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Offshore wind energy policy for India—Key factors to be considered

Swaminathan Mani *, Tarun Dhingra [1]

University of Petroleum and Energy Studies (UPES), College of Management and Economics Studies, Energy Acres, PO Bidoli, Via Prem Nagar, Dehradun–248007, Uttarakhand, India

HIGHLIGHTS

- We identify the components of an offshore wind energy policy by literature survey.
- 21 components are identified that form the master list of building blocks.
- These components are then logically grouped under five themes.
- A 100 wind energy stakeholders in India are interviewed to rank these components.
- Offshore wind energy policy can formulated using the components with highest score.

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ABSTRACT

Indian Economy is growing at a healthy pace during the last few years. To sustain this growth, power sector needs to build additional generation capacity. However, continued dependence on fossil fuels to power the growth of electricity generation capacity, is hardly sustainable. Renewable Energy source forms a miniscule portion (25 GW, ~12%) of India's overall power generation today (202 GW). The share of wind energy (17 GW) is 67% of the total renewable energy basket. But the contribution from offshore wind farms is non-existent, as all the wind energy generated in India is only through onshore wind farms. India needs a policy framework to encourage the development of offshore wind farms. Several European countries have effective offshore wind energy policies that have helped them to accelerate the growth of their offshore wind energy sector. This paper does an exhaustive literature survey, to identify 21 building blocks of a successful offshore wind energy policy initiative adopted by select European countries, which have been classified under 5 broad categories—Government support, Fiscal and quota based incentives, Availability of local expertise, Capital for investments and Building an enabling ecosystem, which can be leveraged by India to articulate its own offshore wind energy policy.

1. Introduction

The total power generation capacity in India in April 2012 was 202 GW (Ministry of New and Renewable Energy (MNRE), 2012). Of this, 66% was fossil-fuel-fired power plants, 19% hydroelectric power, 2% nuclear power, and 12% renewable energy, as shown in Table 1. In the business as usual scenario, coal is likely to dominate the energy fuel mix in the future too (Ministry of Power, 2011).

India that is experiencing accelerated growth is likely to consume energy more than ever before (Planning commission, 2010). This growth also places massive demands on the consumption of energy. India today only produces 660 billion kW h of electricity and over 400 million Indians have no access to electricity. Acute energy scarcity in India will hamper its industrial growth and economic progress. However, these rapid enhancements in additional generation capacity need to come, in large proportions, from clean energy sources, as continued dependence on fossil fuel to power its economy will leave a devastated ecology apart from draining the foreign exchange reserves. India dependence on the fossil fuels contributes significantly to greenhouse gases emissions. If India failed to protect its environment, not only its economic growth would be impeded but also would pose serious health hazards (Pode, 2010). Increased awareness and regulations around greenhouse gas emissions, environmental concerns and global warming will put additional pressure on India to move away from polluting fossil fuels.

India has access to substantial renewable energy sources whose potential can be tapped to bridge some of the deficit experienced in power generation and reduce the pressure on the

* Corresponding author. Tel.: +91 9989047746; fax: +91 135 2776090.
E-mail addresses: swaminathanmani@yahoo.com, drswaminathanmani@gmail.com (S. Mani), tdhingra@ddn.upes.ac.in (T. Dhingra).
[1] Tel.: +91 9837321447.

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Table 1
Total installed power generation capacity in India as of 30th April 2012.
Source: CEA, 2012.

Fuel	MW	(%) Age
Total Thermal	**133363.18**	**65.97**
Coal	113,782.38	56.29
Gas	18,381.05	9.09
Oil	1,199.75	0.59
Hydro	38,990.40	19.29
Nuclear	4,780.00	2.37
Renewable energy sources	**25017.88**	12.37
Total	**2,02,151.46**	**100.00**

Table 2
Achievement of renewable energy sources (in MW) in India, April 2012.
Source: Ministry of New and Renewable Energy (MNRE) (2012).

Renewable energy systems	Target for 2 012-2013	Achievement during April 2012	Cumulative achievement up to 30.04.2012
Wind power	2500	36.65	17389.31
Small hydro power	350	5.75	3401.06
Biomass power	455	16.00	1166.10
Bagasse cogeneration		7.5	1992.73
Waste to power—urban	20	–	89.68
-Industrial		–	–
Solar power (SPV)	800	37.72	979
Total	**4125**	**103.62**	**25017.88**

need to commission fossil based power plants. India has begun well by having a dedicated ministry for renewable energy for policy formulation and for providing oversight. Several proactive initiatives from the ministry, research institutions, academia, private investments, thought leaders, financial institutions and project developers have resulted in India installing over 25,000 MW from clean energy sources in the overall power installed capacity of 202,000 MW as of April 2012 which has contributed to India becoming No 5 in the world in terms of installed wind energy capacity (Table 2).

However, India has not tapped the potential it has in the offshore wind energy sector. India has over 7000 km of coastline, access to funds, technological knowhow, project management capabilities, economic need, captive market and ecological compulsions to adopt offshore wind energy in an accelerated manner.

Today, Europe is a world leader in adoption of offshore wind energy in their countries which was due to several investor friendly policies formulated by EU. India has similar experience of proactive policies driving the growth of onshore wind energy sector in the country.

However, India is yet to formulate policies focused on offshore wind energy that would encourage the growth of that sector in the country. India can consider and implement some of the best practices of select countries in Europe that have successfully harnessed offshore wind energy for electricity generation. This research does an extensive literature survey of the offshore wind energy policies adopted by 4 countries (the UK, Germany, Netherlands and Denmark) with largest installation of offshore wind farms to understand the basic elements of policy formulation.

