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Hydropower and Environment Study pertaining to Indian Scenario-A Review

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Abstract: Role of Hydropower is essential for both the renewable form of energy and its contribution towards nation building, but the impact has to be studied so that it does not affect the environment. Symbiotic methods of hydropower generation have to devised in such a manner that generation capacities gets increased without putting a load on the nature.

I. INTRODUCTION

A. History of Hydropower Generation

Vitruvius was the first architect to explain that water wheel could generate power. The Barbegal from France in the 4th century A.D. worked on water wheels and generated a system of sixteen water wheels which followed the principle of kinetic energy into mechanic energy.

The world's first hydroelectricity project was used to power a single lamp in the Crag side country house in Northumberland, England, in 1878. Four years later, the first plant to serve a system of private and commercial systems was opened in Wisconsin, USA, and within a decade hundreds of hydropower plants were in operation. In Indian scenario the oldest hydropower station is Sidrapong Hydel Power Station located at the foothills of Arya Tea Estate at an altitude of 3600 ft and 12 km from Darjeeling. The first plant consisted of two 65 kW Crompton – Brunton single phase, 2300 volts and 83.3 Hz alternators coupled with two Gunter turbines. India is the 7th largest producer of hydroelectric power. Hydropower potential of 84000 MW at 60% load factor is one of the largest in the world. The present installed capacity as on 31st March 2016 is 42783 MW which is 14.35 % of total utility electricity generation capacity in India. Hydropower is considered as one of the most economic and non-polluting source of energy. Power generated from water is termed as hydroelectricity, meaning electricity generated by hydropower or from the use of the gravitational force of falling or flowing water. This form of energy neither produce any direct waste matter nor is subjected to exhaustion. The beauty associated with hydroelectric power is its simplicity it follows a simple procedure which takes place by the conversion of forms of energy into one another and finally into work. Hydropower fills the 15 % of the world's electricity requirements.

State Wise Hydropower Generation: (as of Nov. 2015)

State	Generation Capacity (in MW)
Andhra Pradesh	1758.87
Arunachal Pradesh	97.57
Assam	429.72
Bihar	129.43
Chandigarh	62.32
Chhattisgarh	120
Delhi	822.05
Gujarat	772
Haryana	1456.83
Himachal Pradesh	3421.51
Jammu and Kashmir	2255.21
Jharkhand	200.93
Karnataka	3599.80
Kerala	1881.50
Madhya Pradesh	3223.66
Maharashtra	3331.84

Manipur	80.98
Meghalaya	356.58
Mizoram	34.31
Nagaland	53.32
Orissa	2166.93
Punjab	3145.13
Rajasthan	1719.30
Sikkim	270.27
Tamil Nadu	2182.20
Telangana	2095.66
Tripura	62.37
Uttar Pradesh	2168.30
Uttarakhand	2441.82
West Bengal	1288.30

It is the largest renewable resource, presently only 150000 MW of energy which is about 17 % of the potential has been tapped so far in India where as in Countries like Brazil, Canada and Norway has been extracted 30 % or more of their hydro potential. Hydropower combined with other purpose not only provides power, but it controls flooding and store irrigation water. The water reservoir can be a important source of CH_2 and CH_4. The hydropower development depends on various factors which include tactical difficulties and political opposition dearth of adequately invested projects land acquisition problem environmental concern, regulatory issue, power evacuation problems, long clearance and approval procedure, the dearth of good contractor and sometime law and order problem and interstate issue are the cause for the slow development of hydropower. Model calculations show if an investment amounting EUR 380 million ensures approximately 30000 jobs per year during the construction phase and around 2500 jobs during the operational phase. Around half of this total effect is caused by the multiplier effect arising from an increase in income. Hydroelectric energy is renewable. This means that we cannot use up. However there is only a limited number of suitable reservoirs where hydroelectric power plants can be built and even less places where such projects are profitable. Generating electricity with hydro energy is not polluting itself the only pollution occurs during the construction of these massive power plants. Hydro electricity is very reliable energy there are very little fluctuations in terms of the electric power that is being the plants, unless a different output is desired. Countries that have large sources of hydropower use electricity as a base load energy source as long as there is water in the magazines electricity can be generated. At times where the power consumption flow water is reduced and magazine levels are being conserved for times when the power consumption is high compared to among other fossil fuels and nuclear energy, hydroelectricity is much safer there is no fuel involved.The environmental consequences of hydropower are related to interventions in nature due to damming of water, changed water flow and construction of roads and power lines. Hydroelectric power plants may affect fish is a complex interaction between numerous physical and biological factors. Building power plants in general are expensive. Hydroelectric power plants are not an exception to this on the other hand, these plants do not require a lot of workers and maintenance cost are usually low. Electricity generation and energy prices are directly related to how much water is available. In the present work a relationship is being tried to be established between the benefits which are being achieved by making use of this highly dependent renewable energy resource and its environmental impact assessment.

