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Article

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Energy Reports

Provided in Cooperation with:

Elsevier

Suggested Citation: Irfan, Muhammad; Zhao, Zhen-Yu; Ahmad, Munir; Mukeshimana, Marie Claire (2019) : Critical factors influencing wind power industry: A diamond model based study of India, Energy Reports, ISSN 2352-4847, Elsevier, Amsterdam, Vol. 5, pp. 1222-1235, <https://doi.org/10.1016/j.egyr.2019.08.068>

This Version is available at:

<https://hdl.handle.net/10419/243664>

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Research paper

Critical factors influencing wind power industry: A diamond model based study of India

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ARTICLE INFO

Article history:

Received 6 July 2019

Received in revised form 17 August 2019

Accepted 28 August 2019

Available online 3 September 2019

Keywords:

Wind energy

Diamond model

Wind turbine

Grid construction

Policies

India

ABSTRACT

The energy needs of India have increased many folds in recent years due to industrialization and ever-increasing population. Wind energy offers excellent opportunities in fulfilling the energy needs of the country. Being renewable, it has enormous resource potential. Since the last decade, the wind energy sector has progressed very quickly. India ranks 4th in the world in terms of installed wind capacity. The cumulative installed capacity has reached 35,288 MW, grabbing 6% global share. Meanwhile, various factors are affecting the development of the wind power industry. This paper aims to identify and analyze the critical factors that are significantly affecting the development and competitiveness of the Indian wind industry. For this purpose, we have adopted the Diamond model approach. After careful analysis, we have found that these factors are: demand condition, factor condition, chance, related and support industry, firm strategy, structure, rivalry, and government. All the factors identified in this model are influencing the wind industry's competitiveness from a different angle. Thus, these factors should be strengthened for the long-term development of the wind industry. Research findings reveal the present status, challenges, and future projections of the wind power industry. Essential policy recommendations have been offered for the sustainable development of this sector. Government and stakeholders can take benefit from this research by understanding the dynamic relationship among all the factors influencing the development of the wind power industry and make procurement strategies accordingly.

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1. Introduction

Energy demand has increased recently due to the development of the global economy. Fossil fuels are the primary energy sources, which accounts for 79% of the world's energy consumption. The World Energy Forum forecasted that fossil fuels are under high pressure of shortage and can deplete in the coming ten decades (Kumar et al., 2010). Such an alarming situation has led policymakers to think about alternate ways of energy generation (Irfan et al., 2019a). As a result, wind energy has emerged as an important alternative to fossil fuels, which can solve the current energy disaster and diminish environmental pollution (Dong et al., 2018; Liu et al., 2018; Kazemi et al., 2017; Han et al., 2017; He et al., 2016). Being sustainable and a promising energy source, wind energy has progressed rapidly in recent years. During the last decade, the global installed wind capacity has grown more than 19% annually (Ning et al., 2017). According

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to the World Wind Energy Association (WWEA), the global wind capacity has reached 597 gigawatts (GW) at the end of 2018. In 2017, the global wind capacity was 546 GW. A significant amount of wind energy, i.e., 50.1 GW, was added within only one year, witnessing the massive development of this sector (WWEA, 2019). Ten countries have 85% share of wind energy worldwide. These are China, The United States, Germany, India, Spain, The United Kingdom, France, Brazil, Canada, and Italy (GWEC, 2017).

India is the second-largest country in terms of population. The share of thermal energy (coal, diesel, gas) is 64% of the total energy supply of the country (CEA, 2018a,b). These thermal resources are under high pressure of shortage due to overuse. Therefore, India is looking for alternate means of energy generation to reduce reliance on thermal energy (Bhat et al., 2001). Wind energy can play a critical role in India's energy mix, encourage sustainable development, and reduce greenhouse gas (GHG) emissions. With continuous government support and the completion of recent wind energy projects, the installed wind capacity has reached 35,288 megawatts (MW), accounting for 6% of the world's share and ranks 4th globally. India has designed a whole industrial chain, i.e., gearboxes, aero-generators, wind

Acronyms and abbreviations

GBI	Generation-Based Incentives
ITLC	Interstate Transmission Losses and Charges
IREDA	Indian Renewable Energy Development Agency
IRENA	International Renewable Energy Agency
MNRE	Ministry of New and Renewable energy
MW	Megawatt
NCEF	National Clean Energy Fund
REC	Renewable Energy Certificate
RPO	Renewable Purchase Obligations
SERC	State Electricity Regulatory Commission
SWES	Small Wind Energy Systems

turbines, water-pumping windmills, wind farms, wind generators, equipment manufacturing, and wind markets (Sharma et al., 2012a,b). Despite these developments, the Indian wind industry is also facing several challenges, including dependence on foreign technology, outdated wind turbines, high transmission and distribution (T&D) losses, the low selling price of wind electricity, high initial costs and the lack of supporting financial regulations (Singh et al., 2004; IRENA, 2012).

Many researchers have investigated the Indian wind industry's development from different perspectives (Pachauri and Spreng, 2002; Pandey et al., 2014; Pohekar et al., 2005; Lenzen et al., 2006; Bhattacharyya, 2006; Kumar and Meena, 2017). Some have addressed the role of wind power in meeting energy needs (Khare et al., 2013; Sholapurkar and Mahajan, 2015). Mabel and Fernandez (2008) studied the status, potential, and future trends of wind energy in India. Lewis (2007) examined the innovation in wind turbine technology. Some researchers have examined the challenges, solutions, and future perspective of the Indian wind industry (Rennkamp and Perrot, 2016). Mallet (2001) pointed out that the success of the Indian wind industry is as much as failure. He examined that the Indian wind industry is facing several barriers, such as technical, economic, infrastructural, and ineffective government policies. Lolla et al. (2015) analyzed the wind energy resources in India from different perspectives, i.e., financial strength and resource distribution. They found out that the lack of financial mechanism and futile policies are hindering the development of the wind industry. Khare et al. (2013) discussed the status of wind energy in India and found that most wind turbines are old and inefficient. Besides, there is a lack of capital subsidy and micro-generation technology, impeding wind energy development.

Iftikhar et al. (2017) found that the lack of standard technology, technical inefficiency, and human resources to manage modern wind projects are hampering wind industry's competitiveness. Schmid (2012) has focused on the government's policy response, financial incentives, and tax structure. Mani and Dhingra (2013) discussed the offshore wind policy of India and argued that India has a stable wind market, and finance is also available, but the country is lacking a practical policy framework.

Several models have been proposed to investigate the development of wind power industry. One of these models is the SWOT analyses model. The SWOT analysis is a well-understood structured planning tool which gives essential information about the strengths, weaknesses, opportunities, and threats, affecting the development of industry (Chen et al., 2014; Markovska et al., 2009). The model is holistic which cover technical, financial, social and logistical challenges and opportunities rather than only

focusing on technical issues, making it suited for a wide range of stakeholders in the industry (Carneiro and Ferreira, 2012; Zhao and Yan, 2012; Jaber et al., 2015; Xingang et al., 2013; Fertel et al., 2013; Terrados et al., 2007). Fertel et al. (2013) utilized SWOT Analysis model and examined positive and negative factors associated with the wind industry. They found the main weaknesses as: “capital intensive nature of wind projects” and “the lack of financial mechanism”, while the major threat was “unpredictable future of wind energy”. Similarly, Patrick Devine-Wright (2005) used the same approach and identified that “opposition from environmental communities”, “noise Pollution” and “visual impact” are the major weaknesses associated with wind farms. Saidur et al. (2011) reported that “efficient tax and financial policies” were the key opportunities, while “lack of good governance” and “competition from other industries” were the major threats which wind industry is facing.

