Evaluating the Role of State Incentives in the Deployment of Wind Energy in India

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Abstract- Since 1991, demand for energy in India has grown considerably. Both governments, i.e. central and state place an array of incentives like Feed in Tariff (FIT), Captive Consumption (CG) and Renewable Purchase Obligation (RPO) at the state level, and Generation Based Incentive (GBI) and other tax incentives at central level to boost incentive in the renewable energy sector. This study empirically examines the role of above mentioned state level incentives in the development of the wind energy sector across different states. This paper uses technique of Fixed Effect Panel Data Modelling of econometric analysis on the state level data of 26 Indian states from 2001 to 2011. The study reveals that on an average RPO is not a significant predictor for the wind energy deployment and over the period negatively affects installation. However other incentives, FIT and CG are significantly affecting wind energy development.

Keywords— Wind Energy, India, State Level Incentives, Econometric Analysis, Panel Data.

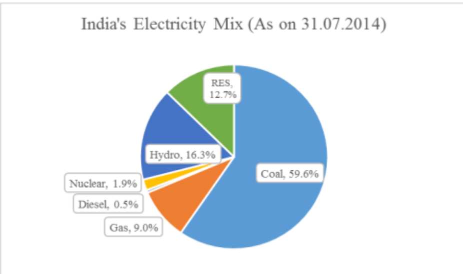
1. Introduction

Energy is a vital input in all sectors of any country's economy (Singh and Parida, 2013). Over the past two decades the requirement of energy has grown considerably due to the speeding up of economic development in India. This demand for energy will continue to rise as rapid growth of economy gets combined with rise in population (Singh and Parida, 2012). However, like many other nations, India has met most of these requirements with the conventional energy sources only such as coal, gas and oil etc. (Mallah and Bansal, 2010). Scarcity of these resources, emission of greenhouse gases, environment distortion and pressure on foreign exchange reserves are some of problems attached with generation of energy from these resources (Mani and Dhingra, 2013). Considering these limitations and growing awareness about climate change and energy independence, Indian government has given attention to the renewable energy sources. Ministry of New and Renewable Energy (MNRE) which administers renewable energy sector in India, includes bagasse cogeneration[1], biomass power, small hydro project (<25 MW), solar power, urban and industrial waste power and wind power in grid connected renewable energy sources. As of 31st July 2014, renewable energy capacity is 31,692.11 MW, which accounts for 12.7% of the

[1] Bagasse cogeneration plant use biomass resources for grid power generation. In this technology, biomass materials includes bagasse, rice husk, straw, cotton stalk, coconut shells, soya husk, de-oiled cakes, coffee waste, jute wastes, groundnut shells, saw dust etc. used for generating energy.

2,50,256.95 MW total installed capacity from all sources (including coal, gas, nuclear etc.). Figure 1 depicts share of various energy sources in India's energy mix.

Figure 1. India's Electricity Mix



Source: Central Electricity Authority, India

Worldwide wind energy has advantage over other renewable energy technologies due to its technological maturity, good infrastructure and cost competitiveness (Islam et al.,, 2013). Hence, globally as well as in India, wind energy has largest share in renewable energy after excluding hydro power (*Renewables 2013 Global Status Report*, 2013). In India, wind energy is the leading renewable energy technology, represents 68.9% of the total renewable energy generation capacity. India has strongly maintained fifth place in the world in installing wind energy, after China, U.S., Germany and Spain. According for Centre for Wind Energy Technology (C-WET), between 2005 and 2009, generation from wind energy growth was higher than 100%, from 24874.07 MU to 59,208.00 MU. Till May 2014, wind energy capacity has existed in 10 Indian states ranged from limited capacity in West Bengal, Odisha to 7276 MW in Tamil Nadu and 4098 MW in Maharashtra. This disparity in the installation can be explained by several reasons like wind capacity, policies of state governments, as well as differences in power sector regulatory environment between states.

As in India, electricity is the shared responsibility of central and state government, hence both Central and State governments had launched various regulations, financial incentives and regulatory changes for the development of wind energy as in India (Schmid, 2012). This paper focuses on various incentives that are implemented by various Indian states for development of wind energy. The objective of study is to empirically examine effect of a particular incentive on wind energy development. This study uses fixed effect panel data modelling with several incentives as independent variables and annual wind energy capacity addition as dependent variable in order to assess the effectiveness of each incentives to develop wind power. The second section of the paper reviews literature. The third section reviews recent experiences with wind energy development in India and discusses factors that appear to have driven wind energy development like government policies to promote wind and other forms of renewable energy, and changes in the regulatory environment. Fourth section of paper describes the data and the methodology used to measure effectiveness of state incentives. The fifth section presents the empirical results. Discussion and conclusions are presented in the final section of the paper.

