



## Hydro Power Opportunity in the Sewage Waste Water

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**Abstract:** The alternative energy source of municipal waste water for micro hydro power generation, are detail discussed in the present investigation. Reuse of municipal waste water can be a stable, inflation proof, economical, reliable and renewable energy source of electricity. Both the historical and the present day civilization of many kind are closely interwoven with energy and there is no reason to doubt but that in the future our existence will be more dependent upon the energy. Electrical energy occupies the top position in the energy hierarchy. But conventional sources of electricity generation are limited in used. So there are many renewable energy resources are used for generation safe fluid. Electricity such as: solar energy, Biomass energy and wind energy etc. But in the modern day one of the most useful resources are including for generation of Electricity is "Sewage based Hydro power plant". The plant will convert municipal liquid waste into power, meeting the energy needs of approximately 35000 homes. Sewage is generated by residential, Institutional, Commercial and Industrial establishments. It includes household waste, liquid waste from toilets, baths, Showers, Kitchen, Sink.

### I. Introduction

An overview of Hydropower application to the waste water (Sewage) is described here. Firstly the waste water treated in Sewage Treatment plant. It includes physical, chemical and biological contaminants. Its objective is to produce an environmentally. Here the solid waste (treated sludge) suitable for disposal of reuse (usually for fertilizers) and treated water used for generating electricity by a small Hydro power plant. Treated water of sewage at a high pressure or flowing with a high velocity can be used to run turbine or water wheel coupled to Generator and therefore of electrical power is becoming more and more popular as it is reliable and requires least maintenance and care. Output power has been estimated for available different head and flow rate of the waste water. Various types of the turbine-generator sets for different available head have also suggested for reliable operation of the developed this plant. The main advantage of this power plant is an independent power plant; it is not dependent on the monsoon because the availability of sewage water is always maintained. Electricity generation through this method is costlier in initial cost but cheapest in maintains and production cost. This plant is focused on reducing fuels. This plant has used a range of innovative solution, including renewable energy and local generation to meet future growth needs while improving efficiency reducing cost.

Hydropower is a renewable, non-polluting and environmentally benign source of energy. Hydropower is based on simple concepts moving water turns a turbine, the turbine spins a Generator and electricity is produced. The use of water falling through a height has been utilized as a source of energy since a long time; it is perhaps, the oldest renewable energy techniques known to the mankind for mechanical energy conversion as well as electricity generation.

Small scale hydropower was the most common way of electricity generating in the early 20th century. The first commercial use of hydroelectric power to produce electricity was a waterwheel. Micro hydropower system is one of the popular renewable energy sources in the developing countries. Small hydropower system (SHPS) is relatively small power sources that are appropriate in many cases for individual users who are independent of the electricity supply grid. Hydroelectric power is the technology of generating electric power from the movement of water through rivers, streams and tides, water is fed via a channel to a turbine where it strike the turbine blades and causes the shaft to rotate . To generate electricity the rotating shaft is connected to generate which converts the motion of the shaft into electrical energy.

A Sewage micro hydropower system can be reliable and provide stable electrical energy micro hydropower system using waste water from community neither requires a large dam nor a land flooded. Only waste water from different part of the city is collected to generate power which has minimum environment impact. In this system, water collected by sewage of city and then this water treated in water of sewage at a high pressure or

flowing with a high velocity can be used to run turbine or water wheel coupled to generator and therefore of electrical power is becoming more popular as it is reliable and requires least maintenance and care.

