International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 08, August 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

Harvesting Electricity from Water Mains Hydropower System Generates Power from Water Pipelines

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ABSTRACT

The development of urban areas has rapidly increased the global energy demand. Of which renewable energy system can provide clean, reliable, secure, competitive energy to meet this demand. Today, not only do we need innovative energy generation techniques which are environment friendly but also cost effective and easy to install. Even a small amount of energy savings made contribute to saving the environment. Water supply is of vital importance for urban development, so the overall pressure in urban fresh water pipeline is usually very high to ensure consistent water supply throughout the urban area. The energy is obtained from the pipe water; where the turbine will rotate due to flow and pressure of water, and the rotating turbine is connected to a generator to generate electricity. In this study, an idea is proposed and studied to extract power from the high head water in the pipelines.

Keywords: Energy efficiency, Hydropower Recovery, Water Utilities

I. INTRODUCTION

Water and energy are two of the most important resources associated with the sustainability of cities and nations. Water is used in various energy generation processes (e.g. hydroelectric, thermoelectric and biomass production), while water treatment and distribution require large amounts of electricity, mainly for pumping. Typically, when we think of hydroelectricity we think of large, capital-intensive projects involving dams, reservoirs and cubic miles of retained water. Rarely do we think of the thousands of small-scale systems throughout the world that do not use dams at all. These tiny generating plants are classified as micro-hydro if they generate less than 100 kW of power. Yet, whether a hydro plant is large or small, the principles behind its operation are the same. Hydropower recovery is a relevant energy efficiency measure that can be applied to water supply systems, resulting in environmental, economic and social benefits. The hydropower potential of Water Supply Systems is known for quite long time, it is still little explored worldwide. Water Supply Systems located in areas with high topographic gradients, or even those exploring high pressure groundwater sources, present large hydraulic heads in pipelines and distribution networks, that can be recovered through hydroelectric power generation. Besides that, Water Supply Systems that use free flow conduits (especially in form of channels) can generate hydroelectric power via hydrokinetic turbines or low head systems. Some works presents estimations of hydropower recovery potentials worldwide.

IJARSE
ISSN (O) 2319 - 8354
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Besides recovering energy, hydraulic turbines can also act as pressure control devices in Water Supply Systems, instead of pressure reducing valves (PRVs), which is an important tool for reducing water losses due to leakage. While PRVs reduce pressure by energy dissipation, hydraulic turbines can convert the pressure excess in the water network into useful electricity. The deployment of small hydropower plants in Water Supply Systems presents a low implementation cost.

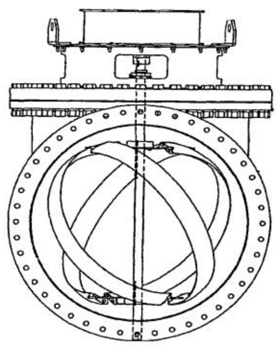
A company named lucid energy is testing and designing this in-pipe system since 2007. The company developed and installed lucid pipe (in-pipe) power system in Portland. They have installed 200kW power system in water pipelines of Portland, which is able to produce an average of 1100Mwh of clean energy per year, enough energy to light up to 150 houses.

II. MAIN COMPONENTS REQUIRED FOR THIS PROCESS

The system depends upon two main components

- In-pipe hydrodynamic turbines
- Generators

The idea of the system is that one can fix hydrodynamic turbines in pumped/gravity fed water pipes that would start rotating as the water flow through the pipe. More the velocity of water more will be the speed of rotation of the turbine, which will result more extraction of energy. The turbine shaft is connected to generator set. Voltage is generated at the terminals of generator. The design of system is main concern. It consists of a hydro-electric generator which is connected externally and a hydrodynamic turbine that is placed inside the flowing water of pipe. The turbine rotates with the flow of water and the shaft of rotating turbine rotates the rotor of generator, in result the electricity is generated. Then the generated electricity is transferred to the grid. The design of turbine is key point to obtain more clean energy from the flow of water. A number of blades and a shaft at the central part are combined to form a hollow turbine. The blades are specially designed to reduce the resistance to the flow of water. The blades are sized according to the need of project (the thinner, the better).



