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Diffusion of Renewable Energy Technologies in India: A Policy Analysis of Wind Energy

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ABSTRACT : *The future economic development trajectory for India is likely to result in rapid and accelerated growth in energy demand. Due to the predominance of fossil fuels in the generation mix, there are large negative environmental externalities caused by electricity generation. In this context, it is imperative to develop and promote alternative energy sources that can lead to sustainability of energy-environment system. Renewable energy is accepted as a key source for the future, not only for India, but also for the world. There is a significant opportunity for Renewable Energy Technologies (RETs) in India. Among different RETs, wind energy has received a considerable attention lately in the world and also in India. Though the policy of the central government for RETs is common for all wherein, individual states have different policy measures. In this study, an attempt has been made to analyze and review the policies of RETs in general and wind energy in particular for the selected few states of India.*

Keywords *- Diffusion, Policy Analysis, Renewable energy technologies, States, Wind Energy.*

I. INTRODUCTION

Energy is the basic building block for socio-economic development. Though fossil fuels will continue to play a major role in most countries, its availability is limited and may not be sufficient in the long run to sustain the demand. Energy security and sustainable development are high in the global agenda due to the impact of volatile energy prices, high demand, concerns over environmental sustainability and the global climate change. To ensure effective realization of the Sustainable Development Goals, economies in the region will need to strive both for higher economic growth and better-quality growth. (UNESCAP, Bangkok 2016) [1].The world energy scenario depicts a picture of concern. The adverse effects on environment caused by the production and consumption of energy have resulted in severe environmental impacts across the globe. The supply of energy is expected to remain adequate in coming years but, imbalance of energy consumption is prevalent around the world. Energy consumption is high in most developed countries. On the other hand, the developing countries need to consume more energy to ensure their economic growth. According to estimates, energy consumption in developing countries is only one-tenth of that in the developed countries.

The total supply of energy in the world by 2020 is expected to be 13,700 Million Tons of Oil Equivalent (MTOE). Oil is the most important, abundantly available and most highly consumed source of energy. However price of crude oil is very volatile and supply is driven by price. Thus, renewable sources of energy are gaining popularity. However, fuel prices and regulatory policies of different countries play an important role in the development of renewals. Renewable power generating capacity saw its largest annual increase ever in 2016, with an estimated 161 gigawatts (GW) of capacity added. The largest component of renewable generation capacity is wind power, which grew by 35% worldwide (REN 21, 2016) [2]. The overall capacity of all wind turbines installed worldwide by the end of 2017 reached 539,291 Megawatt (WWEA 2017) [3]. It also avoids the emission of carbon dioxide the main GHG, but also produces none of the other pollutants associated with either fossil fuel or nuclear generation. The Indian renewable energy sector has shown impressive growth in the past few years and investments into the sector have increased significantly.

II. ENERGY SCENARIO IN INDIA

According to various projections, in the near future, India's demand of energy would rise so sharply, that it would be quite difficult for India to sustain itself in this competitive world. Commercial primary energy consumption in India has grown by about 700% in the last four decades. With a targeted GDP growth rate of 7 to 8 percent, and an estimated energy elasticity of 0.80, the energy requirements of India are expected to grow at 5.6- 6.4 percent per annum over the next few years. For achieving energy sustainability, India should aim at two goals namely i) Increase the supply of energy and ii) Improve energy efficiency or reduce energy requirements. The main challenge facing India's energy sector would be to increase its efficiency in

an environmentally and socially acceptable manner. It needs to augment its domestic energy resources. It is a long term imperative that renewable resources are to be exploited optimally as India's sustained economic development is vitally dependent on its energy security and on the promotion of sustainable and environment friendly energy technologies.

