**Advances in Energy Research**, *Vol. 2, No. 2 (2014) 85-95*
DOI: http://dx.doi.org/10.12989/eri.2014.2.2.085


# Technical feasibility study for power generation from a potential mini hydro site nearby Shoolini University

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*(Received August 14, 2014, Revised November 18, 2014, Accepted November 21, 2014)*

**Abstract.** Small Hydro-Power (SHP) is an environmental friendly technology. Usually hydro power generation projects are viewed as constructing large dams and reservoirs but available new research and engineering techniques have helped hydro power generation without large dams and without large reservoirs. In India, there are several water installations, irrigation dams, canals, streams or running rivers not tapped to generate power. In these cases the existing system and facilities can help in generating power with less investment and time. This area is yet unexplored. Harnessing a stream for hydroelectric power is a major undertaking for the energy crises and the global issues to go green. In this technical note a potential site for mini hydro power plant nearby Shoolini University is identified and examined for the economic feasibility.

**Keywords:** hydro energy; energy power; renewable energy

## 1. Introduction

Power is a word which is often used to indicate the strength of a nation. Being a true patriot one always dreams for his nation as a most powerful country by Catalao *et al*. (2009). It is also true that nation get strengthened from the available and potential energy resources. It is estimated that global warming will increase the temperature by about 8.3°F or 4.6℃, during fossil fuel life time i.e. until fossil fuel runs out in about 2240. The earth will experience a climate change and will revert to mild climate similar to that of the Oligocene and late Eocene periods of 23 to 37 million years ago. Polar ice will slowly melt to produce a sea level rise of few millimeters a year, which will reach 20 feet or 6.10 meter above current levels about in 2418 by Krishnan (1995). The current national and international policies of reducing emission are futile as it can only delays by a few years when the fuel will burned and only slightly alter the path to the eventual outcome (Kaygusuz 2002, 2004). This can only be avoided if the policies are framed to eliminate the emission instead of reducing the emission though it is almost impossible with current energy crises that hugely depends on conventional energy resources to develop power as shown in the Fig. 1 (Kaygusuz 2002, 2004).

So as a collective solution, to the scarcity of the conventional energy resources and its adverse effects on the environment, is in the promotion of Green Energy. The energy consumption pattern

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http://www.techno-press.org/?journal=eri&subpage=7 ISSN: 2287-6316 (Print), 2287-6324 (Online)

