IMPACT ON SHP DUE TO OTHER RENEWABLE ENERGY

A DISSERTATION

Submitted in partial fulfillment of the

Requirement of award of degree

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ALTERNATE HYDRO ENERGY SYSTEMS

By

AYUSH JAIN

DEPARTMENT OF HYDRO AND RENEWABLE ENERGY

INDIAN INSTITUTE OF TECHNOLOGY

ROORKEE-247667 (INDIA)

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CANDIDATE'S DECLARATION

I hereby declare that the report which is being presented in this dissertation work **"IMPACT ON SHP DUE TO OTHER RENEWABLE ENERGY "** in partial fulfillment of the requirements for the award of the degree of **Master of Technology** in Alternate Hydro Energy Systems, submitted in **Alternate Hydro Energy Centre, Indian Institute of Technology Roorkee, Uttarakhand, India**, is an authentic record of my own work carried out during the period from July 2018 to June 2019 under the supervision of **Prof. S K SINGAL**, Head of Department of Hydro and Renewable Energy, Indian Institute of Technology Roorkee.

I have not submitted the matter embodied in this report for the award of any other degree or diploma.

Date: 12 June 2019

Place: Roorkee **(AYUSH JAIN)**

CERTIFICATE

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Prof. S. K. SINGAL
Department of Hydro and Renewable Energy
Indian Institute of Technology
Roorkee -247667

ABSTRACT

The Small Hydro Power (SHP) is reliable, environment friendly and sustainable energy resources among other renewable energy resources for the geographically remote areas. It is necessary to maintain the growth of SHP as the electricity demand is increasing and also to reduce the carbon emission SHP can play an important role. In recent years there has been a fast growth in the renewable energy sector but the growth in SHP is not as same as the other renewable energies. The impact of other renewable energies on SHP need to be analyzed to see the factors that are responsible for the decline in growth of SHP.

In the present time the main focus is on the renewable energy power development as renewable energy is the solution to the environmental problems and also the solution of energy deficit in country. The growth of renewable energy is significant in the past decade but it is seen that each renewable energy growth is not the same. To provide electricity in the remote areas SHP plays a crucial role, so proper policies should be made to promote the SHP. Power generation from the intermittent energy sources is uncertain by its nature and the primary source of energy, for instance wind, cannot be gathered and used when desired so SHP can also be a solution to this problem. The main advantage of SHP is that the power is generally available on demand since the flow of water can be controlled and it can also help in meeting the peak and intermittent energy demand.

Under this dissertation work, impact on SHP due to other renewable energy sources has been studied. Government policy of various states in order to analyze the effect of policy on the growth of renewable energy. The generic tariff policy of SERCs of various years is also studied to identify what are the reasons and factors responsible for increase in tariff of one renewable energy and decrease in tariff of other renewable energy. Regression analysis is done to establish a relationship between a dependent variable i.e. Renewable energy share and two independent variables i.e. Policy and tariff. The results are analyzed to see whether these have a positive or negative impact on the growth of renewable energy and also the significance of the impact is analyzed. The overall growth of renewable energy is good, but the situation of Small Hydro power is not as good as compared to the other renewable energy resources. The regression analysis of all the five states has common trend that the change in policy has negative impact on Small Hydro Power and other than the state of Karnataka the tariff also has a negative coefficient which implies that it has negative impact on growth of small hydropower

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Date: 12 June 2019

Place: Roorkee **(AYUSH JAIN)**

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CHAPTER 1
INTRODUCTION

1.1 GENERAL

Conventional energy sources based on oil, coal, and natural gas have been effective drivers of economic progress. However, with the fast decline of conventional energy sources and increased demand for power, electricity usage has grown exponentially. Due to environmental issues, many organizations have encouraged extensive research into more efficient and green power plants using sophisticated technology. As environmental concerns are growing, both clean fuel technologies and alternative energies are being intensively pursued and investigated. In reality, fossil fuel and renewable energy prices, social and environmental costs move in opposite directions and the financial and political mechanisms required to promote the extensive spread of sustainable renewable energy markets. It is clear that the renewable energy sector is growing at a good rate. Shifting to renewable energy helps us fulfill the dual objectives of lowering greenhouse gas emissions, thereby decreasing future extreme weather and climate effects, and ensuring reliable, timely and cost-effective energy delivery. Investing in renewable energy can contribute significantly to our energy security.

Electric energy security is essential, yet the high cost and limited sources of fossil fuels, in addition to the need to reduce greenhouse gasses emission, have made renewable resources attractive in world energy-based economies. The potential for renewable energy resources is enormous and they can in principle, exponentially exceed the world's energy demand; therefore, these types of resources will have a significant share in the future global energy portfolio, much of which is now concentrating on advancing their pool of renewable energy resources. The energy resources have been split into three categories: fossil fuels, renewable resources and nuclear resources. Renewable energies are energy sources that are continually replenished by nature and derived directly from the sun (such as thermal, photo-chemical, and photo-electric), indirectly from the sun (such as wind, hydropower, and photosynthetic energy stored in biomass), or from other natural movements and mechanisms of the environment (such as geothermal and tidal energy). Renewable energy sources that meet domestic energy requirements have the potential to provide energy services with zero or almost zero emissions of both air pollutants and greenhouse gases. Harvesting the renewable energy in decentralized manner is one of the options to meet the rural and small-scale energy needs in a reliable, affordable and environmentally sustainable way.[1]

1.2 RENEWABLE SOURCES OF ENERGY

Renewable energy sources are those resources which can be used to produce energy again and again, e.g. solar energy, wind energy, biomass energy, geothermal energy, etc. and are also as called alternative sources of energy. Renewable energy system development will make it possible to resolve the most crucial tasks like improving energy supply reliability and organic fuel economy; solving problems of local energy and water supply; increasing the standard of living and level of employment of the local population ensuring sustainable development of the remote regions in the desert. [1] India's total grid connected renewable energy is 75760 MW. The figure 1.1 shows the renewable energy share in India. The share of solar power is 34%, wind power is 47%, small hydro power is 6% and share of bio power is 13% as on 31.01.2019 as per MNRE (Ministry of New and Renewable Energy) [2].

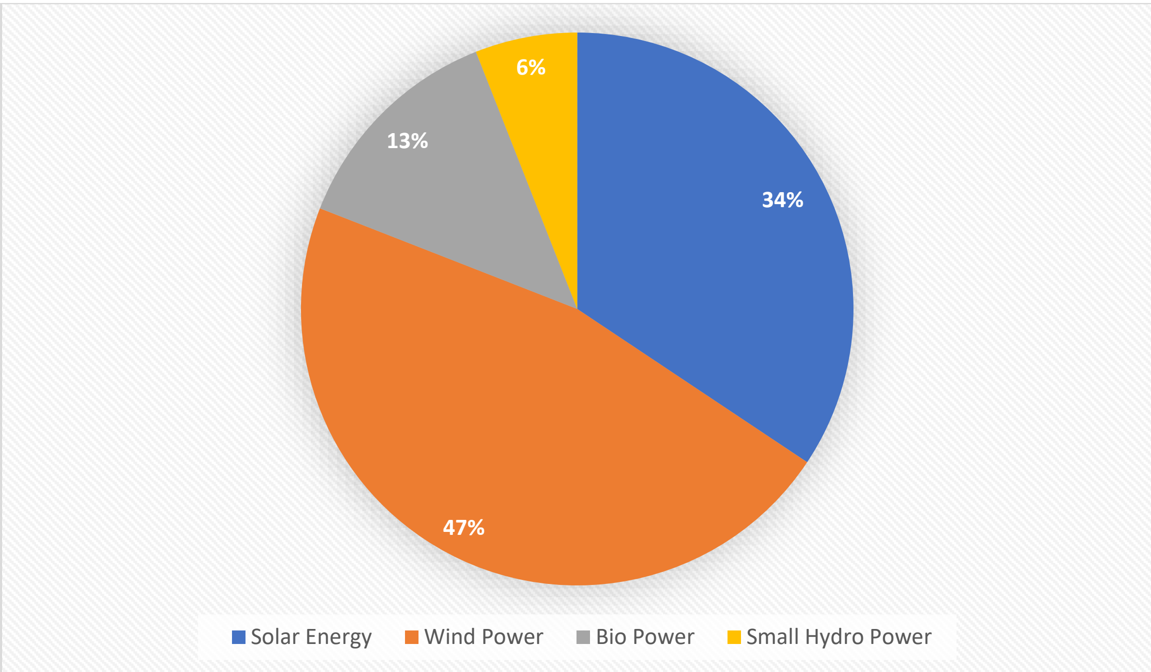

Fig 1.1: Renewable Energy Share in India [2]

1.2.1 Solar Energy

Solar energy is an effective promising alternative and clean source of energy to meet up the rising demand for clean energy, and it also play an important role for the sustainable development of the society worldwide. Solar energy is a cheap, abundant and everlasting source of renewable energy and thus it can be integrated with different systems deals with energy consumption to overcome the dependency of present society on conventional fuels**.** Integration of solar energy with other types of other energy systems plays an important role in the strengthening of sustainable development of technology. For example, both heat and electricity can be obtained from the integration of solar thermal components with solar photovoltaic (PV) cells to form a hybrid unit [1]. India is located geographically between tropic of cancer and Equator; it has an average annual temperature ranging between 25 °C - 27.5 °C. With this advantageous geographical location, India receives a global solar radiation over a range of 1200 kWh/m2/year to 2300 kWh/m2/year. The south east coast of India is considered to be sunniest parts in the country. To harness solar energy under this geographical advantage, Ministry of New and Renewable Energy (MNRE) has targeted to install plants for the generation of 100 GW of power by 2022 [2]. Figure 1.2 shows the year wise solar power installed capacity. In the year 2011-12, 904 MW solar power was installed and the growth of solar power is at great pace which can be seen in year 2017-18, 9362 MW of solar power was installed.

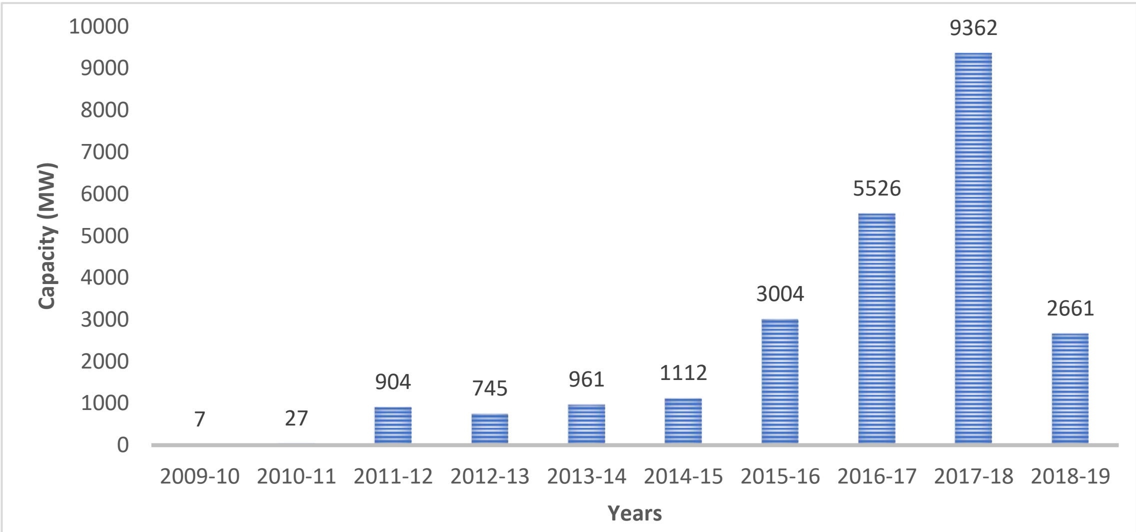

Fig 1.2: Year wise solar power installed capacity [2]

1.2.2 Wind Energy

The movement of wind is a complex mechanism which involves the interaction of sun and earth. It is considered to be the most widely distributed source with worldwide potential of 432,883 MW. The magnitude and direction of wind varies spatially. Thus, scientific wind mapping is done extensively in India for its effective utilization. The areas with least wind power density of 400 W/m^2 at 30 m of height are identified and considered as optimal locations for the exploitation of wind energy. Harnessing wind energy to generate electricity involves points of interest and problems as well. Generation of electricity through wind energy is considered as a promising source as it depends on the motion of wind causing the movement of turbine blades. The source is assumed to be available throughout the year, with some fluctuations. However, noise from the gearbox and the generator are considered as major environmental impacts. It is expected that noise with an intensity of 50–60 dB is experienced within a buffer distance of 40 m. [3] Presently; India has an installed capacity of 34.40GW and makes up the majority contributor in renewable energy sector. To harness wind energy under this geographical advantage, Ministry of New and Renewable Energy (MNRE) has targeted to install plants for the generation of 60 GW of power by 2022[2]. Figure 1.3 shows the year wise wind power installed capacity.

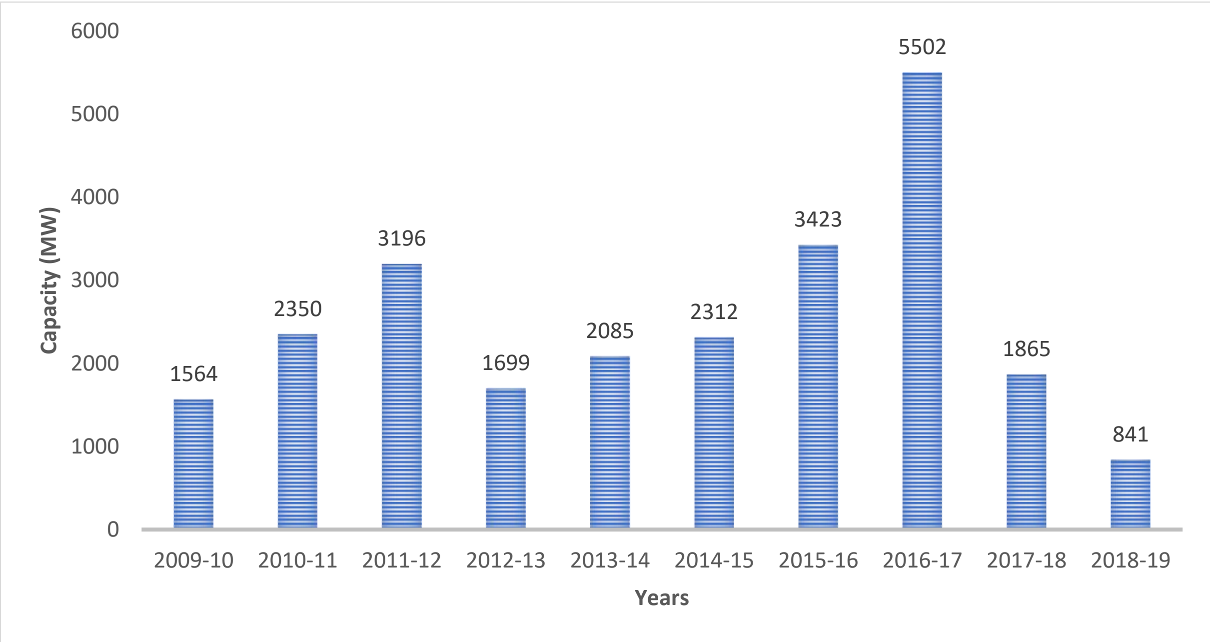

Fig 1.3: Year wise wind power installed capacity [2]

1.2.3 BIOMASS ENERGY

Biomass is a distinctive source of energy because it is worldwide available and renewable, unlike fuels such as oil and gas, which are concentrated in limited geographical areas. Therefore, it can play an important role to meet the future energy mix in many countries. India is an agricultural country, so biomass is available in large quantity in the form of husk, straw, jute, cotton, shells of coconuts wild bushes, etc. Photosynthesis reaction plays a vital role in the production of biomass. Biomass account about one third of total fuel used in the country. The total potential of biomass power generation in India is about 30,000MW. Mainly Uttar Pradesh, Punjab, Karnataka, Bihar, Gujarat, Tamil Nadu; And Andhra Pradesh states of India have very large biomass/bioenergy Potential. A large amount of biomass used for electricity generation comes from bagasse (crushed sugarcane or sorghum stalks), which can be used in combustion-powered generators. In India, the biomass programmes are mainly targeted to meet the needs of rural and remote areas and have helped in reaching electricity to the interior un-reached section of the population. Globally, biomass fuels accounts for 13% of total energy requirements. Biomass is one such source that can be used to provide sustainable supply of the required energy through biogas, vegetable oil, biodiesel, producer gas, and by directly burning the biomass. Biomass can be converted into suitable form of energy through different conversion technology. [1]

1.2.4 SMALL HYDRO POWER

In India, hydro projects up to 25 MW station installed capacity are classified as Small Hydro. The estimated potential of small hydro power is about 20,000 MW out of which only 4528 MW has been exploited. Small hydro power projects are normally run-of-river and no dam needs to be constructed. These projects do not encounter the issues associated with large scale hydro projects of deforestation, resettlement and rehabilitation. The projects have potential to meet power requirements of remote and isolated areas. These projects have the potential to turn around economic activities in local areas, villages and remote areas. These factors make small hydro as one of the most attractive and reliable renewable sources with grid quality power generation. With the advancement of technology, it is now possible to set up economically viable low head small hydro projects on existing canals and fall structures, dam outlets and small streams spread through the country. Small hydel projects normally do not encounter the problems associated with large hydel projects of deforestation and resettlement. The projects have potential to meet power requirements of remote and isolated areas. These factors make small hydel as one of the most attractive renewable source of grid quality power generation. Small hydro being mostly run of river types is environmentally friendly as it has zero emissions while generating electricity. There is no storage of water and no dam is constructed in these projects and hence there are no displacements of habitation. The projects can address power requirement of local areas and avoid long transmission losses. Small hydro projects can also be helpful in mobilizing resources and save life in case of emergency in remote areas. From an energy security perspective, Hydro is the most secure of all sources since it is dependent on locally available resource and quite predictable water cycle. It can be an excellent source of power generation to meet peak demands if small storage of one or two days is introduced. In the situation of energy shortages and non-availability of power in remote areas SHP can provide long term effective solution. [7] Figure 1.4 below shows the year wise small hydro power installed capacity. In the year 2011-12, 353 MW small hydro power was installed and the growth of small hydro power is declining which can be seen in year 2017-18, only 105 MW of small hydro power was installed.

