International Journal of Advance Research in Science and Engineering
Volume No.06, Issue No. 11, November 2017
www.ijarse.com
IJARSE
ISSN: 2319-8354

# Regional Innovation System in Wind Energy—The Case of Maharashtra

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**ABSTRACT**

The paper outlines the renewable energy technologies in the context of the Indian state of Maharashtra. It particularly focuses on the technology of wind energy and its creation and diffusion in the region. To have an analytical understanding, here wind energy is explained using the framework of Regional System of Innovation. The argument presented in the paper is that who are these actors involved in the creation and diffusion of wind technology in the region. To map it, the kind of R&D being done, the interaction between the R&D institutes, universities, both public and private; firms; government policies and regulatory frameworks; are outlined in the RIS framework.

***Keywords: Regional System of Innovation, Wind Energy, Maharashtra***

## I INTRODUCTION

The systems of innovation approach to the production of scientific and technological knowledge has gained popularity in policy and academic circles from past few years. According to Freeman, 1995—An innovation system is a network of organisations within an economic system that are directly involved in the creation, diffusion and use of scientific and technological knowledge, as well as the organisations responsible for the coordination and support of these processes.

It is being endorsed by some of international bodies, like the Organization for Economic Co-Operation and Development (OECD), World Bank and some United Nations agencies. India though does not have a clear outline of national system of innovation. OECD has usually pointed out towards the lack of a proper innovation system in India.

The systems of innovation approach can be split into 4 sub-categories—namely National Innovation System (NIS), Sectoral Innovation System (SIS), Regional Innovation System (RIS) and International System of Innovation (ISI). Taking whichever approach will be inappropriate if one does not use it along with the international dimension of innovation system.

In this paper, I will be using the approach of Regional System of Innovation (RIS) to understand the landscape of production of Wind Energy in the state of Maharashtra. It is been done to find the stakeholders involved in the creation and diffusion of this technology in the region; and how are they influencing the wind production in the region. Hence this explains the use of RIS in the study here.

## II REVIEW OF LITERATURE

### 2.1. Wind Energy

What is Wind Energy? According to Energy Alternatives India (EAI) [Accessed on April 3, 2017]; Wind Energy is a renewable energy resource. But it is irregular as compared to solar; meaning wind speeds may vary within minutes and affect the power generation. In cases of high speeds it may even result in overloading of generator. Energy from the wind can be tapped using turbines.

Setting up of these turbines need little research before being established. It first needs the wind resource to be determined in the area of proposed site (Ibid). There are a number of steps involved before setting up of plants, like—the wind resource data is an estimation of average and peak wind speeds at a location based on various meteorology.

The next step is to determine access to the transmission lines or nearest control centre where the power generated from the turbines can be conditioned, refined, stored or transmitted. It is also necessary to survey the impact of putting up wind turbines on the community and wildlife in the locality. If sufficient wind resources are found, the developer will secure land leases from property owners, obtain the necessary permits and financing; purchase and install wind turbines.

The completed facility is often sold to an independent operator called an independent power producer (IPP) who generates electricity to sell to the local utility, although some utilities own and operate wind farms directly. Now wind mills can be set up on ranging scales, depending on the need and potential of that region. The ones identified by EIA are:

i. On-shore grid connected Wind Turbine systems
ii. Off-shore wind turbine systems
iii. Small Wind and Hybrid Energy Decentralized systems

Some of the advantages of setting up wind energy systems are (EIA):

i. Can be used for both distributed generation and grid interactive power generation.
ii. Ranges of power producing turbines are available. A Micro-turbine is capable of producing 300W to 1MW and a large wind turbine has typical size of 35kW-3MW.
iii. Wind turbine is suitable to install in remote rural area.
iv. Average capacity factor can be close or higher than 30%.

Some of the disadvantages of setting up wind energy systems are (EIA):

i. Electricity production depends on -wind speed, location, season and air temperature. Hence various monitoring systems are needed and may cost expensive.
ii. High percentage of the hardware cost (for large WT) is mostly spent on the tower designed to support the turbine.

Although wind energy turbines have relatively little impact on the environment when compared to power generation from fossil fuels, concerns have been raised by environmentalists over their usage. According to a

US Department's report on 'Programmatic Environmental Impact Statement,' it identified few impacts of wind energy farms on environment, like [Accessed on April 3, 2017]:

i. **Noise:** Since they are mechanical devices, they produce noise when they operate.

ii. **Visual Impacts:** Some people have aesthetic issues with the high visibility of the wind turbines.

iii. **Birds and Bats Mortality:** This is the most controversial biological issue related to wind turbines. And to try and address this issue, the private and government research agencies have to engage in research into collisions, relevant bird and bat behaviour and mitigation measures.