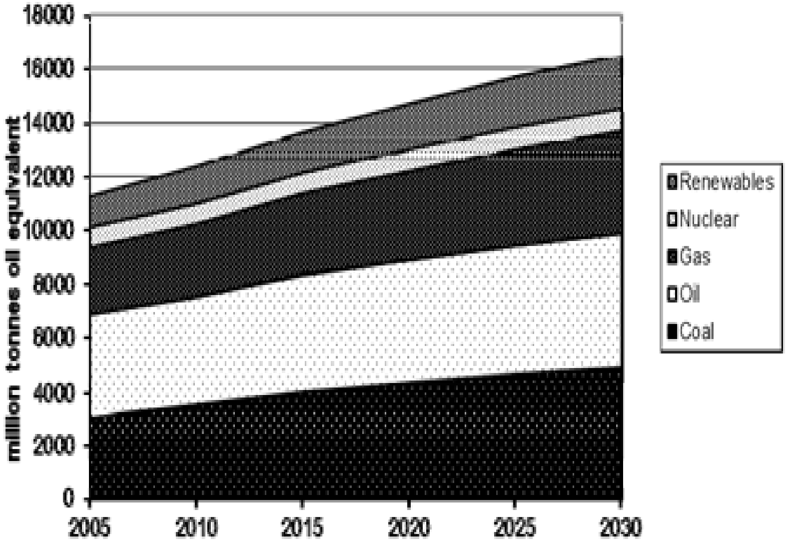


Fig. 1 World primary energy consumption

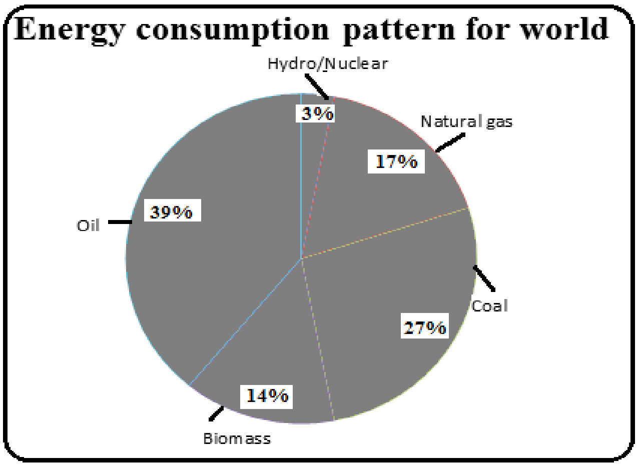


Fig. 2 Energy consumption pattern for world

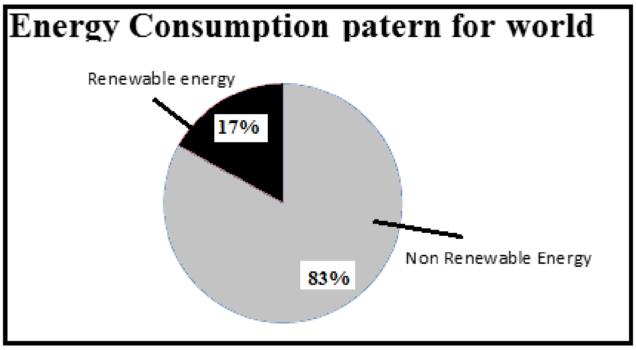


Fig. 3 Energy consumption pattern for world

of world developed and developing countries are shown in Figs. 2-3 (Panwara *et al*. 2011).

## 2. Micro-hydro as a source of green power generation

Micro-hydropower in comparison to other nonconventional energy sources includes the following (Gurbuz 2006, Mohamad *et al*. 2011, Lejeune and Hui 2012):

### *2.1 Selection of potential sites*

Hilly areas with natural water falls on the dam-toe or canal drops are suitable sites for micro-hydropower plants. For such site selection long range studies are not required. Sites for biomass plants are usually located by taking into consideration the availability of water, raw materials for biogas generation, free open space, total space required, minimum gradient, water table, distance from wells, and grid. Wind power plants are situated at a certain place where wind velocities are very high and relatively constant all over the year.

### *2.2 Problems while connecting to the National Grid*

Micro-hydropower plants produce nearly constant input power. The only variation results in change of seasons due to the seasonal climate changes and water flow rate. So overall for a certain season, the power is almost constant. The power fed to the main national grid network is very smooth with no such nonlinearities that are present in other sources of energy. Power fed to the grid produced by solar and wind energy consists of fluctuations on voltage and frequency levels, harmonic distortion, nonlinearities, and other abnormalities. This usually occurs due to the variation in wind velocities and solar light intensity all throughout the day. In numerous occasions the power needs to be put off grid because of certain factors going below the threshold level during power transmission and distribution.

### *2.3 Problems governing operation, maintenance, and control*

Micro-hydropower is easy to operate and there is no need for rigorous maintenance, whereas wind power plant causes severe noise pollution, teething troubles, and poor performance due to operation and maintenance problems. Major challenge relies on designing signal conditioner, computer interfacing, and software for system operation. The pulsating input power pattern for the wind power station is another major problem. Moreover, there are various problems while handling biogas: pollutants such as effluent slurry, accumulation of volatile fatty acids, gas forming methanogenic bacteria, and leakage of gas from gas holder. Other problems include drop in Ph level and failure of digester.

### *2.4 Effects on the environment*

Micro-hydropower, wind, and solar power plants are clean and pollution free. They are basically very environment friendly sources. Although wind power plants create noise pollution, biomass causes environmental pollution and it does not meet the pollution control regulation, whereas micro-hydropower maintains the ecological balance and stream flow of the rivers. The impacts on the environment of each energy sources have been studied thoroughly and the enhancement of these technologies has been considered.

## 3. Advantages of micro-hydro power plant (Paish 2002)

### *3.1 Efficient energy source*

It only takes a small amount of flow (as little as two gallons per minute) or a drop as low as two feet to generate electricity with micro hydro. Electricity can be delivered as far as a mile away to the location where it is being used.

