Electrification of Rural Areas by Renewable Energy Sources-Small Hydro: A Review

Virendra Sharma
Professor
Department of Electrical Engineering
Arya College of Engg. & IT
Jaipur, Rajasthan, India
vsharmakiran@gmail.com

Aditya Singh
B.Tech. III year
Department of Electrical Engineering
Arya College of Engg. & IT
Jaipur, Rajasthan, India
as284253@gmail.com

Abstract :The power transmission to rural areas is one of the most tedious tasks tackled in the developing countries like India. Since the rural areas are blessed with abundance resources of renewable energy like Small hydro and therefore, meeting the energy requirements of such inaccessible remote areas through the available renewable energy attempts are made to cover the significance of electrification of rural areas using renewable energy. This paper explores the various challenges faced in the process of electrification of rural areas in India. It also highlights the alternatives available including usage of renewable energy towards decentralized electrification and policy recommendations for the use of renewable energy technologies. There are complex socio-economic issues that are hindering the growth of renewables in rural India, especially in off-grid villages. The present paper deals with the planning of remote area for meeting the energy needs by optimal utilization of renewable energy resources in the State of Himachal Pradesh.

Keyword: *GVREP,RESSH, MHPP,MNES andVPP*

*****

I. INTRODUCTION

It is now well known that electric power play a key role in economic growth and prosperity. But access to electric power remains a dream for majority of the poor living in developing countries. Still after 100 years of Edison‘s statement that ―we will make electricity so cheap that only rich will burn candle we still have 1.6-2 billion people who do not have access to electricity and 2.5 billion people still depend on traditional biomass for their domestic energy need. It is thought-provoking fact that the majority of these people are living in the developing world [1, 2]. The global electricity generation is projected to increase at an annual rate of 2.4% between the years 2004 and 2030 and will reach 30.36 trillion kWh in year 2030. At present the global electricity generation is around 21 trillion kWh [3]. India is endowed with enormous renewable base of the order of 1, 00,000 MW, out of which only 3.5% of the total potential has been harnessed so far. Ministry of Non-conventional Energy Sources (MNES), Government of India, has fixed a target of harnessing at least 10% of the total potential during 11th and 12th plan period. As per recent, estimates, there are about 18,000 un-electrified villages in the country, which have no access to grid electricity. The energizing such areas are a challenge to be faced by the country. The present paper deals with scenario of electricity supply to rural population in the country, status & problems of rural electrification in the country, case study of Himachal Pradesh state which will covers the power potential available in the state, state govt. policies for private participation in setting up of independent power plants/captive power plants, strategies required to be adopted for power generation from renewable energy sources viz. solar, biomass, wind & small hydropower.

II. ENERGY FOR UPLIFTMENT

The majority of the people living in rural areas, lack a number of facilities, as a result of poverty & insufficient access to energy, state that electricity is essentially necessary to promote human progress in developing countries and therefore, accessibility of electricity is a must for the upliftment & overall development of remote rural areas having no grid supply Table-I indicates that investment in energy supply & use is necessary for the development of industrialized & developing nations.

TABLE-1.1: POPULATION WITH ACCESS TO ELECTRICITY

Population / Countries	**Population with electricity (%)**	**Rural Population (%)**	**Rural Population with electricity (%)**
Industrial Countries	100	27	100
China	75	66	63
India	25	73	10
Sub Saharan-Africa	19	69	5
Least Developed	13	80	5
Other	78	45	63
Total Developing Countries	52	63	40
Total World	63	55	54

The above table indicates that only 10% of the rural areas have access to electricity & there is lot of work needed to energize such villages [13].

The rural electrification is seen as a remedy to a number of problems such as deforestation for fuel wood, poverty & migration to urban areas. The rural electrification has been differently analyzed in different countries & hence the different objectives were considered-

- Support to agricultural, industrial & commercial development including irrigation.
- Reduce irrigation from rural areas to urban areas.
- Substitution of more costly energy sources.
- Improvement of quality of life & time savings by the use of domestic electrical equipments.
- Enhance security, political stability.
- Improvement of living standards of rural poor.
- Alleviation of urban/rural disparities.
- Mitigation of deforestation.