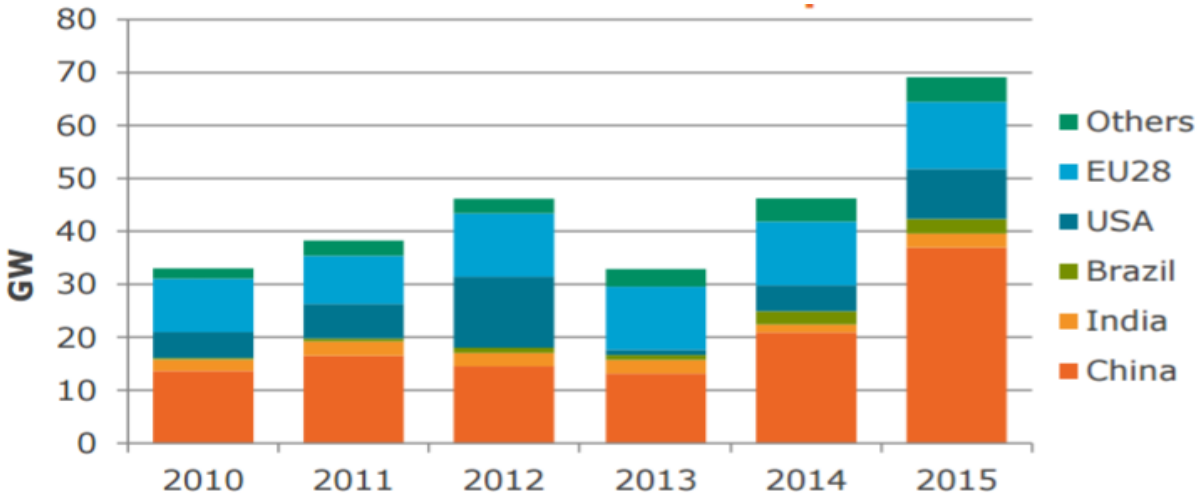
iv. **Production of Toxics:** Though wind turbines do not produce carbon dioxide and other harmful gas emissions; they do produce small amounts of lubricating oils, hydraulic and insulating fluids. Therefore, a high chance of contamination of ground water is possible.

Similarly, Dai et. al, 2015 also state in their paper that—"the continuous growth of the wind energy industry in many parts of the world, especially in some developing countries and ecologically vulnerable regions, necessitates a comprehensive understanding of wind farm induced environmental impacts."

### 2.2. India's position in wind energy production

Globally, prominently wind energy along with solar; have been identified in having ample potential for power generation and commercially viable for developing countries. India's performance in harnessing wind energy has been moderate when compared to other developed and developing nations. To reach its target set up for 2022, India is pacing up in the wind energy sector. The next figure will give some estimates of India's global position in this sector.

**Figure 1: Wind Power—new installed capacities by 2015**




(Source: Global Energy Trends, 2016)

The Indian government has itself been promoting solar and then wind energy as the prime sources of renewable energies, since the time of the inception of renewable energy technologies. The policy and regulatory frameworks have primarily been focusing on these two technologies.

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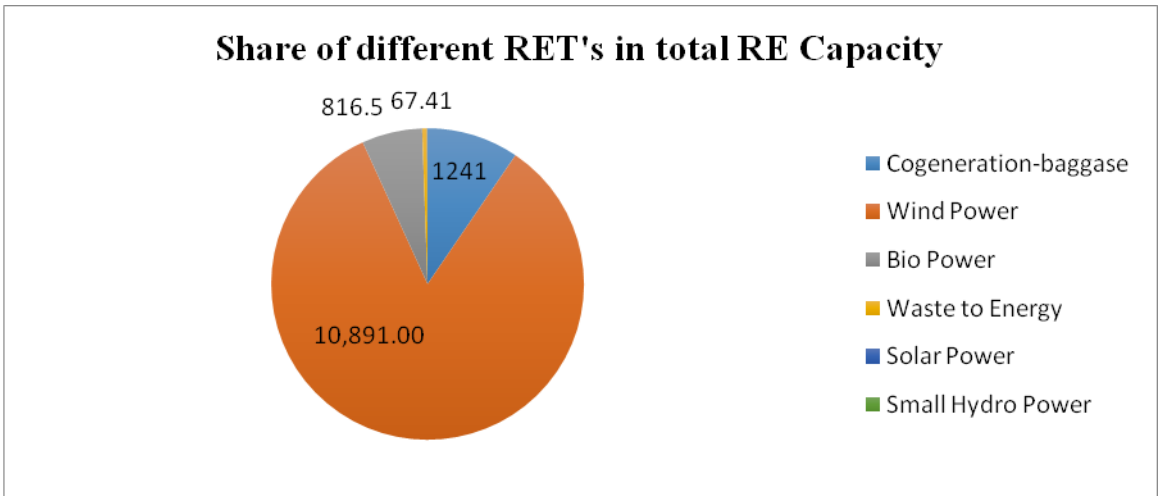
If we look at the share of different renewable energy technologies, the share of wind energy has been quite promising from almost a decade. The next figure will give an insight into the same.

