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Small Hydro Power Plant: A Promising Renewable Energy Technology to Arrest Energy Scarcity in India and Emerging Technologies

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Abstract—*There is no universal standard definition of small hydro development. Different country adopts different specifications. Definition of SHP varies worldwide. In India install capacity less than 25MW is considered as small hydro. Although SHP technology is considered as a matured, reliable, environmental friendly and do not create any pollution during operation and offer highly reliable power with low running and maintenance cost. But India is lacking in implementing such projects effectively in spite of having good potential of 20,000 MW.India is need to go for structural change in SHP investment policies and funding practices for research and development in SHP in order to reach parity with China which is fastest growing country in overall hydro power sector including SHP. The paper is addressing present scenario of SHP in India, about its achievements, gaps in harnessing the untapped potential and emerging technologies. Furthermore it also emphasis on existing policies and its implementation in every hydro rich states.so that by encouraging SHP we can take our country on the path of inclusive and sustainable development.*

Keywords: *Small Hydro Power, Sustainable Development, Policy*

1. INTRODUCTION

The Tibetan Plateau, the world's third pole, gives birth to many of Asia's major rivers. Southern Himalayan watershed nations India, Nepal, Bhutan and Pakistan are all developing massive hydro power schemes to avail the opportunity to develop and generate electricity to boost their developing economy [1]. Hydro power projects are having overall install capacity of 990GW worldwide [2].Small hydro currently contributes over 40GW of world small hydro capacity. The global small hydro potential is estimated to be around 100 GW.China is world leader in terms of both large and small hydro power capacity. India is endowed with immense amount of hydro-power potential and ranks 5th on global scenario in terms of exploitable hydro-potential [3]. The estimated potential of small hydro and large hydro power in India is about 20,000 MW and 150,000MW respectively. Most of the potential in north Himalayan States as river-based projects and in other States are canal based. The mandate of development of small hydro power schemes are given to the MNRE under the aegis of GoI.There is no universal standard definition of small hydro development. Different countries adopt different specifications as shown in Table 1. Definition of SHP varies worldwide. In India install capacity less than 25MW is considered as small hydro [2]. The technology of SHP is matured and reliable.SHP is environmental friendly and do not create any pollution during operation and offer highly reliable power.

S/No.	Country	Install Capacity (Up to)
1	UK(NFFO)	5 MW
2	UNIDO	10 MW
3	India	25 MW
4	Brazil	30 MW
5	Sweden	15 MW
6	Colombia	20 MW
7	Cambodia	15 MW
8	Australia	20 MW
9	China	25 MW
10	Philippines	50 MW
11	New Zealand	50 MW

(Source: MNRE)

2. BRIEF HISTORY

The first SHP station commissioned in India was a 130 kW plant installed at Sidrapong, Darjeeling in 1897 [7] right after 15 years when first hydroelectric scheme was installed in Wisconsin USA in 1882 only three year after Edison invented electric bulb [4].Another small hydro power unit of 4.5 MW commissioned in 1902 at Sivasamudrum [2].Before independence most of the hydropower plants was only small and medium units. After independence focus changed to large projects because of Nehru's vision for self-sustained economy through agriculture and industrialization. He wanted to promote multipurpose hydro projects for sustainable and inclusive development. Therefore he stated HPPs are temples of modern India!

