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TURNING RAIN INTO ELECTRICITY

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Abstract: This work explores the use of rainwater for electricity generation by means of microturbines. It highlights the environmental benefits compared to fossil fuels and its applicability in remote areas or green homes. PowerSpout microturbine specifications and a potential generation estimation formula are provided. Microturbines can produce alternating current and direct current power. A method for generating electricity from rainwater using microturbines is described. This may be a beneficial solution in areas with limited access to electricity or for those seeking a more environmentally friendly way to generate power. The paper also details the specifications of one particular microturbine, the PowerSpout, and provides a formula for estimating its potential generating capacity.
Keywords: Electric power, storm water, flow rate.

INTRODUCTION

Since ancient times, the Greeks have been harnessing water power by means of water wheels. With the advent of water turbines in the 19th century, this energy source became essential for the Industrial Revolution. Despite advances in other energy technologies, hydropower has maintained its relevance.

Today, energy is an indispensable resource for the progress of society. Its generation is essential for development in various fields, from technology to culture.

In Mexico, energy needs have experienced considerable growth due to the increase in per capita energy consumption and technological advances. This growing demand poses a challenge for energy generating companies. Given this scenario, it is necessary to transform the energy system to achieve sustainable development in the energy, environmental, economic and social spheres. In this context, renewable energy sources take on particular relevance.

The Mexican regulatory framework has evolved since 1992, encouraging the participation of private initiative in electricity generation through mechanisms such as self-supply, cogeneration and independent production. However, the use of small-scale hydropower is still limited. In recent years, new regulations have been approved to promote the participation of these renewable energies in the national energy matrix.

The implementation of a low-impact electricity generation system is suggested, taking advantage of rainwater harvesting through the use of a run-of-river and pumping hydroelectric system. The system consists of capturing rainfall to generate energy by means of a turbine, taking advantage of the circulation of the fluid from a high point to a lower one; subsequently, the water that has been captured is stored and once used to generate electricity, part of the water is pumped back to the main reservoir to restart the cycle. The pumps used in this process consume a small fraction of the electrical energy produced. Alternatively, generators can be designed with reversible capacity, functioning both as turbines to generate electricity and as pumps to lift the water. The main benefit of the project will be the use of the water captured for the generation of electricity and the reduction of electricity consumption costs, although it will not eliminate it completely. In order to establish a solid basis for decision making, a thorough analysis will be carried out to define the technical and economic parameters required to evaluate the feasibility of this small-scale hydroelectric plant project.

As part of the project planning, an exhaustive analysis of the components to be used will be carried out, considering costs and technical designs to ensure the feasibility of its construction.

METHODOLOGY OR DEVELOPMENT

In this work we intend to propose an alternative to the generation of electric energy by taking advantage of the benefits offered by nature and thus be part of the solution required by the country in the face of the adversities that occur globally. We propose the construction of a small-scale pumped hydroelectric power plant, which will be installed in the buildings of the UAM-Azcapotzalco, in addition, we intend to select the usable surfaces in the available buildings and what are the limitations and / or conditions that must be met to make feasible the development of the project.

A small-scale pumped hydroelectric system will be developed that will use captured and stored water to generate electricity. This energy will be used to operate the water return pumps and to supply energy to the different areas of the university. This means offering an alternative for generating electricity from the use of natural resources, in this case rainwater. To reduce expenses in the use of energy and to be able to capture water for its use.

Carry out a diagnosis for the implementation of the project in the university facilities, which means estimating the rainwater harvesting capacity.

In order to maximize the energy efficiency of the project, the most appropriate turbine for the system conditions will be selected. In addition, an innovative rainwater harvesting system will be developed to allow optimal use of rainwater, guaranteeing its sustainability and adaptability to different scenarios.

To reduce the environmental and economic impact of supplying electricity to a house, taking advantage of the rainy season in the country.

Use rainwater to generate electricity, a viable alternative to reduce the environmental and economic impact of energy supply and generation.

The coverage of the project was initially only intended to be carried out in a residential house, but if it can be implemented correctly in the UAM-AZC, in the future it could be implemented in a complete neighborhood, or with some modifications it could be implemented in buildings, for apartment areas or shopping centers that are not very high.

The basis of our project are the hydroelectric plants, obviously on a much smaller scale, since for hydroelectric plants are required very large amounts of water, and for this they build dams and have large volumes of water that can have access to them at any time, the principle of power generation by hydroelectric plants is relatively simple because it takes advantage of the potential energy of water, to use it as mechanical energy and thus produce electricity. That is, with the water currents move blades or blades of a turbine, and these generate electrical energy thanks to a winding system.