2. Literature Review

The literature on wind power has mainly focused on discussions on specific set of topics, with the majority of research focused on describing current status, development of wind power in certain countries, possible opportunities and challenges that can be encountered in the future (Mondal et al.,, 2010; Al-Badi et al., 2009, 2011; Dehghan, 2011; Ghobadianet al., 2009; Han et al., 2009). Other types of research includes investigations into feasibility and implication of integrating large scale wind power into the power grid (Li et al., 2012), applying simulation models to investigate optimized policies to support renewable energy (Liu et al., 2011) as well as studying drivers for wind power development, including the degree of private participation, network stability, public acceptance and project planning (McLaren Loring, 2007). (Nguyen, 2007) and (Oikonomou et al., 2009) used GIS based analytical method to investigate financially feasible renewable energy development models and the promotion of market penetration strategies. Influence of diffusion measures on sustainable energy standards or green energy policy implementation using innovation diffusion theory and logistic regression has also been studied (Menz and Vachon, 2006) (Chandler, 2009). Some researchers used structural equation modelling to see how renewable energy influence gross domestic product (GDP) of country while others conducted interviews and literature reviews to study issue of renewable energy intermittence (Sovacool, 2009). (Tang et al., 2013) investigated the role government organizations in the development of wind energy infrastructure by using the innovation diffusion theory based approach.

Some econometric studies have been done to examine the role of state level incentives in the development of renewable energy technologies (Carley, 2009; Menz and Vachon, 2006; Yin and Powers, 2010). (Menz and Vachon,

2006) used cross sectional data to analyse the effect of incentive in the development of renewable energy, while (Yin and Powers, 2010) used a panel data approach. All these econometric studies have analysed role of state incentives in the development of wind energy in the U.S market. (Feiveson and Rabl, 1982) argued that incentives to promote alternative energy are necessary to spur consumer adoption due to market failures in conventional energy and utilities market. Wind Energy has higher capital cost than conventional energy technologies, but requires no fuel inputs and thus can deliver saving over conventional technology. Cost competitiveness of wind energy technology depends generally on the upfront cost of wind technology, expected savings of conventional energy and availability of public subsidies for renewable technologies. In India, studies largely focused on status and future developments of renewable energy and wind power (Khareet al., 2013; Mani and Dhingra, 2013; Sharmaet al., 2012). However, systematic scholarly research that empirically investigates factors contributing to the development of wind energy sector in India has been lacking. In order to address this gap in literature this study aimed to evaluate role of incentives in penetration of wind energy specifically in Indian electricity market.

3. Background

3.1. Wind Energy in India

The oil shock of the late 1970s had prompted energy planners all over the world to look for alternative sources of energy. The sudden increase in the price of oil had affected the balance of payment situation adversely. Hence, Indian government initiated to concentrate on renewable energy with the missionary work of becoming self-sufficient in energy. In 1981, Indian government had instituted Commission for Additional Sources of Energy (CASE) with the purpose of formulation and implementation of policies for development of new and renewable energy and increasing R&D activities in the sector for technical progress. In 1982, a new department, Department of Non-Conventional Energy (DNES) was created in the Ministry of Energy and CASE got transferred in this department. In 1992, this DNES was subsequently turned into the separate ministry, Ministry of Non-Conventional Energy Sources (MNES) and became world’s first ministry dedicated to renewable energy. This ministry has been re-named to Ministry of New and Renewable Energy (MNRE) in October 2006.

Due to the efforts of MNRE and State governments, wind energy in India has grown from 1,666.8 MW to 21,268.39 MW between 2002 and May 2014. During this period, Cumulative Annual Growth Rate (CAGR) for wind energy was 26%. This has increased share of wind energy based capacity in India’s energy mix to 9% in 2013 from just 2% in 2003. However, wind energy has largest share in renewable energy with 68.9% of total renewable energy capacity in India. Generation from wind energy capacity has also grown to more than 100% from 18.923 Billion Units (BU) in March 2005 to 119.483 Billion Units in March 2012. The state of Tamil Nadu, Maharashtra and Gujarat are the main contributors to this growth as Tamil Nadu installed capacity of approximately 7276 MW while Maharashtra and Gujarat have installed 4098 MW and 3414 MW respectively.

3.2. Drivers of Wind Energy Development

Past studies have shown that development of wind energy is largely influenced by technological development of wind turbines, government policies for promotion of wind energy and economic factors such as GDP, population growth rate and shortage in supply of electricity.

3.2.1 Technological development

According to Global Wind Energy Council (GWEC), India is becoming a major hub of wind turbine manufacturing. Leading manufacturers such as Suzlon, Vestas, Enercon but also new entrant such as GE, Gamesa and Siemens have setup manufacturing facilities in this country. As of 2014, India was having wind turbine manufacturing capacity of 9,500 MW with 16 wind turbine manufacturers. These manufacturers are designing technologically advanced class II and Class III turbines, which are suitable for medium to low wind regime of India. Average size of wind turbines in India has also increased gradually from 767 KW in 2004 to 1,117 KW in 2009. These larger machines have subsequently increased the plant utilisation factor (PLF) from 10-12% in 1998 to 20-22% in 2010. With these technological advancements cost of generation from wind is coming down significantly.

3.2.2. Regulatory changes

The ultimate objective of renewable energy policy is to significantly increase the share of renewable energy sources into India’s energy mix (Maithani, 2008). Indian government has made vital changes in the energy laws and policies to increase the share of renewable energy.

With Electricity Act, 2003 several provisions regarding the non-conventional energy sources was implemented. Section 3 (1) and Section 3 (2) mandates central government to prepare and publish the national electricity policy and tariff policy, in consultation with the state governments at regular intervals. The goal of these policies should be development of power systems based on such as coal, natural gas, nuclear substance, hydro and renewable energy with proper utilisation of resources. Section 61 and 86 were introduced that instruct State Electricity Regulatory Commissions (SERCs) to take care of the promotion of cogeneration and generation of electricity from renewable sources of energy, while specifying terms and conditions for determination of tariff and also lay down minimum percentage of electricity to be purchased from such resources.

