

**INNOVATIVE**  
**BUSINESS MODELS**  
for Wind Repowering  
Project Aggregators and  
Implementation  
Guidelines



## **INNOVATIVE BUSINESS MODEL FOR WIND REPOWERING PROJECT AGGREGATORS AND IMPLEMENTATION GUIDELINES**



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# Table of Contents

1.	Introduction.....	10
1.1.	Need for Repowering .....	12
1.2.	Benefits of Repowering.....	13
1.3.	Objective of the Study.....	14
2.	Indian Repowering Initiatives till March 2022 .....	17
2.1.	National Repowering Policy of Wind Power Projects (MNRE,2016).....	17
2.2.	National Tariff Policy, 2016.....	18
2.3.	State-Level Repowering Policies .....	18
3.	National Repowering & Life Extension Policy- 2023 .....	22
3.1.	WRPA in the National Repowering Policy 2023 .....	23
3.2.	Wind Repowering Project Developer (WRPD) – Roles and Responsibilities.....	25
3.3.	CNA/SNA-Roles and Responsibilities .....	26
3.4.	Repowering Project Stakeholders and Their Roles .....	27
4.	WRPA.....	34
4.1.	WRPA Categories .....	34
4.2.	MNRE/NIWE in WRPA selection.....	35
4.3.	Wind Repowering Committee (WRC) in WRPA .....	35
4.4.	Roles and Responsibilities of WRPA in Repowering Policy .....	36
4.5.	Boundary and Scope of Deliverables for WRPA.....	37
4.6.	Policy and Regulatory Gaps, and Challenges for Repowering in Aggregation Projects .....	39
5.	WRPA Business Models.....	43
5.1.	Brief Overview of Business Models.....	43
5.2.	Cost assumptions for the WRPA business model .....	47
5.3.	Key Features of WRPA Business Models.....	50
6.	Financial Viability and Risk Analysis of Proposed Business Models.....	64
6.1.	Financial Viability of Model-1 .....	64
6.2.	Financial Viability of Model-2 .....	65
6.3.	Financial Viability of Model-3 .....	67
7.	Conclusions and Recommendations .....	75

# List of Figures

Figure 1: Cumulative Installed Wind Capacity in India (GW) .....	10
Figure 2: New Wind Turbines with Increased Power Generation Capacity .....	12
Figure 3: Wind Turbine Installation Trend .....	12
Figure 4: Repowering Project Stakeholders .....	28
Figure 5: Role of NIWE.....	29
Figure 6: Roles and Responsibilities of WRPA .....	31
Figure 7: Key WRPA Framework Elements .....	34
Figure 8: Potential WRPA categories.....	35
Figure 9: Functions of WRC .....	36
Figure 10: Scope of WRPA Business .....	38
Figure 11: Repowering Challenges in India .....	39
Figure 12: Different types of WRPA Business Model .....	43
Figure 13: Basis of WRPA Business Model Development.....	44
Figure 14: WRPA Business Model-1 .....	44
Figure 15: WRPA Business Model -2 .....	46
Figure 16: WRPA Business Model-3 .....	47
Figure 17: Salient Features of WRPA Business Model-1 .....	51
Figure 18: Process flow for Model 1 (without Govt. Incentive) .....	51
Figure 19: Process flow for WRPA Business Model-1(with Govt. Incentive).....	52
Figure 20: Model-1 Calculation .....	52
Figure 21: Salient Features of WRPA Business Model-2 .....	54
Figure 22:Process Flow for WRPA Business Model-2(without govt incentive) .....	55
Figure 23:Process flow for WRPA Business Model-2(with govt. incentive) .....	56
Figure 24: Model-2 Calculation .....	56
Figure 25:Cash flow for WRPA business model-2 per MW (21st year of WTG Operation) .....	58
Figure 26: Revenue Gap and NPV under model-1 per MW for different years of WTG operation .....	65
Figure 27: Total WRPA cost and NPV under Model-2 per MW for different years of WTG operation.....	66
Figure 28: Levelized cost of WRPA for different repowering ratios at the Vankusawade site .....	68

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Figure 29: Levelized WRPA cost for different CUF for the repowering of the Vankusawade site .....	69
Figure 30: Levelized cost of WRPA for different repowering ratios at the Muppandal site .....	71
Figure 31: Levelized WRPA Associated risks with various WRPA Business Models .....	72
Figure 32: Possible Types of Risks in WRPA Business.....	72

## List of Tables

Table 1: State-wise Repowering Potential (MW) as of 2022.....	11
Table 2: A Comparative Analysis of Repowering Policies of Different States .....	18
Table 3: Key features of Karnataka Repowering Policy.....	20
Table 4: Repowering Project Stakeholders and Their Roles.....	27
Table 5: Potential WRPA Categories and Key Drivers for their inclusion.....	34
Table 6: Scope of WRPA .....	38
Table 7: Repowering Challenges for the Indian Wind Sector.....	39
Table 8: Advantages and Challenges of Model-1 for WRPA Business.....	45
Table 9: Advantages and Challenges of Model-2 For WRPA Business .....	46
Table 10: Advantages and Challenges of Model-3 for WRPA Business.....	47
Table 11: Cost Components of WRPA Business .....	49
Table 12: WRPA cost per MW for different years of WTG Operation considered for Repowering.....	49
Table 13: Data Input & Assumptions for WRPA Business Model-1.....	50
Table 14: WRPA Model-1 Calculation Sheet (without Incentive).....	53
Table 15: Data Input & Assumptions for WRPA Business Model-2.....	54
Table 16: WRPA Model-2 Calculation Sheet .....	57
Table 17: Process flow for WRPA Business Model-2(With Govt. Incentive) .....	58
Table 18: A comparison of different WRPA Business Models.....	59
Table 19: Differences in Model 1, 2, and 3.....	59
Table 20: Distribution of Wind turbines at the Vankusawade site .....	60
Table 21: Total WRPA cost calculation for the Vankusawade site.....	61
Table 22: Distribution of Wind turbines at the Muppandal site .....	62
Table 23: Total WRPA cost calculation for the Muppandal site.....	62

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Table 24: Economic Viability of Model-1.....	64
Table 25: Economic viability of Model-2 .....	65
Table 26: Levelized cost of WRPA for Vankusawade site.....	67
Table 27: Levelized cost of WRPA for Vankusawade site with different Repowering Ratio and 35% CUF.....	67
Table 28: Levelized cost of WRPA for Vankusawade site with different CUF .....	69
Table 29: Levelized cost of WRPA for Muppandal site.....	70
Table 30: Levelized cost of WRPA for Muppandal site with different Repowering Ratio and 35% CUF.....	70
Table 31: Levelized WRPA cost with different CUF for the Muppandal site.....	71
Table 32: WRPA business risk for different proposed models .....	73