III. RURAL ELECTRIFICATION VIA RENEWABLE ENERGY

At the end of 10th five year plan of the government of India renewable energy sources succeeded to meet only 1% of rural energy need; therefore, in the subsequent plan i.e. 11th five year plan, there are two programs introduced based on renewable energy. Namely, Remote Village Renewable Energy Program (RVREP) and Grid-connected Village Renewable Energy Program (GVREP).Some of the challenges faced during rural electrification are listed below.

- Incomplete coverage
- Faulty definition/Incomplete Data
- Low demand, low consumption and shift in focus
- Long and cumbersome procedures
- Financially un-viable.
- Active Participation by Local Bodies
- Lack of measures for capacity enhancement
- Over-emphasis on grid rural electrification

Rural electrification has been financially non- viable, has reached the limits of its success and has become a largefinancial burden on electric utilities. However, the policy makers in the country have, over the years, considered thatelectric supply from the grid as a symbol ofa progress and consequently have laid over emphasis on it in the planningprocess. In contrast to the developed countries, in a developing country like India, with its large rural population and the much higher levels of poverty, the provision of grid electricity is economically unviable.

Table 1.2 Shows value of household electricity and without house hold electricity with states.

States	Households without electricity **Rural (%)**	Households without electricity **Total (%)**
Assam	87.6	81.3
Bihar	94.4	87.4
Gujarat	43.6	34.1
Haryana	36.8	29.7
Karnataka	58.3	47.5
Kerala	58.1	51.6
Madhya Pradesh	65.5	56.7
Maharashtra	41.6	30.6
Orissa	82.6	76.5
Himachal Pradesh	23.0	17.7
Rajasthan	77.6	65.0
Tamil Nadu	55.5	45.3
Uttar Pradesh	89.0	78.1
West Bengal	82.3	67.1
AVERAGE TOTAL	**66.42**	**57.0**

As can be seen for the Table 1.2 about 57% of total households in the country are not yet electrified [14]. Of these, 66% of the rural households do not have access to electricity. Most of the electrified households face a severe problem of clean power during peak hours i.e. from evening 6PM to 9 PM. and also face severe voltage fluctuations during the peak hours. Hence it is virtually equivalent to no electricity as during this period the villager performs his household activities. The situation calls for alternative options for supplying grid quality power and renewable energy sources based power production is of worth consideration for such situations.

IV. RENEWABLE ENERGY RESOURCES BASED RURAL ELECTRIFICATION IN THE STATE OF HIMACHAL PRADESH

A. About the Himachal Pradesh State

Himachal Pradesh, a small hilly, mountainous state with huge cultural heritage is a natural paradise in North India. With its fast growing economy, the state has very low poverty ratio and very low crime rate in comparison to the rest of the country. As a model state with high Literacy rate of 83.78% denoting rising socio-economic development has given primary importance to health and education system.