National Electricity Policy, 2005 aims to complete the objective of supply of reliable and quality power of specified standards in an efficient manner and at reasonable rates.

Tariff policy announced in January 2006, mentioned that, pursuant to the provision of section 86 (1) (e) of the Electricity Act of 2003, appropriate commissions shall fix a minimum percentage of total energy to be purchase from renewable energy, considering their availability in the region and its impact on retail tariff (Chattopadhyay and Chattopadhyay, 2012). This policy also included provision of providing preferential tariff to renewable energy sources by keeping in view that these sources will take time to compete with the conventional energy sources.

3.2.3. Government incentives for wind energy

As mentioned above, in India electricity is the shared responsibility of central and state governments; central government issues its set of incentives and guidelines for the promotion of wind energy, while individual states develop their own policies under the guidance of central government (Rao and Kishore, 2009).

3.2.3.1. Central government incentives to promote wind power

The Electricity Act of 2003 brought big changes into Indian power sector such as deregulation of power generation, open access in transmission and allowing state electricity regulatory commissions to fix the renewable energy procurement. Till 2020, India envisages 65 GW of electricity generation from wind power saving 173 million tons of CO_2 emissions each year (Ramasesha, 2013). Currently, Indian government supports renewable energy through number of incentives such as Generation Based Incentive (GBI), Accelerated Depreciation (AD)[2], Renewable Energy Credits (REC), Income tax exemptions and Clean Development Mechanism (CDM) for promotion of wind energy. Recently, Indian government has introduced Generation Based Incentive (GBI) scheme for providing incentive to Independent Power Producer (IPP). This incentive is available exclusively for the sale of power to the grid. Under this policy, GBI of INR 0.50/KWh will be given for the electricity fed into the grid for a period of not less than 4 years and a maximum period of 10 years with a maximum limit of INR 10 Million per MW. The annual maximum limit for this incentive is INR 2.5 Million/MW.

Government of India also provides AD benefit to investors[3] for installing wind energy projects. Under this scheme, 80% of the value of wind turbine equipment can be claimed as depreciation in the first year itself if the project is commissioned before 30th September and 40% if the project is commissioned between 30th September and 31st March. Accelerated Depreciation is one of the method of accounting used for income tax savings. Under this method, fixed asset i.e. wind turbine generator, depreciated heavily in the earlier year of asset life. For tax purposes, accelerated depreciation provides huge relief to the wind power project owner by reducing the taxable income of year in which the project is commissioned. Global Wind Energy Council Report, India Wind Energy Outlook, 2011 notes AD has been the biggest driver in the growth of wind energy in India (*Indian Wind Energy Outlook 2011*, 2011). Moreover, income generated by sale of wind energy is free from any taxes for 10 years. A National Clean Energy Fund was created by in 2011 for funding innovation and research projects in renewable energy. This fund is provided capital by imposing cess on coal, peat and lignite to fund. Currently, clean energy cess of INR 50 per tonne on coal, peat and lignite provide corpus to this fund. All these policies have been launched by the central government with the aim of promoting wind energy in India.

3.2.3.2 State Government Incentive to Promote Wind Power

[2] Accelerated depreciation is basically increasing the depreciation on an asset which allows the asset owner to write off more of the value of the asset for some years of ownership thereby reducing taxable income.

[3] In India, wind energy projects are largely installed by companies; public and private both and high networth individuals like sportsmen, film actors etc.

Various SERCs have declared preferential Feed in tariff (FIT) to purchase energy from wind energy projects. FIT is a tariff guaranteed by SERCs to buy electricity from renewable energy sources. While determining FIT, SERCs follows cost plus methodology to ensure a fair return on equity for wind energy investors. This tariff varies across states depending upon state resources, tariff regulation and project cost in the particular state. As on 2014, 15 states have declared FIT for wind energy projects. SERCs also allow Captive Consumption (CG) of the power generated from wind energy project. Some energy intensive Industries like textile and cement have invested in wind energy projects for their captive consumption[4] (Jagadeesh, 2000). (Ghoshet al., 2002) mentioned that around 80 percent of energy generated from wind power projects is used for captive consumption.

Generally, state governments also provide various types of financial incentive to promote wind energy and other renewable energy sources. These financial incentives include subsidies, which can be provided during installation or operation of the project. The aim of these incentives is to reduce financial hurdles that make renewable technologies unattractive compared to conventional sources. Many states provide subsidy for off grid solar energy projects. But only Maharashtra provides infrastructure subsidy for wind energy projects. It pays for 50% of the evacuation cost as subsidy after first year of operation. According to GWEC average evacuation cost[5] of wind energy project is 40 lakhs to 50 lakhs per MW.