## Abbreviations

AD	Accelerated Depreciation
AEP	Annual Energy Production
APERC	Andhra Pradesh Electricity Regulatory Commission
APPC	Average Power Purchase Cost
BMs	Business Models
CNA	Central Nodal Agency
COD	Commercial Operation Date
DPR	Detailed Project Report
EPA	Environmental Protection Act
GEDA	Gujarat Energy Development Agency
GERC	Gujarat Electricity Regulatory Commission
GETCO	Gujarat Energy Transmission Corporation Limited
IA	Implementing Agency
JV	Joint Venture
MEDA	Maharashtra Energy Development Agency
MNRE	Ministry of New & Renewable Energy
MoEFCC	Ministry of Environment, Forests and Climate Change
PPA	Power Purchase Agreement
PSE	Public Sector Enterprise
REC	Renewable Energy Certificate
RREC	Rajasthan Renewable Energy Corporation Limited
RVPN	Rajasthan Rajya Vidyut Prasaran Nigam Limited
SNA	State Nodal Agency
SPV	Special Purpose Vehicle
TANGEDCO	Tamil Nadu Generation and Distribution Corporation Limited TNERC
WEG	Wind Energy Generators
WRC	Wind Repowering Committee
WRPA	Wind Repowering Project Aggregator
WRPD	Wind Repowering Project Developer

## Executive Summary

The history of commercial wind farm development in India can be traced back to the early 1990s. During this period, the focus was primarily on identifying and developing sites in prime wind areas. These areas were characterized by high wind potential, making them ideal for wind power generation. The wind regimes at these sites were classified as class I/II. This classification indicates the highest wind resource quality, characterized by consistent, strong wind speeds. Such conditions are highly suitable for wind energy projects, as they allow for optimal power generation.

However, these older wind farm sites, despite being in prime locations with high-quality wind regimes, are not fully optimized according to current standards. The technology and equipment used during the initial development phase of these sites are now outdated compared to the latest advancements in wind turbine technology. The newest turbines are more efficient and capable of producing more energy. Therefore, there is a need to repower these older wind farm sites. Repowering involves replacing older wind turbines with newer, more efficient ones. This process maximizes the potential of the available wind resources and enhances power generation.

By repowering these sites, India can significantly increase its wind power generation capacity. This increase in clean, renewable energy production is crucial for India to reach its clean energy targets. Therefore, repowering represents a significant opportunity for India to progress towards a more sustainable and environmentally friendly future.

The National Repowering & Life Extension Policy for Wind Power Projects (Dec 2023)<sup>1</sup> is a significant step in this direction. It provides a framework for repowering both standalone and aggregated projects. Standalone projects are those where a single entity owns a single wind turbine or a group of wind turbines. On the other hand, aggregation projects involve multiple owners sharing common infrastructure for a group of wind turbines. This policy encourages the repowering of these projects, thereby facilitating the efficient use of wind resources. It not only ensures the optimal utilization of wind potential at these sites but also contributes to India's clean energy targets.

For aggregation projects, the National Repowering & Life Extension Policy for Wind Power Projects (Dec 2023) has outlined specific modalities for developing repowering projects. The State/Central Nodal Agency (SNA/CNA) plays a pivotal role in this process. They have the authority to identify potential turbines for repowering. Once these turbines are identified, the SNAs/CNA can either nominate any state/central Public Sector Enterprises (PSEs) as Wind Repowering Project Aggregators (WRPA) to repower the project or invite private developers to submit proposals for the same. The selection of the private developer as WRPA is a transparent process based on minimum technical criteria and the submission of consent letters from all the identified turbine owners.

Furthermore, the policy also allows private developers to take the initiative. A private developer can identify potential turbines for repowering and submit a proposal to the SNAs/CNA. This proposal must include consent. Letters from all the identified turbine owners. In such cases, the SNAs/CNA will nominate the private

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<sup>1</sup> <https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2023/12/202312131874296229.pdf>

developer as the WRPA. This flexibility in the policy allows for a more inclusive and comprehensive approach to repowering, ensuring that all potential opportunities for enhancing wind power generation are explored and utilized.

Outdated, inefficient turbines weigh down India's wind energy sector. To counter this, repowering is crucial. However, its progress is hampered by a lack of implementation guidelines and innovative business models for Wind Repowering Project Aggregators (WRPAs), impeding a smooth transition to more efficient wind projects. This report addresses these challenges by:

1. Identifying innovative WRPA business models (including risk analysis).
2. Develop guidelines for aggregation projects.

The methodology employed for this report is comprehensive, encompassing stakeholder consultations, analysis of existing repowering policies, evaluation of the roles and responsibilities of WRPA and WRPD, documentation of business model options, and economic viability assessments.

The primary objectives of this report are to develop possible WRPA business models and provide implementation guidelines for aggregation projects. The report aims to analyze various WRPA business model options and assess their economic viability. Additionally, it seeks to define WRPA's roles and responsibilities within the repowering policy, identify key stakeholders, and address policy and regulatory gaps. The report also aims to evaluate the challenges facing repowering aggregation projects, particularly in Maharashtra and Tamil Nadu.

To achieve these objectives, the report adopts a methodological approach that involves defining the WRPA framework, identifying stakeholder roles and assessing the economic viability of proposed business models. It also includes a risk analysis for each business model, defines the boundary limits and scope of deliverables for WRPA and addresses policy and regulatory gaps. The report further discusses WRPA's selection and bidding processes, approvals, and intimation to the State/Central Nodal Agency (SNA/CAN) regarding WRPA's project development, among other implementation aspects.

# 1. Introduction

India boasts a cumulative installed renewable energy capacity of approximately 190,573 MW<sup>2</sup> (as on 31.03.2024). Among these capacities, wind energy continues to play a significant role, contributing around 45,887 MW, accounting for approximately 24% of the country's total renewable energy generation capacity. The major wind energy installations in India remain concentrated in the western and southern regions. Coastal locations in these areas provide favorable wind conditions, complemented by supportive state policies. States such as Gujarat, Rajasthan, Maharashtra, Tamil Nadu, Andhra Pradesh, and Karnataka continue to witness substantial investments in the wind energy sector. The year-wise installed capacity (from FY 2010-11 to 2023-24)<sup>3,4</sup> is shown in Figure 1

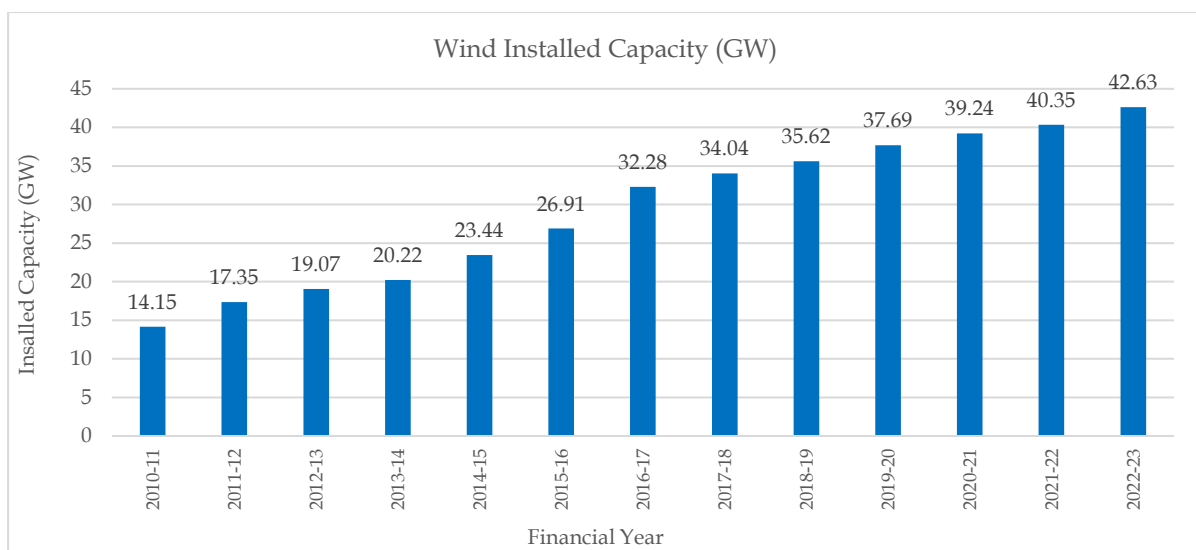


Figure 1: Cumulative Installed Wind Capacity in India (GW)

