

Repowering of old wind turbines in India



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Indo-German Energy Forum Support Office
c/o Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
1st Floor, B-5/2, Safdarjung Enclave
New Delhi 110 029, India
Email: info@energyforum.in
Website: www.energyforum.in
Tel.: +91 11 4949 5353

Project Lead: Mr. Balwant Joshi

Principal Investigator: Mr. Krishnajith M U

Project Team:

Mr. Balwant Joshi (Idam)
Mr. Ajit Pandit (Idam)
Mr. Krishnajith M U (Idam)
Mr. Anny Mary (Idam)
Mr. Sujoy Das (Idam)
Mr. Markus Wypior (GIZ)
Mr. Anil Kumar Bellary (GIZ)
Ms. Sandra Soares da Silva (KfW)

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Study by:

Idam Infrastructure Advisory Pvt. Ltd
Regd. Off: 801, 8th Floor, Crystal Plaza
158, C.S.T. Road, Kalina
Mumbai 400 098, India
Email: contact@idaminfra.com
Website: www.idaminfra.com

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Bhanu Pratap Yadav, IAAS
Joint Secretary



भारत सरकार
नवीन और नवीकरणीय ऊर्जा मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF NEW AND RENEWABLE ENERGY

FOREWORD



The Government of India's renewable energy (RE) target of 175 gigawatt (GW) has led to an unprecedented capacity addition in recent years. In the case of wind energy, the Government has not only set a target of 60 GW but has also initiated competitive bidding, resulting in significant decrease in the cost of wind energy. Owing to these initiatives, presently, India has successfully achieved 71 GW of RE capacity as on 30 June 2018.

In India, wind energy has been a flag bearer in the RE sector having 34 GW capacity, which is about 48% of total RE capacity. According to the National Institute of Wind Energy (NIWE), an autonomous body under the Ministry of New and Renewable Energy, wind power potential is estimated to be 302 GW at 100-meter hub height and hub heights of new wind machines are higher than 100 meters.

As in case of most natural resources, development of wind projects started in the 1990s and early 2000 and it took place at the best windy sites in Tamil Nadu, Gujarat and the other hilly regions. As a result, smaller wind turbines of lower capacity and efficiency were installed at best windy sites. Now turbines are much bigger and with enhanced efficiency which have to settle for lesser windy sites. For effective utilisation of 'wind resource' as a national energy source, it is necessary that wind potential at these sites is appropriately utilized.

Thus, replacement of old wind turbines with new wind turbines or 'repowering' assumes importance. 'Repowering' was successfully executed in Germany besides other countries. The Government of India announced the 'Policy for Repowering of Wind Power Projects' on 05 August, 2016. State Government of Gujarat has recently announced the 'Gujarat Repowering of the Wind Projects Policy- 2018'. However, despite the policy, actual uptake of repowering project is rather slow. In this context, an up to date and revised study on the 'Framework for Repowering of Old Wind Turbines in India' commissioned by IGEF/GIZ and prepared by Idam Infrastructure Advisory Pvt. Ltd. assumes importance. It critically analyses market for repowering in India, reviews existing policies of both central and state governments and provides an overview of international success stories.

I sincerely hope that this revised and updated report by IGEF and Idam Infra re-ignites the debate on the challenges faced by repowering projects and leads towards potential solutions. I look forward to an accelerated push to the repowering of wind-turbines projects in India, thus contributing to the clean energy transition and meeting the Intended Nationally Determined Contributions (INDC) goals.

B B Yadav
Joint Secretary (Wind Energy), Ministry of New and Renewable Energy (MNRE)

Block No. 14, CGO Complex, Lodi Road, New Delhi - 110 003
Telefax : 91-11-24360359 • E-mail : yadavbp@cag.gov.in

Key Findings

1

In India more than 10 GW of old wind turbines with less than 1 MW capacity are installed in very wind rich class 1 sites. 2,5 GW with less than 500 KW turbine capacity are presently installed in India.

2

Repowering these relatively old wind turbines with modern turbines promises to more than quadruple the energy generation on these sites.

3

Capacity Utilisation Factor (CUF) of old wind plants with less than 500 KW even in wind rich class 1 sites is in the range of 10-14%, while in these wind rich sites the effective CUF can be at least 25%.

4

Business models for successful implementation of repowering projects in India have been developed. A promising one is covered in this report.

5

Lack of implementation due multiple reasons, but especially due to constraints, not incentivising sufficiently to bring very fragmented, existing individual wind mill owners together.

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Executive Summary

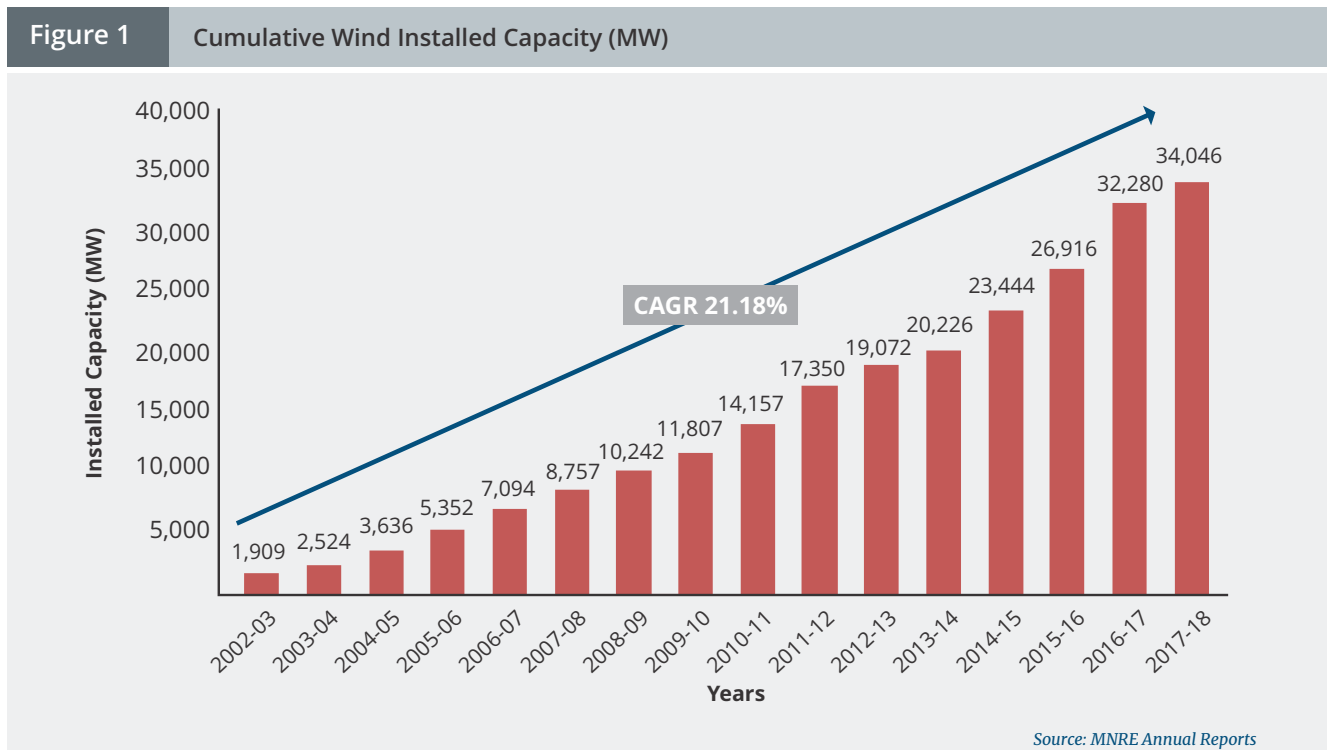
As wind power generation facilities age through the years of operations, toward the end of their useful lives, project owners are faced with plant end-of-life decisions. This report is intended to inform policymakers, wind power project developers, investors, funding institutions and other stakeholders within the wind industry regarding the technological options, business opportunities and challenges associated with such plant end-of-life decisions, in particular, repowering. This report extensively deals with several local site-specific issues that are the potential roadblocks for repowering in India. India has witnessed aggressive growth in harnessing wind energy for nearly two decades. Development of wind power projects started way back in mid-1990's. These wind power projects are located at the wind resource rich sites, with turbines of very low capacity, less than 500 kilowatt (kW) and with a hub height of not more than 25 to 30 meters. The research carried out for this study reveals that such projects currently have an average capacity utilisation factor (CUF) of only 10% to 14% even though these sites have very good wind resource. It can be understood that, had those sites been available for modern wind turbines to be installed, the effective CUF would have been at least 25%.

Under such circumstances, and amidst a conducive environment for accelerated growth of renewable energy, the Government of India has announced an ambitious target of 160 gigawatt (GW) of wind and solar energy installations by 2022. The plan embarks upon wind energy deployment of 60 GW by 2022. To achieve such an ambitious target; depending on greenfield projects, especially in windy sites with average wind resource profile, may not yield the desired outcome. Hence, to increase the wind energy portfolio and to ensure energy security in the long run, repowering of old wind power projects appear to be the most effective tool to harness massive potential of wind energy.

This report also aims to develop understanding of the repowering framework in Germany, Denmark, Spain and Netherlands whose success in repowering of wind energy is commendable. Various issues acting as a bottleneck and various interventions influencing the growth of repowering projects have been studied in detail. Based on the daunting issues for repowering, long-term sustainability of projects and other relevant assumptions, a holistic business model has been proposed. The study addresses the concerns of various stakeholders who are likely to be involved in the implementation of the proposed business model with clear definition of their roles and responsibilities. Success of the proposed business model would also, to a large extent, depend on the Government support at various levels – an aspect that has been covered in this report. Policy support in the form of financial incentives, as well as solutions to potential regulatory and contractual hurdles, would be necessary if an accelerated deployment of repowering and investment in this business segment is to be created.

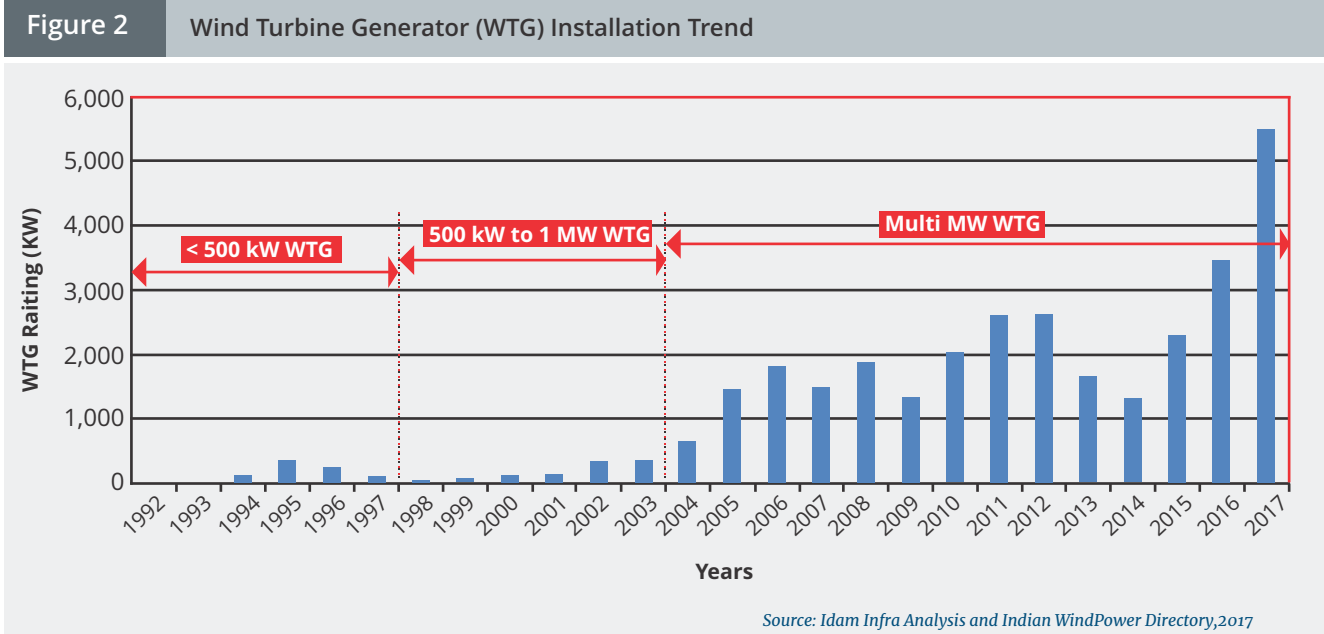
1. Introduction

India has a cumulative renewable energy installed capacity of 69,022 megawatt (MW) as on 31 March 2018. Out of the total installed RE capacity, 34,046 MW is contributed by wind energy that accounts for 49.32% of the total renewable energy generation capacity. Although the total potential of wind energy is more, the country can harness only a part of it due to many reasons — a solution to some is repowering. The major areas with wind energy installations are concentrated in the western and southern parts of the country, mainly due to the coastal location that brings in wind and conducive policies of the respective states. Over the years, the States of Gujarat, Rajasthan, Maharashtra, Madhya Pradesh, Tamil Nadu, Andhra Pradesh and Karnataka have witnessed significant investment in the sector. The cumulative deployment of wind energy systems over the years is shown in Figure 1.



In India, wind power development commenced with the installation and demonstration of the first wind turbine generator unit, with a unit size of 55 kW. Installation of wind turbines of different class and unit sizes ranging from 90 kW to 225 kW quickly followed. With an increase in the participation of wind market in 1990s, wind turbines of 225 kW to 500 kW unit size was the preferred choice. In contrast, today, the most popular wind turbine unit size in India ranges from 1 MW to 3 MW. The hub height of wind turbines, which was initially 26 metres(m) has increased to about 80m to 100m today. The standard commercially available wind turbine size which was 150 kW 15 years ago and 500 kW 10 years ago, has now moved up to 2,000 to 3,000 kW.

The evolution of wind turbines since the last two decades is depicted in Figure 2.



The old wind turbines below 500 kW range is still in operation in many states such as Tamil Nadu, Gujarat, Madhya Pradesh and Maharashtra. Studies reveal that about 10% of the total wind installations in India have less than 500 kW rating totalling around 3,500 MW. It would also be worthwhile to note that most of these turbines have been installed at Class I wind sites with high wind power potential. This shows that a significant potential for repowering exists in India.

To harness the available wind resource at these wind rich sites, repowering activities must be adopted on a priority basis, which could be a viable option for the investors and would vastly increase the total renewable energy generation capacity of India.

1.1 Objective Of The Study

In India, the National Institute of Wind Energy or NIWE (erstwhile C-WET) estimated the total potential of installed capacity of wind energy at 100meter hub height to be 302 GW. The objectives are framed based on the target of Indian Government of deploying 60 GW of wind energy by 2022. The primary objective is to lay a guideline for the optimum utilization of Class I wind resource rich sites by repowering the old wind turbines.

The broad objectives of this study are mentioned below:

- I. Overview of the wind energy sector in India.
- II. Identifying the potential benefits and challenges associated with wind repowering.
- III. Overview of international experience in repowering with focus on Germany, Denmark, Spain and Netherlands.
- IV. Overview and identification of major factors that influence the decision of repowering by project developers and the correlation between various factors
- V. Detailed overview of the financial requirements of repowering and identification of suitable business model for all the parties involved.
- VI. Detailed overview of the policy and regulatory interventions required.
- VII. Detailed overview and identification of total repowering market potential in India.
- VIII. Knowledge sharing through stakeholder consultations.

1.2 Key Components Of The Study

The study is divided into following four modules to provide focused attention to each key component of the work.

- Market Study for Re-Powering
- Evaluation of Business Model and Selection
- Development of Implementation Roadmap for Selected Model
- Development of Draft Guidelines for Repowering

1.3 Potential Benefits And Issues Associated With Repowering Projects

The old wind turbines, especially those nearing the completion of their life, suffer from several operational, technical and financial problems such as the following:

- Poor control mechanism
- Grid integration control
- Poor regulation
- Reactive power control

However, there is a better alternative to address the sub-optimal utilization of Class I wind potential sites in the country. This process involves replacement of small WTGs with modern and more efficient WTGs of higher capacity. This process is called repowering of old wind power projects.

According to a research performed by Grontmij, in 'Replacement of Existing Wind Turbines, 2000', repowering can be done in any of the following ways:

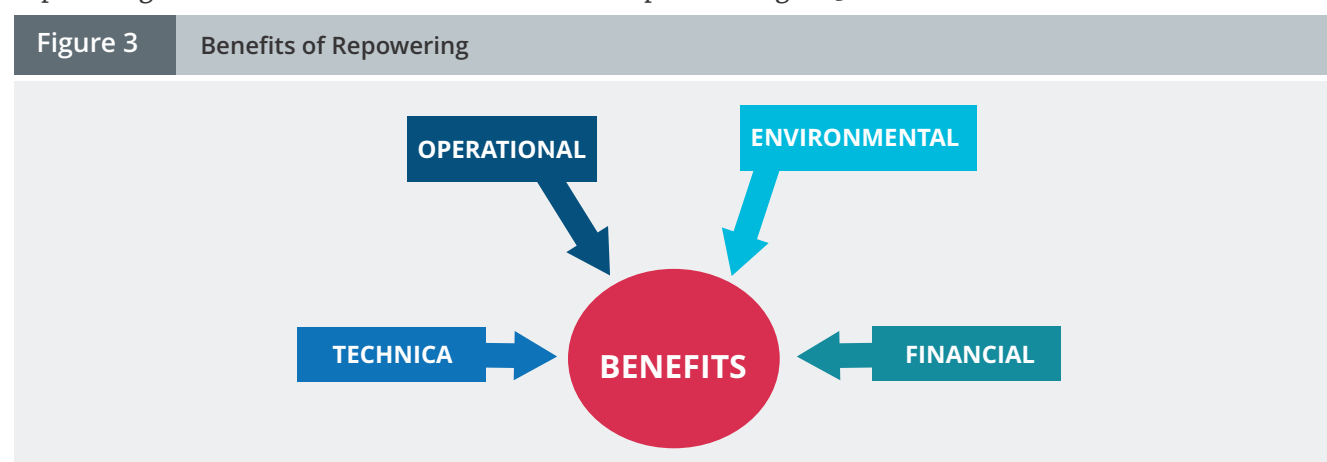
- One-to-one replacement
- Two-to-one replacement
- Clustering into farm
- One-to-one up scaling of wind farm

Each of these alternatives has its own advantages and disadvantages. Alternative 1 has the largest electricity production potential and alternative 4, the lowest. For each alternative, there is a positive impact on the landscape, the best one being alternative 3, i.e., clustering into wind farm model.

In this study, clustering into wind farm model is envisaged, wherein, the multiple solitary wind turbines at different locations of a wind farm are replaced with higher capacity state of the art, but fewer in number WTGs to develop a wind farm. This model is very apt in the Indian context as the potential sites are filled up with turbines with very low capacity, which can be replaced by newer and higher capacity turbines.

1.3.1 Potential Benefits Of Repowering

Repowering of wind farms offer several benefits as depicted in Figure 3.



Technical

- i. Efficient utilisation of potential wind sites producing higher quantum of energy.
- ii. Improved CUF at given wind farm site.
- iii. Higher efficiency.

Operational

- i. Reduced operation and maintenance (O&M) costs.
- ii. Modern wind turbines/farms offer better integration with grid.
- iii. Better management of grid parameters and provision of higher operational flexibility for the system operators

Environmental

- i. Reduced impact on movement of birds.
- ii. Reduced noise pollution

Financial

- I. Achieve better wind power economics.
- ii. Reduction in land area per MW of wind farm.
- iii. Additional energy generation can yield higher profits including more Renewable Energy Certificate (REC) offerings.
- iv. Clean Development Mechanism (CDM) benefits.

Owing to the reduced number of turbines, chances of collision or affecting the movement of birds (migratory or otherwise) is minimal. Moreover, the modern turbines generate less noise pollution due to higher design sophistication and better technology.

1.3.2 Driving Factors To Influence Repowering Installations

- For independent wind power producers (IPPs)/wind power generating companies trying to scale-up their wind portfolios and achieve critical mass rapidly, there has been a preference for turbines of larger size. This due to the power potential of a wind turbine determined by the square of the rotor diameter - a large turbine, delivering more power than two separate turbines of half the size.
- In addition, for offshore markets to minimize the installation cost per MW, a significant proportion of the cost of foundation (the largest possible capacity) is installed on each foundation unit.

From the **Government perspective**, following are the reasons to promote repowering:

- The additional generation will create a larger base for wind energy, thereby increasing the renewable energy portfolio of the country.
- Although the repowered wind turbines are taller in height, quality of the landscape is often perceived as being 'improved', since the number of turbines is reduced in the changed scenario.

1.3.3 Key Implementation Issues And Challenges

Several challenges exist in the implementation of repowering program on a large scale. Majority of these challenges are technical, administrative and contractual in nature. However, a conducive policy regime and a structured business model can help address the concerns of all stakeholders and pave way for the adoption of repowering in many states. The challenges in early adoption of repowering are as below:

I. Turbine Ownership:

Repowering will reduce the number of installed turbines and there may not be any replacement of turbines. The number of owners may be more than the number of installed turbines. Hence, the issue of turbine ownership is important.

ii. Land Ownership:

Multiple owners of the same wind farm land may create complications for initiating repowering projects.

iii. Power Purchase Agreement (PPA):

The procurer may be not be interested to modify/revise a PPA signed with the state utility for 10, 20 years or more, before its expiry, as the new tariff would be higher than the one at which the original PPA was signed.

iv. Electricity Evacuation Facilities:

The current grid facilities that are designed to support the generation capacities may require augmentation and upgradation.

v. Additional Costs:

Additional decommissioning cost for old turbines needs to be assessed. Although, these costs can be covered to a large extent by the mere scrap value of old turbines.

vi. Disposal of Old Turbines:

Old turbines can be disposed either by scrapping or buy-back by the government or the manufacturer, or by exporting to other countries. The old turbines cannot be installed in any other location within the country.

vii. Lack of Incentives:

One of the primary barriers to repowering is the general lack of economic incentive to initiate the project.

viii. Policy Package:

Unavailability of a proper policy framework encouraging repowering project.

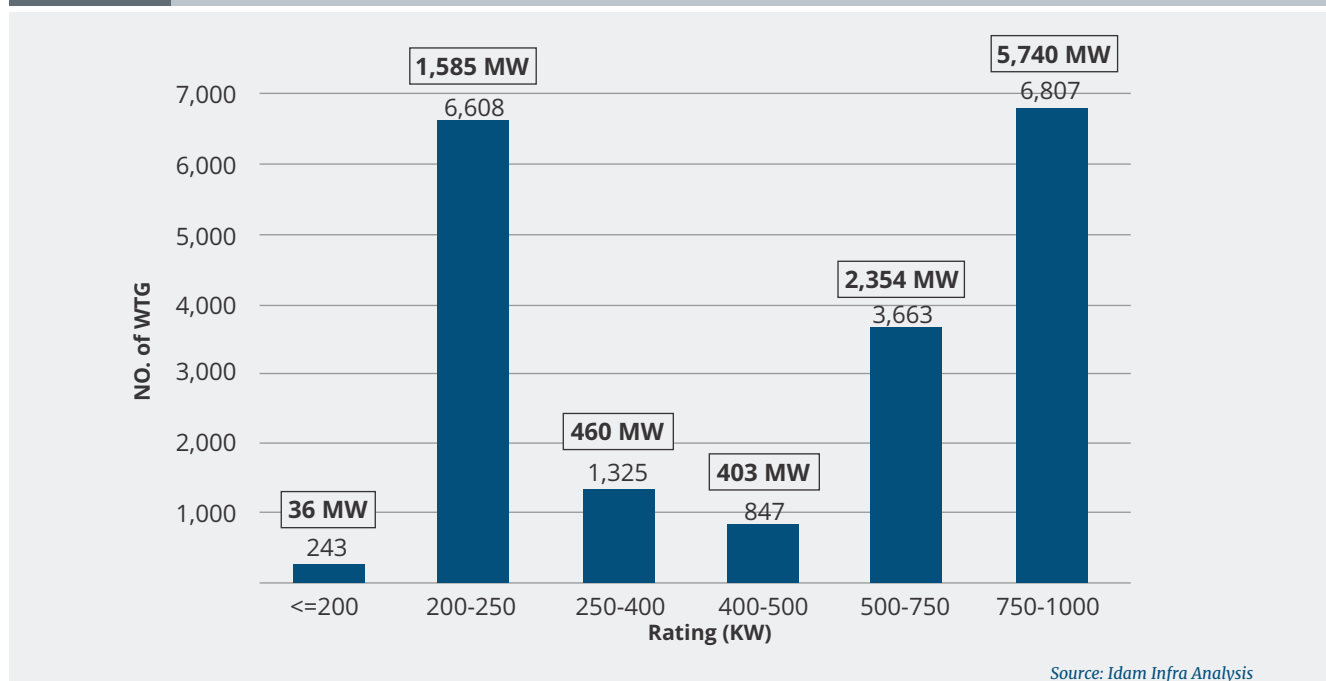
Considering India's power requirement, percentage of RPO of various Indian states and the target set by the Government, repowering would be an ideal option. This will also encourage the wind power market in the country to fully utilise the wind resources at many good wind rich sites.

2. Market Potential Assessment For Repowering

2.1 Wind Power Development In India

India has witnessed substantial growth in wind energy capacity addition over the last decade. The growth momentum has spread across major wind rich states such as Gujarat, Maharashtra, Madhya Pradesh, Tamil Nadu, Rajasthan, Andhra Pradesh and Karnataka. However, it is observed that there were significant installations prior to 2002 involving wind turbine generators with capacity less than 1 MW. The first WTG was commissioned in the late 80s with a turbine capacity size of just 55 kW, and thereafter the WTG size started increasing. Till date, around 19,503 WTGs of below 1 MW capacity is installed in various parts of the country with a cumulative capacity of more than 10,578 MW. It is pertinent to note that, these WTGs are installed in the best wind sites of the country highlighting a bare fact that these sites are not optimally utilized. Distribution of WTGs of capacity less than 1 MW is depicted in Figure 4.

