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Scenario of Small Hydro Power Projects in India and Its Environmental Aspect

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Abstract - *In India, many people from rural area or isolated area or where distribution of electricity is not possible are not getting facility of electricity and we all know that how electricity is important in our daily life. Also India said in Action plan that is submitted to the UN climate body, UNFCCC, that 40 percent of its electricity in 2030 from "Non fossil fuel based sources" like solar, wind or hydropower. To minimize this problem Indian government keen to install small hydro projects in various potential sites. The main aim of this paper is to give the details of total potential projects and sites for small hydro projects in India which include developed, under developing and to be developed. This review provides the No. of Sites and Capacities in different States of India. Also take out critical issues facing by Investors, Stake holders, Agencies, etc. For development of the Small Hydro Power projects, Government gives Incentives/Subsidies to the Govt. / Private sector. It gives the details of financial support given by Govt. of India. This article also gives the details of Greenhouse gas (GHG) emission by various resources.*

***Key Words*: Hydro Power Plant, Power, Small Hydro Power Projects, Schemes, Classification, Greenhouse Gas Emission, G-res Tool.**

1. INTRODUCTION

Electricity plays an important role in our daily life. Electricity produced in India by two types of energy: Non Renewable energy (Fossil fuels and inefficient coal based power plant) and Renewable energy (Wind, Tidal, Hydro, etc.). Estimated that total power requirement to addressed the need of country is about 309.680 billion kWh per during period year of 2017-18. But available power is about 307.755 billion kWh, so power shortfall by 1.925 billion kWh (-0.6%). The peak demand was 1,59,816 MW but available power was 1,58,393 MW, so shortfall by 1,423 MW (-0.9%).[1]

It can be seen from Chart no. 1 that how power generation is growing year by year:

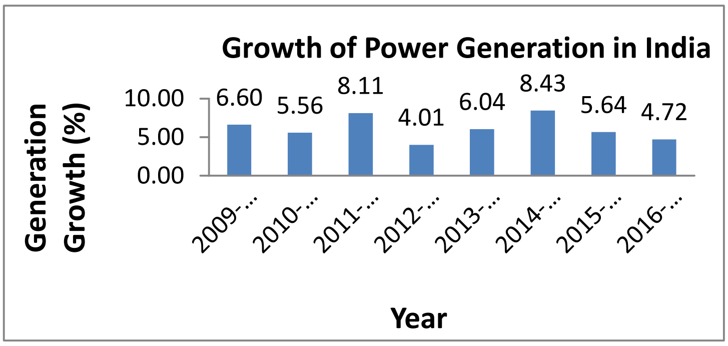


Chart no. 1: Groth of power generation in India over year. [1]

Billions of people around the world have no access of electricity, in India it is near about 300 million people. Due to immense pressure on power generation to meet the power demand, India is looking forward to Non-conventional approach by setting up power plant driven by Non-conventional energy like small hydro project, biomass power, wind, tidal, hydro, solar, biomass gasifier, etc. Total installed capacity for Power generation by different resources is shown by fig.1:

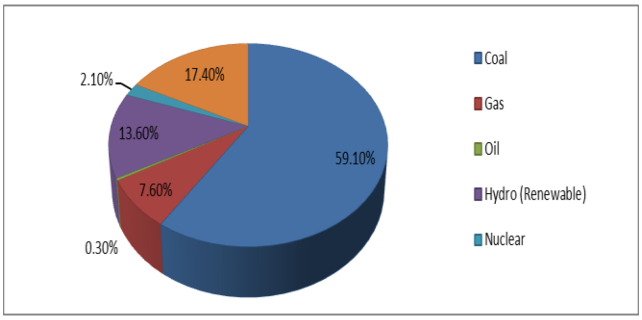


Fig. 1: Different types of energy used in power generation.

2. HYDRO POWER PLANT:

2.1. Brief History:

The world's first hydroelectric project is used to power an arc lamp in the Crag side country house in Northumberland, England in 1878. In 30 September, 1882, the first plant Vulcan Street plant is commissioned in Wisconsin, USA to serve a system of private and commercial customer of power output 12.5 kW. [2]

India is the 7th largest producer of hydroelectric power. India has been always a dominant player in global hydroelectric power development. First hydroelectric plant is in India was established at Darjeeling in 1898 and after four years, another plant established at Shivanasamudram.[3]

2.2. Classification:

Hydro Power Plant can be classified on the basis of Head required, Capacity of Power production, Purpose, Types of projects, Transmission systems, etc.