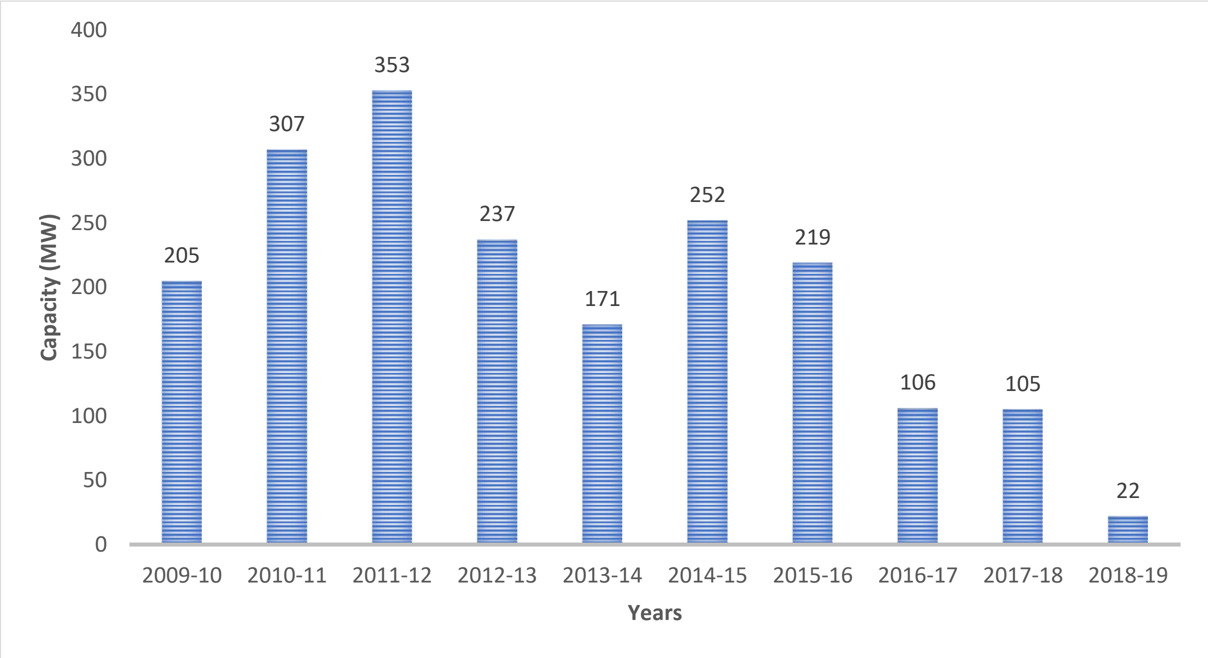

Fig 1.4: Year wise small hydro power installed capacity [2]

1.3 DEVELOPMENT OF RENEWABLE ENERGY IN INDIA

Promotion of renewable energy in India effectively started with the setting up of a Commission for Additional Sources of Energy in the Department of Science and Technology in 1981. An independent department – the Department of Non-conventional Energy Sources was set up in 1982; the Department was converted into the Ministry of Non-conventional Energy Sources (MNES) in 1992. Indian Renewable Energy Development Agency (IREDA) was established in 1987 to finance renewable energy projects. The MNES was renamed to MNRE in October 2006. [5]

MNRE established a wide range of research, development and demonstration activities, elaborate incentive schemes and state level nodal agencies for promoting RETs in the country. Renewable energy business in India has now grown into a sizable industry as a result of sustained efforts of MNRE and its state nodal agencies, impetus from occasional energy shocks and growing involvement of the private sector. State wise installed capacity of renewable energy in various states is shown in the table 1.1.

Table 1.1: - State-wise installed capacity of Grid Interactive Renewable Power as on 31.01.2019.[2]

S. No	State/UTs	Small Hydro Power (MW)	Wind Power (MW)	Bio Power (MW)	Solar Power (MW)	Total (MW)	Potential (MW)
1	Andhra Pradesh	162.11	4076.45	500.34	2889.29	7628.19	54916
2	Arunachal Pradesh	107.9			5.39	112.49	10236
3	Assam	34.11			18.65	52.76	14330
4	Bihar	70.70		121.20	142.45	334.35	12559
5	Chhattisgarh	76.00		230.50	231.35	537.85	19951
6	Goa	.05			1.69	1.74	912
7	Gujarat	45.70	5965.87	77.30	2003.03	8091.90	72726
8	Haryana	73.50		205.66	219.59	498.75	6470
9	Himachal Pradesh	860.61		7.20	4.50	872.32	36446
10	Jammu & Kashmir	179.03			14.38	193.41	118208
11	Jharkhand	4.05		4.30	32.41	40.76	18580
12	Karnataka	1230.73	4682.80	1799.80	5328.81	13042.14	44015
13	Kerala	222.02	52.50	.72	138.49	413.73	8732
14	Madhya Pradesh	95.91	2519.890	120.75	1649.89	4386.44	66853

15	Maharashtra	375.570	4794.13	2528.69	1619.56	9317.95	74500
16	Manipur	5.45			3.23	8.68	10811
17	Meghalaya	31.03		13.80	.12	44.95	6185
18	Mizoram	36.47			.50	36.97	9261
19	Nagaland	30.67			1	31.67	7513
20	Odisha	64.63		59.22	390.27	514.12	27728
21	Punjab	173.55		326.35	905.62	1405.52	6768
22	Rajasthan	23.85	4299.72	121.30	3141.89	7586.76	148518
23	Sikkim	52.11			.01	52.12	5307
24	Tamil Nadu	123.05	8764.34	1003.88	2233.34	12124.61	34152
25	Telangana	90.87	128.10	177.60	3583.61	3980.18	20410
26	Tripura	16.01			5.09	21.10	2131
27	Uttar Pradesh	25.10		2117.51	902.33	3044.94	27593
28	Uttarakhand	214.320		130.50	304.27	649.09	19071
29	West Bengal	98.50		319.92	69.56	487.98	7222
30	Andaman & Nicobar	5.25			6.56	11.81	373
31	Chandigarh				32.40	32.40	50
32	Dadar&Nagar Haveli				5.46	5.46	95
33	Daman & Diu				14.47	14.47	25
34	Delhi			52.00	124.21	176.21	2181
35	Lakshadweep				.75	.75	10

36	Pondicherry				1.80	1.80	123
37	Others			4.30		4.30	1812
	Total (MW)	4528.04	35288.10	9918.54	26025.97	75760.66	896602

1.3.1 DEVELOPMENT OF SMALL HYDRO POWER

India has one of the world's largest irrigation canal networks of the world with thousands of dams. The Himalayan ranges in the north have numerous rivers and streams with perennial flows. Considering the fact that small hydropower projects can provide a solution for the energy problem in remote hilly areas where extension of grid system is comparatively uneconomical, promoting small and mini hydro projects is one of the objectives of hydropower development in India. Indian history in SHP developments is more than a century old; the first project of 130 kW was commissioned in the hills of Darjeeling in 1897. This was followed by Sivasamudram project of 4.5 MW in Mysore district of Karnataka in 1902. A 3 MW plant was established at Galgoi in Mussoorie in 1907, and a 1.75 MW plant was established in 1914 at Chaba near Shimla. Some of these nearly 100-year old plants are reported to be still functioning properly. Later, between 1930 and 1950, some low head plants were installed on a number of canals on the river Ganges. MNRE has set up an Alternate Hydro Energy Centre (AHEC) at Indian Institute of Roorkee in the year 1982 to promote SHP. MNRE has been responsible for small and mini hydro projects up to 3 MW station capacity since 1989. From 1989 to 1993, the thrust of the programme was on setting up of demonstration projects in various States to create interest of State Governments and electricity boards to set up SHP projects. For this purpose, capital subsidy of up to 50% of the cost of project subject to a maximum of INR 250 million per MW was provided. During 1993–94, keeping in view the overall policy of Government of India to encourage private sector participation in the field of power generation, the thrust of SHP programme was also shifted to encouraging private sector to set up commercial SHP projects. [5]

1.3.2 DEVELOPMENT OF SOLAR PV

IREDA launched its Solar PV development programme in 1993–94 in order to promote commercialization of the technology based on experience gained since the initiation of India's national solar PV programme in the mid-1970s. Production of PV modules and cells has been increasing steadily, although rather slowly, since then. India's production of solar module increased from 9.5 MW in 1998–1999 to about 4 MW in 2004–2005. Although the growth is impressive, it is low compared with the global growth in recent years. Thus, world PV production increased from 287.7 MW in 2000 to 1759 MW in 2005 corresponding to a 6.1-fold rise in five years. Global demand for PV modules has been driving up their export from India. Also, export has been growing faster compared with PV production; the percentage of cumulative production exported was 35% in 2001, 43% in 2002, 50% in 2003, 55% in 2004 and more than 60% in the year 2005. Cumulative PV module production in India by the end of December 2005 was 245 MW; about 160 MW of this was exported. PV systems are used for a wide range of applications in India. [5]

1.3.2.2 DEVELOPMENT OF SOLAR THERMAL

A subsidy-based solar thermal programme was launched in India in 1984 and continued up to 1993. Government support for the technology in the form of subsidy, demonstration, and training led to development of a substantial manufacturing base in the country and its steady, albeit slow, growth. Capital subsidy was removed and provision for soft loan was introduced in 1994 however, this did not significantly affect the growth of the technology. Growth of solar water heating was slow in India until recently; the cumulative installation of solar water heaters by the end of December 2004 was about 1 million square meter of collector area. Growth of solar water heating has increased quite significantly in the last two years; the cumulative collector area increased by 66% after 2004 to 1.66 million square meters at the end of January 2007. [5]

1.3.4 DEVELOPMENT OF WIND POWER

Work on wind energy started in India at low key in 1960s a 4.9 m diameter conventional multi-vane wind mill was developed at National Aeronautical Laboratory (NAL) in mid-1960s. Sail-type windmills were developed under a project initiated by NAL during 1976–1977. The initial application of windmills was mostly for supplying irrigation water. A landmark ‘‘Wind Energy Data Handbook’’ was published by the Department of Non-conventional Energy Sources (now the MNRE) in 1983. India initiated a national wind power programme in 1983–1984 with three components: wind resource assessment, demonstration projects and industry-utility partnership. An extensive Wind Resource Assessment was launched in 1985; so far, five volumes of the Handbook on Wind Energy Resource Survey have been published. Though incentives and marketoriented policies existed during the late 1980s, private sector participation in wind power generation effectively started only after the announcement of the ‘private power policy’ of 1991. This ultimately led to successful commercial development of wind power technology and substantial additions to power generation capacity in the country. The Indian wind industry was placed fourth in terms of total installed capacity in the world by the year 1993. A short-term decline of wind power in India started in 1996 as a result of changes in government policies, including introduction of Minimum Alternate Tax (MAT) in the year 1995–1996, that made the incentive package less attractive. As a result, India’s wind power programme fell back to fifth position after the United States, Germany, Denmark, and Spain in the year 1999. To overcome the problem of falling profitability of private wind farm operations in the country (in the mid-1990s, 96–98), some states started supporting the wind power companies and investors with liberal policy initiatives. The wind energy situation started to improve in 1999 and the upswing is still continuing. Technological maturity and introduction of suitable machines for the Indian conditions resulted in overall higher capacity utilization. India is the fourth largest wind Producer in world, after China, USA and Germany. The cumulative installed wind power capacity in India at the end of 2018 was 34402 MW.[5]

1.3.5 DEVELOPMENT OF BIOMASS

Initial research and development efforts on biogas technology started in 1920s [26]. The first demonstration unit of floating-drum biogas digester design, popularly known as the Khadi and Village Industry Commission (KVIC) design (or simply the Indian type biogas digester design) was established in 1950. All India Coordinated Biogas Programme (AICBP) was launched in 1975 for largescale dissemination of biogas plants. A fixed dome biogas digester design, called the Janata biogas plant, was developed in 1978. Demonstration of community biogas plants started in late 1970s. National Programme for Biogas Development (NPBD) was launched in 1981–1982. Deenbandhu biogas plant design, which was an improvement over the Janata biogas plant, was introduced by an NGO in 1984. Biogas programme gained momentum during 1985–1992 partly due to substantial subsidies, which were introduced to promote the technology; annual installation of biogas plants was 160,000–200,000 during this period. Although subsidies for biogas plants were reduced during early 1990s, dissemination of the technology was not much affected. Over 500 biomass power and cogeneration projects with aggregate capacity of 8414 MW have been installed.[7]

CHAPTER 2
LITERATURE REVIEW

Earlier authors have carried out work on evaluation and analysis of policies and the literature available has been studied. The comprehensive literature review is presented as follows

Bandyopadhyay et al. [6] presented a study of Impact of Renewable Energy Sources on Indian Electricity Grid and find out the major challenges faced by the renewable energy sector and grid. The bulk of the renewable capacity is programmed to come from solar and wind sources which are intermittent in nature. Paper also discussed the challenges involved with large scale integration of renewable energy sources with Indian electricity grid which is presently dominated by conventional energy sources.

Paper has discussed the challenges to Indian Electricity Grid system in view of the revised target set by Government of India to have 175 GW of installed capacity from Renewable energy sources. It is concluded that the share of energy generation from Renewable energy sources is going to increase from 7% at present to around 20% of the total energy requirement by the year 2022. However, this increase in generation from RE sources will lead to conventional generating plants to be more flexible to cater to the increased ramping requirements due to variability associated with RE generating sources. Advanced forecasting techniques need to be adopted to accurately predict the output generation from Renewable Energy sources. The study suggested that the Transmission system needs to be strengthened to evacuate renewable energy from rich RE states to other parts of the country.

Mishra et al. [7] presented a paper on growth and future of SHP. The objective of the study is to comprehensively review the current status of small hydro power development in India and develop scenarios of growth. Potential and installed capacity, technological status, policy and regulatory support to small hydro power and the whole process of developing a small hydro power plant have been comprehensively reviewed. Major barriers in the growth of the small hydro power development have been identified. Future growth scenarios of small hydro power up to 2050 have been developed using Vensim DSS package. Model simulation indicates that with the current rate of capacity addition, the country will not be able to fully exploit small hydro power potential even by 2050. The country is targeting to add nearly 420 MW/year of SHP addition in 12th plan. However, with this capacity addition rate, the country will not be able to harness full SHP potential even by 2050. Further, target of harnessing 50% of the SHP potential in next 10 years does not seem feasible even in high growth scenario. Therefore, country must make all attempts to accelerate the growth of the SHP sector and should target a capacity addition rate of nearly 600 MW/year. The paper suggested that the country must make all attempts to accelerate the growth of the small hydro power because it has significant potential to contribute to energy poverty alleviation in rural and remotes areas.

Kamal et al. [8] studied the Scenario of Small Hydro Power Projects in India and its Environmental Aspect, its 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.

Jhaab et al. [3] studied the status of renewable alternatives in India. The techno economic factors and environmental aspects associated with each of these alternatives are discussed. The study focusses on prioritizing the renewable sources based on a parameter introduced as Energy Index. This index is evaluated using cumulative scores obtained for each of the alternatives. The cumulative score is obtained by evaluating each alternative over a range of eleven environmental and techno economic criteria following Fuzzy Analytical Hierarchy Process. The energy consumption in India is growing rapidly and is expected to follow the similar trend in the future. Meeting the demand with the present available pattern of energy sources with coal as the major contributor may not be possible in future. So, there is a great need to accelerate the development of new and renewable energy sector in India. It is concluded from the study that the geothermal source is the most preferable alternative with highest Energy Index. Hydro, Wind, Biomass and Solar sources are subsequently preferred alternatives.

Bhide et al. [9] presented the paper on Energy poverty: A special focus on energy poverty in India and renewable energy technologies. The focus of the article was to bring to light the problems faced in India in terms of energy consumption as well as the hindrances faced by renewable-based electrification networks. Government policies aimed at addressing these issues, as well as the current state of renewable energy technologies in India are discussed, so as to analyze the possibility of a solution to the problems of finding a sustainable method to eradicate energy poverty in India.

Bhattacharya et al. [5] studied the Renewable energy in India and its Historical developments and prospects. He studied the growth of various renewable energy such as solar

Small hydro, Biomass. In spite of many successes, the overall growth of renewable energy in India has remained rather slow. A number of factors are likely to boost the future prospects of renewable energy in the country; these include global pressure and voluntary targets for greenhouse gas emission reduction, a possible future oil crisis, intensification of rural electrification program, and import of hydropower from neighboring countries.

Pillai et al. [10] studied the Status and Potential of Renewable energy in India, paper reviews the status and potential of different renewables in India. The paper documents the trends in the growth of renewables in India and establishes diffusion model as a basis for setting targets. The diffusion model is fitted to the past trends for wind, small hydro and solar water heating and is used to establish future targets. The economic viability and green-house gas (GHG) saving potential is estimated for each option.

Sharma et al. **[11]** analyzed the strategies, policies and development of hydropower in India: Special emphasis on small hydro power. Paper focused on the efforts to analyze the current status, future strategies and policies of hydropower development in India with special emphasis on SHP.

Kumar et al. [12] found that the energy issues faced by developing economics can be solved by adopting the renewable energy sources and technologies. To overcome the energy requirement, India will require an assured supply of 3–4 times more energy than the total energy consumed today. India is increasingly adopting responsible renewable energy techniques and taking positive steps towards carbon emissions, cleaning the air and ensuring a more sustainable future.

Paish [13] explained that hydropower plays a major role in global power generation. However, for rural electrification, small hydropower plant mostly 'run off river' is preferred as it is cost effective and environment friendly.

Purohit [14] observed the process of clean development mechanism of Kyoto protocol. The purpose of the study is to promote sustainable development by deduction in carbon dioxide emission at lower cost. For sustainable rural development, small hydropower projects could be best to meet out the requirements of CDM as the directly displace the greenhouse gas emissions. Through supportive policies and CDM technique, the maximum utilization potential of SHP projects is more feasible.

Schdmit [15] concentrated on developing the power sector through renewable energy techniques and also summarized the effects of Electricity act 2003 and Tariff Policy 2006 and implementation of feed in tariffs and minimum quotas on clean electricity sourcing and found that tariff policy 2006, state policies, quantity-based instruments and participation of private sector could significantly promote the development of renewable energy sector.

Chattopadhyay et al. [16] discussed on the issue of achievable high target power generation through renewable sources. The focus must be on right policy design, starting from resource potential, its spatial and seasonal distribution based on climate data analysis for the economic and sustainable development of power sector.

Naidu [17] explained the potential of renewable energy power sector based on SWOT analysis and explored the possibilities of applying renewable energy power generation and sustainable development of power sector.