This research would also attempt to fill the gap of absence of literature on factors that drive the growth of offshore wind energy for India, by identifying a set of 21 variables that form the core components of offshore wind policy. These 21 variables were subjected to factor analysis to logically group these variables under 5 broad categories or levers viz., *Government support*, *Fiscal and quota based incentives*, *Availability of local expertise*, *Capital for investments and Building an enabling ecosystem*. These levers can be exploited by the policy makers in India to grow the offshore wind energy sector in the country. It is hoped that this research will add to the existing body of knowledge, as very little literature is currently available on the offshore wind energy sector in India.

Table 3
Projections for electricity requirement for India.
Source: Ministry of Power, Government of India (2000–2011).

Year	Billion kW h		Installed capacity (GW)	
Year	@8%	@9%	@8%	@9%
2006–2007	700	700	140	140
2011–2012	1029	1077	206	215
2016–2017	1511	1657	303	331
2021–2022	2221	2550	445	510
2026–2027	3263	3923	655	785
2031–2032	4793	6036	962	1207

1.1. Projections for energy requirement for India

The projections of power requirement for the Indian economy growing at 8% and 9% per annum is given in Table 3 below (Ministry of Power, 2005). Taking even a conservative growth of Indian economy at 8% per annum for the next 2 decades; India needs an installed capacity of over 950,000 MW from the present 170,000 MW—a capacity addition of over 40,000 MW every year for the next 20 years or around 750 MW every week. Of course the capacity addition figures are much higher if one considers the economy growth rates of over 9% per annum.

India experienced a generation deficit of approximately 10% and a corresponding peak load deficit of 12% (over 15 GW). India is likely to import over 100 Million Tonnes of Coal in 2011/12. The oil import bill is expected to rise to $120 billion in 2011/12.

2. Renewable scenario in India

Thankfully, India is blessed with generous sustainable resources, as shown in Table 4, to make a shift to renewables; abundant solar resources available for 300 days in a year, plentiful small hydro potential in the Himalayan states, long coast line of over 7000 km for tapping the offshore wind energy, several zones with wind speeds of over 7 m/s for onshore wind energy installations, a predominantly agrarian economy to act as a perennial supply chain for Biofuels

Consequently, India has made an impressive start in the renewables journey (Ministry of New and Renewable Energy (MNRE) 2010). India's long coast is likely to offer a large potential to harness offshore wind energy; proper assessment and development of this potential would offer challenges and new opportunities to India's wind energy industry (Bhattacharya and Jana, 2009).

2.1. Review of literature and current scenario

Usha Rao and Kishore (2009) used the theory of diffusion of innovation to study the growth of wind power technology in different states of India. It is found that there is a correlation between the diffusion parameters and the composite policy index. Hence is strong policy framework is a prerequisite for the growth of offshore wind energy in India. As per (Goyal, 2010) Onshore wind power development in India grew over 27% when dedicated policies for renewable energy sources were declared by the Government. As stated by Pillai and Banerjee (2009) onshore

Table 4
Development of grid connected renewable power in India (in MW)
(*Source*: Ministry of New and Renewable Energy (MNRE), Government of India & Planning Commission reports, 2011).

	Achieved		**In process**	**Anticipated**	**Targets**	**Estimated potential**
Five–year plan	Cumulative installed capacity by the end of 9th plan	10th plan–additions during the plan period	Anticipated in the 11th plan (additions during the plan)	By the end of the 11th plan (Cumulative installed capacity)	By the end of the 13th plan (cumulative installed capacity)	Medium term
Years	Through 2002	2002-2007	2007-12	Through 2012	Through 2022	10 Years
Wind	1667	5415	10,500	17,582	40,000	102,000
Small Hydro	1438	520	1400	3358	6500	15,000
Biomass	368	750	2100	3218	7500	23,700
Solar	2	1	1000	1003	20,000	20-30MW/Sq. km
Total	**3,475**	**6,686**	**15,000**	**25,161**	**74,000**	~ **150,000**

wind development has been accelerated by the provision of several incentives and enabling policies. As per (Bhide et al, 2011) several promotional incentives have been made available for wind power projects. As per (Purohit and Purohit, 2009), minimum level of remuneration appears necessary to encourage wind power deployment. Singh and Sood (2008, 2011) gives the comparative overview of all existing regulatory policies for the promotion of electricity generation from renewable energy sources that are either implemented or in the process of implementation.

\Similarly, multiple international literatures corroborate the view that focused policies interventions by several countries around the world have encouraged the growth of renewable energy sources. Saidur et al. (2010) have found that FIT, RPS, incentives, pricing law and Quota system are the most useful energy policies practiced by many countries around the world, which has helped these countries to significantly accelerate the generation of wind energy. As per (Luthi and Prassler, 2011) while the cost of wind energy has come close to grid parity in locations with consistently strong winds, its growth has been, and still is, largely driven by policy incentives. Menanteau et al. (2003) have shown that a number of renewable energy technologies have benefited to varying degrees from support of incentive programs introduced in the industrialized countries over the last 20 years. The impact of these instruments has been particularly felt in the case of wind energy, which is now nearly competitive with conventional technologies. As per (Gutermuth, 2000) the feed-in tariffs in operation in Germany, Denmark and Spain have led to sustained development of wind power, both in terms of installed capacity and at the industrial level. (Alishahi et al., 2012) have shown that different methods of structuring incentives have important impacts on the investment strategies of wind energy generation. Lewis and Wiser (2007) has clearly proven that a stable feed-in tariff to be one of the most successful mechanisms to date for promoting large-scale wind energy markets.