Himachal popularly called ‚Devbhoomi, the apple state of India is nestled in the western Himalayas between 30º 22‟ 46” to 33º 12‟ 40” North latitude and 75º 47‟ 55” to 79º 04‟ 20” East longitude. To the East it makes India’s border with Tibet, to the North lies the State of Jammu & Kashmir, Punjab to the West, Uttrakhand to South East and Haryana to the South West. It is the 18th State of the Country, (15/01/1971). Spread over an area of 55,675 Sq. Km., the territory of Himachal Pradesh is mountainous with altitudes varying from 350 m. (1150 ft.) to 7000 m (22965 ft.) above the mean sea level. The geographical area of the Pradesh accounts for 1.7% of the total area of India (3,287,263 Sq. Km.). It is inhabited by 68, 56,509 - population (Males 3473892 & Females 3382617 - 2011). The Himalayan region occupies an important place in the economy of the country. Encompassing the upper reaches of the Sutlej, Beas, Chenab, and Ravi rivers, the total hydropower potential of Himachal Pradesh is estimated at more than 23,000 MW, of which 6460 MW has been tapped so far after decades of comparatively modest hydropower expansion, state authorities plan to more than double the installed capacity by 2017 “to develop Himachal Pradesh as the Hydro-Power State of the country”. Because of the lucrative “export” of peak demand electricity to urban and industrial centers in the Gangetic plains, hydropower is playing an increasingly important role in the state's economy. Its forest resource provides timber, fuel wood, fodder, medicinal herbs, resin and a number of other minor forest products. Its water resources are used for generating hydro-electricity and providing irrigation and drinking water. Several major rivers including the Ganga and its tributaries have their origin here. Himachal Pradesh with Shimla as its capital is administratively divided in 12 Districts, 77 Tehsils & 34 Sub-Tehsils, in 52 Development blocks. It has 3243 Panchayats, No. of census villages are 20118. One Municipal Council & 20 Nagar Parishads, 32 Nagar Panchayats. It has 4 Lok Sabha, 3 Rajya Sabha & 68 Vidhan Sabha seats.

B.Power Scenario in Himachal Pradesh

Owing to various factors, the plant load factor of the power stations of the Himachal Pradesh State Electricity Boards is around 20 to 25%. Thus, the maximum peak demand is lower than expected. The area of major drawback in the growth and expansion of the power sector is the inadequate transmission and distribution systems and the debilitation performance of the existing system. Though Himachal Pradesh has an excellent potential for harnessing hydro-electricity, not much progress has been made in this regards in the past, result in the hydro thermal of mix 7.93, tremendous exists, therefore, in the area of development of the hydro sector in the State for meeting peak requirement. At present, in the developing state of country's economy, requirement of electrical power for both industrial and agricultural use has been increased over the year. Thus, it is necessary to commission projects to generate power to bridge the ever-increasing gap in demand and supply scenario.
The total installed capacity in the state of Himachal Pradesh as on 2003 is 964.80 MW, of which 255.00 MW is contributed by the Central sector, 323.80 MW by the State sector and the balance of 386.00 MW by the private sector. The state has an identified hydral power potential of 20,376 MW as in Table 1.3.

TABLE-1.3: Power Potential of Himachal Pradesh State

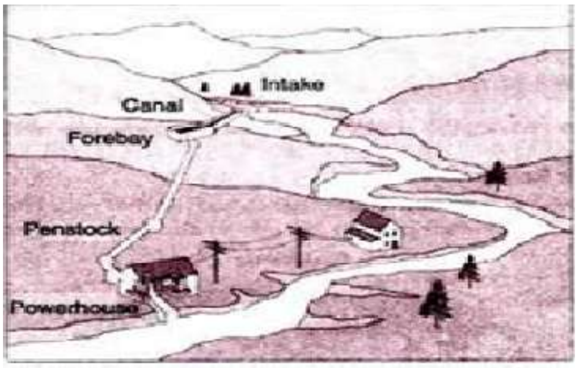
Basin	Hydro Power Potential (MW)
Beas	4,501
Ravi	2,361
Sutlej	8,634
Yamuna	1,049
Chenab	3,267
Mini Micro Projects	5,64
Total	**20,376**

Out of this identified potential, 3,942 MW has been harnessed. A number of mini and micro hydel power plants can also be installed at various identified locations, each of which may provide 1 MW to 10 MW power to the adjacent localities. The Government plans to accord "Industry Status" to such mini/micro power generating units, which would be allowed to wheel energy [15].