Figure 4 WTG Capacity Wise Classification (From 1989-90 to 2016-2017)



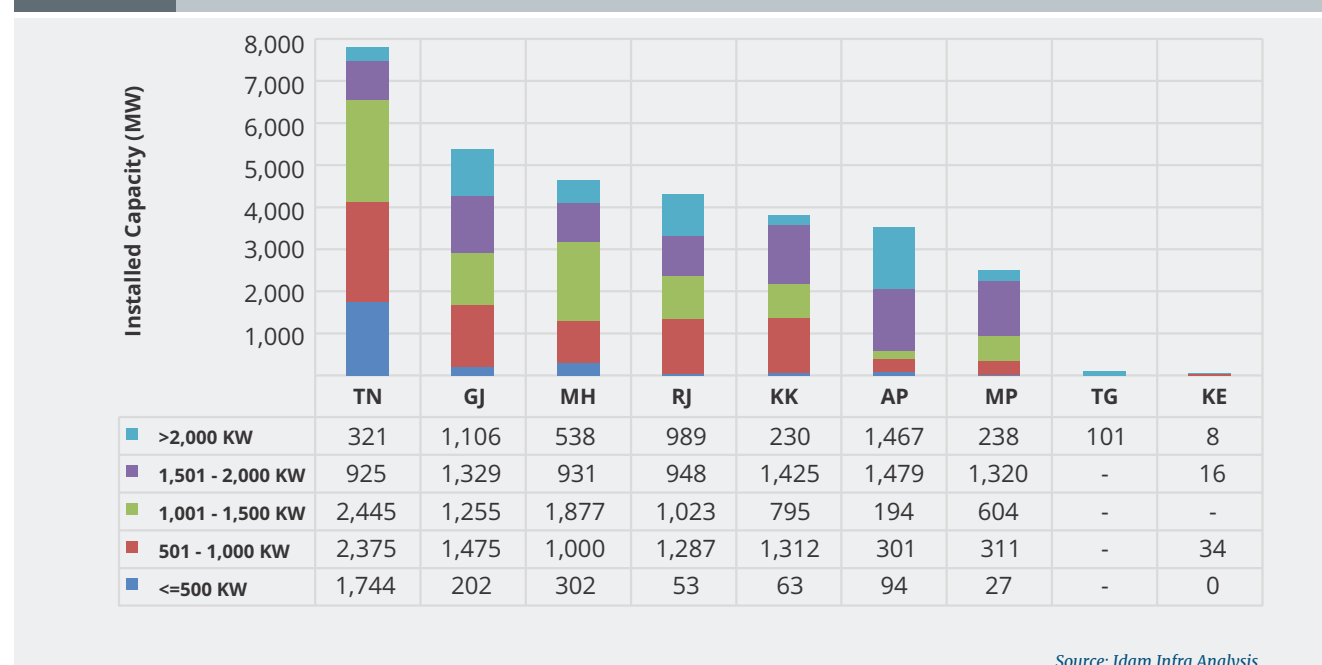
The above graph shows that if the installed WTG of capacity size less than 1 MW is considered, a repowering potential of at least 10,578MW exists which is spread across 19,500 odd wind turbines.

It is also observed that a significant repowering potential exists in the country if WTGs with capacity size below 500 kW is taken into consideration. As on 31 March 2017, around 2,484 MW of installed capacity exists with turbine size below 500 kW. Each of these WTGs can be replaced with more efficient WTGs with a turbine having capacity between 1 to 3 MW. Currently, in the Indian market, turbine manufactures such as Siemens Gamesa, INOX, Suzlon Energy, Vestas Wind Technology, GE India, Regen, Acciona, etc. have turbine models of capacities greater than 1MW. Siemens Gamesa and INOX have wind turbines with capacity ranging up to 2MW, Suzlon up

to 2.1 MW, Vestas Wind up to 2.1 MW, GE India up to 2.33 MW, Regen up to 2.8 MW, Acciona up to 3.0 MW, etc. Installation of new turbines of higher capacity results in the overall increase of capacity by 2 to 3 times.

Based on the WTG capacity, the development of wind energy in various states is illustrated in Figure 5. The figure depicts a significant quantum of installation of WTGs of capacity below 500 kW. Besides, the maximum potential for repowering of such projects with turbine size below 500 kW exists in Tamil Nadu, Maharashtra and Gujarat with an installed capacity of 1,744 MW, 302 MW and 202 MW respectively.

Figure 5 All India WTG Wise Installed Capacity as on 31 March 2017



2.2 Methodology For Market Potential Assessment For Repowering

During our analysis for assessment of repowering potential across the country, the installed capacity of each WTG was considered. The analysis considered installations since 1995 to bring up the potential in the respective states. Analysis of market potential included turbine size, completion of operational life of 15 years, year of commissioning, resource location, operating PLF (Plant Load Factor), etc. The primary data collected was analysed using the above parameters to quantify the number of turbines of each category of capacity size across all states.

From this analysis, the total capacity for repowering potential for each state was identified. Based on the criteria such as the life of project, WTG capacity size, etc., the potential that can be repowered commencing from 2017, as well as quantification of potential for the next 10 years, i.e., till 2027, was performed. This analysis was undertaken depending upon the date of commissioning of wind power plants. To identify the potential, projects commissioned prior to 2002 were selected. The results are summarized in Table 1.

Table 1 State-Wise Repowering Potential (Capacity <1 MW)**Break-up of All India installed WTGs(COD prior to 31-Mar-2002)**

	State	<=500 KW	500 to 1000 KW	Total (KW)
	Andhra Pradesh	84,890	1,500	86,390
	Gujarat	1,51,795	2,200	1,53,995
	Karnataka	30,075	36,900	66,975
	Maharashtra	2,41,795	1,59,150	4,00,945
	Madhya Pradesh	21,100	0	21,100
	Rajasthan	14,040	0	14,040
	Tamil Nadu	7,75,780	58,250	8,34,030
	Kerala	225	0	225
	Total	13,19,475	2,58,000	15,77,475

Source: Indian Wind Power Directory, 2017

- Estimate of repowering potential for WTGs with capacity sizes less than 1,000 kW and with date of commissioning prior to 2002 is 1,577.4 MW.
- Tamil Nadu (834 MW) and Gujarat (153MW) lead the repowering business opportunity.

Further, in case of the WTGs commissioned prior to 2007, there powering potential for such projects completing an operational life of 15 years till 2022, is summarized in Table 2.

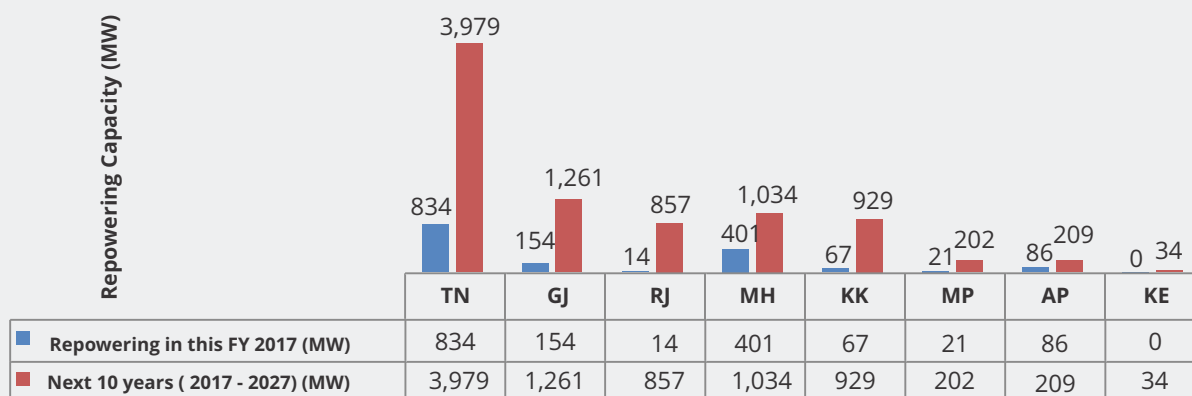
Table 2 State-Wise Repowering Potential (Capacity <1 MW)**Break up of all India installed WTGs (COD prior to 31 Mar 2007)**

	State	<=500 KW	500 to 1000 KW	Total (KW)
	Andhra Pradesh	86,240	31,200	1,17,440
	Gujarat	1,59,595	2,77,850	4,37,445
	Karnataka	45,945	4,90,300	5,36,245
	Maharashtra	2,42,545	3,49,550	5,92,095
	Madhya Pradesh	21,550	20,700	42,250
	Rajasthan	52,725	2,69,550	3,22,275
	Tamil Nadu	14,66,320	8,80,000	23,46,320
	Kerala	225	0	225
	Total	20,74,920	23,19,150	43,94,070

Source: Indian Wind Power Directory, 2017

- Estimate of the repowering potential for WTGs with size less than 1,000 kW and date of commissioning prior to 2007 is 4,372MW.
- Key states —Tamil Nadu (2,324.3 MW), Maharashtra (592 MW) and Karnataka (536 MW).

Similarly, to assess the potential for the next 10years, i.e., up to 2027, the capacity commissioned from 2002 to 2012 were identified. The repowering potential of each state (till 2027) is identified in Figure 6. The graph covers two bars - one showing the repowering potential as on 2017 and the other showing the repowering potential that would exist by the end of 2027.

Figure 6 Repowering Potential in Wind Rich States


Source: Idam Infra Analysis

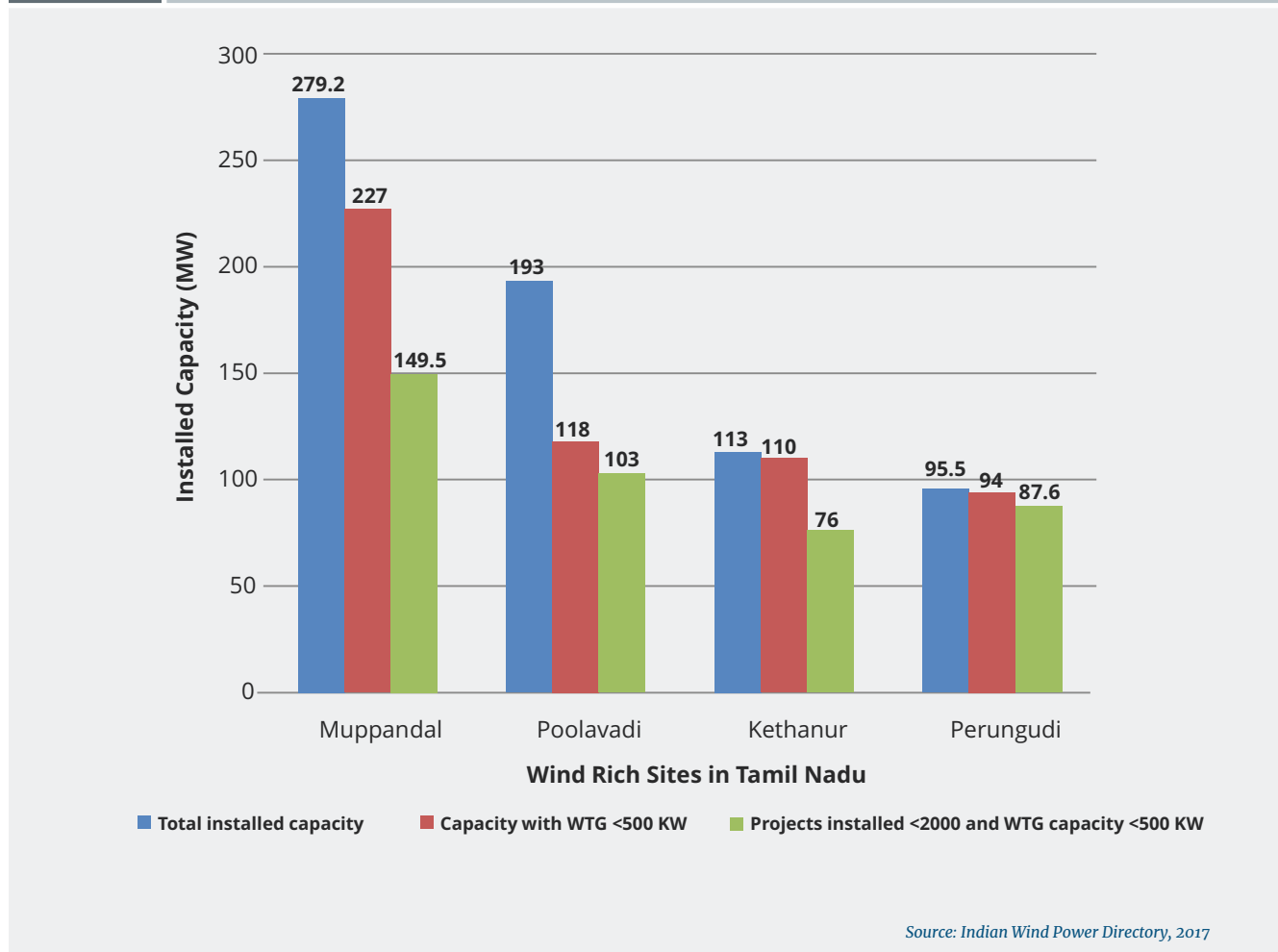
2.3 Market Potential In India (focus On Tamil Nadu, Gujarat)

As illustrated in Figure 6, the major potential for repowering is in Tamil Nadu and Gujarat. Hence, these two states have been selected for further study and analysis of site-based potential.

2.3.1. Tamil Nadu

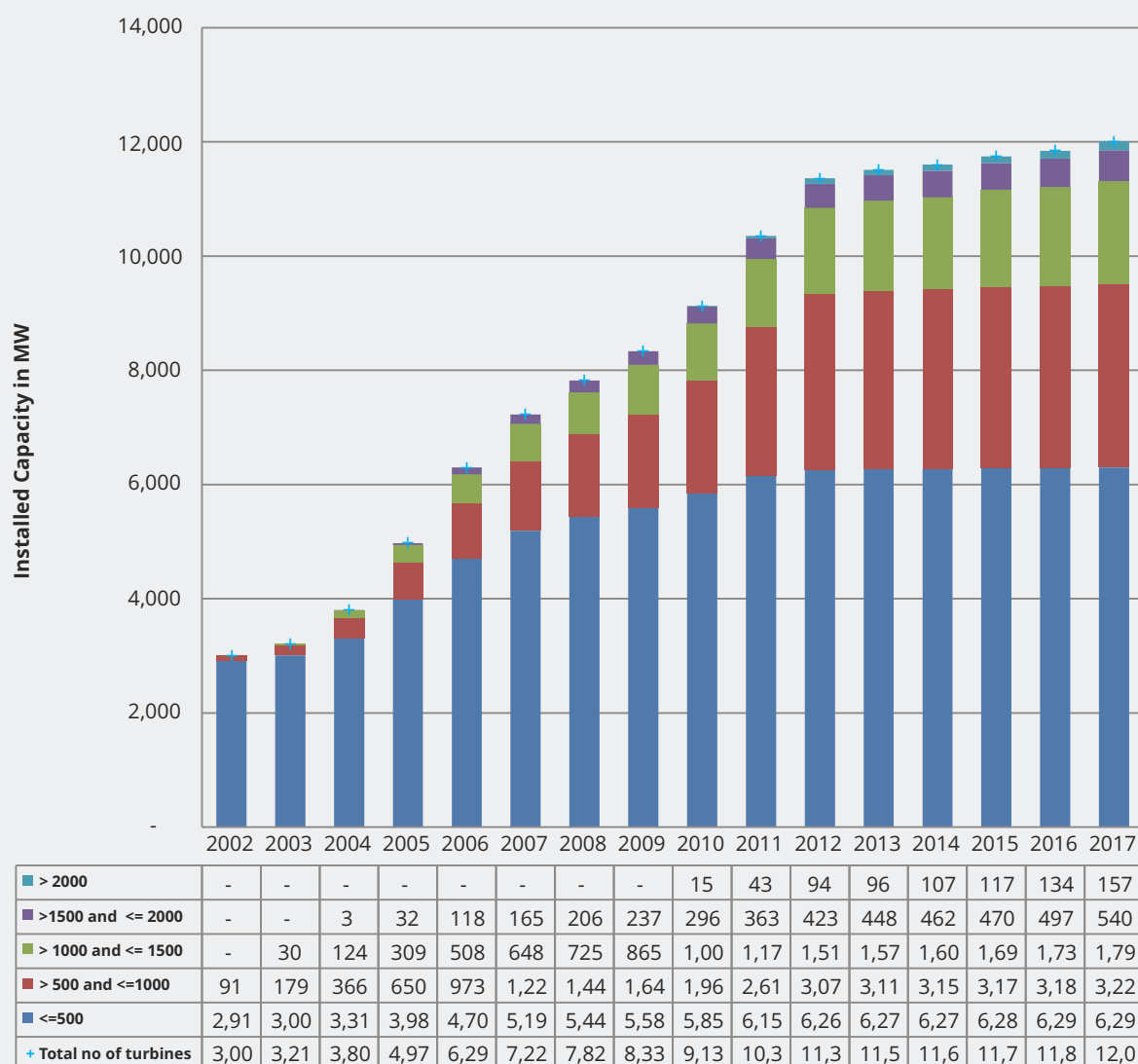
Tamil Nadu has the highest installed capacity of wind energy in India. The installed wind energy capacity of the state is 8,197.08 MW as on 31 March 2018. This accounts for 24.01% of the country's total installed wind energy capacity. The state has some of the India's best wind resource rich sites that include Muppandal, Tirunelveli, Kethanur, Poolavadi, Gomangalam etc. The wind resource rich sites have a wind power density ranging more than 200-250 W per sq.mt.

Analysis of wind resource rich sites with the highest repowering potential is depicted in Figure 7.

Figure 7 Repowering Potential of Wind Rich Sites in Tamil Nadu (in MW)


The above figure shows that sites such as Muppandal, Poolavadi etc., have huge potential for repowering. As observed, Muppandal area alone has installed capacity of 279 MW, out of which, around 227 MW was installed using turbines of capacities 500 kW or below. When we consider projects commissioned before 2002 with WTG capacity size of 500 kW or below, sites such as Muppandal, still have an installed capacity of 149.5 MW. It may be noted that, these projects present immediate repowering potential as prevalent in 2017 since all these projects fall under the category of having completed at least 15 years of project life with WTG capacity size of 500 kW or below.

A similar exercise was performed to estimate the installed wind energy capacity of Tamil Nadu, based on the WTG capacity and the year of commissioning as shown in Figure 8.

Figure 8 WTG Capacity Wise Installation in Tamil Nadu Since 2002


Source: Indian Wind Power Directory, 2017

By 2002, Tamil Nadu had already installed a capacity of 834 MW. As also observed, 78 WTGs have capacities higher than 500 kW and less than 1 MW size. However, all other WTGs used were of capacity sizes less than 500 kW. Hence, all the projects had completed 15 years old and the repowering potential so far stands at 834 MW. A gradual increase in the deployment of WTG with higher capacities was observed over the years. By the end of 2017, there is still 6,296 turbines in Tamil Nadu having capacity sizes less than 500 kW of WTG size.

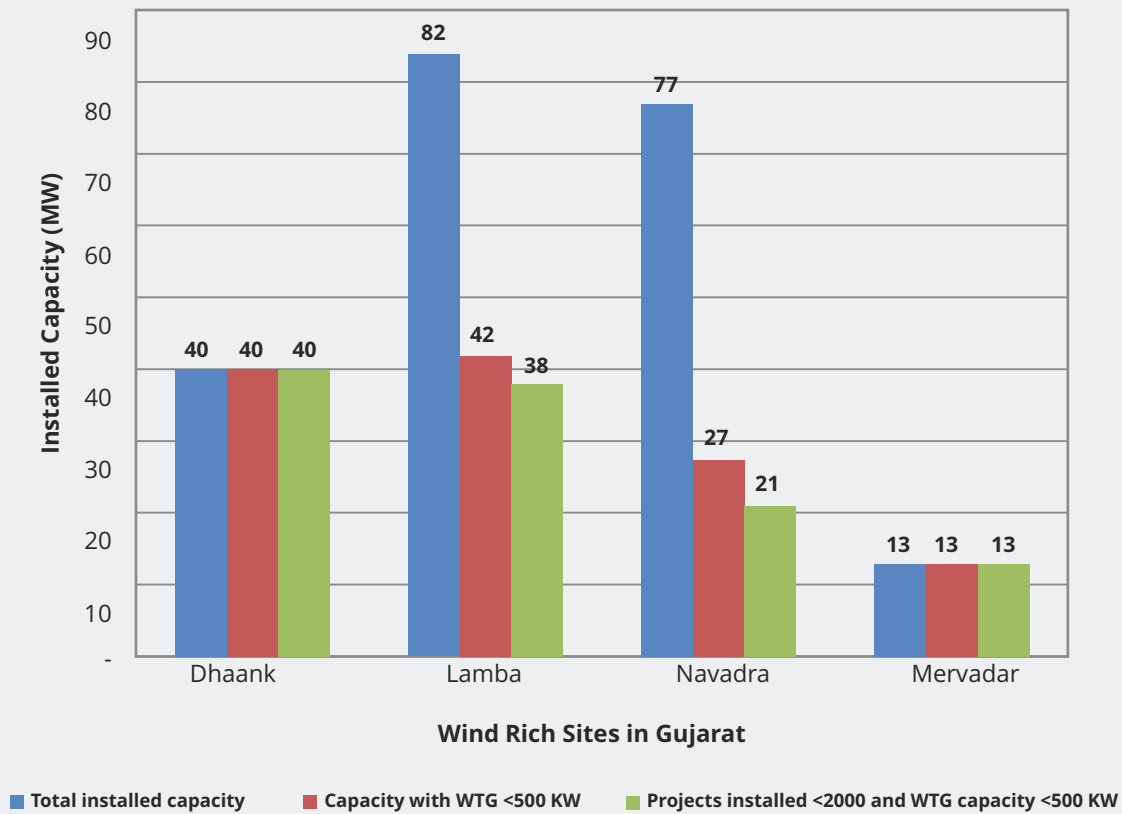
2.3.2 Gujarat

In India, Gujarat is one of the leading states for wind power development. Till the end of March 2018, Gujarat had an installed wind energy capacity of 5,574.75 MW. In a document published on 26 April 2015, MNRE has envisaged at least 8,800 MW of wind power to be installed in Gujarat by 2022.

Bhavnagar, Rajkot, Kutch and Jamnagar are the four major districts in Gujarat blessed with rich wind energy potential. Dhaank, Lamba, Nevada and Mervadar sites in Rajkot and Jamnagar districts have old wind farms at an excellent wind resource site considered as the potential site for repowering.

Analysis of few wind rich sites with highest repowering potential is shown in Figure 9.

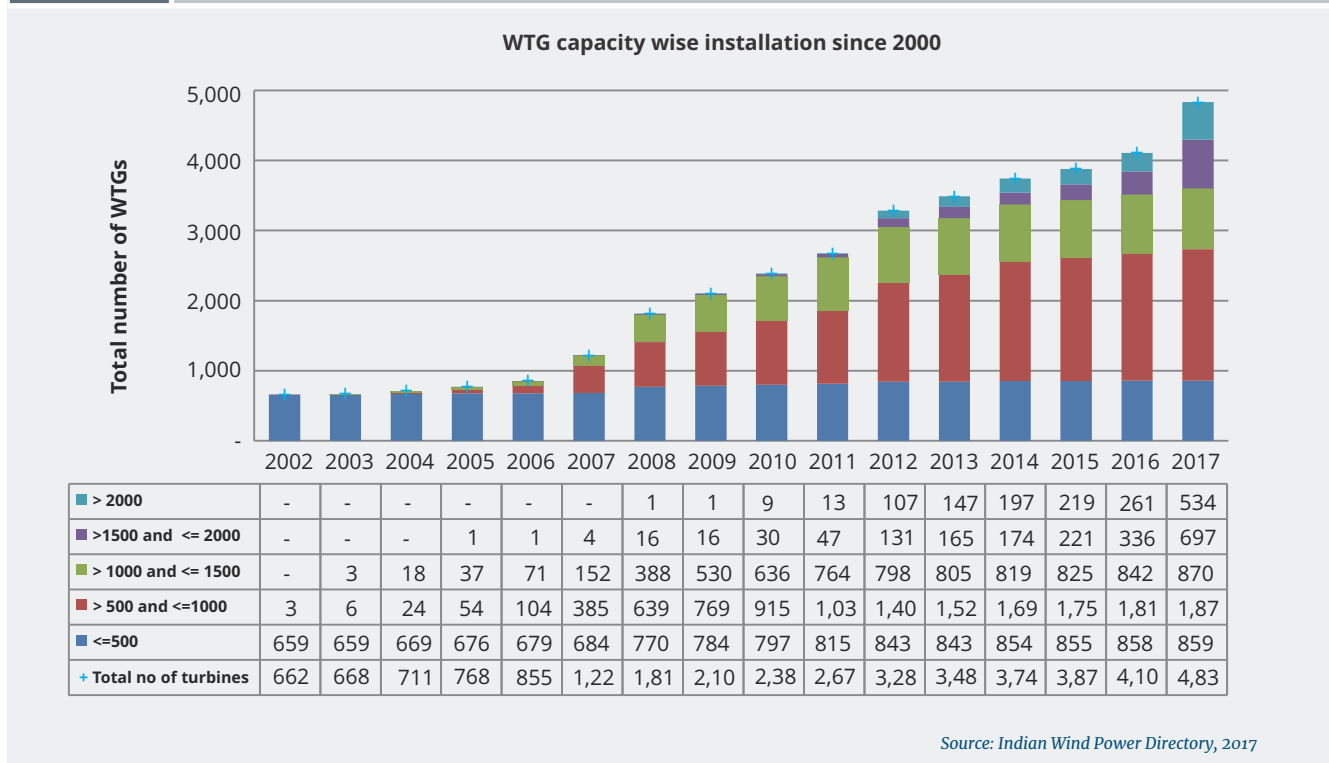
Figure 9 Repowering Potential of Few Wind Rich Sites in Gujarat



Source: Indian Wind Power Directory, 2017

The above analysis shows that these four sites have huge potential for repowering. As observed, only Lamba area has an installed capacity of 83.8 MW, out of which around 41.8 MW was installed using turbines of capacity sizes 500 kW or below. When projects that were commissioned before 2002 are considered with WTG capacity sizes of 500 kW or below, sites such as Lamba, still has an installed capacity of 37.9 MW. It can be said that these projects present immediate prevalent repowering potential as on 2017, since all these projects fall under the category of having completed at least 15 years of project life with WTG capacity sizes of 500 kW or below.

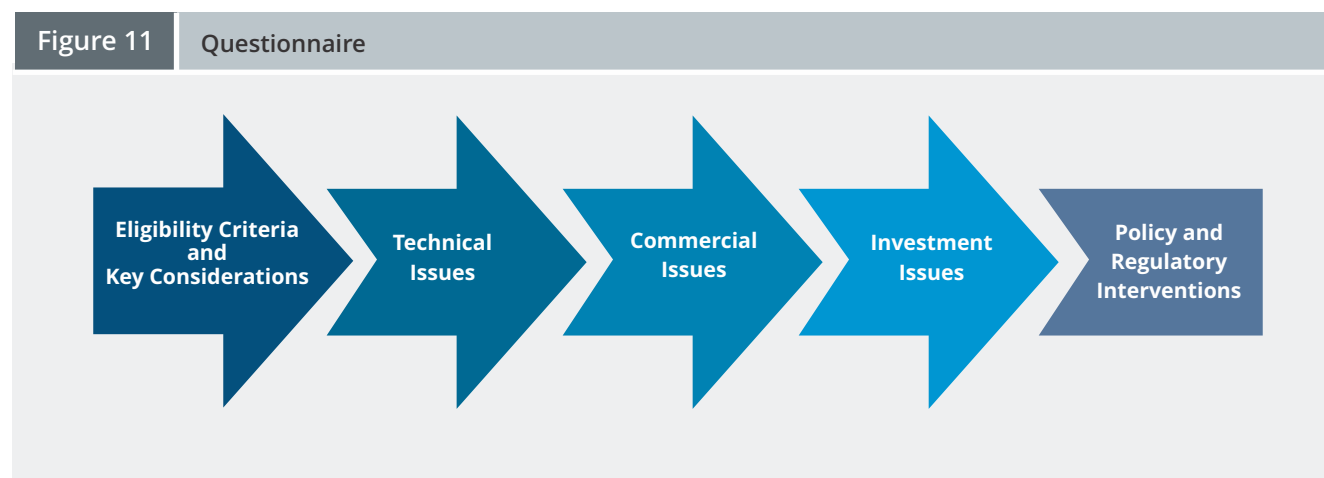
A similar exercise was undertaken to estimate the installed capacity of wind energy in Gujarat, based on the WTG capacity and the year of commissioning as shown in Figure 10.