Huber et al. (2004) give a concise summary of comprehensive effects of different design elements of renewable energy policy instruments. Their major conclusions were that well-designed FITs were more effective and cost-efficient than other promotion schemes. Boyle (2007) mentions that uncertainty of policy environment was one of the deterrents to offshore wind development in the UK. An analysis carried out by Dinica (2006) examines the diffusion of renewable energy technologies taking into account the role of investors. Mitchell et al. (2006) compare the UK quota obligation system with the German FIT system and come to the conclusion that low risks implicate high policy effectiveness and that the German FIT-system provides higher security for investors than the British Renewables Obligation. Butler and Neuhoff (2004) conclude that the "resource-adjusted costs to society of the FIT is currently lower than the cost of the TGC systems". Held et al. (2006), Ragwitz et al. (2006) show that instruments, which are effective for the promotion of RES-E are frequently economically efficient as well.

Hvelplund (2001) advocating feed-in tariffs on the grounds that they alone have fostered dramatic capacity growth. Ackermann et al. (2001), Haas et al. (2007), Reiche and Bechberger (2004), Saidur et al. (2010) mentions that almost all countries that utilize wind energy for power generation have policies specific to wind energy. Johnstone et al. (2010) and Frondel et al. (2010) studied the impact of public policies on RE, and concluded that the effect of public policies largely depends on the kind of RE source. Buen (2005) concludes that policy has contributed to high degree of innovation and diffusion of Wind energy in Denmark; whereas lack of cogent policy derailed the wind energy sector in Norway–thereby establishing a direct correlation of policy measures and performance of Wind Industry in Nordic. Lund (2009) mentions the fast and high penetration of wind energy technologies indicates a very favourable long-term policy framework. The main key to the Danish success in the development of wind power during the 1990s has been a stable legal framework and a favourable policy environment (Haas et al., 2007).

So, several literatures confirm the hypothesis that a stable, focussed, policy environment needs to be created to accelerate the growth of wind/renewable energy sector in the country. The literatures also help identify the various components or constructs of a successful policy initiative.

3. Discussions

The inferences drawn from the survey is grouped into few key messages as shown in Table 5.

There is no study which has been carried out to develop and empirically test a model of constituents of effective offshore wind energy policy for India. This paper would attempt to fill the gap of absence of literature on offshore wind energy policy for India by identifying a set of variables that form the core components of policy intervention needed for India to proliferate of offshore wind farms in the country.

The following superset of variables, as shown in Table 6, was found from the literature survey that formed the building blocks of policy roadmap adopted by these countries. No one country has adopted all the factors in their policy but have picked a smaller set that probably suited their local conditions. As part of this exercise, 100 stakeholders of Wind Energy in India were asked to

Table 5
Summary of literature survey organized as per themes.

S.No	Themes	Select author(s)	Context	Inferences
1	Current status and future plans of energy sector in India	Planning Commission of India (2009), Kirit Parekh reports (2009), Line Ministries (2008, 2009)	India	India needs abundant supply of power to support its growth. Use of fossil fuels is not sustainable in the long run.
2	Fallout due to use of fossil fuels	Breeze (2008), World Climate program (2010), Pode (2010), Saidur et al. (2010)	Global	Continued use of fossil fuel will leave a totally degraded ecology for the future
3	Renewable energy scenario/ potential in India	MNRE (2010), Bhattacharya and Jana (2009), Bhide and Monroy (2011), Usha Rao and Kishore (2009), Srinivasan (2009), Goyal (2010), Pillai and Banerjee (2009), Singh and Sood (2011). World Bank (2010), Lalwani and Singh (2010), Purohit and Purohit (2009)	India	Details about the immense Renewable Energy potential that can be harnessed by India.
4	Renewable Energy policy of India	MNRE (2010), Bhide and Monroy (2011), Usha Rao and Kishore (2009), Srinivasan (2009), Goyal (2010). Singh and Sood (2008). World Bank (2010).	India	Policy aspects of renewables but **no mention of offshore wind energy**, either in the policy aspects or potential aspects.
5	Renewable energy in Europe—focus on wind (both onshore and offshore wind)	Haas et al. (2007), Bloem et al. (2010), EWEA (2008, 2009), Wiser and Bolinger (2010), Lund, 2011, Moller (2011), Green and Vasilakos (2011).	Europe	History and growth of renewables in Europe with focus on Wind Energy sector growth (both onshore and offshore wind) and current status.
6	Policies adopted by countries in Europe to for Wind energy sector–focus on offshore wind energy	Lewis and Wiser (2007), Beccali (2003), Luthi and Prassler Prasseler (2011), Alishahi (2012), Dinica (2006), Huber (2003), Held et al. (2006), Ragwitz et al. (2006), Mitchell et al. (2006); Toke (2011), Butler and Neuhoff (2004)Sperling et al., 2010, Foxton (2005), Aitken (2010).	Europe	Several literature that talks about how having a consistent and cogent policy has helped grow the wind energy sector in Europe (specifically the offshore wind energy sector)
7	Slow adoption of offshore wind in some European countries due to lack of cogent/consistent policies	Boyle (2007), Buen (2005), Meyer (2007), Van Rooijen and Van Wees (2006)	Europe	How inconsistent or lack of cogent policies can slow or reverse the growth of wind energy sector in Europe.

rank these factors (1 being the highest) and the normalized results are presented.

The ranking of these variables is based on the perception survey administered to the stakeholders of wind energy in India. A variable having low scores does not mean they are unimportant. Higher scores were given by the respondents to those variables that need immediate attention of the policy makers in India. The 21 variables found from literature were then subjected to factor analysis to logically group them under 5 factors using the statistical method as explained in the next section (Mani & Dhingra, 2012).

