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A4_12 Pico-Hydro Powered House

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Abstract

This paper looks at the plausibility of using wastewater from a single first floor bathroom to generate energy in a household. It was found that the average two person household would only generate enough energy over a year to power a 100 Watt light bulb for around 6 hours. This is not a considerable amount but in higher buildings with larger populations of people it could be a very cost effective method of power generation.

Introduction

The water that goes down our plugholes is usually not thought about, but it is potentially a source of power. This paper investigates whether it is plausible to generate a useful amount of hydroelectric power from household wastewater. We assume the water used is the water that comes from one first floor bathroom in a typical two-storey home and that the turbine collects grey-water from the sink and shower only. The energy is generated when the water, falling one storey down, flows into a turbine that in turn generates power. The term Pico-hydro is defined as waterpower up to 5kW as this amount of power is seen as suitable for a small low energy community or one household [1].

Theory

Hydroelectric power is generated from either harnessing the kinetic energy of water or the gravitational potential energy of water. The gravitational potential can be exploited by allowing the water to fall from a height and turn a turbine at the bottom.

The power generated from a turbine is found by dividing the gravitational potential energy equation,

$$E_g = mgh, \qquad (1)$$

by time and equating the approximate mass flow rate,

$$\frac{m}{t} \approx \frac{dm}{dt} = \rho v A. \qquad (2)$$

The energy over time is the ideal power generated by the system,

$$P_{ideal} = \rho A v g h, \qquad (3)$$

where ρ is the density of the water, v is the velocity of the water, A is the area of the pipe the water is flowing through, g is the acceleration due to gravity and h is the height the water falls from. Av is otherwise known as the flow rate, Q, so the hydroelectric power generation is given by the formula,

$$P = \rho Q g h \varepsilon. \qquad (4)$$

This is no longer ideal because the efficiency of the turbine, ε, has been included.

Calculations

The efficiency of a low-head turbine can be as great as 70% [1] and so the value of ε is taken to be 0.7. The value of ρ for water is known to be around 1000kgm^{-3} and the acceleration due to gravity as 9.81ms^{-2}.

We can assume the turbine is around a storey below the first floor water sources, a storey being around 8 ft (2.4m), this being the value of h. In the UK 46% of households have an electric shower that has a flow rate of between 3 and 8 litres per minute [2]. An average tap has a flow rate of 10 litres per minute [3]. The combined and therefore maximum flow rate, *Q*, is 18 litres per minute, which when converted to SI units is $0.0003 m^3 s^{-1}$.

The power generated by the turbine is calculated to be 4.9W.

Considering a household with two people, we would assume that the shower and tap combination would be used around twice a day for around 10 minutes. Over this 20 minute period we can work out how much energy could be stored assuming a 100% efficient storage system. This works out to be 5880 J per day. Over a typical year this is 2.1×10^6 J (2.1 MJ).

Discussion

Over a year, a typical UK household will use around 3300kWh according to Ofgem statistics [4]. Converting this to Joules gives us a value of 1.2×10^{10} J (12000 MJ). This value is 10^4 larger than the amount generated by the turbine over the same length of time so would not come close to powering the average UK household.

Over a year the energy generated using the turbine could keep a 100 W light bulb on for around 6 hours. The cost of a low-head turbine system would be quite low considering that it is being implemented in rural communities across many third world countries [1]. This means that in the future, when fossil fuel power becomes even more expensive, this type of household system may be cost effective. This paper has only considered a two-person household with one bathroom. Larger buildings, like blocks of flats and hotels, could see considerable savings, especially due to the value of *h* being much larger.

Conclusions

Overall it was found that for the average two-person household in the UK the installation of a low-head turbine as a pico-hydro system would not generate enough power to run the household. It was found however that due to the relative cost effectiveness of using wastewater as a power source it would help with saving fossil fuel generated energy. When used in taller, highly populated buildings the technology could prove to be incredibly advantageous but this would have to be looked into further.

References

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