Others have tried to examine the whole wind power industry and analyze its competitiveness by adopting the “Five Forces Model”. Michael Porter developed the “Five Forces” model in 1980 to find the impact of different factors, affecting the competitiveness of an industry. According to this model, every industry has five key stakeholders, namely buyers, suppliers, competitors, substitutes, and potential competitors. These stakeholders significantly affect the joining forces. These forces are: (i) The bargaining power of buyers (ii) The bargaining power of suppliers (iii) Threats from other industries (iv) Threats from substitute products (v) Threats from potential competitors (Porter, 1980). Five Forces model is a very helpful tool to examine the status of an industry, analyzes its competitive environment and in turn, offers valuable responses to develop effective strategies for industries and corporations.

Both models have advantages as well as disadvantages. As, SWOT analysis model provides crucial information about the internal and external environment of the industry, i.e., strengths, weaknesses, opportunities, and threats, however, the model involves a subjective process during data collection and analysis which indicates the bias of the individuals who participate in data collection and brainstorming process. Similarly, the Five Forces model successfully analyze the competitive environment of an industry. However, the model only considers the above factors and ignores other factors which may have a bearing on the environment in which the company is operating. For instance, if an industry is operating in an environment where all the Five Forces i.e., entry barriers, weak bargaining power of suppliers, no competition, no substitutes and company products are inelastic, but if government imposes taxes on industry products, then the whole porter's Five Forces model will be of no use.

Despite this, none of the researchers has focused on analyzing the competitive environment of the Indian wind power industry and the development of related implementation strategies. It is necessary to analyze the wind industry comprehensively to bridge this research gap. Further motivation to write this paper is to improve the Indian wind industry's value chain, which other researchers have neglected in the past. We have adopted the Diamond model technique for this purpose. The emphasis has been given to investigate how the competitiveness and development of the Indian wind industry have been affected by major factors in this model. The Indian wind industry is enjoying certain opportunities and at the same time, facing numerous challenges as well. It is crucial to find out solutions for these challenges and turn them into opportunities. This is another motivation to conduct this study. Similarly, the Indian government has announced several laws and policies for the wind power industry. With the passage of time, these laws and policies need amendment. Therefore, this study will also focus on these laws, regulation, and policies and provide insights for all stakeholders. This is the first research to

use the diamond model technique, as previous studies did not attempt to utilize it in the Indian wind industry's perspective. This study not only contributes to new literature by identifying the key factors which affect the development and competitiveness of Indian wind industry but can also serve as a guide for policymakers, stakeholders, investors, and government to better understand Indian wind industry and make their strategies accordingly.

Apart from the introduction section, the rest of the paper has been organized as follows: Section 2 illustrates research methods. The Indian wind power industry has been analyzed in Section 3 by using the "Diamond model". The wind industry has been analyzed from six angles. These are demand condition, factor condition, chance, firm strategies, structures and rivalries, related and support industry and government. Future prediction of technology and potential future problems faced by the wind industry have been discussed in Section 4. Based on research findings, important discussion and policy recommendations have been provided in Section 5. Section 6 concludes the study. And finally, Section 7, discusses future research directions and limitations of the study.

2. Research methodology

Porter's "Diamond model" identifies the critical factors, affecting the development of an industry. Furthermore, the model emphasizes the behavior of government and firms' strategies, so that how an industry can improve its competitiveness according to these factors. The model consists of four main parts, i.e. (i) factor condition (ii) demand condition (iii) firm strategy, structure and rivalry, and (iv) related and support departments. Additionally, there are two accessory factors: chance and government, as shown in Fig. 1 (Porter, 1990).

"Factor condition" offer initial advantages, infrastructure, capital, and natural resources. "Demand condition" measure the demand of customers and affect product development, speed, and innovation directions. "Related and support departments" consider the industry's supply chain feature. If there present an already established industry, individual firms experience competitive advantages, i.e., innovation and cost-efficiency. An industry's rules and regulations are covered by "firm strategy, structure, and rivalry" section. It inspires investment, competition among local rival industries, and encourages incentive structure across leading institutions (Zhao et al., 2009). For qualitative analysis, we have collected data from multiple sources, including literature reviews, policy studies, energy reports, and regulation studies. After careful examination of data, we have proposed and analyzed these factors comprehensively and offered corrective measures to solve the significant wind energy development issues in India. The schematic diagram of the diamond model has been shown in Fig. 1. By assessing and examining these factors, the research methodology will answer the following research questions:

1. What are the main factors which affect the Indian wind power industry?
2. What are the opportunities and challenges for the Indian wind energy sector?
3. What strategies should be made by stakeholders and government to develop the wind power industry in India further?

3. Diamond model analysis of the Indian wind industry

3.1. Factor condition

3.1.1. Wind energy resource potential

India has enormous wind energy potential. National Institute of Wind Energy and State Nodal agencies examined 836 wind

Table 1

State-wise wind power potential and installed capacity in India (MSPI, 2019; MNRE, 2017).

State	Wind power potential (MW)	Installed capacity (MW)
Gujarat	84,431	5,537
Karnataka	55,857	3,793
Maharashtra	45,394	4,777
Andhra Pradesh	44,229	3,835
Tamil Nadu	33,800	7,969
Rajasthan	18,770	4,282
Madhya Pradesh	10,484	2,498
Telangana	4,244	101
Kerala	1,700	51
Others	3,342	2,445
Total	302,251	35,288

monitoring stations and found that 252 stations have the potential for commercial wind power installations (MNRE, 2018). Ministry of New and Renewable Energy (MNRE) estimated that the grid-connected wind power potential is 3,02,251 megawatt (MW) in the country (MSPI, 2019). Table 1 shows the wind power potential and installed capacity in different Indian states.

3.1.2. Change in energy structure

India has experienced rapid growth in energy consumption since the last 25 years to satisfy domestic and industrial needs (Sharma et al., 2012a,b; Madan et al., 2018). At the same time, the renewable energy sector is also progressing at a good pace. At the end of 2017, energy generation from renewable sources increased by 17%, and wind energy contributed more than half of it (BP Statistical Review of World Energy, 2018). Indian government emphasized to change the energy structure by increasing the share of renewable energy in the total energy mix of the country. According to India's long-term plan for renewable energy capacity addition, the government has announced to upscale renewable energy capacity to 175 GW, out of which 60 GW will be generated from wind energy (MNRE, 2017). Fig. 2 presents the renewable energy mix of India.

According to the Department for Promotion of Industry and Internal Trade (DPIIT), foreign direct investment (FDI) inflows in the Indian renewable energy sector stood at US\$ 7.83 billion. Since 2014, 42 billion US\$ has been invested in India's renewable energy sector. New investments in clean energy have reached US\$ 11.1 billion in 2018 (Chaurasiya et al., 2019). The renewable energy market has grown substantially with the increasing investment in this sector. The wind energy sector is leading other renewable energy sectors, with a total market share of 45.8%. Similarly, solar energy has a market share of 35.2%, while bioenergy and hydropower have a market share of 13.3 and 5.6%, respectively (CEA, 2019). India has enormous wind energy potential. Therefore, the government has planned to change the current energy structure by increasing the share of wind energy in total electricity generation of the country. The market share of different renewable technologies has been depicted in Fig. 3.