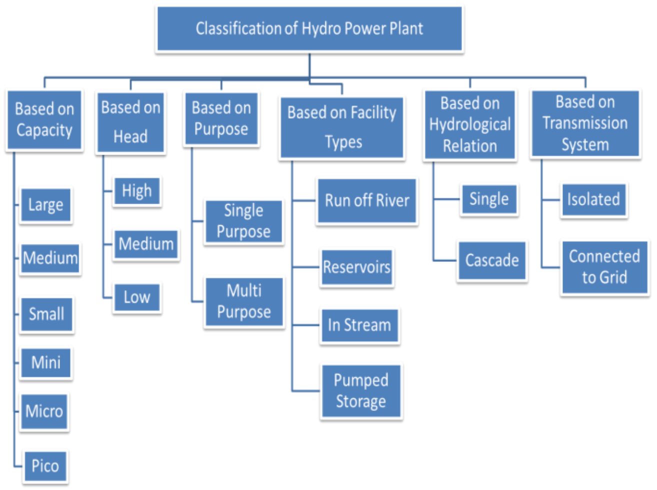


Fig. 2: Classification of Hydro Power Plant.

2.3. Working Principle:

Basic principle is that conversion of energy of water into electrical energy. Water comes from the reservoir by opening of gate of Dam which carries potential energy is covey to the inlet of turbine by means of large diameter pipe called Penstock. At the end of penstock Nozzle is fitted to give the kinetic energy to the water. Water from the nozzle hits the blades of turbine and exerts an impulse force which spins the blades of turbine. Blades are fitted on the periphery of runner which is connected to generator.

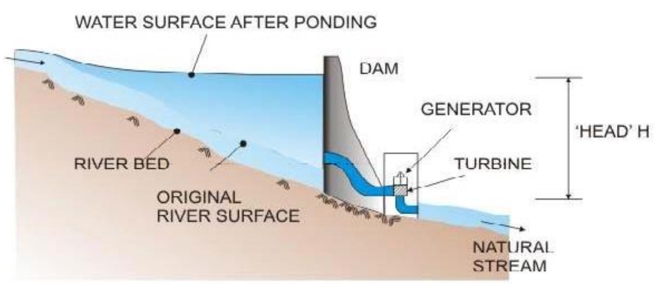


Fig. 3: A typical arrangement of Hydroelectric Power Plant.

Power production of any plant depends mainly on the Density of flowing fluid, Elevation between Head race and Tail race known as HEAD, Discharge of flowing fluid at the exit of nozzle and Efficiency of plant.

$$\text{Power (Watt)} = 9.81 \times \text{Density} \times \text{Available Head} \times \text{Discharge} \times \text{Efficiency}$$

2.4. Hydroelectric Schemes:

There are mainly four schemes are used widely and they are:

2.4.1. Run-of-river without Pondage:

This type of Hydroelectric Plants is that which use stream as it comes, that means there is no requirement of storage. This scheme is only beneficial if stream flow is available throughout the year or which stream has minimum Dry season. [4]

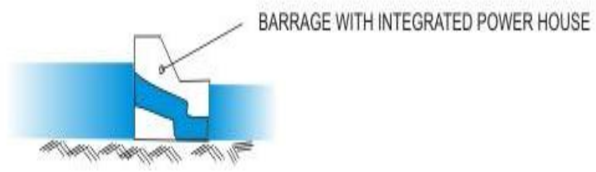
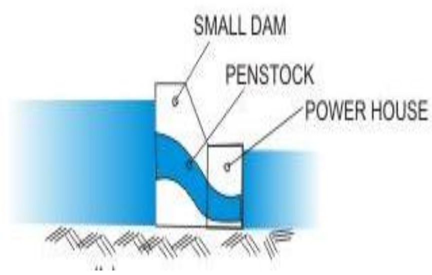


Fig. 4: Run-off-river without pondage (no storage). [4]

2.4.2. Run-of-river with Pondage:

In this scheme some storage is provide to compensate the variation of stream in river due to change in season like Dry or Wet, Load fluctuation, etc. At off-Peak load condition, most of units are shut down. So storage space conserved the excess water and allowed it to flow when load is at Peak. In this scheme some storage is provide to compensate the variation of stream in river due to change in season like Dry or Wet, Load fluctuation, etc. At off-Peak load condition, most of units are shut down. So storage space conserved the excess water and allowed it to flow when load is at Peak.