3. CURRENT SCENARIO OF SHP IN INDIA

SHP occupies an important place in renewable energy system having second largest share in terms of install capacity after wind energy. India has achieved 187.22MW in the current financial year 2014-15 from SHP from target of 250 MW.The cumulative install capacity achieved as on 31.12.2014 is 3990.83MW [5].The overall scenario of SHP in India is not very impressive although we have huge potential of 20,000MW out of which around only 3990.83MW is achieved (i.e. approx. 19.95%) rest are still untapped. MNRE aims at harnessing 50% of the potential by 13th plan. And 50% of the potential lies in Himalayan states, Karnataka, Andhra Pradesh and Maharashtra [5]. State wiseSHPpower potential is given in fig.1 in which it is observed that SHP potential is highest in the state of Karnataka having install capacity of 4141.12MW. Hydro state of Himachal Pradesh is found second in terms of small hydro power potential having capacity of 2397.91MW.After these two states are followed by Uttrakhand, Jammu and Kashmir, Arunachal Pradesh, and Chhattisgarh having potential of 1707.87 MW, 1430.67MW, 1341.38MW, and 1107.15 MW respectively. The projects already installed under different government programs are less in number as well as negligible in install capacity compared to SHP potential in India. There is very large gap between potential capacity and installed capacity. The projects under implementation are not satisfactory. It is also observed that project are installed and implemented accordingly based on available potential in different states which means that there is no irregularity in carrying out SHP projects as shown in Fig.2. The implementation is highest in the state of Karnataka having 1031.66MW means 24.91% of available potential is achieved and further under implementation is 173.09MW.Hydro state of Himachal Pradesh is second highest having 638.9MW means 26.66 % of available potential is harnessed and further under implementation is 76.2MW. Now it's clearly understood that Himachal Pradesh is at better position than Karnataka in terms of SHP projects implementation. Himachal Pradesh is followed by Maharashtra, Andhra Pradesh, Uttrakhand, Punjab, and Jammu and Kashmir. At present the project under implementation are mainly focusing in two states Uttrakhand and Karnataka having 174.04MW and 173.09MW respectively.GoI is neglecting hydro rich states like Jammu and Kashmir, and Arunachal Pradesh, in recent years because the figures under implementation is very less only about 17.65MW and 22.23MW [6]. The year wise growth trend of capacity addition and cumulative addition in SHPs over the years for 11th and 12th plan in India from 2006-07 to 2016-17 is plotted and shown in Fig. 3 [15].

4. PRIVATE SECTOR INITIATIVE FOR SHP IN INDIA

India is undergoing world's largest SHP programme through private sector participation. Therefore large part of capacity addition is now coming through private sector participation in recent years. Policies for private sector participation for SHP development announced by 23 states. Around 313 SHP projects aggregating 1586 MW in India is commissioned by private sector in early 2014. Karnataka and Himachal Pradesh are on top in achieving 828.30MW and 353MW respectively under private initiative program [6].As on March 2013, the per capita total electricity consumption in India has achieved 917.18 kWh [11].

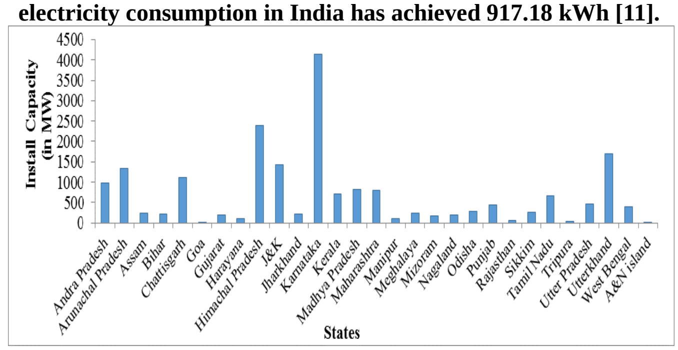

Fig. 1: State wise SHP power potential

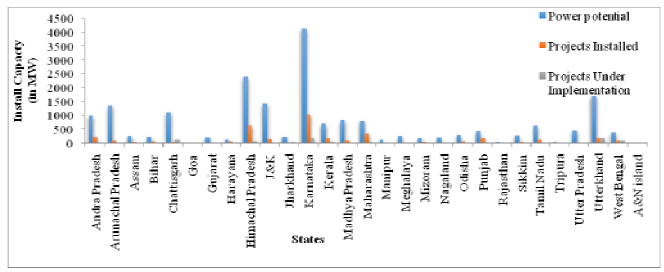

Fig. 2: State wise distribution of SHP potential, Installed and under implementation