3.1.3. Programs and projects

Several programs and projects have been initiated for the meaningful implementation of changing the energy structure. Eight Indian states, namely, Andhra Pradesh, Gujarat, Tamil Nadu, Karnataka, Kerala, Madhya Pradesh, Maharashtra, and Rajasthan, have abundant wind resources. The Indian government assisted the provincial governments of these states and State Nodal agencies in establishing wind farms (Mahesh and Jasmin, 2013). Tamil Nadu state has the largest installed wind capacity of 7969 MW. Gujarat is the second state in terms of installed wind capacity. With the construction of new wind plants, the installed capacity

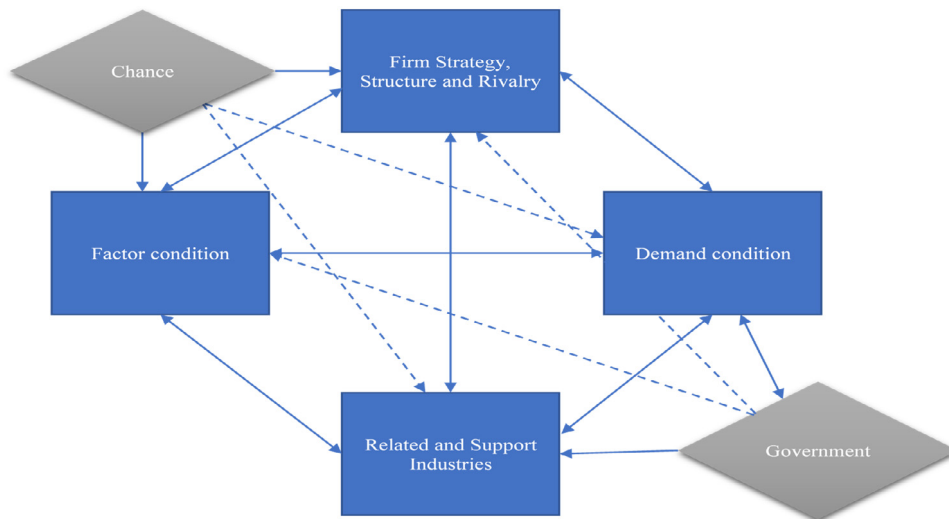


Fig. 1. Diamond model of wind power industry.

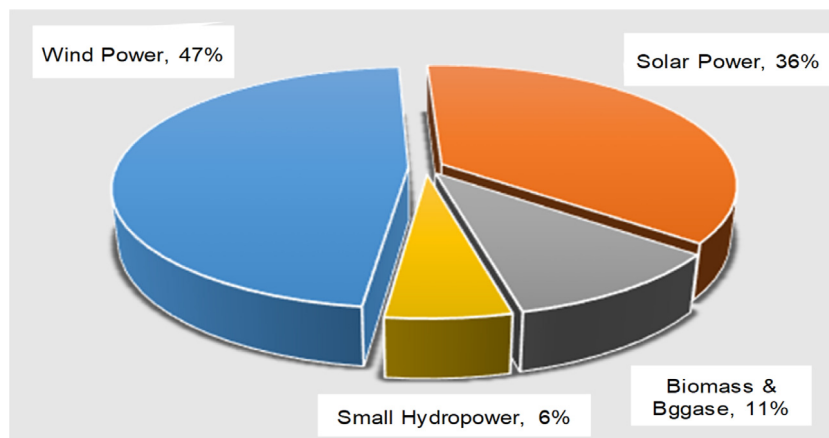


Fig. 2. Renewable energy mix of India (MNRE, 2017; IRENA, 2019).

has reached 5537 MW. The state is seeking potential areas to establish offshore wind power plants at coastal sites. Maharashtra is another leading state in terms of installed wind energy. A wind farm has been established at Satara in this state. The state has cumulative installed wind capacity of 4777 MW, while Rajasthan state has achieved the total installed capacity of 4282 MW.

Madhya Pradesh state started demonstration projects and motivated potential developers to invest in wind projects. Currently, it has several wind farms and windmills at Bhopal. Being the largest producer of solar energy, the Andhra Pradesh state start installing wind turbines in 2002. Karnataka state has a vast coastline, and good wind speed is consistently available all over the year. With the installation of new wind turbines, the state has reached a total capacity of 3793 MW. Kanjikode and Ramakkalmedu are the two new wind farms which have been constructed in Kerala state during 2013.

99.54% of wind turbines have been installed in the seven major Indian states. Among these, 40% are concentrated in Tamil Nadu and Gujarat, reflecting that these states have crafted the wind energy policy efficiently, while other states have started developing policies progressively for wind turbine installations. Majority of the wind turbines have been installed in rural regions, while some installed in suburban and hilly areas. For instance, the largest Indian wind farm is located in Muppandal. This is a small village on the southern tip of India in Tamil Nadu state. The installation

of wind turbines in this region is due to the fact that the wind from the Arabian Sea gusts through mountain passes, which is very important to generate wind electricity. Similarly, Jaisalmer wind park, the second-largest wind farm is also located in a small village named Marsagar (Global Energy Observatory, 2019). Table 2 shows the largest wind power projects with cumulative capacity in different Indian states along with site installation i.e., urban, suburban, and rural (Dawn et al., 2019).

3.2. Demand condition

3.2.1. Huge demand for energy

Energy development is based on stable market demand. India's energy needs are increasing prodigiously. Since the last three decades, electricity generation and consumption have become doubled (Singal, 2007). During the period 2008–2017, the electricity generation has increased by 5.45%, and consumption increased by 7.82%. Fig. 4 shows the cumulative installed electricity generation in India between the period of 2009–2018. India has the highest per capita energy consumption in South Asia (MSPI, 2019). At the start of the 12th five-year plan, the per capita electricity consumption was 5448 kWh, which has grown to 6487 kWh during the financial year 2017–2018. Fig. 5 illustrates the per capita electricity consumption in India from 2011–12 to 2017–18. (CSO, 2019).

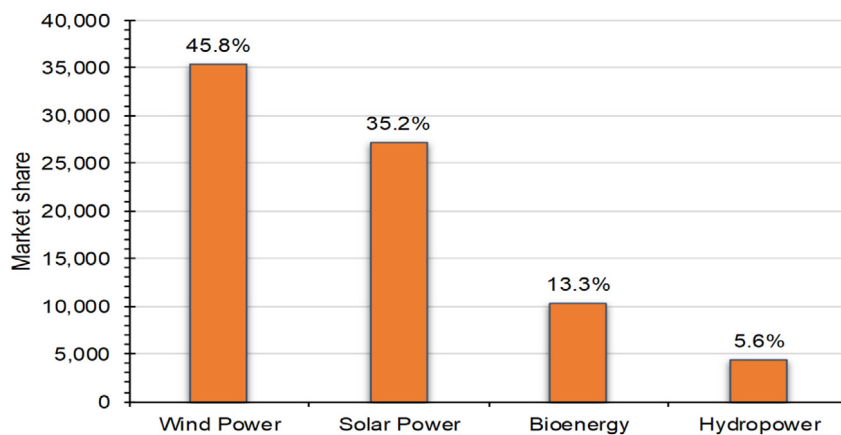


Fig. 3. Market share of renewable energy technologies in India (CEA, 2019).

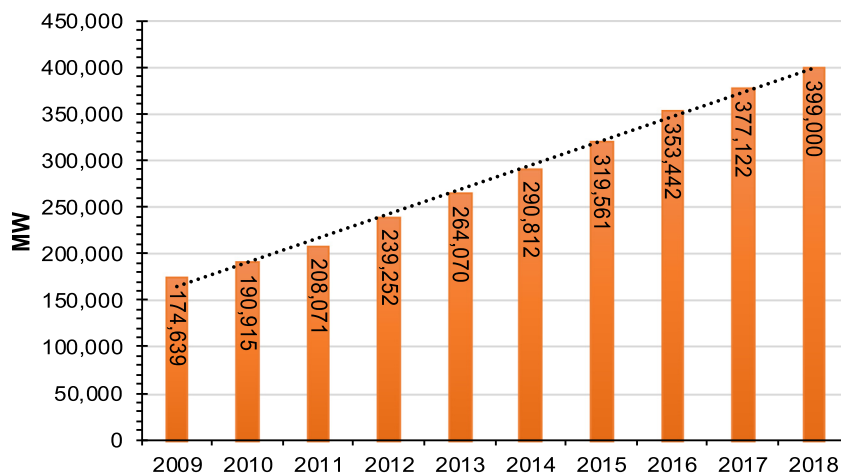


Fig. 4. Cumulative installed electricity generation in India from 2009–2018 (MSPI, 2019).