Figure 10 Repowering Potential of Gujarat


The above analysis shows that by 2002 Gujarat had an installed capacity of 154 MW. Only three WTGs were of capacities greater than 500 kW and less than 1 MW size; however, all other WTGs used were of capacities less than 500 kW contributing to the development of 154 MW. As all the projects had completed 15 years, they were eligible for repowering. Therefore, Gujarat witnessed a gradual increase in the deployment of WTGs of higher capacity over the years. By the end of 2017, there is still 859 turbines of capacities less than 500 kW.

3. Stakeholder Consultation and Key Learnings

The purpose of stakeholder consultation was to highlight the key issues influencing repowering decisions and provide possible solutions, recommend policy requirements, highlight techno-commercial needs with total market potential for repowering of old wind turbines in India. A theme-based questionnaire was created and circulated amongst the various stakeholders to receive feedback and suggestions on various issues that may impact the future of repowering projects. The questionnaire was based on the themes mentioned in Figure 11.



To gather different perspective(s) of various stakeholders associated with repowering, a consultation process through structured interview was planned.

Questionnaire was circulated to the following stakeholder groups as under:

- **State Nodal Agencies:** GEDA (Gujarat), KREDL (Karnataka), MEDA (Maharashtra), TEDA (Tamil Nadu) and RRECL (Rajasthan).
- **State Utilities:** Gujarat, Maharashtra, Karnataka, Rajasthan, Tamil Nadu and Tata Power.
- **State Electricity Regulatory Commissions:** GERC (Gujarat), MERC (Maharashtra), KERC (Karnataka), MPERC (Madhya Pradesh), RERC (Rajasthan) and TNERC (Tamil Nadu).
- **Wind Industry Associations:** IWPA, InWEA, IWTMA and WIPPA.
- Wind developers/IPPs.
- WTG manufacturers

The purpose of the questionnaire was to identify the major impediments, catalysing factors and eligibility criteria for repowering projects. The analysis of the responses is shown in the following sections.

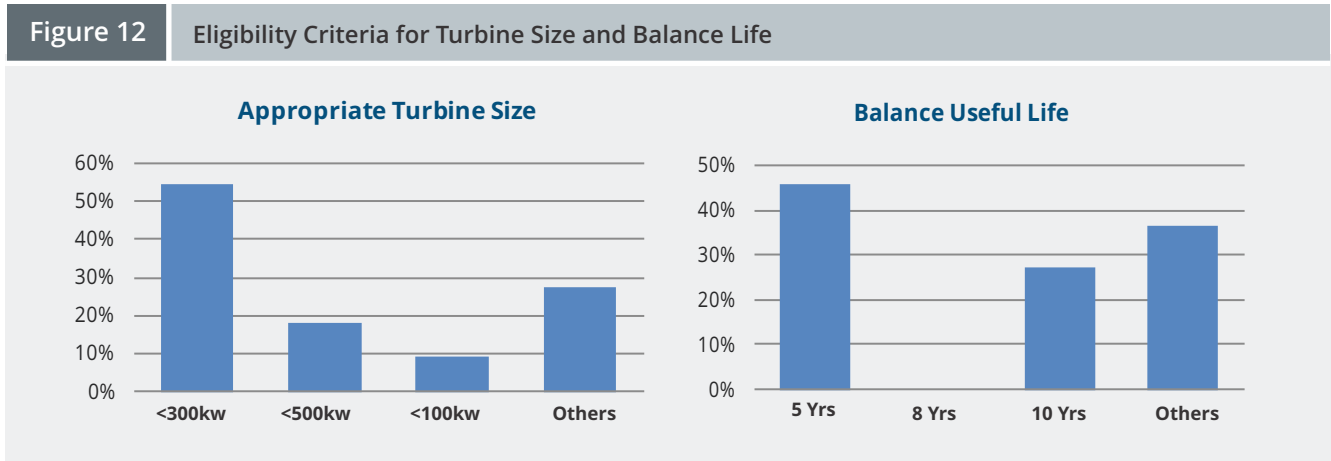
3.1 Analysis Of Response Of The Questionnaire

The responses were classified into four segments, namely, eligibility criteria, technical aspects, commercial aspects, and policy and regulatory interventions required. The subsequent paragraphs deal with each of these aspects.

3.1.1 Eligibility Criteria

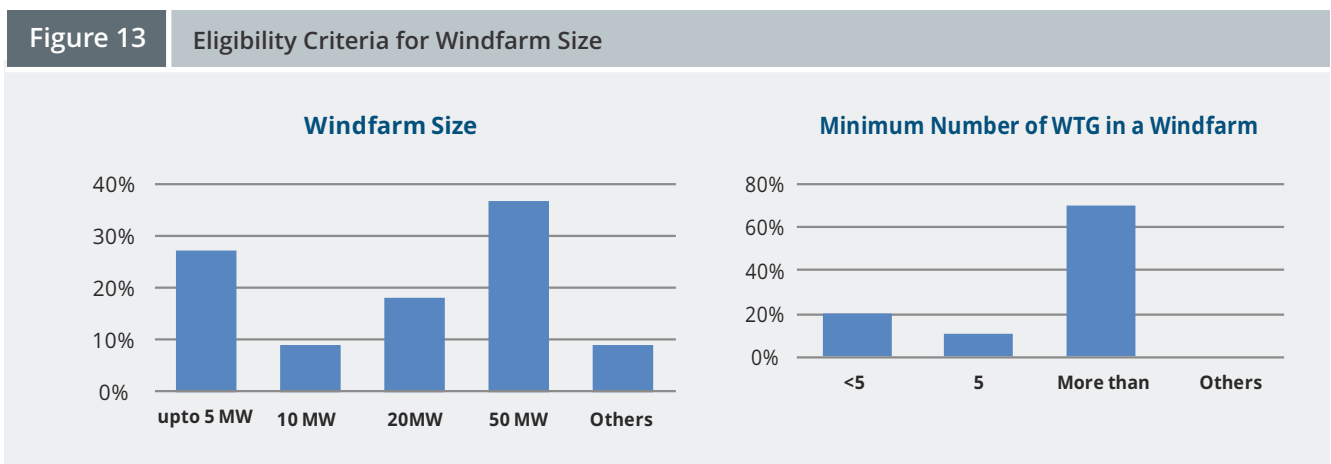
The decision of repowering is based on several factors. The questionnaire included questions on appropriate turbine size, balance life of project, wind farm size, connectivity requirements etc. In many cases, there are operational projects where the installed per WTG capacity size is less than 500 kW but have completed an operational life of only five to seven years in some other cases, the WTGs are installed, each of capacity size 1 MW or above with a completed life of more than 10 years. Such scenarios extensively persist in the wind industry in India. Hence, a conscious call regarding the eligibility of wind projects for repowering should be taken at an expert level. The eligibility should consider factors such as old and lesser capacity size turbines, completed project life, number of turbines in a windfarm etc.

The responses sought in this regard have been analysed and presented in Figure 12. The stakeholder responses are shown in percentage terms.



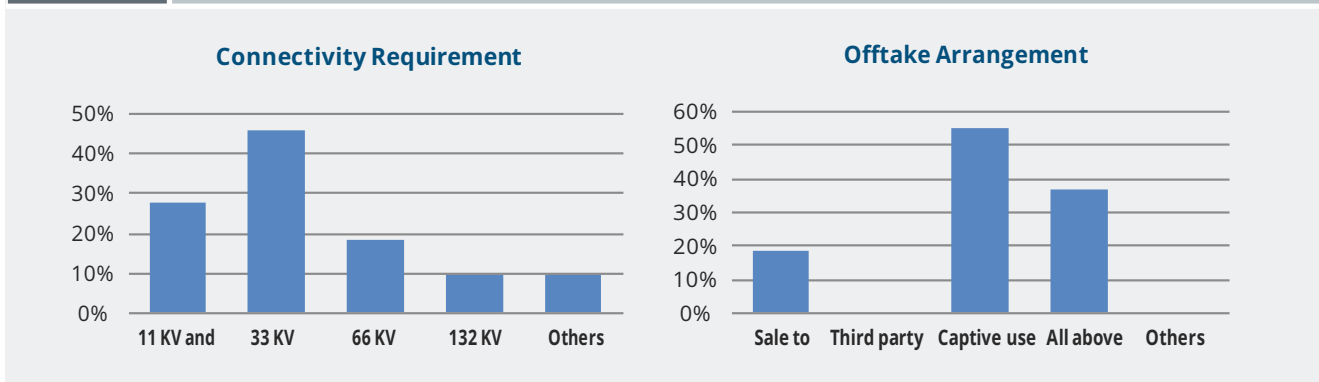
It is observed that more than 50% of the stakeholders have WTGs of capacity size less than 300 kW, which is apt for repowering. In terms of balance useful life, over 40% experts believed it must have around five years of remaining service-life to be eligible for repowering.

Stakeholders also suggested that the minimum number of WTGs in a windfarm must be more than 10. As repowering is not necessarily a one to one replacement scheme, it may involve replacement of several low capacity WTGs by a new one of higher capacity.



In addition, any repowering initiative in a multi owner windfarm would require a holistic business model that would suffice the requirement of all owners such a comprehensive case can be a precedence to develop appropriate Policies and Regulations. The most pertinent aspect of repowering is represented in Figure 14.

Figure 14 Eligibility Criteria for Offtake Arrangement

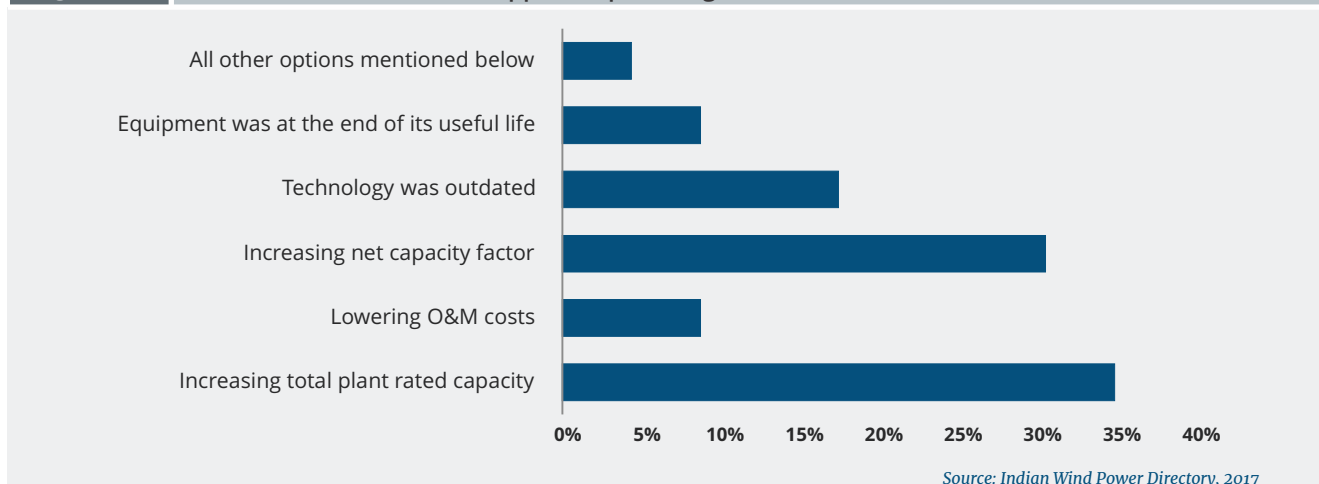


The above figure shows that many stakeholders suggested that WTGs must be connected to at least 33 kilovolt (kV) transmission line for evacuation. It is evident that most of the old wind power projects in both Gujarat and Tamil Nadu are connected to 11 kV that poses a serious technical problem for evacuation of higher capacities upon repowering. As repowered projects would have a significant higher energy generation, it would require 66 kV interconnection to the substation. The Green Energy Corridor project in India needs to incorporate repowering potential sites as major generation centres and design the evacuation infrastructure accordingly. Besides, the state transmission companies of wind resource rich states should involve wind power developer's views for their periodic transmission planning. Without proper transmission infrastructure up-gradation to evacuate the repowered energy, possible repowering projects will be hindered, thereby harnessing sub-optimal premium wind resources.

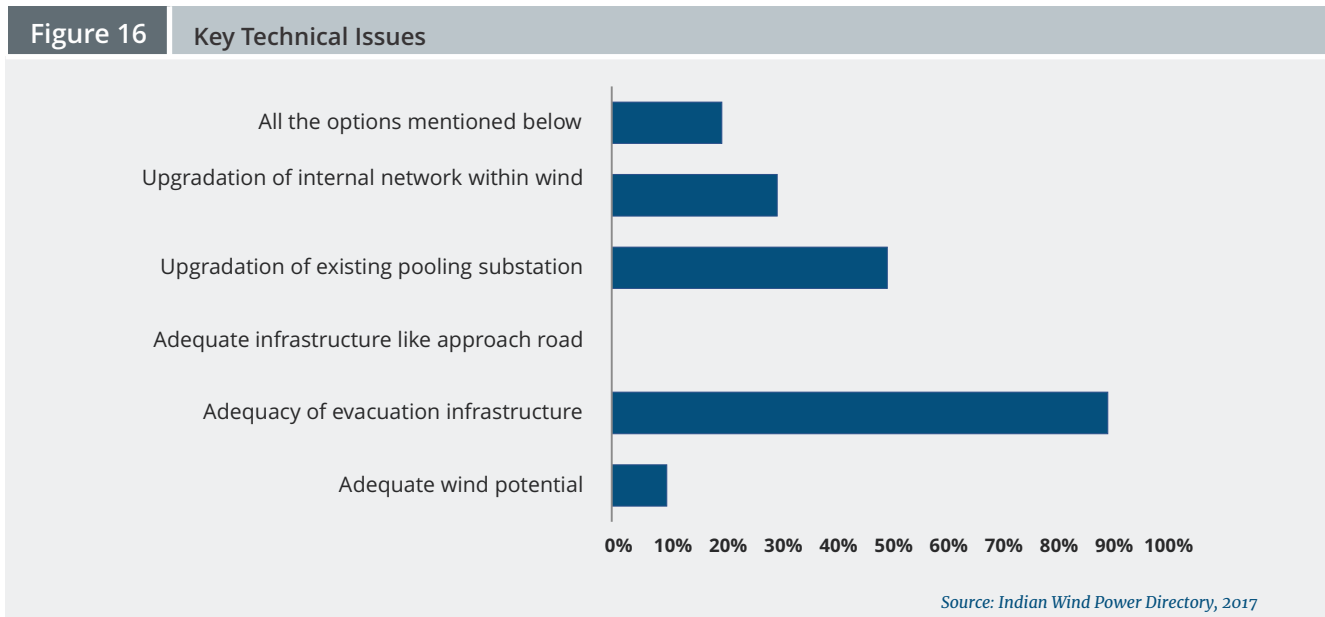
3.1.2 Technical Aspects

Repowering would enhance the generation of electricity from a site. While, a complex blend of various issues would be a bottleneck for repowering, there are some technical reasons that would support repowering decision. The responses are presented in Figure 15.

Figure 15 Technical Parameters to Support Repowering



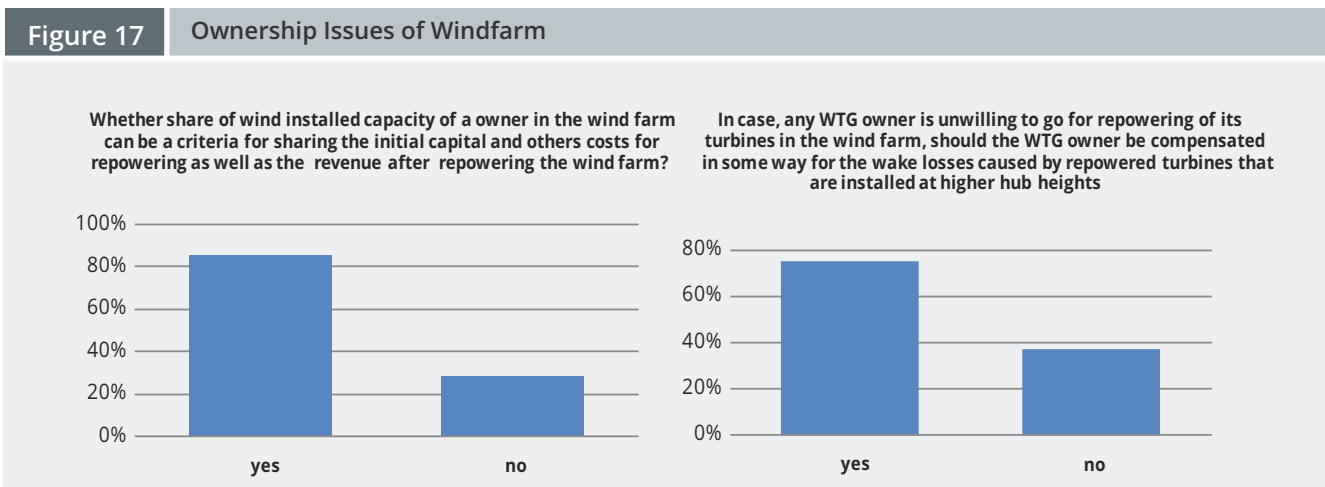
Many technical factors have been cited as factors that influence repowering decisions. The major factors as cited by stakeholders include increased plant load capacity (PLF), deployment of new WTG technology and lower (O&M) costs among the others. While the supporting factors for repowering have been identified, the technical issues that pose as challenges for repowering, have also been identified as outlined in Figure 16.



The above Figure shows that, more than 90% of the respondents have cited adequacy of evacuation infrastructure to be single most important technical parameter and a prerequisite for repowering projects. While a significant number of respondents have opined the feasibility upgrade to the nearest pooling substation as a key decision parameter.

3.1.3 Commercial Aspects

Commercial issues are complex and entails dealing with multiple stakeholders such as the windfarm owners of a single windfarm, suppliers and O&M agencies, parties of PPA like utilities. Since repowering of old wind turbines may replace multiple smaller capacity turbines by few higher capacity turbines, multiple commercial issues should be addressed. Few such relevant issues were framed in the questionnaire and presented for expert stakeholder suggestions. The responses are compiled graphically in Figure 17.

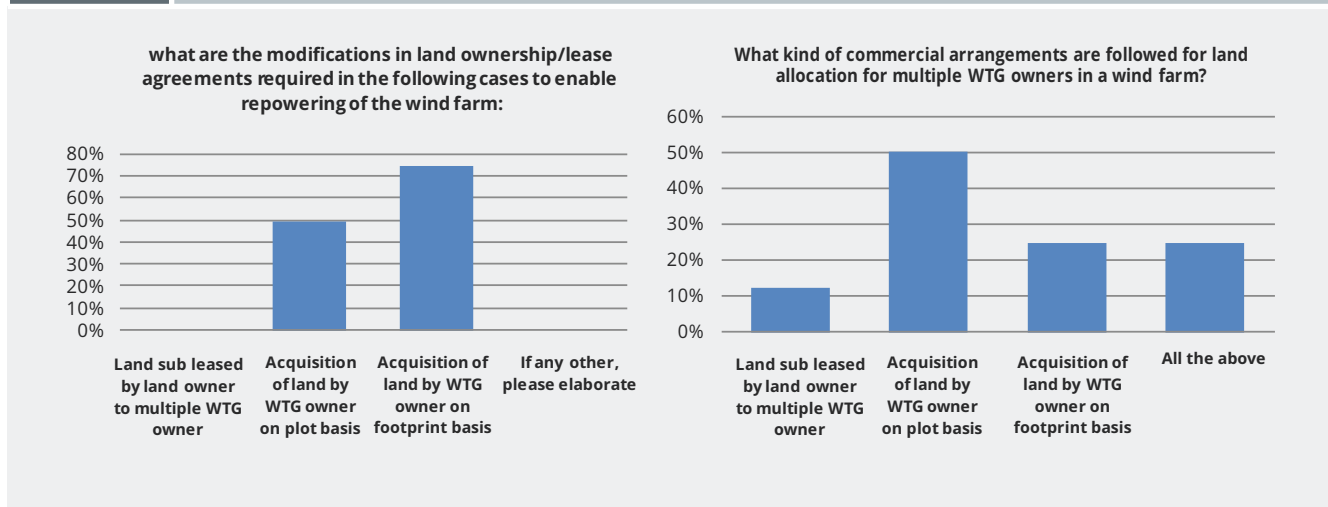


In a scenario where fewer number of low capacity WTGs are decommissioned to accommodate a modern WTG of higher capacity, 80% stakeholders suggested that, share of wind installed capacity of an owner in a windfarm can be a criterion to share the initial capital cost, while the revenue earned from the project shall be shared in the ratio of equity investment in the project. In a scenario where an owner is not willing to go for repowering, nearly 80% of the stakeholders reveal, such parties should be compensated for their land.

There are several land ownership models across various states. Windfarm land is owned by multiple owners in a farm either on project plot basis or footprint basis. Further, there are issues associated with Right of Way, access/approach road and lease of land. One major commercial issue in repowering is the necessity for modification of the old PPAs. Any repowering initiative would mean additional investment for the desired additional generation. This would increase the per unit generation cost. Since the utilities are already in a secured PPA with developers with still few years of plant life remaining, the utilities would be sceptical to such an initiative as they are procuring power at a much cheaper rate through the existing PPAs.

Whereas, in the repowered scenario, developer would recover the additional generation cost through a higher tariff. Under such circumstances, opinions were sought from an expert about the possible solutions regarding commercial issues.

Figure 18 Land Ownership Issues



The study reveals that there are varied responses regarding the commercial impediments of repowering. Many respondents opined that though modification of the existing PPA would be a major hurdle, the modification of tariff would be a major challenge. It is well understood that not only the additional cost of per unit generation must be reflected in the modified tariff, but also the increased cost cannot be imposed on the utilities. It must be adjusted either through the government subsidy route for limited time till the completion of the early PPA, or through some new market mechanism.

Regarding the aspect of whether the developer should be compensated or not, as discussed in the above paragraph, most of the stakeholders have opined that developers should be compensated either through additional feed-in tariff (FiT) or through capital subsidy in the form of Accelerated Depreciation(AD) or Generation Based Incentive (GBI). The responses are compiled as shown in Figures 19 and 20 respectively.

Figure 19 Commercial Issues Related to PPA

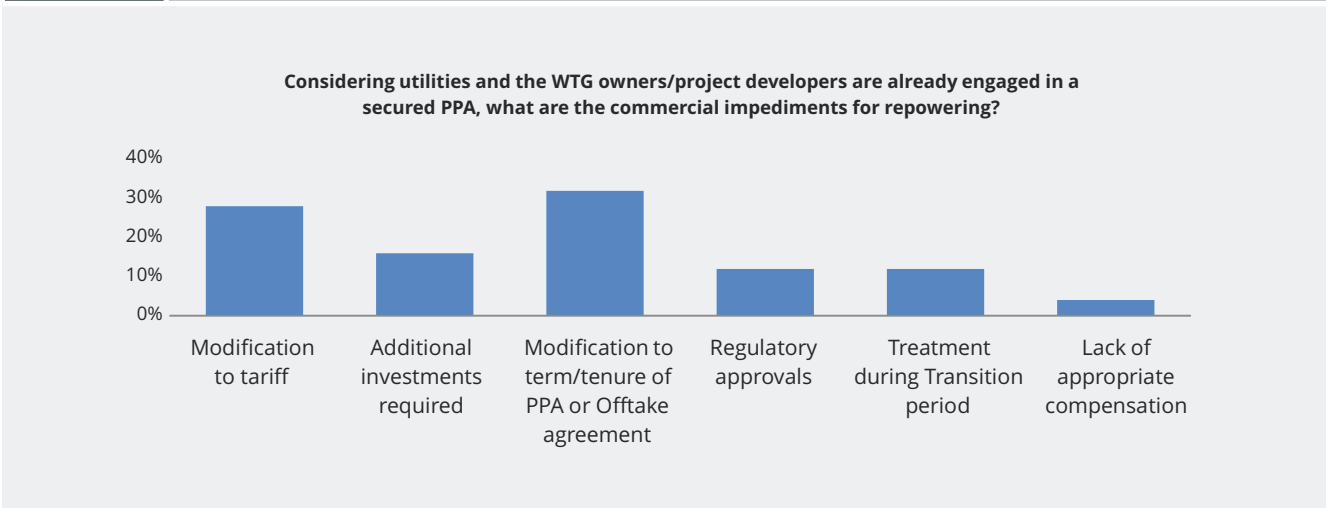
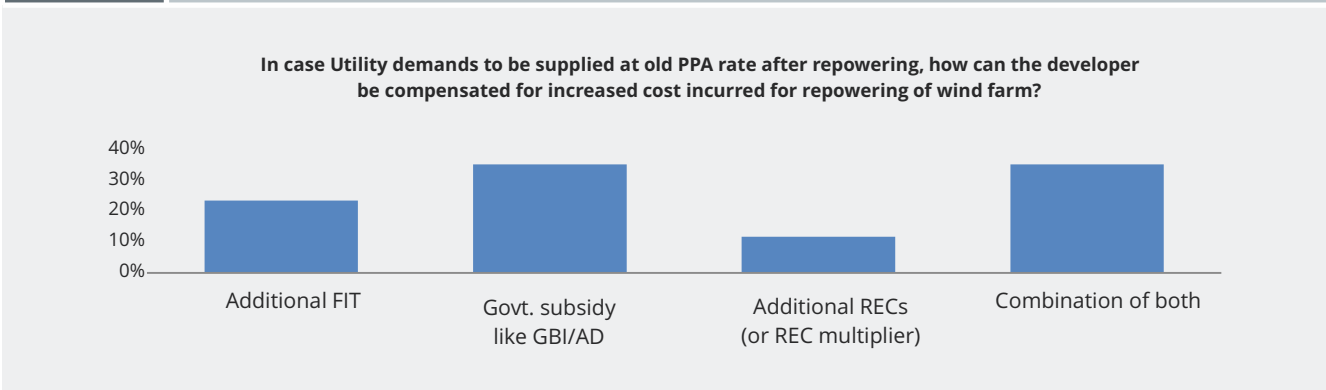


Figure 20 How the Developer should be compensated



In consultation with the response of stakeholders, it is observed that majority has opined that higher tariff approved by the Commission would be a way of making the utilities procure power at the current tariff that is higher than the tariff in the old PPAs. Alternatively, the RPO compliance mechanism can be strengthened to compel the utilities either to buy repowered power or to buy the required REC(s).