Painuly [18] suggested that potentially renewable energy sources play an important role for intensification of rural electrification programme in remote areas. However, penetration of economically viable renewable energy is not achieved due to various barriers. Also, for sustainable development of power sector a framework has been developed to identify the barriers and suggested the measure to face them.

CAG report on small hydro power [19]

According the cag report on small hydro power, during 2007-12, MNRE was able to achieve its target. However, during 2012-14 there was a shortfall of around 38 *per cent*. As of March 2014, of the identified 6,474 potential sites for SHP projects of 19,749 MW, only 997 projects (3,803 MW) were completed and 254 projects (895 MW) were under implementation i.e. only 19 *per cent* of total potential sites had been exploited. MNRE had planned to install 7,000 MW by the end of 12th FYP (upto 2017).

Cag report observed delays and problems in conducting feasibility studies for identifying potential sites for setting up Small Hydro Power projects, which was a critical planning activity for development of Small Hydro Power. In Himachal Pradesh 37 consent letters were issued but the Independent Power Producers did not submit any Detailed Project Report even after five years; out of 88 Detailed Project Reports submitted by Himurja to the Department of Energy for technical approval none had been approved and the Independent Power Producers had not submitted feasibility study reports for 78 projects allotted to them. Further, due to delays and problems in according technical approvals to Detailed Project Reports, allotment of projects, acquiring land for setting up projects and obtaining forest and environmental clearances, several projects could not be taken up and completed in time. Report also observed deficiencies in post-commissioning maintenance of the projects. Test check revealed that 60 projects in five States were shut down, under repair and maintenance or working below capacity, resulting in loss of power generation, revenue losses, unfruitful expenditure on out of order plants, wasteful expenditure on abandoned plants, etc. There were instances of non-recovery of liquidated damages, environmental dues, commitment fees, diversion of funds, excess payments to developers, non-revision of tariffs, etc. There were also deficiencies in monitoring and evaluation of projects by MNRE and State agencies.

2.1 OBJECTIVES

An extensive literature review has been carried on the development of renewable energy in India. The research was particularly directed to find out the development of small Hydro power in recent years and to see what impact of other renewable energy growth is on the SHP. Based on literature review it has been found that there is decline in the growth rate of SHP in the last few years and if SHP continues to grow at same rate it will not be able to harness its full potential in foreseeable future. A very few studies have been done to investigate the impact of other renewable energy on the SHP. Keeping this in view the present study has been carried out with the following objectives.

1. To study the government policy of centre as well as government policy of various states for renewable energy sources.
2. To identify the growth rate of various renewable energy sources and factors responsible for increase or decline in growth rate.
3. To study the regulations and guidelines framed by State Electricity Regulatory Commission (SERC) of various state, as these regulations plays a significant role in deciding the tariff of renewable energy sources.
4. To analyse the impact of various renewable energy sources on SHP.

2.2 METHODOLOGY

In order to achieve the above objectives, the various steps which are being followed in the methodology are listed below

1. The review of available research papers and several reports have been carried out on growth of small hydro power and impact of government policies. Some pervious thesis

related to the subject are also studied thoroughly. Various investigations had been carried out to study the decline of Small hydro power.

2. Identification of various factors to compare the state government policy of various renewable energy mainly biomass, wind power, solar power and small hydro power. Parameters such as land allotment, sale of power and tariff charges, wheeling charges etc.
3. Regression analysis is done to establish a relationship between the growth of renewable energy and policy change and tariff, to see whether these factors have a positive or negative impact on policy.
4. Analysis for impact of other renewable energy on SHP.

Chapter 3
RENEWABLE ENERGY POLICY

3.1 EVOLUTION OF POLICY

Energy is concurrent subject and the responsibilities for policy making are shared between the central and state level governments. The administration of power within each state is the purview of the concerned ministry and the state-owned electricity boards that oversee generation, transmission, and distribution. Both at the central level and the state level, public-sector undertakings provide the vehicles for these activities and these entities command a sizeable market share across the value chain from production to distribution. In addition, there is a regulatory machine through the Central and State Electricity Regulatory Commissions that is responsible for overseeing the functioning of these bodies and for tariff rationalization. The renewable sector has historically come to depend to a large extent on state-level policy environments. With state-level implementation details such as the exact feed-in tariff for wind power projects, wheeling charges for renewable energy projects, etc., being finalized at the state level, state-level policies influence the relative investment attractiveness for developers in a particular state and sector.

Feed-in tariffs and renewable procurement obligation, over the years, have been an effective tool to incentivize renewable energy investments. As the industry grew, especially with entry of IPPs and large-scale projects, governments moved away from feed in tariffs to market-based mechanisms such as tradeable green certificates, market premium, and tendering. Fiscal incentives such as capital subsidy, tax credits, lower taxes, public investment support, and energy production payments helped renewable energy generators compete in the mainstream power markets.

3.2 GROWTH OF RENEWABLE ENERGY IN INDIA

In recent years the focus on the renewable energy is increased which resulted in the formation of govt policies for various renewable energy, more and more incentives. The main policies which are responsible for the growth are Jawaharlal Nehru Solar Mission launched in 2010, the accelerated depreciation tax benefit for renewable energy which was reestablished in 2014 and was fixed on 80% and the most important one in recent times is 175 GW renewable energy target for 2022. Grant and subsidy are provided for the growth of renewable energy but these incentives are not uniformly divided among various renewable energy which leads to the unequal growth among various renewable energy sources. The table 3.1 shows the installed capacity of renewable energy, it is evident from the table that the installed capacity of solar in year 2010 is 32 MW which is increased to 23114 MW in year 2018 in the span of a decade it is a significant increase and it is good for the growth of country as it decreases our dependency on fossil fuel. Total installed renewable energy capacity has increased from 10256 MW in year 2006-07 to 75760 MW in 2018 this increase in renewable energy plays an important role for providing energy access, reducing consumption of fossil fuels and helping India pursue its low carbon developmental pathway. The figure 3.1 shows that from after year 2015 there is steep growth rate in solar power whereas the growth rate of small hydro power is almost constant.

Table 3.1: - Installed capacity of renewable energy [2]

RE(MW)/YEAR	2010	2011	2012	2013	2014	2015	2016	2017	2018
Biomass	997	1142	1263	1365	1365	4550	7907	8414	8700
Wind power	13184	16179	18634	21132	22465	25088	28700	32848	34402
Small hydro power	2953	3300	3552	3804	3990	4176	4333	4418	4493
Solar power	32	481.48	1446	2647	3062	4878	9012	12288	23114

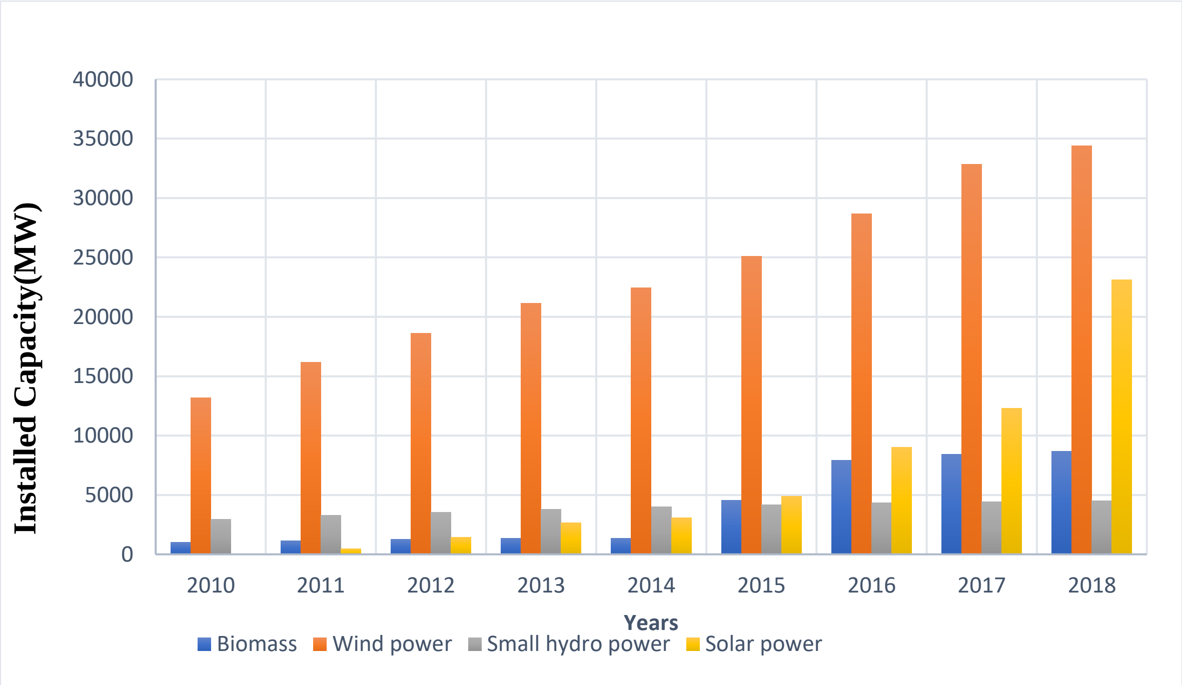

Fig 3.1: - Growth of Renewable Energy in India

3.3 POLICY FRAMEWORK FOR RENEWABLE ENERGY

Implementing reform in the power sector is a complex issue due to the multiplicity of institutional stakeholders, both at the state and the national level, and their inter-se dynamics. At the central level, the MNRE is the nodal ministry dealing with renewable energy. MNRE has set up three specialized technical institutions - National Institute of Solar Energy, National Institute of Wind Energy and Sardar Swaran Singh National Institute of Renewable Energy. IREDA is a non-banking financial company operating under the MNRE, which provides loans and also directs funds and other initiatives to promote renewable energy. The Ministry of Power (MoP) formulates the broader electricity law framework through the NEP and NTP, along with amendments to the Electricity Act, which has a direct impact on renewable power procurement and the overall institutional structure for such procurement. Therefore, at the Central level, MNRE leads the charge on renewable energy development and deployment but relies on the MoP for large-scale policy changes to further its objectives.

At the state level, there are nodal agencies and energy departments, which operate under the administrative control of state governments. These agencies channel Central-level subsidies, implement pilot projects and coordinate among other local level agencies. The SERCs have the most direct impact on feed-in tariffs, RPOs and open-access charges. All central agencies have a state counterpart, which has the final say on how renewable energy projects are developed. Progress on the ground depends mainly on state-level policies on feed-in tariffs and RPOs, evacuation, clearances, open access, and facilitation from state nodal agencies. They also devise policies for the development of renewable energy within the state and oversee its implementation. [20] Table 3.2 provides an overview of the roles of state and central government agencies in policy development, regulation and promotion of renewable energy.

Table 3.2: Roles of state and central government agencies in policy development, regulation, and promotion of renewable energy [20]

Level	Central Government (MoP/Ministry of Finance)	Ministry of New and Renewable Energy (MNRE)	Central Electricity Regulatory Commission (CERC)
Central	• Develops national electricity tariff policies, which	• Develops national renewable energy laws	• Sets guidelines for feed in tariff design for different

	includes renewable energy • Provides fiscal incentives to promote renewable energy	• Technical standards for renewable energy • Conducts resource assessment for renewable energy; supports R&D in renewable energy technologies • Promotes effective use of information technology for renewable energy, manages database • Reviews renewable energy programs to understand their effectiveness and efficiency	renewable energy technologies • Regulates the regional electricity corporation
	State Government	**State Nodal Agency**	**State Electricity Regulatory Commission (SERC)**
STATE	• Develops state-level renewable energy policy • Provides fiscal incentives for promoting renewable energy sources within the state	• Conducts resource assessments for various renewable energy source. • Allocates renewable energy projects and progress monitors • Facilitates clearances and land acquisition • Creates awareness and educates the masses	• Determines feed-in tariff for different renewable energy technologies • Determines RPOs and enforcement mechanism • Sets regulations on intrastate wheeling, open access, and third-party sale

		about adoption of renewable energy • Maintains database on renewable energy sources	

3.4 TIMELINE OF VARIOUS RENEWABLE ENERGY POLICY

GoI has taken numerous Objectives to accelerate the development and investment in renewable energy sector. The author attempts to summarize the different renewable energy policies below

1. **Electricity act 2003: -** Electricity act came in 2003 to promote cogeneration and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with grid and sale of electricity to any person, and also specify, for purchase of electricity from such sources, a percentage of total consumption of electricity in the area of distribution licensee.
2. **National Electricity Policy 2005: -** The National Electricity Policy (NEP) 2005 aims to exploit feasible potential of RE resources; reduce capital costs; promote competition and private sector participation. The NEP stipulates that the share of electricity from non-conventional sources would need to be increased progressively as prescribed by SERCs. Purchase by distribution companies shall be through competitive bidding process.
3. **National Tariff Policy 2006: -** The appropriate commission fixes a minimum percentage for purchase of energy from RE sources taking into account availability of such resources in the region and its impact on retail tariffs. RE procurement by distribution companies is done at preferential tariffs determined by the appropriate commissions. NEP says that a minimum percentage of RE procurement should be made applicable and the central commission should lay down guidelines within three months for pricing non-firm power, especially from non-conventional sources, to be followed in cases where such procurement is not through competitive bidding.
4. **National Action Plan on Climate Change 2008: -** The National Action Plan of Climate Change by the Government of India identifies 8 core national missions running through 2017, envisaging several measures to address global warming. One of

the mission's states that a dynamic minimum renewable purchase standard (DMRPS) be set, with escalation each year till a predefined level is reached.

5. **Jawaharlal Nehru National Solar Mission (Phase I II III) 2010:** - The Jawaharlal Nehru National Solar Mission (JNNSM), or the National Solar Mission, is an initiative of the Government of India and State Governments to promote solar power in India. Inaugurated in January 2010, the JNNSM has been revised twice and now boasts a target of 100 GW of solar PV by 2022.The objective of JNNSM is to establish India as a global leader in solar energy by creating the policy conditions for its deployment across the country. Each Phase is supported by differing key policies and targets.
6. **Accelerated Depreciation Tax Benefit- 2014:** - The accelerated depreciation tax benefit for renewable energy plant developers was re-established on 30th of March 2014 after a two-year long gap. The accelerated depreciation benefit was fixed on 80% level until 31st of March 2017. As of 1st of April 2017 the accelerated depreciation tax was lowered to 40% under the Union Budget 2016-2017
7. **Indian National Policy on Biofuels 2015:** - The National Policy on Biofuels aims to ensure that a minimum level of biofuels become readily available in the market to meet the demand at any given time. An indicative target of 20% blending of biofuels, both for bio-diesel and bio-ethanol, by 2017 is proposed. The blending level of bio-ethanol has already been made mandatory, effective from October 2008 and will continue to be mandatory leading up to the indicative target.
8. **India 175 GW Renewable Energy Target 2022- 2015**: - In 2015 India's Ministry of New and Renewable Energy adopted new renewable energy target of 175 GW to be achieved by 2022. The majority of the targeted capacity is to come from solar PV – 100 GW, followed by 60 GW from wind and residue capacity split between biomass (10 GW) and small hydropower stations (5 GW). Prior 2015, the solar PV capacity target for 2022 was 20 MW.

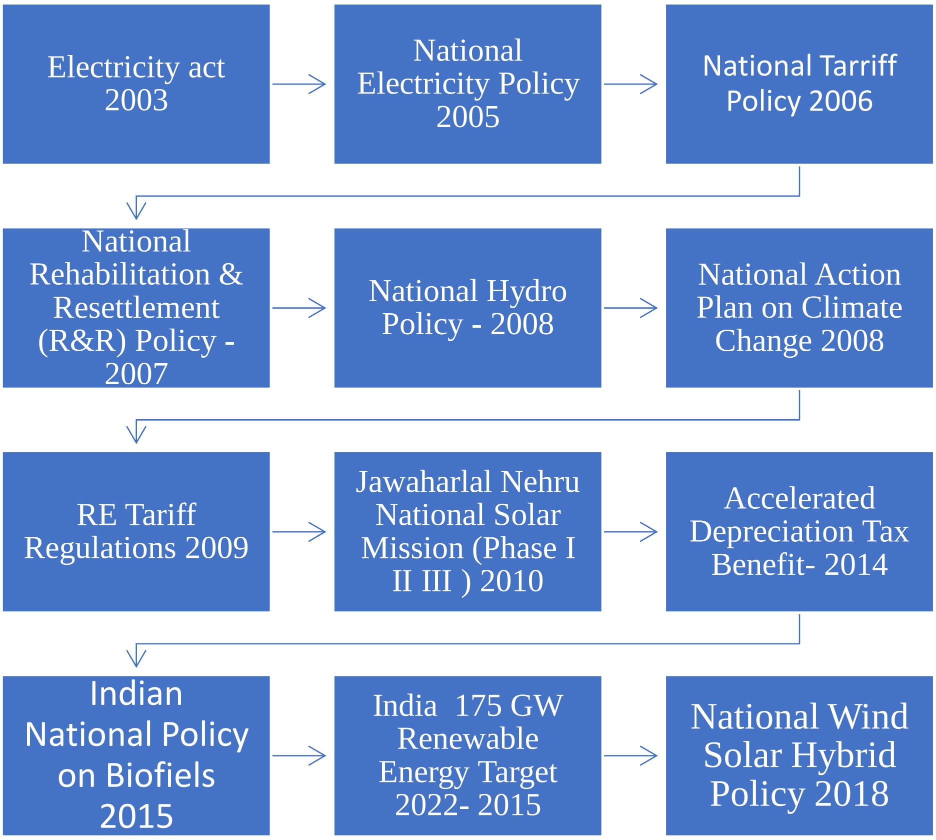

Figure 3.2: - Policy Timeline [21]

3.5 RENEWABLE ENERGY INTEGRATION

Wind and solar energy offer environmental benefits, low operating costs, and reduced dependence on imported fuel thus ensuring energy sustainability. However, wind and solar generation vary with wind speed, direction of wind and atmospheric temperature and solar insolation. This variability affects how power systems with high penetrations of renewable energy sourcesoperate. On generation side renewable power generators (wind and solar generation) are considered to inherit most variability and intermittency. But the demand side is also variable and changes every second. In order to meet the grid operating norms and maintain grid security, balancing reserves as well primary response is required from generation side. According to a report released by PGCIL which highlights that due to high penetration of solar energy, grid will witness high ramp down and ramp up requirements. In order to meet ramps storage technology should be used, another useful alternative can be small hydro power which is flexible in nature as well as clean and can be useful to meet the peak demand.