As mentioned above, the Electricity Act 2003 mandates a minimum percentage of power to be procured from renewable energy sources by obligated entities. These obligated entities are distribution companies, captive consumer and open access user who is purchasing or generating energy by burning coal or gas. Under this act, implementation of the Renewable Purchase Obligation (RPO) is to be guided by respective SERC after considering the situation in their state. RPO acts as a mandatory provision for procurement of energy from renewable energy sources. All states except Sikkim and Arunachal Pradesh have fixed their RPO targets (Shrimali and Tirumalachetty, 2013). These RPO targets range from 0.25% in Karnataka to 10.15% in Tamil Nadu. This policy has been given strength with a penalty provision to be used in case any distribution company fails to meet its RPO target. This motivates distribution companies to invest in renewable energy projects. In some states RPO includes a minimum percentage of power to be purchased exclusively from wind energy. This policy impact directly to wind energy sector and will lead to more deployment of wind energy. To overcome disparity in the availability of renewable energy sources among states, the government launched the Renewable Energy Credits (REC) mechanism (Shrimali and Tirumalachetty, 2013). REC framework has been started by Indian government to address the disparity between availability of renewable energy sources and the requirement of the obligated entities to meet their RPO by purchasing green attributes of RE from other entity in the form of REC. The value of one REC is equivalent to one MWh of electricity injected into the grid from renewable energy source (Shrimali and Tirumalachetty, 2013). Since, March 2011, RECs are being traded on the platform of Indian Energy Exchange (IEX) and Power Exchange of India (PXI) (Gupta & Purohit, 2013). This enables state with less renewable potential in meeting their RPO targets by purchasing RECs from energy exchanges.

To promote manufacturing of wind turbine some state government has kept most of the wind turbine parts free from excise duty[6]. Some states like Tamil Nadu provide electricity at lower rate to the wind turbine manufacturing companies. Indian government also encourage export of renewable energy technologies, by setting up special economic zones for renewable energy sector. Some states like Gujarat and Rajasthan also provide land to project developers for setting up wind energy project.

4. Empirical Analysis: Methodology and Data

In order to test the effectiveness of state incentives, empirical analysis was conducted on annual wind energy installation, wind energy potential and other socioeconomic variables. Out of total twenty eight states and seven union territories, this research, has considered states which are having potential of wind energy according to the wind resource assessment of C-WET. After removing states that

[4] Electricity Act, 2003 defines “captive generating plant” as a power plant set up by any person to generate electricity primarily for his own use.

[5] Evacuation cost includes cost of setting up transmission infrastructure such as laying of 33 KV feeder, construction of extra high tension substation and extra high transmission line required for transmitting energy generated from wind turbine to national grid.

[6] An excise duty is an inland tax on the sale, or production for sale, of specific goods or a tax on a good produced for sale, or sold, within India.

have no potential of renewable energy 28 units are left. Gross Domestic Product (GDP) data of two Union Territories, Daman & Diu and Lakshadweep was not available for this reason these states also been removed from the study. This study considers time period of 2001 to 2011 as during this period wind energy sector has got proper attention and states had introduced number of incentives to promote wind energy. After filtering with above mentioned data limitations, final sample size has 286 observations (26 Units & 11 Years). The summary statistic of data is presented in Table 1.

Table 1. Variable Definitions and Summary Statistics, n = 286

Variable	Definition	Variable Type	Mean	Std Dev	Min	Max
INSTAL	Annual Installation of wind energy	Cont	55.51	157.50	0	1083.50
SGDP	Per Capita GDP of States	Cont	35836.53	21229.52	6200.00	124721.00
POPU	Annual Population of states (in Lakhs)	Cont	41.09	42.96	0.36	199.63
RPO	State has RPO Incentive	Bin	0.34	0.47	0	1
FIT	State has FIT Incentive	Bin	0.30	0.46	0	1
WRPO	State has special RPO for Wind Energy	Bin	0.14	0.35	0	1
CG	State allow captive generation	Bin	0.24	0.43	0	1
POTEN	Gross potential of wind energy in every state	Cont	3952.62	7674.01	16.00	35071.00

4.1 Dependent Variable

This analysis examines the annual amount of grid connected wind capacity installed in a state (in megawatt, MW) from 2001 to 2011 (INSTAL). C-WET keeps track of the annual installation of wind energy in every state (Sharma et al., 2012). As table 2 shows, during this period, wind energy in India increased considerably from 1666.7 MW to 17351.5 MW

Table 2. State wise Annual Capacity Addition

State	Andhra Pradesh	Gujarat	Karnataka	Kerala	Madhya Pradesh	Maharashtra	Rajasthan	Tamil Nadu	West Bengal	Others
Up to March'2002	93.2	181.4	69.3	2	23.2	400.3	16.1	877	1.1	3.2
2002-03	0	6.2	55.6	0	0	2	44.6	133.6	0	0
2003-04	6.2	28.9	84.9	0	0	6.2	117.8	371.2	0	0
2004-05	21.8	51.5	201.5	0	6.3	48.8	106.3	675.5	0	0
2005-06	0.45	84.6	143.8	0	11.4	545.1	73.27	857.55	0	0
2006-07	0.8	283.95	265.95	0	16.4	485.3	111.9	577.9	0	0
2007-08	0	616.36	190.3	8.5	130.39	268.15	68.95	380.67	0	0
2008-09	0	313.6	316	16.5	25.1	183	199.6	431.1	0	0
2009-10	13.6	297.1	145.4	0.8	16.6	138.9	350	602.2	0	0
2010-11	55.4	312.8	254.1	7.4	46.5	239.1	436.7	997.4	0	0
2011-12	54.1	789.9	206.7	0	100.5	416.5	545.7	1083.5	0	0
2012-13	202.1	208.3	201.7	0	9.6	288.5	614	174.6	0	0
2013- May 2014	305.4	239.4	273.8	19.8	53.0	1076.2	135.1	113.8	0	0
Total	753	3414	2409	55	439	4098	2820	7276	1.1	3.2

All these installations are connected to the grid and are used for commercial purposes, i.e. either sale to electricity board or captive consumption. As on 31st March 2012, the installed capacity of 17,351.5 MW mainly spread across Tamil Nadu, Maharashtra, Gujarat, Rajasthan, Andhra Pradesh, Karnataka and Madhya Pradesh. In India, installation of wind energy geographically very concentrated, with Tamil Nadu, Gujarat and Maharashtra alone have installed 70% wind energy. Nevertheless, recently wind capacity has been expanded to other states like Madhya Pradesh, Andhra Pradesh and Rajasthan as well. This variation in installation across states suggests a role for state incentives in facilitating wind energy deployment.

