Micro-Generation of Electricity From Tap Water
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Abstract- Why rely on a waterfall for power generation? Instead use the forceful tap water or the shower in our washrooms. Tap Water is a suggestion for the growing power demand. If every house could use a cheap mini generator for every tap, can't that light up the bathrooms when the tap is opened? The idea could be extended to the overhead tanks too. The energy is trapped from the tap water, where the work of the turbine could be done by a mini fan, which is connected to a mini-sized generator to generate Electricity. The USP or the thing that makes this idea unique is that No conditions apply! Every house will have a tap and every household wants to reduce the EB bill. It could be possible with a moderate investment. If batch processing could be achieved, the manufacturing cost would come down too. However, the challenges that come on the way are many. They include varying force of water, intermittency in the usage, the very less power that one could trap from every water tap. Then why not all the taps, but the problem of integrating a number of generators to supply and store energy in a single battery or integrating them to the grid voltage and frequency becomes a major issue that has to be handled. Thus we need to develop a circuit for CHARGING A SINGLE BATTERY FROM MULTIPLE ENERGY SOURCES and develop a successful design to trap energy from the taps and integrate them. This idea will not only be useful for the tap but in most cases of renewable energy tapping as in a cycle dynamo in a gym or electricity from rain, where the main problem is the integration of micro energy sources. This paper throws light on one of the most important practical aspect of micro-generation of green energy and its integration to the grid whose idea can be extended to other green energy sources also.

I. INTRODUCTION
The urban water cycle consumes energy to provide us water for all purposes like drinking water, water for industries, etc. It also treats our waste water and recycles it. But it can also provide energy by several means such as:

- Using the velocity or force of water in the drinking water network to turn a turbine and generate electricity.
- Using wastewater as a source of heat for heat pumps.
- Using the sewage sludge (wastewater treatment sludge) in an anaerobic digester (using anaerobic bacteria) to produce biogas.

In some mountainous places, there can be a huge altitude difference between the houses on the higher altitudes and the ones at the lower.

It causes a problem of difference in pressure, because if the pressure is at least 2bars in the upper houses, it means that in the lower ones, the pressure is very much higher. If the altitude difference is 10 meters, the pressure difference is 1 bar usually.

Assuming a 100 meters altitude difference, the pressure in the lower place would be 12 bars which is very high. Hence, the tap, dishwasher, washing machine and other devices cannot support such a pressure. Hence, a pressure reducing device is installed in order to reduce the pressure on the lower altitude part of the water network.

The turbine will extract the energy contained in the water and causes rotation of the generator which hence produces electricity. As the velocity is the same before and after the turbine, the loss of energy is taken on the pressure of water. So, turbines reduce the pressure indirectly. We can hence use a turbine to reduce the pressure in a water network of a place of varying altitudes.

The higher the difference in altitude, the higher the flow is. The turbine will now turn fast due to the higher pressure loss. One should also note that the pressure of water must not fall under 2 bars. This can occur at peak demand. This requires some control circuit to maintain the water pressure.

II. USING TAP WATER AS A SOURCE
The idea is that one can fix up mini fans that would start rotating as the tap is opened. The higher the force or pressure of water, the higher is the speed of the fan. The fan shaft is connected to a mini generator set. Voltage is generated at the generator terminals. This voltage can be stepped up and can be used to charge the battery.

To avoid the storage trouble, we can design a control circuitry that would switch on the washroom light as and when the tap is opened or at least this power can be used for water induction heater.

Our taps pose a real challenge. They are just a meter in size and hold very much lesser water and potential energy when compared to a dam and the hydro electric power plant. Hence the difficulty arises in harnessing this small but valuable power from the taps. The turbine should fit into the pipe and the device should be able to generate more power, at least the power required to light a fluorescent lamp.
III. DESIGN CONSIDERATIONS

The device design is of main concern now. It consists of an external hydro-electric generator and a highly efficient spherical water turbine that dips into the flowing water and claims the residual pressure. The turbine in turn drives a rotating shaft which rotates the rotor of the micro-generator producing electricity.