Small Hydro power has its advantages over other renewable energy sources one of them being its more predictive nature as compared to wind and solar. The other advantage being its ability to meet peak power demand and it can be turned off & on whenever required. The life span of SHP is 10 years more than the other renewable energy sources such as wind and solar.

3.6 CENTRAL ELECTRICITY REGULATORY COMMISSION (CERC) REGULATIONS

The tariff of renewable energy projects is single part tariff consist of return on equity, interest on loan capital, depreciation, interest on working capital, operation and maintenance expenses. For renewable energy technologies having fuel cost component, like biomass power projects and non-fossil fuel-based generation, single part tariff with two components, fixed cost component and fuel cost component.

Capital cost and Operation and Maintenance expenses are two important components of tariff. The variation of both these components are shown in the figure 3.3 & figure 3.4 below. Capital cost of solar power was 1690 lakh/MW in year 2010 with advancement of technology & government policies its capital cost came down to 530 lakh/MW in the year 2017, in other two renewable energy technologies there was slight increase in capital cost over the span of 8 years the capital cost of wind energy increased from 467 lakh/MW to 620 lakh/MW while the capital cost of SHP increased from 453 lakh/MW to 593 Lakh/MW. [29]

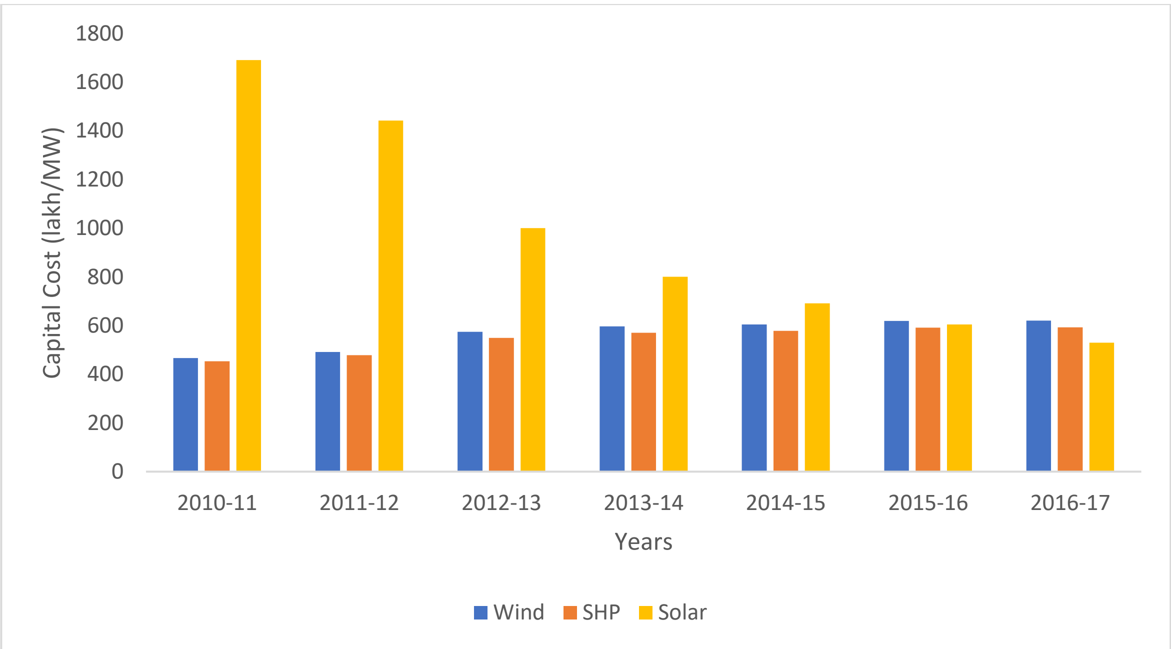

Fig 3.3: - Capital cost of various renewable energy sources

The Operation and maintenance cost of a component is the cost associated with the operating and maintaining that component. The O&M cost of Solar, wind and small hydro power are shown in the figure 3.4. The O&M cost for SHP is highest among all the renewable energy sources for the year 2016-17 O&M cost was 17.49 lakh/MW which shall be escalated at a rate of 5.72 % per annum over the tariff period for determination of the levelized tariff.

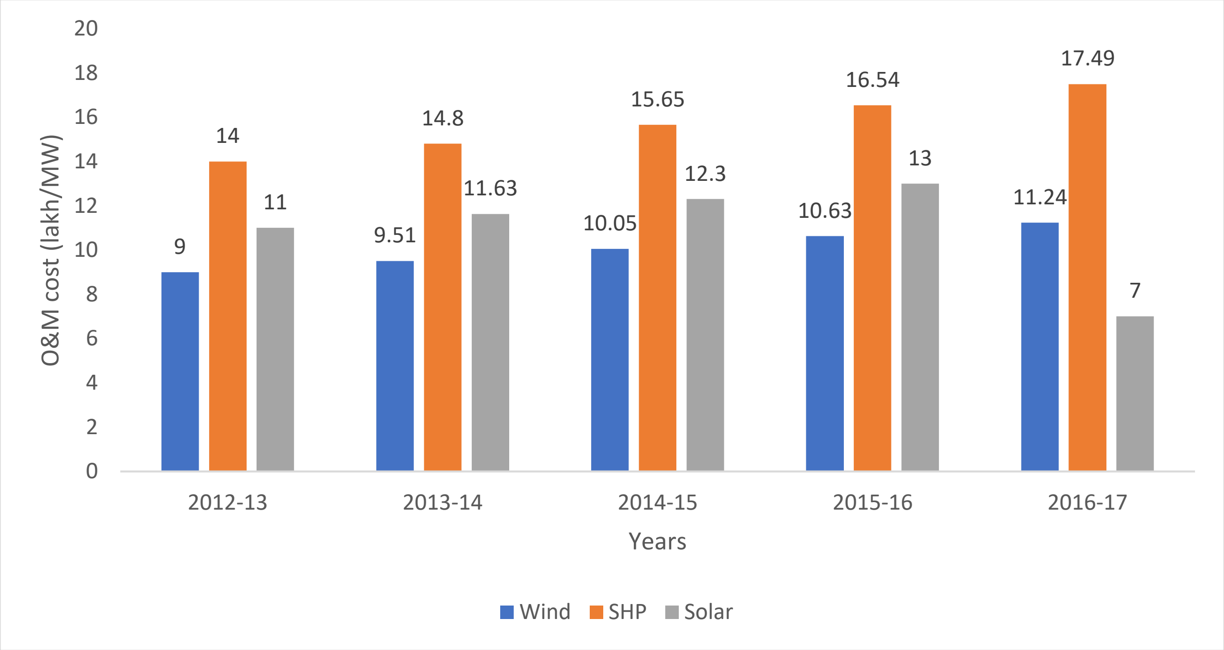

Fig 3.4: - O & M cost of various renewable energy sources

CHAPTER 4
METHODOLOGY FOR IMPACT ANALYSIS

The development of renewable energy depends on various factors which includes the state and Centre government policies for renewable energy. CERC and SERC regulations of various states, tariff norms, RPO (Renewable Purchase Obligation) regulations and technological advancements. External factors such as political, economic, Socio cultural, Environmental and legal affect the growth of renewable energies. Moreover, different renewable energies have different factors affecting their growth and development.

4.1 Regression Analysis

Regression analysis is a statistical method for establishing the connection between variables which have reason and result relation. Main focus of univariate regression is analyzing the relationship between a dependent variable and one independent variable and formulates the linear relation between dependent and independent variable. Regression model with one dependent variable and more than one independent variable is called multilinear regression. Multilinear or multiple regression analysis is performed so as to determine the correlations between two or more variables having cause effect relations.

Multiple linear regression is a statistical analysis tool used to explain the relationship between one continuous dependent variable and one or more independent variables.

$$\mathbf{Y_j = \beta + \beta_1 x_{1j} + \beta_2 x_{2j} + \varepsilon}$$

The X's are the independent variables. Y is the dependent variable. The subscript j represents the observation (row) number. The β's are the unknown regression coefficients. Each β represents the original unknown parameter. The ε is the error (residual) of observation j. The Y here is share of respective renewable energy in total renewable share of state, β is the constant and x1j is 1 if j is greater or equal to the year of introduction of new government policy and zero otherwise. The other independent variable is tariff.

For analyzing the regression analysis, regression statistics plays an important value. P-values and coefficients in regression analysis work together to tell you which relationships in your model are statistically significant and the nature of those relationships. The coefficients describe the mathematical relationship between each independent variable and the dependent variable. The p-values for the coefficients indicate whether these relationships are statistically significant or not. The sign of a regression coefficient tells you whether there is a positive or negative correlation between each independent variable and the dependent variable. A positive coefficient indicates that as the value of the independent variable increases, the mean of the dependent variable also tends to increase. A negative coefficient suggests that as the independent variable increases, the dependent variable tends to decrease. Another important factor is R-squared, R-squared is the percentage of the response variable variation that is explained by a linear model. It is always between 0 and 100%. R-squared is a statistical measure of how close the data are to the fitted regression line. The larger the R^2, the better the regression model fits your observations.

For the analysis of growth of various renewable energies, multiple regression analysis is done so as to see the effect of policy change and tariff on the development of renewable energies as well as their impact on SHP.

1. **Policy Change:** - State government as well as central government has changed the renewable energy policy to promote and encourage its growth. Sometimes the policy of particular renewable energy is changed or amended and sometimes the policy of all the renewable energies are changed. These policies changes have a large impact on the growth and development of renewable energy so to quantify the impact of policy change on various renewable energies it is chosen as one of the independent variables and an attempt is made to establish a relationship between percentage share of a particular renewable energy and policy change.

2. **Tariff:** - The tariff for RE projects is single part tariff consist of Return on equity, Interest on loan capital, Depreciation, Interest on working capital, Operation and maintenance expenses. For renewable energy technologies having fuel cost component, like biomass power projects and non-fossil fuel-based cogeneration, single part tariff with two components, fixed cost component and fuel cost component, is to be determined. Tariff covers lots of factors, first one is capital cost of project which changes over the years, with advancements in technology for example the capital cost of solar projects has declined over the years while the capital cost of other renewable energy has slightly increased.

CHAPTER 5
IMPACT ANALYSIS OF POLICY

The term impact analysis can be interpreted in two ways first one is Ex ante impact analysis and second one is Ex post impact analysis. In ex ante impact analysis, it involves doing a prospective analysis of what the impact of an intervention might be while in ex post impact analysis the evaluation aims to understand to what extent and how a policy intervention and other factors affects the dependent factor or variable. In this research post impact analysis is done to see how the policy change and tariff rates has affect the renewable energy growth and development in various states. A statistical technique is used to determine how different values of an independent variable will impact a particular dependent variable under a given set of assumptions. This technique is used with in specific boundaries that will depend on one or more input variables, such as the effect that changes in policy and tariff in different states will have on share of various renewable energy.

The input for the impact analysis or the dependent variables is policy change and tariff. The main aspects of policies such as upfront fees for allotment, application fees, wheeling charges, sale of power option and banking charges. These all parameters are different in different states policy hence these parameters will affect the growth rate and tariff of different renewable energy in different states.

5.1 STATE POLICY FOR RENEWABLE ENERGY

State governments has announced the policy for promotion of renewable energy in their respective states and amendments are also made in these policies are from time to time to consider the advancement in technology and changes made in central government policies. The state regulatory commissions (SERCs) have been deciding tariff.

5.2 Maharashtra

5.2.1 Maharashtra Renewable energy policy 2015 [22]

Maharashtra introduced a new policy for grid connected power projects based on New & Renewable Energy sources in 2015, a total of 14,400 MW capacity power projects based on new and renewable energy sources are targeted to be installed in the next 5 years under these policy which includes 5000 MW of Wind Power projects, 1000 MW of Bagasse’s based , 400

MW of Small Hydro Power, 300 MW of Biomass based projects, 200 MW of Industrial Based power projects and 7500 MW of Solar Power projects.

Policy for Small Hydro Power

i. Land allotment: Govt. land to be provided on lease rent @ Rs.1/ KW of installed capacity/year, Otherwise private land at developer cost.

ii. Sale of Power and tariff: Project developer can sell power primarily to any distribution licensee in the state for fulfilling the Renewable Purchase Obligation at a preferential tariff fixed by MERC (Maharashtra Electricity Regulatory Commission). After fulfilment of Renewable Purchase Obligation of the distribution licensee, the project developers will have the option of captive use or third-party sale within or outside the state.

iii. Wheeling: Wheeling charges and Transmission losses will be decided by time to time by MERC.

iv. Power Evacuation and Grid Interfacing: The project developer will undertake it with its own expenditure the laying of transmission and distribution lines required for the project in line with the technical specifications and estimates approved by MSETCL / MSEDCL. The project holder as per availability of funds will be given financial assistance by MEDA as reimbursement from the green cess fund up to a maximum of Rs. 1 crore per project for expenditure made on evacuation arrangement.

v. Incentives: A capital subsidy of Rs. 50,000 per kW of generation capacity, subject to a maximum of Rs. 1 crore per project will be given from green cess fund by MEDA. Electricity duty will not be levied for the first 10 years in respect of the small hydro power projects established under this policy for captive use.

Policy for Solar Power

i. Land allotment: Government land up to 4 hectares will be given if available for grid connected solar power projects up to 2MW capacity, without auction on lease at 50% concessional rate. The private land owners may give their land on rental/ lease basis for solar power projects

ii. Sale of Power and tariff: Power can be sold to the distribution licensees or it can be used for captive purpose within or outside state or for third party sale or for Renewable Energy Certificate mechanism.

iii. Power evacuation and grid Interfacing: The regulations and orders of MERC in the matter of evacuation arrangement and expenditure will be applicable to the solar power projects under this policy.

iv. Incentives: Electricity duty will not be levied for the first 10 years in respect of the solar power projects established under this policy for captive use.

5.1.2 Small Hydro power policy for Maharashtra 2005 [23]

i. This policy is intended to encourage the participation of both the Captive Power Producers (CPPs) and Independent Power Producers (IPPs) in development of SHP in the state.

ii. The SHP allotted under this policy will be on Build, Operate & Transfer Basis (BOT). The BOT period will be of 30 years.

iii. Grid interfacing and evacuation arrangements will be decided by MERC from time to time.

iv. The project developer will undertake the erection work of transmission lines up to the substation.

v. Water royalty: Developer will pay the water royalty at the rate of Rs.0.05 per unit of energy generated and charges for maintenance of intake structure, penstock etc. at the rate of Rs 0.05 for every unit generated.

vi. Sale of Power: Generated electricity can be sold to any consumer located in the state of Maharashtra or any willing distribution licensee or any power trading company.

5.2.3 Comparison of Policy of various renewable energy

In the table below policy for grid connected power projects based on New & Renewable Energy Sources -2015 is compared for solar, wind and small hydro power.

Table 5.1: - Comparison of solar, small hydro and wind energy policies of Maharashtra

S.No	Description	Solar	SHP	Wind
1.	Land allotment	• Deemed non-agricultural land status is given in respect of the land procured for the solar power projects under this policy.	• Govt. land on lease rent @ Rs.1/ KW of installed capacity /year, Otherwise private land at developer cost.	• Deemed non-agricultural land status is being made applicable in respect of the land procured for wind power projects.

		• The private land required for the solar power projects developed under this policy will be procured by the project developer himself.		
2.	Sale of Power and Tariff	• Power can be sold to the distribution licensees by competitive bidding, or it can be used for captive purpose within or outside state or for third party sale or for Renewable Energy Certificate mechanism.	• Sell power primarily to any distribution licensee in the state for fulfilling the Renewable Purchase Obligation at a preferential tariff fixed by MERC. After fulfilment of Renewable Purchase Obligation of the distribution licensee, the project developers will have the option of captive use or third-party sale within or outside the state.	
3.	Wheeling		• Wheeling and transmission losses as per MERC.	
5.	Power Evacuation and Grid Interfacing	• The regulations and orders of MERC in the matter of evacuation arrangement and expenditure will be applicable to the solar power projects under this policy. • The supervision charges for setting up of evacuation arrangement will not be applicable.	• The project developer will undertake, with own expenditure the laying of transmission and distribution lines required for the project in line with the technical specifications and estimates approved by MSETCL/ MSEDCL	• The regulations and orders of MERC will be applicable to wind power projects under this policy in the matter of evacuation arrangement and expenditure. • The supervision charges for setting up of evacuation

				arrangement will not be levied
6.	Incentives and General		• A capital subsidy of Rs. 50,000 per kW of generation capacity, subject to a maximum of Rs. 1 crore per project will be given. • CPPs exempted from Electricity Duty on self-consumption for first 10 years. • CPPs exempted from tax on sale of Electricity for consumption in Maharashtra.	• The wind power projects under this policy are exempted from obtaining NOC / consent from the Pollution Control Board

The table 5.2 shows the installed capacity of various Renewable energy of Maharashtra till 2017. The installed capacity of SHP was 245 MW in 2010 and in year 2017 it was 349 MW while the total renewable energy increased by 212% during 2010-2017. The installed capacity of solar increased from 2 MW to 763 MW during the same time period and installed capacity of wind power increased from 2078 MW to 4778 MW. The growth rate of Renewable energy is good in the state but there is decline in the growth rate of SHP which is a matter of concern.