Table 2

Largest wind energy projects in India (Dawn et al., 2019).

No.	Wind project	Location	Capacity (MW)	Site installation
1	Muppandal Wind Farm	Kanyakumari, Tamil Nadu	1500	Rural
2	Jaisalmer Wind Park	Jaisalmer, Rajasthan	1064	Rural
3	Brahmanvel Wind Farm	Dhule, Maharashtra	528	Suburban
4	Dhalgaon Wind Farm	Sangli, Maharashtra	278	Suburban
5	Vankusawade Wind Farm	Satara Dist, Maharashtra	259	Hilly
6	Vaspet	Vaspet, Maharashtra	144	Rural
7	Beluguppa Wind Park	Beluguppa, Andhra Pradesh	100.8	Rural
8	Mamatkheda Wind Park	Mamatkheda, Madhya Pradesh	100.5	Rural
9	Anantapur Wind Park	Nimbagallu, Andhra Pradesh	100	Rural
10	Damanjodi Wind Power Plant	Damanjodi, Odisha	99	Hilly

Due to an increase in fossil fuel prices, India's thermal power plants are facing enormous competition. From a future perspective, traditional energy sources cannot bear this pressure and are unable to fulfill massive energy demand. Meanwhile, wind energy has the potential to fill this gap. As a mature renewable sector, having enormous potential and firm growth, India's wind industry is expanding market demand and will grow significantly over the next years.

3.2.2. Installed wind capacity

As there is huge electricity demand in India, therefore, the Indian government is looking for clean and efficient ways to fulfill this ever-increasing energy demand. Since 1990, the cost to generate electricity from wind resources has reduced considerably and now is par with coal-fired power plants (Khan

et al., 2012). Table 3 demonstrates an estimated Levelized cost of electricity generation by the year 2020 in a different currency of US Dollar, Indian Rupee (INR), Pakistani Rupee (PKR) and Bangladeshi Taka (BDT) (EIA, 2018). Being cost-effective, wind energy-based power plants have a competitive advantage over other energy sources, as evident from the table. Moreover, wind electricity generation is cheapest in India as compared to other South Asian countries like Pakistan and Bangladesh. According to the International Renewable Energy Agency (IRENA), the newly installed wind capacity has proliferated in India from 2009–2018. Within ten years, the cumulative installed capacity has grown from 10,925 MW to 35,288 MW, accounting for 47% of India's total renewable energy. The cumulative and annual installed wind capacity has been shown in Fig. 6 (IRENA, 2018, 2019).

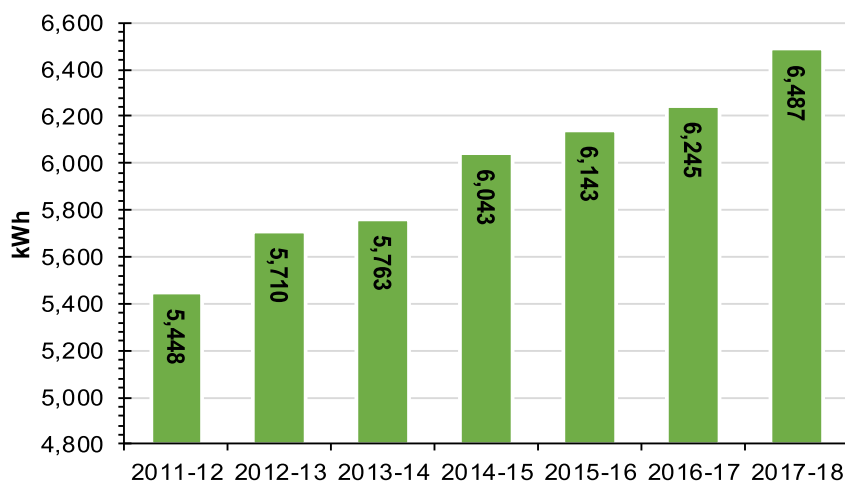


Fig. 5. Per capita electricity consumption (CSO, 2019).

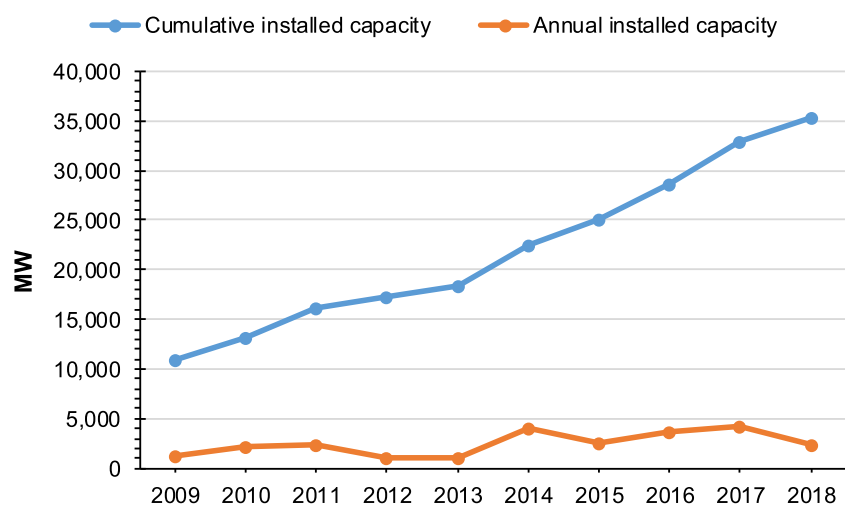


Fig. 6. Cumulative and annual installed wind power capacity from 2009–2018 (IRENA, 2018, 2019).

Table 3

Estimated Levelized cost of energy generation from different sources by the year 2020 (EIA, 2018).

Energy source	Price in MWh generation in different currencies			
	U.S (Dollars)	India (INR)	Pakistan (PKR)	Bangladesh (BDT)
Solar Thermal	197	14 113	26 411	16 530
Advanced Coal with CCS	128	9 137	17 098	10 701
Solar PV	107	7 669	14 351	8 982
Advanced Coal	106	7 554	14 137	8 848
Biomass	94	6 695	12 529	7 841
Conventional Coal	92	6 566	12 288	7 690
Hydro	90	6 437	12 047	7 539
Combined Cycle (Average)	89	6 401	11 980	7 497
Advanced Nuclear	89	6 366	11 913	7 456
Combustion Turbine Average	87	6 212	11 625	7 275
Wind	75	5 378	10 063	6 298
Geothermal	57	4 074	7 625	4 772

3.2.3. Power supply condition

As the installed wind capacity has increased, the power supply condition of the country improved. Energy demand and supply gap have been decreased recently in the country due to active policies and corrective measures to support renewable technologies. The gap was 6103 MW (9%) during 2014. However, it has

been reduced to 1617 MW (3.2%) at the end of 2018. The country still has a shortage of 23 Billion kWh (2.1%). Fig. 7 summarizes the power supply condition in India from 2014–2018 (CEA, 2016, 2017, 2018a,b).

3.3. Chance

Every year, a hefty budget is spent on the import of costly fossil fuels (Lolla et al., 2015). Therefore, the Indian government is keen to utilize alternative energy sources to reduce the intake of fossil fuels (Sharma et al., 2012a,b). The wind industry has a lot of opportunities in this scenario. With the supporting government policies and continuous R&D activities, wind energy has turned out to be a promising clean energy technology and is developing at a rapid pace (Jethani, 2016a,b).