### *3.2 Reliable electricity source*

Hydro produces a continuous supply of electrical energy in comparison to other small-scale renewable technologies. The peak energy season is during the winter months when large quantities of electricity are required.

### *3.3 No reservoir required*

Micro-hydro is considered to function as a ‘run-of-river’ system, meaning that the water passing through the generator is directed back into the stream with relatively little impact on the surrounding ecology.

### *3.4 Cost effective energy solution*

Building a small-scale hydro-power system can cost from $1,000 (RS. 50,000) - $20,000 (RS. 10,000,00), depending on site electricity requirements and location. Maintenance fees are relatively small in comparison to other technologies.

### *3.5 Power for developing countries*

Because of the low-cost versatility and longevity of micro hydro, developing countries can manufacture and implement the technology to help supply much needed electricity to small communities and villages.

### *3.6 Integrate with the local power grid*

If your site produces a large amount of excess energy, some power companies will buy back your electricity overflow. You also have the ability to supplement your level of micro power with intake from the power grid.

## 4. Disadvantages of micro hydro power plant (Paish 2002)

### *4.1 Suitable site characteristics required*

In order to take full advantage of the electrical potential of small streams, a suitable site is needed. Factors to consider are: distance from the power source to the location where energy is required, stream size (including flow rate, output and drop), and a balance of system components - inverter, batteries, controller, transmission line and pipelines.

### *4.2 Energy expansion not possible*

The size and flow of small streams may restrict future site expansion as the power demand increases.

### *4.3 Low-power in the summer months*

In many locations stream size will fluctuate seasonally. During the summer months there will likely be less flow and therefore less power output. Advanced planning and research will be needed to ensure adequate energy requirements are met.

### *4.4 Environmental impact*

The ecological impact of small-scale hydro is minimal; however the low-level environmental effects must be taken into consideration before construction begins. Stream water will be diverted away from a portion of the stream, and proper caution must be exercised to ensure there will be no damaging impact on the local ecology or civil infrastructure.

## **5. Misconceptions - myths about hydro power (**Paish 2002**)**

### *5.1 Small streams do not provide enough force to generate power*

The Truth: Energy output is dependent on two major factors: the stream flow (how much water runs through the system) and drop (or head), which is the vertical distance the water will fall through the water turbine.

### *5.2 A large water reservoir is required*

The Truth: Most small-scale hydro systems require very little or no reservoir in order to power the turbines. These systems are commonly known as ‘run-of-river’, meaning the water will run straight through the generator and back into the stream. This has a minimal environmental impact on the local ecosystem.

### *5.3 Hydro generators will damage the local ecosystem*

The Truth: Careful design is required to ensure the system has a minimal impact on the local ecology. A small amount of energy compromise may result, but this will ensure that the project does not have an effect on local fish stocks. The Environment Agency requires that stream levels must be maintained at a certain level in order to sustain the life within. Since there is no loss of water in the generation process, these requirements can easily be met.


Fig. 4 Schematic illustration of run-of-river mini hydro-power plant

### *5.4 Micro hydro-electricity is unreliable*

The Truth: Technology advances (such as maintenance-free water intake equipment and solid-state electrical equipment) ensure that these systems are often more reliable in remote areas. Often these systems are more dependable than the local power main.

### *5.5 The electricity generated is low quality*

The Truth: If the latest electronic control equipment, inverters and alternators are used, the resultant power supply has the potential to be of higher quality the main electrical power grid.

### *5.6 Hydro power is free*

The Truth: Micro power development can be cost-intensive to build and maintain. There are some fixed maintenance costs. These costs vary according to site location and material requirements.

