

# Potential of Hydro Power Plant in India and its Impact on Environment

Roshni Bhoi<sup>#1</sup>, Dr. S.M. Ali<sup>#2</sup>

<sup>#1</sup> M.TECH( Power & Energy System), School of Electrical Engineering, KIIT University, Odisha, India

<sup>#2</sup> Professor, School of Electrical Engineering, KIIT University, Odisha, India

**Abstract---** This paper presents a survey report of hydro power plant in India. There are various renewable energy resources like sun, wind, water, ocean, tidal etc. Among all the source, hydro plant are emerging in the developing India. After non-renewable source like fossil fuel and nuclear, major part of the India is looking for the green energy. So for a long run point of view India Government have passed various plan and policy for the development of hydro plant where water is the main source and electricity is obtain from the flow of water. . There are various factor to be considered to run and develop a hydro plant. The plant run need a systematic process which are discuss in the paper. This paper also include the major hydro project of India.

**Keywords---** Hydro power plants, potential, policy, projects in India

## I. INTRODUCTION

About 26% of energy is contributed by hydro power to India[1]. For India, the total capacity is more than 2 Lakh MW and so hold the 5th position for electricity generation in the world. According to the 2010 census of India planning commission, nearly 28.8% of Indian are below poverty line . India's per capita consumption is among the lowest in the world. In many villages household have no access to electricity. The government has programmed for an increase in per capita availability to 1000 KWh from existing 600 KWh by the end of 11thfive year plan. To provide "Electricity for all" by 2012, is a attempt by the Indian government which was requiring an installation of additional capacity of more than 100,000 MW. The major electricity resources plant are thermal, hydro, nuclear and other renewable energy resources which includes solar, wind, geothermal, tidal, etc.

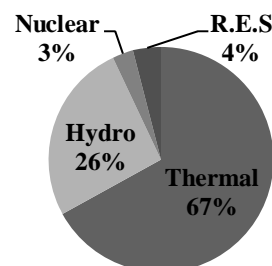


Fig 1: Different form of energy used in India

## II. HYDRO POWER PLANTS

The main source of hydroelectricity is the water which is readily available in India. Hydroelectric power defines the usage of water resources towards inflation free green energy in the absence of fuel cost with mature technology characterized by highest prime moving efficiency and spectacular operational flexibility. Water power can be used in various form. The most important way is the hydroelectric dam, where water stored is responsible for the turbine rotation and thereby capture the energy which is used to run the generator. Hydro power can be classified as: large hydro power, medium hydro power, Small hydro power. These are classified according to the power generation capacity.

- Large hydro power: >100 MW
- Medium hydro power: 30-100 MW
- Small hydro power: 1-30MW

There are some hydro plant which are used for very small scale purpose. Those are classified as: Mini hydro power whose capacity is between 100kW to 1MW and Micro hydro ranging upto 100kW. These are generally use to feel a small community or rural industry where grid is not available.

## III. MECHANISM

The water is stored behind a dam. This reservoir is located very high as height of a reservoir decide the force of water flowing to the turbine. Since the height increase the potential energy of water at the reservoir also increase. The gate control the water

flowing into the plants. Depending on the load demand the water is allowed into the turbine. The water flowing from the control gate have both potential and kinetic energy. The water flow through to the turbine through the penstock which are designed to transport water from intake to turbine without any cavitations problem. The water further increases in the penstock due to the height. The height of water at the water reservoir and amount of water into the penstock determine the total power generation by a hydro plant. Then water then allowed into the turbine generator unit. The water strikes the blade of the turbine and the potential and kinetic energy of water is converted to the rotational energy which drives the blades of the turbine. The shaft of the turbine which is enclosed inside a generator start to rotate due to the rotating blades. This rotating shaft produce alternating current in the coils of the generator. This rotating shaft inside the generation is responsible for the production of magnetic field which is further converted to the electrical energy by electromagnetic field mechanism. Thus shaft connecting the turbine and generator plays a vital role here. Thus, hydroelectric power plants produces electricity from the energy of water. This electric is the transfer to the grid.

