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Technology Diffusion Analysis and Future Trends of Wind Power in Selected States of India

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Abstract: **In India, the wind power generation has gained a high level of attention and acceptability. Individual states of India have varying policy measures to encourage growth of the wind power sectors which had influenced the rates of diffusion in wind energy in different states. The theory of diffusion of innovation is used to study the growth of wind power technology in different states of India. The future growth pattern to achieve the technical wind potential is predicted and analyzed using Logistic model. The state level data of cumulative wind power installed capacity is used to obtain the diffusion parameters**

***Index Terms*— diffusion, forecasting, logistic, power, wind.**

I. INTRODUCTION

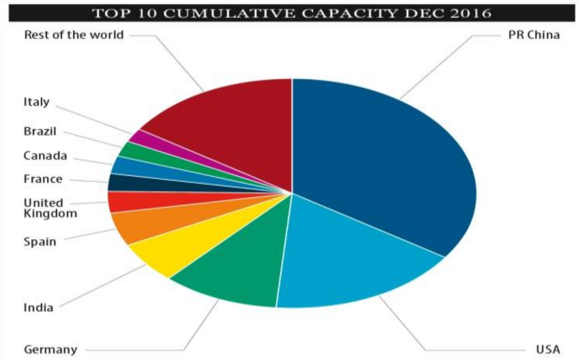
Energy is an essential factor for economic growth and improvement to quality of life in society. Conventional energy sources based on hydrocarbon oil, coal, and natural gas causes huge carbon emissions, which leads to harm the environment and to human health. Growing concern for the rise in fossil fuel prices, environmental degradation, emission of greenhouse gases, limited coal availability, global warming, erratic weather patterns have cast a shadow over the future of coal, oil and other conventional sources of energy and it has led to the world's interest in renewable energy sources. Wind is commercially and operationally the most doable renewable energy resource and emerging as one of the largest source in renewable energy sector. Wind being widely available, and producing no pollution during power generation, has considerable potential as a global clean energy source.

India had mere 1350 MW generation capacity at the time of independence in 1947 and in 2016 India has 305554.25 MW generation capacities [9]. About 14.48% of this is the contribution of renewable energy. India has good potential of wind throughout the country. As a result of social, economical and industrial development of country, the demand for electricity grows rapidly in India. Almost all types of oil and natural gas are imported from neighboring countries. Rapidly growing demand of energy forces India to search for renewable energy sources such as wind energy. As a result of scientific assessment of wind resources [5]-[7] throughout the country, wind power has emerged as a feasible and cost efficient option for power generation. India now ranks fourth in the global wind power installed capacity index after China, USA and Germany as per global wind energy council in the third week of December 2016 [6].Fig-1 shows the global wind power installed capacity of top ten countries

II. DIFFUSION

The diffusion of an innovation is a process by which an innovation is communicated through certain channels over the time among the members of a social system [4]. Diffusion model had been mostly used to forecast the demand of new

TOP 10 CUMULATIVE CAPACITY DEC 2016



Country	MW	% Share
PR China*	168,690	34.7
USA	82,184	16.9
Germany	50,018	10.3
India	28,700	5.9
Spain	23,074	4.7
United Kingdom	14,543	3.0
France	12,066	2.5
Canada	11,900	2.4
Brazil**	10,740	2.2
Italy	9,257	1.9
Rest of the world	75,577	15.5
Total TOP 10	**411,172**	**84**
World Total	**486,749**	**100**

Source: GWEC

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Fig-1 Global installed wind power as per GWEC

technology. The general pattern of technology adoption is an S-shaped curve when the percentage of the installed base captured by the new technology is plotted over time. The curve generally comprises of three distinct phases:

i) A slow growth over a long period, during this introduction stage, the process staff learns the new production technology, product quality is slow growth.

ii) A rapid take-off period -At this stage, the staff has already learned the new production technology and gets more experiences via repeated operations, and then the product quality is quick growth

iii)A flattening of the curve, signifying a near completion of diffusion - For the maturity stage, staff has already made plentiful experience and learned a practiced operational skill, and product quality grows up to maximum and tends a stable state.

There are several instances of occurrence of multiple S curves for the same technology/product class which signify introduction of new models in the market. The estimated member of adopters of an innovation defines the 'market potential'.