3.3.1. Industry opportunities

With the quick development of wind power industry, opportunities and challenges both exist. The key opportunities for the Indian wind industry are as follows: (i) vast wind resources in eight states (Mabel and Fernandez, 2008). (ii) Huge electricity demand and high prospects for wind energy (MNRE, 2017). (iii) Government support for the development of the wind industry in the form of supporting policies and regulations (Khare et al., 2013). (iv) Reduction in the cost of generating wind electricity

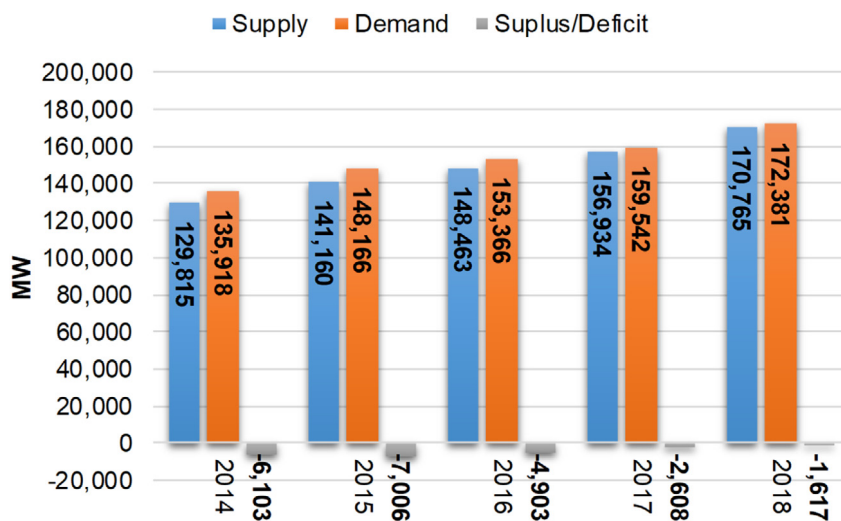


Fig. 7. Power supply condition in India during 2014–2018 (CEA, 2016, 2017, 2018a,b).

due to technological advancements and local manufacturing of key equipment (Khan et al., 2012). (v) Improve energy composition by contributing more to the total energy mix of the country. (vi) Development of the local economy. With the current pace of wind energy development, India attracts \$10,637 million in foreign investment every year. Additionally, create 213,000 new jobs in manufacturing, operation, and project development sectors (Sharma et al., 2012a,b).

3.3.2. Industry challenges

Meanwhile, the Indian wind power industry is also facing several challenges, such as (i) wind energy resource distribution is imbalanced. Some states have massive wind potential, but energy demand is low in these states. Whereas, some states have enormous energy demand, but they have fewer wind resources. (ii) Another major challenge is inefficient and outdated wind turbines (Singh et al., 2004). Although some states have abundant wind resources, they are not utilizing them properly due to old fashioned wind turbines. The introduction of new and powerful wind turbines in these states would bring significant benefits. (iii) Lack of financial mechanism and economic incentives are other significant challenges, impeding wind industry development (Henriksen, 2013). (iv) Wind energy projects often come with strong public opposition. This opposition is usually characterized by the NIMBY (not in my back yard) concept. Although wind energy is relatively clean and does not pollute the environment, compared with other conventional energy sources. But concerns exist, as wind turbines used to generate electricity are very noisy and have a visual impact on the landscape, which can spoil the view of people living near them (Ackermann and Söder, 2002). (v) Like other renewable technologies, wind energy projects are capital intensive. Massive investment is required to begin a new project. The transportation of wind turbines to remote areas, packing, and storage of all associated components result in high initial cost (Zhao et al., 2014). (vi) Dependence on foreign technology to manufacture core parts and equipment is another challenge. Lack of modern technology, small scale manufacturing facility, insufficient technical capacity, and human resources are constraining the competitiveness of wind industry (Iftikhar et al., 2017). Modern technology and skilled workforce are desperately required for the healthy growth of the industry. Table 4 summarizes the Indian wind industry's major opportunities and challenges.

Table 4

Major opportunities and challenges of the Indian wind power industry.

Sr. No	Opportunities	Challenges
1	Enormous wind energy resources	Imbalanced distribution of wind resources
2	Rising electricity demand	Old and inefficient wind turbines
3	Huge government support	Lack of financial mechanism
4	Improve energy composition	Strong public opposition to wind farms
5	Cost reduction in wind electricity generation	High initial cost
6	Developing local economy	Dependence on foreign technology

3.4. Firm strategy, structure, and rivalry

Several constraints, i.e., small market size, poor quality of local key parts, lack of standard technology, and massive investment to establish wind farms are hampering the sustainable development of the Indian wind industry. Most wind turbine manufacturing firms in India have adopted specialization, technological innovation, and differentiation strategies to remain competitive in this rivalry environment. The firms adopting specialization strategy, focus on only one area of specialization to gain a competitive advantage over other firms. On the other hand, firms taking technological innovation approach, actively increase research and development (R&D) activities to improve core technologies better than their competitors. Meanwhile, firms concentrating on differentiation strategy, entirely focus on the marketing and branding of their leading products to distinguish them from rival firms.

In addition, Indian wind companies can make the production process better, efficient, and streamlined by adopting a vertical integration strategy. With a short production cycle, the quality will also improve. Let us take the example of Suzlon. Established in 1995, Suzlon is the world's 5th largest wind turbine manufacturing company and 1st largest in India. The company decided to fulfill the requirements of the wind industry by making state of the art wind turbines. It bought "Hensen" (a Belgian gearbox manufacturing company) in 2006 and "Repower" (a German company) in 2008 (Arora et al., 2010).

The company has spread its footprints across six continents. In countries like Denmark, the Netherlands, and Germany, it has the most extensive wind energy research facilities. Efficient production facilities, modern and bigger wind turbines and diversified global market, contributed towards the success of Suzlon.

Currently, the company occupies a 35% market share in India and have a total installed capacity of 17,900 MW in the world (Suzlon, 2019). Tremendous potential exists for the development of the wind power industry. However, it lacks comprehensive industry standards. Moreover, the traditional electricity industry has more market access threshold than the wind power industry. Many wind companies are functioning in India at the moment, and many more are entering the market consistently. Above all, India's wind industry is facing fierce competition.

3.5. Related and support industry

The value creation and competitiveness of wind industry depend on the collaboration between all related and supporting departments (Liu et al., 2018). Although Indian wind equipment manufacturing industry is not so mature and started its operation in 1990, still it has made a significant contribution to cumulative installed capacity. In 2017, the newly installed annual wind capacity reached to 4178 MW, highest ever in the history of India (IRENA, 2019).

3.5.1. Wind equipment manufacturing

Wind equipment manufacturers have increased the supply of wind turbines, as the demand for wind turbines grew in the country. The two major types of wind turbines being deployed in India are “stall regulated turbines” (SRT) and “pitch regulated turbines” (PRT). SRT has fixed rotor blades whereas, the blades can be adjusted in PRT according to wind speed. Moreover, steel tubular, lattice, and concrete tubular towers-oriented wind turbines are also present in the country. The country has a domestic hub of manufacturing wind turbines. Currently, indigenous wind turbines have attained the annual production capacity of 10,000 MW. Over 20 different companies are manufacturing various models of wind turbines in India; These include Indian companies with local technology and subsidiaries of foreign companies.

The traditional horizontal axis wind turbines are much more widely used in India as compared to vertical axis wind turbines. Both types of wind turbines have pros and cons. Horizontal axis wind turbines are more suitable for large wind farms, harness more wind energy and less exposed to mechanical stresses. On the other hand, vertical axis wind turbines are usually used for small scale purposes, do not have electromagnetic interference, blade rotation space is quite small, have strong wind confrontation capability and produce less noise compared with horizontal axis wind turbines (Khare et al., 2019).

Meanwhile, wind turbine size had gradually increased in India from 0.05 MW in 1985 to 3 MW in 2018. Acciona wind power, manufactures wind turbines with a diameter of 125 m and a capacity of 3 MW. India has 625 functional micro and mega-scaled wind farms. Currently, all newly constructed mega-scaled wind farms are using bigger wind turbines to harness more wind electricity. Smaller wind turbines with a capacity of 1–1.5 MW are being employed in micro-scaled wind farms of the country (Kumar et al., 2016).