4. Methodology

Descriptive research (Conclusive research) was the chosen research methodology as it renders itself to analysis using statistical tools. Since the strategy of inquiry used was 'survey' employing predominantly close ended questions, predetermined approaches and numeric data—quantitative research methodology was the chosen methodology for analysis.

4.1. Sampling procedures

4.1.1. Target population

The target population for the survey was any organization or individual having interest in the wind energy industry in India. This included companies that have an active presence in India and all those who are keen to set up base in India to exploit the wind energy potential offered by the country.

4.1.2. Sampling frame

The respondents who have a stake in wind energy in India and who have an active presence in India were identified as part of the sampling frame. The stakeholders of wind energy industry include wind turbine manufacturers, policy makers, R&D institutions, project developers, consultants, academia, wind industry associations, regulatory agencies, financial institutions, EPC contractors, thought leaders in wind energy and independent power producers.

4.1.3. Sampling element

The sampling element was defined as people those who were in the executive decision making authority in their respective companies/organization.

4.1.4. Sampling unit

The sampling unit was defined as those in executive leadership roles in organizations with interest in wind energy in India, who actively participates in large industry conferences as speakers or panel discussions chair or as session chair.

4.1.5. Sampling technique

Proportionate stratified sampling was used during the data collection process. The population was divided into different strata (Policymakers, Academia, Wind turbine manufacturers, association members) and number of elements from each stratum in relation to its proposition in the total population was selected. The percentage of these stakeholders in the sample size is given below

1. Wind Turbine Manufacturers—25%.
2. Policy Makers, MNRE, R&D Institutions—15%.
3. Project Developers & EPC Contractors—20%.
4. Independent power producers—10%.
5. Thought leaders—10%.
6. Financing Institutions (IREDA, EXIM Bank)—10%.
7. Others (Captive users, Regulatory agencies, Electricity Boards)–10%.

4.1.6. Sample size

The sample size of 100 was considered for this research work.

4.1.7. Instrument design

The instrument that was used in the data collection exercise for this research was a questionnaire which contained 34 questions in 8 sections. The questionnaire had most of the questions with pre-defined choices, as shown in Appendix B.

Table 6
Operating definitions of variables identified through literature survey.

SNo.	Components/building blocks/variables	Rank
1	**Feed in Tariffs (FiT):** Feed in tariff is the rate at which the renewable energy developer will be paid by the utilities/distribution companies for every unit of electricity fed into the grid.	1
2	**Accelerated Depreciation (AD):** Companies that are setting up a renewable energy projects can avail depreciation at higher rates (80% in the case of wind farms) in the first year of operation.	2
3	**Generation based Incentives (GBI):** GBI is a bonus payment given per unit of power injected into the grid to the renewable energy generator, over and above the FiT system.	2
4	**Legally enforceable RPO/REC:** Renewable purchase obligation (RPO) mandates the distribution utilities to source a pre-decided quantity of electricity, usually a proportion of their supply, from renewable energy sources. Making this RPOs/REC legally enforceable will make it attractive for investors.	1
5	**Faster approvals/Single window clearance**: Providing single window clearances for setting up offshore wind energy projects will reduce the gestation period for project go-live and also enhance the ease of doing business.	1
6	**Continuity of policies for long term (more than 10 years):** Continuity of policies for a long term (10 years or more) for predictability and stability in the policy environment.	2
7	**Adequate evacuation infrastructure to transmit power from high seas:** Availability of and access to transmission infrastructure/Grid connectivity from the offshore wind parks to onshore substations.	1
8	**Tariff determination on wind speeds and not on Zones:** Specific tariff rates based on speed of the winds will help development of low wind speeds areas.	5
9	**Financial incentives like zero import duty, excise duty waiver**: Offering financial incentives like waiver of custom duty, import duties exemptions, tax related schemes for setting up of offshore wind parks.	3
10	**Availability of expert EPC contractors:** Shortage of skilled resources to install offshore wind farms will invariably delays the commissioning of these farms which then has an impact on cash flows and profitability.	3
11	**Availability of local manufacturing expertise for Wind Turbine:** It is relatively inexpensive to source from domestic manufacturers compared to imports and it also reduces the supply chain wait- time dependencies.	3
12	**Growth of ancillary units (eg Gear box):** Similar to the availability of wind turbines locally, growth of ancillary units that are locally present will accelerate reduction in costs of components thereby increasing adoption.	4
13	**Superior program execution skills of the developer:** High quality program managers to supervise the installation and commissioning of offshore wind parks.	2
14	**Accurate data on offshore wind potential sites and wind speeds:** The power output from a wind farm varies directly to the cube of the wind speeds and hence impacts profitability. Hence, accurate data on offshore wind speeds is important to judge the financial attractiveness of the project.	1
15	**Skills development and training of human resources:** Offshore wind energy project needs 20 people for every MW of capacity installed to manage the project. Skills development and training of these resources is important to ensure smooth functioning of these offshore wind farms.	3
16	**Active Research institutions working on offshore wind energy:** Research institutions that focus on innovation and technology advancement of the offshore wind sector components, research on advances in foundation engineering etc. are vital to accelerate the growth of the offshore sector.	3
17	**R&D facilities to localize production of expensive equipment:** Growth of R&D facilities that work on finding ways to localize production of all components of offshore wind equipment to reduce the overall costs of offshore wind farms.	3
18	**'Priority sector' tag to offshore wind energy sector:** Declaring offshore wind as a priority sector will help the sector access funds from banks at attractive rates thereby increasing the attractiveness of the investments in offshore wind projects.	3
19	**Availability of capital at attractive rates of interest:** If capital is made available at attractive rates, in the absence of priority sector tag - that would help reduce the overall debt servicing burden for the offshore wind energy project developers.	2
20	**Creation of offshore wind energy fund to reduce cost of capital:** Creation of offshore wind energy fund, using the cess levied on coal and other fossil fuels, and using the accrual to lend to offshore wind energy projects will ease the burden on the developers.	2
21	**Moratorium on interest payments for the first 5 years of project go-live:** The offshore wind project developers being offered a 5 year moratorium on interest payment after the project goes-live will help in de-risking the investment from the vagaries of learning curve, which is inevitable in any project with large capital investments.	4