The key lies in a number of intelligent designs to extract more energy from flowing water. A number of thinner blades is desired to mitigate the water bypassing. The 8-blade turbine would only take away a fraction of kinetic energy because it strikes an accurate balance between water volume, pressure and consumption of hydrokinetic energy, which boosts the efficiency without reducing the momentum of running water in order to guarantee a reliable water and power supply. The Turbine blades are carefully sized to (the thinner, the better) intersect the largest possible area of water flow and minimize water bypassing.

To achieve maximum power output, a hollow central rotating shaft is proposed to utilize the full harnessed energy for conversion into electric power. As it is the drinking water pipe, care should be taken so that there is no lubricant used in any of the rotating parts of the turbine and generator. This is done in order to avoid any sort of contamination.

IV. ELECTRICAL OUTPUT OBTAINED

When the above circuit was constructed with the tap, a normal sized tap water filter fan and a 6W DC generator. With normal or at the most maximum water force from a single tap, the generator terminals gave a power of 0.5 to 0.75 W at the maximum. When plotting the load curve for the maximum power obtainable, it was found that the device delivers a maximum of 1W at most. However, as the tap water force decreases the output almost drops to zero.

The output voltage seen was 3.5V at the generator terminals. With a normal load like a lamp the device would generate few milli-amperes which is absolutely negligible.

Even when stored in a battery, the electric storage efficiency comes to play, where the energy trapped gets almost exhausted by the various stages of conversion. So, the investment made on the apparatus does not serve the purpose.

Investing on such separate micro-generation units for every tap is impossible and totally uneconomical. Hence we need to find a way to integrate the negligible amount of intermittent energy to give a reasonable wattage. If several such tap could feed a single battery, this will give a reasonable power with reduced investment. Since a single battery is going to be used, the efficiency of the battery storage is not going to cost us a significant loss.

V. CHARGING A SINGLE BATTERY FROM MULTIPLE ENERGY SOURCES

A single battery charging device with multiple sources consists of: a battery; an input power controlling circuit and a charging circuit connected to an external power source for determining the power charging of the battery. The power charging control circuit is used for detecting the voltages of the battery for determining whether the power input controlling and charging circuit is charged to the battery; the power charging circuit gets its input from an Ethernet power supply and it feeds the charging circuit. The charging circuit is then connected to the battery device; the power charging control device is connected to the Ethernet power supply for controlling the voltage so that it increases to a uniformly charging voltage.
Fig 3: Block diagram of Multi-Source Charging

It also consists of an inter-control device and a switch for the drive. It is an optical transistor with a light emitter that acts as an optical coupler. The optical transistor is used for switching purpose and the light emitter acts as the driver. This is not the only design possible. However it is better and easily implementable compared to the others.

There is also a polarity detection, protection circuit and an over voltage limiter circuit that is basically formed by a diode to protect the system against improper battery polarity.

The driver is installed to the power input controlling and charging circuit. The switching device for the input is connected to the power charging control unit for an Ethernet power supply. Switching of the switch devices actuate the charging control unit to charge the battery cell.

The external power supply can be drawn from solar panels or water generator, wind generators, heat generators, etc. However to be application specific, we consider the taps to be integrated as the separate external power supplies for the device.

VI. ADVANTAGES OF THE MULTI-STORAGE CHARGER DESIGN

- Regeneration power source is utilized. Hence the power is saved. There is negligible or no release of carbon.
- One power charger’s failure will not affect the entire battery storage system.
- The inter-control devices help in quick switching among the two charging devices without much time delay.
- The voltage of the external source can direct the output device connected directly.
- At the times of over-voltages if any, the control circuit does not allow the output and hence the devices are protected.
- The presence of battery polarity protection circuit disables the connection in case of improper connection. Hence the rest of the power system remains unaffected due to the polarity reversal.

VII. APPLICATION OF MULTI-SUPPLY CONCEPT TO THE TAP SYSTEM

The above Multi supply batter storage is designed for two different supplies. When one tap is to produce 750mW, it doesn’t make a big difference on integrating just 2 taps. Hence the circuit has to be extended to a number of taps. The cost invested does not seem to be very economical.

However as told previously this idea could be implemented on the pipes rooting down from the overhead tank, so that the power output is reasonably higher for the amount invested. The design complexities also arise. Still, hoping that the water network has more scope to tap some green energy, some countries have put forward their steps to tap the electricity that the water network would provide us with. They are mentioned below.