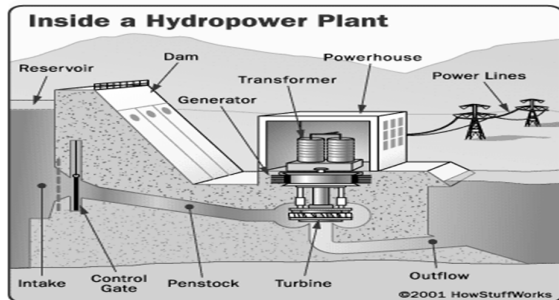


Fig 2: A inside view of a hydro electric power plant

#### IV. STORAGE SYSTEM

Depending on the capacity the storage for the hydro power can be classified as 'storage type' or 'run-of-river types'. In storage type, a dam need to be constructed across the river to store the water hence provide the ability to supply the water even at the time of critics. But in run of river type the water directly flow o the turbine no construction of dam is required here. The small hydro, mini hydro and micro hydro are the example of run of river type whereas medium and large hydro used storage type. But since India has tropical climate, generally small reservoir are prefer for the Small hydro power plant.

#### V. CIVIL COMPONENTS

It consist of the components which are responsible for the delivery and entry of the water into the turbine units. There are generally : Intakes, spillways, forebay tank, penstock, tailrace.

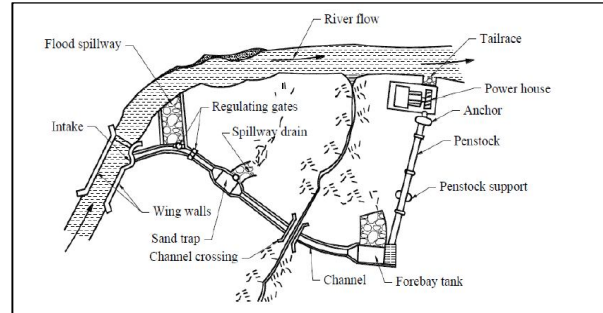


Fig 3: Layout of the Hydro power plant in an Area

**Intake:** These are the structured-diversion gates valve which divert the source of water to the hydro power plant. It helps to provide the required quantity of water toward the plant without disturbing the normal flow of river. The trash racks generally act as a filter for the aquatic animals and water born objects to enter into the waterways to the plant. Intake can be side type or bottom type. Bottom type are used for small hydro plant.

**Headrace Canal:** These also termed as waterway channel from intake to forbays. It collect the water from intake. These canal can pipe or long canals. When large hydro plant are considered the canals are constructed but in small hydro pipes are connected to forbay from the intakes. These pipes are further provided by filters which prevent mud and sand from enter the turbine system. These are constructed very careful since it help to determine the speed on the water inside the turbine.

**Spillway:** These are the basic part of hydro power plant in the flood prone areas. These are the gates which split which remove the excess water of flood by diverging their flow away from the plant, thereby minimize the adverse effect of heavy water to the plant and its components.

**Forbay tank:** These are a kind of storage tanks which are present at the end of a headrace pipe or canal. These are the input to the penstock. Their main aim is to prevent cavitations due to the entry of air into the penstock. The water of Forbay is an important factor for small hydro

plant as it determine the operational head of the plant.

*Penstock:* These are close conduct pipes used to feed water in to the turbine in hydro power plant. These are the most important civil part because at this stage the kinetic energy of water is converted to the electrical energy. The pressure inside the penstock should be maintain properly, generally 120 psi or more is better. They should have sufficient diameter so as to avoid friction losses due to moving water. Water hammering is caused by the rapid loss of momentum of the water in the pipe and this kinetic energy must go somewhere so the pipe contorts, expands and bangs against the interior of the walls to absorb the stress. The same affect will take place in a penstock with long runs with a high rate of flow. Therefore, ensure the pipe and gate valves are able to withstand these forces.