Figure 21 Procurement of Power at Higher Tariff

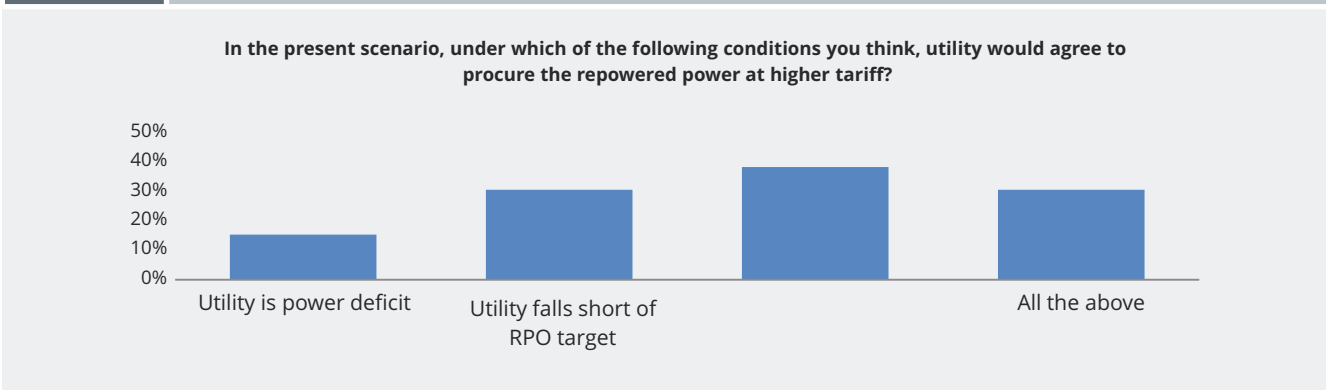
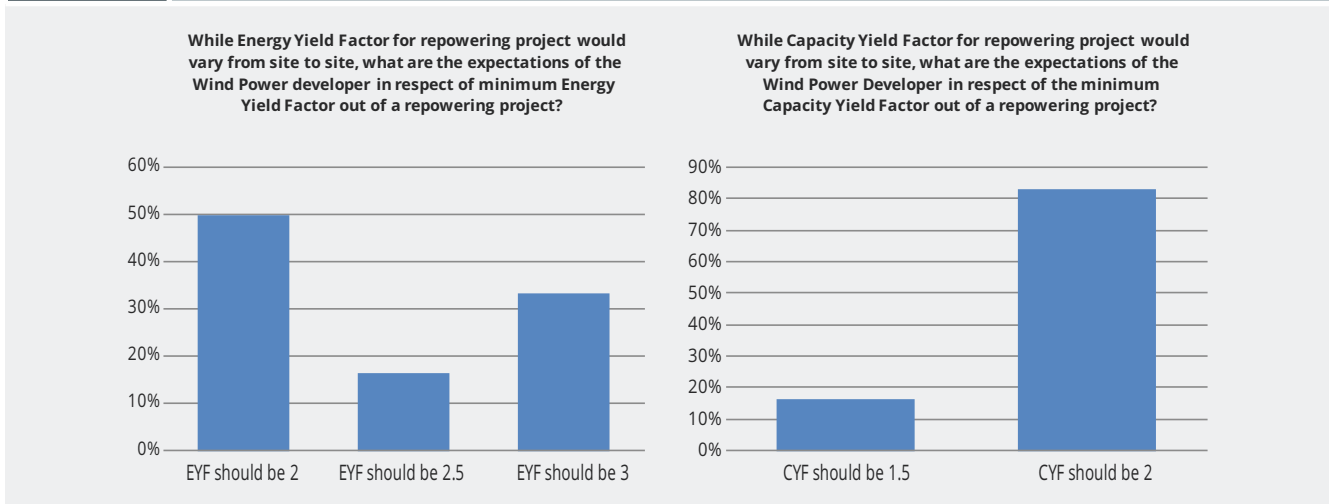


Figure 22 Capacity Yield Factor and Energy Yield Factor

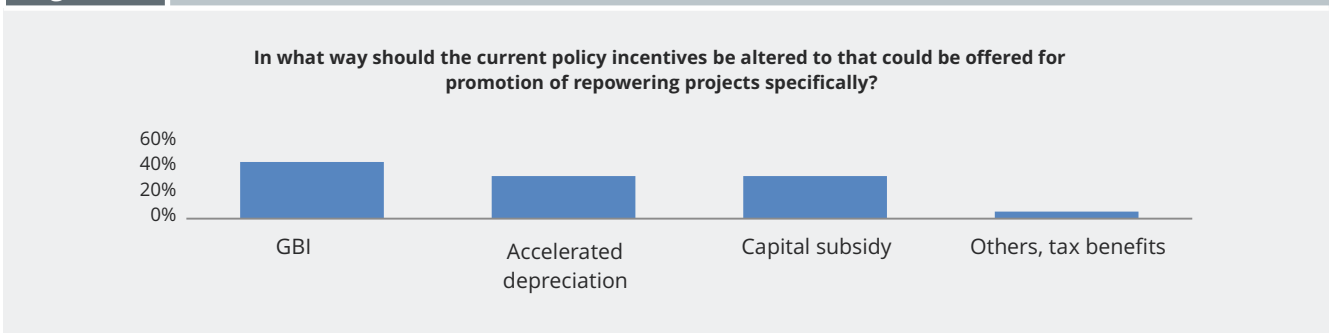


While it is understood that both capacity yield factor and energy yield factor parameters are site dependent and would vary from case to case basis for repowered sites, under ideal scenario, around 50% responses said the energy yield factor should be 2. While more than 80% of responses suggested capacity yield factor should be 2.

3.1.4 Policy And Regulatory Interventions

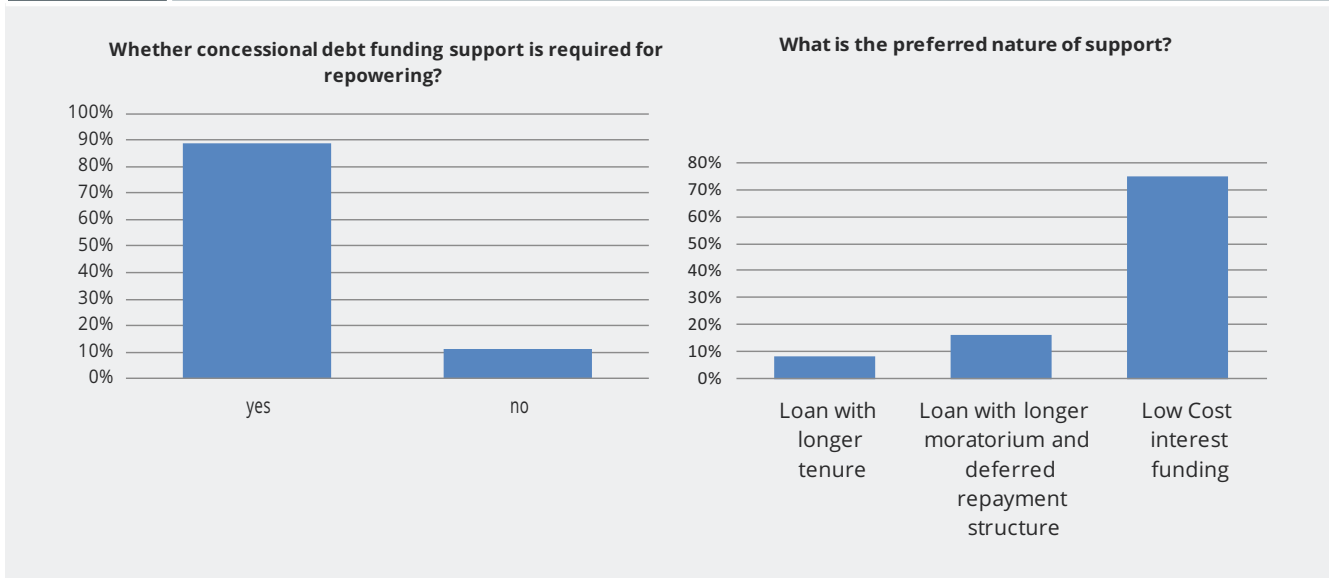
It is understood that any repowering initiative would not only increase the electricity generation by 2 to 3 times, it will also make the appearance of the landscape better. Moreover, repowering would help to fetch the aspirational target of the Government of India having 60GW of wind energy by 2022. However, to promote the repowering projects by the developers, certain policy incentives are envisaged. While most of the stakeholders believe that the GBI per unit of energy generation would be the best instrument, some stakeholders believe that AD or capital subsidy would be the best way to incentivize the investors Policy incentives for repowering is represented in Figure 23.

Figure 23 Policy Incentives for Repowering



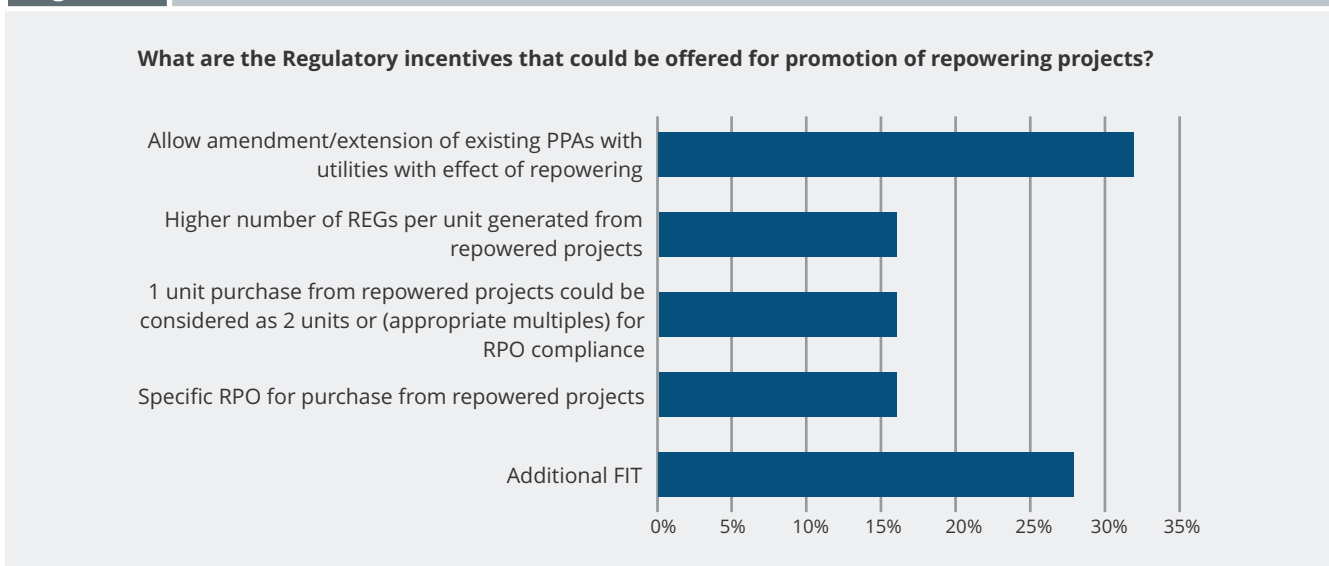
Apart from the conventional forms of incentives for the promotion of wind energy, other promotional features such as concessional debt funding support are also envisaged. As shown in Figure 24, around 75% of the stakeholders have opined for low cost interest funding to be incorporated in the policy framework. Such low-cost funding can be entrusted with organizations such as Indian Renewable Energy Development Agency (IREDA), Export-Import (Exim) Bank, Power Finance Corporation (PFC), etc.

Figure 24 Other Policy Support



While policy parameters can catalyse repowering initiatives, the congenial regulatory framework would drive the scheme forward by providing long-term certainty to the investors for the sale-to-distribution company (DISCOM) model, investors would look at a higher tariff to make the repowering projects financially viable. Some other features offered by the Regulators are shown graphically in Figure 25.

Figure 25 Regulatory Initiatives for Repowering



The above Figure demonstrates that stakeholders have favoured the amendment of existing PPAs and provision of additional FiTs as the most coveted measure for repowering initiatives toward implementation.

3.2 Summary Of Stakeholder Consultation Process

Consultation with the members of wind energy associations and officials of state renewable energy development agencies provided useful insights as well as raised several issues that may hinder the repowering of old wind projects in India. The key driving factors for repowering as stated by various stakeholders are summarized below:

- WTGs having capacity less than 300 kW and have completed a life of 20 years are most suitable for repowering.
- Upgradation of existing evacuation infrastructure is cited as one of the most critical factors to undertake repowering projects. WTGs must be connected to at least 33 kV or preferably 66 kV lines for proper evacuation.
- Share of the installed capacity of an owner in a windfarm can be a criterion for sharing the capital investments as well the revenues after repowering the windfarm in the ratio of equity investments.
- Modification of the existing PPAs with generators and utilities for the revision of tariff may not be acceptable to the utilities because of the poor financial condition of the latter.
- The Government may provide appropriate subsidy(ies) in the form of GBI or additional FiT etc. for the developers
- The state regulatory commission should form or strengthen RPO compliance mechanisms for the obligated entities.
- A conducive model policy may be issued by MNRE which in turn may be adapted by the states in their policy instrument for addressing the above issues.

3.3 Key Learnings And Feedback From Stakeholder Consultation

Key learnings and feedback received through stakeholder consultation process on the key issues influencing the development of repowering business has been summarized in Table 3.

Issue	Key Challenges by Respondents	Suggestions
Ownership	<ul style="list-style-type: none"> • Issues regarding ownership of windfarm with multiple wind turbine owners in given wind farm • All parties'/WTG owners may not be keen on repowering 	<ul style="list-style-type: none"> • A suitable business model must be evolved where interest of all parties is taken care of • Formation of Special Purpose Vehicle (SPV) with equity participation from the concerned parties with sharing of revenues in proportion to equity interest could be a solution
Evacuation	<ul style="list-style-type: none"> • Most of the old wind projects are connected to 11 kV line (particularly in TN) posing a major hurdle for any repowering initiative 	<ul style="list-style-type: none"> • The evacuation infrastructure must be upgraded to 66 kV systems • In some cases, upgradation of the pooling substation may be required
Land	<ul style="list-style-type: none"> • Multiple ownership of land for a given wind farm poses another challenge for repowering projects • Optimal micro-siting for repowered site requires unhindered access, planning and flexibility on the site 	<ul style="list-style-type: none"> • Lease of land or right to use land on footprint basis in favor of SPV could be explored to address the requirement in case of multiple landowners
Power offtake arrangement	<ul style="list-style-type: none"> • Retaining earlier power offtake arrangements (sale to DISCOM or captive) and identifying off-takers of extra power generation post repowering 	<ul style="list-style-type: none"> • Multiple options available for power offtake,viz., a) sale to DISCOM, b) captive model, c) sale to any third party by open access route and combination to be allowed • Existing off-take to be protected at least for residual life period
Tariff and incentives	<ul style="list-style-type: none"> • Existing tariff is too low as the PPAs signed for over 20 years have a perpetual nature with no termination clause 	<ul style="list-style-type: none"> • FiT for wind should prevail.However, to continue the tariff of old PPAs, the developer would require a certain incentive over and above FiT

Issue	Key Challenges by Respondents	Suggestions
Tariff and incentives	<ul style="list-style-type: none">• Current tariffs are unviable for repowering projects	<ul style="list-style-type: none">• In case of captive power plants, attractive wheeling and banking provision must be brought in
Utility	<ul style="list-style-type: none">• Utility is in a secured PPA with the developer at a much lower cost• Utility would not allow break away to enable repowering	<ul style="list-style-type: none">• Utility off-take would be as per the old PPA rates to continue the balance tenure of existing PPA• New PPA shall cover the new FiT for additional generation through repowering

4. International Case Studies

Globally, the Government policy initiative is one of the main driving factors behind the rapid growth of renewable energy. In this chapter, the policy support and incentive structures that propelled repowering business in the European market have been analysed. It is observed that Germany, Denmark, Spain, Netherlands and United Kingdom (UK) have remained pioneers of onshore wind energy installations across Europe. However, in the repowering business, Germany and Denmark have been the most progressive in the world. Hence, it is vital to understand the kind of policy support and regulatory interventions required to promote repowering in the country. For this, a country-specific study was undertaken for Germany, Denmark, Spain and Netherlands to analyse the requirement of key driving factors in the Indian context. Key learnings were captured subsequently.

Europe has traditionally remained one of the largest markets for wind power development in the world. Even with China, India and North America moving up the ladder in wind energy deployment, Europe would still hold about 32% share of the global wind energy installed capacity.

Back in 2010, China became the world's largest wind energy producer and the boom is continuing unabated, especially fuelled by the government support and ambitious renewable energy targets. In 2018, although China and USA are the two biggest wind power generating nations, Germany is the largest annual market for wind power in Europe with a cumulative installed capacity of 57.4 GW. While the market distribution changes annually, the industry is moving towards European Union's target of supplying 20% of Europe's electricity by the end of 2020. In Europe, 16.8 GW of new wind power was added during 2017, bringing the total installed capacity to 168.7 GW, and generated about 336 TWh of electricity accounted for about 18% of the Europe's electricity consumption.

4.1 Germany

Germany is the first European Union country with the largest wind installed capacity, followed by Spain, UK, France and Italy. Nearly, 50% of the current wind power capacity in Germany was installed after 2000. The Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz [EEG]) was a key enabler for the wind capacity addition achieved by Germany.

Below listed are the various implications of EEG on repowering from 2000 to 2017:

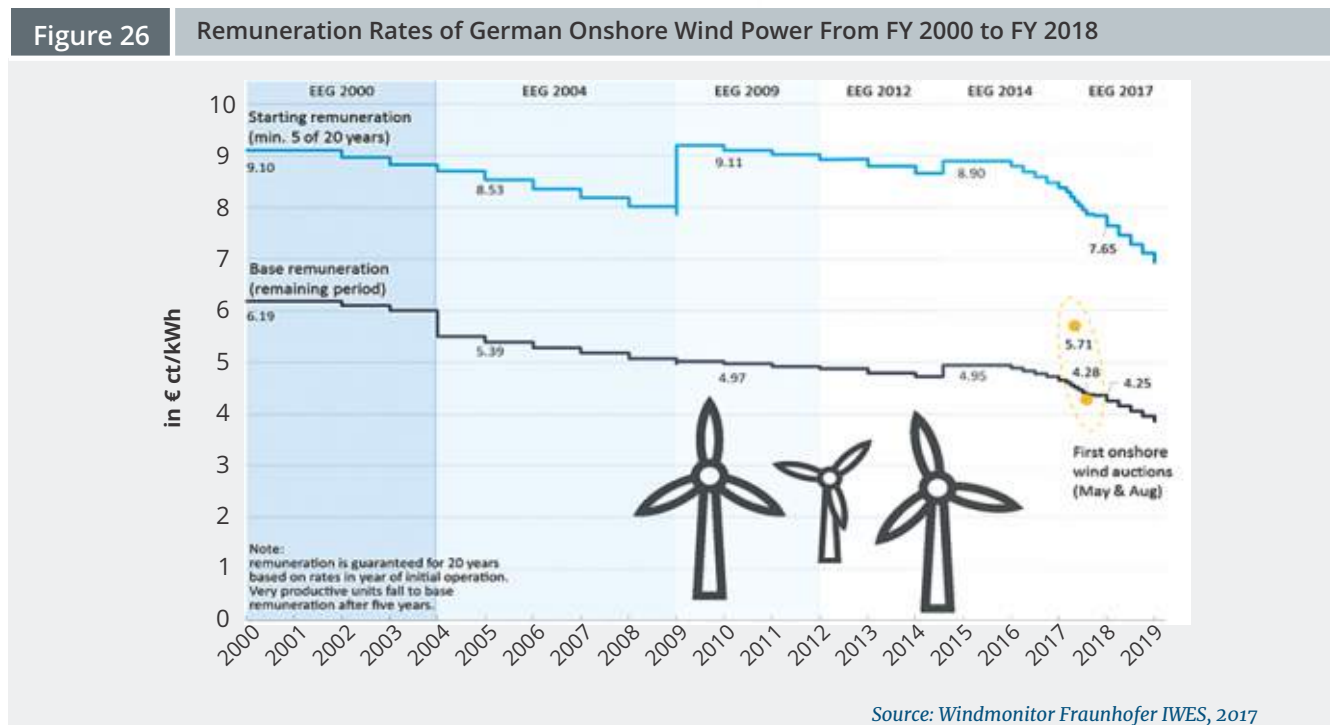
- EEG 2000: The EEG Law complied with the EU criteria by setting time limits on compensation, establishing cost-oriented rates, differentiating according to energy source, plant size and location, introducing a degressive structure and insisting on regular reviews. The Law, however, was silent on any incentives for repowering.
- EEG 2004: Amendment to the Renewable Energy Sources Act (EEG) in 2004 offered an additional financial incentive to repower wind projects installed before 1995. Before 2004, German FiTs provided some encouragement for wind repowering, by offering new wind projects and higher FiTs than existing projects in operation. Since 2004, FiTs offered longer and higher income for wind turbines thereby replacing/restructuring the existing projects built before December 1995 and were at least three times the capacity of the older turbines. The repowering incentives (RI) offered by the EEG had no effect since the spacing requirements and the height limits made it impossible to achieve the required tripling of installed nominal capacity.

- EEG 2009: FiT for onshore wind farms was increased from EUR 8.03 to EUR 9.2 cents/kilowatt-hour (kWh) for the first five years of operation, and EUR cents 5.02/kWh thereafter. This tariff will be decreased annually for new installations by 1%, as opposed to the previous 2%. Similarly, the law would increase the repowering incentive to support the replacement of old turbines by the new ones. The initial remuneration would be increased by EUR 0.5 cent/kWh. The replaced turbines must be in the same administrative district and be at least 10 years old. The new turbine must have at least twice, but no more than five times the original turbines capacity.
- EEG 2012: The EEG amendments 2012 retained the incentives on repowering projects. FiT for onshore wind projects remained at 8.93 cents/kWh for the initial five years and the base tariff as 4.87 cents/kWh for the rest of the project life. This FiT was subjected to an annual digression of 1.5%. An incentive of 0.5 cents/kWh, as mentioned earlier, was retained in the amendment. However, the law stated the incentive amount shall be reduced by 0.01 cents/kWh annually. There were certain conditions laid out for the applicability of incentives as mentioned below:
 - The repowered capacity must be at least twice the earlier capacity.
 - The onshore plants must be commissioned prior to 2002.
- EEG 2014: The revised version of the EEG 2014 gave additional impetus to the repowering of older wind turbines as the financial incentive meant for repowering was granted only for projects which could be completed until the end of the year. Therefore, in 2014 a last chance was offered to the operators of older wind turbines to use the repowering incentive by dismantling an old wind turbine and installing a new one in the same region. With the EEG revision in force since August 2014, repowering has acquired another significance for the future development of German wind energy market. Since the EEG 2014 came into effect, the Federal Network Agency (Bundesnetzagentur) established a register of installations for all new renewable energy plants commissioned and decommissioned. The obligation to report is a prerequisite for claiming the EEG remuneration, and therefore since August 2014 a clearly improved database for repowering became available.
- EEG 2017: The reform introduced public tender procedures for wind, solar and biomass projects in country's efforts to shift from FiT support renewable energy deployment to market orientated price finding mechanism. With that, projects will no longer be eligible for statutory FiT remuneration; but, will have to bid for it in public auction organised and monitored by the Federal Network Agency (BNetzA). Successful projects will receive contracts for 20 years based on the sale of electricity produced at the bid price quoted during the auction process. Repowering incentive continued to be abolished in this Law as well.

The compilation of the FiTs with digression rates and repowering incentive over the period from EEG 2000 to EEG 2017 is depicted in Table 4.

Amendments	Particulars	Initial FiT	Base FiT	Repowering Incentive	Degression
EEG 2000	New Wind Project	9.10	6.2	NA	1.50%
	Repowering Project	9.10	6.2	NA	1.50%
EEG 2004	New Wind Project	8.7	5.5	NA	2%
	Repowering Project	8.7	5.5	0.5	2%
EEG 2009	New Wind Project	9.2	5.02	NA	1%
	Repowering Project	9.2	5.02	0.5	1%
EEG 2012	New Wind Project	8.93	4.87	NA	1.50%
	Repowering Project	8.93	4.87	0.5	1.50%
EEG 2014	New Wind Project	8.9	4.95	NA	NA
	Repowering Project	8.9	4.95	Abolished	NA
EEG 2017	New Wind Project	-	-	NA	NA
	Repowering Project	-	-	Abolished	NA

The remuneration rates of German onshore winds from FY 2000 to FY 2018 is represented in Figure 26.



More sites for wind energy deployment are being developed in middle and southern Germany. This has created a market for newer turbines based on the modern technologies, which can optimally utilise the sites with lower wind speeds. Apart from the new installations, Germany has also witness degressive repowering activities replacing the first-generation turbines of 300 kW or lower capacities by the latest ones that could be as big as 2 MW.

Improved energy generation in modern turbines has made it economically viable to replace older turbines after an average run-time of 10 years. According to BWE, presently, 41% of the installed capacity in Germany will be completing 15 years by 2020 and the same would be considered as repowering potential by then. Apprehensions for the abolition of RI through EEG amendment, 2014 can be attributed as the main reason for significant higher repowering installations in 2014.

