Built in gutter generator

Rostyslav Kalynovskyi1, Hennadiy Kytsun2

1. National University “Lviv Polytechnic”, UKRAINE, Lviv, E-mail: rostyslav.kalynovskyi.mki.2018@lpnu.ua

2. National University “Lviv Polytechnic”, UKRAINE, Lviv, E-mail: genadiy@polynet.lviv.ua

***Hydroelectric electricity is typically generated by large scale dam projects that block rivers and pass water over turbines. In this fashion, the amount of electricity that can be generated ranges from a few kilowatts to hundreds of megawatts. The streams and rivers effectively funnel the amount of rainfall covering a huge land area into a concentrated flow with enough kinetic and potential energy to justify large infrastructure projects to power a large number of households.***

Кеуwords: hydroelectric, gutter, rainfall, electricity

**Introduction**

Any body of mass that has been raised above the Earth's surface has a potential energy relative to the same mass on the Earth's surface. As explained above, by running elevated water over a turbine, some of this potential energy can be converted into kinetic and electrical energy. In the water cycle, water evaporates via solar energy and gains potential energy that is then lost again when the water precipitates. This cycle of evaporation, rain, turbine, provides a mechanism for the conversion of solar into electrical energy. At best, the amount of electrical energy that can be generated is equal to the potential energy of the rain.

This gravitational potential energy is simply equal to the product of mass, height, and gravitational constant (9.81 m/s2). For example, the potential energy of a cubic meter of water (1000kg) in a stratus cloud at 2000 m of elevation is about 20 MJ, or 5.5 kWh. This means that in a region where the average amount of rain is about 0.40 m, the total amount of rain potential energy lost over a 1 km2 plot of land is about 7.8 x 1012 J, 2.18 x 106 kWh, or enough energy for about 220 homes. Unfortunately, the vast majority of this energy is lost via friction with the air during the rain fall. The next section looks at the total amount of kinetic energy that is still present when the rain hits the ground.

In order to account for the total amount of amount of potential energy that practically be used, assume that the rain is funneled (via home gutters) and then stored into a tank located about roof level, say, 7 m off the ground. The total amount of potential energy of the rain water in the tank would be equal to about 70 kJ per cubic meter of water. As an example, if the total roof space were about 185 m2 (2000 sq feet), the amount of potential energy would be 130 kJ (0.036 kWh) per cm of rain. In a college town where the amount of rain is only about 43 cm/year, this amounts to only about 1.5k Wh. Even in the rainiest place on earth (13.3m in Lloro, Colombia) the amount of energy generated would be 48kWh. In order to capture enough rain for a years worth of energy, the amount of surface area at 7 m and exposed to 100 cm of rain per year would need to be about 515000 m2. This assumes a perfectly efficient generator, which does not exist.

**Table 1:** Examples of the potential energy of rain on the roof of two buildings and into the Columbia River Basin

|  |  |  |  |
| --- | --- | --- | --- |
|  | Case 1: A Sample House | Case 2: The Empire State Building | Case 3: The Grand Coulee Dam |
| Height | 7 m | 325 m(Excluding Tower) | 170 m |
| Surface Area | 185 m2 | 8000 m2(Base) | 334 x 109 m2(Estimate) |
| Rainfall | 0.43 m | 1.15 m | 0.14 m(Reversed Engineered) |
| Rain Mass(=1000 kg/m3) | 79600 kg | 9.2 x 106 kg | 47 x 1012 kg |
| Potential Energy (J) | 5.5 x 106 J | 29 x 109 J | 78 x 1015 J |
| Potential Energy (kWh) | 1.5 kWh | 8.1 x 103 kWh | 22 x 109 kWh |

As shown above, trapping rain, storing it, and running it past a turbine is one mechanism of converting the energy of rainfall into electricity. Another option that can be used in tandem is to capture the kinetic energy of the rain directly. This can be done using piezoelectricity, where crystals convert mechanical motion into electricity.

Again making the unrealistic assumption of perfect conversion, the amount of kinetic energy in a object is half the mass times the velocity squared. The velocity of rain is limited by air resistance and typically has a maximum of around 8 m/s. Doing the calculation, the amount of kinetic energy falling on a 185 m2 roof is about 59.2 kJ (0.016 kWh) per cm of rain. This is only about 1.6 kWh of energy per year in an area that receives a meter of rain per year. As an unrealizable limit, the total amount of rain kinetic energy over the USA is about 65 billion kWh (a quarter of the total energy use).

There are practical applications that arise from this effect, however. Recent research has demonstrated how this effect can power small sensors that use only a little amount of energy and are inconvenient to power by other means.

**Conclusion**

Here is shown basic calculations and estimates for the amount of energy that could potentially be harvested from rain. In moderate scales, there is little potential for energy generation using either the potential or kinetic energy of falling water. In the gigantic scale, however, where nature has carved out a large basin to catch rainfall, dams and turbines can be installed to produce significant amounts of electricity. On small sensors, the kinetic energy of rain can provide enough energy in order to sustain operation. Overall, using precipitation to generate electricity can be used situationally to compliment other technologies, but is not an end solution.

References

[1] A Melnyk - Advances in cyber-physical systems, 2016. [*Cyber-physical systems multilayer platform and research framework*](https://scholar.google.com.ua/scholar?oi=bibs&cluster=11531840343799784057&btnI=1&hl=ru)*.*

[2] V Hlukhov, A Kostyk, I Zholubak, M Rahma - Advances in Cyber-Physical Systems, 2 (2), 2017, 2017. *Galois fields elements processing units for cryptographic data protection in cyber-physical systems**.*

[3] V Hlukhov, A Lukenyuk, S Shenderuk - Advances in Cyber-Physical Systems, 2016. [*Satellite scientific data collection and accumulation system as a basis for cyber-physical systems construction*](https://scholar.google.com.ua/scholar?oi=bibs&cluster=16187406270421515087&btnI=1&hl=ru)*.*

[4]A Melnyk - Advances in Cyber-Physical Systems, 2016. [*Parallel ordered-access machine computational model and architecture*](https://scholar.google.com.ua/scholar?oi=bibs&cluster=11794423692840069770&btnI=1&hl=ru)*.*