Amongst the different renewable energy sources,wind energy is making a significant contribution to the grid power installed capacity of India, and is emerging as a competitive option. The Indian government expects renewable energy to contribute 10% of the total power generation capacity from the present 7.7% by 2012 and have 4%–5% share in the electricity mix (Ishan Purohit, et al, 2009) [4]. India is now the fifth largest wind market in the world (WWEA 2009). The wind energy sector in India has seen a shift in the past couple of years from a manufacturer focused industry to one led by mainstream power developers. The original impetus to develop wind energy in India came in the early 1980s from the government, when the Commission for Additional Sources of Energy (CASE) had been set up in 1981 and upgraded to the Department of Non-Conventional Energy Sources (DNES) in 1982 (Afgan et al, 2008) [5]. This was followed in 1992 by the establishment of a full-fledged Ministry of Non-Conventional Energy Sources (MNES), renamed as Ministry of New and Renewable Energy (MNRE) in 2006. The Indian Renewable Energy Development Agency (IREDA) was established in 1987 as a financial arm of the Ministry to promote renewable energy technologies in the country. The wind energy program of MNRE was aimed at catalyzing commercialization of wind power generation on a large scale in the country. India's wind power potential has been assessed at 45,000 MW for sites having Wind Power Density (WPD) greater than 200 W/m^2 at 50 m hub-height. The total gross on–shore wind energy potential in India is estimated to be of 48,561 MW as given in Table 1.

State	Capacity in MW
Andhra Pradesh	1870
Gujarat	4230.5
Karnataka	3086.2
Kerala	44.21
Madhya Pradesh	1019
Maharashtra	4669
Telangana	100.21
Rajasthan	4858
Tamil Nadu	7688.21
Total	**27565.33**

TABLE I. Installed potential of wind power across different states*

But, the total installed capacity is only 27565.33MW as on December 2016 [6]. The availability of loans up to 70% of the total cost of the project, 80% depreciation in first year, zero import duty and tax holidays for new projects for 5 years are a few policies of government which are attracting new players in this sector. 216 wind monitoring stations in 13 states and Union Territories having a mean annual wind power density greater than or equal to 200 W/m^2 at 50 m height above ground level has been identified for wind power development as given in Table 2 [7].

States	Potential sites
Andhra Pradesh	32
Gujarat	38
Kamataka	26
Kerala	17
Madhya Pradesh	7
Maharashtra	31
Orissa	6
Tamil Nadu	41
Rajasthan	7
Uttaranchal, West Bengal, and Andaman Nicobar	01 in each State
Lakshadweep	8
Total	**216**

Table 2. Distribution of potential sites across different states*

Largest ever Wind Power capacity addition of 5502.39 MW in 2016-17 exceeding target by 38%. During 2017-18, a total 467.11 MW capacity has been added till 30.11.2017, making cumulative achievement 32746.87 MW. Now, in terms of wind power installed capacity India is globally placed at 4thposition after China, USA and Germany [8].

III. WIND ENERGY DIFFUSION:POLICY ACROSS DIFFERENT INDIAN STATES

A range of policy support measures and incentives announced by the government, for introducing state of-the-art wind energy technologies on the one hand, while encouraging private entrepreneurs to take up commercial projects on the other led to significant progress in the sector. While style and content differs, the basic policy structure is similar across states. This is to provide legal support and economic incentives, while obligating (by means of legislation) the power company to buy electricity from wind power, and encouraging businesses to develop wind power through incentives such as investment, tax, and price. A number of infrastructural situations have also spurred wind energy use. Table 3 presents the summary of key state government incentives for wind energy projects in India. At the central government level, although there is no national policy for renewable energy,

there are a number of measures that help drive wind energy development, including fiscal incentives such as income tax exemption for 10 years, 80% accelerated depreciation, sales tax exemption, and excise duty exemption. Though there are a set of incentives and guidelines for promotion of wind power at the central government level (IEA 2016) [9] the individual states follow their own policies. In addition, several states have implemented fiscal incentives. These included (GOI 2015)

- Preferential tariffs for wind electricity.
- Initiation of a comprehensive wind resource assessment programme throughout the country.
- Establishment of Centre for Wind Energy Technology (C-WET).
- Accelerated depreciation, initially 100% but later reduced to 80%.
- No duty on imported components.
- Low interest loans for a limited period through Indian Renewable Energy Agency (IREDA).

The incentive of accelerated depreciation proved to be a major boost for wind power development, as it translated into substantial tax benefits for profit making companies.

The common features of policy parameters include:

(i) Preferential tariffs:- These are the rates paid by the utility per kWh to a wind power producer. For encouraging renewable power, governments in various states have paid higher rates compared to conventional electricity (grid power) rates.