## 6. Identified site for the small hydro power plant

Fig. 4 shows the schematic illustration of run-of-river mini hydro-power plant in the Shoolini University, Himachal Pradesh. It is well known that in India Himachal Pradesh have lots of potential sites for the generations of hydro power and very few of them have yet identified. One such site has been identified by the author around the **Shoolini University, Bhajol District Solan (HP)** which is one of the renowned fast growing University in Himachal Pradesh. The site has enough potential not only to satisfy the energy requirements of Shoolini University but also the

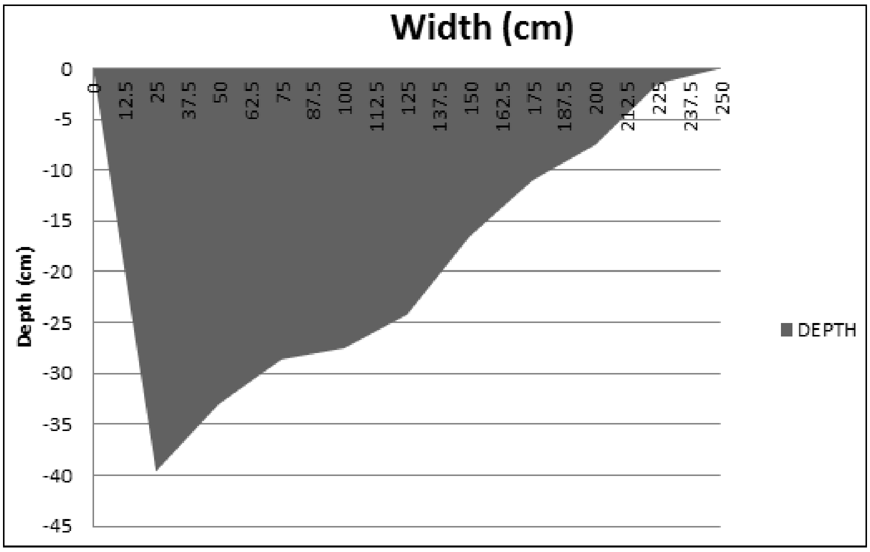


Fig. 5 Depth of the Rivulet across its width

Table 1 Data recorded for width, depth and velocity head

| Width In *W*, (Cm) | Water Level At Given Width (*W*) $D_w$, (Cm) | Velocity Point From Free Surface $D_v$ (60 % Of D) (Cm) | Velocity Point Form Bottom Surface $H_b$ = ($D_w$-$D_v$) (Cm) | Pitot Tube Height From Bottom Of Revulet (Cm) | Velocity Head At Velocity Point (Cm) | Average Values At Section Considered |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | |
| 12.5 | | | | | | 11.88 |
| 25 | 39.6 | 23.76 | 15.84 | 39.6 | 23.76 | |
| 37.5 | | | | | | 23.6225 |
| 50 | 33 | 19.8 | 13.2 | | 23.485 | |
| 62.5 | | | | | | 23.3475 |
| 75 | 28.6 | 17.16 | 11.44 | 34.65 | 23.21 | |
| 87.5 | | | | | | 19.8 |
| 100 | 27.5 | 16.5 | 11 | | 16.39 | |
| 112.5 | | | | | | 12.98 |
| 125 | 24.2 | 14.52 | 9.68 | 19.25 | 9.57 | |
| 137.5 | | | | | | 8.9525 |
| 150 | 16.5 | 9.9 | 6.6 | | 8.335 | |
| 162.5 | | | | | | 7.7175 |
| 175 | 11 | 6.6 | 4.4 | 11.5 | 7.1 | |
| 187.5 | | | | | | 5.55 |
| 200 | 7.5 | 4.5 | 3 | | 4 | |
| 212.5 | | | | | | 2.45 |
| 225 | 1.5 | 0.9 | 0.6 | 1.5 | 0.9 | |
| 237.5 | | | | | | 0.45 |
| 250 | 0 | 0 | 0 | 0 | 0 | |

couple of nearby villages. Out of several potential benefits one is unsung that is the savings of power losses during transmission. So it always preferred to develop methods to generate energy around the area where it is required.

### *6.1 Recorded data for the site*

Table 1 shows the recorded data for the velocity head across the width at different depths of the revolute. Fig. 5 shows the cross section of the revolute and Table 2 below shows the recorded data for the potential head for the site. Fig. 6 shows the velocity distribution across the width of the rivulet. Fig. 7 shows the combined distribution of depth and velocity distribution across the width of the rivulet. The data in the Table 2 is recorded from the point where diversion for the run-off-river is proposed to the point where discharge is proposed.

