Overview of small hydro power plant in pashdan dam in karukh Herat Afghanistan

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Abstract

The objective of this project is to come up with the design of small hydropower plant capable of generating 1.3 MW at Karuk River passing through East of Herat City in Afghanistan. The whole Karukh County is suffering from power shortage. This is because the power from the national grid is not sufficient to cater for the demand of the area. The hydropower plant will has an immediate effect on industries already set up. These industries has been suffering from regular power outages and high cost of grid electricity. We selected our discharge to be 4.1m/s which was used for all our calculation in pashdan dam. Thus, the net head (35,5M) and design discharge are the two most important parameters used for design analysis and selection of hydropower components.

Lastly, the project is capable of producing more than 1.3 MW of electrical energy. However, pursuing this will be out of our small hydropower bracket. If this project is implemented then the community and country at large can benefit. This project will create employment for the locals and skilled Afghani'. Therefore, during the implementation of the project, we recommended that the other specialist in other fields to be involved

Keyword: Karukh, Afghanistan, Small Hydropower plant overview

1. Introduction:

1.1 Definition and classification of small hydropower

Small hydro power may be classified according to different criteria, such as head powerhouse layout and installed capacity of SHP. SHP are classified in term of their capacity. SHP capacity may very at different times and in different countries but it has no strict definition. Generally small hydro power plant is the scheme with installed capacity up to 10 MW

Advantages of a Small Hydro Power Plant

2. Its mature technology and small investment risk.

3. Its low operating costs, easy maintenance and reliable power supply.

4. Little environmental impact during construction, with some positive impact on the environmental

5 The obvious social benefit to a developing local economy and improvements in the

material and spiritual life of local residents.

6. Increasing revenue for the local government and income for local people.

7. Creating more jobs and reducing the migration of rural people into cities.

8. Developing tourism in rural areas

Disadvantages of small hydropower plant

1. Relatively high initial capital cost which might make it expensive for individual

Institutions to afford.

2. Must be sited where there is a water fall

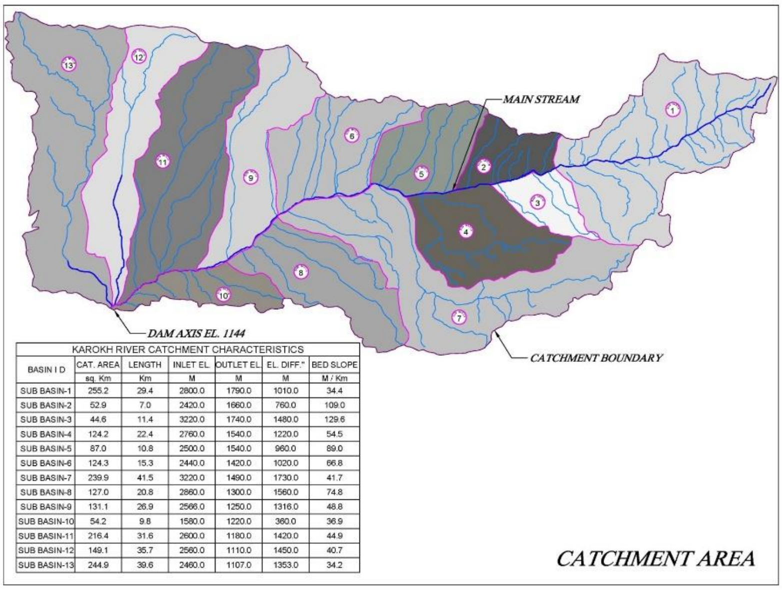
3. Because its installation involves some site work, it is bound to interfere with the river flow and ecosystem. This may lead to objection by the local people who might affected by such interferences.

1.2 Background of Pashdan dam

The proposed Pashdan Dam will be located on Karukh river, a right bank tributary of the Hariyrood river. The dam site is located at about 17.5 km from Karukh town and 21 km south-west of Herat; at latitude 340 24’ 20.8” and longitude 620 25’ 18”. The project aims at store the water of Karukh river for supply of dependable irrigation water, hydropower and drinking water purposes. Hydrological review studies of the project were carried out to re-confirm critical aspects of the project for initiating the detailed design. The existing contract for detail design and construction of Pashdan Irrigation and Hydropower Project included construction of an irrigation system comprised of two newly proposed left and right bank canals only. Upon special recommendation of his Excellency the Minister of MEW, and as per MEW letter 248/134, dated 14-04-2012, it was decided to additionally include upgrades and development of the existing Joe-Sultani canal for special consideration under this project. MEW Letter No. 88/108, dated 12-11-2012 further specified a command area of 1000 ha, to be included under the project.