(ii) Wheeling charges:- The costs charged by the utility for allowing the power producer to generate electricity at one point and use it at another point using the grid lines is called the wheeling charge. Many states had a wheeling charge of 2% in early 90s, but some of them increased to 12% later.

(iii) Banking:- This allowed the producer to produce power at one point of time and use it at a later time. Most states have banking period ranging from 6–12 months.

(iv) Availability of adequate transmission facilities:- Providing the transmission facilities from the point of generation to the nearest interconnection point in the grid is the responsibility of the State Government implemented through the State Transmission Utility. Additional state incentives:- Almost all the States have a package of incentives for industries to promote investments, and hence economic development. These constitute additional subsidies, tax holidays, reduced excise duties and sales tax exemptions.

(v) Third Party Sale:- Some state governments allowed the wind power producers to negotiate and sell electricity to a third party other than the State Electricity Board (SEB) or the Distribution Companies (DISCOMS). This provided an additional avenue for the wind power producers to earn more revenues.

(vi) Land availability: Acquiring land for installation of wind power depended on whether the land was privately owned or had to be acquired from the government. In some States, availability of private lands made it easier for developers to acquire land for installations.

States	Wheeling (Return on Equity)	Banking	Buy-back rate by State Electricity Board (SEB)	Renewable Portfolio Standards (RPO)
Tamil Nadu*	5% of energy	5% (12 months based on financial year-April to March)	Rs. 3.40/kWh (Levelized.)	13%
Karnataka*	5% of Energy+Rs.1.15/kWh as cross subsidy	2% of energy input/month for 12 months	Rs. 3.40/kWh without any escalation for 10 years	Min 10%
Andhra Pradesh*	At par with conventional	Allowed	Rs. 3.50 w.e.f 9-9-2008 (Frozen for 10 years)	5%
Kerala*	5% of Energy	9 months (Jun-Feb)	Rs.3.14/kWh (fixed for 20 years)	2%
West Bengal	Rs. 0.30/unit or 7.5% of energy whichever is higher	6 months	To be decided on case basis with a cap of Rs. 4/kWh	08-09: 2-4.8%, 09-10: 4-6.8%, 10-11:7-8.3%, 11-12: 10.00%
Gujarat*	4% of energy	Monthly settlement	Rs.3.50/kWh without any escalation fixed for 20 yrs.	2%
Madhya Pradesh*	2% of energy transmission charges as per ERC	Allowed	Rs.4.03 to Rs.3.36 (constant) reducing 17 paise/year for first 4 years	10%

Maharashtra*	2% of energy as wheeling+5% as Transmission & Distribution loss	12 months	Rs. 3.50/kwh (escalation of 15 paise per year for 13 years)	07-08: 4%, 08-09:5%, 09-10: 6%
Rajasthan*	10% of energy	06 months	Rs3.71/kWh for Jaisalmer, Jodhpur, etc, and Rs.3.67/unit for other districts (base year 08-09).	08-09: 6.25%, 09-10: 7.45%, 10-11: 8.5%, 11-12%: 9.50%
Punjab*	2% of energy	Allowed	Rs. 3.66/unit with 5 annual escalation @5% up to 2012	08-09: 6.25%, 09-10%: 7.45%, 10-11 – 8.5%, etc
**Policy announced by State Electricity Regulatory Commission in the respective state*				