4.2 State Government Incentive

(Evans,andOlson, 2003) mentioned that in case sample size is small, the selection of policies need to be parsimonious, but this is not applicable in this case as the study covers 26 units of the total 35 units. This study hypothesise that if other things are equal, then states with incentives will have more annual installation as incentives generate motivation to invest in wind energy. Data on the state level incentives have been collected from many sources like wind tariff order issued by many SERCs, MNRE etc. However, MNRE provides the current policies it does not include the older policies which have expired. Number of reports and tariff orders of SERCs have been referred to collect details about old policies. Although every effort has been put up to find out the presence of incentive in a state, it might be possible that some incentive may be unnoticed. Major incentives issued by SERC and MNRE are collected properly. However, if any, incentive has been ignored, this will not affect the results.

Four major incentives for wind energy feed in tariff (FIT), captive consumption (CG), renewable purchase obligation (RPO) and special RPO for wind (WRPO) are included in the study. FIT provides guaranteed sale price to the investor for the energy generated by the wind turbine while with CG, investor can set off its energy consumption of manufacturing and commercial unit with the generation at the wind turbine site. RPO and WRPO are command and control incentive under which electricity distribution company has to purchase a specified level of energy from renewable energy (Shrimali and Kniefel, 2011). The assumption is that promotional incentive i.e. FIT and CG should attract more investment to the wind energy than policies instructed by SERC such as RPO and WRPO.

In India, 13 states are offering FIT incentive, but as Table 3 shows, this incentive varies widely in terms of price and tenure of Power Purchase Agreement (PPA)[7]. Tamil Nadu n offers FIT of INR 3.39 per kWh, while Uttarakhand offers as high as INR 5.15/kWh. State government

[7] A Power Purchase Agreement (PPA) is a contract between buyer and seller of electricity. It defines all the commercial terms for the sale of electricity between two parties, including project start date, selling rate of electricity, payment terms and termination.

Table 3. Incentives across different states

State	Feed In Tariff (In INR)	PPA Tenure (in Years)	Third Party Sale	Captive Usage
Andhra Pradesh	3.50	25	Permitted	Allowed
Gujarat	4.23	25	Permitted	Allowed
Haryana	6.14	25	Permitted	Allowed
Karnataka	3.70	10	Permitted	Allowed
Kerala	3.64	20	Permitted	Allowed
Madhya Pradesh	4.35	25	Permitted	Allowed
Maharashtra	Wind Zone I – 5.67 (w/o AD), 4.86 (with AD)	13	Permitted	Allowed
	Wind Zone II – 4.93 (w/o AD), 4.23 (with AD)			
	Wind Zone III – 4.20 (w/o AD), 3.60 (with AD)			
	Wind Zone IV – 3.78 (w/o AD), 3.24 (with AD)			
Odisha	5.31 (w/o AD) 4.48 (with AD)	13	Permitted	Allowed
Punjab	5.96 (w/o AD) 5.36 (with AD)	10	Permitted	Allowed
Rajasthan	5.18 (w/o AD) 4.90 (with AD)-for projects in Jaisalmer, Jodhpur and Barmer districts. 5.44 (w/o AD) 5.14 (AD)-for other districts	25	Permitted	Allowed
Tamil Nadu	3.51	20	Permitted	Allowed
Uttarakhand	Wind Zone I – 5.15 (w/o AD), 4.75 (with AD)	25	Permitted	Allowed
	Wind Zone II – 4.35 (w/o AD), 4.00 (with AD)			
	Wind Zone III – 3.65			

	(w/o AD), 3.35 (with AD) Wind Zone IV – 3.20 (w/o AD), 2.90 (with AD)			
West Bengal	5.70	10	Permitted	Allowed

provide FIT for wind energy to ensure fair returns from wind energy projects. But revenue from wind energy also depends on Plant Load Factor (PLF) of the wind project in the state. PLF is the capacity utilisation factor of the wind turbine and is calculated by dividing actual electricity generation by total capacity of wind turbine. Hence state with lower PLF, provide higher FIT to ensure competitive return from project, while state with higher PLF give lower FIT, for example Uttarakhand assumed lower PLF (20%) in comparison to the Tamil Nadu (27.15%), hence, Uttarakhand give higher FIT.

At the beginning of study period i.e. 2001, only seven states were offering some form of incentives for wind energy. FIT was the most prevalent but some states were also offering CG. However, as on 2011, 22 states were having at least one type of incentive. Six states: Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan were having all four types of incentives. Most states had one or two types of incentive. However, four states i.e. Andaman & Nicobar, Arunachal Pradesh, Puducherry and Sikkim had none of the incentive for wind energy deployment. RPO was the most widely used incentive in 2011, as it is available in 22 states. FIT was available in 12 states, while CG were available in 10 states. Six states were having special RPO for wind energy i.e. WRPO.