Fig, 5: Run-off-river with Pondage. [4]

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2.4.3. Storage Schemes:

A large storage capacity reservoir is developed by constructing a Dam across the river. [4]Generally excess water of rain fall is store in reservoir and releases it gradually during lean flow. There is more certainty of availability of stream as compared to Run-of-river scheme.

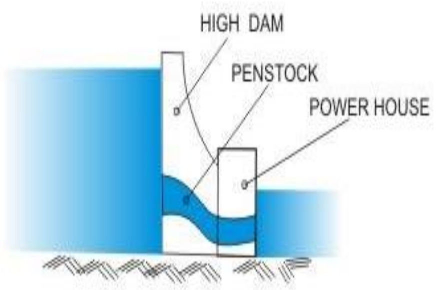

Fig. 6: Hydroelectric Plant with storage (Reservoir). [4]

2.4.4. Pumped-Storage Schemes:

This scheme used the flow at higher potential to one at lower potential to generate electricity. This is mainly used for Load balancing. The water is release from the upper reservoir to run the turbine during Peak demand. During off-Peak demand excess power is used to run the pump for deliver water from lower reservoir to upper reservoir.

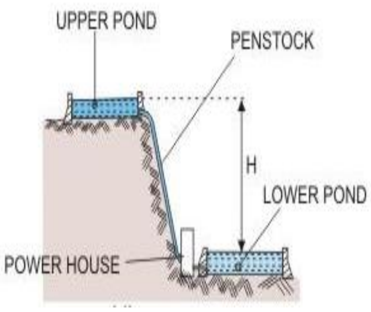

Fig. 7: Pumped-storage scheme. [4]

3. SMALL HYDRO POWER IN INDIA:

First small hydro projects in India having 130 kW capacity commissioned in the hill of Darjeeling in 1897. Since then around 700 small hydro projects with less than 25 MW capacities are already commissioned. About 57,260 MW (21.2%) of total power generation is contributed by Renewable energy resources. India targeting 175 GW power generation from RES by 2022. Out of 175 GW, renewable energy sector of India targeted 5 GW from small hydro Power projects. [5]

To meet the electricity demand especially in rural and remote areas, India move towards small hydro projects where free water flow is used for clean source of power generation. Small hydro projects have been playing vital role in power generation where transmission of electricity is not feasible since 1897.

3.1. Classification of Small Hydro Power in India:

Small Hydropower plant can be classified by two ways, either by Capacity or Head:

Table no. 1: Classification of Small Hydro on the basis of Capacity [6].

Classification of Small Hydro in India		
Type	Use	Capacity (kW)
WATER MILLS	For local use	Up to 5
MICRO	Village electrification	Up to 100
MINI	Village electrification & Grid	101 to 2000
SMALL	Grid	2001 to 25000

Table no. 2: Classification of Small Hydro on the basis of Head [7].

Classification of Small Hydro on the basis of Head	
Ultra low Head	Below 3 meters
Low Head	Less than 40 meters
Medium/High Head	Above 40 meters

3.2. Schemes of Small Hydropower Systems:

Mainly three schemes are available which distinguish small hydropower systems and they are:

3.2.1. Run-of-River Schemes:

In this scheme no storage is available. It uses stream as it comes. Such streams have limitation of flow because stream is not available throughout the year. So unit should be shut down during Dry condition.

3.2.2. Canal fall based Schemes:

Water fall from irrigation canal is used for power generation. It can be proposed where discharge is high and available Head is about 3 to 8 meters. Power house can be constructed adjacent to the fall structure of upstream of canal. Scheme can be economical if two or three fall combine together to raise the Head [7].

3.2.3. Dam-Toe based Schemes:

This scheme utilizes the head of existing Dam or barrage located in the Dam. Water is taken out from the reservoir which is behind the Dam through irrigation Vent or through separate intake.

3.3. Potential of Small Hydropower in India:

The Government of India plan to achieve a target of 5 GW power from SHP projects. To meet this target, Ministry of New and Renewable Energy, Under Govt. of India has been assigned to develop SHP projects up to 25 MW capacities across the country. Total identified sites and Potential capacity in country as on June 2017 of Small hydro power projects is about 7200 and 21188.69 MW respectively. [8] These sites are identified by Govt. agencies as well as Private developers.

Total Potential Capacity of SHP Projects in India is given by Chart no. 2. It is based on Category of Projects like Run off water, Canal based and Dam toe based.