The wind turbines were first installed in the states of Tamil Nadu, Gujarat, and Maharashtra, and later in Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh, and Telangana. Most of the old turbines installed before 2005 operate below capacity, and many have also exceeded their design life. India's wind turbine technology has advanced over the years, moving from sub-MW to 4+ MW turbines. The necessity of repowering these old wind farm sites was felt by many stakeholders, considering the facts, which are as follows:

- The turbines have crossed their design life, and the operational age of many of the wind turbines has exceeded 20 to 25 years.
- Non-availability of old wind turbine components and OEMs, resulting in underperforming assets and compromising on safety.
- Old wind farms with Sub-MW turbines occupy most windy (Class-I, II) sites.
- Evolving wind power policy and regulatory framework at the national and state levels

<sup>2</sup> <https://mnre.gov.in/physical-progress/>

<sup>3</sup> MNRE Annual Reports

<sup>4</sup> <https://www.renewablesindia.in/>

- Growing energy demand and thrust for clean and renewable energy (RE) to meet India’s global commitments for addressing climate change.

Repowering received little attention, and only a small number of initiatives materialized after the 2016 Repowering Policy. The National Institute of Wind Energy (NIWE) assessed a repowering potential of 25.4 GW in 2022, considering wind turbines with capacities below 2 MW.

The following are the state-by-state details of the repowering potential, as shown in Table 1

Table 1: State-wise Repowering Potential (MW) as of 2022

States	Total Capacity below 0.5 MW	Total Capacity between 0.5-1 MW	Total Capacity between 1-1.5 MW	Total Capacity between 1.5-2 MW	Total Capacity below 02 MW
Tamil Nadu	1181	2919	1813	1473.5	<b>4100</b>
Maharashtra	243	1068	1389	731.35	<b>1311</b>
Karnataka	0.3	954	652	1417.05	<b>954.3</b>
Gujarat	51	1457	1352	1805.35	<b>1508</b>
Rajasthan	39	1192	788	914.9	<b>1231</b>
Madhya Pradesh	0	290	260	1012	<b>290</b>
Kerala	0	18	0	10	<b>18</b>
Andhra Pradesh	92	378	195	1701.2	<b>470</b>
Total	1610	8280	6449	9067	<b>25406</b>

The older turbines, installed in the early 1990s, are now operating below capacity, and many have exceeded their design life. As a result, they produce significantly less energy than the newer, more efficient wind turbines currently available, as shown in Figure 2. The necessity for repowering is further underscored by the fact that the latest wind turbine technology is more efficient, enabling it to capture more wind energy. Repowering can therefore help India achieve its goal of using 100% renewable energy.

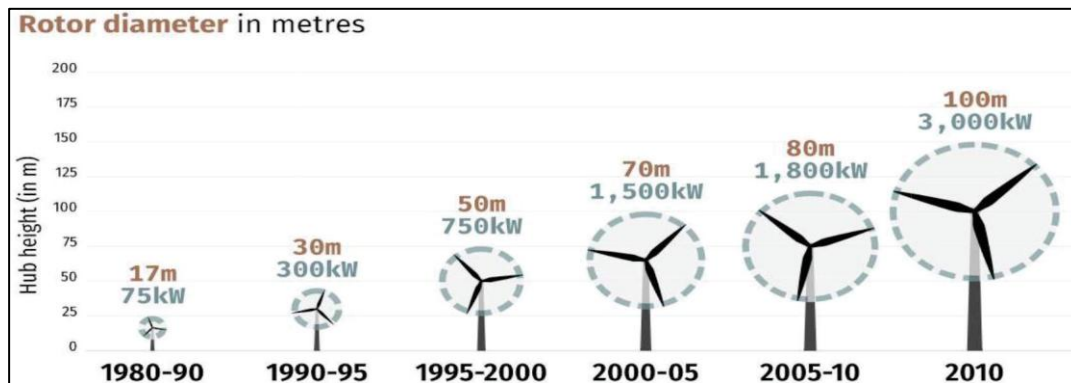


Figure 2: New Wind Turbines with Increased Power Generation Capacity<sup>5</sup>

### 1.1. Need for Repowering

In India, wind power development commenced with the installation and demonstration of the first wind turbine generator unit, rated at 55 kW. Installation of wind turbines of different classes and unit sizes, ranging from 90 kW to 225 kW, quickly followed. The evolution of wind turbines in the last two decades is depicted in Figure 3

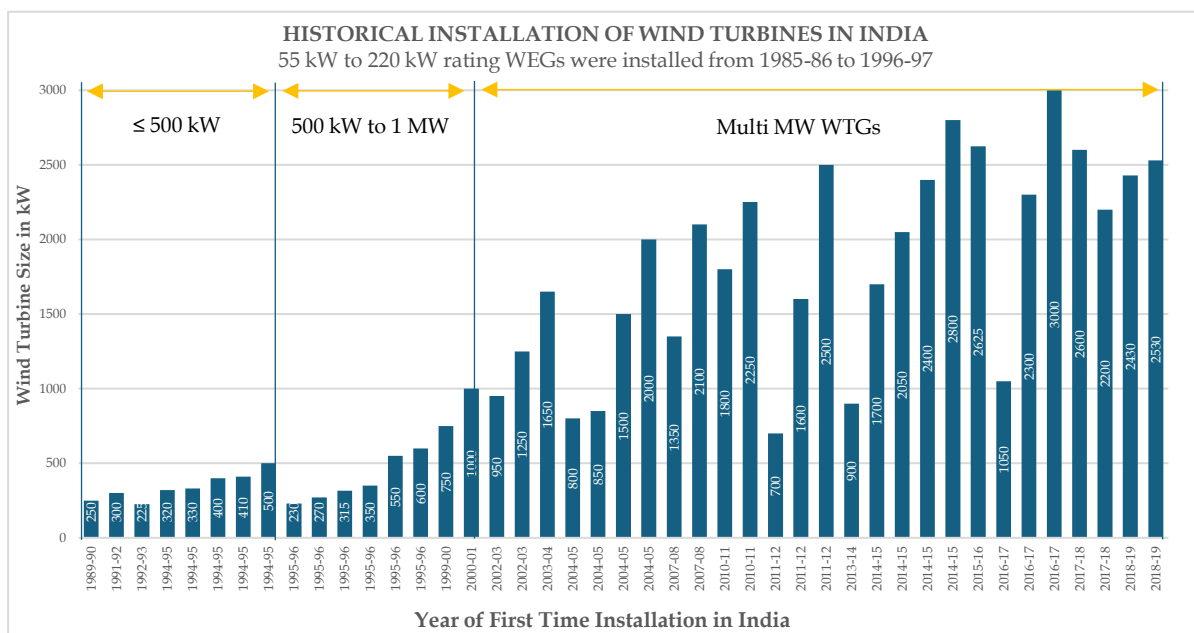


Figure 3: Wind Turbine Installation Trend<sup>6,7</sup>

With increased participation in the wind market in the 1990s, wind turbines with a capacity of 225-500 kW were 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 meters (m), has increased to about 80-100m today. The standard commercially available wind turbine size, which was 150 kW 15 years ago and 500