*Tailrace:* these are similar to the headrace but situated at the end of the plant. The main function is the convey the used water of turbine back to the water source.

## VI. POWERHOUSE

At the end of the every hydro project a power house is constructed which deals with the generation and supply of electricity. It also consist of control room which control each and every activity of the plant. This generally consist of turbine-generator set, drive system, Load controller and distribution unit.

*Turbine:* The part play an important role as it extract energy from the water strikes and covert this kinetic energy of water to mechanical energy. This mechanical is converted to electrical by the generator coupled with the turbine. The hydro turbine basing on the working operation can be classified as reaction turbine and impulse turbine. In impulse turbine the kinetic energy of water jet is converted to the mechanical energy whereas in reaction turbine mechanical energy is obtained from the conversion of kinetic energy of pressurized water .Base on the head it can be classified as:

Turbine type	Head range, H (m)
Kaplan and Propeller	2 < H < 40
Francis	10 < H < 350
Pelton	50 < H < 1300

The Pelton turbine is an example of Impulse turbine and Francis, Kaplan and Propeller operate in the impulse type.

*Generator:* there are various type of generator used in hydro system like synchronous generator, DC generator and Induction generator. Large hydro power plants uses synchronous generator where as for small grid induction generator are used. DC generator are to service and are used in small scale hydro plant as they produce rectified alternating current. The turbine-generator set need to be house in same place.

*Drive system & Load controllers:* It comprises of turbine shaft, generator shaft, couplings, bearings, gearboxes and pulleys. Its main function is to transmit the power produced in turbine to the generators at a stable frequency and voltage at a required speed and direction. All the hydro plant need to be control the power flow. This load control is done by the load controller. The installation of load controller depend on the generator used.

*Distribution Unit:* It include the transmission and distribution of the electricity to the consumer. Based on the capacity of hydro power plant grid are classified as local grid and extensive grid. For large hydro and medium hydro extensive grid are used, which can provide electric supply to more than 10,000 consumers. For small hydro plant can provide electric to consumer upto 10,000 so confined to local grid only. Beside this the mini and micro hydro plant are standalone type they don't require grid. A storage system such as battery is feed to such type of system. Again based on the distribution system load can be also classified as load plant and peak load plants.

TABLE I  
COMMON DIFFERENCE BETWEEN HYDRO POWER PLANTS

FACTORS	LARGE HYDRO PLANTS	SMALL HYDRO PLANTS
TURBINE	Francis turbine & Pelton turbines	Kaplan turbine
STORAGE TYPE	Reservoir storage	Run-of-river
POWER	100 MW+	1 MW – 10 MW
GRID SYSTEM	Extensive grid	Local grid
GENERATOR	Synchronous	Induction

HEADS	100meters +	2-100 meters
INVESTMENTS	Large construction cost, Large maintenance cost	Low construction cost Less maintenance cost
CATCHMENT	Requires a large area for water storage	Small area is required as it is based on run-of-river
CONSUMERS CAPACITY	1-10,000	>10,000

## VII. ENVIRONMENTAL ASPECTS

### A. Benefit of hydro plant

*Renewable and green:* It's a green and renewable form of energy. Its availability is unbounded. It emits low carbon emission and is eco friendly. Its help in reducing the global warming. However, Water is source which is unlimited and cannot finish at any point of time, there are limited number of areas where a profitable hydro power plants can be constructed. But still it is a step to green energy.

*Reliability:* Hydro electricity is very reliable. The fluctuation in terms of electric power is very less. This fluctuation is also seen when there is demand of different output. So, Countries which large hydro resources use hydro electricity as energy source base load.

*Flexibility:* Using the closing and opening of gate the water flow control become easy. As the time of high consumption there the opening of extra gate increase the water flow and more electricity is produced. Similarly which there is low consumption, some the gate are closed to meet the requirement.