Specific market players improve the value chain of the wind industry. These players consist of raw material suppliers, component manufacturers, original equipment manufacturers, power plant developers, information technology developers, and service providers (Fig. 8). Many large wind farms bought suppliers of critical components, i.e., generators, blades, and gearboxes to avoid supply chain bottlenecks, which is a constant threat to the regular operation of wind farms. By carrying suppliers in house, they could ensure that they would get the desired products at an acceptable price and well on time. The improved value chain brings out opportunities in each stage for every market player (EAI, 2019). It is quite interesting that Indian wind turbines

Table 5

Top Indian wind equipment manufacturers (IWTMA, 2018).

Wind equipment manufacturer	Installed capacity (MW)	Market share (%)
Suzlon Energy Ltd	626.3	35.2
Gamsea Wind Turbines	552.2	31.1
Vestas Wind Technology	181.6	10.2
INOX Wind Ltd	174	9.8
GE India Industrial Ltd	96.9	5.4
Wind World India	44	2.4
Regen Powertech	43.5	2.4
Pioneer Wincon	19.5	1.1
Acciona Windpower Nordex	18	1
RRB Energy	12.6	0.7

have the lowest cost in the entire world (Jethani, 2017). Due to this fact, domestic wind turbine manufacturers have increased their production capacity. Now, 70%–80% of wind turbines are being produced in the country by local manufacturers. As supply has increased, the prices reduced, which is positively affecting the development of the Indian wind industry. Conversely, in an environment where there is a shortage of supply, the prices will go up for wind turbines and all associated components.

Suzlon energy limited, Gamsea wind turbines, Vestas wind technology, INOX wind limited, GE India Industrial limited are the leading wind equipment manufacturing companies in India (IWTMA, 2018). Table 5 depicts the installed capacity and market share of top wind equipment manufacturing enterprises. Major bearing manufacturers include Schaeffler, FAG, SKF, and Rothe Erde, whereas ZF wind power and Winergy are the top gearbox suppliers (Eletimes, 2019).

3.5.2. Grid construction

As the grid construction concerned, it was designed for traditional electricity production, instead of renewable energy generation. Wind energy connection with the national grid has not been regulated during grid scheduling. MNRE has set parameters to address the issue of connecting wind electricity to the national grid. The most important is, technical protocols and management guidelines should be specified to bring wind energy into national grid planning. “Availability-based tariff” has been introduced, and all new wind turbines should comply with the guidelines proposed by MNRE. Moreover, to guarantee the safety of grid operation and wind power plants, it is necessary to clarify the relationship between grid extension and wind power development. Following these regulations, grid companies have developed new measures to assist wind electricity connection to the national grid.

“The bundled grid-connected wind power project” was started in Tamil Nadu during 2010. Suzlon Energy Limited supplied the necessary equipment for the project. Later it was connected to the southern regional grid. Annual electricity generated from this project is 9300 MWh. Meanwhile, the project will reduce 8620 tonnes of carbon dioxide equivalent to GHG (UNFCC, 2010). Another similar project was set up in Maharashtra. This project consists of 33 wind turbines, having a total capacity of 49.5 MW. These projects have improved the national energy structure and reduced GHG emissions significantly (UNFCC, 2012). The Indian wind power industry chain has been shown in Fig. 9.

3.6. Government

The government performs a critical role to control all the above-mentioned factors and regulate wind energy market. The Indian government has formulated a series of laws, regulations, and supporting policies for wind industry development (Mani and Dhingra, 2013).



Fig. 8. Wind energy market players.

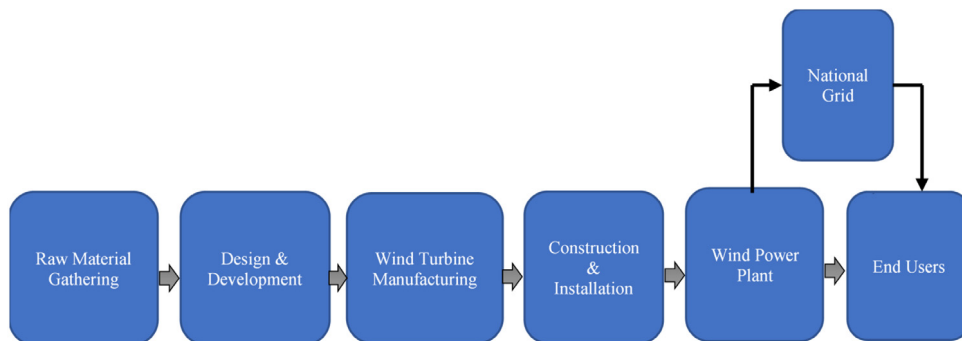


Fig. 9. Wind power industry chain.

3.6.1. Laws and regulations

- (1) The "Energy Conservation Act" took into effect in 2001. This was the first law to cope up with energy issues. The act specifies that energy consumption standards will be formulated for domestic and industrial users. Every newly constructed building should follow the energy-saving building code. All appliances should display energy consumption tags and comply with energy performance standards. This act established a bureau of energy efficiency (BEE). The key responsibilities of the BEE are: to implement the act by specifying codes and standards for domestic and industrial equipment. Moreover, energy efficiency should be improved by energy audits (Ministry of Law and Justice, 2001).
- (2) The Ministry of Law and Justice (MLJ) promulgated the "Electricity Act" in 2003. This act stipulated that "state electricity regulatory commission" (SERC) will be responsible for promoting electricity generation from renewable sources. SERC will assist in connecting renewable electricity with grid and distributing to end-users. Moreover,

the share of renewable electricity will progressively be increased. Distribution companies will purchase renewable electricity by a competitive bidding process. To develop renewable technologies quickly, SERC will determine the differential in prices (Ministry of Law and Justice, 2003). Moreover, SERC has implemented renewable portfolio obligation in every Indian state. The main sections which emphasize the utilization of renewable energy are as follows: (i) The state commission shall encourage the deployment of renewable energy and offer suitable conditions to connect it with the national grid. (ii) The Commission shall determine tariff by specifying terms and conditions (Sharma et al., 2012a,b).

- (3) MNRE enacted "National Renewable Energy Act" in 2015. The main features of this act are: (i) to support energy production by utilizing renewable energy sources in such a way that they do not have adverse impacts on the environment, (ii) minimize reliance on traditional sources, (iii) ensure energy security in the country, (iv) and minimize the emission of CO₂ and other hazardous gases. With the

implementation of this act, the national and international objectives shall be achieved, and the aim of increasing the share of electricity from renewable sources will be realized (MNRE, 2015).

3.6.2. Policies

Besides these laws and regulations, several policies have been released by the Indian government. The purpose of these policies is to develop the wind energy infrastructure promptly in the country (Kumar and Meena, 2017). The detail of these policies has been given below.

