Assessment of Hydropower Potential Through Canal Falls Situated Along Vadodara Branch Canal

KEYWORDS: fossil fuel, hydropower, renewable energy, sustainable, small hydropower project, canal falls

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ABSTRACT *Reduction of fossil fuel and the failure to meet the rising demand of electricity are the some drawbacks for the economic development of India. Hydropower is a renewable, non-polluting and environmentally benevolent source of energy. It is perhaps the oldest renewable energy technique for electricity generation. Hydropower, large and small remains the most of the "renewables" for electrical power production. It is recognized that small hydropower project (SHP) can play significant role in meeting energy requirements in remote & hilly regions where extension of grid is uneconomical. This research paper is an in-depth scenario on proposed SHP going to begin on Vadodara Branch Canal (VBC) of Narmada Canal system. VBC is off take at 81.804 km of Narmada Main Canal (NMC) having total length of 115.05 km. The objective of this paper to analyses and assess the potential of hydropower generation through various canal falls situated along the VBC. The whole project is carried out by Sardar Sarovar Narmada Nigam Limited (SSNNL). In this paper the evaluation of daily, monthly and yearly hydropower generation through canal falls is shown.*

INTRODUCTION

Hydropower is considered a renewable energy source. A renewable energy source is one that is not depleted (used up) in the production of energy. Through hydropower, the energy in falling water is converted into electricity without "using up" the water.

Head = The Height From Which Water Falls

The farther the water falls, the more power it has. The higher the fall, the farther the water falls, producing more hydroelectric power. Power production is also directly proportional to head as wells as directly to proportional to discharge. That is, water falling twice as far will produce twice as much electricity. ($P\alpha H$, $P\alpha Q$)

P (kW) = Q (m^3/s) x H (m) x ηtot x 9.81

P = electrical power output (kW)

Q = rated discharge in (m^3/s)

H = net head in (m)

η_{tot} = total efficiency ($\eta_{turbine}$ x $\eta_{generator}$ x $\eta_{gearbox}$) This can range from 60% (0.60) for older, poorly maintained hydro plants to 90% (0.90) for newer, well maintained plants.

CLASSIFICATION:-

Hydropower projects are generally categorized in two segments:

1. Small hydro (< 25MW) – canal based or run of the river
2. Large hydro (>25 MW) – either run of the river type or associated with large dams

The Further Classification of Small Hydropower Schemes in India is as under:

Type	Use	Capacity
Water Mills	For local use	Up to 5 KW
Micro	Village electrification	Up to 100 kW
Mini	Village Electrification & Grid	101 kW to 2000 kW
Small	Grid	2001 kW to 25000 kW

[Kanjlia V.K.-Research article-12 (9)]

BACKGROUND

Initially, hydropower was specifically used in water wheels for lifting water up from the water source, e.g. river, to a water supply network, irrigation, mills and other mechanical applications. But during the last century it became an efficient source for power generation, and the development of hydropower was usually associated with building large dams. Large number of massive barriers of concrete, rock and earth were placed across river valleys, world-wide, to create huge man-made water reservoirs. While these created a steady power supply in addition to irrigation and flood control benefits. But dams, in most cases, flooded large areas of fertile land and displaced millions of local inhabitants. In many cases rapid silting up of the dam has reduced its productivity and lifetime. There are also numerous environmental problems that can result from such major interference with stream/river flows. However, at present the exploitation of large hydro sources is mainly saturated, especially in developed countries.
[Jaber J.O. April-12 (5), Paish O. February-02 (8)]

One of the oldest technologies for electricity production is hydrogenation. It has many advantages as compared to other technologies, and only 17% of world energy is supplied by hydroelectric plants. India is very rich with hydropower potential and considered as one of the pioneering countries in establishing hydroelectric power plants. In terms of usable potential India stands fifth in world but only 19.9% has been developed or used for development. Researchers evaluated that hydropower can meet the growing demand of energy of the country for the generation of electricity. It is the largest renewable energy resource. Presently only 150000 MW of en-

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ergy which is about 17% of the potential has been tapped so far in India whereas countries like Brazil, Canada and Norway have been extracted 30% or more of their hydro potential. [Chaurasiya P.K. March-13 (4)]

What is Small Hydropower?

Small hydropower is a key element for sustainable development due to following reasons:

- SHP is a renewable source of energy.
- SHP is a cost effective and sustainable source of energy that cause less and simple construction work and in expensive equipment are required to establish and operate small hydropower projects. The cost of electricity generation is inflation free.
- Proper utilization of water resources and no big water storage is required.
- SHP aids in conserving fossil fuels.
- Clean and non-polluting source of energy.
- Development of rural and remote area where extension of greed is uneconomical.
- SHP also gives additional benefits along with power generation such as irrigation, water supply, flood prevention, fisheries and tourism.