1.3 Catchment Area and Sub-Basin Characteristics

The Karukh River originates from the slopes of Koh-i-Bande Sabzak at an altitude of about 2,600 m. The river quickly descends to the lower plateau and after flowing due west, parallel to the main Hariyrood valley, spreads over the flat valley slope, about 15 Km above the city of Herat. The catchment area of Karukh river upto the proposed dam site was re-computed from 1:50,000-Scale Russian topographic maps. The catchment area was computed as 1851 sq. km. in close approximation of the 1847 sq. km. reported in the feasibility study by CES. The whole catchment area is sub divided into thirteen sub catchments area according to major tributaries which originate from different directions and areas. Respective sub catchments, length, inlet and outlet elevations and slope of each stream are illustrated in **Error! Reference source not found.**.



KAROKH RIVER CATCHMENT CHARACTERISTICS						
BASIN I D	CAT. AREA	LENGTH	INLET EL.	OUTLET EL.	EL. DIFF."	BED SLOPE
	sq. Km	Km	M	M	M	M / Km
SUB BASIN-1	255.2	29.4	2800.0	1790.0	1010.0	34.4
SUB BASIN-2	52.9	7.0	2420.0	1660.0	760.0	109.0
SUB BASIN-3	44.6	11.4	3220.0	1740.0	1480.0	129.6
SUB BASIN-4	124.2	22.4	2760.0	1540.0	1220.0	54.5
SUB BASIN-5	87.0	10.8	2500.0	1540.0	960.0	89.0
SUB BASIN-6	124.3	15.3	2440.0	1420.0	1020.0	66.8
SUB BASIN-7	239.9	41.5	3220.0	1490.0	1730.0	41.7
SUB BASIN-8	127.0	20.8	2860.0	1300.0	1560.0	74.8
SUB BASIN-9	131.1	26.9	2566.0	1250.0	1316.0	48.8
SUB BASIN-10	54.2	9.8	1580.0	1220.0	360.0	36.9
SUB BASIN-11	216.4	31.6	2600.0	1180.0	1420.0	44.9
SUB BASIN-12	149.1	35.7	2560.0	1110.0	1450.0	40.7
SUB BASIN-13	244.9	39.6	2460.0	1107.0	1353.0	34.2

Figure Error! No text of specified style in document.**.1 Catchment Area of Karukh River at Pashdan Project Site.**

2 Methodology:

2.1 Introduction

Adequate flow and head are necessary requirements for hydro generation. Consequently site selection is conditioned by the existence of both requirements. The site evaluation was done to get the exact place to install power house and where to construct things like intake weir, intake, and channel, fore-bay settling basin, spillways, penstocks, tailrace and powerhouse.
The topographic of the site was considered and geological area of the site dealt with to give easier for construction.

2.2 Electromechanical Equipment

This chapter gives the main description of the elect mechanical equipment, some preliminary design rules and some selection criterion.

2.3 Powerhouse

The role of the powerhouse is to protect the electromechanical equipment that convert the potential energy of water into electricity.

2.4Hydraulic turbines

Hydraulic turbines transform the water potential energy to the mechanical rotational energy. Formulae are based in work undertaken by siervo and Lugaresu11, siervo and level 12 13, Lugaresi and Massa 14 15, Austerre and Verdehan 16 Giraud and Beslin 17, Belhaj 18, gordon19 20, Schweiger and Gregori21 22 and others, which provide a series of formulae by analyzing the characteristics of installed turbines. Based on the formulae given by the authors above Francis turbine was chosen for this project. The details about Francis turbine are given below; all the formulae use SI units and refer to IEC standards (IEC 60193 and 60041).