<sup>5</sup> Science in the News, Harvard University

<sup>6</sup> Idam Infra Analysis and Indian Wind Power Directory, 2017

<sup>7</sup> <https://indianwindpower.com/data-repository/uploads/YearwiseTurbineRatingIntroducedpdf.pdf>

kW 10 years ago, has now increased to 2,000-3,000 kW. The old wind turbines, especially those nearing the completion of their design life, suffer from several operational, technical, and financial problems, such as the following:

- Poor control and regulation mechanism
- Grid integration control - (need to comply with Low Voltage Ride Through (LVRT) and High Voltage Ride Through (HVRT))
- 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 replacing small WTGs with modern, more efficient, higher-capacity WTGs. To harness the available wind resources at these wind-rich sites, repowering activities must be prioritized, a viable option for investors that would significantly increase India's total renewable energy generation capacity. Repowering can be done in any of the following ways:

- One-to-one replacement
- many-to-one replacement
- Clustering into a farm
- One-to-one upscaling of the wind farm

## **1.2. Benefits of Repowering**

Repowering of wind farms offers several benefits. They are as follows:

### **Technical**

- i. Efficient utilization of potential wind sites produces a higher quantum of energy.
- ii. Improved Capacity Utilization Factor (CUF) at a 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 the grid.
- iii. Better management of grid parameters and provision of higher operational flexibility for the system operators

### **Environmental**

- i. Reduced the impact on the 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 Certificates (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) are minimal. Moreover, modern turbines produce less noise pollution due to greater design sophistication and improved technology.

From the Government's perspective, the 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, the quality of the landscape is often perceived as being improved, since the number of turbines is reduced in the changed scenario

### 1.3. Objective of the Study

The role of the WRPA has been conceived in the National Repowering & Life Extension Policy for Wind Power Projects (Dec 2023)<sup>8</sup> to address old, discrete wind turbine assets. The effort of the current assignment has deliberated on viable WRPA business model options, WRPA selection criteria, and implementation guidance. In this context, the donor agency desired to support India's efforts on repowering by way of supporting the following activities, considering Maharashtra and Tamil Nadu for pilot studies:

- a. Identification of innovative business models for WRPA and carrying out risk analysis
  - b. Method/process for selection of WRPA
  - c. Preparation of implementation guidelines for aggregation project/WRPA
  - d. Stakeholder workshops for consultation and dissemination. The objectives of the study can be summarized as follows:
- **Develop Innovative Business Models for WRPA:** The primary objective is to create innovative business models for WRPA in India. This involves identifying and defining WRPA's roles and responsibilities, as well as assessing the economic viability and associated risks of proposed business models.
  - **Facilitate Sectoral Transition:** The project aims to facilitate a sectoral transition by employing the Awareness-Solution-Articulated (ASA) framework. This involves constructing well-defined WRPA business models and expressing solutions through a consultative process involving key stakeholders and sectoral experts.
  - **Implementation Guidelines:** The study aims to highlight various aspects crucial for the effective implementation of aggregation projects, such as the selection process of WRPA, the bidding process, approvals, and intimation to the State/Central Nodal Agency (SNA/CNA) with respect to project development by WRPA, selection of Wind Repowering Project Developer (WRPD), and decommissioning and site clearance.

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<sup>8</sup> <https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2023/12/202312131874296229.pdf>

- **Economic Viability and Environmental Impact:** The study seeks to assess the economic viability of proposed business models, including the reduction in land area per MW of wind farm, additional energy generation, and the potential for higher profits. It also aims to address environmental concerns, such as reduced impacts on bird movement and noise pollution, as well as the financial and regulatory risks associated with wind repowering projects.
- **Stakeholder Consultation and Knowledge Dissemination:** The project aims to obtain necessary input from stakeholders on proposed business models, draft implementation guidelines, and the process of WRPA selection through stakeholder consultation workshops and knowledge dissemination sessions.

The current report is a compilation of various WRPA business models, their financial viability, and the associated risks. The report discusses possible WRPA business models, the selection process, and implementation guidelines for aggregation projects.

## Report on Structure

**Section 1** introduces repowering in India's wind sector, emphasizing its benefits, including efficient site utilization, improved Capacity Utilization Factor (CUF), and enhanced overall efficiency.

**Section 2** provides an overview of India's repowering initiatives, highlighting central and state-level interventions. It discusses key policies, including the MNRE's 2016 National Repowering Policy, as well as state-specific policies such as the Rajasthan Wind and Hybrid Energy Policy and the Gujarat Repowering Policy. The section also identifies policy gaps, particularly in Tamil Nadu and Maharashtra, stressing the need for state-specific regulatory measures.

**Section 3** outlines the new repowering initiatives under the National Repowering & Life Extension Policy for Wind Power Projects (Dec 2023). It details eligibility criteria, implementation frameworks, and classification of projects into standalone and aggregation categories. The section also highlights the role of the Wind Repowering Committee (WRC) in overseeing policy execution.

**Section 4** defines the roles and responsibilities of key stakeholders, including WRPA, WRPD, and other involved entities. It also presents the WRPA business model framework, detailing selection criteria, category definitions, and the scope of deliverables.

**Section 5** explores different WRPA business models, their characteristics, and associated cost assumptions. It presents three viable models and analyzes capital expenditure, interest rates, return on equity, debt-to-equity ratios, and site handover values. A comparative analysis highlights key differences in implementation criteria and driving entities.

**Section 6** assesses the financial viability and risks associated with each WRPA business model. It evaluates models based on cash flow, Net Present Value (NPV), and Internal Rate of Return (IRR). Risks are categorized into business, regulatory, financial, and environmental risks, detailing stakeholder-specific challenges for WRPA entities, Wind Turbine Generator (WTG) owners, WRPDs, and government agencies.

**Section 7** presents conclusions and actionable recommendations for WRPA projects, summarizing key findings and providing strategic guidance for stakeholders.

## **Conclusion**

This study highlights the urgent need for innovative WRPA business models and clear implementation guidelines. The proposed models and recommendations offer valuable insights for policymakers and implementing agencies, paving the way for a more efficient and sustainable wind energy sector in India.