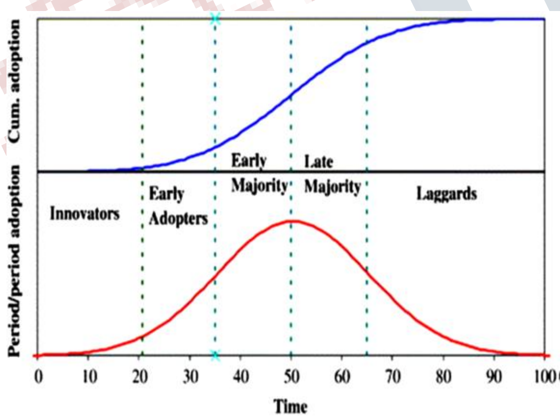

Fig-2 Diffusion curves

The recent focus on finding solutions for mitigating global warming has resulted in renewable energy technologies gaining importance. Among the renewable energy technologies, wind power is one of the fastest growing technologies globally. Utilization of wind power is extremely site specific and the success of wind technology presumes that the energy demand exists at that point of time and location. Currently ten States of India, namely, Tamil Nadu, Karnataka, Andhra Pradesh, Gujarat, Rajasthan, Maharashtra, Madhya Pradesh, West Bengal, Kerala, and Orissa are implementing major wind energy programmes. However, the four States – Maharashtra, Gujarat, Tamil Nadu and Andhra Pradesh which account for 60% of the total potential have 90% of the total installed wind generation capacity. The rates of diffusion and achievements have been different for different states depending on specific issues such as grid quality, availability of land for installations, distance from the generation point to feed-in point, etc

III. MATHEMATICAL PRESENTATION OF LOGISTIC MODEL

Technological forecasting method is used to predict the growth and direction of any technology. Different growth patterns are being used for technological forecasting. In this paper, the logistic curve is used. The logistic curve has been used for many years in estimating industrial growth. The logistic curve is used to model a variety of physical situations in which the growth rate of the parameter depends on the size of the parameter in such a way that if the parameter grows beyond the inflection point, the growth rate decreases. The general form of logistic function is given by equation (3).
The diffusion of wind power in different states can be forecasted using the logistic growth model [3]

$$N(t) = \frac{M}{1+e^{-bt+a}} \qquad (1)$$

where N(t) is the cumulative installed capacity of wind power projects in the country at time t ,M is the total wind power potential of the country," b" is the adoption rate of wind power projects in the country, and " a" is the integration constant. The peak time at the point of inflection, t' or t50%, for the logistic growth model can be derived by taking the second derivative of Eq. (1) with respect to t, setting it equal to zero, and solving for t. Thus

$$t' = a/b \qquad (2)$$

Eq.(2) shows that parameters a and b determine the timing of the inflection point.
Eq.(1) can also be written as

$$N(t) = \frac{M}{1+e^{-b(t-t')}} \qquad (3)$$

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The model parameter values are required for forecasting the diffusion path of a new energy technology. If technology market penetration data is available the regression coefficients" b "and "a" can be estimated by a linear regression of the loglog form of Eq. (1) as given below in log-log form of eq. (1)

$$\ln\left[\frac{M-N(t)}{N(t)}\right] = a - bt \qquad (4)$$

The parameters **a** and **b** can be combined into one single parameter, t*, defined as the point of inflection. This is given by the equation

$$t^* = a/b$$

The rate at which diffusion was occurring at the point of inflection can be derived as in equation (5)

$$\left(\frac{dN}{dt}\right)_{t=t*} = M/2b \qquad (5)$$

IV. CALCULATION AND RESULT

Cumulative wind potential installed in different states of India from yr 2002 to 2016 [8-11] is as shown in Table 4.1 Based on algorithms expressed in section 3, the parameters **a** & **b** for wind potential installed in Gujarat ,Rajasthan, Maharashtra & Karnataka states of India are found using Excel as in table 4.2

Table 4.1 Cumulative wind potential installed in different states of India from yr 2002 to 2016