C. Status of Rural Electrification in Himachal Pradesh State

As per Census 2011, there were 17495 census villages in Himachal Pradesh. Of these, 110 census villages were un-electrified., 108 villages of seven districts namely Chamba, Kangra, Shimla, Mandi, Kinnaur, Lahaul & Spiti and Sirmour have been covered and one village (Vari Koksar) of Lahaul Block has been covered for electrification under R.V.E. plan by Director (Himurja). Only one village Chandori Dhar of Mehla Block of District Chamba having migratory population still remains to be covered. What is more distressing is that due to poor availability of power in the rural area coupled with long neglect of rural distribution lines due to lack of fund etc. The conductor, wire, transformers, poles etc. have been either stolen or totally damaged in many previously electrified villages, which now need to electrify a fresh. The State Government has decided to take up rehabilitation of these de-electrified villages in a big way over a period of next five years and also to electrify new villages (about 23000) in the 10th plan period.

Energy sources have taken priority. Much of the small hydro potential is in the hilly and remote, inaccessible areas of India, where generation from other sources or transmission of power over long distance would not be feasible. The development of this local potential meets a long felt need [8]. Conventional energy sources based on oil, coal, and natural gas have proven to be highly effective drivers of economic progress, but at the same time have damaged the environment and human health. The social, economical and environmental effects of renewable energy system have also been discussed. The uses of renewable energy system instead of conventional energy system to control the social, economical and environmental problems have been further identified. The results show that the trends of total emission reduction in different years are exponentially increasing after the installation of renewable energy system in remote areas. Stepanescuetal. [9] studied the possibilities of implementing small hydro power plants in a valley from Romania using hydrographical data. These power plants are combined to form a virtual power plant. The implementation of the VPP, using the water sources, has an advantage on the reduction of major investments for the grid and maintains the environment clean.



[10,12]. Technical solutions to be used in micro-hydro power plants and proposes suitable equipment for a particular solution, based on average values of water fall and water flow. An economic analysis of the considered power plant is also presented[11] highlighted that Micro hydropower plants are emerging as a major renewable energy resource today as they do not encounter the problems of population displacement and environmental problems

ISSN: 2454-4248
24 – 28

associated with the large hydro power plants. In this paper the work is carried out for evaluating Micro hydro power plants (MHPP) generation availability that can be applied to generation systems reliability and to generation planning studies. The outlines to estimate small hydro potential is discussed below.

V. MICRO HYDRO POWER (MHP) SYSTEM FOR STUDY AREA (PANGI BLOCK)

Potential Assessment

For potential assessment of below 100 kW & above some data is required, which we have collected during data collection periods is given in Table 1.4.

Table 1.4:SITE DATA OF MICRO HYDRO POWER (MHP)

Sl. no	**Data**	Site 1	Site 2	Site 3	Site 4	Site 5	**Total**
1	New head (m)	2.5	3	2.75	2.5	2.0	**12.75**
2	Discharge (m^3/sec)	.05	.08	.08	.085	.085	**.38**
3	Capacity-y (kw)	.99	1.9	1.74	1.68	1.346	**7.661**

Accordingly a potential of **7.661 kW** has been considered for the present study [16].

Development of Cost Function: The capital cost includes following two major components:

Civil works*:* The principal elements of civil works are given below:

- Intake weir/ Fore bay tank/ Gates/ Penstock
- Tail race /Power channel
- Power house building

Electromechanical equipment*:* The principal elements of electromechanical equipment are as follows:

- Turbine
- Generator
- Controls

The overall capital investment is the sum of the two. From the practical examples the cost of different projects has been listed in the Annexure I. The Following empirical formula is thus derived using linear regression analysis.

Fixed Cost = (0.07H+2.78Q+0.256P+37) in Rs. Lakhs …..(1)

Where H = Head in m

Q = Discharge in m3/sec

P = Turbine rating in kW

For the present study the operating and maintenance cost/annum is taken as roughly 2% of the total capital cost.