**Figure 2: Technology wise grid-interactive RE capacity in India as on October 31, 2009 (in MW)**




(Source: MNRE, 2009)

If we compare the statistics with the current trends, the solar power has far gone ahead in power generation than the wind power in last decade.

Under National Wind Resource Assessment programme, the Ministry through National Institute of Wind Energy, Chennai and State Nodal Agencies had installed and monitored 794 dedicated Wind Monitoring Stations (WMS) of height ranging from 20 m to 120 m (20m, 25m, 50m, 80m, 100m & 120m) throughout the country as on 31.12.2014 (MNRE) [Accessed on April 3, 2017].

The study identified major geographic regions which have more potential of harnessing wind energy. Geographically, India's potential for utilization of wind energy for electricity generation is of the order of about 1,02,788 MW (Ibid). India is having a coastline of 7517 km and its territorial waters extend up to 12 nautical miles into the sea, for off-shore potential (Ibid).

The unexploited resource availability has the potential to sustain the growth of wind energy sector in India in the years to come. The potential for wind energy power generation for grid interaction has been estimated taking sites (geographically viable) having wind power density greater than 200 W/sq. m at 80 m and 100 m hub-height with 2% land availability in potential areas for setting up wind farms @ 9 MW/sq. km (Ibid).

Also, Wind turbines are now being set up at even 120 m hub-height and the potential of wind resources at this height is even more. In 2015, the MNRE set the target for Wind Power generation capacity by the year 2022 at 60,000 MW. The next figure will provide the recent statistics of wind energy production, region-wise:

**Figure 3: State-wise % of Wind Potential Utilized as on 31-03-2016**

| S. No | State | Cumulative Wind Power Installed Capacity operational at the end of FY 2016 (MW) | Total Wind power potential at 100 meter above ground level (MW) | Percentage of Wind Power potential utilized |
|---|---|---|---|---|
| 1 | Andhra Pradesh | 1431.45 | 44229 | 3.24% |
| 2 | Gujarat | 3948.61 | 84431 | 4.68% |
| 3 | Karnataka | 2869.15 | 55857 | 5.14% |
| 4 | Kerala | 43.5 | 1700 | 2.56% |
| 5 | Madhya Pradesh | 2141.1 | 10484 | 20.42% |
| 6 | Maharashtra | 4653.83 | 45394 | 10.25% |
| 7 | Rajasthan | 3993.95 | 18770 | 21.28% |
| 8 | Tamil Nadu | 7613.86 | 33800 | 22.53% |
| 9 | Telangana | 77.7 | 4244 | 1.83% |
| 10 | Others | 4.3 | 3342 | 0.13% |
| | **Total** | **26777.45** | **302251** | **8.86%** |

(Source: MNRE, 2016)

### 2.3. The landscape of Maharashtra in wind energy production

Maharashtra is one of the few states which has an ample potential of wind energy, due to its geographic location. The development of wind power in India began in 1986 with the first wind farms being set up in coastal areas of Maharashtra (Ratnagiri), Gujarat and Tamil Nadu with 55 kW Vestas wind turbines –and these demonstration projects were supported by the Ministry of New and Renewable Energy (MNRE).

All the major manufacturers of wind turbines including Suzlon, Vestas, Gamesa, Regen, Leitner Shriram have presence in Maharashtra (MNRE). Statistically, the state has shown a good progress right after Tamil Nadu, in exploiting the potential of wind energy.

The state has frequently been coming out with its renewable energy policy, with a special focus on wind energy and the recent one came out in the year 2015. According to the Maharashtra Energy Development Agency (MEDA), Government of Maharashtra—the renewable energy policy, 2015 states that "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." Also, there is a mention of "a target of commissioning of wind power projects of 5000 MW" (Ibid).