4.2. Questionnaire development

Structured–undisguised questionnaire was used in the survey – as they are reliable, standardized, simple to administer, easy to tabulate and analyze – where the responses permitted to the respondents were predetermined on a 1–7 likert scale. The instrument was checked for its reliability (using cronbach alpha) and validity using statistical techniques, which are beyond the scope of this paper but can be obtained from books on advanced research methodology. Detailed questionnaire is attached as Appendix B, which can be used by other researchers working in the field of renewable energy—as this questionnaire has been checked for validity and reliability.

4.2.1. Information sought

The list of variables found from literature survey was presented to the respondents in the form of questions and they were asked to choose an option (in the 7 point likert scale) whether a particular variable would aid the growth of offshore wind energy in India [strongly disagree (1) to strongly agree rating (7)]. There were questions on their perspective on offshore wind energy in India to judge the integrity of answers and to prevent mechanical answers to the questions.

4.2.2. Method of administration

The questionnaire was handed over predominantly in person at wind energy conferences in India, so that access to the right stakeholders and their response rates could be better compared to mail interview.

4.3. Pilot testing

The questionnaire was pre-tested with 25 wind energy stakeholders in the country during an international conference. The responses were added in a dummy table to make sure the questions were understood correctly and the answers were in line with the questions asked. A couple of ambiguous questions were re-worded, ordering of the questions were changed as per the feedback received before the questionnaire was administered again.

5. Factor analysis

Factor analysis was used in the research work to group the 21 variables identified under 5 factors based on their co-relations. Factor analysis is a statistical procedure used to uncover relationships among many variables. This allows numerous

inter-correlated variables to be condensed into fewer dimensions, called factors. Factor analysis is a method of data reduction. It does this by seeking underlying unobservable (latent) variables that are reflected in the observed variables (manifest variables). The amount of variance a variable shares with all other variables included in the analysis is referred to as communality. The covariation among the variables is described in terms of a small number of common factors plus a unique factor for each variable.

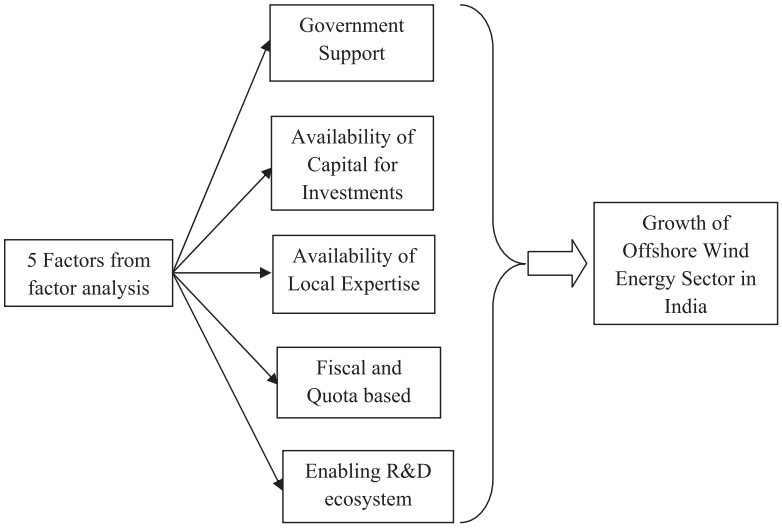
Factor analysis usually proceeds in two stages. In the first, one set of loadings is calculated which yields theoretical variances and covariances that fit the observed ones as closely as possible according to a certain criterion. These loadings, however, may not agree with the prior expectations, or may not lend themselves to a reasonable interpretation. Thus, in the second stage, the first loadings are "rotated" in an effort to arrive at another set of loadings that fit equally well the observed variances and covariances, but are more consistent with prior expectations or more easily interpreted. The variables usually load significantly on only one factor. Based on the variables that load, a suitable name is assigned to the factors.

- Extending financial incentives like subsidies, moratorium on interest payment, zero duty on imports, excise duty waiver and tax benefits for offshore wind energy projects.
- Tariff determination on wind speeds and not based on zones.

3. (*Factor* 3) *Availability of local expertise*
- Expertise and availability of EPC contractors for commissioning of the wind farms.
- Manufacture and availability of offshore wind energy components, locally.
- Growth of ancillary units.
- Superior program execution skills and capabilities.

4. (*Factor 4*) *Enabling Institutional ecosystem*
- Active research institutions working in the field of offshore wind energy.
- Build accurate data on offshore wind potential sites and wind speeds (Wind resource map and Bathymetric data).
- Skills development and training of the human capital on offshore wind systems.
- R&D to localize production of expensive equipments to bring the overall costs down.