B. Positives drawn out of hydropower

Propelled by sustained economic growth and rise in income levels, India is poised to face significant increase in energy demand in the next few decades which also translates into higher demand for electricity. The gap in the electricity demand supply situation is highlighted by the fact that the country experienced a peak deficit of 5.2 % and energy deficit of 4.2 % in F.Y. 13 – 14 with the surplus western and eastern region unable to compensate for the severely deficit Northern, Southern and North Eastern Region. Considering energy elasticity of .8, India is projected to require around 7 % annual growth in electricity supply to sustain a GDP growth of around 8.5 % p.a. over the next few years. This requires tapping all potential sources to address the deficit and meet the demand growth for accelerating economic development while taking into account considerations of long term sustainability, environmental and social aspects. Climate change and other negative effects of using fossil fuels for use of power generation along with growing concerns over energy security are driving the expansion of hydropower around the world. Conversion efficiency of

Thermal plant is also about 40 % as against 80 % for hydro which means that for every 1 million units actually generated 1.5 million is wasted. India is endowed with rich hydropower potential to the tune of 148 GW (which would be able to meet a demand of 84 GW at 60 % load factor) which makes it one of the most important potential sources to meet the energy security needs of the country. Hydropower plants can also start and shut down quickly and economically giving the network operator vital flexibility to respond to wide fluctuations in demand across seasons and at different times of the day. This flexibility is important in a highly populated country like where household electricity demand is a significant portion of total demand and this demand in concentrated in a short period of time. While hydropower plants have large upfront capital cost they also have long and productive lives, which sufficiently help reduce costs overtime. For e.g. the Bhakhra Nangal plant now more than 40 years old has a operating cost of only Rs. 0.10 per unit. Hydropower plants are thus generally cheaper in the long run than the natural gas based plants, which are constantly at risk from fuel price fluctuations in the global market. While India plans to develop mainly run off river projects, multipurpose hydropower plants with water storage facilities can help manage critical water resources in an integrated manner by serving as flood controls as well as sources of irrigation and much needed drinking water. The Tehri dam in Uttrakhand, today caters to one third of the drinking water needs of Delhi. Dams and reservoirs are designed to last over 100 years which other type of energy source has such a long life? The long life of the hydro project can be deciphered from the fact that the first hydro project of India is still in operation at Darjeeling.

The cost of generation of the various sources of power generation in India according to Rangan Banerjee (Forbes Marshall Chair Professor, IIT Bombay) is as follows:

S. No.	Source	Cost of Generation Rs./ kWh
1.	Coal	3
2.	Gas	3.5 – 4
3.	Nuclear	4
4.	Solar PV	10
5.	Solar Thermal	15
6.	Wind	4 – 6
7.	Hydropower	2.5 – 3.5

As according to the table it can be correctly deciphered that hydropower generation in the current scenario is the cheapest form of energy available and the potential of this source should be utilized to its utmost without wasting any drop of it.

C. Negatives associated with Hydropower

Positive Impacts of Hydropower are good enough to make one believe that it is a must require in the present day scenario for the nation to move forward, but what comes with positives also does carry some negatives. Historically many dam projects were evaluated based only on projected economic benefits and the direct cost of the dam construction, ignoring the other potential losses in environmental degradation, cultural destruction and displacement of affected people. When one factors in these negative externalities, it is unclear whether dams are net positive or net negative. In addition, dams and other large infrastructure projects are prone to cost overruns and delays, which can turn an initially net positive project in net negative by the time of completion.