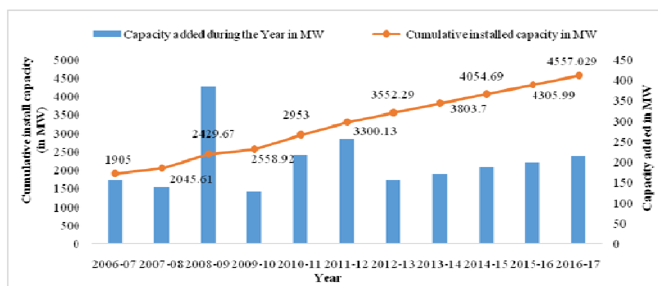

Fig. 3: Growth of install capacity addition of SHPs in India

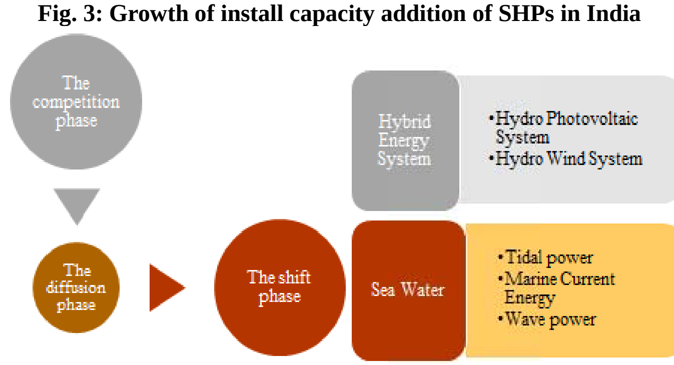

Fig. 4: Technological paradigm for SHPs development in China [8]5. Current status of SHP in China

China has an installed hydropower capacity of 249 GW, ranked first in the world. China is one of the fastest growing countries in the hydro power sector [8]. The reasons for faster SHP development in China are decentralized development and management mechanism focusing on local stake holder, Policy stimulates development, close relationship with rural electrification programme, emphasis on cost-effective SHP technology, Local grid development and SHP own supply area [9]. The Chinese Government are prioritizing hydropower development as well as other renewable energy sources out of which, small hydropower is significant contributor, with 45,000 stations nationwide. The annual output of, accounting 27 per cent of the nation's hydropower installed capacity and 25 per cent electricity output respectively. At present there is Technological paradigm for hydropower development in China. There are observed different phases in technological development in China one stage substituting the other. They are categorized as competition, diffusion, and shift phase as shown in Fig.4. Competition phase implies technological development in hydraulic turbine manufacturing. EIA on turbine design concepts is found close to nullity in has helped in acceptance of hydropower plants in the low-carbon market which is significant. Diffusion phase is about observing SHPs through the output generation capacity and use of energy in the market place. In shift phase technology shift take place at technological saturation, which indicates the trends such as hybrid energy systems (HES) and the use of seawater resources [10].

5. GOI POLICY ON SHP DEVELOPMENT

- In august 1998 the GoI announced a policy on hydropower development and revised in November 2008.[14]
- Hydro is used to supplement the base load provided by thermal power plant.
- MNRE is the nodal ministry for SHP development in India [6].
- CERC announced the tariff calculation guidelines for renewable technologies including SHPs [6].
- SHP is the focus area of MNRE and the programme is mainly private sector driven.
- The electricity act 2003 and tariff policy are favourably tilted towards power generation from renewable [6].
- Status of electricity is a concurrent subject both central and state government have authority [6].
- Buy back of small hydropower is generally based on the guidelines issued by the Central Electricity Regulatory Commission (CERC), with variations given by the State Electricity Regulatory Commissions (SERCs) of many states [14].
- Project held for environment and forest clearance concerned state government or developer to get the timely environment and forest clearance [6].
- 1 % of free power with matching1% support from state government for local area development to the affected local population [14].
- Problemssuch as local agitation (law and order), land acquisition etc. need to be resolved by concerned of state government [6].
- SHPs (having installed capacity less than 25MW) have exempted from environmental clearance, they need not undergo EIA process. However there are conditions where clearances may become necessary [6].
- The developer of SHP shall ensure minimum flow of 20% for the conservation of ecosystem and the people affected by the plant [6].
- There is provision of different incentive schemes by MNRE to promote SHPs in India by supporting financially to private, cooperative, joint and government sector [6].
- In order to improve quality and reliability of projects, GoI has made mandatory to get the project tested for its performance by an independent agency and achieving 80% of the envisaged energy generation before the subsidy is released [12].
- To ensure project quality/performance, the ministry has been insisting to adhere to IEC/International standards for equipment and civil works [13].
- The subsidy available from the Ministry is linked to use of equipment manufactured to IEC or other prescribed international standards [13].