6. Factors obtained from statistical analysis



7. Variables grouped as different factors

1. (*Factor 1*) *Fiscal and quota based incentives*
- Feed-in tariff (Higher tariff for offshore wind vis-a'-vis other renewable).
- Accelerated depreciation.
- Generation based incentives (GBI).
- Enforcement of Renewable purchase obligations (RPO)/renewable energy certificates (REC).

2. (*Factor* 2) *Government support*
- Faster approvals and Single window clearance mechanisms for offshore wind energy projects.
- Sustainability of policies environment for a longer term (10 years or more).
- Constructing evacuation Infrastructure and facilities for storage of electricity not injected into the grid.

5. (*Factor 5*) *Availability of capital for investments*
- Availability of capital at attractive rates of interest similar to what is extended to priority sector projects.
- Moratorium on interest payments for the first few years of project go-live.
- Offshore wind energy fund from cess levied on carbon emissions or a Government backed guarantee to reduce the cost of capital.
- Financial Institutions willing to lend to offshore wind projects as priority sector.

8. Conclusions and recommendations

India needs every avenue of energy source to power its economy. However, offshore wind energy is an untapped source. Offshore wind policy formulation for India must cover five broad

areas of Government support, fiscal and quota based incentives, availability of local expertise, capital for investments and enabling R&D ecosystem. All these 5 levers (factors) positively contribute to the growth of offshore wind energy in India, (obtained logistic regression techniques beyond the scope of this paper). The relative impact of these factors on the growth of offshore wind energy in India obtained using logistic regression techniques are fiscal and quota based incentives (33.6% impact), Government support (32%), enabling R&D ecosystem (25.3%), availability of local expertise (5.7%) and capital for investments (3.4%). As can be observed 3 levers (Fiscal and quota based incentives, Government support and enabling R&D ecosystem) have high impact on the growth of offshore wind energy in India. Based on the research the following recommendations are made to policy makers in India to foster the growth of offshore wind energy in the country.

8.1. Nodal agency for faster approvals

India needs to create a nodal agency, under MNRE, to act of the ''single window approval'' authority for all offshore wind energy projects, similar to what has been done in Denmark, which will liaise with other government agencies, as needed, to secure all necessary approvals and consent for offshore wind energy farms. There are several ministries or departments in India that needs to be approached to obtain consent by the developers of offshore wind energy projects. Such cumbersome procedures will delay the commissioning of these projects resulting in substantial cost and time overruns, which could not be afforded by developers who have to incur huge capital costs for offshore wind farms. Expecting a project developer to obtain these approvals from multiple agencies will be a daunting, show-stopper experience. Hence, it is important that a nodal agency under MNRE should be created to provide a single window clearance for offshore wind energy projects. Many of the challenges in obtaining approvals can be resolved, if MNRE identifies a large chunk of area in the seas that have all the clearances in place prior to inviting bids to installation of offshore wind energy technology park.

8.2. Accurate data on wind speeds

India needs to build bankable data on wind speeds at the seas to predict the exact potential of offshore wind energy. Wind speeds are very critical to estimate the power output of the offshore wind farms, which decides the cash flows and hence the viability of the project. As the power output varies directly to the cube of the wind speeds, even a minor variation in estimating the wind speeds may results in huge deviation in the power output for the offshore wind farms. Hence, the need to predict the wind speeds as accurately as possible.

8.3. Evacuation infrastructure

Several research papers have concluded that availability of evacuation infrastructure is one of the most important criteria for growth of offshore wind energy in any country. Numerous projects in Europe are facing delays due to non-availability of adequate evacuation infrastructure. Also, transmission infrastructure costs are quite high for offshore wind farms, as sub-sea cabling requires superior engineering skills. European countries have adopted different models for sharing the prohibitive costs associated with construction of evacuation infrastructure. In Denmark, for instance, the costs associated with evacuation infrastructure are being borne by the Government, whereas in Netherlands the project investor bears the costs fully and in Germany it is being borne by the Transmission System Operator. Research conducted by independent agencies like EWEA, EEA suggest that investors prefer the Denmark model of government fully contributing to the building of transmission infrastructure while recovering the costs from the public via a small increase in tariff. Similar model ('Socialising the costs') can be thought of in India, as the capital investments needed for setting up offshore wind energy farms are prohibitive vis-à-vis other renewable energy technologies. A project developer will not be able to bear the additional costs of building the evacuation system as well.

8.4. Develop and communicate policy intent for long term (10 years or more)

Published research has shown that having a focused policy for offshore wind energy farms and having a continuity of these policies for longer term has helped offshore wind energy sector to grow in countries compared to those countries that had ''Traffic signal'' type of 'start-wait-stop-start' policy measures. Policy continuity for long term gives the investors assurance of support from the government for the sector; thereby reducing the risk of future cash flows. Uncertainties in continuation of benefits have slowed down investments in several countries like Sweden and Netherlands in Europe. Even in India, when accelerated depreciation (AD) for onshore wind energy projects was withdrawn, investments have slowed down. Now project developers in India not only want accelerated depreciation to be re-introduced but they also want an assurance from the government that such fiscal benefits will continue for long term to make further investments in the onshore wind energy sector.

8.5. Legally enforceable payment mechanism

Onshore wind energy developers in India have faced long delays in realizing payments from the state distribution companies/electricity boards that purchase the electricity generated by these wind farms. This delay has severely affected the cash flows and working capital of project developers. As offshore wind energy projects are much more capital intensive than the onshore wind farms, delays in releasing the payment on time will put the overall viability of the project in jeopardy. Unfortunately, the financial health of most of the distribution companies in India is poor, which restricts their payment capacity on time. The project developers are then left with no problem resolution mechanism to realize the money due to them, in the event of a default or delay by the state electricity boards or distribution companies. Hence, suitable legal armour needs to be provided for the project developers to induce confidence that the money due to them will be disbursed on time by the SEBs. Legally enforceable payment mechanism will offer the necessary problem resolution protection and a means of escalation mechanism, which can be exercised in the event of severe delays of accounts receivables for project developers, which is lacking at the moment.