Andhra Pradesh	Tamil Nadu	Gujarat	Maharashtra	Karnataka
•Stable wheeling policy since 1994-95; 2% charges •Stable banking facility for 12 months but charges increased from2001/02.Buy back fixed at Rs. 2.25 with annual escalation at 5% •Third Party Sale (TPS) allowed till 1997-98 and thereafter withdrawn capital subsidy provided not stable policy	•Stable policy; but wheeling charges increased from 2% up to 2001 to 5% highest •Stable policy; but banking charges increased from 2% up to 2001 to 5% highest. Buy back started at Rs.2.00 but was later allowed as per guidelines at Rs.2.25 with esc. rate at 5% from the base year 1994-95; however it was fixed at Rs. 2.7 in 2001 •TPS allowed initially for a year and later not allowed •Capital subsidy provided up to 1996-97 more stable	•Short term wheeling policy; Highest wheeling charges of 4% from 2002 onwards •Banking allowed fro six months as compared to 12 in other states. Buy back at the lowest rates of Rs.1.75 and later increased from 2002 to Rs. 2.60 •TPS not allowed No lack of policy from 1999 to 2001/02	•Most favorable and stable policy; 2% since 1997-98 •Most favorable and stable policy-12 months since 1997-98 Highly favorable tariff; Rs. 2.25/kWh (5% esc. 1994-95) and fixed at Rs. 3.50/kWh (Rs. 0.15/kWh per year in 2003-04 •TPS allowed •Provided from 197-98 Progressive	•Most stable and favorable policy; 5% of wheeling policy+Rs.1.15/kWh as cross subsidy •Allowed at 2% banking for 12 months •Favorable tariff Rs.3.40/kWh without any escalation for 10 year of commercial operation. •TPS allowed •No electricity duty for 5 years.

A summary of policies that are state specific are listed in Table IV. Examining the table, it is obvious that policies varied across states and across times within the same state. The little or no impact of policy regulation in Gujarat is confirmed by the fact that the wind specific policies were on hold during the transition phase into the regulatory regime. The state of 'policy on hold' that continued for over three years in Gujarat underplayed the initial gains arising out of the policies in place during 1991–1997. The states like Gujarat and Maharashtra with overall stable and progressive policies shows higher investments among 28 states during 1996–2001,during which these two states ranked higher than TN and AP (MNRE website 2017) [6,7].

IV. OUTCOME OF DIFFERENT POLICY INITIATIVES ACROSS VARIOUS STATES

The wind energy program of MNRE is aimed at catalyzing commercialization of wind power generation on a large scale in the country. A market-oriented strategy was adopted from inception, which has led to the successful commercial development of the technology. The broad based national program included wind resource assessment; research and development support; implementation of demonstration projects to create awareness and opening up of new sites; involvement of utilities and industry; development of infrastructure capability and capacity for manufacture, installation, operation and maintenance of wind power plants; and policy support. Further, the policy initiatives of different states have also resulted in certain positive outcomes. A notable feature of the Indian program has been the interest among private

investors/developers in setting up of commercial wind power projects. MNRE provides support for research and development, survey and assessment of wind resources, demonstration of wind energy technologies, and has also taken fiscal and promotional measures for implementation of private sector projects (GOI 2016, MNRE 2016). The Central Electricity Authority (CEA) has begun compiling the renewable energy generation data since 2014/15.The state-wise quantum of energy produced from wind energy during 2014/15, 2015/16, and 2016/17 is described in Table 5. The contribution of wind energy in the total renewable generation during 2014/15, 2015/16, and 2016/17 was 55%, 50%, and 56%, respectively achieve optimum generation of power in the most efficient and cost-effective manner, MNRE issued revised guidelines for wind power projects in 1996. These guidelines, relating to preparation of Detailed Project Reports (DPRs), micro-siting, selection of wind turbine equipment, operation & maintenance, performance evaluation, etc., have created and raised the level of awareness among the State Electricity Boards, State Nodal Agencies, manufacturers, developers, and investors about planned development and implementation of wind power projects. However, due to the advancement in wind turbine technology and requirement to comply to various standards and regulations issued by CERC, CEA, and other regulatory bodies, the need to issue comprehensive guidelines for development of onshore wind power projects in the country was felt. It is also observed that from the table that, Tamil Nadu is at the first place in wind power generation among Indian states, followed by Gujarat, Maharashtra, Karnataka, Rajasthan, etc. The total generation capacity in India is 45697.54 MU until 31st December 2017 [10]. There after the growth rate declines and reaches towards the saturation level in some of the states.