[Jaber J.O. April-12 (5)]

HYDROPOWER SCENERIO OF INDIA

India is blessed with immense amount of hydro-electric potential and ranks 5th in terms of exploitable hydro potential on global scenario. The present installed capacity of India as on 30-06-2011 is approximately 37,367.4 MW which is 21.53% of total Electricity generation of India. Few public sector companies which are engaged in development of hydropower in India are National Hydroelectric Power Corporation (NHPC), Northeast Electric Power Company (NEEPCO), NTPC-Hydro, Sutlej Jal Vidyut Nigam Limited (SJVNL), Tehri Hydro Development Corporation. These public sectors has a predominant share of 97%. The North-Eastern part of India: Arunachal Pradesh, Nagaland, Manipur and Mizoram and also the area of between Mumbai and Mahe on the west coast has dominant annual rainfall. The major hydroelectric power plants are located in Bihar, Punjab, Uttaranchal, Karnataka, Uttar Pradesh, Sikkim, Jammu & Kashmir, Gujarat and Andhra Pradesh. Hydropower projects with a capacity of up to 25 MW comes under a category of small hydropower (SHP) in India. Estimated SHP potential of India is about 15,000 MW, of which 11% has been tapped so far. The Ministry of New and Renewable Energy (MNRE) supports SHP project development throughout the country. So, far, 523 SHP projects with an installed capacity of 1705 MW have been installed. Besides this, 205 SHP projects with an aggregate capacity of 479 MW are under implementation. With this capacity addition, on an average of 100 MW per year and gradual decrease in gestation periods and capital costs, the SHP sector is becoming increasingly competitive with other alternatives. Presently, the following forms of hydro power projects are existing in the India:

- Storage Schemes
- Run-of-River (ROR) Schemes without Poundage.
- Run-of-River Schemes with Poundage.
- Pumped Storage Schemes

[Chaurasiya P.K. March-13 (4)]

ASSESSMENT OF HYDRO CAPACITY:

- The Studies were carried out by the Central Electricity Authority, Ministry of Power, during 1978-1987 have placed the hydro power potential at 84044 MW at 60% load factor and the economically exploitable hydro potential as 1,48,701 MW including 2300 MW of small hydro schemes.
- An exercise was carried out by Central Board of Irrigation and Power (CBIP) in the year 2011-12 to assess the hydro capacity in the country
- The study considered all the projects i.e. under operation, under construction and concurred by Central Electricity Authority (CEA), for which Detailed Project Report (DPR) and Project Final Report (PFR) have been prepared, under survey & investigation, allotted by state and those identified so far.
- Details of all the projects have been brought out in CBIP publication titled "Hydroelectric Projects in India". The publication gives the general and salient features of all the projects above 25 MW capacity.

[Kanjlia V.K.-Research article-12 (9)]

STUDY AREA

Vadodara Branch Canal (VBC) off- takes from chainage 81.804 Km. of Narmada Main Canal (NMC) having total length of 115.05 Km.

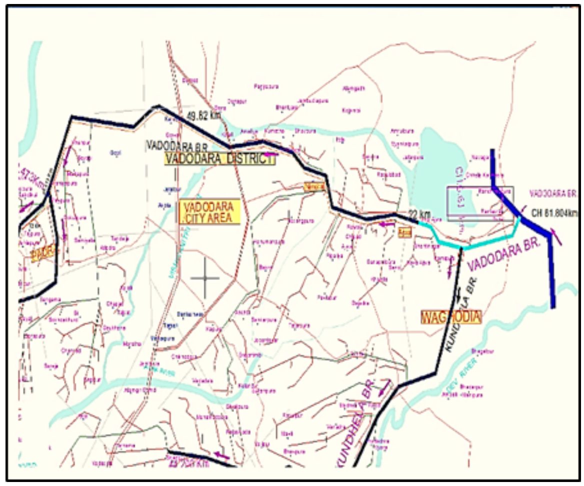

Fig-1 Layout Diagram of VBC upto 50 km

Source- SSNNL, Vadodara.