4.3 Control Variables

This study includes per capita state gross domestic product as control variable. Consistent with pervious environmental policy researches (Ringquist, 1994; Sapat, 2004), this study predict that states with greater wealth, other things equal, will have a higher percentage of renewable energy because they have the resources to invest more heavily in renewable energy deployment. Wealthier consumers are more likely to invest in wind energy even if less incentives available. This variable is labelled as SGDP, which is GDP per capita within a state for in a given year, in Indian rupees by adjusting with 2005 prices. Data for SGDP was taken from the official website of the Planning Commission of India. State population (POPU) was incorporated in the model as a second socioeconomic control variable. Data regarding the population has been extracted from the Census Bureau of India. In India, the census bureau records population data after every ten years. This study used exponential growth rate and multiplied this with the population of 2001 to obtain annual data. Increase in population will put more pressure on limited fossil fuel resources. States with higher population will likely construct more energy capacity to satisfy growing demand for electricity; renewable energy development may be a viable option for satisfying rising demand. It is also possible, however, that rise in population will be associated with increase in base-load fossil fuel generation, such as coal-based power.

Wind differs from other energy sources in being both highly variable geographically and not directly transportable among regions (Menz and Vachon, 2006). Development of wind energy in a particular state depends on the quality of wind resource. Wind energy potential (POTEN) variable is time-invariant and, therefore, only included in the model separately from state fixed effects. For wind power potential, we use C-WET estimates of wind energy generation potential of the state at 80 meter hub height. CWET is an autonomous body established by the Indian government for carrying out wind resource assessment in the country. These data are highly reliable as CWET has done this assessment by collecting wind data from a wide network of 790 wind monitoring stations in 31 states and union territories. Only note of caution for using this data in the analysis is theoretical resource potential. This study do not convert from resource potential to electricity potential because this conversion would require critical assumptions about the overlap between technical, economic, and political feasibility, which is beyond the realm of this analysis

The falling price of wind turbines will improve the potential return on investment for wind energy technology. Final installation costs for wind turbines vary significantly across states depending on local labour and installation costs. Unfortunately, historical data on wind turbine installation costs are available only as national averages. For this reason, wind turbine price variable was not included in the model. The effect of changes in wind turbines and installation costs on the market deployment of wind energy will be captured primarily by the state and year fixed effects.

Per Capita state GDP, Population, Potential and the dependent variable shows non normal distribution across states in a given year, and were normalized using a natural logarithmic transformation. The results should be interpreted as elasticity, meaning percentage change in wind installation as a result of 1% change in GDP, Population or Potential. Annual Installation was normalized by taking the natural log of (1+$INSTAL_{it}$) to retain observations for states that have no installation for some years. This adjustment is appropriate as dependent variable can be equal or greater than zero, as natural log of zero is undefined. While the use of 1 as a constant is necessary in this situation, the result may be sensitive to the choice of constant.

4.4 Model Specification

Two model specifications were estimated in this analysis are:

$$INSTAL = \beta_0 + \beta_1 FIT + \beta_2 CG + \beta_3 RPO + \beta_4 WRPO + \gamma C_{it} + T_i + \varepsilon_{it} \quad \text{(Model 1)}$$

$$INSTAL = \beta_0 + \beta_1 YFIT + \beta_2 YCG + \beta_3 YRPO + \beta_4 YWRPO + \gamma C_{it} + T_i + \varepsilon_{it} \quad \text{(Model 2)}$$

Where 'i' represents state and 't' denotes year. C_{it} represents state fixed effect and T_i is time fixed effect. The error term, ε_{it}, is independent and identically distributed across state and year.

In the first specification, dummy variables have been used to indicate presence of four types of incentives that are available for wind energy technology; feed in tariff (FIT), captive generation (CG), renewable purchase obligation (RPO) and specific percentage of wind RPO (WRPO) to indicate the presence of incentives. For each type of incentive, dummy variable was coded as 1 for each year if the incentive is present and as 0 if not present. With inclusion of separate variables for different types of incentives, it is possible to empirically test the impact of incentives individually as well as their combined effect (Gouchoeet al., 2002).

In the second specification, impact of four types of incentives since adoption has been tested. This specification test the hypothesis that impact of state level incentives strengths over time, as the knowledge and understanding about incentives increased. Howell-Moroney (2007), mentioned as the knowledge about an incentive spreads or it becomes wider to include more beneficiaries, their impact gets increased. In this specification, duration variable were coded as 1 for the first year in which the incentive implemented, 2 for the second year available, 3 for the third year and so on. This model includes four incentive variables are denoted as YFIT, YCG, YRPO and YWRPO.