Table 5.2: - Installed capacity of Renewable Energy in Maharashtra

RE (MW)/YEAR	2010	2011	2012	2013	2014	2015	2016	2017
Biomass	218	403	603	757	940	1113	1968	2065
Wind power	2078	2317	2733	3022	4369	4638	4666	4778
Small hydro power	245	275	281	300	335	337	346	349
Solar power	2	4	20	100	323	379	430	763

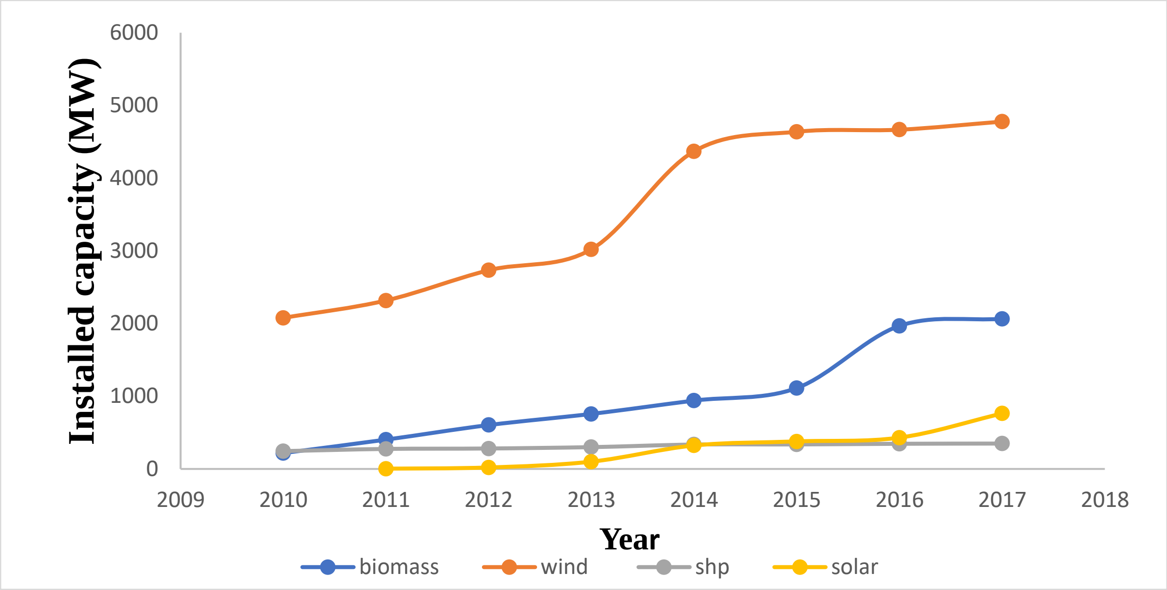

Fig 5.1: - Growth of Renewable Energy in Maharashtra

The % share of various renewable energy over the years from 2010-2017 is shown in table 5.3. The major percentage of renewable energy in the state is dominant by wind energy followed by solar power and small hydro power. The share of solar power is increased in the last few years from .09% in year 2010 to 12.96% in 2017 while the share of SHP is declined from 10.55 % to 5.93 % in 2017.

Table 5.3: - Percentage share of Renewable Energy in Maharashtra

RE (% share)	2010	2011	2012	2013	2014	2015	2016	2017
Wind power	89.36	89.25	90.27	88.31	86.9	86.63	85.73	81.12
Small hydro power	10.55	10.6	9.27	8.77	6.67	6.29	6.36	5.93
Solar power	0.09	0.15	0.66	2.92	6.42	7.07	7.91	12.96

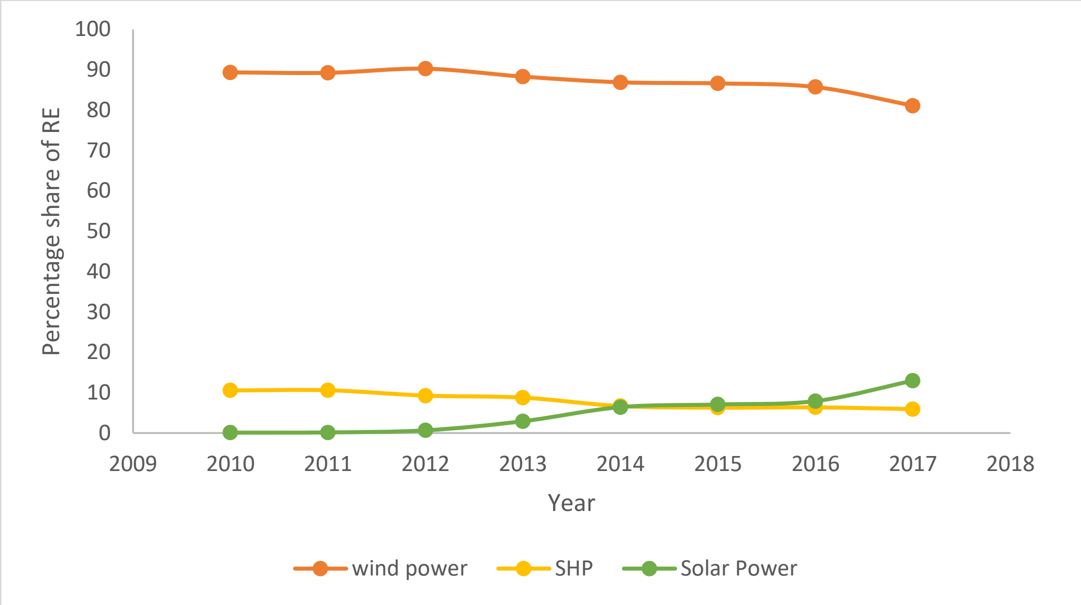

Fig 5.2**: -** Share of Renewable Energy in Maharashtra

5.2.4 Maharashtra SERC Regulation

MERC is responsible for determining the tariff and regulations of all RE projects in Maharashtra. The regulations made by MERC will be applicable to all RE projects to be commissioned within Maharashtra for generation and sale of electricity from such RE projects to all distribution license within Maharashtra. The Work of MERC includes the to define the tariff period of various renewable energies and to determine the generic tariff, wheeling & banking charges, regulations for power evacuation and grid interfacing.

To determine the tariff of RE, MERC in the year 2010 published the "terms and condition of Renewable energy regulations 2010". And for each financial year they determine the generic tariff using these regulations and CERC guidelines. [30]

Changes over the years in MERC regulations

For Financial year 2010-11

i. Any Internal line losses / transformation losses up to interconnection point are to be paid by the developer
ii. Water royalty charges for SHP projects have not been factored while determining tariff.
iii. To promote Mini/Micro projects: the tariff of these projects should be higher by Rs0.50/kWh of 1MW to 5MW project.

For financial year 2011-12

i. To encourage Mini/Micro Hydro: preferential tariff incentive of Rs 1.00/kWh up to 500 KW and of Rs 0.50/kWh for projects between 500 KW to 1MW.

For financial year 2013-14

i. MSERC shall take into the consideration the incentives & subsidy offered by state or central govt while determining the tariff.
ii. To deal with the issue of intermittent generation of RE sources such as wind solar, it should be dealt in accordance with IEGC and also with the introduction of RRF mechanism (Renewable regulatory fund)

For financial year 2017-18

i. Important suggestion was given by the IPP that mini/micro hydro projects at remote location which are not in the vicinity of a transmission or distribution network. The net metering arrangement applicable to roof-top solar projects should be extended to such mini/micro hydro projects to measure any injection into the network.
ii. The major change in the regulations in this year was that the capital cost of Solar PV projects based on recent bids of solar auctions within the state & not as" summation of parts".

5.2.5 Regression analysis for Maharashtra

Univariate regression is used for analyzing the relationship between a dependent variable and one independent variable and formulates the linear relation between dependent and independent variable. Regression model with one dependent variable and more than one independent variable is called multilinear regression. In our case independent variables are more than one hence multilinear regression analysis is used. The equation that follows in multilinear analysis is given below

$Y_j = \beta + \beta_1 x_{1j} + \beta_2 x_{2j} + \varepsilon$

The X's are the independent variables, Y is the dependent variable. The subscript j represents the observation number. The β's are the unknown regression coefficients. Each β represents the original unknown parameter. The ε is the error (residual) of observation j. The Y here is share of respective renewable energy in total renewable share of state, β is the constant and x_{1j} is 1 if j is greater or equal to the year of introduction of new government policy and zero otherwise and the other independent variable is tariff. The results obtained after the regression analysis are shown in the table 5.4, 5.5 and 5.6

Table 5.4: - Effect of the change in policy and tariff on SHP in Maharashtra

	Coefficients	P- value
Intercept	19.1974	0.001
Policy change	-2.4529	0.003
Tariff	-2.3284	0.028

p<0.01(most effective factor), p<0.5(effective factor), p<0.1(least effective factor)

The regression statistics for the above analysis which shows the effectiveness of regression analysis for the given data are the values of R square and adjusted R square the closer these values are to 1 the better it explains the variation. R square value for this analysis is 0.9633 and the value of adjusted R square is .9486

From the above result of multiple regression analysis where the dependent variable was % SHP share in total RE share of state of Maharashtra, and the independent variable was the tariff and policy change. The value of both the coefficients have negative sign which shows that both factors have negative effect on share of SHP. Moreover, the effect of policy change is more profound as compared to the variation in Tariff because the p-value for policy is less then .01 which means it is more effective and in case of tariff p-value is more then .01.

Table 5.5: - Effect of the change in policy and tariff on Solar in Maharashtra

	Coefficients	P- value
Intercept	6.8893	0.001
Policy change	4.7582	0.011
Tariff	-0.5245	0.212

p<0.01(most effective factor), p<0.5(effective factor), p<0.1(least effective factor)

The regression statistics for the above analysis which shows the effectiveness of regression analysis for the given data are the values of R square and adjusted R square the closer these values are to 1 the better it explains the variation. R square value for this analysis is 0.9224 and the value of adjusted R square is .8509.

From the above result of multiple regression analysis where the dependent variable was % Solar share in total RE share of Maharashtra, and the independent variable was the tariff and policy change. The coefficient of independent variable policy change is positive which shows that the policies have positive impact on the share of Solar energy and it's p-value is also less then .01 which means it is the most effective factor while the other factor tariff has negative value but its p-value is more than 0.1 hence its effect on the share is not that much as compared to another variable.

Table 5.6: - Effect of the change in policy and tariff on Wind in Maharashtra

	Coefficients	P- value
Intercept	79.2191	0.0001
Policy change	-4.4403	0.021
Tariff	2.0959	0.253

p<0.01(most effective factor), p<0.5(effective factor), p<0.1(least effective factor)

The regression statistics for the above analysis which shows the effectiveness of regression analysis for the given data are the values of R square and adjusted R square the closer these values are to 1 the better it explains the variation. R square value for this analysis is 0.8345 and the value of adjusted R square is .6963

From the above result of multiple regression analysis where the dependent variable was % Wind share in total RE share of Maharashtra, and the independent variable was the tariff and policy change. The coefficient of independent variable policy change is negative which shows that the policies have negative impact on the share of Wind RE while the other factor tariff has positive value but its p-value is more than 0.1 hence its effect on the share is not that much as compared to another variable.

Maharashtra has rich potential of Wind Power & the Renewable energy in the state is also dominated by wind power. The overall growth rate of renewable energy in the state is good, but the growth rate of SHP is declining and the major reasons for it is less focus on it, in the 5 GW target of SHP by the year 2022 the share of Maharashtra was only 50 MW which is already achieved. MERC regulations which is responsible for determining the tariff and regulations has done very little to promote the growth of SHP, to promote mini/micro hydro the tariff of these projects was increased by Rs.50/kWh of 1MW to 5MW project. The other factors which can be concluded from regression analysis are policy change and tariff. The results of analysis show that the new policy introduced has a negative impact on SHP while it has positive impact on Solar and Wind energy.

5.3 Karnataka

5.3.1 Karnataka Renewable energy policy 2009-14 [24]

Karnataka government introduced a renewable policy to enhance the contribution of Renewable Energy in the total installed capacity of the state from **2400** MW to about **6600** MW by **2014.**

In order to facilitate Renewable Energy project financing and Energy Conservation and Efficiency measures Green Energy Fund ‘’Akshaya Shakthi Nidhi’’ is established by govt. “Green Energy Cess” of Rs 0.05 (five paise) per unit would be levied on the electricity supplied to commercial and industrial consumers.

i. Land Policy: Inventory of surplus and unused land available with Public Sector Undertakings, State Govt., Urban Local Bodies/ Gram Panchayath lands and suitable private waste lands to be done by govt body.
ii. Renewable energy special economic zone are to be developed by government as the Renewable Energy and allied sector requires to be supported with Renewable Energy equipment manufacturing industries. Renewable Energy Sources like wind and solar require considerable extent of land for setting up manufacturing units of Solar Photo Voltaic and wind Turbine etc.
iii. Evacuation arrangement: Karnataka Power Transmission Company Limited will undertake the augmentation of transmission lines and lying of new lines and receiving stations as required. Respective Renewable Energy Project Developers will bear the cost of transmission lines from the project site to the substation as per grid norms
iv. Wheeling of Electricity: Wheeling charges @ 5 %will be applicable subject to the KERC norms.
v. Banking of Electricity: The banking facility for the power generated shall be allowed as determined by KERC from time to time for the energy banked with the Karnataka Power Transmission Company Limited / distribution licensee.

5.3.2 Comparison of various renewable energy policy of Karnataka

In the table below the renewable energy policy (2009-14) for wind energy and small hydro power is compared with the solar policy (2014-2021).

Table 5.7: - Comparison of solar, small hydro and wind energy policies of Karnataka

S.no	Description	Solar	Hydro	Wind
1.	Land allotment	• GoK contemplates to facilitate deemed conversion of land for solar projects • A separate dedicated cell with staff drawn from revenue dept shall be created in KREDL, to ensure creation of Govt. Private land bank. • GoK will permit the purchase of agricultural land for development of solar project and contemplates time bound permissions on payment of specified fees.	• 10% barren Govt. land reserved for industrial use at declared RE sites will be given to KREDL for developing the land for projects. • Forest land identified for RE projects to be processed within a period of 4 months. • KREDL will sub-lease the Developed land to developer for 30 years.	• The Govt waste lands in windy locations identified for industrial development will be offered to set up wind projects • Identified revenue, private and forest land to be developed by KREDL.
2.	Sale of power and tariff	• Solar power project developer can sale power to state ESCOMs, 3rd party sale and	• Obligatory to sell electricity generated from RE projects to respective geographical	• Obligatory to sell electricity generated from RE projects to respective

		captive consumption. • GoK intends to bring various HT categories of consumers with connected load of more than 50 kVA under Solar Purchase Obligation (SPO) with the consent of KERC.	ESCOMs in which the project is located, at the Tariff determined by KERC.	geographical ESCOMs in whi ch the project is located, at the Tariff determined by KERC.
3.	Wheeling	• Wheeling charges 5%to be applicable as determined by KERC from time to time. • All transactions between KPTCL / ESCOMS / Distribution Licensee and the Developer involving wheeling or sale of power to be settled on monthly basis.	• Wheeling charges 5%to be applicable as determined by KERC from time to time. • All transactions between KPTCL / ESCOMS / Distribution Licensee and the Developer involving wheeling or sale of power to be settled on monthly basis	• Wheeling charges 5%to be applicable as determined by KERC from time to time. • All transactions between KPTCL / ESCOMS / Distribution Licensee and the Developer involving wheeling or sale of power to be settled on monthly basis
4	Banking	• Banking and cross subsidy charges to be applicable as	• Allowed for energy banking with	• Allowed for energy banking with

		determined by KERC from time to time.	KPTCL/Distribution licensee.	KPTCL/Distribution licensee.
5.	Power Evacuation and Grid Interfacing	• The developer shall be responsible for connecting the generating station to the nearest grid sub-station or inter-connection point with the grid.	• KPTCL /KREDL to provide transmission lines and developers to bear the cost of lines from the project site to the sub-stations as per grid norms.	• KPTCL /KREDL to provide transmission lines and developers to bear the cost of lines from the project site to the sub-stations as per grid norms.
6.	Incentives and General	• Tax concessions in respect of entry tax. • The Industrial Consumers opting to draw power form Solar Power Projects under Renewable Energy Certificates (REC) Mechanism, Projects under Captive Generation and Projects under IPP are allowed corresponding pro-rata reduction in contract demand on a permanent basis.	• Generation from RE sources be treated as industry and incentives to be extended. • KREDL to facilitate availing CDM benefits. • State Government committed to procure RE power subject to KERC guidelines and reserves the first right of refusal or purchase of power. • 50% of the installed capacity assigned for captive use to be allowed.	• Generation from RE sources be treated as industry and incentives to be extended to RE. • KREDL to facilitate availing CDM benefits. • State Government committed to procure RE power subject to KERC guidelines and reserves the first right of refusal or purchase of power.

The table 5.8 shows the installed capacity of various Renewable energy of Karnataka till 2017. The installed capacity of SHP was 640 MW in 2010 and in year 2017 it was 1231 MW, the increase in total renewable energy was 343% during 2010-2017. The potential of SHP is largest in Karnataka among all the state but its growth rate is not good in the state. The installed capacity of Solar Power was 6 MW in 2010 which increased to 1231 MW in 2017 and the installed capacity of wind power was 1473 MW which increased to 3793 MW in 2017.Renewable energy sector is growing at a good rate in the state but the decline in the share of SHP is concerned matter.

Table 5.8: - Installed Capacity of Various Renewable Energy in Karnataka

RE (MW)/YEAR	2010	2011	2012	2013	2014	2015	2016	2017
Biomass	336	365	441	491	603	737	1401	1605
Wind power	1473	1727	1933	2135	2549	2872	3154	3793
Small hydro power	640	783	882	964	1105	1178	1221	1231
Solar power	6	6	9	14	67	104	327	1801

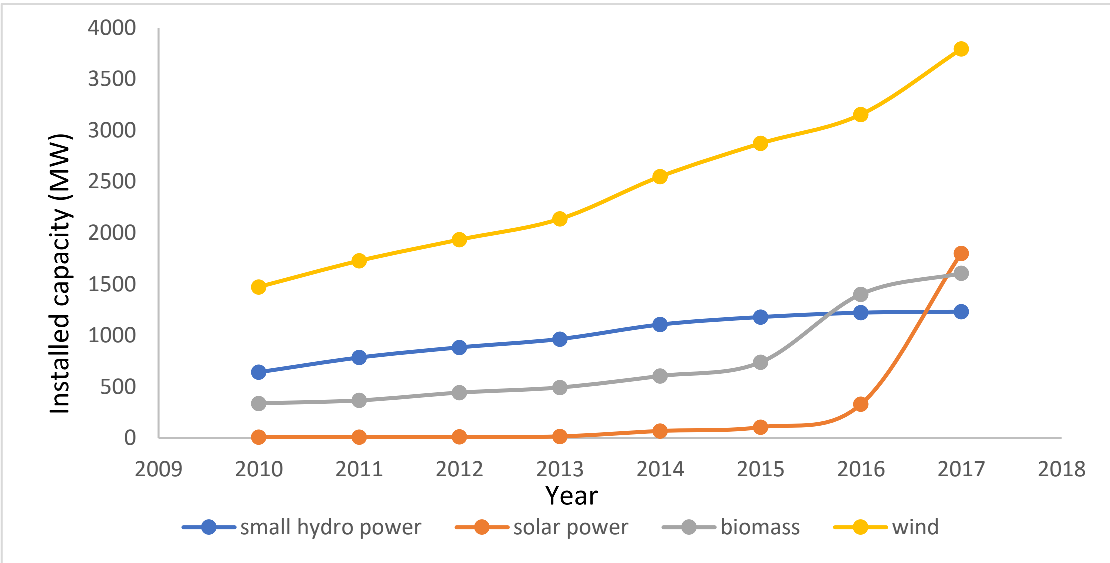

Fig 5.3: - Growth of Renewable Energy in Karnataka

The % share of various renewable energy over the years from 2010-2017 is shown on table 5.9. The major percentage of renewable energy in the state is dominant by wind energy followed by solar power and small hydro power. The total share of renewable energy has grown over the years. The percentage share of wind power has increased from 69.50% in 2010 to 71.01% in year 2017, while the percentage share of solar power is increased in the last few years from .28% in year 2010 to 26.39% in 2017 but in the case of small hydro power percentage share is decreased from 30.22% in 2010 to 18.03% in 2017.