- (1) National Tariff Policy was promulgated in 2006. SERC prepared renewable purchase obligation (RPO) by distribution licensees. Ministry of Power estimated the growth trajectory of RPO up to 2019 and informed RPOs all over the country. As eight states have more wind potential, therefore there is always a problem of interstate transmission losses and charges. The main objective of this policy is to waive the interstate transmission losses and charges (ITLC) to sell wind electricity among different states. According to this policy, wind power projects commissioned till March 31, 2019, can waive interstate transmission losses and charges up to 25 years from the commencement date of the project. Moreover, projects having power purchase agreements with distribution companies can also waive interstate transmission losses and charges (Ministry of Power Resolution, 2016).
- (2) Government of India announced the “Generation-Based Incentives” (GBI) policy in 2009 (Jethani, 2016a,b). The objective of this policy is to reward wind farms by changing the payment method from installation-based to generation-based. Even though the government was providing tax benefits like Accelerated Depreciation (AD) to wind farms, but their efficiency did not improve. Therefore, GBI was introduced to improve the efficiency of wind farms. Another reason for this policy is to install wind capacity according to its real potential. As, 302,251 MW wind energy potential exists in the country, but only 35,288 MW has been realized so far (Irfan et al., 2019b; GWEC, 2014).
- (3) MNRE declared the “Renewable Energy Certificate” (REC) policy in 2010 to promote renewable energy technologies in the country (Potdar et al., 2016). The objective of this policy is to determine the floor price and forbearance price for renewable energy projects. Central electricity regulatory commission (CERC) is responsible for deciding this price. Indian Renewable Energy Development Agency (IREDA) will provide all the financial assistance required by wind energy projects. REC would be traded within the floor and forbearance price during power exchange (Sholapurkar and Mahajan, 2015).
- (4) National Clean Energy Fund (NCEF) was created in the union budget 2010–11. Its objective is to support R&D activities of renewable energy technologies. NCEF collected Indian rupees (INR) 3864 crore at the end of 2012. As the awareness among masses is increasing about the adverse effects of thermal energy, they are embracing clean energy. Currently, the fund has a net worth of 10,000 crore rupees. The Indian government allocated 200 crore rupees from this fund, for green India mission program during 2014. Another 200 crores were allocated for environmental remediation program (Mani and Dhingra, 2013).
- (5) Government of India proposed “Land Allocation Policy” to encourage investment in wind energy projects. The objective of this policy is to simplify the process of getting land for the installation of new wind farms (Kumar and Thapar, 2017).

- (6) MNRE sanctioned “Wind Bidding Scheme” (WBS) in 2016. The main objective of this policy is to sell wind electricity between different states by constructing the Inter-State Transmission System (ISTS) connected wind farms, having a capacity of 1000 MW (Solar Energy Corporation of India, 2017).
- (7) Most wind turbines introduced before 2000, have the capacity less than 500 kW. Keeping in view this fact, MNRE announced “Repowering Policy” in 2016 to update wind turbines. According to this policy, all wind turbines having a capacity of 1 MW or below can take benefit from this policy. IREDA will provide an additional interest rate rebate of 0.25% for these projects (Jethani, 2016a,b).
- (8) MNRE announced “Small Wind Energy Systems” (SWES) policy to benefit rural householders. According to this policy, the government will provide rural dwellers INR 1 lakh per kW to install SWES. The policy was so successful that residents in 23 states had installed these systems, with an installed capacity of 3155 kW (Jethani, 2017). Table 6 summarizes the major laws and policies related to the Indian wind industry.

3.6.3. Tax structure

Due to favorable taxation, India has become an attractive market for investors. Several tax waiver schemes such as feed-in-tariff (FIT), accelerated depreciation, RPO, relief from excise and customs duty, liberalized foreign investment have accelerated the quick deployment of wind energy in the country. Investors significantly invested in wind projects, with the announcement of tax incentives in 1990. With the development of an investor-friendly tax structure, investors can enjoy depreciation allowance, tax holidays, and fiscal incentives. Moreover, the government particularly encourage foreign investors by giving the lure of 100% FDI (Mahesh and Jasmin, 2013).

The major tax incentive for private investors is that they can 100% depreciate capital equipment during the first year of operation. Similar incentives like soft loans and low custom duty on importing foreign wind equipment have extremely motivated them. Besides federal government's tax initiatives, several states also have announced attractive tax policies including capital subsidy, wheeling, banking fees, and third-party terms and conditions to buy wind electricity (Singh et al., 2004). Fig. 10 summarizes the government's support mechanism for the wind power industry.

4. Future prediction of wind technology and potential problems

The wind industry is facing intense competition from other renewable energy technologies due to several reasons. First, other renewable energy technologies are also becoming as cost-effective as wind energy at the same time. Second, in contrast with other renewable technologies, wind energy is site-specific. Wind turbines should be in the path of some serious winds to produce electricity. If there is no wind, there is no power, whereas solar photovoltaic (PV) can be installed anywhere and produce enough energy to fulfill electricity needs. Fourth, solar PVs are stationary and require minimum maintenance. On the other hand, wind turbines have moving parts which result in severe deterioration and require regular maintenance. Fifth, a solar power system requires less monitoring, has better reliability, provides more predictable energy output and less eye-catching than a wind turbine. Moreover, it allows quick installation with less cable required, totally silent in operation and is more useful at sites where wind speed is less than 5 m/s. Therefore, the future of the wind industry is unpredictable.

Table 6
India's wind industry related laws and policies.

Policy	Ministry involved	Content
Energy Conservation Act, 2001	Ministry of Power, Central government	Formed energy consumption standards. Domestic and industrial users should abide by these standards.
Electricity Act, 2003	Ministry of Power, Central government	Assigned RPO targets for electricity distribution enterprises, so they must buy a part of their total energy requirement from renewable energy sources.
National Renewable Energy Act, 2015	Ministry of New and Renewable Energy	Reduce CO ₂ emissions and ensure energy security
Tariff Policy (2006)	Ministry of Power, Central government	Assist in selling wind electricity among different states by waiving interstate transmission losses and charges.
Generation Based Incentive (2009)	Ministry of New and Renewable Energy	IREDA will provide a GBI of INR 0.50 per unit for ten years to compensate wind energy projects.
Renewable Energy Certificate (2010)	Central Electricity Regulatory Commission	To promote sustainable development by endorsing renewable electricity in the energy market of India.
National Clean Energy Fund (2010)	Ministry of Finance, GOI	To promote clean energy technologies and provide funding for research activities.
Small Wind Energy Systems (2011)	Ministry of New and Renewable Energy	Assist local people who are far away from the national grid by providing a subsidy of INR 1 lakh to buy small wind energy systems.
Land Allocation Policy (2012)	Ministry of New and Renewable Energy	To simplify the procedure of allocation of land and other formalities for the establishment of wind farms.
Repowering Policy (2016)	Ministry of New and Renewable Energy	To maximum exploit wind energy resources by replacing old wind turbines with modern and powerful ones.
Wind Bidding Scheme (2016)	Ministry of New and Renewable Energy	Establish a 1000 MW Inter-State Transmission System (ISTS) connected wind power projects to facilitate the interstate sale of wind power.

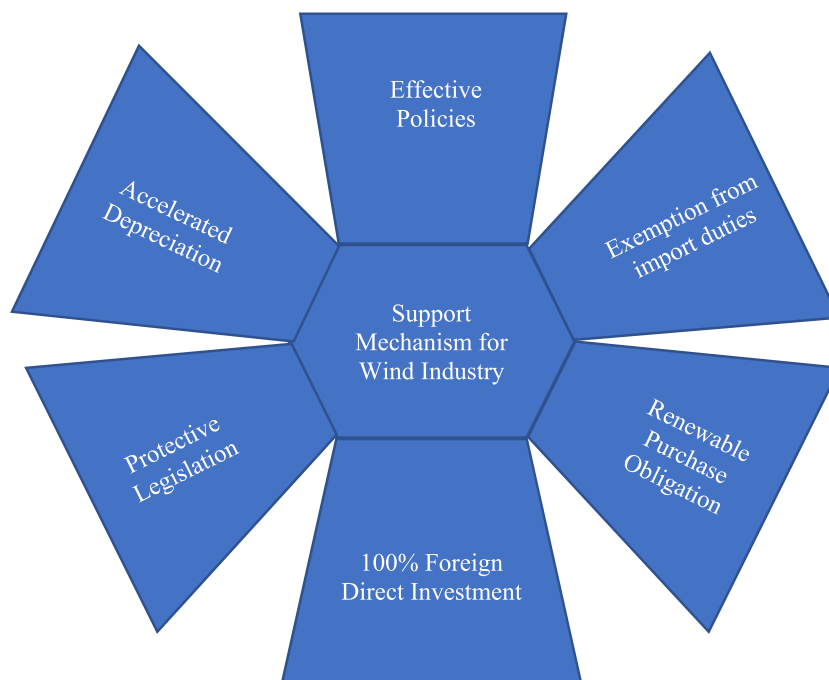


Fig. 10. Support mechanism for the wind power industry.