4.5 Model Estimation

Table 4. Regression Results

Parameters	Model 1	Model 2
FIT/YFIT	0.435***	0.613***
CG/YCG	2.804***	0.098***
RPO/YRPO	-0.262	-0.231***
WRPO/YWRPO	0.427*	-0.362***
POTEN	0.230***	0.149***
POPU	0.040	0.151***
SGDP	0.297**	0.620***
State dummy variables	Yes	Yes
Time dummy variable	Yes	Yes
R Squared(with State and Time Effects)	0.79	0.80
R Squared(without State and Time Effects)	0.51	0.54
Number of Observation	286	286

Since ample heterogeneity is available across states, so Hausman tests are performed on both specifications to examine if fixed effects are necessary. Null hypothesis in the case of Hausman test is no presence of heterogeneity across states. Hausman test significantly rejected this hypothesis, which indicates differences are present between states which cannot be captured by explanatory variables. Hence, there is need to control for this unobserved differences. For this reason, study included state dummy variable as explanatory variable. By including state dummy variable, constant term starts changing for each state which avoids heterogeneity bias that would have occurred if a common constant term is included for all states.

Significant increase in wind energy installation over the years suggests presence of unobserved time specific effects that are common across states. These effects can include an increase in the concern about the environment, reduction in the wind turbine cost, etc. Hence to avoid heterogeneity bias, time fixed effects are included in the model by using year dummy variables.

Time – series cross-sectional models frequently suffer from additional data concern, including serial correlation, panel heteroskedasticity, and contemprous correlation of the error terms (Sarzynskiet al., 2012). To check the presence of auto correlation, Wooldridge test was performed, which showed auto correlation is present in the model. Also modified Wald test was done to find out if group wise heteroskedasticity is present in the model. This test could not reject the presence of heteroskedasticity. Then, Frees test which was conducted to determine presence of contemporaneous autocorrelation among states showed presence of the same. Therefore, Prais-Winston estimation with Panel Corrected Standard Errors (PCSE) method was applied in both specifications. PCSE make use of ordinary least square coefficient estimates and residuals to compute standard errors that correct for panel heteroskedasticity (Beck,and Katz, 1995). This method has been widely used in political science and public policy econometric analysis because of prevalence of panel heteroskedasticity and it removes the problem of autocorrelation.

5. Empirical Results

The results of the regression analysis are presented in Table 4.

Model (1) and (2) presents the effect of the four state incentives on the grid connected wind turbine installation from 2001 to 2011 under two different specifications. Model (1) test the average effect of having a state incentive in a given year, while Model (2) tests for the incremental effect of keeping state incentive for an additional year. Results of this study show that states that offer feed in tariff and captive generation see more installation of wind energy from 2001 to 2011 than states not having these incentives. On the other hand, states that are having RPO do not have more deployment of wind energy during the study period than states not having this incentive. Investors who are putting project to take the benefit of feed in tariff and captive generation can also claim accelerated depreciation of central government. Hence, effect of feed in tariff and captive generation should be attributed to the combined presence of state and central government benefits, not only of the benefits offered by states.

The impact of feed in tariff and captive generation appears quite important to market deployment. Keeping other variables constant, states having a dedicated incentive that allows captive generation will have 280% more deployment than states not having these incentives. In the following years, states having captive generation will install 9% more wind energy per year, as compared to states not offering this benefit.

Probable reason for the differential effect of captive generation and feed in tariff with RPO is related to the design of the incentives and ease with which it can arrange. Energy intensive companies are allowed to use central government's accelerated depreciation benefit with captive generation. Combination of these two benefits increases rate of return wind turbine owner significantly since by putting up wind energy project for their own use, they can completely set off this expensive consumption with the energy generated from wind turbine. Moreover, documentation for setting off consumption with generation is very simple and can be easily executed before installing the wind power project. Recall that feed in tariff is the guaranteed price offered by SERCs for buying electricity generated by wind energy. In this case also, investor can easily signed power purchase agreement with state government before putting up wind power project. This agreement guarantees purchase of all the energy generated during life of the project at pre agreed price. Hence, this agreement safeguards position of the investor from future uncertainties.

In principle, RPO should also functions as well as feed in tariff and captive consumption since this benefit can also be claimed with central government's accelerated depreciation or generation based incentive. Still, findings indicate that states with RPO and WRPO do not have more installation of wind energy in comparison to those states that do not have this incentive. This result may be due to the structure of RPO, as it is obligation only on electricity distribution companies, so target audience of this incentive is very small. Moreover, it is true that the rule regarding the penalty provision in case of nonfulfillment of RPO obligation has existed in most of the state, but this provision is not strictly enforced. Special RPO for wind energy indicate positive effect on development of wind energy in the states that have this incentive. But in model 2, this variable also become negative indicating in the long run this provision is not contributing to the development of wind energy. As positive effect of special RPO for wind energy in model 1 is changing to negative in the model 2, which is testing incremental effect of this incentive, this is again stressing to the same point which says it is ineffective in long run if it does not have strong penalty provision.

In sum, result of this analysis suggest that wind energy market have been responsive to simplicity of incentive offered and easiness with which these benefits can be claimed. Feed in tariff and captive generation are simple and easily available for whole life of the project, hence found to have significant impact on the development of wind energy. However, RPO and wind RPO does not exhibit any effect on development since they suffer from implementation complexity.

Moreover, findings of this study suggest that wind energy installation has increased with every additional year in the state that is offering feed in tariff and captive consumption.

The coefficients in model 2 are consistent with model 1 but have smaller impact in comparison to model 1. The coefficients in model 1 highlight the average effect of an incentive during entire study period while coefficients in model 2 show incremental effect of having an incentive for another year. Results of model 2 suggest that these incentives became more effective over years, probably as with passage of time, policy implementers and investors both gain experience. As a result of gaining experience, both parties get familiar with each other and also with rules and regulations a policy involve. On a whole, results indicate that states with feed in tariff and captive consumption had more deployment of wind energy than states that do not have these incentives. Also, development of wind energy over time increase much faster in states with these incentives than states without these incentives.