2.5Frances turbines

Frances turbines are reaction turbines, with fixed runner blades and adjustable guide vanes, used for medium heads. In this turbine water entry is radial but exits axially. A horizontal axis Francis turbine. The draft tube of a reaction turbine aims recover the kinetic energy still remaining in the water leaving the runner. The kinetic energy is proportional to the square of the velocity. Hence a draft tube is required to reduce the turbine outlet velocity. An efficient draft tube would have a conical section but the angle cannot be too large, otherwise flow separation will occur. The optimum angle is 7^{o} but to reduce the draft tube length, and therefore its cost, sometimes angles are increased up to 15^{o}.

2.5.1Specific speed

The specific speed constitutes a reliable criterion for the selection of the turbine, without and doubt more precise than the conventional enveloping curves, just mentioned.

2.5.2Turbine selection criteria

The type geometry and dimensions of the turbine will be fundamentally conditional by the following criteria:

- Net head
- Range of discharge through the turbine
- Specific speed
- Rotational speed
- Cavitation problems
- Cost

2.5.3Net head

The gross head is well defined as the vertical distance between the upstream water surface level at the intake and the downstream water level for reaction or the nozzle axis level for impulse turbines.

The net head is the ratio of the specific hydraulic energy of turbine by the acceleration due to gravity. This definition is particularly important, as the remaining kinetic energy in low head schemes cannot be neglected.

The first criterion to take into account in the turbine's selection the net head.

2.5.4 Discharge

A single value of the flow has to no significance. It is necessary to know the flow regime,
Commonly represented by in flow duration curve (FDC) as explain earlier un

2.5.5 Cavitation

When the hydrodynamic pressure in a liquid falls below the vapor pressure of the liquid, there is a formation of the vapor phase. This phenomenon compel the formation pf small singular bubbles that are carried out of the low-pressure region by the flow and collapse in regions of higher pressure. The formation of those bubbles and their subsequent collapse gives rise to what is called cavitation. The cavitation calculation is dealt with under the design analysis.

2.5.6 Rotational speed

The rotational speed of a turbine was calculated to be 738 RPM.

2.5.7 Runaway speed

Each runner profile is characterized by the maximum runaway speed. This is the speed, which the unit can theoretically attain in the case of load rejection when the hydraulic power is at its maximum. Depending in the type of turbine. It can attain 2 or 3 times the nominal speed.

It should be remembered that the cost of both generator and eventual speed increaser may be increased when the runaway speed is higher, since they should be designed to withstand it.

2.5.8Turbine efficiency

The efficiency characterizes not only the ability of a turbine to exploit a site in a optimal manner but also its hydrodynamic behaviour. Average efficiency means that hydraulic design is not optimum and that some important problems may occur e.g. cavitation, vibration, etc. This can strongly reduce the yearly production and damage the turbine. The turbine efficiency was chosen from the best workout of Francis turbine. But only manufacturers can provide the most dependable efficiency for the turbine.

2.5.9Speed increasers

Due to low rotational speed of Francis turbine this design, the speed is adapted to increase the speed on generator to the required speed without directly coupling the two, hence. Belt speed is selected.

2.6 Generators

2.6.1 Type of generators

Synchronous generator is selected due to its advantages compare to asynchronous. Independent exciter of rotor is provided for each unit applicable for both independent and existing power network.

2.6.2 Exciters

In case of synchronous generator, A exciter is necessary for supplying field current to generator and keep the output voltage constant even if the load fluctuates.

2.6.3Synchronous generator:

The synchronous alternator is an electrical machine which converts the mechanical power from a prime mover into an AC electrical power at a particular voltage and frequency. The synchronous motor always runs at the fixed speed called synchronous speed.

2.6.4Speed Governors:

It is adopted to keep the turbine speed stable because the speed fluctuates, changes in load, water head and flow. The change of generator rotational speed results in the fluctuation of frequency. The governor comprise of speed detector controller and operation. Hence dummy load type was adapted.

2.6.5 Switchgear equipment

In many countries the electricity supply regulations place a statutory obligation on the electric utilities to maintain the safety and quality of electricity supply within defined limits. Afghanistan is not exception in this obligation. According to this project the plant is going to operate in such a way that safety is first priority during operation. Thus switchgear must be installed to control the generators and to interface them with the grid or with a isolated load. Also metering equipment must be installed at the point of supply to record measurement according to the requirements of the electric utility.

