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## P3_7 A Solar Powered Leicester


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**Abstract**

In this paper the feasibility of meeting the power consumption demands of Leicester using only solar panels fitted to the rooftops of houses was studied. It was found that every household in the city would need at least 47 of the highest efficiency solar panels commercially available today affixed to the rooftops, which would not be practical.


### Introduction

With fossil fuels running low and the controversy surrounding the use of nuclear materials as a source of power, the world is turning towards renewable sources of electricity. This paper looks at the feasibility of powering Leicester using solar panels alone. The proposed model determined how many solar panels would be required on top of each house in order to supply all the electricity that the city requires.

### Theory

It was assumed that the total energy consumed by the nation is evenly distributed among the total number of households in the UK. Therefore the fraction of the population that resides in Leicester consumes the same fraction of the total energy consumption. This was assumed as it was not possible to find an estimate for both the amount of energy used by the city of Leicester specifically and also an estimate for the number of houses occupied in Leicester.

The study was localised to Leicester since solar irradiance varies greatly with geographical location. This way, it could be assumed that the solar irradiance remained constant with respect to geographical region but not with respect to time. The solar irradiance varies dramatically with respect to the position of the planet in relation to the Sun and so varies with the time of year. As such, an annual average for the irradiation was used. This estimate was found to be 2.99kWh/m$^2$ per day in Leicester along the plane perpendicular to the Sun's rays [1], which maximises the irradiation. As such it was assumed that all solar panels were orientated in such a way to maximise the solar flux incident upon them.

Solar panels aren't currently very efficient in converting the solar energy directly into electricity. The theoretical limit on the efficiency is 30% as the efficiency is directly related to how well the light spectrum matches the band gap energy [2]. Currently, the best commercially affordable solar panels operate at efficiencies of below 20%. The best of these is the *Sanyo HIT-N240SE10* with an efficiency of 19% and a plate surface area of 1.26m$^2$ [3]. The energy produced by each panel was calculated using equation (1),

$$E = IA\varepsilon, \tag{1}$$

where $I$ is the irradiance, $A$ is the area of the plate and $\varepsilon$ is the efficiency of the panel. Substituting the values obtained earlier, it was found that each panel could produce 0.716kWh per day, corresponding to 261kWh per year per panel.

There were 26.0 million households in the UK in 2010 [4]. It was estimated by the Leicester Statistics and Research centre that 306,600 people live in Leicester [5] and, according to the World Bank, the total population of the UK was 62.219 million in 2010 [6]. It was assumed that the ratio of the population of Leicester to the total population of the UK would be a good approximation for the ratio of households in Leicester to the total number of households in the UK. Using the data above, the population of Leicester was 0.493% of the total population. This corresponded to 0.128 million households in Leicester. If, to begin with, one panel was placed on the top of each house then the total energy generated would be 33.4MWh per year. In 2010, 319.2TWh was used nationally [7]. Scaling this down to the population of Leicester meant that 1.57TWh must be generated by these panels in order to generate all of the electricity required. As such, it was found that each house would be required to accommodate 47 solar panels. If every house was modelled as an average sized detached house with a trapezium shaped roof, as shown in figure 1; with dimensions of 12m, 8m and 6m corresponding to lengths 1, 2 and 3 in figure 1 respectively, the roof would still only be able to accommodate 33 solar panels [8].

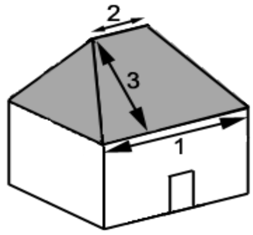

**Figure 1: Model house [8].**

If future developments increased the efficiency of the solar panels to their maximum theoretical efficiency of 30%, then 30 solar panels would be required per house. Although this number is within the limit of our model, it is highly idealised since there are a large number of semi-detached and terraced houses in reality. Also we would need to reach the theoretical limit of efficiency for the solar panels. The model did not take into account the decrease in efficiency with age of the panels either. For the *HIT-N240SE10*, the efficiency would fall to 90% and 80% of its original value after 10 and 25 years respectively [3]. Working through equation (1) again with this new decreased efficiency, it was found that the number of panels on each house would need to be increased to 53 and 61 to compensate for this.

**Conclusion**

This paper investigated the possibility of generating all of the electricity required by Leicester through the use of solar panels attached to the roof of each house. It was found that each roof would need to house 48 solar panels in order to make this a reality, increasing to 61 panels after a period of 25 years due to degradation. Even when each house was modelled as a detached house, the maximum number of panels that could fit was 33. This model had its limitations as it did not take into account panels on the roofs of other buildings, such as industrial buildings, as it was difficult to obtain a reliable estimate for the numbers of those around.

**References**

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