S.NO.	Year	Cumulative installed capacity as on 31 march 2016			
		Rajasthan	Gujarat	Maharashtra	Karnataka
1	02-03	61.37	187.6	402.3	124.9
2	03-04	175.77	216.5	408.5	209.8
3	04-05	279.51	268	457.3	411.3
4	05-06	352.785	352.6	1002.4	555.1
5	06-07	464.535	636.6	1487.7	821.1
6	07-08	534.985	1253	1755.9	1011.4
7	08-09	734.585	1566.6	1938.9	1327.4
8	09-10	1084.585	1863.7	2077.8	1472.8
9	10-11	1521.285	2176.5	2316.9	1726.9
10	11-12	2066.935	2966.4	2733.4	1933.6
11	12-13	2698.935	3174.7	3022	2135.3
12	13-14	2796.935	3454.5	4096.5	2318.3
13	14-15	3320.435	3581.4	4369.95	2548.8
14	15-16	4005.935	3948.61	4653.83	2639.55

Table 4.2 - Parameters of Logistic model for different states

S. No.	Constant	Rajasthan	Gujarat	Maharashtra	Karnataka
1	b	0.381	0.298	0.255	0.244
2	a	3.980	3.942	2.027	3.554
3	R^2	0.984	0.945	0.75	0.908

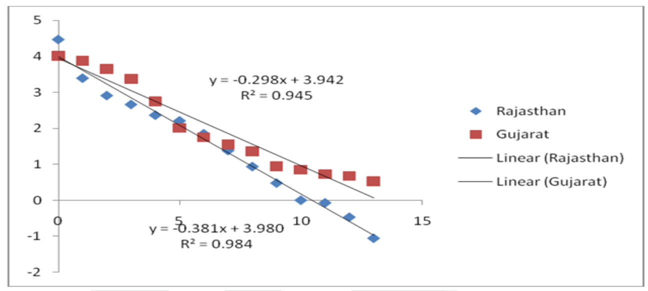

Fig 4.1 - Linear regression using excel for Rajasthan and Gujarat

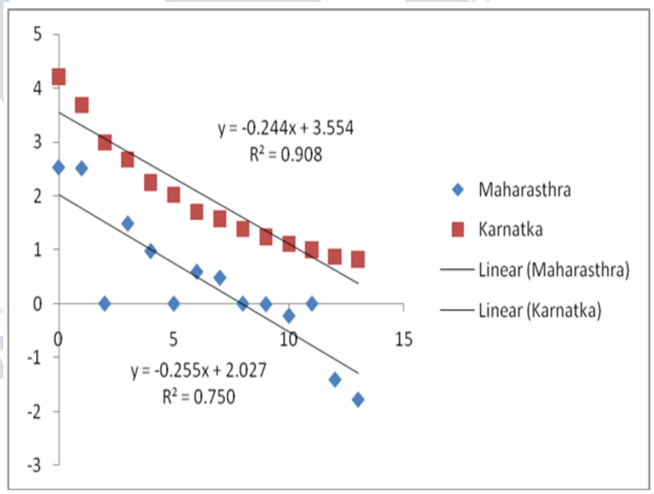

Fig 4.2 - Linear regression using excel for Maharashtra and Karnataka

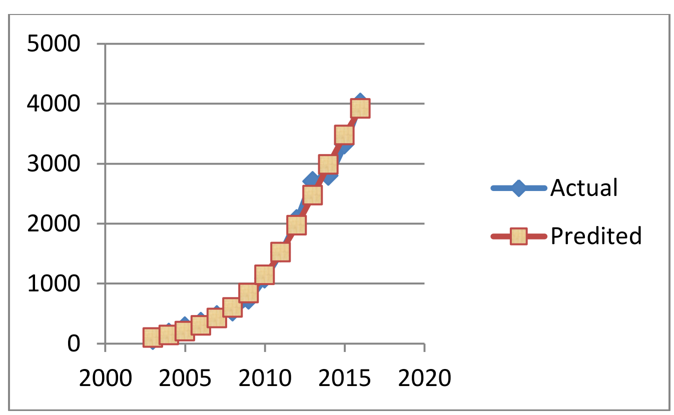

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Fig 4.3- Comparison of actual power with predicted power for Rajasthan