## I. Hydropower Theory

To determine the power potential of the water flowing in sewage, it is necessary to determine both the flow rate of the water and the head through which the water can be made to fall. The flow rate is the quantity of water flowing past a point in a given time. Typical flow rate units are liters per second or cubic meters per seconds. The head is the vertical height, in meters from the turbine up to the point where the water enters the intake pipe or penstock. The potential power can be calculated as:

Theoretical power (P) = Flow rate (Q) × Head (H) × Gravity (g) [ $P = 9.81 \times Q \times H$ ] in (KW)

Whereas: Q is in cubic meters per seconds, H in meters and  $g = 9.81 \text{ m s}^{-2}$

However, energy is always lost when it is converted from one form to another small water turbines rarely have efficiencies better than 80%. Power will also be lost in the pipe carrying the water to the turbine, due to frictional losses. By careful design, this loss can be reduced to only a small percentage. A rough guide used for small systems of a few KW rating is to take the overall efficiency as approximately 50%. Thus, the theoretical power must be multiplied by 0.50 for a more realistic calculation.

Annual energy (KWH/year) = P (KW) × CP × 24 hrs. × 365 days

Where CP is the capacity factor, which tells how long the turbine will be in operation, and is expressed as:  
Capacity factor (%) = Energy generated per year (KWh/year) / P (KW) × 24 hrs × 365 days

To calculate the actual power output ( $P_{act}$ ) from micro-hydro power plant, it is required to consider friction losses in the penstock pipes and the efficiency of the turbine and generator. Typically overall efficiencies for electrical generating systems can vary from 50 to 70 % with higher overall efficiencies occurring in high head systems. Therefore, to determine a realistic power output as shown in Table 1, the theoretical power must be multiplied by an efficiency factor of 0.5 to 0.7 depending on the capacity and type of system as given below.

$$P_{act} = Q \times H \times g \times e$$

Where e = efficiency factor (0.5 to 0.7). The efficiency factor of 0.7 has been used for reliability evaluation of the proposed system based on sewage waste water. Table 1 represents the output power of different types of head and flow of water.

**Table 1: Represents flow rate and realistic power output**

|    | Flow rate liters per second (lps) |      |      |      |      |       |       |       |
|----|-----------------------------------|------|------|------|------|-------|-------|-------|
| H  | 05                                | 10   | 15   | 20   | 25   | 40    | 60    | 80    |
|    | Power output (W)                  |      |      |      |      |       |       |       |
| 2  | 69                                | 137  | 206  | 275  | 343  | 549   | 824   | 1099  |
| 4  | 137                               | 275  | 412  | 549  | 687  | 1099  | 1648  | 2197  |
| 6  | 206                               | 412  | 618  | 824  | 1030 | 1648  | 2472  | 3296  |
| 8  | 275                               | 549  | 824  | 1099 | 1373 | 2197  | 3296  | 4395  |
| 10 | 343                               | 687  | 1030 | 1373 | 1717 | 2747  | 4120  | 5494  |
| 14 | 481                               | 961  | 1442 | 1923 | 2403 | 3846  | 5768  | 7691  |
| 20 | 687                               | 1373 | 2060 | 2747 | 3434 | 5494  | 8240  | 10987 |
| 30 | 1030                              | 2060 | 3090 | 4120 | 5150 | 8240  | 12361 | 16481 |
| 40 | 1373                              | 2747 | 2940 | 5494 | 6867 | 10987 | 16481 | 21974 |

## II. Classification of Hydropower

Hydropower can be classified on the basis of installed capacity, as large, medium, small, mini, and micro hydro power plants. The mini, micro and Pico hydro plants come under the subcategory of small hydro plants. These are briefly described in Table 2.

**Table 2: Classification of Hydro Power Plant**

| S. No | Types of Hydropower Plant | Description                                                                                                                |
|-------|---------------------------|----------------------------------------------------------------------------------------------------------------------------|
| 1.    | Large Hydro               | More than 100MW and usually feeding into a large electricity grid.                                                         |
| 2.    | Medium Hydro              | 15-100 MW usually feeding a grid                                                                                           |
| 3.    | Small Hydro               | 1-15 MW usually feeding into a grid                                                                                        |
| 4.    | Mini Hydro                | Above 100 KW, but below 1 MW either stand-alone schemes or more often feeding into the grid.                               |
| 5.    | Micro Hydro               | From 5 KW up to 100 KW, usually provided power for a small community or rural industry in remote areas away from the grid. |
| 6.    | Pico Hydro                | From a few hundred watt up to KW.                                                                                          |