VIII. FOCUS ON WATER ELECTRICITY BY COUNTRIES

The Department of Building Services Engineering (BSE) and the Water Supplies Department (WSD) of the Hong Kong Special Administrative Regional Government are trying to work on extracting electricity from the water mains in their country. It has a network of water mains running over 7,800 km, and kept monitoring to make sure their water supply network is kept clean and maintained efficiently remain clean and well-maintained. Those devices require power. On the other hand, it also has the capability to resolve the ever-growing power requirement.
They are focusing on plans to put small turbines into our pipes to produce electricity from drinking water network. The mini-hydro power plants are being put to test in a number of locations including underground pits and outdoor environments. The estimates show that the in-pipe turbines are expected to save 700kWh of electrical energy. The carbon emission is estimated to be reduced by 560kg per year.

IX. RECENT TRENDS

Though the water network electricity is gaining momentum, another area where water could help with the micro-generation on electricity. A fluid flowing through a microscopic channel is capable of producing electricity when its electro-kinetic energy is harnessed.

If it is practicable, then it would be possible to power a mobile phone by squirting water through a number of such microscopic channels.

The ions that are oppositely charged are attracted and hence pushed to the far end of the channel, while the similar charges are left behind at the other end. This forms a potential difference across the two ends of the microscopic channel. By fixing electrodes between these two ends and using a conducting wire, we can realize electricity. Research on this area has scope for future developments.

X. PRINCIPLE OF CONVERSION OF HYDRO-KINETIC ENERGY

The basic principle involved in this is the phenomenon of separation of charges at the interface between the liquid surface and the channel surface. A very small part of one charge, either positive or negative gets dissolved in water. This makes the surface negatively or positively charged respectively. This may lead to a Helm Holtz double layer formation as the correspondingly opposite charges in the liquid form a double layer along with the surface charges. This electric Double Layer is the cause for the energy conversion.

XI. CONVERSION TO AC MAINS VOLTAGE

Having seen the water electricity and its power output in the experiment, we can extend this idea to higher level water pipes and networks for more electric power generation. If the micro-generation is to be empowered as a higher level power generation as planned in Hong Kong, the grid integration of this energy is a must.

While working on the tap water electricity, we tried to implement this grid integration using the circuit below. Since the power rating of the device is very low, building this circuit was in a way simpler. Here, it is designed for 30VA power rating to convert a 12 volt DC into a 230V, 50 Hz AC.
Although the circuit is designed for a 12V DC, it is ideal to use a 9V DC, as there is almost 3V drop between the collector and emitter of the power transistor. The high saturation voltage poses a definite problem of power wastage.

The presence of the 230V output can be indicated using a VDR voltage dependant resistor. The S10K250 clips of the spikes and surges that will appear at the power transistor switching points. The output of the circuit is approximately a square wave as it includes the distortion as a result of using the transformer. The circuit is capable of supplying fluorescent lamps, incandescent bulbs, motor circuits and other electronic devices.

Although the PCB could carry only low power and low voltage handling devices, the circuit remains the same as used for tap water electricity. Although we aimed at 9V ideally, the practical single tap water force could give a maximum of 4V only. Hence the power from the tap was stored in a car battery of 12V and the battery voltage was converted to the ac mains voltage and frequency.

Fig 6: Design of 12V DC to 230V, 50Hz AC inverter circuit

Grid integration experiments need at least a few kWh of energy. Integration of renewable energy to the grid or even to the micro-grid is a still tedious task. When one area of green energy research aims at trapping energy from all ways possible, the other big area of research is to integrate them to the grid. The difficulties in the grid integration process is due to the nature of renewable energy such as:
- Non-controllable variability
- Partial unpredictability
- Frequency regulation
- Intermittent nature of energy
- Location dependence

XIII. Future Scope

Since, renewable energy is the future of the power generation, the tap water electricity can be further applied to trap energy from the drinking water networks and suitable grid integration techniques have to be developed as grid integration challenges are device specific.
The work focuses on utilizing the water power for the energy needs and can also be used in the frequency control area by adopting the analogy of a pumped water storage plant.

This idea hence paves way for future research in this area. From the Energy estimates, we can see the emerging importance of renewable energy world-wide. This also shows the importance of such green energy resources such as the one presented in this paper. In addition to it lies the most challenging task of the grid integration of such renewable energy resources.

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