The EEG amendment that commenced on 01 August 2014, mandated the formation of a Central Turbine Registry to capture the additions of wind energy turbines, repowering and dismantling data in detail. In 2017, 315 old

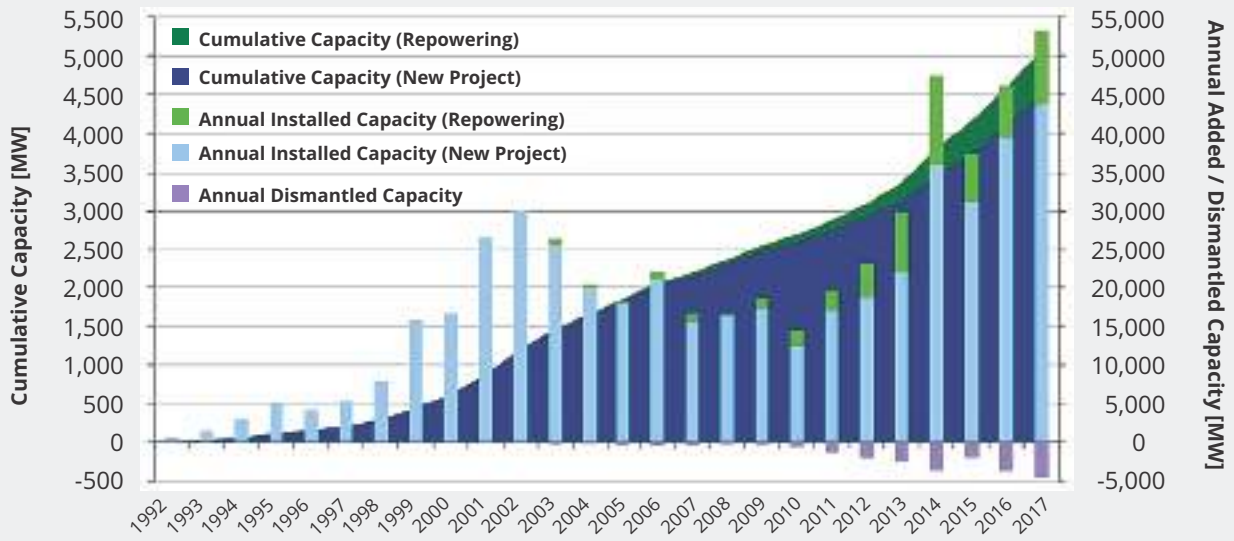
Status of Land-Based Wind Energy Development		Capacity (MW)	Number of WTG
Development 2017	Gross addition during FY 2017	5,333.53	1,792
	Repowering share (not binding)	951.77	315
	Dismantling in 2017 (incl. subsequent registration) (not binding)	467.27	387
	Net addition during 2017	4,866.26	1,405
Cumulative 31 December 2017	Cumulative WTG portfolio Status: 31 December 2017 (not binding)	50,776.93	28,675

Source: BWE

WTGs with installed capacity of 467 MW were identified for repowering. The same was replaced by 315 new WTGs having total installed capacity of 952 MW. The net addition in 2017 came to 4,866 MW. Therefore, by the end of 2017, the cumulative WTG portfolio increased to 28,675 WTG with a cumulative capacity of 50,777 MW. This equates to an increase of the cumulative capacity of 11% compared to the preceding year.

Onshore wind energy in Germany has recorded a huge expansion in the transition phase of the new tendering system. According to the German Wind Energy Association (BWE), a total of 2,281 MW (gross) was newly installed in the first half of 2017 thus equating to 790 wind power plants. Expansion in the first half of 2017 is therefore 11% higher than the level reached in the same period of the previous year.

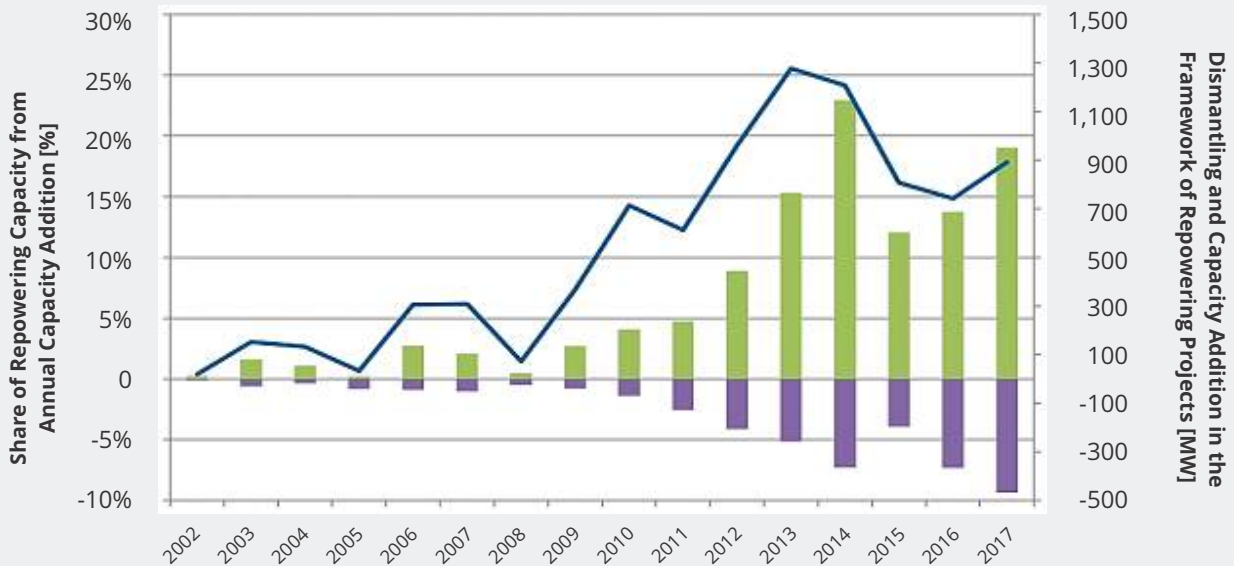
Figure 27 Annual Installed and Cumulative Capacity (MW) in Germany Including Repowering and Dismantling



Source: BWE

The identified annual newly-added repowering capacity, the dismantled capacity, as well as the share of the capacity of repowering turbines in the annual gross additions over time is illustrated in Figure 28. The repowering capacity notably declined following the cancellation of the repowering incentive with the EEG 2014, increased in 2017 and reached its second highest value since 2014.

Figure 28 Annual Installed, Dismantled and Cumulative Capacity of Repowering Projects



Source: BWE

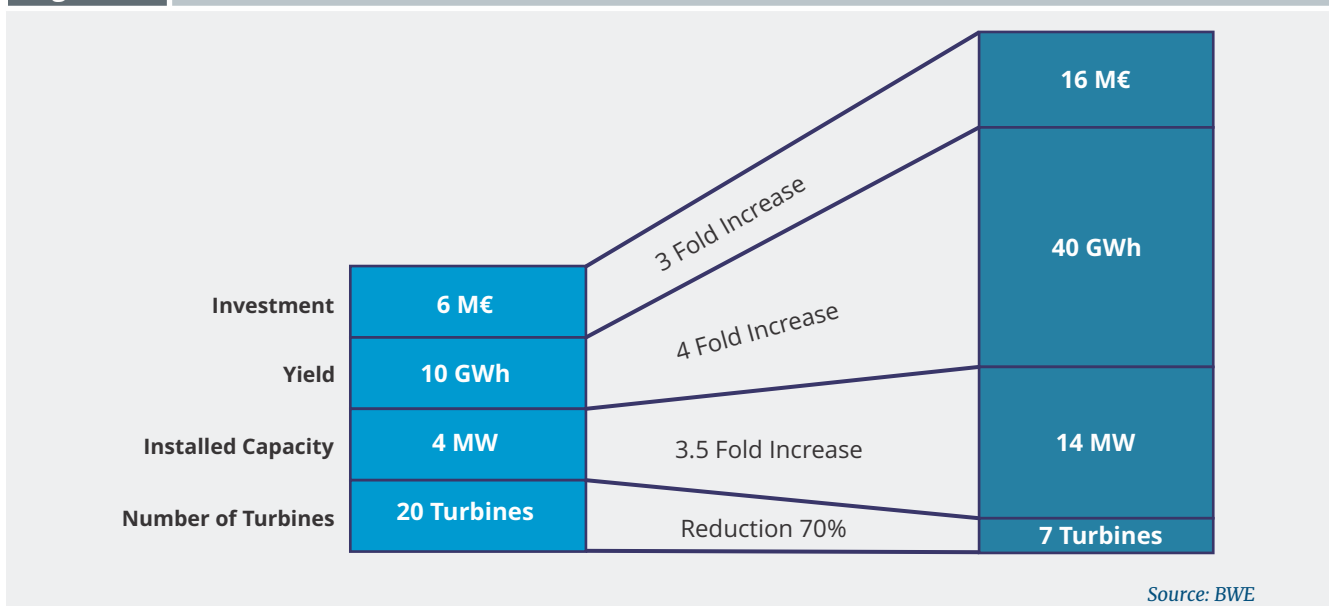
The below image depicts an example of repowering in Germany where 20 turbines of 200 kW were replaced with seven turbines of 2 MW. It was observed that the investment was tripled, but the annual energy production increased fourfold.

Figure 29 Illustration of Repowering in Germany



Further, the installed capacity increased by a factor of 3.5 as shown in Figure 30 and the energy production increased proportionally with the installed capacity. This is due to the taller wind turbines accessing the increased wind speed present at higher altitudes.

Figure 30 Illustration of Energy Production and Installed Capacity

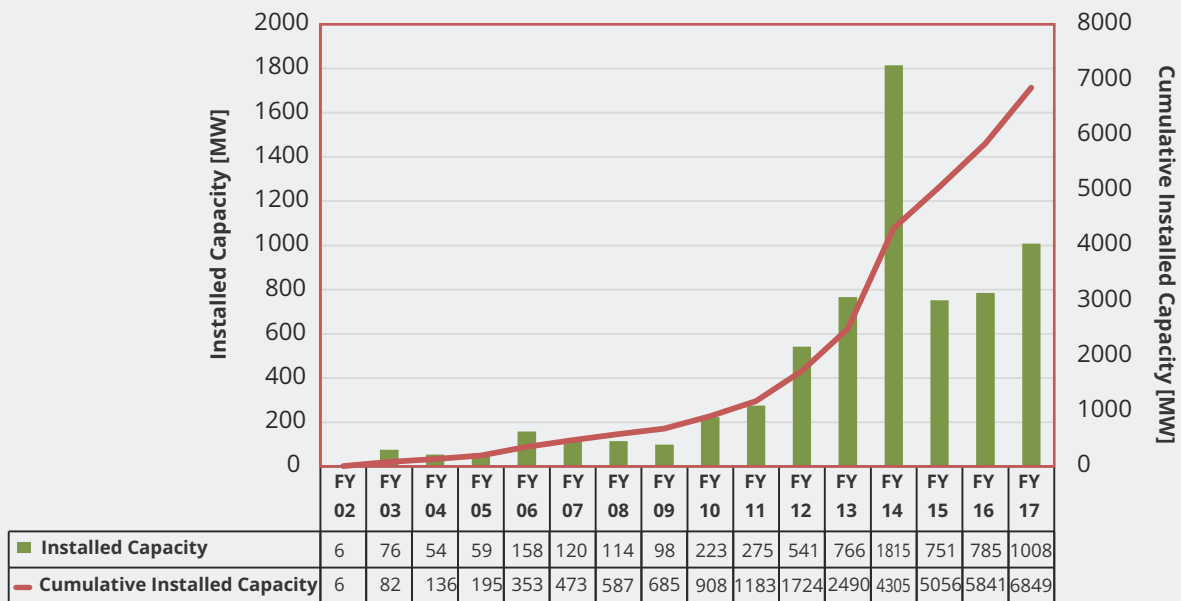


Following observations can be made regarding the repowering scenario of Germany. The rapid installations that occurred via repowering programmes can be attributed to the amendment in EEG in 2009.

- By 2017, there were 28,675 onshore wind turbines in Germany (Deutsche Wind Guard, 2017).
- In 2017, at least 387 WTG's with a combined capacity of 467.27 MW, were dismantled.
- With an identified capacity of 951.77 MW, this equates to a repowering share of at least 17.84% of the gross capacity addition for 2017.

The year wise repowering installation in Germany is depicted in Figure 31.

Figure 31 Repowering Growth Trend in Germany (MW)



Source: DEWI

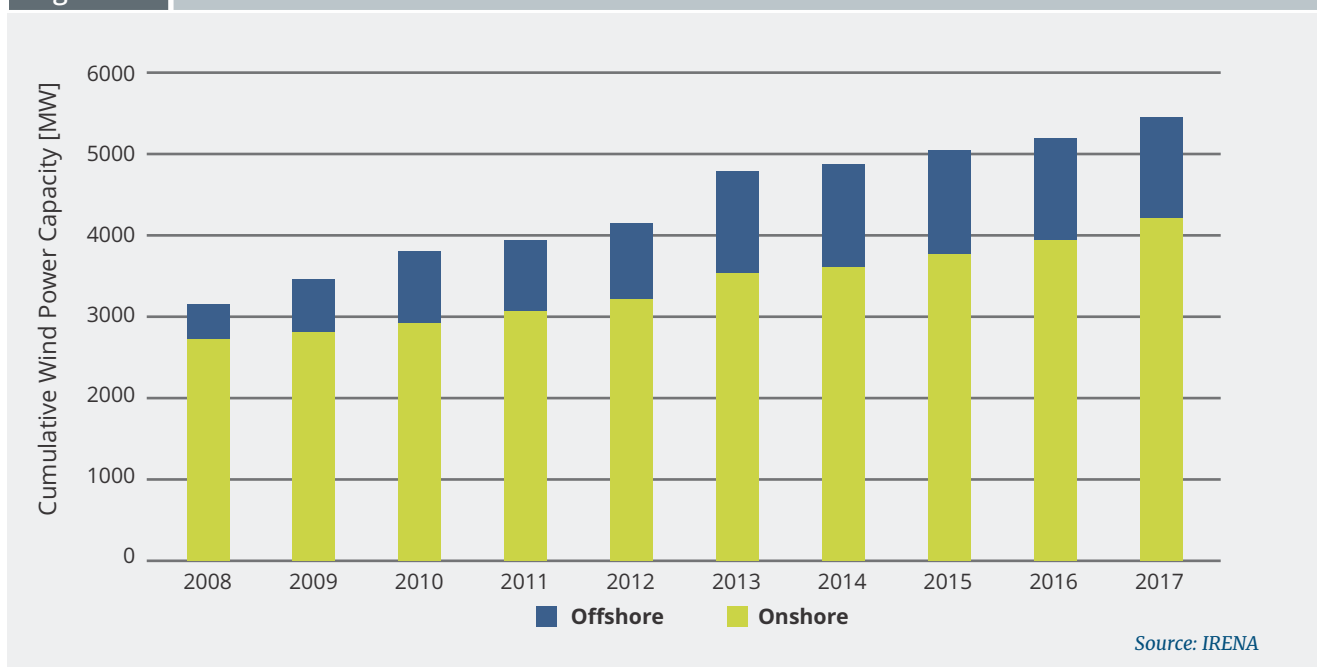
It can be observed that from FY 2007 to FY 2017, WTG capacity addition through repowering has achieved Compound Annual Growth Rate (CAGR) of 30.6% as against 7.2% CAGR for the green-field wind projects.

4.2 Denmark

For over 20 years, wind power has been one of the main renewable energy sources, especially in countries such as Denmark, one of the pioneer countries in developing onshore wind turbines. Whereas offshore wind utilization is still risky as the repowering of wind farms offer an interesting alternative to further increase the generation of renewable energy.

To meet the ambitious renewable energy targets set by the EU and those announced in the National Renewable Energy Action Plan, Denmark will need 6.4 Terawatt hours (TWh) of onshore wind power by 2020. Since the best sites for onshore wind are already being used by the small scale wind generators, the potential for repowering in Denmark is huge.

According to the Danish Register of wind turbines, as of December 2017, the installed wind power capacity is 5,475 MW. It has doubled since 2001, although the actual number of turbines has dropped by 20% owing to the use of larger and more efficient machines. In 2017, wind turbines supplied enough power to cover 43.4% of Denmark's electricity consumption. This is the highest share ever recorded, overturning the previous record set in 2015. Denmark was the first country to actively support wind repowering in part because wind turbine installations began in the early 1980s, so many aging small (< 75 kW) wind turbines exist throughout the country. Denmark recognized that these smaller aging turbines were an obstacle to new project development, and removing and repowering those turbines would require an overt and explicit incentive. Denmark's repowering programme has led to repowering of two-thirds of the oldest turbines in the country. The onshore and offshore cumulative wind capacity (MW) from FY 2008 to FY 2017 is depicted in Figure 32.

Figure 32 Cumulative Wind Power Capacity (MW) From FY 2008 to FY 2017


Repowering Initiatives in Denmark

In Denmark, repowering was undertaken in different stages. The first repowering scheme was initiated from 2001 till the end of 2003 targeting turbines up to a capacity of 150 kW. For decommissioning of these small turbines, the owners received a 'Repowering Certificate' equivalent to an additional tariff of 2.3 Euro cents/kWh for two to three times the scrapped capacity for 12,000 full-load hours. Since these certificates could be traded, the scheme made it possible to install much larger turbines. During the lifetime of the scheme, around 1,480 lower capacity old turbines with a combined capacity of 122 MW were replaced by 272 new turbines having a combined capacity of 324 MW. The scheme was most effective for turbines in the capacity range of 55–95 kW in which more than 80% of the turbines were decommissioned, whereas only 25% of the 150 kW turbines were decommissioned.

In the second stage, projects with turbine size greater than 100 kW could install twice the capacity removed and received the same treatment. The scheme was announced in 2004 for a period of 2005–2009. This scheme was targeting bigger turbines having a capacity up to 450 kW. In this scheme, the turbine owners received repowering certificates equivalent to 1.6 cents/kWh for two times the decommissioned capacity for 12,000 full-load hours. Besides the Repowering Certificate, the wind turbine was given a general subsidy of 1.3 cents/kWh and the balancing fee of 0.3 cents/kWh. The subsidy is restricted so as the sum of the repowering subsidy, the general subsidy of 1.3 cents/kWh and the spot price could not exceed 6.4 cents/kWh. The Repowering Certificate system enabled successful repowering in Denmark.

The certificate holder is awarded a higher price for electricity produced from new turbines up to a maximum of two or three times the replaced capacity. The incentive is regulated in relation to the market price of electricity. The Danish FiT framework is briefed below:

The tariff is distinguished in the following three onshore categories:

- Old wind turbines connected to the grid before 2000: Turbines connected to the grid prior to 2002 received a general price guarantee of 80 €/MWh for a 10-year production period.
- Wind turbines connected between 2000 and 2002: Turbines connected to the grid in the period between 2000 and 2002 received a FiT of 58 €/MWh up to a production limit of 22,000 full-load hours

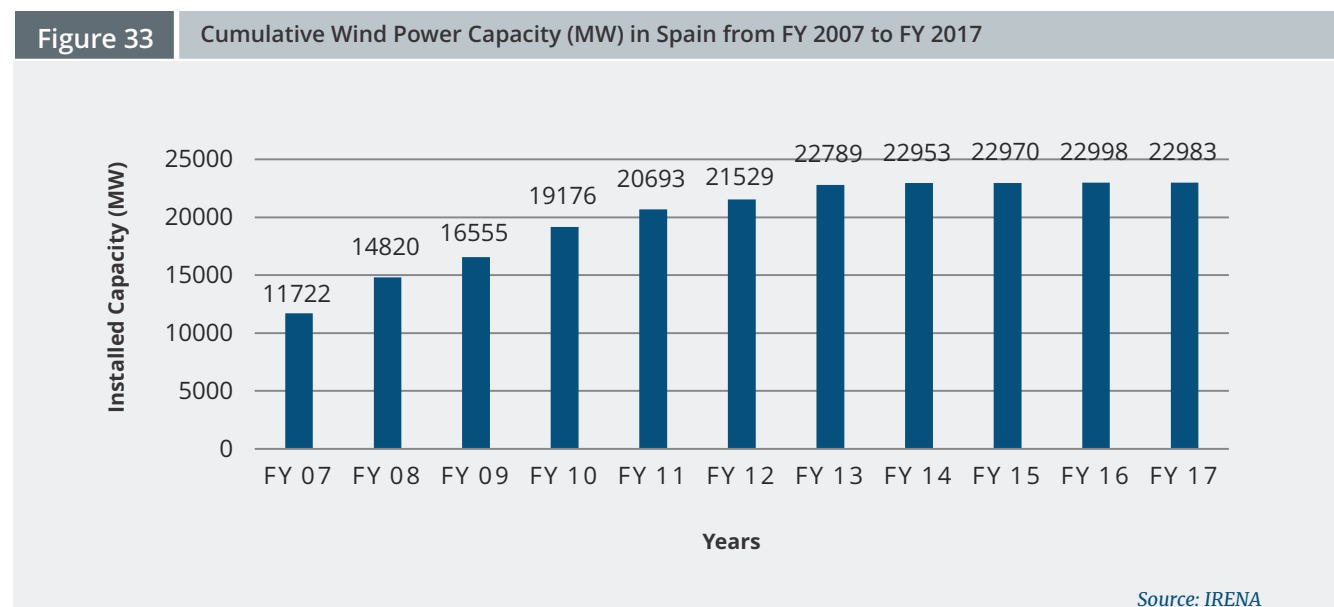
- New wind installations connected to the grid after 01 January 1 2003: Turbines connected to the grid after 01 January 2003, had to sell electricity at the market price. In addition, Turbines received a subsidy of 16 €/MWh for the duration of 20 years.

4.3 Spain

Spain is the second largest European wind energy market after Germany and has the fifth largest wind installed capacity after China, United States (US), Germany and India. The European Union's renewable energy directive sets a binding target of 20% final energy consumption from renewable sources by 2020. Spain has the same target as that of the EU, whereby 20% of its energy consumption shall be met from renewable sources by 2020. In addition, Spain must acquire at least 10% of their transport fuels from renewable sources by 2020.

Installed Wind Capacity in Spain

Spain has total installed wind capacity of around 23 GW (mostly onshore capacity) by the end of 2017 which further constitutes 18.6% of the total generation installed capacity in Spain as shown in Figure 33.



In Spain, almost no new wind turbines have been installed since 2013 due to the drastic change of legislation, referred to as “Energy Reform”. The new regulation in 2013 entailed a complete removal of subsidies and incentives, such as prior FiT and feed-in premium schemes. The following policy and fiscal instruments have supported Spain's wind market through 1990s and 2000s, viz., tax-free depreciation of assets, reduction of income from certain intangible assets, local tax exemptions and FiTs. However, limitation and elimination of incentives over the past years have led to a curtailment of new wind power installations. In January 2012, Spain suspended its special registry of renewable energy projects due to budgetary concerns. Further, in February 2013, it withdrew the option to receive premium over-market FiT rates for renewable energy projects, which now receive only a fixed FiT with annual degression.

Wind Repowering in Spain

In Spain, most of the wind turbines are owned by a handful of large operators. This has significantly impacted the lifetime extension strategy as larger operators have more operational data available. However, presently, no political repowering subsidies exist, and the repowering bonuses were announced in the Renewable Energy Plan PER 2011-2020; but has never materialised due to subsequent suspension of the plan.

Despite such circumstances, Nordex, one of the large wind turbine manufacturer, had recently won its first repowering project of a Spanish wind farm reducing the number of turbines at the site from 90 to 12. The said

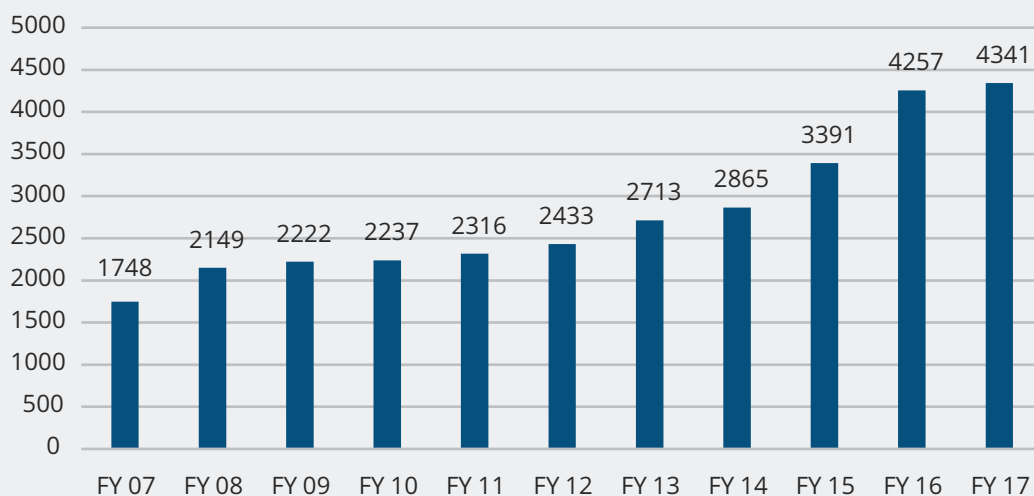
project would remove 90 numbers of 22 old turbines at Acciona Energia's 30 MW El Cabrero project in Andalucía, southern Spain. The site's 330 kW turbines will be replaced with eight N100 3 MW and four AW 70 1.5 MW machines. El Cabrero will have a reduced operating cost due to the lower number of turbines, and an increased energy yield despite having a slightly lower nominal capacity. The said project is envisaged to be completed in the second half of 2018.

Meanwhile, during December 2017, the Spanish wind energy association (Asociación Empresarial Eólica, AEE) published a growth plan in which the country should reach 40 GW of installed capacity by 2030. Repowering of ageing wind farms and new installations are considered imperative to Spain, meeting this target as envisaged in the growth plan. Repowering is also equally relevant for Spain in meeting its target of 20% of its energy consumption from renewable sources by 2020.

4.4 Netherlands

Netherlands had a total installed wind capacity of 4,341 MW by 2017. The country targets onshore and offshore wind capacity addition of 6,000 MW and 2,500 MW respectively by 2020. Energy from wind capacity is expected to contribute significantly to the country's commitment of meeting 14% of its final energy consumption from renewable sources by 2020.

Figure 34 Cumulative Wind Power Capacity (MW) in Netherlands From FY 2007 to FY 2017



Source: IRENA

As per the 2014 EU Commission directive on incentive design guidelines for renewables, it is mandatory for all European nations to migrate to market-based incentives for onshore wind by January 2017. Six out of 11 countries, including Netherlands, have already adopted one or another form of market-based mechanism to set incentives. Netherlands, driven by a clear policy and pre-planned yearly auction until 2020 is expected to comfortably achieve their wind capacity addition target.

Wind Repowering in Netherlands

Despite its small wind market, Netherlands is seen as a large growth opportunity for wind repowering as the onshore turbines are older and of smaller capacities. During 2016, RWE Energy along with several partners and original equipment manufacturers began installing 86 modern turbines at the Noordoostpolder wind farm on the banks of Lake IJsselmeer. The newly repowered area will have 48 Siemens 3-MW offshore turbines and 38 huge Enercon 7.5-MW E-126 turbines. At this site, RWE will remove its 50 WindMaster 300kW turbines once installation of the first 12 Enercon E-126 model is complete. The WindMasters' hub height of 30 meters (m) and

rotor diameter of 25 m are dwarfed by Enercon's 135-m hub height and 127-m rotor.

Simultaneously, investments to the tune of more than 200 Million Euro was being discussed by the end of 2017 to repower one of the oldest wind farms in the country, namely Wieringermeer. The project is expected to repower older wind turbines with updated technology for a capacity of 180 MW by 2019.

Wind capacity installation in the country started around 1985. Several smaller and older wind farms in Netherlands consist of much smaller turbines compared to those typically deployed today. This provides sufficient scope for repowering of old wind installations in the country. Broad estimates set the repowering potential in the country to be around 1,000 MW.