Table 5. Wind power generation in MU across different states in India*

States	Up to 2014/15 in MU	Up to 2015/16 in MU	Up to 2016/17 in MU
Tamil Nadu	10147.1	7273.23	11935.26
Maharashtra	6804.8	6121.34	7490.75
Gujarat	5660.09	6446.58	7720.01
Karnataka	4658.1	4797.95	6058.65
Rajasthan	4171.63	4767.63	5764.12
Madhya Pradesh	592.25	1558.43	3256.38
Andhra Pradesh	1675.82	2013.04	3187.85
Kerala	58.4	51.45	72.59
Telangana	0	0	211.93
Total(All India)	**33768.2**	**33029.4**	**45697.54**

***source: MNRE, Wind power 2017-18**

The results indicate that the diffusion of wind energy technology may reach 99% of the maximum utilization potential by 2020 [11].

Wind energy in Tamil Nadu has already gained importance showing a good progress in the development. The highest growth rates for Tamil Nadu, Gujarat and Maharashtra was observed in 2015 and 2017, respectively, and is likely to reach 99% of their maximum utilization potential by 2020 [12]. It may be noted that the states of Gujarat and Andhra Pradesh have a similar growth pattern and appears to reach the highest growth rate in 2018 and 2019, respectively. After 2014, Gujarat is slowly picked up and considerable growth rate has been observed in the wind sector (MNRE 2018) [13]. Gujarat may achieve 94% of its potential only by 2030. Andhra Pradesh shows a gradual and steady increase in harnessing its technical wind potential and it can achieve 98% of its potential only by 2030. The success of Tamil Nadu in wind energy, merits further probing. Tamil Nadu could attract investors due to one or more of the following [14]:

• Tamil Nadu has shown remarkable progress in the field of wind energy utilizing almost 80% of its wind power potential with more than 41% of India's total wind installations.

• The windy sites were close to towns for accessibility in bringing labor and providing accommodation for the personnel involved in the projects. Good windy sites like Muppandal, etc, were well interlinked with highways.

• Boom in Textile and Cement industry where huge profits were earned and hence tax concessions was obtained by setting up wind farms

• Grid network by Tamil Nadu Electricity Board (TNEB) was well connected and mainly passing through the wind sites.

• Most of the wind turbine manufacturers/suppliers were located in Tamil Nadu (like a hub for wind turbine manufacturers) and hence generated investor's have confidence in the supply of machines and after-sales service of the machines. Also a bunch of local players many of them based in the engineering hub of Coimbatore which churn out small aero generators of kilowatt capacity.

• Chennai port of Tamil Nadu has excellent facilities for import of heavy machinery of the turbine components and this facilitated inter-state and international transportation.

• Active promotional steps were taken by TNEB and the Tamil Nadu Energy Development Agency (TEDA).

• TNEB extended all facilities for private entrepreneurs like consultancy services, processing of the application for issuance of No Objection Certificate (NOC), and other clearances, extending

grid connections to wind farms and executing new dedicated sub-stations.

• The TNEB is also in the process of setting up of five 400 kV substations and three 230 kV substations that would address the bottlenecks in evacuation of wind power.

• TNEB established an effective system for registering the energy generation by each turbine and so enabled turbine owners to adjust their energy bill in accordance, or effect payment to those who sold to TNEB.

In this backdrop, it may be observed that at the national level the suppliers must provide turnkey solution by looking at the land development issues. This helps in boosting the acceptance of wind farm projects by Indian investors who do not feel comfortable in tackling the related issues, reduce delays in execution and negotiate the land related costs with the owners and civil contractors. Some states with Renewable Portfolio Standards (RPS) or other policies to promote wind generation have introduced Feed in Tariffs (FITs) for wind generation which is higher than that for conventional electricity [15]. In Karnataka, for instance, the tariff for wind generation is about Rs.3.50kWh compared to only Rs. 1.50kWh for coal generated power.

V. SUMMARY

In view of the rapid and accelerated growth in energy demand, apart from environmental concerns, Renewable energy sources hold a key in Indian energy scenario. Amongst RETs, wind energy has a special significance and in this study wind energy growth pattern is reviewed since its inception in 1980's. Wind power penetration is not constrained by technical problems with wind power technology, but by regulatory, institutional, and market barriers (Jagdeesh A, 2010) [16]. It is observed that the presence of such non-economic barriers have a significant negative impact on the effectiveness of policies to develop wind power, irrespective of the type of incentive scheme.