The policy of 2015, specifically mentions that the wind energy projects are exempted from obtaining NOC/consent from the Pollution Control Board. Hence, we can see that the state is playing an active role in the wind energy sector. Maharashtra has many sites scattered within the state that has wind energy turbines, ranging from small to big ones.

The biggest wind parks having the maximum wind speeds are in—Brahmanvel windfarm in Dhule with a capacity of 528 MW, Dhalgaon windfarm in Sangli with a capacity of 278 MW and Vankusawade Wind Park in

Satara district with a capacity of 259 MW (MEDA). The prime observation on the setting up of these plants is that, their producers are all private firms –and the government only pays them for setting up the plants on potential sites.

Now, the question comes—to which extent has the technology been diffused within the state of Maharashtra? Therefore the core argument of the paper is that despite the policies of the state and satisfactory amount of R&D being done by private firms; there are many places in the state that are still devoid of access to electricity. Also the maximum numbers of unelectrified households are the rural ones.

According to the latest statistics, 240 million people in India were not having access to electricity (Singh and Sundria, 2017). Since the energy demands are rising drastically and India is not self-sufficient to depend on conventional sources of energy alone, the government had strictly come out with the renewable energy policies to exploit the potential of available resources. Hence, a target of achieving 172 GW renewable energy by 2022 was set up by MNRE in this direction. So according to the geographical feasibilities, regions were identified and the work is still in progress.

Though Maharashtra is performing better than other states, it still has villages which are fully un-electrified. As per the recent statistics provided by the Open Government Data (OGD) Platform India, March 2015—the state has 36 un-electrified villages. These are the figures provided by the government portal. The numbers can be definitely much more than being projected.

Hence we can conclude that only the creation of a technology is not sufficient, but to which extent has it got diffused into the society is as important; because only then a technology is called to be successful. Therefore to understand the process behind this creation and diffusion of wind technology, an analysis of the network of the actors engaged in this process is necessary and the approach of systems of innovation can be used to analyse this.

In this context, I think that the approach of Regional System of Innovation (RIS) can do justice to study the landscape of wind energy production in Maharashtra, hence we proceed with it.

## III OBJECTIVES

### 3.1. Broad Objective

To examine the creation and diffusion of the wind energy technology in the region of Maharashtra using the approach of regional innovation system (RIS).

### 3.2. Specific Objectives

i. To identify the key drivers of wind technology in region.
ii. To figure out the nature of interactions between the enterprises, government bodies, universities and research laboratories.
iii. To find out the kind of diffusion of knowledge and technology between stakeholders and later their movements into the larger society.

## IV RESEARCH METHODOLOGY

### 4.1. Theoretical Framework

The approach of RIS had come out after the research framework of NIS by Lundvall (1992), Nelson (1993) and Edquist (1997); by various scholars. The concept of regional innovation systems is relatively new at the level of policy making all over the world.

Because of the weaknesses of national innovation systems, governments practically everywhere in the advanced economies were promoting regional innovation and cluster-building policies as ways of boosting national competitiveness (UNIDO, 2003). As regions become more specialized and pull the institutional support structure along, so foreign direct investment (FDI) seeks out such centres of expertise by following domestic investment as part of global location strategy (Ibid). A region is an intellectual concept. The boundaries of regions are not fixed once for all; regions can change, new regions can emerge and old ones can perish (Ibid).

Regions exist only in terms of the criteria by which it is defined, of which four are the most commonly used (Ibid):

i. It must not have a determinate size;
ii. It is homogeneous in terms of specific criteria;
iii. It can be distinguished from bordering areas by a particular kind of association of related features; and
iv. It possesses some kind of internal cohesion.