Therefore unit cost of generation has been computed using the following expression:

CoE=[0.07H+2.78Q+0.256P+37]*10^6*PRF+[O+Mcos *ts*]
Total annual energy generation (kwh)
………(2)*Calculation of Site* *1.*

Civil works**:** The principal elements of civil works are given below:

Elements	Rs.
Intake weir/Forebay tank/Gates/Penstock	607.70
Tail race/Power channel	4877.74
Power house building	16748.72
Total	22,234.16
3% contingencies	667.02
2% Work charged	444.68
Grand Total (A)	23,345.87

Electromechanical equipment**:** The principal elements of electromechanical equipment are as follows:

(i) Turbine -Rs 5000.00
(ii) Generator -Rs 5000.00
(iii) Control -Rs 400.00
Total capital cost =Rs 33,745.87
O+M cost =Rs 674.92

Fixed cost= 0.07H+2.78Q+0.256P+37
=0.07*2.5+2.78*0.05+0.256*3+37
= 0.175+0.139+0.768+37
= 38.082 in Rs. Lakhs
PRF=0.12

CoE=[0.07H+2.78Q+0.256P+37]*10^6*PRF+[O+Mcos *ts*]
Total annual energy generation (kwh)

$CoE = [0.07 * 2.5 + 2.78 * 0.05 + 0.257 * 3+37*10^6$ *0.12+674.2
2851.2*365
CoE=Rs 4.4 kwh/Yr

VI.CONCLUSION

Rural electricity access in India is currently inadequate for needs of the rural population, and there is observed and revealed willingness to pay for better electricity supply. The Indian government is pursuing large scale initiatives towards greater access mainly through grid expansion. Renewable energy distributed generation projects, if widely replicated, can ease the burden on both electricity supply shortfalls and reduce the urgency of costly grid extension. Needless to say,"renewables" will have a big role to play in meeting rural electrification targets in the country. Grid connection will not be a viable option for at least 20 per cent of the unelectrifiedvillages, which will have to opt for renewable energy solutions. There are signs of the attitude changing. Be it the policy-backed fine-tunings or the new programs launched by the government, the RE-based remote village electrification drive is certainly poised for better times. A policy paradigm shift is needed to make electrification integral to all rural development plans. Technology has shown the way to lighting up rural India, now it is only an enabling policy environment that can ensure that the lights do not go off. A strategy involving pilot projects, tracking of costs and dissemination of information is likely to result in the growth of DCRE in India‘s power needs.

VII. Future Scope

As per updated newsrenewable electricity sources are targeted to grow massively by 2022, including a more than doubling of India's large wind power capacity and an almost 15 fold increase in solar power from April 2016 levels. Such ambitious targets would place India amongst the world leaders in renewable energy use and place India at the centre of its International Solar Alliance project promoting the growth and development of solar power internationally to over 120 countries.

India was the first country in the world to set up a ministry of non-conventional energy resources, in the early 1980s. India's overall installed capacity has reached 329.4 GW, with renewables accounting for 57.472 GW as of 14 June 2017. 61% of the renewable power came from wind, while solar contributed nearly 19%. Large hydro installed capacity was 44.41 GW as of 28 February 2017 and is administered separately by the Ministry of Power and not included in MNRE targets.

From 2015 onwards the MNRE began laying down actionable plans for the renewable energy sector under its ambit to make a quantum jump, building on strong foundations already established in the country. MNRE renewable electricity targets have been upscaled to grow from just under 43 GW in April 2016 to 175 GW by the year 2022, including 100 GW from solar power, 60 GW from wind power, 10 GW from bio power and 5 GW from small hydro power. The Ministry of Power has announced that no new coal-based capacity addition is required for the 10 years to 2027 beyond the 50 GW under different stages of construction and likely to come online between 2017 and 2022 The ambitious targets would see India quickly becoming one of the leading green energy producers in the world and surpassing numerous developed countries. The government intends to achieve 40% cumulative electric power capacity from non fossil fuel sources by 2030.