The station and unit capacity of small-scale hydropower are:

| Type        | Station capacity  | Unit capacity   |
|-------------|-------------------|-----------------|
| Micro hydro | Up to 100 kW      | Up to 100 kW    |
| Mini-hydro  | 101 to 2000 kW    | 101 to 1000 kW  |
| Small hydro | 2001 to 25,000 kW | 1001 to 5000 kW |

### III. Components of Micro Hydro Power System (MHPS)

The principal components of the micro hydropower system using sewage system are sewage tank, penstock, turbine, generator for reliable operation of the system.

#### (A) Selection of Penstock Pipe

It is a closed conduit which connects the surge tank to the scroll case of the turbine. The penstock is often the most expensive item in the project. Several factors should be considered when deciding which material to use for a particular penstock design pressure, i.e. the roughness of the pipe's interior surface, method of joining, weight; ease of installation, accessibility to site, design life, maintenance, weather conditions, availability, relative cost and likelihood of structural damage.

The pressure rating of the penstock is critical because the pipe wall must be thick enough to withstand the maximum water pressure, otherwise there will be a risk of bursting. The pressure of the water in the penstock depends on the head, the higher the head, the higher the pressure. The most commonly used materials for a penstock are mild steel, high density poly ethylene (HDPE) and unplasticized polyvinyl chloride (uPVC), because of their suitability, availability and approvability. The UPVC exhibits excellent performance over mild steel and HDPE in terms of least friction losses, weight, corrosion, and cost, etc. Comparison of the penstock materials considering friction, weight, corrosion, cost, joining and pressure have given in the Table 3. uPVC penstock pipe has been used at sewage power generation system due to listed advantages compared to others and has proposed for future work in this field.

**Table 3: Comparisons of Penstock Materials**

| S. No. | Materials  | Friction/Weight | Corrosion | Cost  | Joining | Pressure |
|--------|------------|-----------------|-----------|-------|---------|----------|
| 1      | Mild steel | ***             | ***       | ****  | ****    | ****     |
| 2      | HDPE       | *****           | *****     | **    | **      | *****    |
| 3      | UPVC       | *****           | *****     | ***** | *****   | *****    |

\*\* Poor, \*\*\* Average, \*\*\*\* Good, \*\*\*\*\* Excellent

#### (B) Selection of Turbines

Turbine is connected either directly to the generator or is connected by means of gears or belts and pulleys, depending on the speed required for the generator. The choice of turbine depends mainly on the head and the design flow for the proposed micro-hydro power installation. The selection also depends on the desired running speed of the generator. Turbines used in the hydro system can be classified as Impulse (Pelton, Turbo and Cross flow), Reaction (Francis, Propeller, and Kaplan) and water wheels (under-shot, breast-shot and overshot). Propeller Kaplan turbine has been proposed for low head available at sewage power generation system at anywhere. Two types of turbines can be used in the recovery of energy from water distribution networks: Pelton and Francis turbines. The choice of turbine for a scheme although is driven by the head and flow range of the scheme (Harvey, 2006) other factors such as rotational speed, runaway speed and cavitation's limit are also taken into consideration. In the water distribution network, the scheme mode of flow discharge is also considered, and for schemes discharging at atmospheric pressure, Pelton turbine is used (Wallace, 1996) while Francis turbines are

more suited for pressured flow systems. However, the final choice of turbine depends on the cost benefit analysis of the potential turbines, taking into consideration the annual energy production and performance requirements.