Table 5.9: - Percentage share of Renewable Energy in Karnataka

RE (% share)	2010	2011	2012	2013	2014	2015	2016	2017
Wind	69.50	72.76	71.01	70.55	72.28	71.02	71.10	71.01
SHP	30.22	31.13	31.24	30.96	29.70	28.36	25.96	18.03
Solar	0.28	0.24	0.32	0.45	1.80	2.51	6.97	26.39

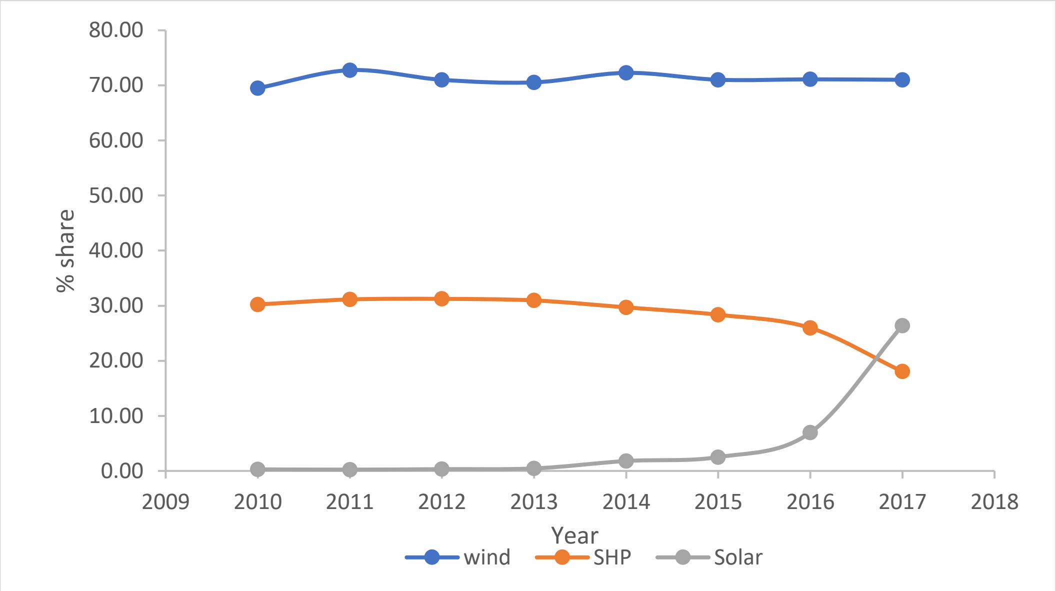

Fig 5.4: - Share of Renewable Energy in Maharashtra

5.3.3 Karnataka SERC Regulations

KERC is responsible for determining the tariff and regulations of all RE projects in Karnataka. The regulations made by KERC will be applicable will be applicable to all RE projects to be commissioned within Karnataka for generation and sale of electricity from such RE projects to all distribution license within Karnataka. The Work of KERC includes, defining the tariff period of various renewable energies and to determine the generic tariff, wheeling & banking charges, regulations for power evacuation and grid interfacing. [31]

Changes over the years in KERC Regulations

KERC 2018 - 2021 Tariff regulations

i. Solar Project Commissioned before 31.03.2017 no banking and wheeling charges.
ii. Wind projects between 10.10.2013 & 03.09.2017, 25% of normal transmission charges & wheeling charges in cash & no line loss
iii. For SHP commissioned during – 01.01.2015 & 31.03.2018, 25% of normal wheeling Charges & 50% of the applicable line loss.
iv. For Wind & SHP banking charges at 2%.
v. RE projects, commissioned after 01.04.2018- shall be liable for 25% of normal transaction or wheeling charges.
vi. To factor the capital subsidies extended by central or state govt. while determining the tariff.

Solar tariff for year 2013 – 2018

i. SERCs are required to reserve a minimum % for purchase of solar energy such that it reaches 8% of the total consumption of the state by march 2022.
ii. Capital cost is based on balance of system basis.
iii. No wheeling & banking charges, or cross-subsidy surcharge on the solar generators.

5.3.4 Regression analysis for Karnataka

Univariate regression is used for analyzing the relationship between a dependent variable and one independent variable and formulates the linear relation between dependent and independent variable. Regression model with one dependent variable and more than one independent variable is called multilinear regression. In our case independent variables are more than one hence multilinear regression analysis is used. The equation that follows in multilinear analysis is given below

$$Y_j = \beta + \beta_1 x_{1j} + \beta_2 x_{2j} + \varepsilon$$

The X's are the independent variables, Y is the dependent variable. The subscript j represents the observation number. The β's are the unknown regression coefficients. Each β represents the original unknown parameter. The ε is the error (residual) of observation j. The Y here is share of respective renewable energy in total renewable share of state, β is the constant and x_{1j} is 1 if j is greater or equal to the year of introduction of new government policy and zero otherwise and the other independent variable is tariff. The results obtained after the regression analysis are shown in the table 5.10, 5.11 and 5.12

Table 5.10: - Effect of the change in policy and tariff on SHP in Karnataka

	Coefficients	P- value
Intercept	142.5237	0.005
Policy change	-40.8778	0.001
Tariff	50.9962	0.241

$p<0.01$(most effective factor), $p<0.5$(effective factor), $p<0.1$(least effective factor)

The regression statistics for the above analysis which shows the effectiveness of regression analysis for the given data are the values of R square and adjusted R square the closer these values are to 1 the better it explains the variation. R square value for this analysis is 0.947 and the value of adjusted R square is .897

From the above result of multiple regression analysis where the dependent variable was % SHP share in total RE share of state of Karnataka, and the independent variable was the tariff and policy change. The coefficient of policy change coefficient is negative therefore it shows that these have negative effect on share of SHP while tariff has positive impact on the SHP Share. Moreover, the effect of policy change is more profound as its p-value is less then .01 which makes its more effective factor as compared to the variation in Tariff because p-value of tariff is .241.

Table 5.11: - Effect of the change in policy and tariff on Solar in Karnataka

	Coefficients	P- value
Intercept	32.4070	0.054
Policy change	6.9138	0.038
Tariff	2.2170	0.456

$p<0.01$(most effective factor), $p<0.5$(effective factor), $p<0.1$(least effective factor)

The regression statistics for the above analysis which shows the effectiveness of regression analysis for the given data are the values of R square and adjusted R square the closer these values are to 1 the better it explains the variation. R square value for this analysis is 0.790 and the value of adjusted R square is .625.

From the above result of multiple regression analysis where the dependent variable was % Solar share in total RE share of Karnataka, and the independent variable was the tariff and policy change. The coefficients of independent variables policy change and tariff is positive which shows that they have positive impact on the share of Solar RE. The p-value of coefficient of policy change is .038 which is less then .01 which shows that policy change is effective factor as compared to the tariff.

Table 5.12: - Effect of the change in policy and tariff on Wind in Karnataka

	Coefficients	P- value
Intercept	70.8663	0.007
Policy change	0.390	0.677
Tariff	0.223	0.832

$p<0.01$(most effective factor), $p<0.5$(effective factor), $p<0.1$(least effective factor)

The regression statistics for the above analysis which shows the effectiveness of regression analysis for the given data are the values of R square and adjusted R square the closer these values are to 1 the better it explains the variation. R square value for this analysis is 0.453 and the value of adjusted R square is .336

From the above result of multiple regression analysis where the dependent variable was % Wind share in total RE share of state of Karnataka, and the independent variable was the tariff and policy change. The coefficients of independent variables policy change and tariff is positive which shows that both have positive impact on the share of Wind RE but p-values of both the factor is more than 0.1 hence their effect on the share is not significant.

Karnataka has the highest potential of Small Hydro Power among all the states i.e. 4141MW out of which only 1231MW is installed. Karnataka introduced a new solar policy in 2014-2021 to promote solar energy, under this policy government plans to make a separate dedicated cell to ensure the creation of Govt & private land banks for the development of solar projects. KERC which is responsible for determining the tariff and regulations, to promote solar power in the state has decided to take no wheeling and banking charges while for Wind and SHP projects 25% of normal transaction charges. The regression analysis for the three renewable energy shows that the policy has a positive impact on Solar power, while it has a negative impact on SHP.

5.4 Uttarakhand

5.4.1 Uttarakhand policy on Hydropower Development [25]

Hydropower projects estimated to have an installed capacity of up to 25 MW are eligible under this policy. The identified potential at present for small hydropower projects ranging in capacity up to 25 MW is about 1700 MW.

i. Sale of Power:The IPP/bidder can sell power to any HT consumer within state, to local rural grids within Uttarakhand which are not connected to Uttaranchal Power Corporation Ltd.'s (UPCL) main grid to rural power distribution entities (i.e. those which sell power to predominantly rural areas), to any consumer outside the state.

ii. Wheeling Charges: Wheeling charges for wheeling the generated energy to third party consumers or outside the State will be as determined by the Uttarakhand Electricity Regulatory Commission (UERC). No wheeling charges are applicable in cases of sales to the UPCL or for sale to rural power distribution entities or local rural grids within Uttarakhand.

iii. Grid interfacing/transmission line: The IPP shall be responsible for laying lines for connectivity to the nearest grid substation at the appropriate voltage, which will normally be 132 KV or 33 KV depending on the capacity of the power station and the distance from the power station to the Grid sub-station.

iv. Banking: Developers can avail of the facility of banking of energy within fixed period spans of 2 months.

v. Royalty: On all projects governed by this policy, royalty payment for the first 15 years of operation would be exempted in all cases of sale of power outside the State or to the UPCL or to consumers in rural areas not served or inadequately served by the concerned existing distribution licensee. In case of sale to other parties, a royalty of 12% of net energy wheeled (after deducting wheeling charges) or supplied directly without wheeling would be charged.

5.4.2 Comparison of various renewable energy policy of Uttarakhand

In the table below the comparison of Uttarakhand solar policy (2013) and policy on hydropower development by private sector.

Table 5.13: - Comparison of solar and small hydro power policies of Uttarakhand

S.No	Description	Solar	SHP
1.	Land allotment	• For setting up Solar Power Plant (Solar PV or Solar Thermal) on different technology, maximum land use permission for Govt land, if available to the Solar Power Developer shall be 2.5 Hectare per MW. • If the developer purchase private land for the project, then they will be eligible for an exemption of 50% on stamp duty.	
2.	Sale of Power and Tariff	• UPCL to have first right of purchase of electricity. • UERC to determine price of electricity. • Government of Uttarakhand to provide guarantee for Payments to be made by UPCL for purchase of Power.	• HT consumer within Uttarakhand, Local rural grids which are not connected to Uttarakhand Power Corporation Ltd (UPCL) main grid. • Rural Power Distribution entities. • Any consumer outside the state or to UPCL
3.	Wheeling	• The wheeling charges shall be applicable as decided by UERC from time to time.	• No wheeling charges are applicable in cases of sales to the UPCL or for sale to rural power

			distribution entities or local rural grids within Uttaranchal. • Wheeling charges for wheeling the generated energy to third party consumers or outside the State will be as determined by the UERC.
4.	Banking		• Developers can avail the facility of banking energy within fixed period spans of 2 months.
5.	Power Evacuation and Grid Interfacing	• T&D lines from generation site to be provided by UPCL/PTCUL.	• IPPs to lay lines for connectivity to the nearest grid substation normally at 132 kV or 33 kV.
6.	Incentives and General	• The Project installed on Govt land: The successful developer shall be required to deposit Bank Guarantee @ Rs 10 Lakhs per MW. • The Project installed on Private land: The successful developer shall be required to deposit Bank Guarantee @ Rs 5 Lakhs per MW • Projects to be offered for 40 years from the date of award.	• No entry Tax on Generation, Transmission equipment & Building Materials for project. • The project shall be made operational within 48 months from the date of receipt of all statutory approvals and clearances by the IPP Incentives for early commissioning. • Levies, taxes, charges on IPPs applicable for 10 years.

The table 5.14 shows the installed capacity of various Renewable energy of Uttarakhand till 2017. The installed capacity of SHP was 133 MW in 2010 and in year 2017 it was 214 MW and the installed capacity of solar power was .05 MW in 2010 increased to 214 MW in 2017. Uttarakhand being an Himalayan state has large number of rivers and hydro power potential but the growth rate of SHP is not much as it should be.

Table 5.14: - Installed Capacity of Various Renewable Energy in Uttarakhand

RE/YEAR	2010	2011	2012	2013	2014	2015	2016	2017
Biomass	5	10	10	10	30	30	72	73
Small hydro power	133	135	171	175	209	209	209	214
Solar power	0.05	0.05	5	5	5	5	45	247

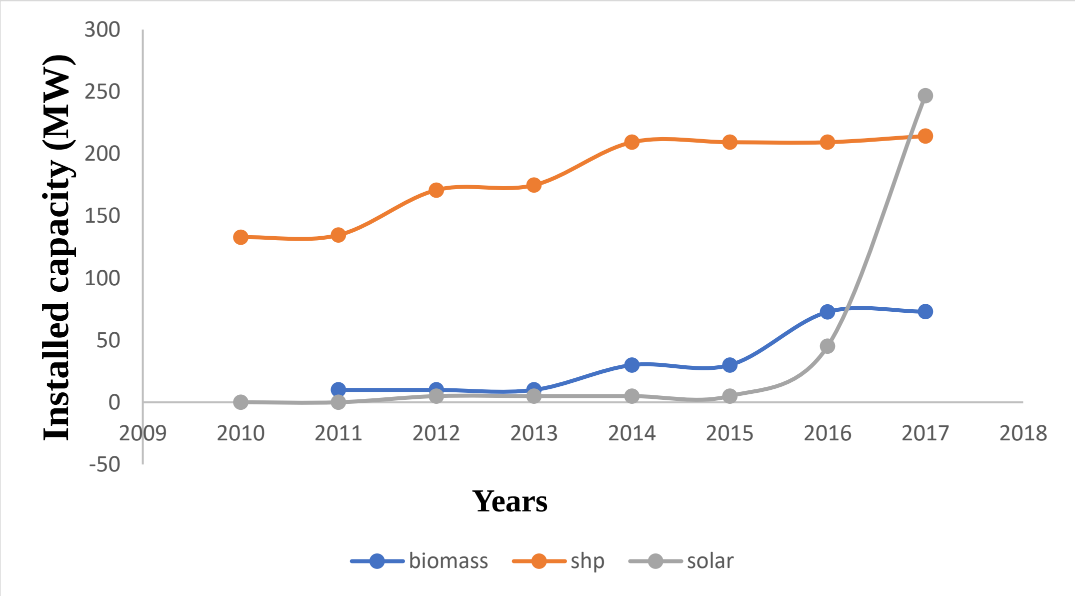

Figure 5.5: - Growth of Renewable Energy in Uttarakhand

The % share of various renewable energy over the years from 2010-2017 is shown in the table 5.15. The major percentage of renewable energy in the state was dominated by Small Hydro Power but in the year 2017 solar power overtook this spot. The share of solar power increased from .04% in year 2010 to 46.22% in 2017, but in the case of Small hydro power its share is decreased from 94.29% in year 2010 to 40.12% in 2017.

Table 5.15: - Percentage Share of Renewable Energy in Uttarakhand

RE (%share)	2010	2011	2012	2013	2014	2015	2016	2017
SHP	94.29	93.05	91.90	92.07	85.66	85.66	63.98	40.12
Solar	0.04	0.03	2.72	2.66	2.07	2.07	13.79	46.22
Biomass	5.67	6.99	6.91	5.38	14.29	12.28	25.33	22.30

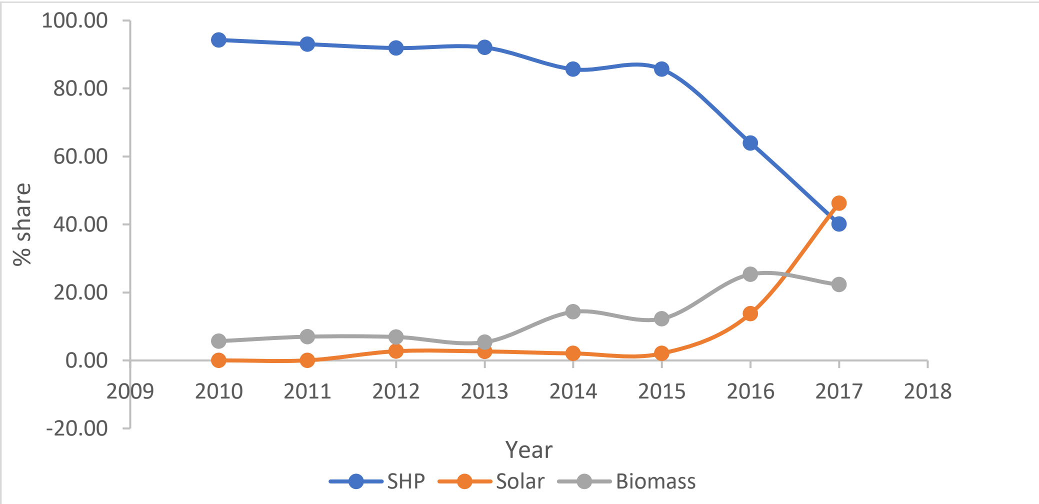

Fig 5.6: - Share of Renewable Energy in Uttarakhand

5.4.3 Uttarakhand SERC Regulations

UERC is responsible for determining the tariff and regulations of all RE projects in Uttarakhand. The regulations made by UERC will be applicable to all RE projects to be commissioned within Uttarakhand for generation and sale of electricity from such RE projects to all distribution license within Uttarakhand. The Work of UERC includes, defining the tariff period of various renewable energies and to determine the generic tariff, wheeling & banking charges, regulations for power evacuation and grid interfacing.