Fig[1]: Blades used in Turbines by Lucid Energy in Water Pipe

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

3.1 Turbine

The turbine is the heart of the hydro system, where water power is converted into the rotational force that drives the generator. For maximum efficiency, the turbine should be designed to match your specific head and flow. There are many different types of turbines, and proper selection requires considerable expertise. A Pelton design, for example, works best with medium to high heads. A crossflow design works better with lower head but higher flow. Other turbine types, such as Francis, turgo, and propeller, each have optimum applications. Turbines can be divided into two major types. Reaction turbines use runners (the rotating portion that receives the water) that operate fully immersed in water, and are typically used in low to moderate head systems with high flow. Examples include Francis, propeller, and Kaplan. Impulse turbines use runners that operate without being immersed, driven by one or more high-velocity jets of water. Examples include Pelton and turgo. Impulse turbines are typically used with moderate-to-high head systems, and use nozzles to produce the high-velocity jets. Some impulse turbines can operate efficiently with as little as 5 feet (1.5 m) of head.The crossflow turbine is a special case. Although technically classified as an impulse turbine because the runner is not entirely immersed in water, this “squirrel cage” type of runner is used in applications with low to moderate head and high flow. The water passes through a large, rectangular opening to drive the turbine blades, in contrast to the small, high-pressure jets used for Pelton and turgo turbines.Regardless of the turbine type, efficiency is in the details. Each turbine type can be designed to meet vastly different requirements. The turbine system is designed around net head and design flow. These criteria not only influence which type of turbine to use, but are critical to the design of the entire turbine system.Minor differences in specifications can significantly impact energy transfer efficiency. The diameter of the runner, front and back curvatures of its buckets or blades, casting materials, nozzle (if used), turbine housing, and quality of components all affect efficiency and reliability.