### **(C) Selection a Generator**

Generators are generally appropriate for micro hydro power generation. Induction generator (IG) offers many advantages over a conventional synchronous generator as a source of isolated power supply. Reduced unit cost, ruggedness, brush less (in squirrel cage construction), reduced size, absence of separate DC source and ease of maintenance, self-protection against severe overloads and short circuits, are the main advantages of IG. Capacitors are used for excitation and are popular for smaller systems that generate less than 10 to 15 kW. All generators must be driven at a constant speed to generate steady power at the frequency of 50 Hz. The two pole generator with a speed of 3000 RPM is too high for practical use with micro hydropower system. The 1500 RPM, four pole generator commonly used. Generator operates at less than 1000 RPM becomes costly and bulky and to match the speed of the generator to low speed of the turbine; a speed increasing mechanism such as belt and /or gear box is required. Output power has been measured at available different heads (minimum / maximum) and waste water flow rate. Type of the turbine-generator sets for different sewage water heads has been proposed in Use of induction generator is increasingly becoming more popular in MHP application because of its simpler excitation system, lower fault level, lower capital cost and less maintenance requirement.

### **(D) Pressure Reducing Valves**

A typical water treatment process normally begins with raw water abstraction by gravity from high pressure to low pressure, or vice versa, and by pumping where the topography poses a limitation to the gravity flow. Similarly, treated water gravitates or is pumped to reservoirs before distribution to meet demand. In either case, the pressure must be reduced to meet the downstream prescribed value, to prevent loss of water through leakages and bursts pipe within the system.

An approach often used to control pressure in water distribution networks is to install pressure reducing valves (PRV) at critical points within the network to regulate the pressure (Wallace, 1996; Williams et al., 1998). Pressure breaking tanks to break pressure and return the water to atmospheric pressure before onward transmission. PRV works by opening and closing their entries to allow the flow of water to meet the required pressure. PRV can function manually using attached levers, or automatically by connecting them to pressure measuring instruments. Two types of valve configuration are used: spring loaded and diaphragm actuated valves. The former is mostly used for low flow rates and the latter for higher flow rates.

During the process of pressure control in water distribution systems, energy is dissipated. Around 85% of the energy wasted can be recovered by replacing the PRV with a turbine or installing the turbine in parallel with the PRV (Wallace, 1996). However, when they are installed in parallel, measures are put in place to allow water to bypass the generator if the turbine shuts down and to prevent damage to the network and plumbing fixtures.

### **(E) Hydropower from Sewage Waste Water**

Treated water of sewage at a high pressure or flowing with a high velocity can be used to run turbine or water wheels coupled to generator and therefore for generation of electric power. Instead of discharging treated sewage effluent directly into the receiving water body, it can be diverted through a penstock under pressure into a turbine to generate electricity. Figure 1 shows the treated effluent passes through a trash rack via an inlet gate into the penstock and down to the turbine, where it strikes the blade and causes the shaft connected to the generator to rotate, thereby converting the rotating shaft into electricity

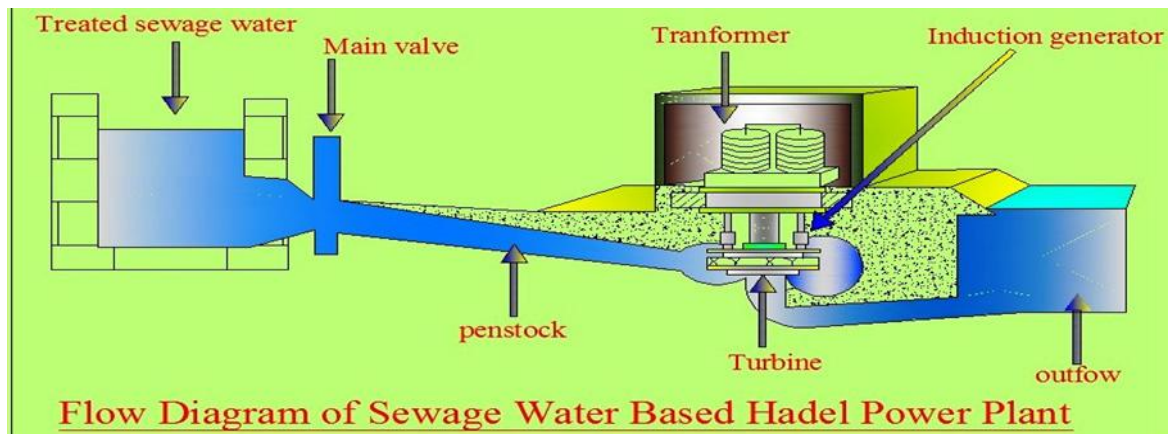
A head of around 6 m exists at the exit flow of most TSF and it is possible to generate around 19 kW, which could displace the cost of pumping the water into the filter. A typical flow rate for a wastewater treatment site treating a wastewater from a population equivalent of 80,000 is around  $2 \text{ m}^3 \text{ s}^{-1}$  and for such a scheme to be viable, a head of at least 5 m may be needed.