Currently nine States of India, viz, Tamil Nadu, Karnataka, Andhra Pradesh, Gujarat, Rajasthan, Maharashtra, Madhya Pradesh, West Bengal, and Kerala are implementing major wind energy programmes. However, the five States Tamil Nadu, Maharashtra, Gujarat, Karnataka and Rajasthan account for more than 96% of the total potential at present. Though there are a set of incentives and guidelines for promotion of wind power at the central government level, individual states follow their own policies. States have established regulatory commissions which formulate and implement policies for, among others, renewable power promotion such as preferential tariffs, wheeling and banking charges, third party sales, etc. In view of Tamil Nadu's success in wind power generation, the policy features of that state was probed in detail.

VI. CONCLUSION

This study revealed that, there are several financial and fiscal incentives provided to the wind power producers at the union and state government level; however, unstable policies of the state governments and poor institutional framework increase the risk associated in the wind energy sector. A preliminary assessment of the status of wind power potential in various states of India indicates that there should be a stable and uniform national policy to make wind power projects financially attractive across the country.

Therefore, for the large-scale penetration of wind energy in India, it is critically important to assess realistic potential estimates and identify niche areas to exploit the wind energy resource. In addition, Capacity Utilization Factor (CUF) for wind power has been an area of concern. Against the International average of 25% - 35%, Indian CUF averages around 25%. Thus wind energy policy must also address this issue appropriately. Apart from the above, installation of high-powered wind turbines in the place of old (aged turbines) using Re-powering of wind turbines, lower capacity machines, intercropping of small windmills among bigger machines, development of offshore wind farms and development of hybrid turbines are some of the important needs to be addressed toward the rapid growth of wind energy industry in India. If India has to match the growth rate in the global wind energy sector, outstanding regulatory and policy issues need to be addressed appropriately.

REFERENCES

[1]. Energy Security and Sustainable Development in Asia and the Pacific (2008), UNESCAP, Bangkok. Also available at http://www. unescap org/sites/default/files/publications/Econoic%20and %20Social%20Survey%20of%2Asia%20and%20t he%20Pacific%202016_0.pdf, assessed on 26th December 2017.

[2]. http://www.ren21.net/wp-content/uplo ads/2017/06/178399_GSR_2017_Full_Report_062 1_Opt.pdf

[3]. http://www.wwindea.org/information2/information

[4]. Ishan Purohit and Pallav Purohit (2009). Wind energy in India: Status and future prospects: journal of renewable and sustainable energy, Vol.4, 2, 701.

[5]. Afgan N.H, Al Gobaisi D, Carvalho M.G, & Cumo M (1998). Renewable and Sustainable Energy Review. Vol. 2, 232-235

[6]. http://www.mnre.gov.in/wp-installed.html, accessed on June 18, 2016.

[7]. www.mnre.nic.in accessed on May 7, 2016.

[8]. http://pib.nic.in/newsite/PrintRelease. aspx?relid=174832, assessed on March 2017.

[9]. https://www.iea.org/newsroom/news/2017/november/a-world-in-transformation-world-energyoutlook-2017.html, assessed on March 2017.
[10]. https://mnre.gov.in/file-manager/akshay-urja/julyoctober-2017/EN/Images/20-25.pdf, assessed on January 2017.
[11]. http://www.cea.nic.in/reports/monthly /executive summary/2017/exe_summary-01.pdf assessed on March 2017.
[12]. World Wind Energy Association (WWEA, 2009). www.wwindea.org accessed on April 16, 2016.
[13]. Government of India (GOI), Integrated Energy Policy Report of the Expert Committee, Planning Commission, New Delhi, 2006
[14]. Dincer I (2006). Government of India (GoI), (Annual reports 1991–2006), India, New Delhi: Ministry of Non-Conventional Energy Resources; 1991–2006, Renewable Sustainable Energy Review. 2000, vol. 4, 157.
[15]. Press Information Bureau, Government of India Ministry of New and Renewable Energy, Year End Review 2017 –MNRE. Available at http://pib.nic.in/newsite/ Print Release.aspx?relid=174832.
[16]. Jagdeesh A, (2000-2010). Wind energy development in Tamil Nadu an Andhra Pradesh, India Institutional dynamics and barriers, Energy Policy, 28, 157-168.