*Vegetation and Fishery:* The area near to a hydro plant can be used for various vegetation. Since water is stored in reservoir the water never get surplus so even in summer the vegetation can be watered from the plant. Beside hydro plant also promote fishery farms.

*Safety:* It a safer compare to fossil fuels and nuclear energy. These plant uses chemical whose regular expose to body can lead to various health problems. Beside this construction of dam also provide safety during the flood and drought.

### B. Problem Associated

Though water is renewable source hydro electric plant cannot be constructed anywhere. Suitable weather condition, local habitat, climatic condition, flow of water, head, are the various factor to be considered while construction a dam of a hydro project. The site should be suitable for the construction of dam and other parts. A large part of the land area is required to install a hydro project so may create disturbance to the local habitat. Requirement of large area is meet by the afforestation programme which disturb the ecosystem. Sometime many aquatic animal are also affected by the construction of dam across a water mass.

The area shouldn't be flood or earthquake prone. The less erosion area is highly preferable. Sedimentation in hydropower reservoir reduces the storage capacity thereby creates problem for the water speed. Action of silt damage the turbine and other equipments.

Hydro plant construction is quite expensive. It requires more manpower compared to other power plants. Its maintenance cost is also high. Since various electric machine and drive are associated with the plant, the loss factor is also high.

## VIII. HYDRO POWER PLANT PROJECTS IN INDIA

India ranks third after China, USA and Russia in the world in terms of numbers of dams. Nearly 4720 large dams have been completed in the country. Hydro generating unit sizes has been increased from 22 MW (from the independence) to 250 MW till today. India has 20 underground power stations with total installed capacity of 9930 MW commissioned so far and 21 power stations with total capacity of 9951 MW are under construction. At present maximum station capacity is 2400 MW is at Nathpa Jhakri hydro station in Himachal Pradesh. The Tehri dam on Bhagirathi River near Tehri in Uttarakhand, is the highest dam in India and possess the tenth position for being the tallest dam in the world. The Hirakud dam on the Mahanadi river, near Sambalpur, Odisha is the longest dam (57.8Km) in the world and was first hydro multipurpose project after independence. The second largest hydro power plant is the Koyna Hydroelectric dam (capacity of 1,960MW)situated at the western ghat of India. Beside these, the

Srisailem Dam across the Krishna River at Srisailem in the Kurnool district of Andhra Pradesh, the Sardar Sarovar Dam on the Narmada River near Navagam, Gujarat, the Bhakra-Nangal Dam a concrete gravity dam across the Sutlej River, Bilaspur, Himachal Pradesh and the Nagarjuna Sagar Dam on the Krishna River at Nagarjuna Sagar Andhra Pradesh are other major leading hydro project in India under operation.