The cost benefit analysis is a useful tool in deciding whether a proposed dam is the best option. Cost benefit analysis originated with the Kaldor – Hicks criterion, which states that a public policy is justified if it produces social gains in excess of social losses so that it is possible from the policy to compensate loosers. A simple cost benefit analysis would consist of calculating the projected economic benefit of the dam and weighing it against the economic cost of building a dam. Increased agriculture productivity does not necessarily lead to increased income, since a large increase in supply of agriculture, all else equal would lead to drop in agriculture price. The dam should also be weighed against the opportunity cost of other critical infrastructure projects and water management solutions. If the dam project has the highest estimated rate of return then planners ought to move forward with it. If it does not another project should be chosen.

Variety of works have been conducted by the various scholars and environmentalists and the following conclusion has been achieved

The various issues associated with the hydropower development in India:

1) Environmental Issues: hydropower facilities can have large environmental impacts by changing the environment and affecting land use, homes and natural habitats in the dam area.

Most hydroelectric power plants have a dam and a reservoir these structures may obstruct fish migration and affect their population. Operating a hydropower plant may also change the water temperature and the rivers flow, these changes may harm native plants and animals in the river and on land.

Reservoirs may cover peoples home, important natural areas, agricultural land and archaeological sites so building dams can require relocating people. Methane a strong greenhouse gas can also be formed in some reservoirs and be emitted to the atmosphere.

2) *Land Submergence:* Submergence of land is a major impact of large hydropower project. Such projects are often also dogged by siltation, delays in construction and heavy debt burdens – factors that are not considered in the project planning exercise. The submergence impacts are as :

a) Loss of forested land
b) Loss of agricultural land
c) Loss of wildlife habitat
d) Loss of Human habitat

3) *Interstate Disputes:* a large number of river water disputes are going between the various states in India because of the construction of the dams. Rivers like Cauvery, Krishna, Tungabhadra, Aliyar and Bhivani, Godavari, Narmada, Mahi, Ravi, Beas Satluj, Yamuna, Karmanasa, Barak River have always been a bone of contention between the states for their waters.
4) *Impacts on Civic Amenities:* a large amount of disruption is made by the construction of hydro power projects in roads, quarries, transmission lines.
5) *Natural Calamities:* hydro projects are located in hilly terrain landslides, hill slope collapses, road blocks etc. Particularly during monsoon season because of heavy rains and unprecedented floods cause severe setbacks in construction leading to time and cost over – runs.
6) *Seismicity:* the biggest challenge offered to hydropower generation is the effect of hydraulic induced seismicity.

a) *Seismic Seiches:* these are standing waves set up on rivers, reservoirs, ponds and lakes when seismic waves from an earthquake pass through an area. They are in direct contrast to tsunamis which are giant sea waves created by the sudden uplift of the sea floor. The biggest of hydropower generating plants are falling in seismic zone IV which make them highly susceptible to seismic Seiches.
b) *Geological Fault Zones:* it is has been a established fact that the hydro pressure on the fault zones can reduce the gap between the geological zones which can result in the seismic activity. In these reservoirs the weight of the water column can significantly change the stress on an underlined fault or fracture by increasing the total stress through direct loading or decreasing the effective stress through the increased pore water pressure. When the reservoirs are filled or drained induced seismicity can occur immediately or with a small time lag.

For triggered Earthquakes to occur, the area is under considerable tectonic stress:

Reservoir Induced Seismicity is a transitory phenomenon which will occur either immediately after filling of the reservoir or after a delay of few years. If there is a delay this depends on the permeability of the rock beneath the reservoir. Once stress and pore pressure fields have stabilised at new values, reservoir induced seismicity will cease. Earthquake hazard will then revert to similar levels that would have existed if the reservoir had not been filled.Even for those reservoirs that show a correlation between earthquake activity and water level. RIS does not continue indefinitely as it is limited by the available tectonic energy.

D. Depth of Reservoir Triggered Seismicity

Depths of reservoir induced earthquakes, especially those occurring immediately after filling of the reservoir, are normally very shallow. If detailed seismograph coverage is available then depths within 1 to 3 km of the surface are common.