4.5 Experience In India So Far

- The older wind farms located in the windy terrains of Muppandhal, Panakudi and Kayathar in the southern districts of Tamil Nadu- Tirunelveli, Thoothukudi, Nagercoil, Kanyakumari and Coimbatore offer huge opportunity for repowering in India.
- LMW Coimbatore site had 29 WTG's of 300 kW capacity each and 2 WTG's of 500 kW capacity each at Kethanur village, Tamil Nadu which are planned to be repowered in phases to a final number of 15 WTG's of 850 kW capacity each.
- At the Fenner India Nagercoil site, 11 WTG's of 225 kW capacity each have been replaced with 3 WTG's of 850 kW capacity each.
- The Policy for Repowering of the Wind Power Projects in the country has been released on 5 August 2016
- The State of Gujarat has come up with a repowering policy dated 21 May 2018, to promote repowering of wind farms in the State.

4.6 Major Learning From International Case Studies

- Amendment to the Renewable Energy Sources Act (EEG) in 2004 offered an additional financial incentive to repower the turbines installed before 1995, but Germany imposed certain restrictions on hub height and capacity increase posing a major hurdle for repowering activities.
- With amendments to the EEG in 2009, more attractive conditions for repowering projects including additional increase in initial tariff for wind turbines by 0.5 cents/unit above the initial FiT of 9.1 cents/unit. Indian regulators can take a note on this feature of providing additional incentive on FiT till the lapse of their existing PPAs with the utilities.
- The concept of Repowering Certificate as introduced in Denmark, can be replicated in India as well.
- A national turbine registry can be developed in India too. It would necessarily capture information about the new turbines being installed, dismantled and capacity used by all the developers across the country.

It is also understood that there are several reasons for the Government to promote repowering in the country. After analysing the major international repowering scenarios, the major reasons for which the Government promoted repowering are briefed below:

- Ensures energy security by incremental clean energy deployment.
- Ensures minimization of electricity demand supply gap for the country.
- Ensures less variability issues with wind power generation; hence, better grid discipline through repowering resulting in shortage of defaults and forced outages.
- Ensures better landscape quality.

4.7 Learning From Indian Experience

In India, repowering of old wind projects is still at a nascent stage. Certain recent policy provisions have been

made to promote the same. A few demonstration projects have been undertaken to understand the issues and its implications in India. Some of the issues that need to be addressed to enable large scale deployment of repowered wind capacity are briefed below:

- Micro-siting is very important for the optimization of wind farm layout and locating new turbines as per the norms specified by the respective state regulatory authorities. But micro-siting for a repowering site may pose real challenge unless the other old turbines in the windfarm are dismantled.
- The number and capacity of old machines to be removed should be planned accurately to avoid significant generation loss for a long duration and simultaneously avoid hindrance for deployment of new turbines.
- Unlike in Denmark and Germany, in India, there are multiple turbine owners in most windfarms. Since repowering would involve removal of multiple turbines by placing few turbines each of higher capacity than before, it would lead to ownership issues in the project. A holistic business model protecting the interest of every stakeholder needs to be in place to address the issue.

4.8 Policy And Regulatory Provisions For Repowering In India

Policy and regulatory framework has been accorded by the Central and State level to facilitate repowering of wind, which proliferates the capacity by two to three times and promotes optimal utilisation of resources.

- The Policy for Repowering of Wind Power Projects notified by MNRE on 05 August 2016, includes the features shown in Table 6.

Features	Description
Objective of Policy	To promote optimum utilization of wind energy resources by creating facilitative framework for repowering.
Eligibility	Initially, wind turbine generators of capacity 1 MW and below would be eligible for repowering under the policy. Based on the experience, MNRE can extend the repowering policy to other projects.
Incentive	<ul style="list-style-type: none"> ● For repowering projects, Indian Renewable Energy Development Agency (IREDA) will provide an additional interest rate rebate of 0.25% over and above the interest rate rebates available to new wind projects being financed by IREDA. ● All fiscal and financial benefits available to new wind projects will also be available to the repowering project as per the applicable conditions.
Implementation Arrangements	The repowering projects would be implemented through the respective State Nodal Agency/Organization involved in the promotion of wind energy in the state.
Support to be provided by the States	<ul style="list-style-type: none"> ● In case of augmentation of transmission system from pooling station, the same will be carried out by the respective State Transmission Utility. ● In case of power being procured by State DISCOMs through PPA, the power generated corresponding to an average of last three years' generation prior to repowering would continue to be procured on the terms of PPA in-force. In addition, remaining additional generation would either be purchased by DISCOMs at FiT applicable in the state at the time of commissioning of the repowering project and/or allowed for third party sale.

Features	Description
Support to be provided by the States	<ul style="list-style-type: none"> State will facilitate to acquire additional footprint required for higher capacity turbines. For placing of wind turbines, 7D x 5D criteria would be relaxed for micro-siting. A wind farm/turbine undergoing repowering would be exempted from not honoring the PPA for the non-availability of generation from wind farm/turbine during the period of execution of repowering. Similarly, in case of repowering by captive user, they will be allowed to purchase power from grid during the period of execution of repowering and on payment of charges as determined by the regulator.
Financial Outlay	No additional financial liability shall be met by the MNRE for implementing the Repowering Policy. The repowering projects may avail the AD benefit or GBI as per the conditions applicable to new wind power projects.
Review of Policy	The Repowering Policy would be reviewed by the Government as and when required.

- National Tariff Policy, 2016 clause 5.11 (g) specifies need for encouragement on Renovation and Modernization of power plant including repowering of wind generating plants. The relevant clause of the Tariff Policy, 2016 states that:

“Renovation and modernization of generation plants (including repowering of wind generating plants) need to be encouraged for higher efficiency levels even though they may have not completed their useful life. This shall not include periodic overhauls. A Multi-Year Tariff (MYT) framework may be prescribed which should also cover capital investments necessary for renovation and modernization and an incentive framework to share the benefits of efficiency improvement between the utilities and the beneficiaries with reference to revised and specific performance norms to be fixed by the Appropriate Commission. Appropriate capital costs required for predetermined efficiency gains and/or for sustenance of high level performance would need to be assessed by the Appropriate Commission.”

- The Gujarat Repowering of the Wind Projects Policy, 2018 notified by the State Government of Gujarat on 21 May 2018, has the following features as shown in Table 7.

Features	Description
Eligibility	Capacity of 1 MW and below would be eligible for repowering under the policy. Based on the experience, the repowering policy can be extended to other projects as well. The life of repowered wind project shall be considered as 25 years or actual life of project whichever is earlier.
Incentive	As provided in the Repowering Policy of Government of India, the repowering projects can avail additional interest rate rebate/fiscal and financial benefits as available to the new wind projects.
Implementation Arrangements	The repowering projects would be implemented through the State Nodal Agency and Gujarat Energy Development Agency (GEDA).

Features	Description
<p style="text-align: center;">Support to be provided by the States</p>	<ul style="list-style-type: none"> ● In case of augmentation of transmission system, from pooling station onwards is required as per the system study undertaken by GETCO due to repowering of Wind project, the owner/developers shall undertake such addition/augmentation in the system up to receiving end substation of GETCO. ● In case of power being procured by State DISCOMs through PPA, the repowering of existing wind project shall be allowed infollowing conditions: <ul style="list-style-type: none"> ● The wind turbine owner/power generator shall supply generation from existing capacity (prior to repowering) as per the terms of existing PPA. The generation corresponding to existing capacity prior to repowering shall be equivalent to average generation during last three years prior to repowering of Wind Mill. ● The additional capacity increased due to repowering shall be procured by State DISCOM considering the RPO requirement and tariff discovered through competitive bidding process as may be decided from time to time. However, it will not be binding for the State DISCOMs/GUVNL to purchase additional wind power to be generated because of such repowering. ● Tariff as fixed in the respective PPA shall not be increased. The benefits granted under the respective Wind Power Policy like land lease etc. will not be increased or the term of such benefits shall not be extended because of such repowering. ● The terms of existing PPA shall be extended for the period equivalent to time taken for repowering of wind turbine subject to maximum of four months. ● In case of wheeling agreement for third party sale/captive use, the wheeling charges on entire repowered capacity shall be applicable as per the GERC order pertinent fromthe date of commissioning of repowered wind turbine for which a new wheeling agreement must be signed.

5. Challenges For Repowering In India

Extensive stakeholder consultations revealed issues related to the potential roadblock for repowering of old wind power projects in India.

5.1 Key Issues For Repowering

Some of the major issues that need to be addressed to make repowering projects successful in the country are briefed below.

5.1.1 Fragmented Ownership Structure Of Wind Farm

In India, there are multiple owners of wind turbines in the same wind farm. Many of these owners who have commissioned their projects prior to 2002, own one or more turbines of capacity less than 500 kW. Repowering of these old wind farms will reduce the number of turbines and there may not be any replacement. For example, in a wind farm, 10 turbines each of capacity 250 kW would be removed for the installation of 3 turbines each of 2 MW capacity. Hence, it complicates the ownership issues of three new turbines. This issue is one of the main commercial bottleneck that needs to be resolved to pave the way for repowering business to be viable in the country.

5.1.2 Loss Of Captive Status If Captive Generators Go For Repowering

The Electricity Rules, 2005 of the Indian Ministry of Power (MoP) states that to qualify as a captive generator, a consumer must own at least 26% equity stake in the generating company and it shall consume at least 51% of the aggregate generation. With such rules in place, if a captive power generator seeks to opt for repowering, it may have aggregate generation increased up to three times more than its initial generation. In such circumstances, in cases where the captive consumption has remained unchanged, the generator will lose its captive status since the user is consuming lower percentage of actual generation by repowered captive generating plant according to the existing rules. It could result in the levying of additional cross subsidy surcharges on the entire consumption of the consumer. In the present legal framework, such captive generators would not take up repowering due to the minimum consumption criteria.

Moreover, all the project owners may or may not participate in a repowering project. Repowering could reduce the number of turbines; but, it may not be possible to evolve exact replacement. Further, it is possible that a repowering project is undertaken by one dominant investor while the rest of the existing captive project owners may be small/minority stake holders as a result, the repowered project may or may not be able to meet the criteria of 26% ownership.

5.1.3 Evacuation Infrastructure Up-gradation

In Tamil Nadu, most of the windfarms that house projects with completed life of more than 15 years are connected to the 11 kV lines for the evacuation of power. However, post repowering, the capacity and aggregate generation may increase by two and three times respectively. Hence, there is a need to upgrade the existing infrastructure such that all the energy generated can be evacuated properly without any congestion for evacuation of wind power and without any forced generation curtailment.

5.1.4 Loss Of Generation During Construction Period

It is implicit that both dismantling of old assets and installation of new assets require certain minimum time to complete. Hence, the loss of generation during the construction period could be an issue for the existing turbine owners

5.1.5 Valuation of Existing Assets

Certain cost aspects are associated with the repowering projects. Apart from the cost of new assets, there are certain other costs such as the cost of decommissioning of old assets, revenue foregone for the remaining life of the existing projects, revenue loss during the construction period, salvage value of the old assets etc. All such cost components should be considered for valuation of the existing wind power project. As on date, no benchmark cost is set for these components in India.

5.2 Recommendations on Key Issues

After several deliberations with the experts and based on the stakeholder inputs, certain solutions were received to address the above issues. All recommendations for the issues (as mentioned above) briefed below.

5.2.1 Fragmented Ownership Structure At Windfarm

The issue of multiple owners of a wind farm poses as the biggest commercial impediment to go for repowering of the old wind turbines. This issue becomes important to be addressed since repowering would not necessarily replace every low capacity turbine by a higher one. It is envisaged that a wind repowering project implementer, who is expected to acquire the existing wind projects and to develop the new repowered project would receive the consent of the existing turbine owners in the following ways:

- Giving stakes of the new repowering project to the existing turbine owners' stakes in the ratio of their equity contribution. This equity contribution shall be adjusted after the valuation of their existing projects.
- For the existing owners who are not willing to invest; but, are interested to be a part of the new repowering project, the Wind Repowering Project Implementer (WRPI) shall give the existing turbine owners stakes of the new repowering project as per the value of the dismantled assets and the revenue foregone.
- For the existing owners who are not willing to be a part of the new repowering project, the WRPI shall offer a complete buyout of the existing turbines with the land rights as per the standard method of valuation.

All existing stakeholders willing to repower, can be made partners in the WRPI promoted SPV, and subsequently the profits can be shared in the ratio of equity shareholding in the SPV.

5.2.2 Loss Of Captive Status If Captive Generators Go For Repowering

Conditions related to the ownership and the consumption have been specified in the Electricity Rules, 2005 notified by the Ministry of Power, Government of India. As a result, modifications to the eligibility conditions as stipulated under The Electricity Rules 2005, needs to be incorporated. The criteria for captive consumers as defined in The Electricity Rules, 2005 can be relaxed as per the notification under Section 176 (z) of the Electricity Act 2003. It is proposed to allow the existing captive users of wind power project to continue to consume energy quantum equal to their captive consumption prior to repowering as calculated below irrespective of whether plant meets the definition set out in the said rule:

The conditions of 51% consumption and of 26% ownership shall not be applicable in case of existing captive users of the repowered power projects, as long as annual captive consumption of

such captive users from the repowered projects remain at least equal to the average annual captive consumption for the last three years prior to commissioning for repowered wind power project.

5.2.3 Evacuation Infrastructure Up-gradation

The WRPI shall be responsible to upgrade the evacuation infrastructure from 11 kV to 66 kV till the pooling substation. Alternatively, the STU can carry out the upgradation activities; but, it shall be adequately reimbursed by the repowering project implementer. However, the STU shall be the responsible entity to carry out the transmission infrastructure upgradation beyond the pooling substation. The cost of creation/up-gradation of evacuation infrastructure shall be factored in the re-powering project at the Detail Project Report as (DPR) stage itself.

5.2.4 Loss Of Generation During Construction Period And Valuation Of Existing Assets

The following cost components must be considered by the WRPI to evaluate the cost of acquisition of the existing wind turbines, and thereby, assess its incentive requirement:

- Loss of generation during the construction period, i.e., the loss of revenue during the transition period.
- Cost of equivalent generation to serve the utility as per existing the PPA rate at least for balance PPA tenure.
- Decommissioning costs associated with old wind project.
- Net benefit of revenue for sale of scrap.
- Cost of up-gradation of evacuation infrastructure.

6. Development of Business Model

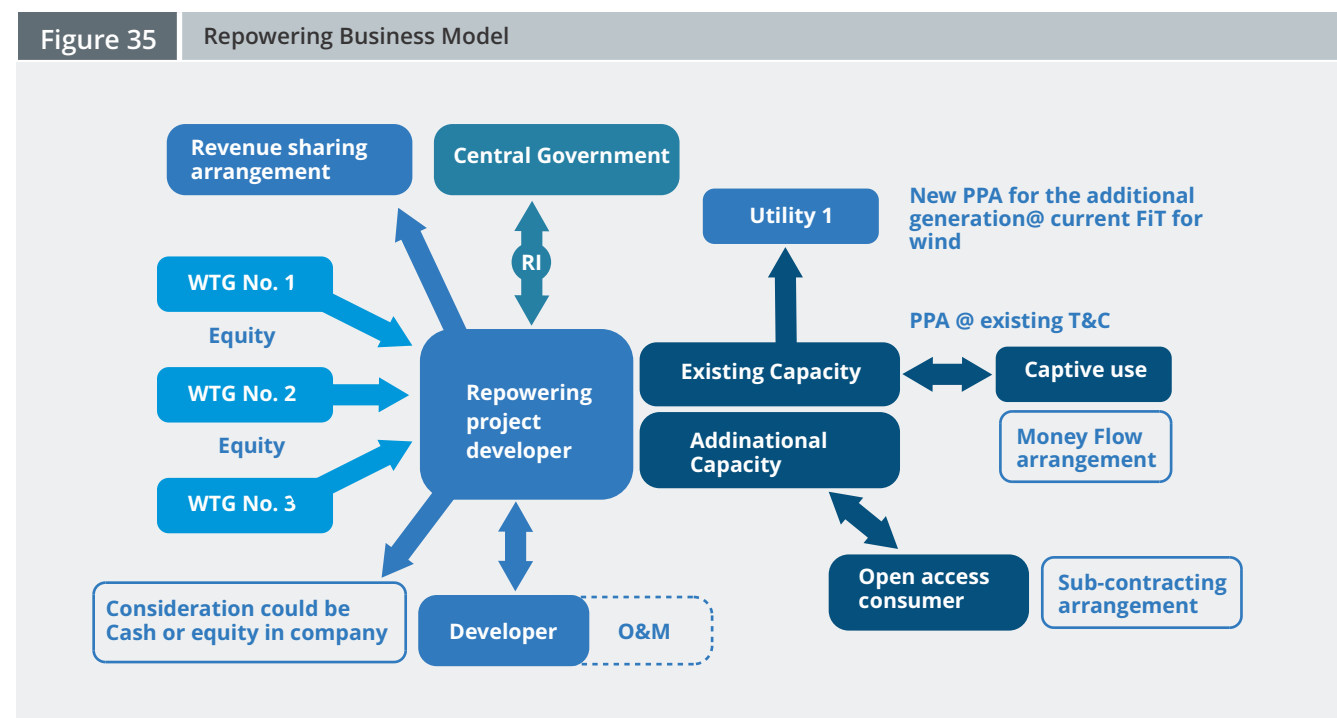
Successful implementation of repowering projects depend upon the formulation of a holistic business model. There are many issues that hinders the growth of repowering as described in the preceding chapters Wind farms with fragmented ownership is the single biggest commercial issue for repowering. Hence, to address these issues a business model has been conceptualised.

6.1 Essential Features Of Business Model

- Since fragmented ownership of wind farm is an issue, a SPV can be formed with equity contribution from each interested party, with an agreement to share the revenue in proportion to equity contribution. A wind repowering project implementer, who can be any person, investor, manufacturer/developer, leading project developer at the windfarm site shall be the primary owner of the project and shall form a SPV-like-structure for the implementation of a repowering project.
- WRPI would procure the existing assets which includes both the turbines and the required land use rights.
- Interest of the utility in terms of existing PPAs (at least for balance tenure of PPA) must be protected.
- Consumers would benefit from the proposed repowered scheme in terms of enhanced renewable generation from given wind farm site.
- The model must be supported by the Government in terms of incentives to make it financially feasible for developers

The business model is so designed that it would not adversely affect any stakeholder, and simultaneously would not lead to an adverse tariff impact for the consumers. The major factors affecting the development of repowering projects in the wind rich sites are accounted for the development of the business model.

The repowering business model is presented in Figure 35.



6.2 Important Features Of Business Model

The components that would impact the functioning of the business model includes parameters such as asset management, contract with utilities, advantages and implementation challenges. These features are outlined in the below sections.

6.2.1 Asset Management

The existing assets of the wind farm would be acquired by the WRPI who can be either an existing owner or may be a third party IPP or any other investor. The transaction is envisaged to occur upon accounting for the revenue foregone, market cost of existing assets and other standard parameters of valuation. The existing asset acquisition can also happen by offering the individual asset owners some stake in the project company. Hence, there can be multiple stakeholders of one Project Company. The ownership of assets depend on the share of investment in the company.

6.2.2 Contract With Utilities

Utilities would continue to procure power at a rate given in the existing PPA. Hence, the remaining amount to cover the cost per unit of repowered project must be borne by the Government till the end of the existing PPA or the balance useful life, whichever is lower.

6.2.3 Advantages

Distribution utilities are likely to support repowering business model as they would continue to receive power at the previous tariff rate at least for the balance PPA tenure with better reliability. Developers can cover its actual cost of generation for the repowered project partly from the utility payment and partly through incentives. The net profit can be shared among the existing wind farm owners according to the ratio of the equity investment in the project company (SPV).

6.2.4 Implementation Challenges

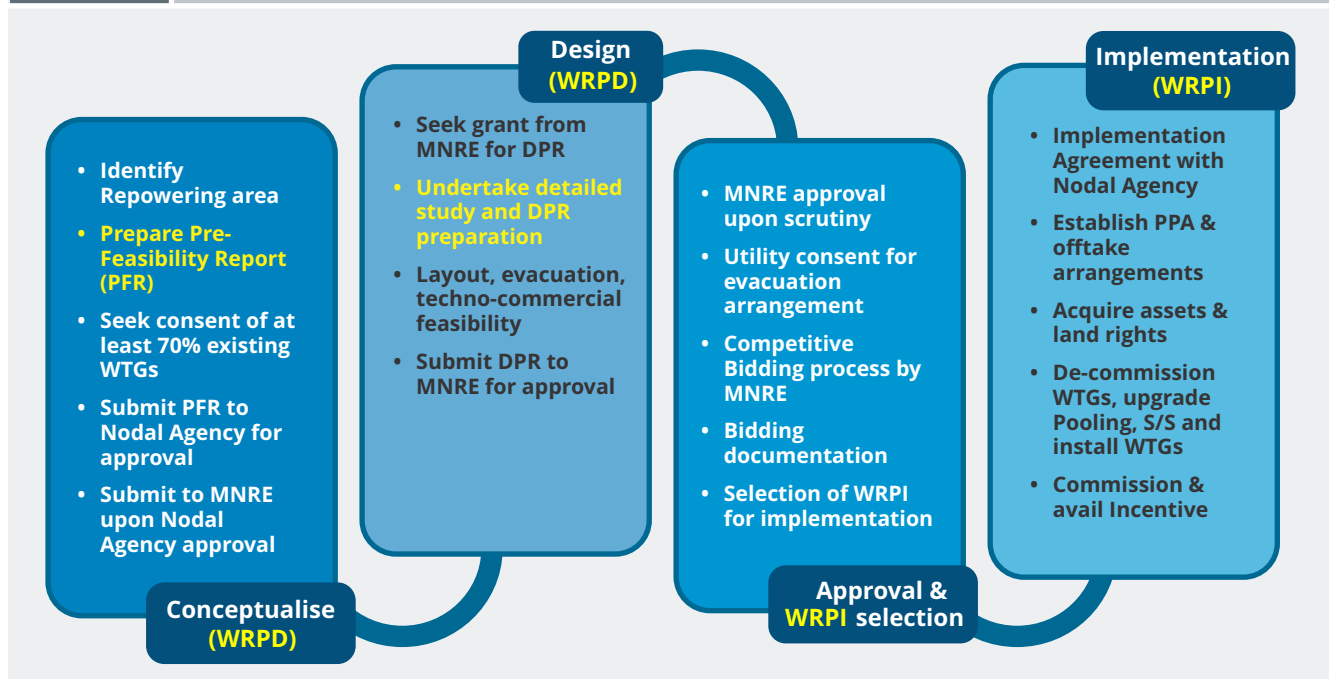
Government must bear the burden of the difference between the lower tariff as mentioned in the PPA and the actual cost of generation from a repowered project for the remaining period of the existing PPA. Owners who are unwilling to be a part of such project, must be compensated separately for buyout of their asset and the deemed loss of generation for the balance life of the assets.

The business model as envisaged would involve the following stakeholders:

- Wind Repowering Project Developer (WRPD)
- WRPI
- Utility
- MNRE
- SERC
- State renewable energy development agencies

The implementation framework and stages for the proposed business model is pictorially depicted in Figure 36.

Figure 36 Implementation Framework and Stages for the Proposed Business Model



6.3 Role Of Various Major Stakeholders

The major roles played by the stakeholders in the formation and subsequent functioning of the business model is outlined below.

6.3.1 WRPD

- The responsibilities of the WRPD includes preparation of Pre-Feasibility Report (PFR) and Detailed Project Report (DPR) for the concerned project. WRPD shall first prepare the PFR and then get it approved from the State Nodal Agency, and finally from MNRE.
- Upon approval from MNRE, the WRPD shall prepare the DPR, and present to MNRE for further approval. WRPD can be any organization with proven technical and management expertise in the field of wind energy.
- MNRE shall incentivise the WRPD in the form of a capital grant to encourage more such players to come up and to initiate the process of repowering.

6.3.2 The Government/MNRE

The Government shall come up with a Repowering Policy to promote repowering power projects in India, the details of which are defined below:

- Government must ensure a long tenure (at least five years) continuous support through the RI to be paid to the WRPI. Government may involve state level renewable energy development agency to monitor the generation and to disburse the required amount.
- To enable continuation of the existing PPAs at earlier Tariff rates, the Government needs to incentivize the developer over and above the rate at which it is supplying power to the utilities. The incentive should be sufficient to match the actual cost of generation from the repowered facility. This should continue for a fixed tenure of five years or until the completion of the earlier PPAs, beyond which this incentive shall not exist anymore.
- The policy document shall continue to have concessional wheeling, banking provisions for repowered captive/group captive projects.

- Government may relax the micro-siting criteria for wind site from 5Dx7D concept to 3Dx5D concept for better utilization of land, wherein, D stands for Diameter of the Rotor.
- The agenda for upgradation of evacuation infrastructure for repowering sites shall be propagated at all necessary levels for quick action.

The Government should lay down some eligibility criteria for participation in repowering schemes, which can be monitored by the state level renewable energy development agencies. The set of criteria can include minimum hub height, minimum expected yield factor, minimum capacity expansion etc. The Government shall conduct a bidding process for the selection of WRPI based on the approved DPR.

6.3.3 WRPI

- The WRPI can be formed by any repowering project developer as mentioned earlier such as a WTG manufacturer, a windfarm developer, a Wind IPP, an owner of the existing wind farm or any other investor who is willing to buy existing assets of the windfarm at a mutually agreed price based on the standard parameters (revenue foregone, remaining asset life etc.). The acquisition may also take place by offering the existing turbine owners some stake in the project company.
- The WRPI would necessarily continue the existing PPA with the utilities with the same terms and conditions.
- For the additional generation, the project developer either should sign new PPAs with various utilities or sell the additional electricity to open access consumers via bilateral transaction in a mutually agreed rate or sell in the spot markets at market price.
- The WRPI must share the profit with other wind farm owners in the ratio of equity shareholding of the project.