The implementation of this type of methods in society is due to the increase in the price of electricity, in addition to being able to save a little money by installing this system that works with rain in the case of domestic turbines. Since rain is something we have, taking advantage of it is something that can benefit us in the long term and even in the short term. Society is realizing that it can save a little money and help not to pollute by using other means of energy generation.

UAM Azcapotzalco has a campus that, in addition to its 26 buildings, houses 72,345.61 square meters of green areas full of varied vegetation. These green spaces significantly enrich the university experience by providing a pleasant environment for study, recreation and the well-being of the entire community.

Figure 1. Azcapotzalco unit distribution

The project intends to use the interconnection that exists between the buildings of the Azcapotzalco unit of the Autonomous Metropolitan University so that the collection of rainwater will allow us to have enough flow to generate electricity and thus supply the facilities of the UAM-A.

STORMWATER HARVESTING DESIGN

Rainwater harvesting and storage offer multiple benefits. In addition to being a renewable energy source, this technology optimizes the use of water for both human consumption and productive activities. This versatility, coupled with its sustainable nature, makes it an attractive solution to the challenges related to water access and energy generation.

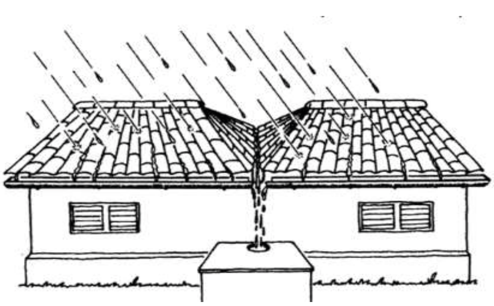

Figure 2 Simplified view of a catchment and storage structure.

The water collector, by means of the roofs, allows high levels of liquid quality.

There are two fundamental characteristics regarding the available catchment area.

1. It should be clean, free of breaks and leaks, and as uniform as possible to facilitate the flow of water into the channels.

2. The maximum capacity of a rainwater harvesting system is directly related to the size of the collecting surface, i.e., the roof area. The gutters, key elements in this system, are responsible for collecting the water from the roof and channeling it to the conduits that will carry it to the hydroelectric generator and storage tank. The choice of gutter material will depend on factors such as durability, corrosion resistance and aesthetics.

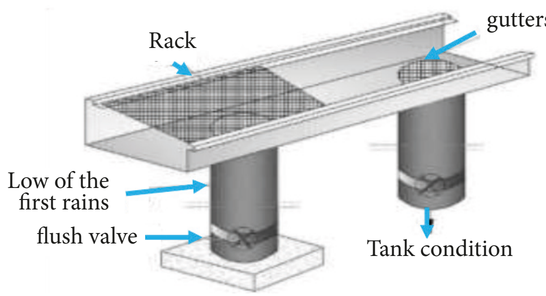

Figure 3. Rainwater conveyance gutters.

Proper design of the water conveyance system is critical to maximize the efficiency of power generation. Ideally, water should flow continuously and without losses from the troughs, through pipes, to the filter and the generator. After this the water will go to the reservoir for storage or pumped back to the troughs for a cyclic process. The filter will be placed at an appropriate height so as not to affect the hydraulic load reaching the turbine. The turbine will be placed at the end of the fall to generate the greatest amount of hydraulic load and function optimally.

The tank will have the capacity to store 5.8 m3 of collected water and will have a 10 cm concrete lining: after excavating and levelling the pit, the bottom and walls are covered with a 10 cm thick layer of concrete. First, the floor is completely covered, leaving a 5 cm wide and 5 cm deep groove along the entire edge so that when the walls are run they fit well with the floor, guaranteeing a seal that does not leak. It is then cured with water. The tank will have an additional outlet to discharge excess water into a larger capacity cistern.

When considering the implementation of a large-scale rainwater harvesting system, accurate calculations of catchment area and storage tank volume are critical. To do this, three key climatic variables must be analyzed: average annual precipitation, rainfall distribution throughout the year, and inter-annual variability.

One millimeter of rain on one square meter is equivalent to one liter of water. However, considering evaporation and conduction losses, it is recommended to apply a catchment coefficient of 75%. The effective catchment area is calculated considering the horizontal projection of the roof.

For the storage tank, a capacity of 5.8 m^3 is established. To determine the catchment area necessary to fill it with 150 mm of rainfall, a catchment coefficient of 75% is considered, resulting in an effective filling height of 112.5 mm.

$5.25m^2 / 0.125m = 47\ m^2\ de$ effective catchment.