Reference

[1] N. M. Ijumba; C. W. WekesahAFRICON, 1996., IEEE AFRICON 4thYear: 1996, Volume: 2Pages: 720 - 723 vol.2

[2] B. K. Blyden; Wei-Jen Lee2006 IEEE Power Engineering Society General MeetingYear: 2006

[3] Amit Soni; C. S. OzverenProceedings of the 41st International Universities Power Engineering ConferenceYear: 2006, Volume: 3Pages: 974 - 977

[4] Ajai Gupta; R. P. Saini; M. P. Sharma2008 International Conference on Electrical and Computer EngineeringYear: 2008Pages: 19 - 24

[5] Subrata Mukhopadhyay; Bhim Singh ,2009 IEEE Power & Energy Society General Meeting ,Year: 2009Pages: 1 - 7

[6] Xia Yang; Yonghua Song; Guanghui Wang; Weisheng WangIEEE Transactions on Sustainable Energy Year: 2010, Volume:1, Issue: 2 ,Pages: 57 - 65

[7] Bunchar Hongpeechar; Wichit Krueasuk; Arnon Poungching-ngam; Pornrapeepat Bhasaputra; Woraratana Pattaraprakorn2011 International Conference & Utility Exhibition on Power and EnergySystems: Issues and Prospects for Asia (ICUE)Year: 2011Pages: 1 - 4

[8] Mohsen Fadaee Nejad; Mohd Amran Mohd Radzi; Mohd Zainal Abidin Ab Kadir; Hashim Hizam, 2012 IEEE Student Conference on Research and Development (SCOReD), Year: 2012 ,Pages: 11 - 16

[9] Maamoon Fadhil Alkababjie; Wael Hashem Hamdon2012 First National Conference for Engineering Sciences (FNCES 2012)Year: 2012 ,Pages: 1 - 6

[10] Subho Upadhyay; M. P. Sharma2013 International Conference on Energy Efficient Technologies for SustainabilityYear: 2013Pages: 343 - 348

[11] A. Dimitriou; P. Kotsampopoulos; N. HatziargyriouMedPower 2014Year: 2014Pages: 1 - 5

[12] Debajit Palit; Gopal K. Sarangi2014 International Conference and Utility Exhibition on Green Energy for Sustainable Development (ICUE)Year: 2014Pages: 1 - 8

[13] Rajanna S.; R. P. Saini2014 6th IEEE Power India International Conference (PIICON)Year: 2014Pages: 1 - 5

[14] H. Patel; S. Chowdhury2015 IEEE Eindhoven PowerTechYear: 2015Pages: 1 - 6

[15] M. Pendieu Kwaye; J. Bendfeld; N. Anglani2015 5th International Youth Conference on Energy (IYCE)Year: 2015Pages: 1 - 5

[16] Alimul Haque Khan; Kazi Rehnuma Zafreen; Mir Muntasir Hossain; Maidul Islam2015 3rd International Conference on Green Energy and Technology (ICGET)Year: 2015Pages: 1 - 5

[17] Taha Selim Ustun2016 IEEE International Conference on Power and Energy (PECon)Year: 2016Pages: 1 - 6

[18] Alpesh M. Patel; Sunil Kumar Singal2016 IEEE 7th Power India International Conference (PIICON)Year: 2016Pages: 1 - 5

[19] S. Rajanna; R. P. Saini2016 IEEE 1st International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES)Year: 2016Pages: 1 - 6

[20] N. Koirala; R. Dhakal; D. Lubitz; S. Bhandari; G. P. Dev; Y. Dhakal; Uttam Niraula2017 IEEE 6th International Conference on Renewable Energy Research and Applications (ICRERA)Year: 2017Pages: 861 - 869

[21] Yemeserach Mekonnen; Arif I. Sarwat2017 IEEE PES PowerAfricaYear: 2017Pages: 595 - 599