Journal of Physics Special Topics

A2_7 Natural Solar Panels

J. Hue, R. Miller, J. A. Farrow and C. Checklin

Department of Physics and Astronomy, University of Leicester. Leicester, LE1 7RH.

Nov 20, 2014.

Abstract
The paper looks at the possibility of retrieving energy from rain and how the energy collected compares to using solar panels instead. It is worked out that the maximum energy obtainable from the collection of rainwater is $2.67 \times 10^9 h$ J per day, where h is the height of the water above the ground. Compared to the Lieberose photovoltaic farm which would produce 6.5×10^{11}J in similar conditions making this imagined method likely unviable.

Introduction
As the world shifts its energy sources away from fossil fuels due to the environmental impacts there is more need to utilize other energy sources. Today solar cells are far more efficient than they used to be and are a very viable option for powering the future. This paper explores another option, of collecting power from fallen rain; water sources absorbing energy from the sun acting as solar panels.

What is exciting is that convective rainfall typically collects moisture from distances 3-5 times the size of the convective event [2]. The ability to seed clouds to create rainfall would theoretically allow the energy to be collected when wanted. In this paper the energy collected by the Lieberose solar farm is compared to that collected by a theoretical rain collector of the same area (which would draw moisture from a distance 3-5 times its size).

Discussion
The Lieberose photovoltaic farm has a solar cell surface area of 5×10^5m^2 [1], which allow it to provide 5.2×10^7kwh per annum. The rain capturer idealized is that of a cylinder, with a base area of 5×10^5m^2, giving it a radius of 398m. It is theorized that a rain event of radius 398m can be created at will by seeding and that it would rain only in the rain capturer. This would obviously not be the case in real life but done for the sake of the paper, as obviously if the energy collected is very low then it can only be lower in real life conditions. Also the capturer is isolated in a body of water, meaning the whole surrounding area provides water vapour to the atmosphere as the sun heats the area.

The highest evaporation rate observed in the world is 2m per year, in the inter-tropical convergence zone [3]. This equates to a rate of 5.48mm per day. This means that if the atmosphere begins devoid of moisture at the beginning of the day, the column integrated amount of water per metre square is 5.48mm.

Convective rainfall events source moisture from distances 3-5 times the size of the event [2]. If the convective event seeded is the size of the capturer, then its diameter will be 796m. Moisture can then be sourced from distances ranging from 2388m up to 3980m. These radii equate to areas of 1.79×10^7m^2 and 4.97×10^7m^2 respectively. Multiplying these areas by the column integrated amount of moisture evaporated in a day, it can be found that the total volume of water in the atmosphere that can be sourced by the rainfall event is 9.81×10^4m^3 to 2.72×10^5m^3. These volumes convert to masses of collected water of 9.81×10^7kg and 2.72×10^8kg.

As the rain capturer will produce energy by using the potential energy of the captured water to drive turbines similar to hydroelectric dams the energy collected (ignoring friction and other processes reducing effiency) will be equal to,

$$E = mgh, \tag{1}$$

where; E is the energy, m is the mass, h is the height of the water stored, and g is the acceleration due to gravity (9.81 ms^{-2}).

So the energy collected would therefore be $9.6 \times 10^8 h$ J to $2.67 \times 10^9 h$ J, where h is the height of the water stored, assuming that the rain capturer can effectively capture the increased energy from the increased potential energy of the stored water.

The sunlight hours at Lieberose are estimated to be 1625 hours per annum [4]. Ecuador in comparison obtains 2058 hours per annum. To compare the energy that a photovoltaic farm the size of the rain capturer would obtain in an area near the equator the annual power produced by the Lieberose value is scaled up by $\frac{2058}{1625}$, giving it a daily power produced of 1.80×10^5 kwh or 6.5×10^{11}J. This is two orders of magnitude higher than the energy produced by the rain capturer at only one meter high.

The power derived from the rain capturer could be increased by making the structure higher, so that captured rain would fall a greater distance.

Conclusion

The latent heat from vapor condensing in clouds is very large, the latent heat of vaporization of water is 2260kJkg^{-1} [5], from the masses of water worked out earlier, this results in energies of 2.22×10^{14}J and 6.14×10^{14}J. Unfortunately the method used is unable to collect energy from this phase change, and further research could be carried out to see if this is possible.

Despite the fact that the collected energy is so much less than that by the photovoltaic cells the price of the structure may be much lower and therefore affordable by poorer countries. Further research may be carried out on the subject to test the viability of such a structure.

In areas where space is more limited the idea of using natural solar cells, i.e. bodies of water, would be innovative but are not viable in the currently imagined format.

References

[1] `http://www.solaripedia.com/files/242.pdf` accessed 20/11/2014.
[2] K. E. Trenberth, A. Dai, R. M. Rasmussen and D. B. Parsons, *The Changing Character of Precipitation*, American Meteorological Society, 2003.
[3] L. Bengtsson, *The Global Atmospheric Water Cycle*, Environ. Res. Lett., 5, 2010.
[4] `http://www.currentresults.com/Weather/Germany/annual-hours-of-sunshine.php` accessed 20/11/2014.
[5] `http://en.wikipedia.org/wiki/Latent_heat` accessed 20/11/2014.