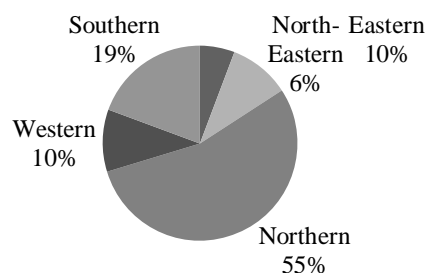


Fig 3: India's region wise potential

TABLE II  
LIST OF HYDRO PROJECT IN INDIA

Sl. No.	State	Total capacity (MW)	Projects installed Capacity (MW)	Number of installed project
1.	Andhra Pradesh	250.50	178.850	57
2.	Arunachal Pradesh	1243.47	45.240	68
3.	Assam	119.54	2.110	3
4.	Bihar	149.35	50.400	7
5.	Chhattisgarh	482.82	18.05	5
6.	Goa	4.60	0.05	1
7.	Gujarat	186.37	7.0	2
8.	Haryana	36.55	62.70	5
9.	Himachal Pradesh	2019.03	141.615	61
10.	Jammu & Kashmir	1294.43	111.83	32
11.	Jharkhand	170.05	4.05	6
12.	Karnataka	1940.31	441.25	70
13.	Kerala	455.53	98.12	16
14.	Madhya Pradesh	336.33	51.16	9
15.	Maharashtra	484.50	209.33	29
16.	Manipur	92.75	5.45	8
17.	Meghalaya	197.32	30.71	3
18.	Mizoram	135.93	17.47	16
19.	Nagaland	149.31	20.67	9
20.	Odisha	217.99	7.30	6
21.	Punjab	270.18	123.90	29
22.	Rajasthan	27.82	23.85	10
23.	Sikkim	214.33	39.11	14
24.	Tamil Nadu	373.46	89.70	14
25.	Tripura	30.85	16.01	3
26.	Uttar Pradesh	267.06	25.10	9
27.	Uttaranchal	1478.24	80.67	88
28.	West Bengal	213.50	98.40	23

TABLE III  
REGION WISE DISTRUTION OF HYDROELECTRICITY

REGION	POTENTIAL (in MW)
North-Eastern	3187
Eastern	5590
Northern	30155
Western	5679
Southern	10763

IX. POLICY FRAMED TO ACCERATE THE HYDRO DEVELOPMENT

*National Water Policy:* This was notified on 2002 by the Government of India. In planning and operation of system, the main priority of water allocation should be to the irrigation, drinking, hydro power, agro industries, ecology , navigation, non-agriculture industries and other water uses. This policy was further revised in 2012 as Draft National Water Policy.

*Electricity Act 2003:* This provide an open access to the transmission at the outset and in distribution in phases. It give freedom for captive generation and multiple distribution licenses in a supply area. It provides recognition of trading as an independent activity.

*Policy of Hydro Power Development:* This policy was notified by Government of India on 31 March 2008. Its main aim to provide level platform to private developers. It maintain a transparent selection criteria for site selection and also provide merchant sales upto 40% maximum value of the saleable energy.

There are various hydro power plant plan which can be described as follows:

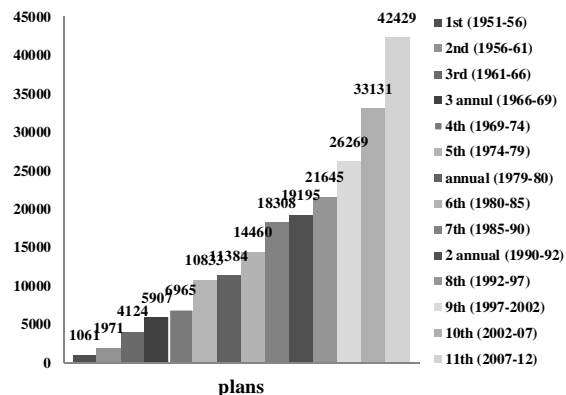


Fig 4: 11 hydro electricity plan from 1951-2012

By 14th plan i.e. 2022-2027, the government have plan to develop a balance potential. Step are taken care to survey and investigation of the activities of all the indentified hydro projects in India by the end of 12th Plan 2012-2017.

## X. CONCLUSION

India's power sector is poised to grow at a fast pace in the coming years. This is a crucial stage for the country's economic growth as it had to stain with the changing world. Measures are being implemented and policy are initiated by the state as well as central government for the betterment of the energy sector of India. Being having a tropical climate , major part of India depend on hydro electric power. Hydro plant are profitable in a environmental aspect as well in economic aspect. Since it a green and clean renewable energy, its development can meet the future demand in electricity. These are the plant which can be constructed on small river so many part of India which are away from the grid having a better resource can implement this form of energy for the basic need. It help in irrigation and cultivation. It also becomes a storage to household during the summer. A hydro plant in So, India govt. should develop more schemes and policy toward the water project. Beside constructing the new plant the old plant should renovated and modernized with new power drives.