Low head hydro is the term often used for a hydro scheme with a head between 5 and 20 m and “ultra-low head” for a scheme with less than 3 m. A low-head hydro scheme requires a large passage/opening to accommodate a high volume of flow, making low head turbines inevitably large in size and expensive (Singal et al, 2008), consequently creating a number of engineering challenges.

In addition, low head schemes suffer from a lot of flow fluctuation due to the variation in headwater and tail water levels. This variation can mean that a head of 3 m is reduced to 1 m, thus reducing the system reliability and power output. Low head sites tend to be more common in runoff river hydro schemes (Furukawa et al, 2010) but can also be available in wastewater treatment outfalls. In the flat south east of England, the majority of the hydro schemes have a head less than 3 m.

The majority of wastewater treatment plants in the UK were built on a flat landscape to take advantage of the gravitational flow of sewage into the treatment works. The low head differential therefore makes high head

hydropower application technically unfeasible.



The option is thus a compact ultra-low-head turbine running at a medium speed, which can be located in the discharge pit, submerged or located prior to the exit flow from the treatment works. Such a turbine should be able to utilize the existing civil structures and be environmentally friendly, cost-effective, durable, a high load factor installation and efficient as a conventional turbine. There are a few different options for low head turbines that can be retrofitted or installed into water and wastewater facilities. At present, at least six types of water turbine can be used based on research studies, manufacturer literature and case histories. Some of these turbines are similar and operate with the same concept as conventional turbines but are modified to take many economic and engineering factors into consideration. They include: Archimedes screw turbines, pit turbines, open flume turbines, watermills, tube turbines and siphonic turbines. Each type operates over a limited range of head and flow.

#### IV. Conclusion

Micro hydro is a primary source of energy in India especially in the southern regions. Promoting renewable energy sources for energy requirements in conjunction with alleviation of rural poverty, diversification of energy resources and reduction of oil imports are needed to shift the economic growth towards greater sustainability, as well as environmental and social stability. This paper presents the feasibility of micro hydro power plant in domestic needs. This paper also deals with simulation of both hydraulic turbine and alternator and their clearly shows the steady state output for various gate position. The feasibility of small hydro power for domestic needs is justified by giving a proposal of the implementation of small hydro power in Sewage water; Hydro power is a proven and generally predictable source of renewable energy and is one of the few that is not intermittent.

Sewage based micro hydro power plant is highly stable, cheap and capable of producing reliable power at need because the head/pressure of the sewage reservoir has been maintained at constant using back up service in during summer and winter cycles. There are different head available in sewage system has been evaluated successfully. Turbine – generator sets has been recommended for different heads of the Sewage power plant for reliable operation. Generator has been used in the developed micro hydro power plant for reliable power generation. Sewage flow rate and head have been measured considering summer / winter and day / night cycles and typical power output has been estimated at different flow rate and head at sewage plant. In the point of the view of the prevention of the holy River from water pollutions, Sewage based hydro power plant has recommended for supply to local farmers for irrigation purpose after proper chemical treatment of the water and generation of the electrical energy. Future research work is proposed for Micro / Pico / Nano hydro power generation from overhead tanks of the bathrooms and kitchen to charge the mobiles and small chargeable batteries.

#### VI. References

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