6.3.4 Distribution Utility

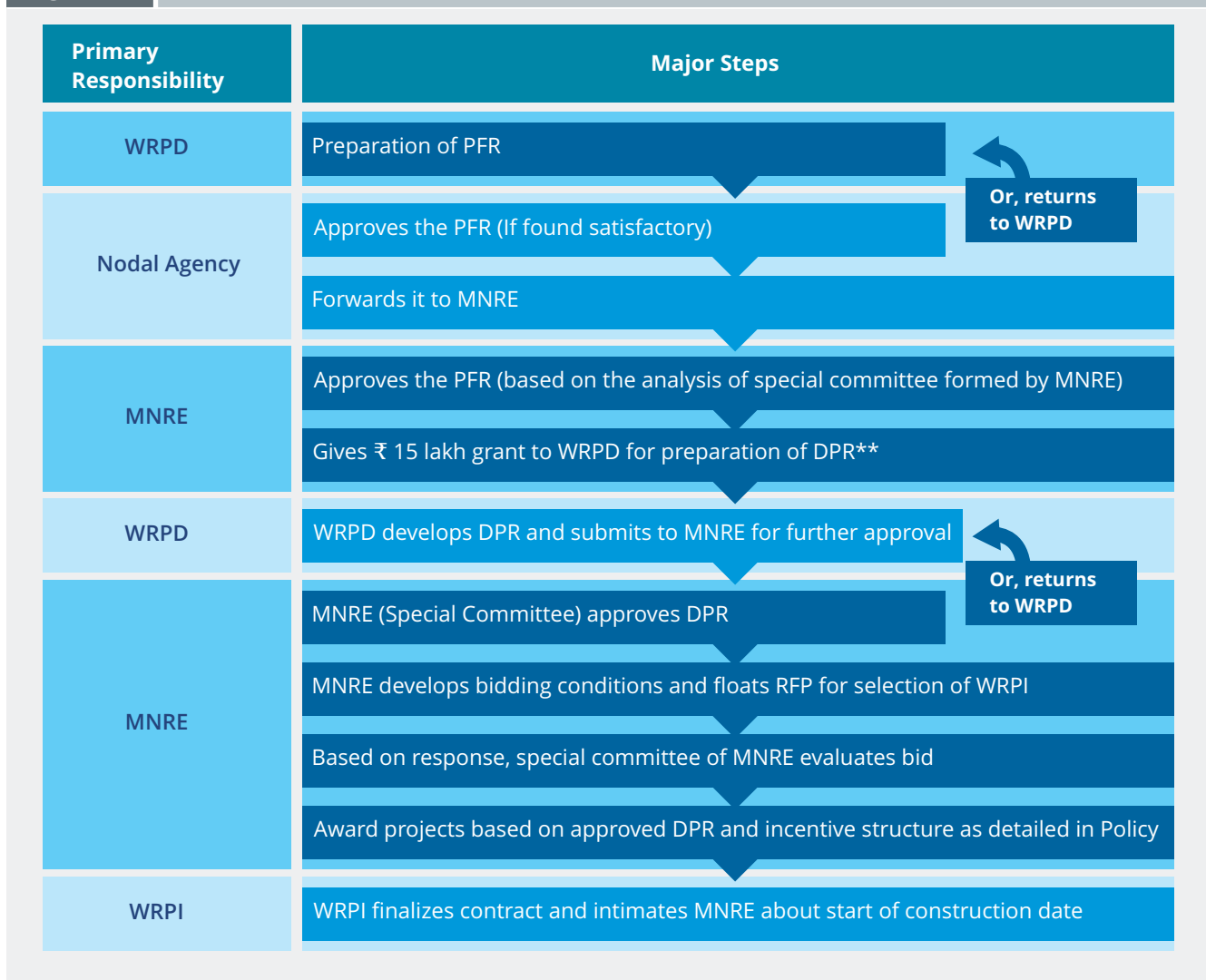
- Distribution utilities are expected to continue purchasing wind power at least equivalent to pre-repowered quantum from the repowered wind farm at an old rate till the completion of the existing PPA.
- Distribution utility may sign new PPA with project developers at an existing FiT for wind after completion of the old PPA.
- Utility can procure power from the market during the construction phase of the repowering project. A strict time frame of six months shall be given beyond which, if the generation does not begin, utility would be compensated.

A detailed process chart, outlining the sequence of activities to be undertaken by the various entities to take up repowering project is depicted in the following sections.

6.4 Process Chart-repowering Project

The repowering project in the envisaged business model would require several activities to be undertaken sequentially as shown in Figure 37.

Figure 37 Repowering Process Chart



** Grant would be given as per the terms and conditions (T&C) specified by MNRE.

50% would be given after the approval of PFR while the remaining 50% would be disbursed after the approval of DPR.

WRPD shall have a maximum of three opportunities to get the DPR approved, failing which WRPD shall refund the initial 50% payment. MNRE shall give in writing the details for not approving the DPR.

6.4.1 Eligibility Criteria For Repowering Project

The repowering project shall satisfy the following conditions:

- The wind turbines in the repowering area should have completed an operational life of minimum 15 years at the start of construction date (SOCD).
- In case, the wind turbines have not completed the stipulated period of 15 years but annual average CUF for three preceding years is below 15%, the same may be considered for repowering.
- Capacity of individual turbine must not be more than 500 kW.

6.4.2 PFR

The PFR to be prepared by WRPD shall contain the following information:

- Definition of repowering area
- Existing wind turbines and turbine owners
- Pooling substation and interconnection arrangement

- Existing offtake arrangements
- Generation from existing wind turbines
- Wind potential in repowering area (incl. WRPD at 80 m hub-height)
- Initial consent of at least 70% turbine owners to consider repowering
- Details about land – ownership, location, latitude/longitude
- Preliminary details about evacuation arrangement – existing and proposed

6.4.3 DPR

The DPR shall include the following details:

- Detailed information about the existing turbines:
 - Coordinates of existing WTG
 - Capacity of each WTG
 - Information about land ownership
 - Electricity generation details for last three years
 - Interconnection arrangements with Single Line Diagram
 - Offtake arrangements including PPA details
 - Budget cost estimate – repowering and de-commissioning
- Details of layout of the new project and selection of machines etc.
- DPR shall demonstrate the feasibility of repowering using minimum three types of turbines currently available in India.
- Land requirement for new turbines and availability of the same.
- Power evacuation arrangement beyond pooling station and estimation of capital expenditure.
- Consent of WTG owners in repowering area to be part of the repowering project and sell existing turbines to WRPI at the price set out in this Policy.

6.5 Financial Incentives For Repowering

In this report, an attempt has been made to quantify the incentives required by the repowering project developers to undertake a repowering project. Currently, the calculations are based on the initial methodology developed for this purpose. Further, assumptions for cost, performance parameters and expected yield from repowering project is based on generic assumption for sample representative case. Therefore, the results presented in this section are indicative and should not be construed as a definitive yield for any repowering project site case.

Following steps were undertaken to arrive at the incentive figure:

- Compilation of existing wind tariff and tariff prior to 2002 for several states.
- Compilation of wheeling charge, loss, CSS (Cross Subsidy Surcharge) for several states.
- Prepared assumptions on realistic basis for energy yield after repowering, duration for commissioning, interest rate for debt etc.
- Based on the assumptions and applicable charges, developed a cost of generation and thereby levelised tariff corresponding to the useful life for repowering projects (with standard pre-tax Return on Equity of 19%).
- Compared the levelised cost with the existing state specific FiT.
- Project the difference between the two as incentive.

Compilation of the prevalent wind tariff structure and the applicable banking/wheeling charges (prior to 2002) and the present wind tariff structure and banking/wheeling charges and other open access charges (2017) in select states have been summarized in Table 8.

Table 8 WindTariff Structure and Banking / Wheeling Charges Before 2002 and 2017

Sl. No.	State	Wind Tariff for Sale to Utility		Wheeling Model: Captive or Third Party Wheeling						
		Prior to 2000/2003		Prior to FY 2000/2003			FY 2017			
				Wheeling Charge	Wheeling Loss	Cross-Subsidy Surcharge	HT-Industrial Tariff (Only Energy Charge)	Wheeling Charge	Wheeling Loss	Cross-Subsidy Surcharge
		₹/Unit	₹/Unit	₹/Unit	%	₹/Unit	₹/Unit	₹/Unit	%	₹/Unit
		a	b	c	d	e	f	g	h	i
1	Gujarat	3.20	4.72	0.00	4.0%	0.00	4.30	0.15	10.0	1.47
2	Karnataka	3.10	3.74	0.00	5.0%	as applicable	6.80	0.57	12.5	1.52
3	Maha rashtra	2.52	3.71	0.00	7.0%	0.00	7.07	1.13	15.0	1.65
4	Rajasthan	3.79	5.52		7.0%	0.00	7.30	0.64	8.0	2.22
5	Tamil Nadu	2.70	2.86	0.00	5.0%	0.00	6.35	0.08	13.8	1.67

6.5.1 Key Assumptions

It is implicit that the repowering projects would require significant additional investments for successful implementation. Hence, the promoters of repowering projects would require certain incentives, at least during the initial years for successful execution of the project. After the detailed analysis of repowering activities in Denmark and Germany, it is observed that the incentives remain most effective when it is over and above the given FiT to the generators such incentives provide the investors with a long-term security for their investments. A detailed financial model is developed to arrive at the incentives required in states such as Tamil Nadu and Gujarat, where repowering potential is maximum. Assumptions impacting the incentive numbers for both old and new repowered wind turbine assets are shown in Table 9 and 10 respectively.

Table 9 Assumptions for Old Wind Power Project Assets

Particulars	Units	Gujarat	TN	Maharashtra	Remarks
Capacity	MW	10	10	10	
CUF	%	13	14	12	Verified by site visits
Wheeling Loss (old BWA)	%	4	5	7	
Degradation	%	0.25	0.25	0.25	
Preferential Tariff before 2000/2003	₹/kWh	3.20	2.70	2.52	From old Tariff Orders
Capital Cost	₹ Cr/MW	4.00	4.00	4.00	
Capital Cost	₹ Cr	40.00	40.00	40.00	
Remaining Life of the Asset	Years	5	5	5	Ideal for repowering

Particulars	Units	Gujarat	TN	Maharashtra	Remarks
Capacity	MW	2	2	2	Latest turbine capacity
No. of machines	No.	10	10	10	
CUF	%	26	30	25	Expected CUF according to potential
Wheeling Loss (old BWA)	%	10	14	15	From SERC Order
Degradation	%	0.25	0.25	0.25	
Preferential Tariff before	₹/kWh	4.72	2.86	3.71	From old Tariff Orders
Capital Cost	₹ Cr/MW	6.19	6.19	6.19	
Capital Cost	₹ Cr	12.38	12.38	12.38	
Remaining Life of the Asset	Years	20	20	20	

6.6 Key Scenarios

Based on the relevant assumptions, certain simulations were carried out to arrive at the minimum incentive that the project company would require to make the business model sustainable. The findings for select states are shown in Table 11.

Incentive (₹/unit)	Case-1 Sale to Utility	Case-2 Captive Wheeling	Case-3 Third Party Wheelingmarks
Gujarat	0.00	0.64	2.14
Karnataka	0.53	0.00	0.00
Maharashtra	1.07	0.00	1.05
Rajasthan	0.0	0.00	0.92
Tamil Nadu	1.12	0.00	0.00

Source: Idam Infra Analysis

It is observed that an incentive of ₹1.12/kWh above the existing FiTs would be required for Tamil Nadu to make it a sustainable business model. Since the incentive requirement would vary from case to case, depending on site specific characteristics, ownership details, balance useful life of the project, off-take arrangement and state specific regulatory framework, it would be inappropriate to devise per unit RI or a fixed incentive quantum or the formulation of the same.

Besides, it would be most prudent and efficient to discover the incentive requirement for repowering project through a transparent competitive process subject to certain ceiling conditions that MNRE may propose to include as part of Repowering Guidelines. This would highlight the most optimal and technically efficient solution for repowering for a given wind farm site by participation of multiple stakeholders once the DPR for repowering a site is ready.

Accordingly, it is recommended to devise a suitable guideline or a ready reckoner to encourage the stakeholders to participate in the repowering project. Draft framework for Repowering Guidelines is proposed under **Annexure II**.

7. Recommendations: Government Intervention For Repowering

The Government should play a critical role in the successful implementation of the envisaged repowering program. It is well understood that any model for repowering would not be feasible without a substantial support by the Government. Alternatively, the Government's active role can pave way for the optimum utilisation of wind rich sites in India, and hence can contribute to the rapid clean energy deployment in the country.

As said, the Government has set an ambitious target of deploying 60 GW of wind energy by 2022; hence, repowering would not only increase the renewable energy portfolio of the country but would also ensure substantial energy security in the long term. To achieve this target, the Government must take up the below mentioned initiatives:

Central Government

- Development of a long-term repowering programme and development of a framework for the implementation repowering of Wind Turbines.
- Issuance of guiding framework to encourage repowering initiatives.
- RI for repowering projects in addition to FiT, AD, GBI or any other existing schemes.
- Continued extension of Tax benefits in the form of AD.
- Modification to the MoP's Electricity Rules 2005, to relax the eligibility conditions for the current captive generators and to encourage participation in repowering projects by the existing wind farm developers
- Publication of a list of wind rich sites where repowering projects are essential. (This although cannot be mandated, should be encouraged).

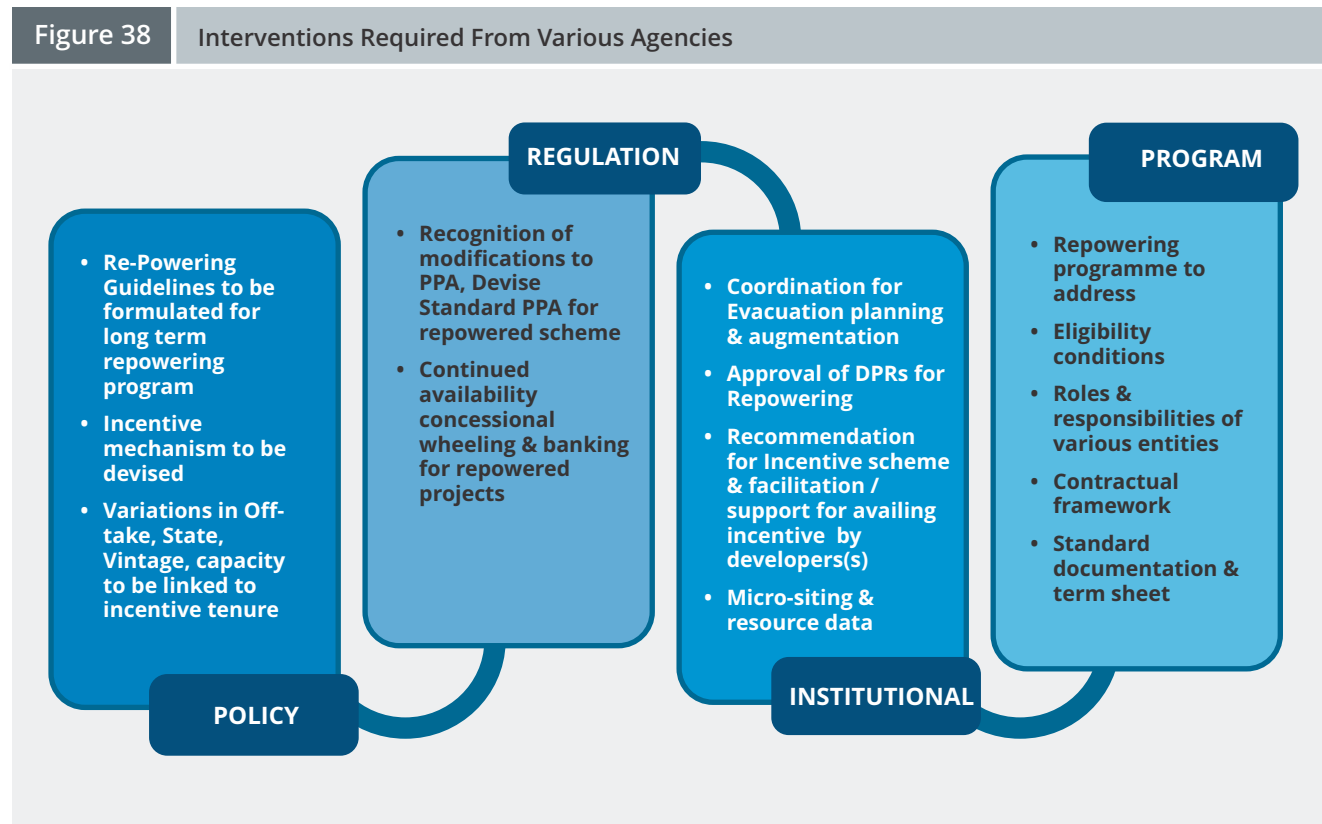
The Central Government has notified a policy for repowering of wind projects on 05 August 2016. Though the policy framework is a good start, many of the aspects listed above which are requisites from the government are not covered under the present policy. The Government may reconsider the policy provisions accordingly and revisit the same.

State Government

- Direct state level nodal agencies for renewable development, to come up with data of remaining plant life and PPA durations for all projects in wind rich sites as identified by the Central Government.
- Facilitate project developers/owners with the required data as and when required.
- Approve repowering project schemes in a timely manner.
- Disburse incentive funds to parties as and when required.

- Facilitate and prioritise development of the evacuation infrastructure for accelerated deployment of repowering projects.

The interventions required from the various agencies are summarized in Figure 38.



8. Conclusion

The research on repowering of old wind turbines in India, prior to and during the preparation of this report, reveals that the existing wind power project developers and other stakeholders are unlikely to pursue repowering on their own in future unless various technical, regulatory and commercial considerations, and the multiple challenges surrounding the repowering project scheme are adequately addressed.

Even if the owners are interested, multiple ownership of WTGs at given windfarm site, continuation of the existing PPAs, willingness of the utilities to support such repowering project schemes through continuation of concessional banking/wheeling arrangements, additional investments required for evacuation infrastructure etc., pose significant challenges for a repowering project even at an inception stage. The repowering business model, developed in this study, considers several implementation issues regarding technical, commercial, regulatory and policy hurdles, and proposes a win-win solution for all upon considering the concerns of various stakeholders.

The present policy initiatives by the Government is a good start, considering the complexities involved. If RI scheme as suggested in this report is introduced by the Government, then with the support of conducive regulatory framework, successful implementation of such business models can catalyse the growth of business opportunities for repowering of old wind power projects in India.

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Annexure I: Note On Issues Related to Captive Power From the Perspective Of Repowering

Background

The development of wind power projects started in India in early 1990s. All such early projects are located at the best wind rich sites in the country. Most of the old turbines are generally with capacity sizes ranging from 55 kW to 500 kW and have a CUF in the range of 10% to 15%.

Modern wind turbines with higher hub heights and with better technology, can deliver CUF more than 25% to 30% at such wind resource rich sites. The total energy generation could be two to three times the energy generated from same piece of land. To optimally utilize the wind resources, the old turbines should be replaced with such modern turbines of higher capacity which may result in the capacity augmentation by around two times or more with a corresponding energy yield increase by around three times the present generation at these windy sites. This process is referred to as repowering of the old wind turbines and would help in not only improving the resource utilisation, but also help in achieving the Indian Government's ambitious target of 60 GW of wind energy.

It is understood that most of the wind energy development that occurred prior to 2002 was for captive consumption, especially in the wind rich states such as Gujarat, Maharashtra, Karnataka and Tamil Nadu. The industries in these states invested in windpower to meet the power requirements of their own industrial units. This has helped these industrial units reduce their energy bills primarily because the power from grid that was made available to them at commercial tariffs, was much higher than the cost of generation from the wind energy sources. While incentives such as AD or GBI could defray the increased costs post repowering, a real impediment could be the loss of “captive” status post repowering due to increased quantum of energy generation.

In this note, the issue related to “captive” status of old wind farms has been analysed from a legal and regulatory perspective, and a solution has been suggested for the inclusion in a suggested repowering policy of the Government of India.

1. Legal Framework

Section 2 (8) of The Electricity Act, 2003 defines captive generating plant as:

(8) “Captive generating plant” means a power plant set up by any person to generate electricity primarily for his own use and includes a power plant set up by any co-operative society or association of persons for generating electricity primarily for use of members of such cooperative society or association.

Further, Section 9 of the Act describes rights and duties of Captive Generating Plant as:

“9. (1) Not with standing anything contained in this Act, a person may construct, maintain or operate a captive generating plant and dedicated transmission lines:

Provided that the supply of electricity from the captive generating plant through the grid shall be regulated in the same manner as the generating station of a generating company.

Provided further that no licence shall be required under the Act for supply of electricity generated from a captive generating plant to any licensee in accordance with the provisions of this Act and the rules and regulations made thereunder and to any consumer subject to the regulations made under sub-section(2) of section 42.

(2) Every person, who has constructed a captive generating plant and maintains and operates such plant, shall have the right to open access for the purposes of carrying electricity from his captive generating plant to the destination of his use:

Provided that such open access shall be subject to availability of adequate transmission facility and such availability of transmission facility shall be determined by the Central Transmission Utility or the State Transmission Utility, as the case may be:

Provided further that any dispute regarding the availability of transmission facility shall be adjudicated upon by the Appropriate Commission.”

Section 42 stipulates the exemption from levying of cross subsidy surcharge on Captive Generating Plants:

Provided also that such surcharge shall not be liveable in case open access is provided to a person who has established a captive generating plant for carrying the electricity to the destination of his own use.

The Ministry of Power through the Notification of Electricity Rules 2005 laid down the legal requirements for a power generating station to be qualified as a Captive Power Plant (CPP). The relevant excerpt of the notification is produced below:

“Requirements of Captive Generating Plant: -

(1) No power plant shall qualify as a 'captive generating plant' under section 9 read with clause (8) of section 2 of the Act unless-

(a) in case of a power plant -

(I) not less than twenty-six percent of the ownership is held by the captive user(s), and

(ii) not less than fifty-one percent of the aggregate electricity generated in such plant, determined on an annual basis, is consumed for the captive use:

Provided that in case of power plant set up by registered cooperative society, the conditions mentioned under paragraphs at (i) and (ii) above shall be satisfied collectively by the members of the cooperative society:

Provided further that in case of association of persons, the captive user(s) shall hold not less than twenty-six percent of the ownership of the plant in aggregate and such captive user(s) shall consume not less than fifty-one percent of the electricity generated, determined on an annual basis, in proportion to their shares in ownership of the power plant within a variation not exceeding ten percent;” (Emphasis added)

State Specific Policy Framework For Wind Energy Based Captive Power

Many states have accorded favourable treatment to the wheeling of power from CPPs based on wind energy source in terms of open access charges.

A. As per Andhra Pradesh Wind Policy 2015, clause 8 on Transmission and Distribution charges for wheeling of power states that:

Clause 8 (b) There will be no Transmission and Distribution charges for wheeling of power generated from wind power projects, to the desired location/s for captive use/third party sale within the State through grid. However, the Transmission and Distribution charges for wheeling of power generated from the wind power projects for sale outside the State shall be as per regulations of APERC.

B. Further, according to Gujarat Wind Policy 2016, clause 15 enables exemption from payment of electricity duty:

Clause (15) Electricity generated and consumed for self-consumption/sale to third party within the State shall be exempted from payment of electricity duty in accordance with the provisions of the Gujarat Electricity Duty Act, 1958 and its amendment from time to time.

Exemption from demand cut to the extent of 50% of installed capacity of wind power project in case of captive consumption and third party sale within the State.

Analysis Of Key Issues for Wind Energy Captive Wheeling and Repowering

Under the present legal framework, a captive consumer must consume not less than 51% of the aggregate electricity generated in such a plant. If the consumer can meet this criterion for captive, there will not be an issue. It is important to note that the existing captive users can consume electricity generated from repowered wind farm to the extent of its annual consumption of electricity. However, post repowering, when the actual capacity and the aggregate energy yield may increase by around two to three times the present quantum, the consumer may not be able to consume 51% of the aggregate energy generated in such a plant.

As a result, the consumer may lose the captive status that could result in levying of additional cross subsidy surcharge on the entire consumption of the consumer. In the present legal framework, such captive generators may not take up repowering due to the minimum consumption criteria.

Further, it may be noted that the early development of wind sector was based on a model of having multiple WTG owners at a windfarm site. Repowering project could include multiple wind projects, captive or otherwise. All the project owners may or may not participate as 'Wind Repowering Project'. Repowering could reduce the number of turbines, and it may not be possible to evolve an exact replacement. Further, it is possible that repowering project is undertaken by one dominant investor, and the rest of the existing captive project owners may be small/minority stake holders as a result, the repowering project may or may not be able to meet the criteria of 26% ownership in such repowered project.

Hence, the minimum consumption criteria and ownership requirement of 51% and 26% respectively would pose as major bottlenecks for the prospective repowering projects for wind captive generating plants. Flexibility in terms of minimum consumption would be required to promote repowering activities for captive generating stations.

It may be noted that the conditions related to ownership and consumption have been specified in the Electricity Rules, 2005 notified by Ministry of Power, Government of India. Therefore, modifications to the eligibility conditions as stipulated under The Electricity Rules 2005, need to be incorporated.

Proposed Solution

The criteria for captive consumers as defined in The Electricity Rules, 2005 can be relaxed by way of a notification under Section 176 (z) of the Electricity Act 2003. It is proposed to allow the existing captive users of wind power project to continue to consume energy equal to their captive consumption prior to repowering as calculated below irrespective of whether the plant meets the definition set out in the said rule or not:

- The condition of 51% consumption and 26% ownership shall not be applicable in the case of existing captive users of the repowered power projects, so long as annual captive consumption of such captive users from the repowered projects remain at least equal to the average annual captive consumption for the last three years prior to commissioning for repowered wind power project.

Table 12

Case I, II and III Captive Generation

Case I : Captive Generation Is Entirely Consumed by Captive Users																	
Pre-Repowering Scenario													Post-Repowering Scenario				
User	Capacity (MW)	CUF (%)	Generation (MU)	Consumption (MU)	Consumption as % of Gen.	Meets CPP Criteria?	User	Capacity (MW)	Generation (MU)	Consumption (MU)	Consumption as % of Gen.	Meets CPP Criteria?					
CPP#1	2	14	2.4528	4	163	Yes	WRPD	15	28.251	15	53	Yes					
CPP#2	2.5	15	3.285	5	152	Yes											
CPP#3	3	14	3.6792	6	163	Yes											
Case II : Captive Generation Is Partly Consumed by the Captive Users and Remaining Sold to Utilities																	
CPP#1	2	14	2.4528	2	82	Yes	WRPD	15	28.251	8	28	No					
CPP#2	2.5	15	3.285	2	91	Yes											
CPP#3	3	14	3.6792	2	82	Yes											
Case III : Mixed Types of Consumption and Sell to Utilities by Captive Generation																	
CPP#1	2	14	2.4528	9	367	Yes	WRPD	15	28.251	16	57	Yes					
CPP#2	2.5	15	3.285	3	91	Yes											
CPP#3	3	14	3.6792	4	109	Yes											

It may be noted that the above scenarios do not consider the following complexities:

- Involvement of “sale to utilities” projects.
- Ownership related issues.

Draft For Proposed Amendment To Electricity Rules, 2005

Draft amendment to the Electricity Rules, 2005 were published by MoP on 22 May, 2018. To facilitate participation of the existing wind captive generators in repowering projects, suitable amendments are necessary which could be considered by the MoP as part of the present revision in the Electricity Rules.

The following paragraph is proposed to be incorporated as the third provision in the Clause 3.1 (a) of the Electricity Rules which deals with requirements of a captive generating plant.

“Provided that in the case of repowered wind generating plant, the conditions mentioned under paragraphs at Sub Clause (i) and (ii) of Clause 1(a) would be considered satisfied if the quantum of captive energy consumption post repowering by existing captive users is at least equal to the average annual captive consumption for the last three years prior to repowering.”