## 2. Indian Repowering Initiatives till March 2022

Central and state policies for wind repowering have been major interventions in India. The MNRE and various state agencies have provided a policy and regulatory framework to support wind repowering, with the vision of encouraging the optimal use of available wind resources. Their major initiatives are:

### 2.1. National Repowering Policy of Wind Power Projects (MNRE,2016)

The salient features of the policy on repowering wind power projects, which was announced on August 5th, 2016<sup>9</sup>, are illustrated below. The objective of the policy is to promote the optimal utilization of wind energy resources by creating a facilitative framework for repowering wind projects in India.

Eligibility	Incentive	Implementation	Outlay
<ul style="list-style-type: none"> <li>Initially limited to wind turbine generators with a capacity of 1 MW or less.</li> <li>MNRE may extend the repowering policy to further projects based on this experience.</li> </ul>	<ul style="list-style-type: none"> <li>IREDA would offer an extra interest rate refund of 0.25% for repowering projects in addition to the interest rate discounts offered to IREDA-financed new wind projects.</li> <li>The repowering project will be eligible for all fiscal and financial benefits offered to new wind projects.</li> </ul>	<ul style="list-style-type: none"> <li>The repowering initiatives would be carried out by the corresponding State Nodal Agency or Organisation tasked with advancing wind energy in the state.</li> <li>If the transmission system needs to be expanded from a pooling station, the appropriate State Transmission Utility will be responsible.</li> </ul>	<ul style="list-style-type: none"> <li>No additional outlay has been provided in the Repowering Policy.</li> <li>Repowering projects are eligible for the AD benefit or GBI under the same restrictions as brand-new wind power projects.</li> </ul>
Support			Review
<ul style="list-style-type: none"> <li>If power is purchased by State DISCOMs through a PPA, the power produced prior to repowering would continue to be purchased in accordance with earlier PPA.</li> <li>Any residual extra generation would be either permitted for third-party sale or purchased by DISCOMs at FiT.</li> </ul>	<ul style="list-style-type: none"> <li>The state will make it easier to acquire the additional area needed for larger turbines.</li> <li>A wind farm/turbine undergoing repowering would be exempted from not honouring the PPA for the non-availability of generation from wind farm/turbine during the term of execution of repowering.</li> </ul>	<ul style="list-style-type: none"> <li>The 7D x 5D requirements for installing wind turbines would be reduced for micro-siting.</li> <li>Like this, captive users who elect to repower will be permitted to do so while the process is being carried out and in exchange for paying fees set by the regulator.</li> </ul>	<ul style="list-style-type: none"> <li>The Government would evaluate the Repowering Policy as and when necessary.</li> </ul>

<sup>9</sup> <https://mnre.gov.in/img/documents/uploads/c71fc782913649efa6ee5bed9b9c2f26.pdf>

## 2.2. National Tariff Policy, 2016

The National Tariff Policy, outlined by the Ministry of Power, focuses on ensuring the availability of electricity at competitive rates, promoting renewable energy sources, and establishing regulatory frameworks to incentivize investment in the sector. It addresses various aspects, including equity norms, depreciation, harnessing captive generation, cross-subsidy surcharge, and trading margins, with a clear emphasis on promoting transparency, efficiency, and sustainability in the power sector. The policy also encourages the procurement of power from renewable energy sources through competitive bidding and provides guidelines for pricing intermittent renewable energy. Additionally, it outlines measures to promote the generation and sale of electricity from renewable energy sources, including the establishment of micro-grids and the mitigation of investment risks in such projects.

Clause 5.11(g) of the National Tariff Policy outlines the need to encourage the renovation and modernization of electricity generation plants, including the repowering of wind power facilities. The relevant section of the 2016 Tariff Policy<sup>10,11</sup>, is as follows:

“Renovation and modernization of generation plants (including repowering of wind generating plants) need to be encouraged for higher efficiency levels, even though they may not have completed their useful life. This should 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 improvements between the utilities and the beneficiaries, with reference to revised, 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.”

## 2.3. State-Level Repowering Policies

The state-level policies and orders of different states before 2024 are compared as follows:

Table 2: A Comparative Analysis of Repowering Policies of Different States

Policy Name	Gujarat (2018)	Andhra Pradesh (2018)	Tamil Nadu (2019)	Rajasthan (2019)	Maharashtra (2020)
<b>Eligibility Criteria</b>	Repowering of old wind turbines with new and advanced technology.	Proposals considered for replacing older turbines with higher capacity WEGs after 15 years of life.	Repowering of existing wind farms with provisions for matching infrastructure and transmission commissioning.	Promote repowering of existing wind turbines that have completed at least 10 years in operation.	No dedicated policy for wind repowering, but provisions outlined in other policy documents.

10 <https://www.wberc.gov.in/sites/default/files/tariff-policy-28.01.2016.pdf>

11 <http://www.cbip.org/Policies2019/New%20Data/SummaryNationalPolicy.pdf>

Policy Name	Gujarat (2018)	Andhra Pradesh (2018)	Tamil Nadu (2019)	Rajasthan (2019)	Maharashtra (2020)
<b>Incentives and Benefits</b>	Reduction in wheeling charges, transmission charges, and cross-subsidy charges. Set up a dedicated fund for repowering.	<ul style="list-style-type: none"> <li>• Priority allotment of government land on a long-term lease basis for wind turbine manufacturing facilities.</li> <li>• Exemption from electricity duty for a period of ten years for consumption of electricity from the first year of operation.</li> <li>• No transmission and distribution charges for wheeling of power generated</li> <li>• Banking Facilities</li> </ul>	<ul style="list-style-type: none"> <li>• IREDA provides an additional interest rate rebate of 0.25% for Repowering projects.</li> <li>• Repowered projects can avail all fiscal and financial benefits available to new wind projects.</li> <li>• Micro-siting criteria relaxed for placing wind turbines.</li> <li>• Exemption from not honoring the PPA during the Repowering execution period.</li> <li>• Option to avail Accelerated Depreciation benefit or Generation-Based Incentive (GBI).</li> </ul>	<p>The policy provides both fiscal and non-fiscal incentives to encourage wind energy manufacturing capabilities.</p> <p>It aims to generate direct and indirect employment opportunities in the wind and ancillary industries.</p>	Same as MNRE policy.
<b>Implementation Guidelines</b>	Not specified.	Not specified.	Procedure for repowering of existing wind farms and proposed tariff for repowered wind farms.	Not specified.	Not specified.

Policy Name	Gujarat (2018)	Andhra Pradesh (2018)	Tamil Nadu (2019)	Rajasthan (2019)	Maharashtra (2020)
<b>Key Features and Provisions</b>	Increase the energy yield of wind power projects and extend their lifespan.	Undertake suitable micro-siting studies to utilize available wind resource potential.	Consultation regarding the procedure for the repowering of existing wind farms and the proposed tariff for repowered wind farms.	Promote repowering of existing wind turbines that have completed at least 10 years in operation.	Not specified.
<b>Additional Information</b>	Gujarat government provides various incentives and benefits for repowering old wind turbines.	Andhra Pradesh encourages repowering through suitable micro-siting studies.	TNERC consulted regarding procedure for repowering existing wind farms and proposed tariff for repowered wind farms.	Rajasthan promotes repowering of existing wind turbines that have completed at least 10 years in operation.	Not specified.