Induced earthquakes at reservoirs that have experienced delayed triggering may be much deeper than, perhaps as deep as 10 to 20 km. These may occur 10 to 20 years after filling of the reservoir.

E. Prediction of Reservoir Triggered Seismicity

It is not easy to predict whether a new reservoir will experience RIS, because the two most important factors - the state of stress and the rock strength at earthquake depths cannot be measured directly. This is the same reason why prediction of normal (non- induced) earthquakes is normally unsuccessful.

II. DISCUSSIONS

Methods are to be devised so as to reduce the effect of hydropower on the environment and such techniques be adopted that the generation capacity increases:

A. To reduce the effects on Environment Following Methods has Been Advised

Run off River type projects: It emits nearly no carbon, no mercury and no particulate matter, because water is dense can produce a lot of energy for a relatively small environmental disturbance. Streaming hydroelectric projects typically cast a very small ecological footprint – provided good design principles are followed. Streaming hydropower projects are usually much smaller. As they are smaller they produce less electricity per site. But because they can create usable power from much smaller streams, there are many more opportunities to use them. Streaming hydro sites also tend to be located closer to the point of electricity usage, substantially reducing the line losses inherent to large power plant designs. Advantages associated with small hydropower Projects: Flooding of the upper part of is not required as it doesn't need a reservoir. As a result, people living at or near the river don't need to be relocated and natural habitats are preserved, reducing the environmental impact as compared to reservoirs. The streaming hydropower projects don't use a dam which eliminates the fish barrier associated. Small run off river projects are free from many of the environmental problems associated with their large scale relatives, because they use the natural flow of river and thus produce relatively little change in the stream channel and flow. The dams built for some run off river projects are very small and impound little water and many projects do not require a dam at all. Thus effects such as oxygen depletion, increased temperature, decreased flow and rejection of upstream migration aids like fish ladders are not problem for many of the run off river projects.

B. Method to incrEase the Capacity of Generation

Comparative Study of the Projects:

A Comparative study of the Top 10 largest power Generating Hydroelectric Dams in India:

Project Name	Type (material)	Height (m)	Capacity (MW)
Tehri	Earth fill and Rock	260.5	2400
Koyna	Concrete	103	1960
Srisailam	Concrete and Earth Fill	145	1670
Rampur HEP and NJPC	Concrete	62. 5	1912
Sardar Sarovar	Concrete	163	1450
Bhakhra Nangal	Concrete	226	1325
Indirasagar	Concrete	92	1000
Nagarajuna Sagar	Masonry	124	816
Idduki	Concrete	168.91	780
Hirakud	Earthen	61	347.5

The table above is prepared to show that the individual dams are able to generate lesser power as compared to the projects which work in tandem.

Rampur HEP and NJPC work in tandem with a single reservoir with the HEP using the outflow water from the larger NJPC project. The dam construction required in case of this project is 62.5 m reservoir for the generation of 1912 MW of energy for both the plants.

This method of working of two projects from a single source can be beneficial where sufficient head can be achieved by the provision of the HRT as the water outflow from one source can be useful in generation of energy at the second source.

III. CONCLUSIONS

From the above data which has been prepared it can be inferred without much ado that hydropower is a boon that is required for a developing country where the nations GDP as a whole is dependent on the energy sources.

Also hydropower does a play a major role in the amount of the renewable form of energy as the cost of generation of hydropower energy with the passage of time is very cheap as compared with the other sources of energy.

Environmental impact Assessment should be carried out in a proper manner before the commissioning, so as the project not only benefits as a renewable source of energy but also reduce the load of the construction of the project on the environment.

Another factor which could benefit the hydropower generation is by making use of the 25000 MW source of small hydropower potential which itself is a source of non-pollution and the other factors like submergence of land, displacement of people, chances of droughts are minimised.

Another important associated with the Hydropower generation is that the costs of land submergence, dislocation of the population, the loss of the flora and fauna, the cost associated with droughts, change of irrigation patterns, landslides should also be given a weightage in the cost benefit analysis of the project so as to reach at an accurate benefit cost ratio of the project.

Finally it can be said “Smart power, Clean power: Smart India, Developed India” feel the power of water.

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