Sixth, electricity generation from wind may be reduced in the future due to the lack of wind. This risk is a major threat to wind farm operators and wind energy markets all over the world. Wind power equipment is costly and requires high initial capital. As the investment in new projects is always risky, investors and private enterprises are reluctant to invest in new wind power projects. Finally, wind farms require a large area of land. The process of purchasing land and necessary paperwork is sometimes very lengthy and cause delays, which is very annoying and cause disappointment to enterprises (Sholapurkar and Mahajan, 2015). Consequently, the enthusiasm of investors in wind energy may be

weakened, which lead to the shrinkage of the industry. Although the Indian government is dynamically promoting wind energy development by making use of the abundant resources, once the demand for wind power decreases or there is an alternative to wind power, most wind power plants will shut down.

5. Discussion and policy recommendations

Indian wind energy market is going through a new revolution, as mature government policies have attracted local and foreign investors to invest in this sector. The government has announced

AD of 80%, much to the delight of wind power stakeholders. Besides, wind tariff has become very attractive recently and is close to the solar tariff in many states. In Maharashtra, Madhya Pradesh and Rajasthan, wind tariff is INR 5, whereas solar tariff is INR 6, leaving a minimal gap. In this scenario, it is projected that there will certainly be a diversion in investments from solar to wind energy in the future (Maurya et al., 2015). Furthermore, traditional thermal energy sources are becoming expensive, and the wind is at par with coal, there have been emerged enough opportunities for Independent Power Producers (IPP) to tap wind potential (Panwar et al., 2011). According to long term plan, the Indian government is planning to upscale the wind generating capacity up to 100 GW by 2022 and at the same time also attract foreign investments of US\$ 16.5 billion (Chaurasiya et al., 2019).

Although the government has put serious efforts for the quick development of the wind industry, still the sector is confronted with numerous issues. Some of these issues related to policy, while some associated with technology, site, and region. Some policies have created high uncertainty to invest in wind energy projects. As, Madhya Pradesh provincial government announced a policy to promote wind energy by waiving electricity duty on wind energy projects for a period of five years, provided that actual generation must be at least 70% of the electricity production, declared in the detailed project report. Due to strict requirements and a short span of time, investors were reluctant to invest in new wind projects (Khare et al., 2013). In a similar study conducted by Mirza et al. (2007) in Pakistan, the researchers found that although the government has acknowledged wind energy as an alternative source of energy and prevailed in policy documents, little substantive action has been taken for its meaningful development. Besides, no specific incentives have been provided to nurture this industry.

There are institutional issues, as well. Lack of collaboration between departments, ministries, and stakeholders, cause delays and restrict the development of the wind power industry. Soon after the announcement of the GBI scheme, the applications of wind project developers were accepted by IREDA but rejected by the federal government. The reason for rejection was, enterprises submitted their applications before the notification of the policy. As a result, investors have lost their faith in the investment climate due to the lack of such inter-institutional collaboration (Jethani, 2017).

Wind projects are also facing fiscal and financial constraints. The government announced GBI for wind energy, but a small budget has been allocated for this scheme. Wind energy projects are capital intensive. Though they do not require fuel during their operation compared with thermal power plants but the initial investment to set up a wind power plant is gigantic. Moreover, the rate of return is prolonged, which offer investors a significant challenge to invest in such projects. Zhao et al. (2011) conducted a study on the PV industry in China and found that the industry is facing financial problems because the PV power development needs massive upfront investment with a long payback period. Our research findings are consistent with this study. Another critical issue is the difficulty in grid connection. Similarly, the lack of appropriate transmission infrastructure, cause problems in the non-dispatching of wind electricity (Irfan et al., 2019b).

Moreover, the essential elements of industry' value chain, i.e., grid construction, end-users, markets, transmission, and distribution network have not been emphasized during their development path. As a result, there is a wide gap between the expected and actual performance of wind industry value chain. The following policy recommendations have been advised based on our research findings.

- *Reform the grid structure:* Quick wind energy development needs reformations in the grid structure. Only a small portion of wind electricity has been connected to the national grid so far as the current Indian grid structure only supports the traditional electricity. Therefore, the grid structure should be reformed on an urgent basis to support wind energy.
- *Adoption of a differentiated business model:* A differentiated business model should be adopted to increase value creation. This can be done by integrating traditional electricity with renewable energy, optimizing energy structure, and begin inter-regional energy trade.
- *Public-private partnerships:* Investment should be boosted in various wind energy development projects by public-private partnerships. Domestic users should also be encouraged to participate in different wind power schemes.
- *Increase R&D activities:* R&D is another vital value-adding segment of the wind industry's value chain. India is currently facing numerous challenges such as inefficient and old-fashioned wind turbines, lack of wind turbines certification system, and reliance on foreign countries for major parts and equipment. R&D activities should be increased to overcome these challenges. In addition, the country should improve innovative and intelligent technologies in the field of big data and turbine manufacturing to decrease operating costs and satisfy the current needs of the wind industry.
- *Developing professional base:* The value creation can be increased further by developing local human resources, as the lack of professional human capital, hampering its steady growth. Wind energy engineering programs should be started at the university level to cultivate professional talent. This will not only fulfill the shortage of professional human resources but also create new jobs in different wind energy segments. The process can be further speeded up by the cooperation of foreign institutions and countries, competent in wind power technology.
- *Government's role:* The role of government is very crucial in the value creation of the wind industry. Supporting policies, legislation, and tax incentives affect the development of the wind industry positively. To increase innovation effect, the government should offer recommendations on policy measures to aid grid connection, reform the power markets, and make regulations to increase the consumption of wind-generated electricity. Above all, this is impossible to achieve without government support mechanism.

6. Conclusions

This study has employed the diamond model technique to analyze the development and competitiveness of the Indian wind power industry. With the ever-changing industry's environment, the government of India is keen to formulate effective strategies. Since India has vast wind resources, several projects and programs have been started to maximum utilize these resources. Research results show that the Indian wind industry has high prospects in the future. However, the industry has confronted with numerous challenges, i.e., initial costs are too high to start a new wind project, wind turbines are old fashioned, the country is still dependent on foreign technology, wind resources have been distributed unevenly in the country, and the lack of supporting financial mechanism. Meanwhile, opportunities also exist. It is essential to boost the industry's competitiveness by creating the value chain and enhancing its innovation capacity. The role of government is crucial in this perspective. The Indian government nurtures an environment through supporting laws, regulations, policies, and tax structure to foster the development of the wind

power industry. Furthermore, grid structure should be reformed to support wind energy, adopt a differentiated business model to gain value creation, public–private partnerships should be encouraged in wind energy projects, R&D activities should be boosted, and professional human talent should be cultivated on an urgent basis to speed up the process of wind energy deployment in the country. It is imperative that all the factors in the diamond model should be strengthened to gain a positive interaction among them. In this way, the competitiveness of wind industry can be improved further.

7. Limitations and future research

Though the research results of this study are in harmony with theoretical predictions, the study also has limitations. The focus of our research was only the wind power industry. However, future studies may combine other industries to infer our research findings in the meta context examination. Future researchers can merge other concepts and models along with our research, to assess the competitiveness of different industries. Moreover, the status of “Diamond Model” established in this research, change both with time as well as with the development level of the industry. Therefore, regular analysis is required to uncover the developments and improvements of the wind power industry over time. It is worth noting that several factors affect the competitiveness of wind power industry. But in this research, a limited number of factors have been investigated. Future studies can overcome this limitation by examining additional factors which may affect the profitability and competitiveness of wind power industry.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

This study is supported by “the Fundamental Research Funds for the Central Universities (2018ZD14)”.

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