## REFERENCES

- [1] Rajan A. T., 2000. Power Sector Reform in Orissa: an ex-post analysis of the causal factors, *Energy Policy*, 28: 657-669.
- [2] MoEF (Ministry of Environment and Forests) 1980. Forest (Conservation) Act, 1980 with Amendments Made in 1988.
- [3] MoP (Ministry of Power), 2008. Hydro Power Policy 2008. (New Delhi: Ministry of Power, Government of India).
- [4] MoP (Ministry of Power), 1998. Policy on Hydro Power Development. (New Delhi: Ministry of Power, Government of India).
- [5] MoRD (Ministry of Rural Development), 2007. The National Rehabilitation and Resettlement Policy, 2007. (New Delhi: Department of Land resources, Land reforms Division, Government of India).
- [6] Nandimath O. V., 2009. Oxford handbook of environmental decision making in India: An EIA model, New Delhi: Oxford University Press.
- [7] Sectoral Overview Report on Hydropower Development in India, AHEC, IIT Roorkee, February 2007.
- [8] P. Saxena and Arun Kumar, "Small hydropower development in India", special publication 25 years of Renewable Energy in India, MNRE, New Delhi, 2007
- [9] Central Electricity Authority, Hydro Development Plan for 12th Five Year Plan, New Delhi, Sept 2008.
- [10] Rudresh Sugam and Urvashi Sharma (2013) "Water data and measurement," Issue brief for the Fourth CEEW-Veolia Water Roundtable on Urban Water Management, 27 May
- [11] Rudresh Sugam and Urvashi Sharma (2013) "Regulatory framework for urban water management in India," Issue brief for the Third CEEW-Veolia Water Roundtable on Urban Water Management, 9 April
- [12] Hermann-Josef Wanger, Jyotirmay Mathur 'Introduction to hydro Electric Systems: basic, technology and operation,' ISSN 1865-3529, ISBN 978-3-642-20708-2, Springer Heidelberg , 2011
- [13] Josepha Sherman 'hydroelectric power' Fact Finder by Capstone Press, 151 Good Counsel Drive, 669, Mankato, Minnesota, 2004
- [14] Working Group on prime Mover and Energy supply models for system Dynamics Performance Studies 'Hydraulic turbine and turbine control models for system dynamic studies' Power systems, IEEE Trans.Vol.7, Issue 1 p.167-179., 1992.
- [15] Atsushi Izena, Hidemi Kihara, Toshikazu Shimujo, Kaiichirou Hirayama, Practical hydraulic turbine Model.', IEEE Conference on, 2006.
- [16] Dr. B. R. Gupta 'Generation of Electrical Energy', Sixth Edition, ISBN : 81-219-0102-2, by Eurasia Publishing House.
- [17] Vineesh V, A. Immanuel Selvakumar, 'Design of Micro Hydel Power Plant', IJEAT, Vol. 2, issue 2, pp. 136-140, December 2012
- [18] C.Jaliu, I. Visa, D. Diaconescu, R. Saulescu, M. Neagoe,'Dynamic Model of a Small Hydropower Plant' , Optimization of Electrical and Electronic Equipment, IEEE trans. Pp: 1217-1223, 2010
- [19] Louis N. Hannett, B. Fardanesh, 'Filed test to validate Hydro Turbine Governing Model structure and parameter', IEEE Trans. On Power System, Vol.9, Issue 4, pp. 1744-1751, November 1994
- [20] H. Weber, F. Prillwitz, 'Simulation models of the hydro power plants in Macedonia and Yugoslavia', IEEE Bologna powerTech Conference, 23-26 June, 2003
- [21] P.S Nigam 'Handbook of Hydro power electric Engineering', Second Edition, NAbhi Publication, N-101A second Floor, Munshiram Building, New Delhi-110001
- [22] Carmen L.T Borges and Roberto J. Into, 'Small hydro power plants energy availability modeling for generation reliability evaluation', IEEE Trans. On Power System, Vol. 23, Issue 3, pp: 1125-1135, August 2008