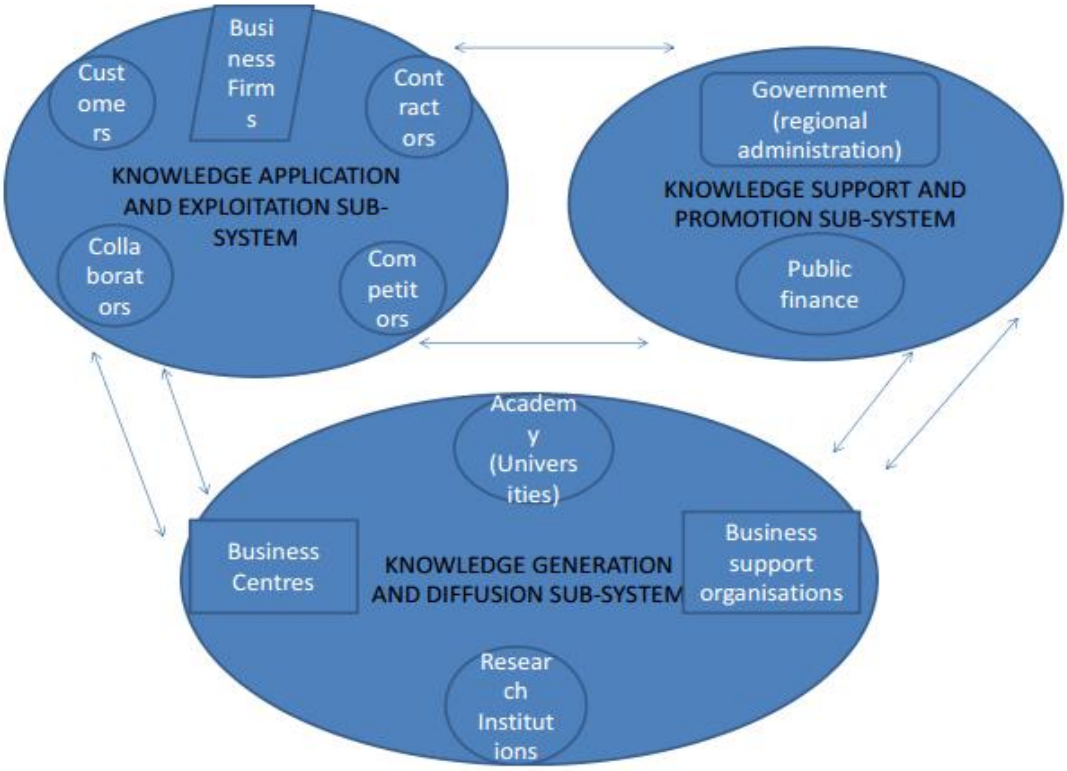
Hence, Lundvall, 1992 defines—a system of innovation as being constituted of a number of elements and by the relationship between these elements. Hence to get an analytical understanding of the kind of creation and its rate of diffusion into a market; economists and policy makers all over the world make the use of the systems of innovation approach.

In this relatively small study we apply the RIS framework to analyse the wind energy sector in Maharashtra.

The next figure will give us a "Regional socio-economic and cultural environment" framework, which has been designed through insights of various scholars and especially from the RIS framework suggested by Cook and Memedovic, 2004.

This framework will help us map the various stakeholders involved in the knowledge creation and diffusion of wind technology in our region.

**Figure 4: RIS Framework for wind energy production in Maharashtra**




(Source: Adapted from Cook and Memedovic, 2004).

The figure displays the knowledge resources, human capital, financial capital and their interactions.

The major stakeholders of RIS model of the Maharashtra region are academic universities, research institutes, governmental organizations, non-governmental agencies and private firms.

Now we will be having a look at the different actors; starting from the government's policies and regulatory frameworks for wind energy production, which makes up for the knowledge promotion and support sub-system—

- *Key Policies of the government*

i. National Off-shore Wind Energy Policy, 2015
ii. Maharashtra Renewable Energy Policy, 2015
iii. Ministry has issued a draft on wind-Solar Hybrid Policy.

- *Regulatory Framework*

i. Regulatory measures have mainly taken two forms: Renewable Purchase Obligation (RPO) and Feed-in Tariffs.
ii. NIWE will also prepare "Guidelines for Offshore Studies and Surveys" for private sector.
iii. Information and Public Awareness Program

*Public Finance*—Government has spent crores of money –given it to private firms mostly for setting up plants. The correct estimate is not known. However, the state currently owes nearly 1,150 crores to big wind energy companies (Hindu, 2017). Due to this reason, the setting up of plants has got stagnated from past two-three years.

*Purchase Power*—According to MNRE, in Maharashtra the 'buy-back rate, per kWh' is 2.86-4.29; which is the cheapest when compared to other states like Tamil Nadu and Madhya Pradesh.

Now we will have a look at various institutions engaged in Research and Development (R&D) and the kind of R&D being done in the state in wind technology; which is our knowledge creation and diffusion sub-system. According to the Ministry of New and Renewable Energy (MNRE), 2016—the MNRE has identified thrust areas for R&D in small wind energy systems. Under this, nine proposals from academic institutions and manufacturers have been identified for funding. And the National Institute of Wind Energy (NIWE) is lending technical support to MNRE in coordinating and assistance in execution of these projects.