### *6.2 Calculations for area, velocity, discharge and power*

From the above recorded data following calculations are made for the area velocity and discharge as shown in the Table 3.

From the Table 2 it can be calculated that the total potential head of the site is = 2978.5 cm or 29.785 m. Also from the Table 3 it can be easily calculated that total discharge available at the site is = 819302.5345 $cm^3$ or 0.819302535 $m^3$.

Table 2 Data recorded for the potential head of the site

| Point no. | Initial height (cm) | Recorded height at adjacent points (cm) | Difference between two consecutive points (cm) |
|---|---|---|---|
| 1 | 140 | Not required | Not required |
| 2 | 131 | 261 | 121 |
| 3 | 110.5 | 205 | 74 |
| 4 | 110 | 365 | 254.5 |
| 5 | 116 | 281 | 171 |
| 6 | 108 | 337 | 221 |
| 7 | 118 | 165 | 57 |
| 8 | 98 | 206 | 88 |
| 9 | 105 | 290 | 192 |
| 10 | 85 | 255 | 150 |
| 11 | 95 | 381 | 296 |
| 12 | 94 | 233 | 138 |
| 13 | 95 | 245 | 151 |
| 14 | 92 | 300 | 205 |
| 15 | 91 | 245 | 153 |
| 16 | 82 | 240 | 149 |
| 17 | 86 | 173 | 91 |
| 18 | 83 | 281 | 195 |
| 19 | 80 | 235 | 152 |
| 20 | Not required | 200 | 120 |
| | Therefore, total head available | | 2978.2 cm |

Table 3 Calculated values for area, velocity and discharge

| Area of the sections | *V*= (2*g*h)$^{1/2}$ | Q = AV |
|---|---|---|
| 495 | 152.6714119 | 75572.34887 |
| 907.5 | 215.2843352 | 195370.5342 |
| 770 | 214.0275566 | 164801.2186 |
| 701.25 | 197.0979452 | 138214.9341 |
| 646.25 | 159.5830818 | 103130.5666 |
| 508.75 | 132.5322791 | 67425.79699 |
| 343.75 | 123.0517574 | 42299.04161 |
| 231.25 | 104.3508505 | 24131.13418 |
| 112.5 | 69.33181088 | 7799.828724 |
| 18.75 | 29.71363323 | 557.1306231 |
| Total Area = 4735 cm$^2$ | Average Velocity = 127.05 cm/s | Total Discharge = 819302.5345 cm$^3$ |

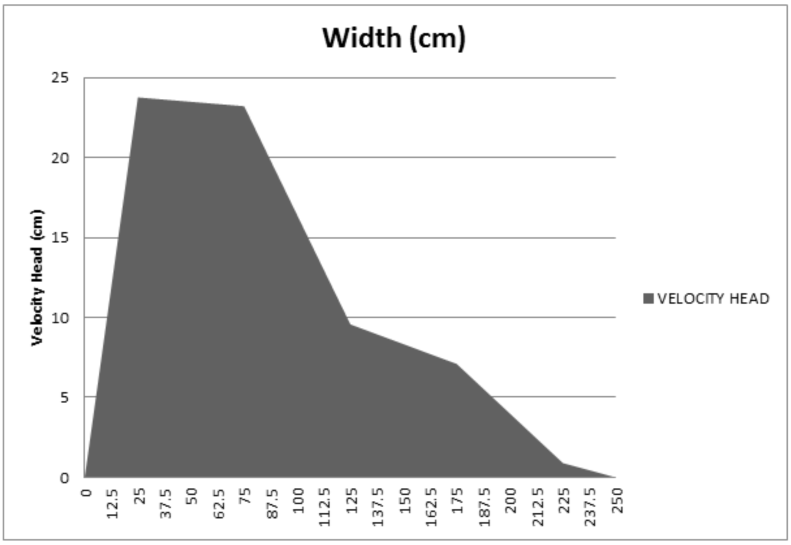


Fig. 6 Velocity distribution across the width of the Rivulet

### *6.2.1 Calculations for power*

Hydraulic power is given by the formula

$$(\rho g h * q * \eta) \tag{1}$$

Where,

$\rho$ = Density of water, kg/m$^3$
$g$ = Acceleration due to gravity, m/s$^2$
$h$ = Available head, m
$\eta$ = Conversion efficiency of the hydraulic machine (60%)

Therefore the calculated value of the power form equation (1) = 143635.6224 Watts or, the calculated value of power = 143.6356224 KW. Finally the energy for the calculated value of the power =143.6356224 (KWH).