The Karnataka government came up with an order dated 2<sup>nd</sup> January 2024 on the repowering policy of wind projects and is summarized in the table below:

Table 3: Key features of Karnataka Repowering Policy

Policy Name	Karnataka, 2024
<b>Eligibility Criteria</b>	<ul style="list-style-type: none"> <li>• Wind turbines not in compliance with the quality control order issued by MNRE,</li> <li>• Wind turbines completed their design life,</li> <li>• Wind turbines with capacity below 2MW,</li> <li>• Based on commercial/voluntary consideration after 15 years of installation.</li> </ul>
<b>Incentives and Benefits</b>	<ul style="list-style-type: none"> <li>• Terms &amp; conditions of loans by REC/PFC/IREDA apply</li> <li>• 0.25% additional interest rate rebate by IREDA,</li> <li>• Fiscal &amp; financial benefits applicable to new wind projects,</li> <li>• Liberty to the developer for micro-siting.</li> </ul>

Policy Name	Karnataka, 2024
<b>Implementation Guidelines</b>	<ul style="list-style-type: none"> <li>• NIWE to maintain the project database of all old projects,</li> <li>• Project commissioning within 2 years from the date of consent,</li> <li>• MNRE empowered to amend policy with approval of the Minister, MNRE.</li> <li>• Wind Repowering Committee to be appointed within one month of policy announcement.</li> </ul>
<b>Key Features and Provisions</b>	<ul style="list-style-type: none"> <li>• Repowered wind projects should generate at least 1.5 times the actual generation before repowering,</li> <li>• Standalone and aggregation project classifications are done in this policy.</li> </ul>
<b>Additional Information</b>	<ul style="list-style-type: none"> <li>• Wind Repowering Committee to facilitate policy implementation,</li> <li>• Transmission arrangements coordinated with STU/CTU,</li> <li>• Additional power can be sold by the owner to any entity,</li> <li>• Old PPA can be terminated with mutual consent,</li> <li>• The SNA or CNA coordinates with the STU or CTU for availability or augmentation of transmission capacity,</li> <li>• The developer is required to issue a notice to the CTU/STU two years in advance and pay transmission charges as per prevailing regulations.</li> </ul>

## 3. National Repowering & Life Extension Policy- 2023

To facilitate repowering, the Ministry of New and Renewable Energy notified the National Repowering & Life Extension Policy for Wind Power Projects – 2023<sup>12</sup>, in December 2023. The goal of the revised repowering policy is to maximize energy yield (kWh) per square km of the project area while leveraging the most cutting-edge onshore wind turbine technologies. This guideline outlines the requirements for developers who wish to repower their outdated wind turbines. The following are a few key features of the policy.

The policy states that “some of the old wind turbines have already reached the end of their design life, while some are approaching it.” The most recent technology is more efficient than these wind turbines. They also feature smaller hub heights (30–60 m), compared to the 120–140 m hub heights of more recent turbines. Lower-hub-height wind turbines cannot capture the wind at higher hub heights. Therefore, it is necessary to replace the older, smaller wind turbines with newer, more powerful, more efficient ones.

### **Turbines below 2 MW capacity**

According to the new policy, wind turbines that require repowering include those with capacities less than 2 megawatts (MW) that have reached the end of their design life as per the BIS norm. The only turbines covered by the 2016 policy were those with capacities under 1 MW. The repowering of turbines under 2 MW capacity must be taken into consideration, the policy states, “since the latest wind turbine technology of 3+MW capacity is being manufactured in the country”.

### **State’s Potential**

Repowering potential considering turbines with a capacity of less than 2 MW have been estimated to be 25397MW, or 25.4 GW in eight states, including Tamil Nadu (7387 MW), Maharashtra (3431MW), Karnataka (3023MW), Gujarat (4665MW), Rajasthan (2934MW), Madhya Pradesh (1562 MW), Kerala (28 MW), and Andhra Pradesh (2366 MW).

### **Incentive/Benefit**

0.25% interest-rate rebate for repowering projects, over and above the interest rate available to new wind projects financed by IREDA, much like the 2016 policy did. The current policy, however, introduces a unique program under which the developer will have the liberty to micro-sit based on an optimized energy output.

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<sup>12</sup> Policy for Repowering of the Wind Power Projects | Ministry of New and Renewable Energy | India (mnre.gov.in)

## Sale of Extra Power through Open Access (OA)

Developers will have the freedom to sell additional wind power generated to distribution companies (DISCOMs) or to any other entity (if the DISCOM refuses) through open access.

## Aggregation as a solution

The new policy allows joint applications by multiple owners for repowering under WRPA mode. The state or central nodal body may then decide which turbines would benefit from repowering. The WRPA will be chosen by the nodal agency from among Public Sector Enterprises (PSEs) or private developers.

## Implementation Framework

According to the 2023 policy, a monitoring and advising committee will be established within a month of the policy's announcement. The Indian Renewable Energy Development Agency (IREDA), Central Transmission Utility (CTU), NIWE, state renewable energy agencies, and independent members, with the Joint Secretary (Wind), MNRE, as Chairman, make up this body, which will be known as the Wind Repowering Committee (WRC).

### 3.1. WRPA in the National Repowering Policy 2023

The revised policy has classified repowering projects into two types:

- 1. Standalone Project** - A wind power project having a single or a group of wind turbines owned by a single entity.
- 2. Aggregation Project** - A wind power project having a group of wind turbines owned by multiple owners with shared common infrastructure.

For aggregation projects, the following modalities shall be adopted to develop repowering projects.

- a. SNA/CNA may identify the potential turbines for repowering. In such cases, SNA/CNA either nominate any State/Central PSEs as WRPA to repower the project or elicit interest from private developers for the same. The selection of the private developer as WRPA shall be transparent, based on minimum technical criteria, and the submission of consent letters from all the identified turbine owners. The indicative parameters for the selection of WRPA may include:
  - Quality Assurance Certificate
  - Financial turnover
  - Experience
  - Repowering plan
  - Old asset evaluation
  - Consent agreement from the existing owners
  - Indication of land rights arrangement
  - Asset disposal plan
- b. Amongst the existing owners of wind power projects, any one owner/developer may act as WRPA with or without partnership with other project developers. The proposed owner shall identify potential turbines

for repowering and submit a proposal to the SNA/CNA, along with consent letters from all the identified turbine owners.

### **Responsibilities of WRPA:**

The policy states that the State Nodal Agency (SNA) or Central Nodal Agency (CNA) may identify potential wind turbines for repowering. In such cases, the SNA/CNA may either:

- Nominate a State/Central Public Sector Enterprise (PSE) as the Wind Repowering Project Aggregator (WRPA), or
- Invite expressions of interest from private developers for the role.

The selection of a private developer by WRPA shall be conducted through a transparent process based on minimum technical criteria. It is recommended that the WRPA be selected by an implementation agency (IA) through a competitive and transparent process. The selection criteria for the WRPA should be finalized by the IA in consultation with the Wind Repowering Committee (WRC).