To determine the tariff of RE, UERC in the year 2010 published the "(Tariff and Other Terms for Supply of Electricity from Renewable Energy Sources and non-fossil fuel based Co-generating Stations) Regulations, 2010." And for each financial year they determine the generic tariff using these regulations and CERC guidelines. In the year 2013 UERC introduced new regulations to determine the tariff of RE and again in the year 2015 and then in year 2018. [32]

Changes over the years in UERC regulations

Amendment in the year 2012

i. Change in deemed generation condition for small hydro projects. The UERC on the request of the generators and after seeking UPCL's views on the issue has decided to do away with the time limit of 20 minutes at a time for outages/interruption. The UERC has increased the total duration of interruptions/outages to 48hours/month.

Amendment in the year 2014

i. The CUF for SHP was revised from 45% to 40%.

ii. Incentive/recovery mechanism for generating beyond revised normative CUF. For generation beyond annual CUF of 40% but up to annual CUF of 45%, tariff shall be Rs. 1.50/kWh. For generation beyond annual CUF of 45%, incentive shall be equal to the levelized generic rates specified in the Regulations at CUF of 45 % reduced by Rs. 0.75 per kWh

Amendment in the year 2015

i. UERC revised the solar and Non-solar RPOs in 2015 as mentioned in the table 5.16

Table 5.16: - Revised RPO targets

YEAR	Renewable Purchase Obligation Non- Solar		Renewable Purchase Obligation Solar	
	Existing	Proposed	Existing	Proposed
2013-14	6.00%	6.00%	0.050%	0.050%
2014-15	7.00%	7.00%	0.075%	0.075%
2015-16	8.00%	8.00%	0.100%	0.100%
2016-17	9.00%	8.00%	0.300%	1.50%
2017-18	11.00%	8.00%	0.500%	2.50%

Amendment in the year 2016

i. UREDA will be providing additional subsidy of 60% for Rooftop and Small Solar PV Power Plants over and above MNRE’s subsidy of 30%, which would result in the total subsidy available to such plants equal to 90%. The table 5.17 shows the applicable tariffs corresponding to level of subsidy for Grid-Connected Rooftop and Small Solar PV Power Plants are as under: -

Table 5.17: - Tariffs corresponding to level of subsidy for Grid-Connected Rooftop and Small Solar PV Power Plants

Category of Developer	**Commercial & Industrial Establishments in Pvt. Sector**	**Central & State Govt. Ministries and their organizations. Govt. Educational Institutions, Hospitals, Community centers, Anganwadis, Panchayat Ghars, etc.**	**Developers getting 60% subsidy from GoU over and above 30% subsidy from MNRE**
Subsidy Level	0%	70%	90%
Gross -Tariff (Rs./kWh)	7.75	4.80	4.35
Less: A D (Rs./kWh)	0.60	0.65	0.65
Net-Tariff (Rs./kWh)	7.15	4.15	3.70

5.4.4 Regression analysis for Uttarakhand

Univariate regression is used for analyzing the relationship between a dependent variable and one independent variable and formulates the linear relation between dependent and independent variable. Regression model with one dependent variable and more than one independent variable is called multilinear regression. In our case independent variables are more than one hence multilinear regression analysis is used. The equation that follows in multilinear analysis is given below

$$Y_j = \beta + \beta_1 x_{1j} + \beta_2 x_{2j} + \varepsilon$$

The X's are the independent variables, Y is the dependent variable. The subscript j represents the observation number. The β's are the unknown regression coefficients. Each β represents the original unknown parameter. The ε is the error (residual) of observation j. The Y here is share of respective renewable energy in total renewable share of state, β is the constant and x_{1j} is 1 if j is greater or equal to the year of introduction of new government policy and zero otherwise and the other independent variable is tariff. The results obtained after the regression analysis are shown in the table 5.18 and 5.19

Table 5.18: - Effect of the change in policy and tariff on SHP in Uttarakhand

	Coefficients	P- value
Intercept	134.762	0.030
Policy change	-17.9940	0.002
Tariff	-11.9009	0.041

$p<0.01$(most effective factor), $p<0.5$(effective factor), $p<0.1$(least effective factor)

The regression statistics for the above analysis which shows the effectiveness of regression analysis for the given data are the values of R square and adjusted R square the closer these values are to 1 the better it explains the variation. R square value for this analysis is 0.637 and the value of adjusted R square is .492

From the above result of multiple regression analysis where the dependent variable was % SHP share in total RE share of Uttarakhand, and the independent variable was the tariff and policy change. As the value of both the coefficients are negative therefore it shows that both factors have negative effect on share of SHP. Moreover, the effect of policy change is more profound as its p-value is .002 as compared to the p-value of tariff.

Table 5.19: - Effect of the change in policy and tariff on Solar in Uttarakhand

	Coefficients	P- value
Intercept	48.1793	0.012
Policy change	7.6845	0.012
Tariff	3.2123	0.625

$p<0.01$(most effective factor), $p<0.5$(effective factor), $p<0.1$(least effective factor)

The regression statistics for the above analysis which shows the effectiveness of regression analysis for the given data are the values of R square and adjusted R square the closer these values are to 1 the better it explains the variation. R square value for this analysis is 0.557 and the value of adjusted R square is .402.

From the above result of multiple regression analysis where the dependent variable was % Solar share in total RE share of state of Uttarakhand, and the independent variable was the policy change and tariff. The value of independent coefficients policy change and tariff is positive which shows that the policies have positive impact on the share of Solar RE. The p-value policy change is .01 which means that policy change is a effective factor as compared to tariff because p-value of tariff is more then 0.5.

Uttarakhand being a Himalayan state has a huge potential of Small Hydro Power. The potential of Small hydro power in state is 1708 MW out of which 214 MW is the installed capacity, and in the target of 5 GW of SHP the share of Uttarakhand is 700 MW. Only one third of the target is achieved by 2017 so the focus of the state government needed to be shifted towards the SHP to achieve its target. Solar policy was introduced in 2013 to promote the solar power in the state and after the introduction of policy the capacity of solar power was increased from 5 MW to 247 MW. One of the provisions of the policy was that the T&D lines from generation site is to be provided by UPCL but in the case of the other renewable energy it is needed to be provided by the project developer. UERC regulations which is responsible for determining the tariff and regulations to promote the SHP change in the deemed generation condition & CUF (Capacity Utilisation Factor) was revised from 45% to 40 % and incentive for generating beyond CUF. But in spite of all these incentives the growth in SHP was not seen the factors responsible for these may be the policy change, which can be clearly seen from the regression analysis result that the policy change and tariff has negative impact on the SHP.

5.5 Uttar Pradesh

5.5.1 Uttar Pradesh Solar Power Policy 2017 [26]

Uttar Pradesh introduced Solar Power Policy in 2017. The State Government will endeavor to achieve 8% of total electricity consumption from solar energy by 2022. For attaining this, installation of 10700 MW capacity of solar power is targeted till 2022 of which 4300 MW capacity will be achieved through installation of Rooftop Solar Power Plant.

i. Land allotment: - Identification of suitable locations and the creation of a land bank. Facilitate allotment of suitable land/space in control of State Government or its agencies.
ii. Sale of power: - For Solar parks in Uttar Pradesh Power Corporation / Electricity Distribution Company to offer purchase of 100 % power generated from solar park out of which at least 50% of generated power will have to be mandatorily sold to UPPCL/Distribution Licensee. Energy generated from solar power projects may be sold to distribution utility of UPPCL, to any third party or used for captive purpose.

iii. Wheeling charges: - Exemption of 50 % on wheeling charges/transmission charges on Intrastate Sale of Power to third party or in case of Captive use. Cross subsidy surcharge and wheeling charges/Transmission charges will be exempted 100 % for Intrastate Transmission system on Interstate sale of solar power.

iv. Power evacuation and grid interfacing: - Responsibility of getting connectivity with the transmission system owned by Discoms/STU to lie with the Project Developer.

v. Incentives: - Solar PV projects shall be exempted from obtaining Environmental clearance. Grid connected Solar PV Projects will be exempted from obtaining any NOC/Consent for establishment and operation under pollution control laws from U.P. Pollution Control Board.

5.5.2 Policy Guidelines for development of Small Hydro Power projects [27]

The state has an estimated over all identified hydro power potential of 568 MW out of which 167 MW capacity comprises to small hydro power sector up to 25 MW capacity which have so far been identified at 60 locations in U.P.

i. Land Allotment: - Necessary land for setting up the small hydro power projects with substation shall be acquired by the state government and transferred to the respective private sector at the acquisition cost. Govt. land for 30 years lease at fixed rate of Rs.100 per acre.

ii. Developer is required to sell power to UPPCL/state DISCOMs, 50% of the cost of transmission system shall be borne by the developer and balanced 50% by the UPPCL/state DISCOMs.

iii. For use of river/canal water, water royalty charged @ 5 paise per unit sold payable by the developer for maintenance and up keeping of canal system

iv. For administrative support and statutory clearance at various levels and financial as well as technical assistance, the facilitation service charges @ 0.25% of the project cost payable by the developer to NEDA/UPJUNL.

5.5.3 Comparison of various renewable energy policy of Uttarakhand

In the table 5.20 the solar policy (2017) and Policy Guidelines for Development of Small Hydro Power Projects are compared.

Table 5.20: - Comparison of solar and small hydro energy policies of Uttar Pradesh

S.no	Description	Solar	Hydro
1.	Land Allotment	• Identification of suitable locations and the creation of a land bank. • Grid connected solar power projects will be implemented on suitable land banks identified and procured by the developer.	• No acquisition fee and stamp duty for land acquired through State Govt. • Govt. land for 30 years lease at fixed rate of Rs.100 per acre.
2.	Sale of Power and Tariff	• Energy generated from solar power projects commissioned during this policy period may be sold to distribution utility of UPPCL, to any third party or used for captive purpose. • Developers who wish to sell the generated power to a third party can set up plants under this policy, but will not be allowed to sign a PPA with the distribution utility of UPPCL, even in future.	
3.	Power evacuation and grid Interfacing	• Grid connectivity and associated evacuation facilities from the solar substation to the "feed in substation" to be provided as per UPERC Regulations	• Developers to provide evacuation facilities from project to grid sub-station.

		• Responsibility of getting connectivity with the transmission system owned by Discoms/STU to lie with the Project Developer • Cost of the line up to the "feed in substation" to be borne by the developer.	• UPPCL/DISCOMs to bear 50%cost of transmission system.
6.	Incentives and General	• Provision of special incentive will be made by the State Government on case to case basis for solar farms where multiple plants are installed and the total investment is over Rs.500 crores. • Expenditure on the construction of transmission line and substation in the Bundelkhand region, to be borne by the State Government.	• Power generation exempted from electricity duty.

From the table 5.21 and figure 5.7, it can be seen that there is no installation of small hydro power in the state after 2010. While there is rise in installed capacity of biomass and solar. The increase in solar capacity can be due to the Solar policy 2017 which had set the target to achieve 8% of total electricity from solar energy, it also gives 50% exemption on wheeling charges. Expenditure on the construction of transmission line and substation in the Bundelkhand region to be borne by the state government. In case of SHP developers to provide evacuation facilities from project to grid sub-station and for the use of river or canal water, water royalty @5 paise per unit sold to be given by the developer.

Table 5.21: - Installed Capacity of Various Renewable Energy in Uttar Pradesh

RE/YEAR	2010	2011	2012	2013	2014	2015	2016	2017
Biomass	567	592.5	644	776	776	936	193	195
Small hydro power	25	25	25	25	25	25	25	25
Solar power	0.38	0.38	12	17	30	140	239	550

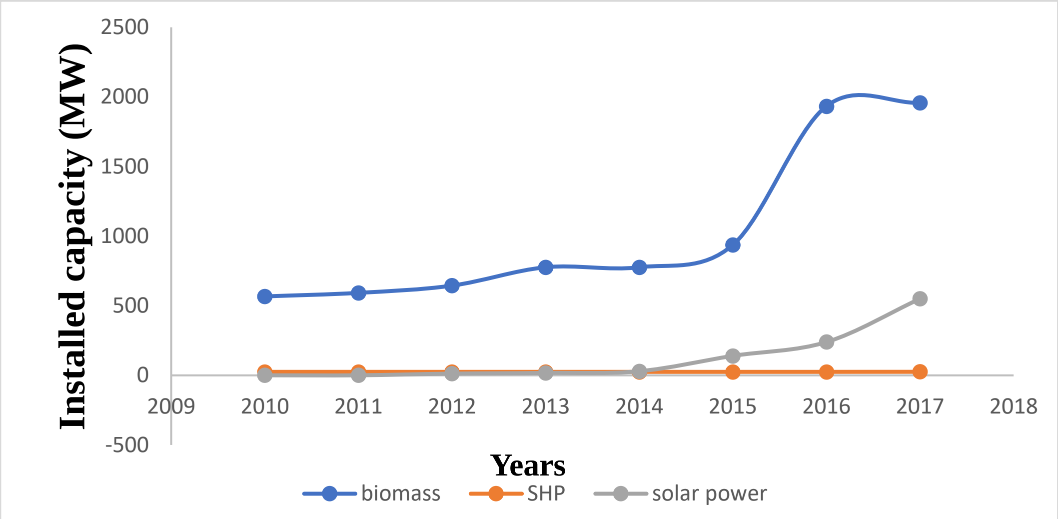

Fig 5.7: - Growth of Renewable Energy in Uttar Pradesh

The % share of various renewable energy over the years from 2010-2017 is shown in the table below. The major percentage of renewable energy in the state is dominant by Biomass followed by Solar and small hydro power. The share of solar power increased from .06% in year 2010 to 21.73% in 2017 and the share of SHP declined from 4.24% to 1.01% in 2017.

Table 5.22: - Percentage Share of Renewable Energy in Uttar Pradesh

RE(Share)/Year	2010	2011	2012	2013	2014	2015	2016	2017
SHP	4.24	4.06	3.68	3.06	3.02	2.28	1.14	1.01
Solar	0.06	0.06	1.82	2.12	3.57	12.71	10.89	21.73
Biomass	95.70	95.88	96.20	95.40	94.81	94.47	92.13	88.10

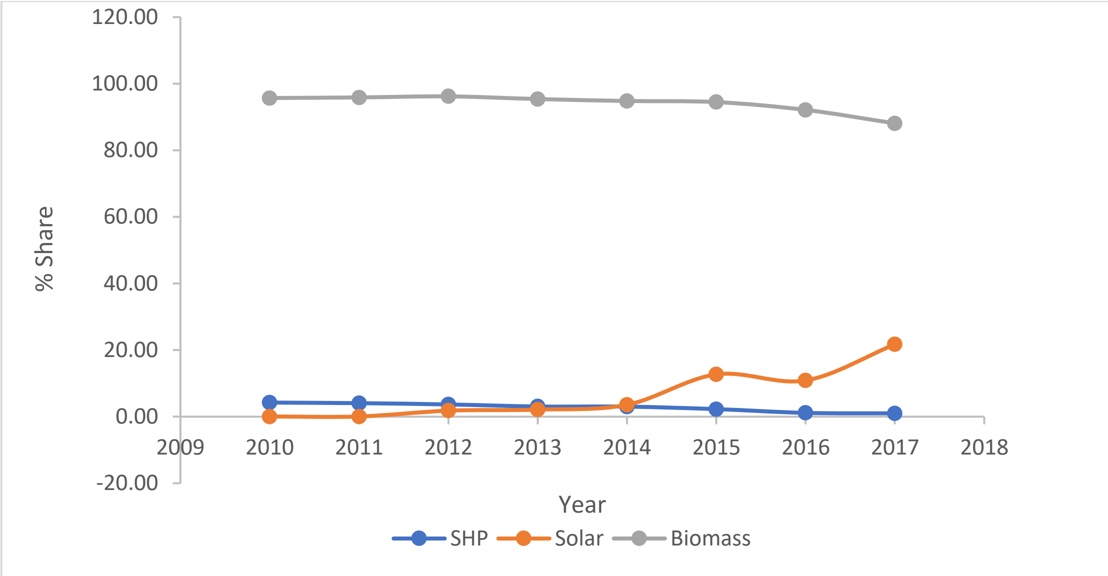

Fig 5.8: - Share of Renewable Energy in Uttar Pradesh

5.5.4 Regression analysis for Uttar Pradesh

Univariate regression is used for analyzing the relationship between a dependent variable and one independent variable and formulates the linear relation between dependent and independent variable. Regression model with one dependent variable and more than one independent variable is called multilinear regression. In our case independent variables are more than one hence multilinear regression analysis is used. The equation that follows in multilinear analysis is given below

$$Y_j = \beta + \beta_1 x_{1j} + \beta_2 x_{2j} + \varepsilon$$

The X's are the independent variables, Y is the dependent variable. The subscript j represents the observation number. The β's are the unknown regression coefficients. Each β represents the original unknown parameter. The ε is the error (residual) of observation j. The Y here is share of respective renewable energy in total renewable share of state, β is the constant and x_{1j} is 1 if j is greater or equal to the year of introduction of new government policy and zero otherwise and the other independent variable is tariff. The results obtained after the regression analysis are shown in the table 5.23 and 5.24

Table 5.23: - Effect of the change in policy and tariff on SHP in Uttar Pradesh

	Coefficients	P- value
Intercept	16.6403	0.0005
Policy change	-1.3688	0.071
Tariff	-3.2104	0.001

p<0.01(most effective factor), p<0.5(effective factor), p<0.1(least effective factor)

The regression statistics for the above analysis which shows the effectiveness of regression analysis for the given data are the values of R square and adjusted R square the closer these values are to 1 the better it explains the variation. R square value for this analysis is 0.975 and the value of adjusted R square is .965.

From the above result of multiple regression analysis where the dependent variable was % SHP share in total RE share of state of Uttar Pradesh, and the independent variable was the tariff and policy change. As the value of the coefficient of tariff is negative therefore it shows that it has negative effect on share of SHP and the value of coefficient of policy change is positive, which shows it have positive impact on SHP. Moreover, the effect of tariff is more profound as its p-value is less the .01 compared to the variation in policy change whose p-value is .071.

Table 5.24: - Effect of the change in policy and tariff on Solar in Uttar Pradesh

	Coefficients	P- value
Intercept	29.1170	0.092
Policy change	4.434	0.059
Tariff	2.258	0.092

p<0.01(most effective factor), p<0.5(effective factor), p<0.1(least effective factor)

The regression statistics for the above analysis which shows the effectiveness of regression analysis for the given data are the values of R square and adjusted R square the closer these values are to 1 the better it explains the variation. R square value for this analysis is 0.680 and the value of adjusted R square is .550.