If we take this into consideration, we see that there is transfer of technology from one region to another, within the RIS framework. This aspect cannot be ignored in the systems of innovation approach and can be called a 'learning process.' Knowledge components from other regions help shape the R&D landscape of a specific region. In this case, the R&D being done in other states is also shaping the R&D landscape of wind energy in Maharashtra.

The public and private R&D institutes hence involved in and for the region are:

i. SSN College of Engineering, Chennai—A novel fused converter for Wind-PV Hybrid System to power rural telephony
ii. Vellore Institute of Technology, Vellore—Development and Installation of Micro Thruster Augmented Wind Power Generator using a 200 kW Wind Turbine at NIWE Facility, Kayathar
iii. Institute of Energy Studies, Anna University, Chennai—Investigations on Small Capacity Wind Turbine with Compressed Air Energy Storage System
iv. M/s Spitzen Energy Solutions (India) Pvt. Ltd., Pune—Design, Development of 3 kW Small Wind Aero-generator and Wind Charge Controller and Design and Development of Efficient Small Wind Mill of 5 kW Capacity For Generating Maximum / Optimum Energy
v. Hindustan Institute of Technology and Science, Chennai—Design and Development of 1 kW Hybrid Vertical Axis Wind Turbine System for Low Wind Speed Regimes; and Hybrid Energy Management using Cyber- Physical Controller for Real Time Energy Management System for Micro Grid Application
vi. Bannari Amman Institute of Technology, Sathyamangalam—An Optimal Design of Axial Flux Permanent Magnet Generator for Low Speed Direct Drive Wind Turbine Applications
vii. Park College of Engineering and Technology, Coimbatore—Design and Development of a Grid-interactive 3 kW Class Rooftop Wind Turbine based Hybrid Renewable Energy System
viii. Maharashtra Energy Development Agency

ix. National Institute of Wind Energy, Chennai
x. Indian Institute of Technology, Bombay
xi. Centre for Wind Energy Technology, Chennai

*The Academic institutes (both public and private) of region imparting higher education in wind energy are:* PRINCE, Maharashtra; IIT Bombay; Nimbkar Agricultural Research Institute, Maharashtra; WISE, Maharashtra and Wind World, Bombay.

With this, we conclude with our third sub-system, the knowledge application and exploitation sub-system; which comprises of the main firms involved in the knowledge creation process.

*There are over fifty private firms setting up wind energy turbines in the Maharashtra region and some of them are:* Suzlon; Bajaj Auto; Sun-n-Sand Hotels; B P Energy; MSPL Limited; Shivashri Techno; Rpower; Saiprasad Group; Roaring 40s Windfarm; Parakh Agro Industries; Greenko Group; CLP India Private Ltd; ReNew Power; Indian Wind Turbine; Kenersys, India; Tata Power; Reliance Power; Inox Wind and Azure Power.

These firms can work individually as well in collaboration among themselves.

The prime customers are domestic and industrial.

Hence, with the above mentioned actors, we map a network of actors involved in the larger picture of wind energy in Maharashtra. The RIS framework has helped to know the significance and influence of these actors on wind technology in the region.

### 4.2. Data Collection Techniques

The data collected is purely based on various secondary sources. No field work was carried out for primary sources.

The secondary tools have heavily relied on the information that could be accessed from the government and other related portals.

## V CONCLUSIONS

The state promises of bright future in the renewable energy sector through its policies and Maharashtra is one of the first states to come out with its wind energy policy. Hence we took this as our case study. The reason why it can boost in the wind energy sector is due to its favourable geographical conditions.

But still many villages, unlike other states, are un-electrified in the region, hence what could be the reasons for the uneven diffusion of this technology. With the help of the RIS framework, we can understand the landscape of the innovations and diffusion taking place in wind energy in this region and can then further analyse reasons for its failure to reach the 'publics' of the Maharashtra region; which will be a helpful tool in policy-making.

Also, why is the government itself not involved in setting up of plants, and not financing the private firms is an area which can be explored further in studies.

## VI LIMITATIONS

The biggest limitation of the study was no primary evidences available to back the study. But the topic was taken since studies like these for such new technologies are scarcely available in the Indian context. This leaves a room for other interested scholars to take up such studies further.

A detailed analysis lacks in this paper, since it is an introduction to such a framework and its use. Hence it has a wide scope for further research.

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