### **Potential WRPA entities may include:**

- Original OEMs (Original Equipment Manufacturers)
- Wind sector service providers
- New OEMs
- Construction companies
- Wind Independent Power Producers (IPPs)

### **WRPA shall perform the following functions**

- Prepare a Detailed Project Report (DPR) covering land acquisition and site development for the repowering project.
- Acquire, lease, or purchase additional land, if required.
- Obtain necessary clearances from the state, central authorities, or any other agencies concerned for decommissioning and project development.
- Acquire all assets at the site, including wind turbines, associated equipment, internal transmission infrastructure, land, and power evacuation rights. Additionally, WRPA shall compensate asset owners for any future revenue loss for the remaining life of the project, if applicable. Asset valuation shall be conducted in accordance with standard market practices, as outlined in the policy.
- Manage the decommissioning of existing assets, ensuring safe removal and lawful disposal of all scrap, including wind turbine blades. The disposal of turbine blades must comply with the applicable norms of the Ministry of Environment, Forest, and Climate Change (MoEFCC) and the Central/State Pollution Control Board (CPCB/SPCB), and a certificate from the appropriate authority must be obtained.
- Prepare the site free from encumbrances for the development of the wind project, ensuring it meets the requirements of a Greenfield project.

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## Procedure for Aggregation Projects

- The following steps shall be followed for aggregation projects:
- The WRPA shall submit the DPR to the respective SNA/CNA.
- Based on the DPR, the SNA/CNA shall coordinate with the State Transmission Utility (STU) or Central Transmission Utility (CTU) to assess the availability and augmentation of transmission capacity, if required. It shall also facilitate the acquisition of additional land, if necessary.
- Any required transmission augmentation shall be carried out by the STU/CTU as per existing provisions and schemes. The developer must issue a two-year advance notice to the CTU/STU to enhance transmission capacity in line with the proposed repowered wind project. Applicable transmission charges shall be paid in accordance with the prevailing regulations.
- Upon scrutiny of the project and confirmation of transmission capacity availability, the SNA/CNA shall issue a consent letter to the project owner/developer after obtaining in-principal consent from the incumbent DISCOM.
- The repowering may be undertaken by the WRPA either:
  - a. Through an open bidding process, or
  - b. By executing the project on an Engineering, Procurement, and Construction (EPC) basis.
- A notice of repowering, along with the DPR, shall be submitted to the WRC (established under Para 8 of the policy). After evaluating the repowering process, the committee may grant a moratorium on power supply under the PPA for a maximum period of two years during repowering.

### Note

1. In the case of In-STS connected wind turbines, SNA shall identify the potential turbines for repowering and carry out the required activities as mentioned.
2. In the case of ISTS-connected wind turbines, the CNA shall identify the potential turbines for repowering and carry out the required activities as mentioned.

### 3.2. Wind Repowering Project Developer (WRPD) – Roles and Responsibilities

It is recommended that WRPD be responsible for developing the repowering project at the site cleared by WRPA for development. WRPD could be a Wind Independent Power Producer (IPP), OEM, O&M operator/service provider, or a private investor selected through a competitive process by the Implementation Agency (IA). WRPD Responsibilities:

- Develop, construct, and implement the project as per the bid conditions.
- Pay approved 'Acquisition Costs' mentioned in the bid document IA.
- Sell power to the IA and sign Power Purchase Agreement (PPA).
- In case WRPA and WRPD are the same entity, the WRPD may also take up the responsibilities of the WRPA.

To summarize, the roles and responsibilities of WRPD include the following:

- Acquisition of site rights from WRPA through the auction process by SNA/CAN.
- Development of a new project based on DPR.

- 
- Project development, installation, commissioning, operations, and maintenance of project assets.
  - Power offtake arrangements – PSA/PPA/Captive

### **3.3. CNA/SNA-Roles and Responsibilities**

The Ministry of New and Renewable Energy (MNRE) is the central nodal ministry responsible for promoting, regulating, and implementing renewable energy in India. MNRE should serve as the implementing ministry at the central level.

#### **State Nodal Agencies (SNAs) for renewable energy implementation, such as:**

- Maharashtra Energy Development Agency (MEDA)
- Gujarat Energy Development Agency (GEDA)
- Tamil Nadu Electricity Generation and Distribution Company (TANGEDCO)

These agencies will play a key role in implementing the repowering policy. The policy also provides for the appointment of a Central Nodal Agency (CNA) to develop repowering projects and facilitate the implementation of ISTS-connected projects. In addition to these agencies, wind turbine OEMs, project developers, and existing O&M service providers for aging wind farm sites will have a crucial role in repowering projects. Repowering projects will be implemented through either:

- The respective SNA/organization promoting wind energy in the state, or
- The CNA is appointed by the central government.

#### **CNA and SNA's Key Functions:**

- Identify potential turbines for repowering.
- Based on the DPR, coordinate with the respective State Transmission Utility (STU) or Central Transmission Utility (CTU) for transmission capacity availability/augmentation, if required, and facilitate additional land acquisition, if necessary.
- Scrutinize the project and assess transmission capacity; thereafter, issue a consent letter to the project owner/ WRPA/developer after obtaining in-principal consent from the incumbent DISCOM.
- Participate in the Wind Repowering Committee (WRC).
- Provide implementation support to WRC and MNRE for repowering projects.
- Identify repowering projects in the state/wind parks.
- Review and recommend standalone repowering projects to the WRC.
- Support the Implementing Agency (IA) in managing the bidding process for selecting WRPA/WRPD for aggregation projects.
- Collect project information for potential repowering projects.
- Assist the National Institute of Wind Energy (NIWE) in maintaining:

- A registry of decommissioned wind projects.
- A pipeline of potential repowering projects.
- Facilitate project development activities, including consenting and approval.
- Coordinate with CTU/STU for transmission infrastructure upgrades.

### 3.4. Repowering Project Stakeholders and Their Roles

In view of the collective wind sector in India, the following are the key stakeholders for repowering projects identified in line with the 2023 repowering policy, as provided in Table 4

Table 4: Repowering Project Stakeholders and Their Roles

Stakeholder	Role
<b>Existing wind turbine asset owners</b>	Provide consent and approval for repowering projects, hand over assets to WRPA, and receive compensation, or be a WRPD and develop a new repowering project.
<b>Project developers</b>	Prepare detailed project reports, acquire additional land as required, obtain development clearances, and develop the site for the repowering project.
<b>Original Equipment Manufacturers (OEMs)</b>	Provide new turbines and associated equipment. Can assist in the decommissioning and disposal of old assets.
<b>Energy Consumers (Industry /DISCOM)</b>	Provide in-principal consent for repowering and continue to procure power as per the terms of the PPA.
<b>Government Agencies</b>	Identify potential turbines for repowering, nominate WRPA, and provide guidelines for Repowering Project implementation and power purchase.
<b>Independent Power Producers (IPPs)</b>	Develop, construct, and implement the repowering project, and sell power to the implementation agency/others.
<b>Independent O&amp;M Service Providers (ISP)</b>	Provide existing/potential I&C and/or O&M services and assist in the decommissioning of existing assets.
<b>Bankers/Project Funding agencies and investors</b>	Provide project investments for asset acquisition and new project development.