These results also indicate that states with higher per capita GDP are more likely to install wind turbines during the study period, after controlling for all other variables. This result confirms the understanding that, state with higher income have more resources to invest in new technologies. These findings are consistent with (Salim and Rafiq, 2012) which found that renewable energy consumption is positively associated with income. Wind energy industry suffers from one disadvantage of having high start-up cost. Due to the requirement of high initial capital, payback period in the industry is very long. But main advantage with this sector lies in its low recurring cost and consistent revenue flow during life of the project. Since, high initial capital is required to start this project hence, only investors with higher income have capacity to adopt this technology.

The results indicate that wind energy potential of the state has positive impact on wind energy deployment in the state. India's wind resource assessment programme started in 1980s, found coastal areas of Tamil Nadu and Gujarat are good locations for wind energy projects. Subsequently, Indian government had started putting up demonstration projects and due to overwhelming success of these demonstration projects commercial activity of wind energy started in these states. Hence, high potential for wind energy in the state is always a positive sign for the development of wind energy.

Control variable population in model 2 has positive impact on the development of wind energy when other variables are kept constant. This incremental effect of population on development of wind energy indicates that with every additional year, installation of wind energy is increasing due to increase in population. As stated above with the increase of population, demand for energy has also increase. Hence, in order to satisfy this demand state has to look for better energy management. Development of more energy sources is a vital element of energy management. This result is positive sign of wind energy industry as, India always have pressure on demand side of electricity due to its rising population.

The dummy variables for state and time have captured a large amount of variation across state and over time. As states generally shows consistently higher wind energy installation than Kerala (reference state) and annual wind energy installation consistently increasing during study period in comparison to 2001 (reference year). Results of these models are robust for different specification and omission of time dummies.

6. Discussion and Conclusion

Existing research on the effect of state incentives on the market deployment of wind energy has kept up with the increasing interest in wind energy from investor, government and general public. This study used 11 years of state level data to examine the effect of four types of incentives launched by Indian states.

Overall, findings of this paper indicate that states offering specific feed in tariff and captive consumption had a significantly stronger market deployment of wind energy than states not offering this incentive. While RPO does not seem to have any impact on wind energy, its incremental effect for additional years is negative. States that have mandated RPO does not have significantly more development of wind energy than states not having RPO. Furthermore, this study shows that states with high GDP have more wind turbine installed than the states with low GDP. One possible reason for this observation can be cost of generating energy from wind is relatively higher in comparison to conventional energy sources. However, as cost of generating wind energy is coming down and at best locations wind farms are already competitive to conventional energy technologies, this factor should become irrelevant in the long run (Río et al., 2011). Also the effect of population is positive on wind energy.

This study allows renewable energy stakeholder to analyse the strengths and weaknesses of the incentives issued by the state governments and identify the factors which negatively affect the renewable energy. Execution of RPO without properly implementing the penalty provision is not contributing to the development of renewable energy. Nowadays, most of the states are having RPO incentive and revising this policy every year. Hence, this serves as important indication to policymaker, that they should strongly consider enforcement of penalty provision while designing RPO policy.

Several caveats of this study must be noted. This paper did not take into account scale, scope and strength of each incentive. Further research should take this into account. For example, Tamil Nadu's feed in tariff of INR 3.50/kWh and Maharashtra offering feed in tariff of INR 5.13/kWh is treated as one in the analysis, as this study consider only presence and absence of an incentive. This analysis did not consider this variation of feed in tariff among states and overtime into account. Further studies should also study impact of third party sale*** on wind energy deployment. Lately, many projects have been established which do not sell energy to state utilities, but directly to big industries at a mutually agreed price. Since these industries purchase energy at a much higher price than state government, many independent power producers are putting wind power project for this reason. Role of third party sale benefit is becoming critical to the development of wind energy. The effect of this program on the wind energy development can also be studied in the future.

Recently, the Indian government has started the Renewable Energy Certificate mechanism to enable obligated entities to fulfil their RPO by purchasing REC from the market. The effect of this program on wind energy deployment can also be studied in future studies.

Other important factor which affect wind energy in India as well as globally is transmission capacity. Grid connected wind power depends heavily on the transmission network provided by the state to transmit power generated from wind project to the national grid. The pace of wind energy development slowed down in Tamil Nadu due to lack of transmission capacity. Voltage and reliability problems with the Indian power grid are also a disadvantage for wind energy sector (Lewis, 2007).

This study have considered the period of 2001 to 2011. In April 2012, the central government has removed the benefit of accelerated depreciation for new projects (Shrimaliet al., 2013). This benefit has played an important role in the growth of wind energy. Removal of this incentive has significantly affected wind energy as the annual installation comes down drastically in the year 2012 to 1698.8 MW from 3196.9 MW in year 2011. This paper has included 2011 as the last year of study, but acknowledges that situation has been changed after this period. Since, development of new policy tools like REC and Third party sale are not studied in this research, but highlight the need for continued evaluation and analysis of state wind energy policies moving forward.

*** Under Third party sale incentive, generator of wind energy is allowed to sell its electricity to private entities other than government distribution companies. Generally, these private entities provides much higher price for electricity than state government. Hence, it improves the return from the wind turbine project.

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