motor.

The onboard batteries will be recharged from the solar energy which will further be used for electric consumption.

The diagrammatic representation is given below:



Solar Panel Arrangement
(diagram not to scale)

4. Results:

Since this arrangement is a suggestion of a practical method and the evaluated results are theoretical only, so definitive results are subjective, requires intense research, more data and refined instruments for accurate results, and is a matter of discussion.

5. Conclusion:

In this paper, an new method of solar energy harvesting is suggested and theoretical analysis is done. In this model, a multiple solar panel arrangement is done which provides approximately 3 times the total energy output if three solar panels are used in a fixed area of land. This model will be useful to significantly increase the amount of solar energy harvest and will be able to supply more electricity thus decreasing the world energy crunch. The suggested model is efficient and cheap.

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