Annexure II: Draft Guidelines and Framework for Wind Repowering

1. Preamble

Over the past 20 years, India's wind sector has seen a remarkable progress. As on 31 March 2018, 34,046 MW of wind generation capacity is installed in India which is about half of the total renewable energy installed capacity of 69,022 MW. Today, India has the fourth highest wind generation capacity in the world.

Presently, there are several wind projects that are operational for more than 15 years. These projects are located at the best wind resource sites. These wind projects typically have turbine sizes ranging from 55 kW to 500 kW. Given the available technology then, many of these wind turbines operate at very low CUF of 10% to 15%. These old inefficient turbines can be replaced with modern high efficiency wind turbines. The CUF of modern day turbines are estimated at 25% to 30% and at 80 to 100 metre hub height. This process of replacement of old wind turbines with high capacity turbines, called 'Repowering', could result in an upsurge in installed capacity and energy yield each by a factor of two to three times. This process of 'Repowering' would help not only in ensuring the optimal utilization of such wind rich sites, but also in avoiding waste of a national resource in the form of wind. Increase in capacity would also help in achieving the target of 60,000 MW of installed wind capacity by 2022 as envisaged by the Government. Hence, it is important that repowering of old wind projects are under taken on a priority basis.

While the rationale for repowering is strong, there are several challenges in implementing such projects. One of the main challenges is the fragmented ownership of the old wind power projects. In any wind power project, different turbines are owned by different persons/entities/individuals having different aspirations and financial capabilities. Further, many projects were developed for captive consumption. Given depreciated value of the assets and the minimum O&M expenses required by these old wind power projects, the cost of electricity from these projects for captive users is very low. Any repowering is bound to increase the cost of electricity to captive users as compared to the operating cost of existing wind power projects. Hence, the idea of repowering is being resisted by such captive users. Further, increase in capacity and energy generation could create problems while complying with the rules for captive generation under Electricity Act 2003. Owing to fragmented ownership, many generators are apprehensive of developing a repowering project.

To address these challenges, the Government may develop a "Wind Repowering Policy (WRP)".

2. Objectives

Following are the objectives to develop WRP:

- Promote optimum utilization of wind resources.
- Create implementation framework for repowering.
- Provide investment security by ensuring long term policy certainty.
- Facilitate private participation through innovative financing and project structures.
- Devise framework for incentive mechanism, as may be necessary, during the initial stages of operationalising repowering policy.

3. Definitions

- “Additional Generation” means total generation from the project after repowering minus pre-repowering generation.
- “Detailed Project Report” (DPR) is the document as defined in Clause 10 of this Policy.
- “Implementation Agreement” is the agreement entered into by the WRPI with Nodal Agency pursuant to this Policy.
- “Nodal Agency” is the agency responsible for wind power development in the State.
- “Pre-Feasibility Report” (PFR) is the document as defined in the Clause 9 of this Policy.
- “Project Execution Period” is the period in months as defined in Implementing Agreement during which the project must be completed.
- “Pre-Repowering Generation” is the average generation for existing wind project for three years immediately preceding the year in which PFR is prepared.
- “Remaining life” of the project would be the remaining contractual period from SOCD for the wind turbines as per PPA. However, if contractual period is not defined in PPA, “Remaining Life” would be five years from the date of SOCD provided the turbines were commissioned before 31 March 2000.
- “Repowering Area” is the area over which existing wind turbines are located.
- “Repowering Project” is the project which involves removal of old wind turbines of lower capacity and installation of modern wind turbines of higher capacity, thereby enhancing the capacity and energy yield from the Repowering Area.
- “Start of Construction Date (SOCD)” is the date on which WRPI would start dismantling old wind turbines. SOCD shall be defined in the Implementation Agreement.
- “Wind Repowering Project Developer” (WRPD) is the person who develops the DPR for the Repowering Project.
- “Wind repowering Project Implementer” (WRPI) is the entity selected through competitive bidding process for implementation of the Repowering Project.

4. Operative Period

The policy can come into effect on the date of issuance and it is advisable to be kept in force for a period of five years or till such time, a new policy is issued. However, amendments may be made during the operative period.

5. Procedures For Implementation Of Repowering Project

The procedures for implementation of a repowering project may be as given below:

- WRPD shall identify repowering area and prepare PFR for the same
- WRPD submits the PFR to a nodal agency for approval
- Upon approval, the Nodal Agency shall forward the PFR to a senior entity that could be the government.
- Approval of the PFR by the senior entity or the government.
- Upon approval, MNRE shall give a grant to WRPD for preparation of DPR.
- WRPD to prepare DPR for submission to the senior entity or the government.
- The senior entity or the government shall scrutinize the DPR for further approval.
- The senior entity or the government shall call bids for selection of WRPI for development of 'Repowering Project' as per DPR.
- Bidding condition would be the lowest 'RI'.
- WRPI to enter into Implementation Agreement with the Nodal Agency.
- WRPI to start 'Repowering Project' on SOCD and complete the project during Project Execution Period.

- SNAs and STUs to ensure availability of evacuation infrastructure beyond the pooling station by the end of project execution period.

A detailed flowchart is enclosed as Annexure 1 at the end.

6. Eligible Entities

All registered companies may be eligible to be Wind Repowering Project Developer (WRPD) or Wind Repowering Project Implementer (WRPI).

7. Eligibility Criteria For Repowering Project

The Repowering Project should, at the minimum, satisfy the following conditions:

- The wind turbines in the repowering area should have completed operational life of minimum 15 years on SOCD.
- In case, the wind turbines have not completed the stipulated period of 15 years but the annual average CUF for three preceding years is below 15%, the same may be considered for repowering.
- Capacity of individual turbine is not more than 500 kW.

8. Grant For Preparation Of DPR

It is important to incentivise the activity of development of 'Repowering Project'. To promote repowering in the country, support is needed for the concept of 'WRPD'. It would be best if any person intending to be WRPD, shall undertake preliminary activities related to identification of repowering project. WRPD shall prepare PFR in line with the provisions of this Policy for the said 'Repowering Project' to the senior entity or the government through the Nodal Agency. The senior entity or the government may undertake assessment of the PFR and approve the same if the project is feasible.

The senior entity or the government is suggested to provide a grant of ₹ 30 Lakh for preparing a DPR for the proposed repowering project. The said grant may be disbursed in two equal instalments of 50% each on achievement of the following two milestones:

- Approval of PFR by MNRE
- Approval of DPR by MNRE

DPR shall be the property of MNRE and would be used by MNRE to undertake competitive bidding for selection of the Wind Repowering Project Implementer.

9. PFR

The PFR to be prepared by WRPD shall contain following information about the repowering project:

- Definition of repowering area
- Existing wind turbines and turbine owners
- Pooling substation and interconnection arrangement
- Existing offtake arrangements
- Generation from existing wind turbines
- Wind potential in Repowering Area (incl. WRPD at 80 m hub-height)
- Initial consent of at least 70% turbine owners to consider repowering
- Details about land – ownership, location, latitude/longitude
- Preliminary details about evacuation arrangement – existing and proposed

10. DPR

The DPR shall include the following details regarding repowering project:

- DPR shall contain following information about the existing turbines:
 - Coordinates of existing WTG
 - Capacity of each WTG
 - Information about land ownership
 - Electricity generation details for last three years
 - Interconnection arrangements with Single Line Diagram
 - Offtake arrangements including PPA details
 - Budget Cost Estimate – repowering and de-commissioning
- Details of layout of the new project and selection of machines etc.
- DPR shall demonstrate the feasibility of repowering using minimum three types of turbines currently available in India.
- Land requirement for new turbines and availability of the same.
- Power evacuation arrangement beyond pooling station and estimation of capital expenditure.
- Consent of WTG owners in Repowering Area to be part of the Repowering Project and sell existing turbines to WRPI at the price set out in this Policy.

11. Competitive Bidding Process

The competitive bidding to be undertaken by the senior entity or the government for selection of WRPI shall be as given below:

- The senior entity or the government shall conduct competitive bidding for selection of WRPI for each DPR for repowering project.
- The senior entity or the government shall issue separate bidding documents later, which would include technical and financial criteria for participation in bidding.
- Bidding documents shall have the DPR prepared by WRPD.
- Criteria for bidding shall be the minimum RI demanded by WRPI to implement repowering project.
- The senior entity or the government shall specify the maximum RI that it is ready to offer for 'Repowering Project'. Bidder bidding maximum discount on this incentive shall be selected to be WRPI for the said repowering project.

12. WRPI

Any Company registered under The Companies Act 1956, satisfying the technical and financial criteria specified in the tender, may be allowed to participate in the competitive bidding process to be undertaken by the senior entity or the government for the selection of a WRPI. The Company bidding the lowest RI shall be selected as WRPI may implement the project through Special Purpose Vehicle set up for this purpose. However, WRPI shall retain minimum 51% stake in such SPV for period of two years after commissioning of the Repowering Project. Implementation of the project through SPV shall not absolve WRPI of its responsibilities and it shall continue to be responsible for the following activities:

- Enter into Implementation Agreement with the senior entity or the government and Nodal Agency.
- Enter PPA with existing owners for pre-repowering generation.
- Acquire assets from the existing owners by cash payment or equity contribution in SPV.
- Obtain all permissions required to undertake repowering related activities
- Remove existing wind turbines.

- Install new wind turbines.
 - Upgrade pooling substation.
 - Enter into agreement for sell of additional generation.

It may be noted that the above list of activities is not exhaustive and WRPI is expected to undertake all activities related to implementation of Repowering Project.

13. Sale Of Electricity

Post repowering, owing to the higher capacity of modern turbines, the electricity generation will substantially go up. However, the existing PPA arrangements in terms of tariff levied for the remaining life of existing PPA or captive wheeling arrangements (as the case may be) and the contracted quantum of energy shall remain unchanged along with other terms and conditions.

WRPI shall sell 'Pre-Repowering Generation' to the buyers in accordance with the pre-repowering arrangements for sell of electricity for remaining life of sale arrangements. WRPI shall be free to sell additional generation to any person. State distribution companies shall not insist on WRPI to sign PPA for Additional Generation. SLDC may develop suitable arrangements for settling transactions for Pre-Repowering Generation (PRG) and Additional Generation (AG).

It is likely that WRPI does not meet the criteria for CPP as set out under Rules notified by the MoP in 2005. Post repowering, the existing project owners may lose the benefit of being captive producer. This will be a major barrier for repowering. Hence, the Government of India will modify the Captive Rules to exempt repowering projects from ownership and consumption requirements.

14. RI

For repowering project, the following RI may be realised in competitive bidding process:

- Under the scheme, a maximum RI of ₹ 1.00 per unit of electricity fed into the grid from Repowering Project shall be provided for a period of five years or upto cumulative total generation of 8 MU per MW from the date of commissioning of re-powered wind power project, whichever is earlier.
- Actual RI payable for each project shall be discovered through competitive bidding process.
- RI shall be paid for 8MU per MW post-repowering generation capacity.

15. Repowering With Wind and Solar Hybrid

Sites where adequate solar energy is available, the WRPI shall put in efforts to develop wind and solar hybrid project. Such projects should have minimum wind capacity of 50% of the project capacity in MW. However, the incentives under the repowering scheme will be available only for wind generation.

16. Transmission Of Power

Enhancement of capacity of pooling station shall be the responsibility of WRPI. However, transmission of power is a high priority pre-requisite to drive repowering of old wind turbines. This Policy aims to work with Central and State Transmission Utilities to address the following issues related to evacuation infrastructure:

- The Central and State Transmission Utilities should upgrade their evacuation infrastructure that presently connects the wind projects which are more than 15 years old. Especially the generators who are connected to 11 KV lines must now connect to 66 KV HT lines for uninterrupted evacuation of the additional generation from the repowered facilities. The STUs may coordinate with the SNAs to identify the potential repowering zones for proper planning of augmentation.
- Augmentation of the pooling substation shall be the responsibility of the WRPI.

17. Roles And Responsibilities Of SNAs

SNAs promoting renewable energy should ensure that the WRPI strictly adheres to the eligibility conditions as mentioned above. Voluntary repowering projects, not adhering to eligibility conditions may be registered for private investors with a clause that no incentive from the Central Government shall be available for such projects.

SNA shall also ensure that the State Transmission Company undertakes upgradation of grid infrastructure till the pooling station.

18. Miscellaneous

Relevant aspects regarding wind resource assessments, grid integration, land policies, wind energy-park, manufacturing of turbines etc., may follow guidelines of the Wind policy as published by the Government.

19. Powers To Remove Difficulty

If any difficulty arises in giving effect to this policy, the senior entity or the government is authorized to issue clarifications as well as interpretations to such provisions, as may appear to be necessary for removing the difficulty either on its own motion or after hearing those parties who have represented for change in any provisions.

Not with standing anything contained in these resolutions, the provisions of the Electricity Act 2003 and the applicable regulations issued by CERC/any SERC from time to time shall prevail for the implementation of this policy.

20. Powers To Add, Modify and Relax

The senior entity or the government should have power to amend/review/relax/interpret any of the provisions under this policy as and when required.

Annexure III: Analysis of Sample reference project in Gujarat

Details of Technical, Financial and Economic Factors

Technical

The project belongs to Private Industrial Entity and is surrounded by WEGs owned by others as against the norm followed in Tamil Nadu for separating distance of 5D x 7D within and outside windfarm, in Gujarat, there is no strict norm of 5D x 7D inside the windfarm but separating distance from near-by WEGs must be 5D x 7D of larger WEGs.

Under this norm only one 1,500/2,000 kW WEG can be installed by removing 14 old WEGs. This shall not be attractive for repowering.

Therefore, WEG of 800 kW rating with rotor diameter of 53 m has been considered and six of them can be installed totalling to 4.8 MW. The CUF would increase from 6.43% to 18.28%.

At the grid substation: A 66/33 kV 5 MVA transformer may be installed and a 33 kV line shall be laid.

Financial

The parameters/assumptions considered for Financial Analysis is provided in Annexure III- Part-A Technical Assumption, Part-B Financial Assumptions.

Considering the captive consumption of entire generation and availing AD benefit, the financial results are –

- Project IRR – 25 years – 21.98%
- Equity IRR – 25 years – 24.10%
- D.S.C.R. – 2.09

The financial results are reasonably attractive to justify repowering. However, for initial attraction some more incentives may be in the form of interest subsidy can be considered.

ECONOMIC

Gujarat is a progressive industrialized State with high demand of electricity. Availability of 10 times more generation from use of same land area is a highly beneficial economic factor.

The project owner shall avail the economic benefit through availability of five times higher generation in captive consumption, the rate of which would increase continuously.

Part-A : Technical Assumptions

- Layout coordinates of 14 Client locations and 13 surrounding non-Client locations were provided along with boundary of Client land.
- Generation data was retrieved from Gujarat SLDC data at Meravadar sub-station for last 5 years the total monthly generation was for 25 nos. of 225 kW WEGs. This was apportioned for 14 WEGs. The CUF at substation was 6.85% and after deduction of wheeling charges of 4% and banking charges of 2% the CUF is 6.43%.
- Contours of the site were generated from DEM at 10m interval.

- Based on the norm of micro-siting in Gujarat of minimum 5D x 7D separation of bigger rotor WEG from existing WEG, layout was prepared for 87 m & 100 m rotor WEG. It was observed that based on the layout, nearby WEGs, and norms, only one WEG could be sited within the existing boundary. This would not justify re-powering of 3.15 MW wind farm with 1.5 MW or 2 MW WEG.
- A fresh micro-siting exercise was carried out with 53m rotor of 800 kW WEG. 6 nos. of WEGs can be accommodated, maintaining the norms. This was taken up for repowering study for 4.8 MW windfarm.
- Energy estimation was carried out for the existing 14 Client locations based on Dhank-1 & Dhank-2 wind masts of C-WET near the site. It was observed that there was over-prediction of generation by the two-mast data. Energy estimation done by the nearest MERRA grid data indicated CUF of 9.66% at wind farm. This is close to the actual generation achieved at the wind farm. The reason for actual generation being lower than the estimated generation from MERRA data could be attributed to various reasons like degradation of WEG due to aging, poor grid, poor O&M etc. Thus, it was considered that the MERRA data represents the wind profile of the site.
- Based on the MERRA data, energy estimation was carried out for the 6 new 800 kW WEGs with 75 m hub-height.
- The net estimated generation for 800 kW WEG with rotor of 53m and hub-height of 75m at wind farm is 76.86 lakh kWh per annum at wind farm, which means CUF of 18.28%. This is also the average generation generally achieved by such WEGs in surrounding areas.
- The total generation from the repowered wind farm has been utilized for captive consumption by Client after considering only 4% wheeling charge. As per present policy and GERC tariff order no Banking is permitted.
- No surplus energy deemed sale has been considered as the entire generation is utilized for captive consumption.

Part-B : Financial Assumptions

While carrying out financial analysis following assumptions have been considered:

- Cost of the Project has been assumed as follows:
 - Price per MW: ₹ 600 lakhs
 - Total Project Cost for 4.8 MW: ₹ 2880 lakh
 - Less: 7% for Land & existing Road: ₹ 201.60 lakh
 - Less: for Salvage value of 14 old WEGs+scrap: ₹ 150 lakhs
 - Add: NPV of loss of generation for 5 years of balance plant life, considering average generation of last 5 years from SLDC data, less wheeling & banking charges of 4%+2%, tariff of ₹ 4.65 per unit with annual escalation of 3%, Less reactive power charges @10% of active generation @ Re. 0.10 per unit, Less O&M charges payable from 15th to 20th year considering ₹ 100 lakhs per WEG of 225 kW, O&M rate in first year @ 1% with 5% escalation. Net present value (NPV) = ₹ 95.93 lakh
 - Net Project Cost: ₹ 2624.33 lakh(b-(c+d)+e)
- Debt Equity: 70:30
- Interest Rate on Loan @11% on declining balance, payable in quarterly instalments.
- Loan repayment period is 10 years with no Moratorium period, Loan repayment is in 40 quarterly instalments.
- Reactive Power: As per GERC Tariff order: 10 paisa per unit of kVARh up to 10% of net energy exported with no escalation. Reactive power consumption is assumed to be @ 3% of Active Generation.
- O & M is free for the first year and payable from 2nd year at the rate of 2% of Project Cost including

Statutory and Forecasting Charges. 5.0% annual escalation has been assumed.

- Insurance: Insurance has been considered @ 0.10% on Capital cost of Project for Burglary, Theft & Fire Insurance.

- Income Tax:

The Income tax benefits are available under two sections of the IT Act for the Project.

AD Benefit u/sec 32 Rules –5 upto 80% of the Project Cost in the first year.

Exemption on Income Tax on earnings from the Project u/sec 80 IA for 10 years

The Tax benefits of the Project have been calculated based on consolidated accounts of a Profit earning entity.

The benefits availed are as follows:

- Inflow from accelerated benefit has been considered on Income from other business after availing 80% depreciation. Tax benefit accrued by availing the 80% AD has been utilized to reduce the Debt burden upfront.
- Income Tax payable has been considered as outflow.
- In the First Year, AD benefit @ 80% has been availed. For subsequent years 80% depreciation is claimed on depreciated value.
- Income Tax is payable on earnings till the cumulative loss is recovered which was incurred by availing AD in the initial years
- Income Tax exemption benefit (u/sec 80 IA) has been considered on Profits after the cumulative loss is recovered.
- Total Income Tax benefit period is 15 years
- Benefit u/sec 80 IA is available for 10 years It has been capped when it exceeds 15 years' total period.
- Full Income Tax rate: @ 30%+ 10% surcharge + 3% cess= 33.990% has been considered on Profits, as income of RIL considered above ₹ 1000 Lakh.
- Minimum Alternate Tax (MAT) rate: @ 20.961% has been considered on Profits.
- The cumulated payment of MAT during the period of benefit u/sec 80 IA has been adjusted from the Full Income Tax payable immediately on completion of period of 80 IA benefit
- as per section 115 JB of Income Tax Adjustment Rules. During this adjustment period, again MAT is applicable.
- After full adjustment of cumulated MAT of 10 years during 80 IA period – Full tax rate is applicable.
- MAT paid during the initial few years has not been adjusted as the adjustment period of MAT is only applicable within a period of 10 years
- Project Life considered as 25 years
- Salvage Value at the end of 25th year has been assumed to be 10% of the Capital Cost.
- Benefit out of Carbon Credit has not been considered
- Wheeling & Banking Charges: As the Wind farm Project shall be located at an area away from the consumption at plant, wheeling charges shall be applicable. As per GERC order the applicable rate is 4%. As per latest policy & order of GERC only month to month adjustment is permitted, therefore no banking charges have been considered.
- GBI has not been considered as AD Benefit has been availed.
- Electricity Duty saving: As per Govt. of Gujarat policy, electricity duty is exempted on electricity consumed from wind power Projects. For cash-flow analysis, the rate of electricity duty has been

considered as 20%. The benefit of electricity duty exemption has been considered as an inflow for the wheeled units for the life of the Project.

- Transmission and Open Access Charges: Since the electricity from the wind power Project shall be wheeled to the captive plant through the GEB grid, Transmission and Open Access charges shall be applicable as per GERC order. The present rate for the year 2013-14 is ₹ 2970/MW/Day. This amounts to ₹ 10.8405 Lakh per MW per annum. This has been considered as expenditure for wind power project.
- The Captive rate has been assumed at ₹ 4.65 per unit with 3% annual escalation.
- The generation has been estimated as 12.81 Lakh per turbine per annum, totalling 76.86 Lakh units per annum. After deduction 4% wheeling, the net energy delivered is 73.79 Lakh units per annum.

The results of the financial analysis are as below:

- Project IRR 25 years - 21.98%
- Equity IRR 25 years - 24.10%
- DSCR - 2.09
- Payback Period (Years)- 6.69
- Over view of major factors influencing decision of repowering by Project developers and the relationship between the various factors (considering reference project in Gujarat).

Factors relating fragmented turbine ownership, grid integration, PPA restructuring, revenue distribution among local community.

Grid Integration

As the MW capacity would increase from 3.150 MW to 4.800 MW, the existing 66 kV substation should be able to cater to the extra demand except for – may be – space needed to install 66/33 kV Substation.

This needs to be verified at site.

PPA Restructuring

For the new installation – a fresh PPA – for captive consumption shall have to be executed as per latest terms and Conditions and there should be no difficulty.

Revenue Distribution

Since the land is already owned by the Investor and no new land is considered to be acquired – there shall be no necessity to share revenue with local community.

- **Detailed over-view of the total market Potential of repowering in India.**
 - **Detailed assessment of the repowering potential in India and the supply chain impacts.**
Immediate plan for repowering may ideally consider replacement of Wind Electric Generators (WEGs) installed up to 31.03.2002 and for WEGs rated up to 600 kW.

Table 13		State - Wise Installed Capacity of Different States (as on 31 March 2002)		
Make	Rating of WEG	Hub Height	Rotor Dia	Larger WEGs were installed after 31 March 2002. The state-wise total installed capacity in different States for WEGs up to 600 kW and installed up to 31 March 2002.
Wind world	800 kW	75 mtr.	52.9 mtr.	
Regen Powertech	1,500 kW	70/75/85/100 mtr.	82.34 mtr.	
Suzlon	1,500 kW	78 mtr.	82 mtr.	
	1,500 kW	120 mtr.	97 mtr.	
Gamesa	1,500 kW	104/93 mtr.	97/114 mtr.	
Inox	1,500 kW	80/92 mtr.	100 mtr.	

State	No. of WEGs	Total MW
Andhra Pradesh	350	89.540
Gujarat	808	178.280
Karnataka	186	63.850
Madhya Pradesh	99	21.690
Maharashtra	901	310.605
Rajasthan	52	15.240
Tamil Nadu	3120	837.665
Total	5,516	1,516.87

The total installed capacity includes 58.915 MW of demonstration windfarms installed by states with the support from the Government of India.

Year wise and State-wise installation is provided in Table 13.

Numerous installations are with Single WEGs, where it shall be difficult to repower with larger rating WEG.

State wise and rating wise single WEG installations are provided in Table 14.

These small and inefficient WEGs can be replaced by following new generation efficient WEGs. The suppliers have adequate capacity to supply and offer efficient O&M service.

Table 14 Year Wise and State Wise Installation

FYYear	States																	
	Tamil Nadu		Maharashtra		Gujarat		Andhra Pradesh		Karnataka		Madhya Pradesh		Rajasthan		Total			
	WEG	MW	WEG	MW	WEG	MW	WEG	MW	WEG	MW	WEG	MW	WEG	MW	WEG	MW		
1985-1986	20	1.1			27	1.595									47	2.695		
1986-1987			10	0.55											10	0.55		
1987-1988	17	1.53	1	0.09	1	0.09					1	0.09			20	1.8		
1988-1989					10	0.55									10	0.55		
1989-1990	51	10.055	10	0.55	14	2.3					5	0.5			90	14.505		
1990-1991	7	1.5			50	10	5	0.55	5	0.55					57	11.4		
1991-1992	7	1.7			16	2.105									23	3.805		
1992-1993	74	17.57													74	17.57		
1993-1994	207	50.465			45	10.825									252	61.29		
1994-1995	814	215.655	6	1.5	167	38.125	37	8.425							1024	263.705		
1995-1996	1023	277.14			212	47.22	144	37.315	15	3.375	32	7.2			1426	372.25		
1996-1997	375	117.355	11	2.77	180	34.81	7	3	6	1.92	9	2.025			588	161.88		
1997-1998	126	33.79	1	0.225	48	17.31	18	4.5	41	9.615	17	3.825			251	69.265		
1998-1999	27	6.655	57	17.875	14	4.7	28	8	10	3.65	15	3.45			151	44.33		
1999-2000	122	36.65	161	49.935	23	8.05	109	27.25	45	14.59	20	4.6			480	141.075		
2000-2001	92	26.12	327	112.085			2	0.5	38	19.8			26	6.86	485	165.365		
2001-2002	158	40.48	317	125.025	1	0.6			26	10.35			26	8.38	528	184.835		
Total WEGs	3,120		901		808		186		186		99		52		5516			
Total MW		837.665		310.605		178.28		63.85		63.85		21.69		15.24		1,516.87		

Table 15 State and Rating Wise Number of Private Windfarm Owners Having Single WEG (as on 31 March 2002)

State	No. of private Windfarm Owners Having Single WEG													Total		
	Rating (kW)													Owners	WEG	Capacity
	80	90	200	225	230	250	300	320	350	400	500	550	600	No.	No.	MW
Andhra Pradesh																
Gujarat		1	4	12		2	7	1	2					29	29	7.21
Karnataka												4		4	4	2.4
Madhya Pradesh				4	1									5	5	1.13
Maharashtra				21	23			1	59	7		7		118	118	38.685
Rajasthan									1					1	1	0.35
Tamil Nadu	2			58	7	72	2	2	2	3	2	7	2	159	159	42.01
Total WEGs	2	1	4	95	31	74	9	4	64	3	9	7	13	316	316	
Total MW	0.16	0.09	0.8	21.375	7.13	18.5	2.7	1.28	22.4	1.2	4.5	3.85	7.8			91.785