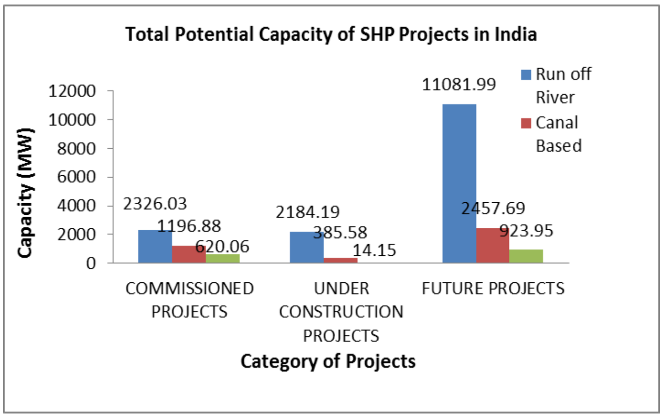

Chart no. 2: Total Potential Capacity in India. [8]

Total Potential identified sites for SHP Project in India is about 7200.Break down of sites are given by Chart no. 3:

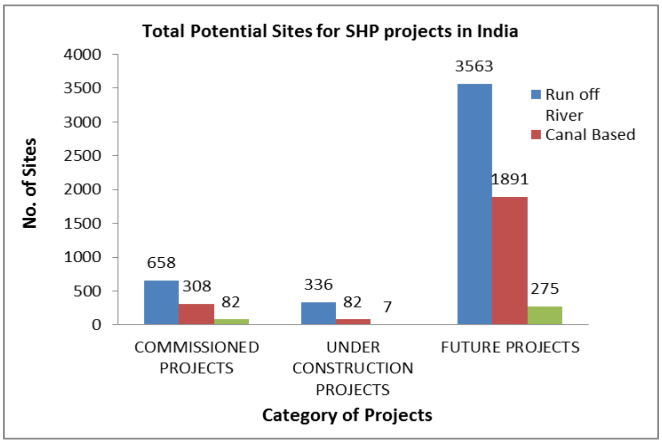

Chart no. 3: Total Potential sites in India. [8]

Total Small Hydro projects and sites in every state are given below:

S. No.	Name of States	Run-of-River		Dam-Toe Based		Canal fall Based		Total	
		No.	MW	No.	MW	No.	MW	No.	MW
1	Andhra Pradesh	1	0.2	15	88.95	437	422.51	453	511.57
2	Arunachal Pradesh	800	2064.91	0	0.00	0	0.00	800	2064.92
3	Assam	103	196.99	0	0.00	3	5.00	106	201.99
4	Bihar	2	0.42	5	7.50	132	519.06	139	526.98
5	Chhattisgarh	130	892.91	36	89.72	33	115.57	199	1098.20
6	Goa	0	0.00	7	4.70	0	0.00	7	4.70
7	Gujrat	21	42.55	3	18.00	268	141.42	292	201.97
8	Haryana	0	0.00	0	0.00	33	107.40	33	107.40
9	Himachal Pradesh	1049	3460.34	0	0.00	0	0.00	1049	3460.34
10	Jammu & Kashmir	387	1779.49	0	0.00	0	0.00	387	1779.49
11	Jharkhand	76	89.20	1	1.00	44	137.76	121	227.96
12	Karnataka	387	2667.41	17	122.50	214	936.59	618	3726.49
13	Kerala	209	431.42	17	152.13	12	63.60	238	647.15
14	Madhya Pradesh	112	302.53	109	405.20	78	112.72	299	820.44
15	Maharashtra	94	252.02	44	277.43	132	257.01	270	786.46
16	Manipur	110	99.95	0	0.00	0	0.00	110	99.95
17	Meghalaya	97	230.05	0	0.00	0	0.00	97	230.05
18	Mizoram	71	160.90	1	8.00	0	0.00	72	168.90
19	Nagaland	92	115.18	6	67.00	0	0.00	98	182.18
20	Orissa	63	84.54	9	36.31	148	165.37	220	286.22
21	Punjab	38	56.90	11	0.51	326	520.87	375	578.28
22	Rajasthan	0	0.00	9	4.87	55	46.80	64	51.67
23	Sikkim	88	266.64	0	0.00	0	0.00	88	266.64
24	Tamil Nadu	101	438.90	37	125.00	53	40.56	191	604.46
25	Tripura	6	38.01	2	5.50	5	3.35	13	46.86
26	A & N Islanc	7	7.27	0	0.00	0	0.00	7	7.27
27	Uttar Prades	2	3.05	30	142.23	220	316.97	251	460.75
28	Uttarakhand	434	1655.31	0	0.00	8	9.01	442	1664.31
29	West Benga	95	272.04	5	1.62	79	118.41	179	392.06
	Total	4575	15609.11	364	1558.16	2281	4040.14	7218	21205.63