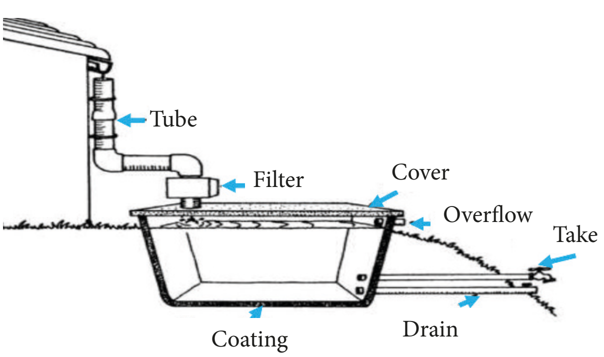

Figure 4. Transversal scheme of the project.

PROJECT CHARACTERISTICS

In this project, the water to be used will be captured in the slab of the unit's buildings and then channeled to the canal, from which the free fall will be used to generate electricity by means of a turbine. Subsequently, a quantity of 5.8 m3 of water will be used to generate electric energy by means of a turbine.

will be stored in a reservoir to be pumped later during low water levels.

The following configuration was proposed:

- Rainwater harvesting works
- Upper reservoir (canal)
- Intake
- Pipelines
- Turbine and generator
- Deposit
- Spillway
- Pumping system
- Overpumping piping

The water catchment system, through the roofs, allows high levels of water quality, this option allows us to create a large difference in height and thus generate a considerable hydraulic load. In our project we will not go into detail with the placement of this infrastructure, we only calculated the effective catchment area we need for the design to be functional, the result was 47 m2.

The open-air channel is used to direct the collected water; there will be galvanized sheet gutters, and then the gutters will lead the liquid to the intake of our project. The height of the building is 8.21 m.

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COSTS OF THE DIFFERENT MATERIALS

The following prices were taken from the following companies or distributors:

- Nacobre (copper)
- Mueller Industries (galvanized)
- EMMSA. PIPING SYSTEM (PVC).
- Advance piping (CPVC)
- Rotoplas (PPR)

	pipe price				
Diameter (Inches)	Copper (6.10 meters)	Galvanized (6.40 meters)	PVC (1 meter)	CPVC (6 meters)	PPR (4 meters)
1/4	312.54	---	---	---	---
3/8	320.55	---	---	---	---
1/2	403.00	292.56	10.28	79.98	57.83
3/4	658.55	388.70	13.75	147.66	99.70
1	931.86	584.53	20.24	302.52	163.00
$1^{1/4}$	1471.26	789.82	28.00	556.92	259.00
$1^{1/2}$	2015.67	946.82	32.75	737.58	378.00
2	3164.14	1270.22	44.31	1248.48	598.00
2 1/2	5972.24	2015.39	70.22	---	1164.00
3	7948.01	2638.19	92.12	---	1660.00
4	13975.09	3755.57	129.65	---	1898.00

Table 1. Table of costs of the different materials.

Based on the costs and properties of the materials mentioned above, it was decided to carry out the project with Rotoplas PPR.

TURBINE AND GENERATOR

These systems convert the potential energy of stored water into electrical energy through a process that involves the initial transformation of potential energy into mechanical energy by means of a hydraulic turbine. The choice of turbine is critical and is based primarily on the height of water fall.

For this type of system, a **"Pelton"** type hydraulic turbine has been chosen, which are the most commonly used in small electric power generating plants.

PLT PELTON MICROTURBINE (POWERSPOUT)

Working range: -Flow rate: 0.1-10Lps (3600-36000L / h)

Operating height: 3-130m.

Power: 10- 1200 W

This turbine is designed to charge battery banks.

12V or 24V or 48VDC or connect directly to the network with a sinusoidal converter (models 170-200).

Approximate price: $40,000.00

Figure 5. Pelton Turbine.

The decision to connect a hydroelectric generation system to the grid or to use it for self-consumption involves evaluating various considerations. Connection to the grid offers a simple and economical solution, but is subject to legal regulations. For self-consumption, there are two main alternatives: with or without batteries. The option with batteries provides greater flexibility, but involves a higher initial investment. The option without batteries is more economical, but requires careful management of the energy generated.

The main benefits of this project are to be able to save on electricity bills, to not pollute the environment and to have a reserve of energy in case there is a failure in the main power supply, with this we are no longer so dependent on the power company. And thus to have a good energy backup or to use less of the energy for which it is paid monthly.

CONCLUSION

Small-scale hydroelectric facilities are presented as a sustainable alternative to generate renewable energy and contribute to sustainable development. In the case of Mexico City, rainwater harvesting is an integral solution to mitigate the water crisis, while generating electricity and reducing pressure on the aquifer. The Universidad Autónoma Metropolitana, Azcapotzalco Unit, through the implementation of rainwater harvesting and use systems, seeks to reduce its dependence on the Federal Electricity Commission (CFE) and allocate the resources saved to other projects.

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