2.6.6Automatic control

Small hydro schemes are normally unattended and operated through and automatic control system. Because not all power plants are alike, it is almost impossible to determine the extent of automation that should be included in a given system.

2.6.7Plant service transformer:

Electrical consumption including lighting and station mechanical auxiliaries may require from 1 to 3 percent in the plant capacity. The higher percentage applies to micro hydro (less than 500 KW). The service transformer must be designed to take these intermittent loads into account. If possible two alternative supplies, two alternative supplies with automatic changeover, should be used to ensure service in an unattended plant.

2.6.8DC control power supply:

It is generally recommended that remotely controlled plants are equipped with an emergency 24 V DC back up power supply from a battery on order to allow plant control for shutdown after a grid failure and communication with the system at any time. The ampere hour capacity must be such that, on loss of charging current, full is ensured for as long as it be required to take corrective action.

3. Result:

SUMMARY OF DESIGN

The following is the summary of the design analysis

no	component	Dimensions/ specifications.	Number
1	Penstock(commercial steel)	Internal diameter 1100 mm Thickness 11 mm Length 114 m	1
2	Weir	Height = 3m	1
3	Side intake	Velocity = 1m/s Width, b = 3m Height, h = 1.36m	1
4	Settling basin	Velocity, v = 0.6m/s Width= 3m Height = 2m Length = 24 m	1
5	Channel: Rectangular. Masonry concrete.	Length, L= 550m Width, B = 2.5392 m Depth, H = 1.2696 m	1
6	Head tank	Head-tank capacity, Vs= 82 m3 /s Depth. Dsc= 0.6m Length, L = 27m Width, B= 5.066m	1
7	Turbine (Francis Turbine)	Shaft power= 1.3 MW Rotational speed = 738 RPM Specific speed = 0.309 Runner outer diameter D3= 0.73m Runner Inner diameter D1 = 0.5m Design flow = 4.1m3 /s Guide vane inlet angle α = 34.28° Guide vane outlet angle ϕ = 17° Runner inlet width B1 = 0.32 m Runner outlet width B2 = 0.30 m Turbine efficiency, Şt = 94%	1
8	Draft tube	Flare angle = 6° Inlet diameter, Di = 0.60 m Outlet diameter, D0 =1.15 m Height = 2 m Tail race water level, T =0.58 m	1
9	Generator (synchronous)	Pole = 4 Rated power = 1.6 MVA Power output = 1.3 MW Frequency = 50Hz Generator efficiency, Şg = 97% Brushless type exciter Power factor Pf = 0.8	1
10	Speed increaser	Belt type Speed increaser efficiency Ş = 98% Ratio = 4.1	1
11	controllers	Dummy load type Dummy load capacity, Pd= 1.6 MW	1

4 Site configuration

Design discharge, Qd = 4.1 m3 /s

Gross head, Hg = 7 m

Net head, Hn = 35.5.5 m

Total head loss Hl = 1.318 m

5. CONCLUSION

The objective of this project was to design for construction a small hydropower plant capable of producing 1.3 MW along river Karukh at Heart.

Benefit of the local community. The project when completed will be capable of generating a lot of revenue. The summary of the design components of hydropower with their specifications are listed in the table under the summary section of this chapter. Also the scheme for this design will be run-of-river scheme as discuss above under literature review because it is cheaper to install and the nature of the river is capable of providing water. All the specifications are provided above including the cost estimate of project. Thus, the objective of project was achieved.

6. RECOMMENDATIONS

The following are the recommendation we suggested:

1- The river is capable of producing more than1.3 MW hence we recommend the changing of focus from small hydropower a medium hydropower plant.

2- This project needed more time for a more detailed report to be created. Hence, anything left out in this project is due to time constraints.

3- This project is site specific hence we would encourage its fast implementation.

4- The local government or any other agency should look for funding to implement the project since it is economically feasible. It will also improve the living standards of the local people.

5- The further detailed design needed is on civil structures preferably by civil engineers and surveyors as these structures are beyond the scope of this project.

6- There is need creating a power distribution network beyond the powerhouse and this need further research on this project.

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