Table no. 3: State wise Potential capacity and sites of Small Hydro Plant. [8]

3.4. Fiscal Incentives to Small Hydro Power projects:

To involve Privet companies, Investors, Agencies, MNRE gives financial incentives and subsidies to the activities towards the development and installation of Small Hydro Power projects are given below [6]:

3.4.1. Support for Survey, Investigation and preparation of DPR (Detailed Project Report) for identification of new potential sites:

- **a.** Rs.6.00 Lakh for Project up to 1.00 MW capacity and
- **b.** Rs. 10 Lakh for Project with more than 1.00 MW & up to 25.00 MW capacities to the Government department/agencies.

3.4.2.

Support to New SHP project in the Government / State sector		
Category	**Up to 100 kW & up to 1000 kW**	**Above 0.1 MW - 25 MW**
N E Region, J & K, H.P. & Uttarakhand (Special Category States)	Rs.75,000 per kW	Rs.1.5 crore/ MW limited to Rs. 5.00 crore per project
Other States	Rs.35,000 per kW	Rs.1.0 crore/ MW limited to Rs.5.00 crore per project

Table no. 4: Financial support to New SHP project in the government/state sector.

a. Minimum of 10% contribution of the project cost from the Organizer/Agency who install SHP project.
b. The subsidy would be released in four installments based on progress in the project.

3.4.3.

Support to new projects in the Private, Co-operative, Joint sector:	
Category	**Above 0.1 MW - 25 MW**
N E Region, J & K, H.P. & Uttarakhand (Special Category States)	Rs.1.5crore/ MW limited to Rs.5.00 crore per project
Other States	Rs.1.0crore/ MW limited to Rs.5.00 crore per project

Table no. 5: Financial support to new SHP project in private sector.

The financial support would be released in two installments. The first installment of 50% of financial support is proposed to be released to the financial institution/bank, after placement of order for electro-mechanical equipment and disbursement of 50% loan during execution of the project and the balance 50% of financial support after successful commissioning of project, commercial generation and performance testing. In case a project is set up by a developer (such as tea garden, captive power projects etc.) fully through its own financial resources, the total financial support will be released directly to him after successful commissioning of the project & performance testing.

3.4.4.

Support to Renovation & Modernization of old SHP projects in Government/state sector:		
Category	**Up to 1000kW**	Above 1 MW & up to 25 MW
All States & UT's	Rs.10,000 per kW	Rs.1.00 crore/MW limited to Rs.10.00 crore per Project

Table no. 6: Financial support to Renovation and Modernization of old SHP project.

a. Minimum 50% contribution of the Project cost from the state sector Project implementing organization of the work.
b. The subsidy would be released in four installments based on the progress in the project.

3.5. Need of Small Hydro Power Plant:

a) To provide electricity to household which is situated at Hilly areas, Near Border, Small villages, Remote areas, isolated area, etc.
b) Life cycle of SHP plant is approximately 50 years which is more than double to other power plant.
c) SHP plant emits least Greenhouse gas as compared to other power plant, so it is an eco-friendly process.
d) Construction of Dam is not required because most plants are run on Run-of-river scheme.
e) They do not cause pollution of Air, Land, Water, etc.
f) This can be also operated with irrigation water flowing through irrigation canal.
g) They have low failure rates, low operating cost and reliable.

4. ENVIRONMENTAL ASPECTS:

The amount of Greenhouse gas (CO_2, Methane, NO_x, etc.) released into the atmosphere as a result of the activities of a particular individual, organization, or community is called GREENHOUSE FOOTPRINT.

Mollifying climate change is the most important goals for strategic sustainable development. According to Sustainable Development Goals (SDG) #13, to control climate change and its impacts. The reduction of Greenhouse gas (GHG) emissions is the focus of a number of international targets and agreements such as the recently ratified Paris Agreement, which seek significant emissions reductions in order to limit global average temperature increases to well below 2°C.