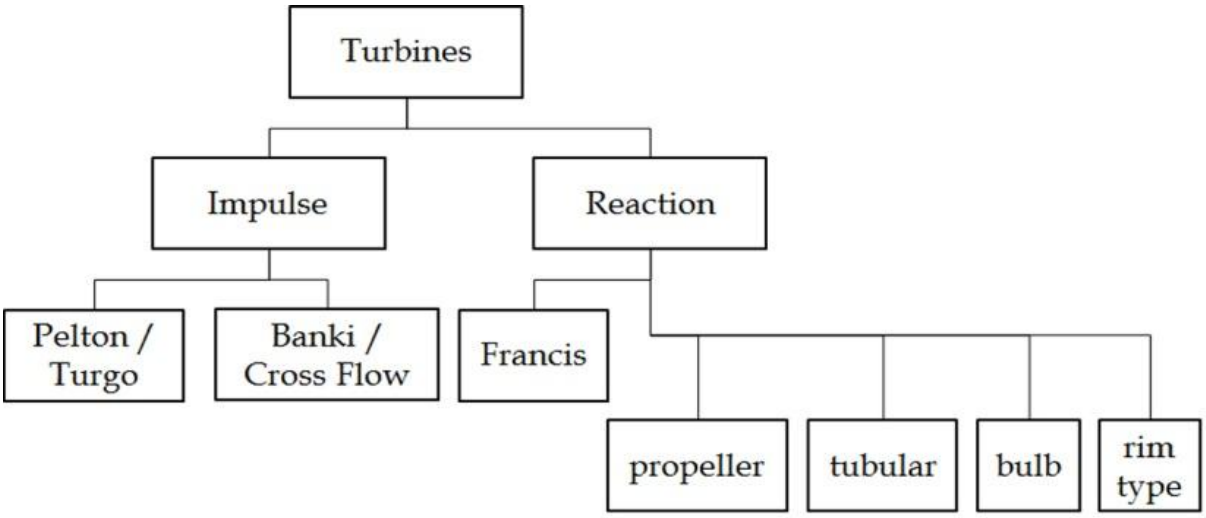

Fig [2]: Different types of Turbines generally we use

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

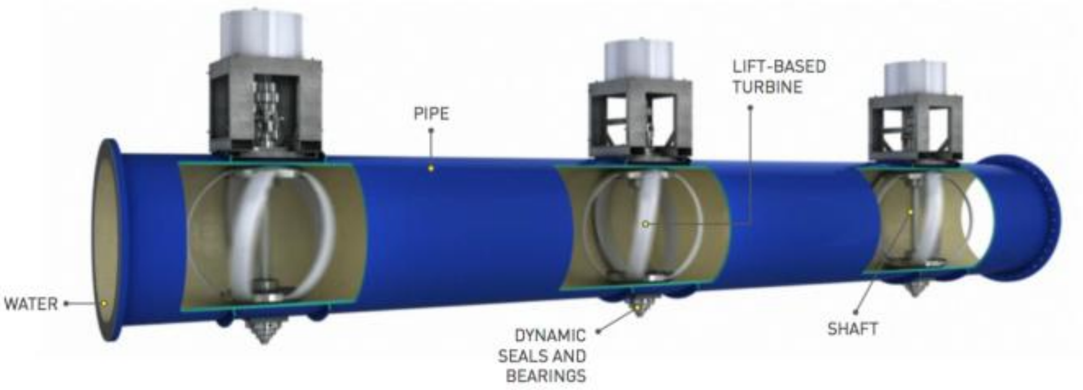


Fig [3]: Turbines used by Lucid Energy

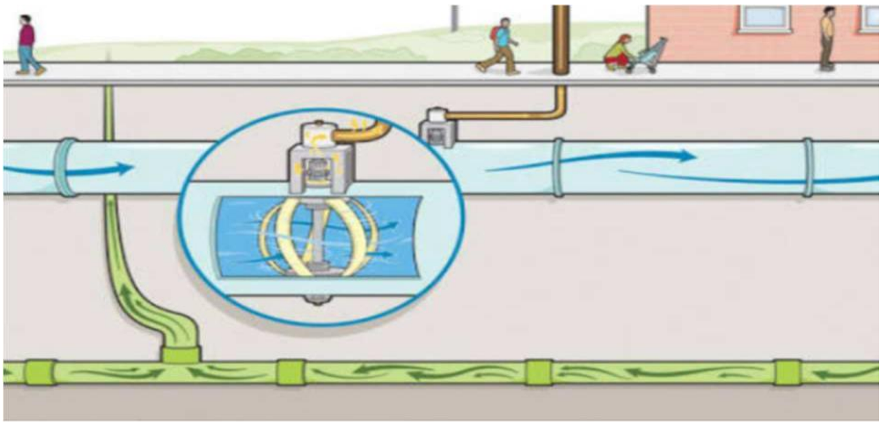


Fig [4]: Lucid Energy transferring the power to grid

3.2 Generator

The generator converts the rotational energy from the turbine shaft into electricity. Efficiency is important at this stage too, but most modern, well-built generators deliver good efficiency. Direct current (DC) generators, or alternators with rectifiers, are typically used with small household systems, and are usually augmented with batteries for reserve capacity, as well as inverters for converting the electricity into the AC required by most appliances. DC generators are available in a variety of voltages and power outputs. AC generators are typically used with systems producing about 3 KW or more. AC voltage is also easily changed using transformers, which can improve efficiency with long transmission lines. Depending on your requirements, you can choose either single-phase or three-phase AC generators in a variety of voltages. One critical aspect of AC is frequency, typically measured as cycles per second (cps) or Hertz (Hz). Most household appliances and motors run on either 50 Hz or 60 Hz (depending on where you are in the world), as do the major grids that interconnect large generating stations. Frequency is determined by the rotational speed of the generator shaft; faster rotation generates a higher frequency. In battery-based hydro systems, the inverter produces an AC waveform at a fixed frequency. In battery less hydro systems, the turbine controller regulates the frequency.