8.6. Encourage R&D in offshore wind energy

India needs to encourage R&D efforts to accelerate learning, bring down the costs of components, build knowledge base, develop skills in offshore wind farms and localize production of wind turbines. Offshore wind energy would need 20 additional resources for every MW of capacity added. India has started well to establish CWET (Centre for Wind Energy Technology, R&D arm of MNRE) to encourage skill development in wind energy. Similarly, R&D efforts to localize production of various components of wind turbine (like gearbox like instance) that are currently being imported at expensive rates, setting up of ancillary units to support the offshore wind industry are needed to

accelerate the growth of offshore wind sector in India. Several countries in the world like China have reduced the overall cost of setting up of wind farms by as much as 50% due to localization. India needs to build R&D capability to achieve similar objectives.

8.7. Fiscal and quota based incentives for offshore wind energy

All the project developers surveyed for this research have expressed their views that offshore wind energy in India would need a higher incentive (higher feed—in tariff vis-à-vis other renewable as adopted by Germany), higher renewable obligation certificates (for example 2 ROCs for every 1 MW h of offshore wind energy as adopted by the UK) at least in the initial few years to be established as another avenue for electricity generation. Accelerated depreciation of 80% of capital cost in the first year, which has been discontinued recently for onshore wind farms, can be re-introduced. Generation based incentives (GBI) with a generous cap of (10% the cost of project as envisaged in select countries in Europe) over the life of project can be considered.

8.8. Financial incentives

Offshore wind energy sector in India can be declared as a 'priority sector' by the Government to help developers' access inexpensive bank loans. A priority sector tag, similar to what is given to agriculture, will entail an interest rate of 2% for loans from the banks. Presently, IREDA charges around 12% interest on the sum advanced for renewable energy projects in the country. As a MW of offshore wind farm is likely to cost Indian Rupees 15 Crores ($\sim$ US $ 3 Million), project developers will find it hard-pressed to service loans at higher rates of interest. Hence, declaring offshore wind as a priority sector will ease a huge amount of burden on project developers and encourage them to take debt on their balance sheets. Cost of capital can also be reduced by levying a cess on fossil fuels and using the sum collected to partly fund offshore wind energy projects in India. Moratorium on interest payments for a period of minimum 5 years was another expectation from the project developers to invest in offshore wind sector in India. Apart from these the Government needs to extend the same benefits given to onshore wind energy sector to offshore as well–in terms of zero import duty on equipment and excise duty waivers to kick start the growth of the sector.

Technology, market and finances are available in India. What is needed is a policy framework.

Appendix A. List of Abbreviations

AD	Accelerated depreciation
CEA	Central Electricity Authority, India
CERC	Central Electricity Regulatory Commission
CWET	Centre for Wind Energy Technology
EPC	Engineering, procurement and construction
EU	European Union
EEA	European Environmental Agency
EXIM Bank	Export-Import Bank
EWEA	European Wind Energy Association
FDI	Foreign Direct Investment
FiT	Feed in tariff
GBI	Generation based incentive
GDP	Gross domestic product
GHG	Greenhouse gases
GW	Giga watt (=1000 Mega watt)
IEA	International Energy Agency
IREDA	Indian Renewable Energy Development Agency
kW	Kilo watt
kw h	Kilo- watt hour (1 unit of electricity)
MNRE	Ministry of New and Renewable Energy, India
MT	Million tonnes
MW	Megawatt (=1000 kilo watt)
REC	Renewable Energy Certificates
RES	Renewable energy sources
RPO	Renewable purchase obligation
RPS	Renewable purchase specification
SEB	State Electricity Boards, India
SERC	State Electricity Regulatory Commission
SPSS	Statistical Package for the Social Sciences (Software tool)
TGC	Tradable Green Certificates
TW h	Terra-watt hour (Billion units of power)
WISE	World Institute of Sustainable Energy, Pune, India
WPD	Wind power density

Appendix B. Questionnaire

Thanks for taking time to answer a set of questions on the Wind energy (offshore) sector in India. There are no 'right' or 'wrong' answers to these questions. Also, your exact identity will not be captured. So please feel free to respond to the best of your belief and conviction. The data collected will be used only for my PhD research work and will not be shared with any third party. It is likely to take about 10 minutes to complete this questionnaire. Thanks.

You are an

a. Wind Turbine Manufacturer
b. Policy Maker (MNRE, Planning Commission)
c. Regulatory Agency (CERC, SERC)
d. Financing Institution (IREDA or other banks)
e. Academic and R&D Institution with interest in Wind Energy
f. Electricity board (Transmission and Distribution companies)
g. Project Developer
h. EPC Contractor
i. Independent consultant/Thought leader
j. Others (Please specify)

Section I

1. India has good potential to grow the offshore wind energy sector in the country

(·) Strongly Disagree (·) Disagree (·) Neutral (·) Agree (·) Strongly Agree

2. For offshore wind energy sector to take-off, comprehensive **offshore wind energy policies** have to be initiated by the Government of India

(·) Strongly Disagree (·) Disagree (·) Neutral (·) Agree (·) Strongly Agree

3. Currently, **technological capability** is available to harness the Offshore wind energy in India

(·) Strongly Disagree (·) Disagree (·) Neutral (·) Agree (·) Strongly Agree

4. **Capital and funds** are available to develop the offshore wind energy sector in India.