From the above result of multiple regression analysis where the dependent variable was % Solar share in total RE share of Uttar Pradesh, and the independent variable was the tariff and policy change. As the value of both the coefficients is positive therefore it shows that it has positive effect on share of Solar. Moreover, the effect of policy change is more profound as its p-value is less than that of tariff.

Uttar Pradesh is dominated by biomass followed by solar power with an installed capacity of 550 MW. There has been no installation of small hydro power since 2010, the state installed capacity of SHP in the state is 25 MW and its target for year 2022 is also 25 MW this could be one of the reasons that much focus was not given for the development of SHP. Uttar Pradesh introduced a solar policy in 2013 and a new solar policy in 2017, to promote the solar power in the state some of the important provision are creation of a land bank and no expenditure on the construction of transmission line and substation in Bundelkhand region need to be borne by the developer, instead to be borne by the state government. Regression analysis result also concluded that the policy introduced and tariff has a positive impact on the growth of solar power.

5.6 Punjab

5.6.1 Punjab New and Renewable sources of energy Policy (NRSE) 2012 [28]

Punjab introduced a NRSE policy to maximise and improve the share of new and renewable sources of energy to 10% of the total installed power capacity in the state by 2022

i. Land allotment: - If the land belongs to local bodies/ gram panchayat, the State would encourage them to provide the land for RE project. For small hydro power developer's irrigation land to be transferred to producers through PEDA on notional lease of Rs. 1.5 lakh per annum per site

ii. Sale of power and tariff: - For any project to be set up under REC mechanism, the first right to purchase power will lie with PSPCL/LICENSEE at APPC tariff. On their refusal, the bidding will envisage sale of power in open access.

iii. Power evacuation: - If the power is sold to PSPCL/LICENSEE on preferential tariff on long term basis, then the transmission line and associated bay at PSPCL/LICENSEE grid substation along with ABT compliant check meters and associated equipment will be provided by PSPCL/LICENSEE. In all other cases, the private developer shall be required to lay its own transmission lines from the switchyard of its generation facility to the PSPCL/LICENSEE/PSTCL grid sub- station at its own cost.

iv. The power producers setting up hydel projects will pay cess @ 1.5 paisa per unit of electricity generated for use of river/ canal water.

5.6.2 Comparison of various renewable energy policy of Punjab

In the table below the NRSE policy is compared for solar, wind and biomass.

Table 5.25: - Comparison of various renewable energy policy of Punjab

S.no	Description	Solar	SHP	Biomass
1.	Land Allotment	• If the land belongs to local bodies/ gram panchayat, the State would encourage them to provide the land for RE project.	• If the land belongs to local bodies/ gram panchayat, the State would encourage them to provide the land for RE project. • Irrigation land to be transferred to power producers through PEDA on notional lease of Rs. 1.5lakh per annum per site	• If the land belongs to local bodies/ gram panchayat, the State would encourage them to provide the land for RE project.
2.	Sale of Power and Tariff	• As per PSERC RE tariff orders and shall be governed by RE regulations. • Projects allotted through tariff based competitive bidding/discount on professional tariff, the tariff arrived after	• As per PSERC RE tariff orders and shall be governed by RE regulations • Preferential tariff of sale of power to PSPCL/ Licensee to be notified by PSERC.	• As per PSERC RE tariff orders and shall be governed by RE regulation • Preferential tariff of sale of power to PSPCL/ Licensee to be notified by PSERC.

		competitive bidding/ discounted tariff to be applicable in accordance with CERC RE Regulations.		
3.	Wheeling	• 2% of the energy fed to the grid or as amended from time to time by PSERC. • Wheeling/transmission of power to be governed by Open Access Regulation	• 2% of the energy fed to the grid or as amended from time to time by PSERC. • Wheeling/transmission of power to be governed by Open Access Regulation	• 2% of the energy fed to the grid or as amended from time to time by PSERC. • Wheeling/transmission of power to be governed by Open Access Regulations
4.	Banking	• Allowed for 1 year. However, energy banked during non-paddy season and non-peak hours will not be allowed to be drawn during paddy season and peak hours respectively.	• Allowed for 1 year. However, energy banked during non-paddy season and non-peak hours will not be allowed to be drawn during paddy season and peak hours respectively.	• Allowed for 1 year. However, energy banked during non-paddy season and non-peak hours will not be allowed to be drawn during paddy season and peak hours respectively.
5.	Power Evacuation and Grid Interfacing	• Interfacing including installation of substation and metering equipment on the LT/HT site of the generating	• Interfacing including installation of substation and metering equipment on the LT/HT site of the generating	• Interfacing including installation of substation and metering equipment on the LT/HT site of the generating

		station up to the interconnection point and its subsequent maintenance to be undertaken by Power Producer/Plant owner.	station up to the interconnection point and its subsequent maintenance to be undertaken by Power Producer/Plant owner.	station up to the interconnection point and its subsequent maintenance to be undertaken by Power Producer/Plant owner.
6.	Incentives and General	• 100% exemption from payment of fee and stamp duty for land required for the project. • Solar PV Power projects exempted for obtaining any NOC/consent under pollution control laws from PPCB.		

The table 5.26 and figure 5.29 show the installed capacity of various Renewable energy of Punjab till 2017. Around 900 MW solar capacity was installed in the span of 7 years. The installed capacity of solar power was 1 MW in 2010 which rises to 905 MW in 2017. While there is slight increase of 40 MW in installed capacity of SHP. The installed capacity of SHP was 132 MW in 2010 which was increased to 171 MW in 2017. Punjab being agriculture state has huge potential of biomass energy, and over the years the installed capacity of biomass is increased from 62 MW in 2010 to 194 MW in 2017.

Table 5.26: - Installed capacity of renewable energy in Punjab

RE/YEAR	2010	2011	2012	2013	2014	2015	2016	2017
Biomass	62	74	90	124	140	140	162	194
Small hydro power	132	154	154	154	157	157	171	171
Solar power	1	2	9	9	55	200	545	905

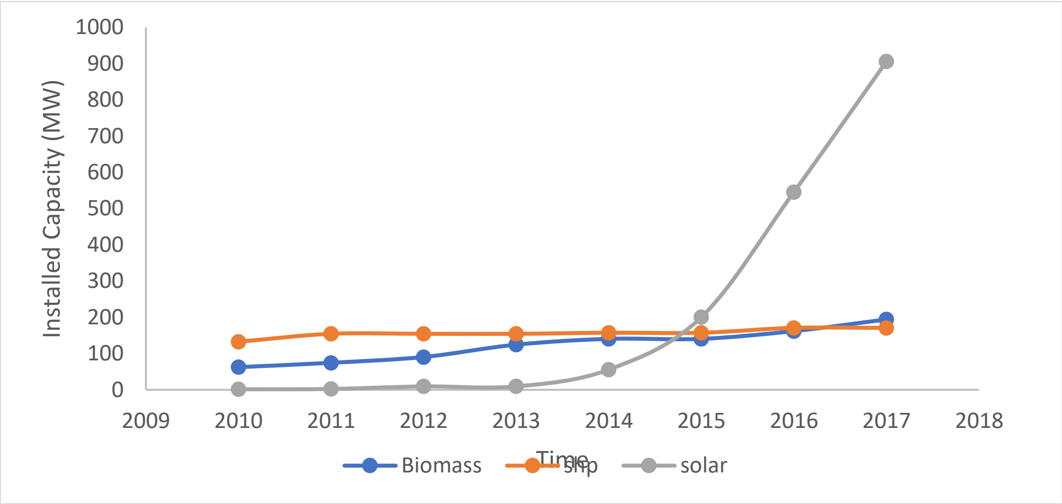

Fig5.9: - Growth of renewable energy in Punjab

The % share of various renewable energy over the years from 2010-2017 is shown in the table 5.27. The major percentage of renewable energy in the state is dominant by Solar power followed by Biomass and small hydro power. The share of solar power increased from .68% in year 2010 to 71.28% in 2017 while the share of small hydro power declined from 67.50% in 2010 to 13.45% in 2017.

Table 5.27: - Percentage Share of Renewable Energy in Punjab

RE(Share)/Year	2010	2011	2012	2013	2014	2015	2016	2017
SHP	67.50	66.79	60.75	53.58	44.50	31.59	19.46	13.45
Solar	0.68	1.01	3.67	3.24	15.77	40.21	62.10	71.28
Biomass	31.83	35.75	36.59	43.18	46.17	39.73	31.17	21.31

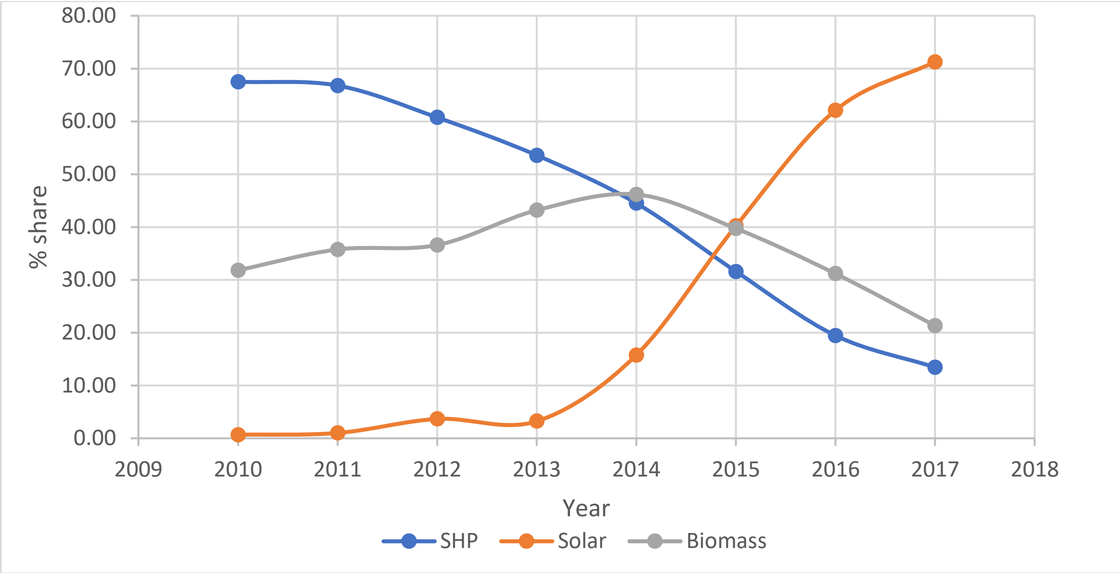

Fig 5.10: - Share of Renewable Energy in Punjab

5.6.3 Regression analysis for Punjab

Univariate regression is used for analyzing the relationship between a dependent variable and one independent variable and formulates the linear relation between dependent and independent variable. Regression model with one dependent variable and more than one independent variable is called multilinear regression. In our case independent variables are more than one hence multilinear regression analysis is used. The equation that follows in multilinear analysis is given below

$$Y_j = \beta + \beta_1 x_{1j} + \beta_2 x_{2j} + \varepsilon$$

The X's are the independent variables, Y is the dependent variable. The subscript j represents the observation number. The β's are the unknown regression coefficients. Each β represents the original unknown parameter. The ε is the error (residual) of observation j. The Y here is share of respective renewable energy in total renewable share of state, β is the constant and x_{1j} is 1 if j is greater or equal to the year of introduction of new government policy and zero otherwise and the other independent variable is tariff. The results obtained after the regression analysis are shown in the table 5.28 and 5.29

Table 5.28: - Effect of the change in policy and tariff on SHP in Punjab

	Coefficients	P- value
Intercept	169.967	0.0006
Policy change	-0.007	0.930
Tariff	-30.570	0.005

$p<0.01$(most effective factor), $p<0.5$(effective factor), $p<0.1$(least effective factor)

The regression statistics for the above analysis which shows the effectiveness of regression analysis for the given data are the values of R square and adjusted R square the closer these values are to 1 the better it explains the variation. R square value for this analysis is 0.931 and the value of adjusted R square is .904.

From the above result of multiple regression analysis where the dependent variable was % SHP share in total RE share of Punjab, and the independent variable was the tariff and policy change. As the value of both the variables are negative therefore it shows that both factors have negative effect on share of SHP. Moreover, the effect of policy change is not as profound as compared to the variation in Tariff.

Table 5.29: - Effect of the change in policy and tariff on solar in Punjab

	Coefficients	P- value
Intercept	30.408	0.043
Policy change	31.508	0.010
Tariff	-2.506	0.451

$p<0.01$(most effective factor), $p<0.5$(effective factor), $p<0.1$(least effective factor)

The regression statistics for the above analysis which shows the effectiveness of regression analysis for the given data are the values of R square and adjusted R square the closer these values are to 1 the better it explains the variation. R square value for this analysis is 0.725 and the value of adjusted R square is .615.

From the above result of multiple regression analysis where the dependent variable was % Solar share in total RE share of state of Punjab, and the independent variable was the tariff and policy change. The value of independent variable policy change is positive which shows that the policies have positive impact on the share of Solar RE while the other factor tariff has negative value but its P value is more than 0.1 hence its effect on the share is not that much as compared to another variable.

Punjab introduced a New and Renewable source of energy policy (NRSE) 2012 to promote the renewable source of energy and increase its share to 10% of total installed capacity in the state by 2022. The main clauses such as sale of power and tariff, wheeling and banking charges, power evacuation and grid interfacing is same for all the renewable energy sources mainly solar, SHP and biomass but the growth rate of all these are different. The regression analysis results for SHP shows that the tariff has a negative impact on the growth while in the case of solar power policy played an important role in its growth.

CHAPTER 5
CONCULSION

Power system of India is undergoing a phase of transformation with the vision of integration of 175 GW of renewables by 2022. Renewable energy (mainly solar & wind) is characterized by inherent issues like variability, intermittency & fast ramping. Thus, commensurate amount of flexible power reserves is necessary to take care of such variations in demand in coming years. Among various renewable energy sources, Hydro power is a source of reliable, flexible and clean energy, because of its ability to meet fast ramping & peak demand it is needed to be promoted more so that it can become a solution for intermittency of other renewable energy sources. The other important advantage that can be concluded from SERCs regulation is the useful life of small hydro is 35 years as compared to the 25 years of Wind and Solar. The CUF (Capacity utilization factor) is also greater than the other renewable energy. The other bigger advantage of small hydro power is that it is an inflation proof source of energy that requires minimal maintenance.

Under the current study, impact of government policies on the renewable energy five states were chosen Karnataka, Maharashtra, Uttar Pradesh, Uttarakhand and Punjab. The reason behind the selection of these states are Uttarakhand covers the Himalayan region, Uttar Pradesh covers the North India, Maharashtra west central region and Punjab. Uttarakhand being a Himalayan state has a huge potential of Small hydro power plants i.e. of 1708 MW which is third highest among all the states and out of which only 214 MW is the installed capacity till 30.04.2019. Karnataka south western state has the highest potential of small hydro power in India i.e. of 4141 MW and Karnataka is also rich in other renewable energy sources, the total installed capacity of renewable energy is largest in India i.e. around 13042.14 MW. The west central state of Maharashtra and the Northern state of India such as Uttar Pradesh and Punjab are chosen so as to cover the various region of India.

6.1 Conclusion

Policies for various renewable energy were compared on several criteria such as land allotment, sale of power and tariff, wheeling charges, banking & wheeling charges etc. State electricity regulatory commission. For statistical analysis multilinear Regression analysis was done. Following conclusion were derived based on the results obtained after regression analysis.

i. In Maharashtra the percentage share of SHP has decreased from 10.55% to 5.93%. The regression analysis result for Maharashtra shows that the renewable energy policy introduced in 2015, has positive and significant impact on Solar power the coefficient of policy change and tariff are 4.758 and 0.524 respectively the larger and positive value of policy change signifies it has more impact on growth of Solar power, while it has negative impact on small hydro power the coefficient of policy change and tariff are -2.453 and -2.324 respectively and the p-value for policy change is less than 0.01 which shows it has more significant impact on share of SHP. The development or growth in wind continues at good rate which can be attributed to another tariff which has positive impact on it.

ii. The regression analysis result for Karnataka shows that the Solar policy 2014, has positive and significant impact on Solar power the coefficient of policy change and tariff are 6.914 and 2.217 respectively, in case of SHP the coefficients of policy change is -40.877 which shows that it has negative impact on the growth of SHP. Other than the policy and tariff, KERC regulations also plays a huge rule in growth of renewable energy.

iii. The regression analysis result for Uttarakhand shows that the policy change and amendments in UERC regulations, has significant negative impact on SHP the coefficient of policy change and tariff are -17.92 and -11.90 respectively the value of both these coefficients are negative and on higher side which shows that both these factors have negative impact on growth of SHP. In case of solar power, the coefficients of policy change and tariff are 7.684 and 3.212 respectively both these values are positive hence both these factors have positive impact on solar power.

iv. In Uttar Pradesh there has been no addition in installed capacity of SHP since 2010 but with the introduction of Solar policy in 2013 and special attention given to the Bundelkhand region the installed capacity of Solar capacity reached to 550 MW. The regression analysis result has shown that the policy change and tariff coefficients for solar power is 4.434 and 2.258 respectively, the positive value implies that they have positive impact on the share of Solar power.

v. The regression analysis result for Punjab shows that the policy and tariff have negative impact on growth of SHP, in fact the coefficient of tariff for SHP is -30.570 and its p-value is .005 both of these values implies that the variation in tariff is a major factor affecting the growth of SHP. For solar power the coefficient of policy change is 31.508, these implies that the policy change has positive impact on Solar power.

It can be concluded that based on current study, the policies have more significant impact than the tariff. Whether it is a Himalayan state of Uttarakhand or in west central state of

Maharashtra the overall growth of renewable energy is good, but the situation of Small Hydro power is not as good as compared to the other renewable energy resources. The regression analysis of all the five states has common trend that the change in policy has negative impact on Small Hydro Power and other then the state of Karnataka the tariff also has a negative coefficient which implies that it has negative impact on growth of small hydropower. A direct relationship between the growth of small hydro power and other renewable energy is difficult to establish but from the current study and comparison of policies, SERC regulations and Regression analysis results it could be said that the other renewable energies has an indirect impact on small hydro power.

6.2 Recommendation

The study might be done on the impact of central government policies on renewable energy by using advanced statistical tools such as SPSS, SAS, Stata etc. Also, efforts can be done to analyze the impact assessment of specific provisions of government policies on the development of renewable energy.

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