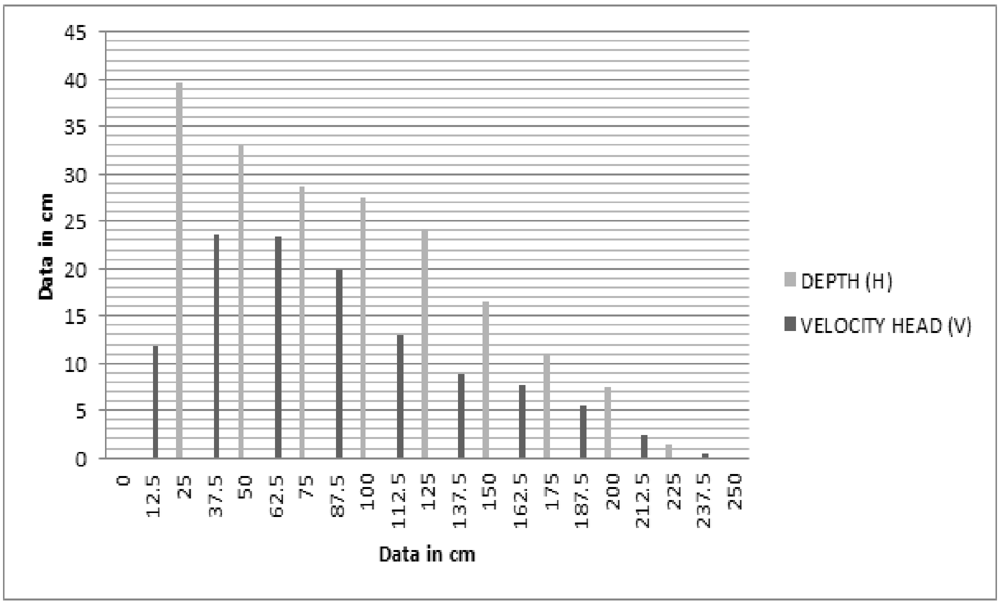


Fig. 7 Combined distribution of depth and velocity distribution across the width of the Rivulet

### *6.2.2 Economic evaluation*

Commercial value of calculated energy @ of Rs. 5 / KWH (i.e. per hour) = Rs. 718.18
Or, Commercial value of the calculated energy @ of Rs. 5 / KWH (i.e. per day) = Rs. 17,236.27
Where, Rs= Indian Rupees/currency.
Or, Commercial value of calculated energy @ of Rs. 5 / KWH (i.e. per annum)
= RS. 62, 91,240.26
Or, Commercial value of calculated energy @ of Rs. 5 / KWH (i.e. per month)

$$= \text{Rs. } 5,\ 24{,}270.02 \quad (2)$$

The average electricity bill paid by the University per month is

$$= \text{Rs. } 15000 \quad (3)$$

From Eqs. (2) and (3) it can be easily concluded that the identified site not only fulfills the energy demands of the Shoolini University but also provides an additional source of income to the University having a commercial value in Rs. 5,09,270.02 per month or Rs. 61,11,240.24 per year.

## 7. Conclusions

From the above it can be easily calculated that the identified mini hydro power site have enough potential to serve the energy demands of the Shoolini University but also have an additional commercial value of Rs. 61,11,240.24 per year. The additional advantage of this green energy is that it is nearby the Shoolini University hence the power losses due to the power transmission will be minimum. Also it is observed that the average investment cost of such a project will be around Rs. 10, 00, 000 (maximum). Hence the identified site is economical from the commercial point view also along with the other advantages of the green energy. It can be equally beneficial for the nearby villages as it can also easily solve their daily energy requirements that also at minimum power losses due to transmission. At last it can be easily concluded that the above identified site can proved to be a potential national asset.

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