(·) Strongly Disagree (·) Disagree (·) Neutral (·) Agree (·) Strongly Agree

5. India has to eventually tap **offshore wind energy** to satisfy the ever growing demand for electricity in the country.

(·) Strongly Disagree (·) Disagree (·) Neutral (·) Agree (·) Strongly Agree

Section II

For the questions below, please choose (on the 7 point scale) your response based on whether the variable proposed is an '*absolute must to have*' for the growth of offshore wind energy sector in India. Please 'tick' or 'circle' your response on the choice for e.g., Agree.

6. Feed-in tariffs is 'an absolute must' to grow the Offshore wind energy sector in India

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

7. Accelerated depreciation has to be offered to grow the Indian offshore wind sector

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

8. Generation based incentives (GBI) must be offered to grow the offshore wind energy sector in India

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

9. Legally binding Renewable purchase obligation (RPO/REC) is an essential prerequisite to see the growth of offshore wind energy sector in India

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

Section III

10. Faster approvals (like Single window clearance mechanisms) is an 'absolute must' to grow the offshore wind energy sector

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

11. Sustainability of policy environment, on offshore wind, for a longer term (say 10 years or more) is very important to accelerate the growth of offshore wind energy sector.

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

12. Construction of transmission infrastructure to evacuate power from offshore wind farms in the seas, is an important prerequisite to grow the offshore wind energy sector.

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

13. Extending financial incentives (like subsidies, moratorium on interest payment, zero duty on imports, excise duty waiver) for offshore wind projects is a must.

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

14. Tariff determination on wind speeds, and not based on zones, is an essential pre-requisite for the growth of offshore wind energy sector

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

Section IV

15. Expertise and availability of EPC contractors for commissioning of the offshore windarms will be a determining factor in the growth of offshore wind energy sector in India.

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

16. Manufacture and availability of offshore wind energy components (like gearbox), locally, will be very important to grow the offshore wind energy sector in India.

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

17. Growth of ancillary units is key to grow the offshore wind energy sector in India.

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

18. Superior program execution skills and capabilities available for execution of projects is critical to grow the offshore wind energy sector in India.

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

Section V

19. Research institutions to build accurate data on offshore wind potential sites and wind speeds (Wind Resource map and Bathymetric data) is critical to grow the offshore wind energy sector in India.

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

20. Institutions focussing on Skills development and training of the human capital, needed to work on offshore wind farms, will be needed to grow the offshore wind sector.

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

21. R&D investments to localize production of expensive equipments, to bring the overall costs down, will be crucial to grow the offshore wind energy sector in India.

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

Section VI

22. Availability of capital at attractive rates of interest, similar to what is extended to priority sector projects, is an absolute must 'to grow the offshore wind energy sector in India

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

23. Moratorium on interest payments for the first 5 years of project go-live, is needed to grow the offshore wind energy sector in India.

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

24. Creation of an offshore wind energy fund, from cess levied on carbon emissions or a Government backed guarantee to reduce the cost of capital, will be needed to grow the offshore wind sector.

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

25. Access to funds (from financial institutions) is not a problem to set up offshore wind energy farms in India.

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

26. Declaring offshore wind energy sector as a"priority sector" for lending will help in the growth of offshore wind energy in India

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

Section VII

27. Offshore wind energy sector can still grow in India without dedicated policies for the sector.

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

28. It's still premature to talk about offshore wind energy in India. Time has not come as yet to tap the offshore wind power in India.

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

29. Offshore Wind energy policies adopted successfully by select European countries (Germany, Denmark and the UK) can be used as a reference by India for bringing out its own offshore wind policy.

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

30. I/my company will not consider investments in offshore wind energy sector in India, until dedicated offshore wind energy policies are put in place in India.

Strongly Disagree | Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Agree | Strongly Agree

Section VIII

Please complete the following sentences

Offshore Wind Energy sector in India
To harness the Offshore Wind Energy India needs to___
Large companies will be interested to invest in offshore wind energy in India if ___
Please rank these variables in order of priority (e.g., Rank 1 means highest priority) that will influence the growth of the offshore wind energy sector.

Sno	Variable	Rank
1	Feed in tariffs (FiT) for offshore wind energy farms.	
2	Accelerated depreciation for offshore wind energy projects.	
3	Generation based Incentives (GBI) for offshore wind farms.	
4	Legally enforceable RPO/REC to buy power from offshore wind farms.	
5	Faster approvals/single window clearance for offshore wind projects.	
6	Continuity of offshore wind policies for long term (more than 10 years).	
7	Adequate evacuation infrastructure to transmit power from high seas.	
8	Tariff determination on wind speeds and not on zones.	
9	Financial incentives like zero import duty, excise duty waiver for offshore.	
10	Availability of expert EPC contractors to deploy offshore wind farms.	
11	Availability of local manufacturing expertise for offshore wind turbine.	
12	Growth of ancillary units (e.g., gear box) for offshore wind farms.	
13	Superior program execution skills of the developer to develop wind farms.	
14	Accurate data on offshore wind potential sites and offshore wind speeds.	
15	Skills development and training of human resources on offshore wind.	
16	Active research institutions working on offshore wind energy.	
17	R&D facilities to localize production of expensive equipments.	
18	'Priority sector' tag to offshore wind energy sector.	
19	Availability of capital at attractive rates of interest.	
20	Creation of offshore wind energy fund to reduce cost of capital.	
21	Moratorium on interest payments for the first 5 years of project go-live.	

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