6. EMERGING TECHNOLOGIES IN SHP

Even though hydro power is over 100 year old, each of hydro projects is unique especially for its civil works. Efforts are to improve the efficiency of the various components of SHP system, through reducing the maintenance and operation cost, by increasing the life of the main components, by optimising the utilization of water especially in views of conflicting demand, and competition with other sources. Generally head under 1 to 1.5 meters are not viable with traditional technology. So new technologies are being developed to take advantage of small water elevation changes, but mostly rely on the kinetic energy of stream flow compared to potential energy due to hydraulic head. These technologies do not need to dam or retain water to create hydraulic head the head is only a few meters. Using the current of a river or the naturally occurring tidal flow to create electricity may provide a renewable energy source. '*Hydro kinetics*' or 'free flow' generation captures energy from moving water without requiring a dam or diversion [16]. It includes generation from ocean tides, currents and waves, hopefully practical application in the near future is likely to be in rivers and streams. The hydrokinetic research and development efforts focus on advancing technologies that capture energy from the nation's oceans and rivers. Unlike hydropower, marine and hydrokinetics represent an emerging industry with hundreds of potentially viable technologies. New silt removal techniques like Coanda System, Serpent Sediment Sluicing System, and Siphon removal can be technically feasible in Himalayan sites like Stakna hydropower at Ladakh in Jammu and Kashmir where silting problem is well pronounced because of inherent glacial water quality, and removal of silt from choked desilting tank proved costly. The new technologies are based on research and development in finding new design and construction techniques, new innovative ideas for constructing weirs, intakes, sophisticated control system through design of optimum software development and efficient generators via recent advancement in power electronic world and new construction materials such as follows:

- HDPE, PVC, and GRP for penstock.
- Plastic or HDPE for trashracks.
- Ultralow head turbines.
- Fish friendly turbines
- New silt resistive materials for turbine.
- New coating for wearing surfaces of the turbines.

7. CONCLUSION

SHP projects are the golden harvest for the people in all the hydro rich states in India. Although few states like Himachal Pradesh is doing exceptionally well in this sector but that is not enough. Every state in India is required to lead in this sector by framing good policies and guidelines for smooth development of SHPs and sustainable development because pace of tapping available potential is not up to the mark. Since private sector participation becomes more pronounced in recent years. Therefore Policy makers should endeavour to design investment friendly policy models and guidelines evolving all stakeholders that will encourage SHPs development in every state in India, especially in Arunachal Pradesh and Jammu and Kashmir which are very reluctant in implementing SHP projects in spite of having excellent potential.

8. ABBREVIATIONS

MNRE Ministry of New and Renewable
USA United States of America
SHP Small Hydro Power
EIA Environmental Impact Assessment
MW Mega Watts
GoI Govt. of India
UK United Kingdom
NFFO Non Fossil Fuel Obligation
UNIDO United Nations Industrial Development Obligation
CERC Central Electricity Regulatory Commission.
HES Hybrid Energy System.
kW Kilo Watt
kWh Kilo Watt Hour
HDPE High-density polyethylene
PVC Polyvinyl chloride
GRP Glass fiber reinforced plastics
SERCs State Electricity Regulatory Commissions
HPPs Hydro Power Plants
IEC International Electro technical Commission

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