GHG emission cause rise in temperature of atmosphere and ocean. This will directly impact on irreversible adverse effect on environment and human health. So it is clear that to reduce the GHG emission developers should quantify Hydropower's GHG footprint. [9]

4.1. SCANARIO OF GHG EMISSION IN INDIA:

India is the fourth biggest emitter of greenhouse gases after China, the United States, and European Union. According to India's INDC (Intended Nationally Determined Contributions) which is submitted to the UN climate body, UNFCCC, Reduce emissions intensity of its GDP by 33 to 35 percent by 2030 from 2005 level.

India's contribution to greenhouse gas emission from fossil fuel combustion is 7 percent globally. To minimize the Greenhouse gas emission, Govt. of India plan to produce 40 percent of electricity from non-fossil sources like wind, solar, hydropower, etc.

Hydro power has least contribution to the Greenhouse gas emission. From all Renewable resources, Small hydro is least GHG emission and it is about 0.24 percent. This is the biggest reason why world is looking into power generation form Hydro.

4.2. ORIGIN OF GHG EMISSION:

Decomposition of organic matter by Bacteria in the sediments and the water column of a water body mainly cause GHG emission. It means that Lakes, Rivers, Ponds, Catchment area (Polluted due to Acid rains), Watershed area, Seasonal Flood zones, Wetlands, Reservoir emits GHG [10]. Also Nutrients and organic matter released by human activity to the water bodies upstream of or within the reservoirs itself. Releasing of waste water from Industry, Agriculture, Fish farming and domestic sewage into upstream or downstream of reservoir, causes GHG emission. GHG emission is happen due to construction of Dams and Reservoirs because during construction many materials are used like Steel, Concrete, etc.

4.3. GREENHOUSE GASES:

There are many gases which has more or less greenhouse effect on atmosphere like Methane has more greenhouse effect than CO_2. Mainly CO_2 and Methane (CH_4) GHG gases emit in fresh water systems. Emission of Methane is directly depends on the characteristics of reservoir like type of land where reservoir construct, type of soil, etc. There is also a little bit of NO_x (Nitrous oxide) due to transportation or extraction of gases. Behavior of GHG is varying with different types of ecological system. For example Forest mostly absorbs CO_2 from atmosphere in the process of Photosynthesis; Wetlands emit both CO_2 and Methane to the atmosphere, so as natural streams, rivers and lakes [11].

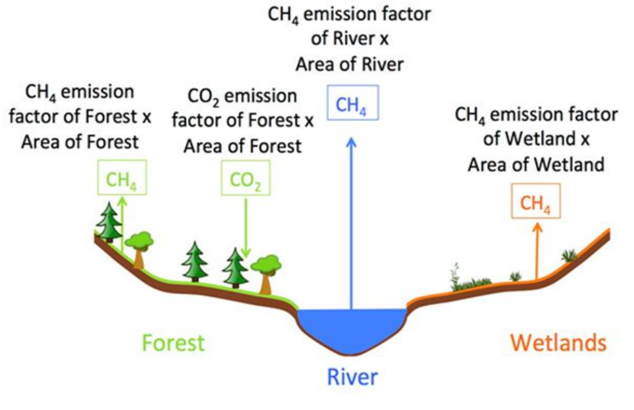

Fig. 8: Behavior of GHG with various Ecological systems.

4.4. G-res TOOL:

GHG reservoir Tool is an online tool which allows users to estimates the GHG emission from Reservoir formation in a landscape, whether from an existing or planned reservoir. It was launched in the 2017 by collaboration of IHA and UNESCO which is began in 2008.

It uses a unique framework to estimate the GHG Footprint to the formation of Reservoir. Thus the Net GHG emission from Reservoir formation is given by [11]:

Net GHG Footprint = [Post-impoundment GHG balance from the catchment after introduction of a reservoir] – [Pre-impoundment GHG balance of the catchment before introduction of a reservoir] – [Emissions from the reservoir due to Unrelated anthropogenic sources]

5. CONCLUSION:

Power generation from fossil fuels is costly as well as polluted in nature. So cope with increase in demand rate and power generation rate we have to use Renewable resource of energy. Power generation from all renewable resource of energy Hydro is the best option because their operating & maintenance cost is low as well as it emits least amount of GHG. But to bring electricity to remote areas it is still costly and there is also problem of grid transmission. So deal with this, Government of India is installing Small Hydro Power Plant across India to bring electricity in Remote areas. Government of India set up a ministry called Ministry of New and Renewable Energy to identify the sites for SHP plant and commissioned the projects. GOI involves govt. agencies, stakeholders, private agencies, etc.

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