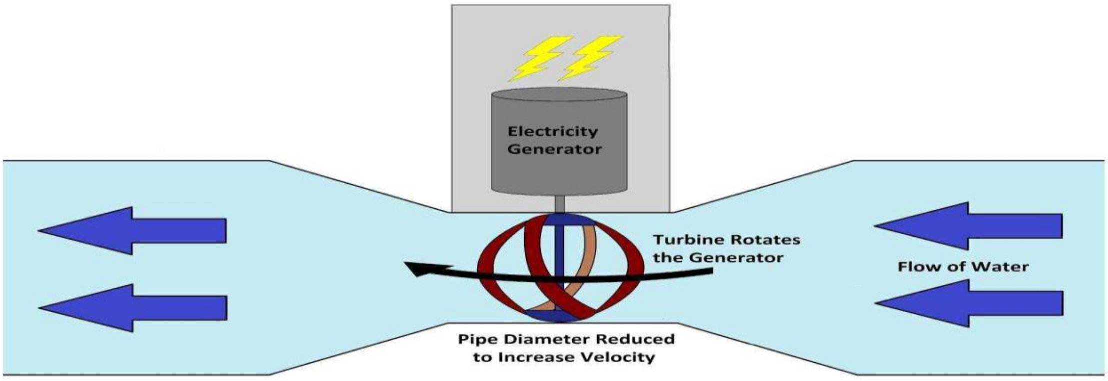


Fig [5]: In-power system model in a water pipeline

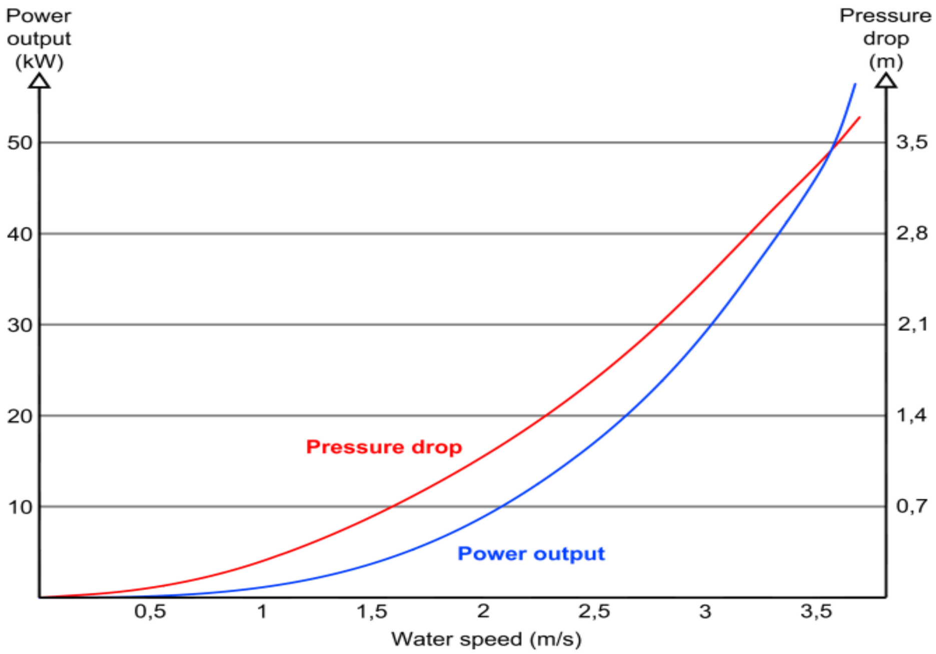
IV. MAIN APPLICATIONS OF IN PIPE HYDRO POWER SYSTEMS

All cities are served by pressured piping grids systems to supply water where it is needed for drinking, domestic or industrial use, while drain and sewage systems are usually gravity fed. Both hold untapped energy deriving from abundant pressure, and drinking water processors and industrial manufacturers typically install pressure reduction valves ("PRVs") – hydraulic devices that maintain pre-set pressure ranges – to relieve the excess pressure and release it as waste heat. Theoretically, all systems that employ pressure reducing devices could replace them with in pipe generators, maintaining the same control on water flow and pressure whilst producing usable electricity.

Fig[6]: Turbine attached with Generator

V. HEAD, FLOW, & EFFICIENCY

If you expect to sell electricity back to the utility, pay extra attention to the efficiency of your hydro system because higher output and a lower cost-per-watt will go straight to your bottom line. Your turbine manufacturer can give you guidance on the most efficient design, as well as grid interconnection controls and safeguards. If you're off-grid, and your site doesn't have lots of head and flow, high efficiency can make the difference between ample electricity for your needs and having to use a backup, gasoline-powered generator. Whether a hydro system generates a few watts or hundreds of megawatts, the fundamentals are the same. Head and flow determine how much raw water power is available, and the system efficiency affects how much electricity will come out the other end. Each component of a hydro system affects efficiency, so it's worthwhile to optimize your design every step of the way.



Fig[7]: Power/Pressure drop chart of a lucidpipe 1000 mm power system.

VI. MAIN BENEFITS FROM THIS TECHNOLOGY

•It produces neat and clean energy (it does not affect environment).

• It does not depend upon weather (like solar system depends upon sun and wind system depends upon air).

• It does not affect the quality of drinking water.

• It is the one of the cheapest way to produce power (where as in case of solar and wind they will cost 3 or 4 times more to produce same amount of energy)

• It can also be installed in Agricultural, industrial, wastewater pipeline.

• Electricity can be produced all the time with the flow of water.

• Quick installation

• Recovers process-based energy.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

VII. CONCLUSION

Hydraulic energy recovery in water supply systems for electricity generation is a technologically feasible alternative to energy efficiency and conservation. As presented in this work, there are several models for its deployment, which can be implemented without negative effects over water treatment and distribution Processes, and with reduced deployment costs, considering that much of the required hydropower system's components already exist, aimed to water supply. The various models analyzed and proposed can also be combined, maximizing the energy recovery system's benefits.

VIII. FUTURE PROSPECTS

- No Carbon emission while generating electricity.
- No coal or oil is used to generate electricity. Natural resources will last for longer time.
- It will reduce the per unit consumption rates, so the electricity will be given to every section.
- It a safer compare to fossil fuels and nuclear energy. These methods use chemical whose regular expose to body can lead to various health problems.

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