

## A3\_3 The Solar Chair?

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October 26<sup>th</sup>, 2011

### Abstract

This article explores the feasibility of using solar energy to execute prisoners on death row. The concept is shown to be possible, results showing a requirement of 86 solar panels of high efficiency to execute one prisoner. The economic practicalities of using solar energy for this purpose are also scrutinised.

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### The electric chair

The electric chair has been used as a means of capital punishment for over 100 years [1]. An electricity generator has been the conventional method used to supply the electrical energy required for this. The ability of electricity to kill resides in the electrical current. A current of merely 0.07A is enough to kill due to fibrillation of cardiac muscle [2]. Using this value for current  $I$ , combined with the values given by the Nebraska electrocution protocols, which stipulate a 15 second application of 2450V [3], the energy required to kill a human is

$$P = IV = \frac{E}{t}, \quad (1)$$

therefore,

$$E = IVt = 2572.5 \text{ J}. \quad (2)$$

### The Sun's power

The next step is to calculate the solar energy incident on the Earth's surface. Using the Stefan-Boltzmann law, and assuming the Sun to behave as a perfect blackbody (i.e. its emissivity equal to 1), the power radiation from the Sun is found to be

$$P = \sigma T^4 A = \sigma T^4 \cdot 4\pi R_{Sun}^2, \quad (3)$$

where  $\sigma$  is the Stefan-Boltzmann constant ( $5.6704 \times 10^{-8} \text{ Js}^{-1}\text{m}^{-2}\text{K}^{-4}$ ),  $T$  is the temperature of the Sun (6000K) [4] and  $R_{Sun}$  is the radius of the Sun (695 500km). This gives a power

$$P = 4.467 \times 10^{26} \text{ W}. \quad (4)$$

At a distance of 1 AU, the intensity  $L$  of the solar radiation becomes (assuming no dispersion)

$$L = \frac{P}{4\pi \cdot (1\text{AU})^2} = 1588 \text{ Wm}^{-2}. \quad (5)$$

Since approximately 59% of solar radiation is reflected by the atmosphere, and a further 23% absorbed by the atmosphere [5], the incident radiation intensity on the Earth's surface is found to be  $286 \text{ Wm}^{-2}$ .

### Green energy

The most efficient solar cells yet invented have an efficiency of 21% and are responsive to about 50% of the solar spectrum [6]. Taking solar cells of this efficiency with an effective area of  $1\text{m}^2$ , the amount of solar cells required to generate the energy required in equation (2) is

$$\frac{E(\text{J})}{L(\text{Js}^{-1}\text{m}^{-2}) \varepsilon \times \gamma \times (1-\alpha-\beta)} = 86 \text{ solar cells}, \quad (6)$$

where  $\varepsilon$  is the solar cell efficiency (0.21),  $\gamma$  is the ratio of solar spectrum responsive (0.5),  $\alpha$  is the ratio of solar radiation absorbed (0.23) and  $\beta$  is the ratio of solar radiation reflected (0.59).

### Conclusion

The calculations above show that capital punishment could be carried out using solar panels. A solar panel costs approximately £3600 to purchase and install [7] so approximately £310,000 executions could be carried out using solar energy. However, this figure is quite a large sum to pay if executions are quite a rare occurrence. For example, there were 46 executions in the whole of the USA in 2010, and only 1 using an electric chair [8]. Taking the cost of electricity to be 20 pence per kWhr, the cost of this execution in the UK would have been £280. So there would need to be about 1070 executions before any savings would be made. If the death penalty rate for the USA and the price of electricity remained constant, and all executions were carried out by a solar electric chair, it would be almost 24 years before the country would make a saving. Since solar cells last for approximately 30 years [9], this means capital punishment can run a surplus for up to 6 years.

However, there are some points that have not been considered. Firstly, the value found for the intensity of solar radiation is a value averaged over the Earth's surface facing the Sun. Therefore there will be fluctuations in this value depending on the distance from the equator, the weather conditions, etc. Secondly, although the energy capability is there, whether there is yet the technological capability in terms of storing and discharging the energy in the manner required from solar cells is unknown, since solar technology has of yet never been used for this purpose.

### References

- [1] [http://inventors.about.com/od/hstartinventions/a/Electric\\_Chair.htm](http://inventors.about.com/od/hstartinventions/a/Electric_Chair.htm) retrieved (26/10/2011).
- [2] <http://hypertextbook.com/facts/2000/JackHsu.shtml> retrieved (26/10/2011).
- [3] [http://journalstar.com/news/local/article\\_96b72d77-1363-5369-a490-3a37210ee6b7.html](http://journalstar.com/news/local/article_96b72d77-1363-5369-a490-3a37210ee6b7.html) retrieved (26/10/2011).
- [4] P. A. Tipler, G. Mosca, *Physics with modern physics for Scientists and Engineers* (W.H. Freeman & Co., 2008).
- [5] <http://earthobservatory.nasa.gov/Features/EnergyBalance/page6.php> retrieved (26/10/2011).
- [6] <http://www.independent.co.uk/environment/worlds-most-efficient-solar-cells-ready-for-use-in-the-uk-2200508.html> retrieved (26/10/2011).
- [7] [http://www.suntap-solar-panels.co.uk/solar\\_panel\\_price.html](http://www.suntap-solar-panels.co.uk/solar_panel_price.html) retrieved (26/10/2011).
- [8] <http://www.deathpenaltyinfo.org/documents/2010YearEnd-Final.pdf> retrieved (26/10/2011).
- [9] <http://www.energysavingtrust.org.uk/Generate-your-own-energy/Solar-PV-electricity-panels> retrieved (26/10/2011).