On left side near village Rameshara which passes through Panchmahals, Vadodara and Bharuch district. The discharge capacity of Vadodara Branch Canal at head is 76.04 Cumecs with section 6.30 X 3.70 +0.90 m. and at tail is 2.46 Cumecs with section 1.40 X 1.30 M. and total CCA is 1,15,928 Ha. The Vadodara Branch Canal is ridge canal passes through different villages of Halol, Waghodia, Vadodara, Padra and Jambusar Taluka. Vadodara Branch Canal crosses Nos. of natural drains, National Highways, State Highways and also passes through city area of Vadodara between chainage 27.00 to 41.00 Km. The work of Vadodara Branch Canal was completed in the year 2001 and water flowing for irrigation since year 2004. The whole monitoring and controlling of VBC is carried out by Sardar Sarovar Narmada Nigam Limited (SSNNL).

The small hydropower units have been plant on various canal falls situated along the Vadodara Branch Canal (VBC) at chainage as follows:

SR.NO.	Chainage (m)	Magnitude of Fall (m)	No. & Type of Gates	
1	6720	4.5	2	Radial
2	11080	3.15	3	Radial
3	14580	3.7	3	Radial
4	21000	3.3	3	Radial
5	22500	3.3	3	Radial
5a	22800	3.25	3	Radial
6	24390	3.1	3	Radial

Table 1 - Canal Fall details concern to SHP.
Source: SSNNL, Vadodara.

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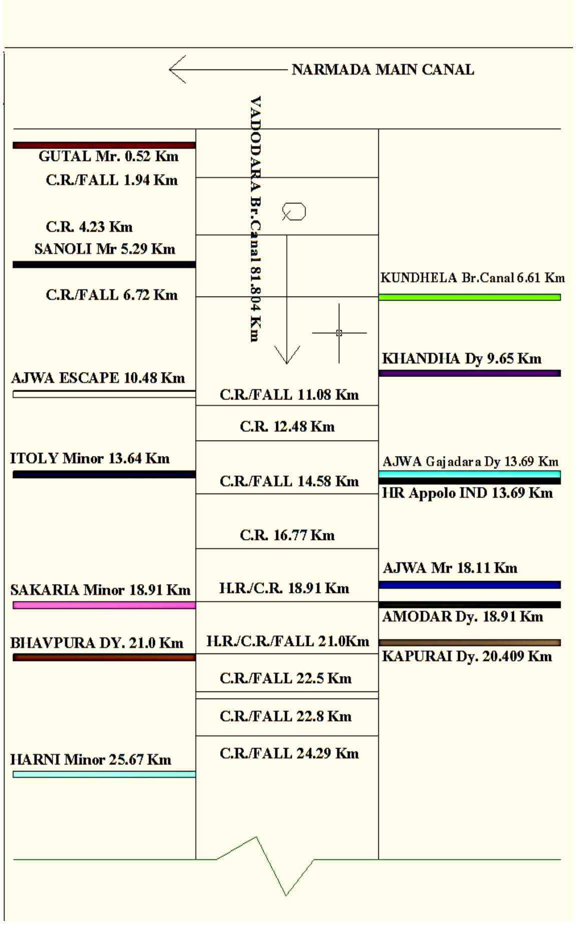
The typical line diagram of Vadodara Branch Canal is as shown in figure given below: Figure 2 - Line diagram of VBC 26 upto km.



DATA COLLECTION

1. Location and location details of falls.
2. Command area details
3. Hydraulic details of canal and canal falls.
4. Daily Discharge data for canal and for every canal fall related to SHP for the period from OCT-2011 to JAN-2014.

METHODOLOGY

- Collecting the required data for the calculation of hydropower potential through canal fall.
- Analysis of the each data collected like available head at each fall, command area, daily discharge data etc.
- The daily discharge data is available as follows:

Table 2 - Discharge data for various canal and outlets situated on VBC

SR.NO	Name of Branch Canal	Discharge in cumecs 1-Dec	Discharge in cumecs 2-Dec	Discharge in cumecs 3-Dec
1	**Vadodara Br.Canal Offtaking**	41.2010	41.6257	45.8732
2	Kadachhala dy	0.1416	0.2832	0.2832
3	Itoly dy.	0.4248	0.4248	0.4248
4	**Koprej Village Tank**	0.0000	0.0000	0.0000
5	**Through 45 No. Syphon pipe**			
6	Amodar dy.	0.5663	0.5663	0.5663
7	Gajadara dy.	0.5663	0.5663	0.5663
8	Khandha dy.	0.1416	0.1416	0.1416
9	Sakaria (Dr.)	0.1416	0.2832	0.2832
10	Ajwa Escape(Ex.VBC-10.48 Km)	0.0000	0.0000	0.0000
11	Alwa (Dr.)	0.0000	0.2832	0.2832
12	Sanoli (Dr.)	0.1416	0.2832	0.2832
13	Kapurai dy (L)	0.2832	0.2832	0.2832
14	Sankarpura Br.Dy.	0.0000	0.0000	0.0000
15	Ex Kapurai dy			
16	Chikhodra br.dy.	0.0000	0.0000	0.0000
17	Ex Kapurai dy			
18	Bhavpura dy.(R)	0.2832	0.2832	0.2832
19	**Beyond 21 Km.**	33.2723	33.2723	37.5198
20	**Kundhela Br.canal offtaking**	3.9644	3.9644	3.9644
21	**Jambusar Br.Canal offtaking**	8.7782	8.7782	8.7782