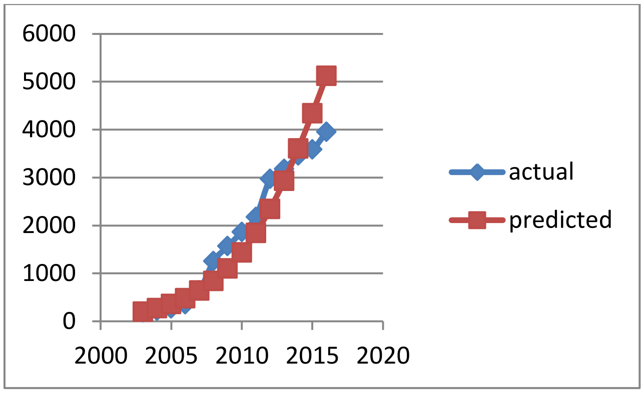

Fig – 4.4 Comparison of actual power with predicted power for Gujarat

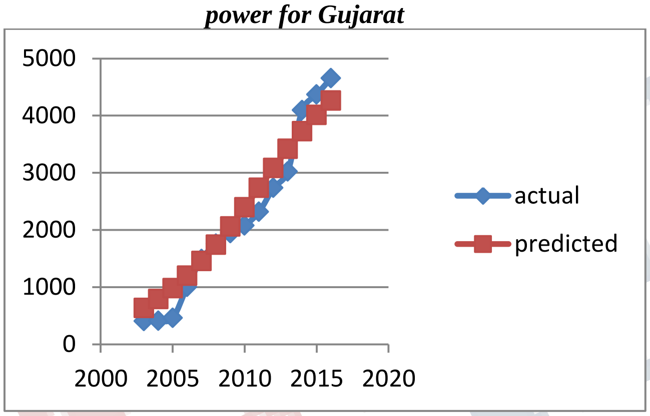

Fig – 4.5 Comparison of actual power with predicted power for Maharashtra

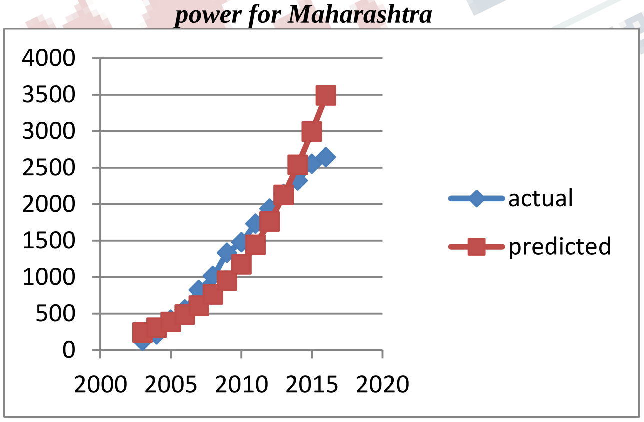

Fig – 4.6 Comparison of actual power with predicted power for Karnataka

Table 4.3 - Forecast Cumulative wind potential installed from year 2017 to 2020

S. No.	year	Rajasthan	Gujarat	Maharashtra	Karnataka
1	2017	4290.95	5906.83	4481.19	3999.58
2	2018	4589.59	6667.58	4666.15	4522.95
3	2019	4818.7	7372.4	4820.32	5039.63
4	2020	4988.85	8000.14	4946.97	5535.03

V. CONCLUSION

The study result put forward that applying logistic growth model to forecast short term cumulative wind potential installed can bring about excellent prediction. The result of this study is important in forecast cumulative wind potential installed. Predicting the wind power is of great importance for state to formulate the port development strategy. In the course of this result, the policymaker can make suitable policies to make the economic firmly developed

REFERENCES

[1] Mahajan V, Peterson RA. Models for innovation diffusion; series: quantitative applications in the social sciences. Sara Miller McCune, Sage Publications, Inc; 1985. p. 87.

[2] P.A. Geroski , Models of technology diffusion, Research Policy 29 (2000) 603–625

[3] M. Carolin Mabel, E. Fernandez Growth and future trends of wind energy in India Renewable and Sustainable Energy Reviews 12 (2008) 1745–1757

[4] K. Usha Rao, V.V.N. Kishore Wind power technology diffusion analysis in selected states of India, Renewable Energy 34 (2009) 983–988

[5] Singh M , Singh P. A Review of Wind Energy Scenario in India, International Research Journal of Environment Sciences, Vol. 3(4), 87-92, April (2014)

[6] www.gwec.net

[7] www.mnre.gov.in

[8] www.cea.nic.in

[9] www.cwet. tn.nic.in