- Calculate the daily discharge data for D/S of each canal fall
- So to get the D/S daily discharge data at each canal fall by deducting the each outlet's discharge from the total discharge of the Vadodara Branch Canal (VBC).i.e.

D/S discharge at any fall = (Total discharge In VBC – discharge of no. of outlet situated on U/S of the fall)

Specimen Calculation:
D/S discharge at 6720 canal fall = Discharge (In VBC – In Gutal minor – In Sanoli minor – In Kundhela Branch canal)

= 41.201-0*-0.1416-3.9644 = 37.095 m^3/sec

*Where GUTAL canal is not in working condition

Table 3 - D/S Discharge data for various canal falls on VBC

SR.NO.	LOCATION OF FALL (CHAINAGE)(m)	Discharge in cumecs 1-Dec	Discharge in cumecs 2-Dec	Discharge in cumecs 3-Dec
1	**6720**	37.0950	37.3782	41.6257
2	**11080**	36.9534	37.2366	41.4841
3	**14580**	35.9624	36.2455	40.4931
4	**21000**	34.6881	34.5465	38.7940
5	**22500**	34.6881	34.5465	38.7940
5a	**22800**	34.6881	34.5465	38.7940
6	**24290**	34.6881	34.5465	38.7940

- Completed this calculation for data available from OCT-2011 to JAN-2014.
- After computing the daily discharge(Q), calculate the power generate from that discharge data using equation given as follows

P (kW) = Q (m^3/s) x H (m) x η_{tot} x 9.81

P = Electrical power output (kW)

Q = Rated discharge in (m^3/s)

H = Net head in (m)

For this project:

$\eta_{gearbox}$ = 93%

$\eta_{turbine}$ = 93.5%

$\eta_{generator}$ = 97%

$\eta_{total} = \eta_{gearbox} \times \eta_{turbine} \times \eta_{generator} =$ 84.35%

Table 4 – Power that can be generate on canal falls based on daily discharge

SR.NO.	LOCATION OF FALL (CHAINAGE)(m)	Power in kW 1-Dec	Power in kW 2-Dec	Power in kW 3-Dec
1	6720	1381.2821	1391.8262	1549.9883
2	11080	963.2070	970.5879	1081.3014
3	14580	1101.0423	1109.7120	1239.7563
4	21000	947.2151	943.3489	1059.3344
5	22500	947.2151	943.3489	1059.3344
5a	22800	932.8633	929.0557	1043.2839
6	24290	889.8081	886.1762	995.1323

RESULT

After the calculation, get the result for power generation capacity on various falls situated along VBC for the year 2012-2013 in following form:

Sr.no.	Month	Monthly Power can be generate in (kw)	Daily Power Generation Capacity (kw)
1	Jul-12	13090.19602	422.2643879
2	Aug-12	26492.55711	854.5986166
3	Sep-12	2772.716648	92.42388828
4	Oct-12	71243.81245	2298.187498
5	Nov-12	174156.2408	5805.208028
6	Dec-12	164612.4485	5310.078985
7	Jan-13	112903.1164	3642.036014
8	Feb-13	139292.341	4974.726464
9	Mar-13	201992.3555	6515.882435
10	Apr-13	56754.1164	1891.80388
11	May-13	2676.102259	86.32587931
12	Jun-13	1992.842108	66.42807025
	Total of Year 12-13 (kw)	**967978.8453**	**2663.330346**

CONCLUSION

- Diffusion of small hydro energy throughout the country should be given priority in solving the energy crisis.
- SHP is a cost effective and sustainable source of energy that cause less and simple construction work and in expensive equipment are required to establish and operate small hydropower projects.
- By generating small hydro energy from the abundance sources India can solve a big portion of energy deficiency.
- The total power generation capacity through various canal falls situated along VBC is 2.67 MW per day based on present daily discharge data for year 2012-13.
- This power can be enhanced on irrigation requirement as per command area development (CAD) limited upto design discharge. Which is quite valuable amount which helps in rural electrification.

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