The stakeholders for a repowering project can be segregated into 3 major groups as shown in Figure 4: a) Government, b) Industry, and c) Financial Institutions. The key stakeholders in a repowering project are as follows:

 <b>Government</b>	 <b>Industry</b>	 <b>Financial Inst.</b>
<ul style="list-style-type: none"> <li><input type="checkbox"/> MNRE</li> <li><input type="checkbox"/> State Nodal Agencies (SNAs)/Central Nodal Agency (CNA)</li> <li><input type="checkbox"/> NIWE</li> <li><input type="checkbox"/> Wind Repowering Committee (WRC)</li> <li><input type="checkbox"/> STU/ CTU</li> <li><input type="checkbox"/> SERCs</li> </ul>	<ul style="list-style-type: none"> <li><input type="checkbox"/> DISCOM</li> <li><input type="checkbox"/> Present Wind turbin asset owners</li> <li><input type="checkbox"/> Wind Repowering Project Aggregators (WRPA)</li> <li><input type="checkbox"/> Wind Repowering Project developer (WRPD)</li> <li><input type="checkbox"/> OEMs</li> </ul>	<ul style="list-style-type: none"> <li><input type="checkbox"/> Indian Renewable Energy Development Agency (IREDA)</li> <li><input type="checkbox"/> Banks</li> <li><input type="checkbox"/> NBFCs</li> </ul>

Figure 4: Repowering Project Stakeholders

## MNRE

The Ministry of New and Renewable Energy (MNRE) is the nodal ministry for formulating a repowering policy and necessary guidelines to facilitate and implement repowering to realize the full potential of wind power in India. MNRE’s Key Roles in Repowering:

- i. Appointing the CNA for repowering projects connected to the ISTS network.
- ii. Appointing members of the Wind Repowering Committee (WRC) within one month of the policy announcement.
- iii. Evaluate the policy efficacy to ensure repowering at scale. Amend and revise the policy if deemed necessary

## State Nodal Agencies (SNAs)/Central Nodal Agency (CNA)

Project selection for repowering will be undertaken by either the CNA, the respective SNA, or another designated state body promoting wind energy.

For Standalone projects:

- Identification of the potential wind turbines eligible for repowering elicits interest from the Project Owner to Submit the DPR.
- Review of the DPR submitted by the project owner.
- The SNA or CNA shall work with the relevant STU or CTU to arrange for availability or, if necessary, augmentation of the transmission capacity based on the DPR.
- Issue a letter of authorization for repowering and obtaining a letter of consent from the current DISCOM.

For Aggregation projects:

- Define the minimum technical criteria for the selection of a private developer as WRPA.
- Identify the potential wind turbines for repowering.
- Select the WRPA for carrying out the tasks of repowering. SNA or CNA may appoint a state or central PSE or an interested private developer as WRPA.
- If there are wind turbines linked to the in-STS, SNA must identify the prospective repowering candidate.
- In the case of wind turbines connected to the ISTS, the CNA is responsible for identifying prospective repowering candidates.

### National Institute of Wind Energy (NIWE)

The National Institute of Wind Energy (NIWE) is the nodal authority for gathering data on wind potential, wind speed, wind power density, and Annual Energy Potential (AEP) for any project site. All repowering calculations must be performed using the wind data provided by NIWE. NIWE has the following roles for wind repowering.

NIWE is an autonomous R&D institution under MNRE. It was established to serve as a technical focal point for the orderly development of wind power deployment. Recently, it has been approved by MNRE as a testing and type certification body in India for all wind-related issues. It has geo-tagged most of the wind turbines in the country. As a result, NIWE had the single largest depository of wind-related information in the country. It has carried out several studies on the repowering of wind farms in India. The roles of NIWE are as shown in Figure 5. NIWE will perform the following functions under this Policy:

- Provide technical inputs to WRC on the viability of the project.
- Provide **implementation support** to **WRC** and **MNRE**.
- Maintain a national registry of decommissioned projects with the help of SNAs.
- Develop & maintain a national level pipeline of potential repowering projects



NIWE shall maintain the database of the repowering project with the details related to the infrastructure ownership, turbines, technology, connectivity Pooling Substation (PSS) and land ownership.



Additionally, NIWE will gather information on each site's performance, examine it, and identify underperforming locations for repowering in accordance with IWTCQ.



In collaboration with SNAs and CNA, NIWE will keep data on projects that have been decommissioned and this data set will be updated on a quarterly basis by NIWE.

Figure 5: Role of NIWE

## Wind Repowering Committee (WRC)

The Ministry will form a WRC within a month of the policy's announcement. It is supposed to monitor the ground-level implementation of the repowering policy in India. As indicated, the WRC shall consist of the following members.

- i. Chairman-Joint Secretary (Wind), MNRE
- ii. Member Secretary- Representative of NIWE
- iii. Member
  - a) Representatives of IREDA, SECI
  - b) Representative of Central Transmission Utility – Member
- iv. Three independent experts from the Wind sector –Member (nominated by MNRE)

The committee will co-opt members from the respective state while taking up specific issues related to the repowering/refurbishment project of that state. MNRE circulated an office memorandum<sup>13</sup> on January 17, 2024, regarding the constitution of the Wind Repowering Committee.

## Central Transmission Utility (CTU)/State Transmission Utility (STU)

The transmission utilities are a key stakeholder in the repowering project. The role of the CTU and STU is to assess and upgrade the transmission infrastructure required to evacuate power from repowering projects. They will do so based on the CAN and SNA's identification of turbines/sites/projects for repowering. SNA/CNA shall coordinate with the respective STU/CTU for the availability/augmentation of transmission capacity, if required, and facilitate the acquisition of additional land, if required. The key responsibility of CTU and STU is to specify the availability/expansion of the transmission network for the repowering project, as required.

## Distribution Companies (DISCOMs):

The incumbent DISCOM is one of the key stakeholders in repowering projects. The Policy for Repowering of Wind Power Projects, 2023<sup>14</sup> by the MNRE provides several guidelines for DISCOMs regarding arrangements for power purchase. The roles of DISCOMs are:

- i. Provide in-principal consent for repowering to CNA/SNA.
- ii. Continue power procurement after repowering, based on the average generation of the last three years, as per existing PPA terms.
- iii. Coordinate with STU/CTU to supply local loads affected during repowering.

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<sup>13</sup> <https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2024/01/202401181390244639.pdf>

<sup>14</sup> Policy for Repowering of the Wind Power Projects | Ministry of New and Renewable Energy | India (mnre.gov.in)

## Existing Wind Turbine Asset Owner

The present owner/s of the wind generation system is a major stakeholder for the sites under consideration for repowering by SNA/CNA.

- i. Owners will provide their consent and approval to the SNA/CNA or the WRPA for repowering projects to happen, as they hold the rights to the entire infrastructure.
- ii. For a standalone repowering project, the DPR must be prepared by the owner and sent to SNA/CNA for approval before repowering can take place.
- iii. The owner must hand over the wind power generation system, land, and other assets to WRPA for a repowering project in aggregator mode. In return, WRPA will compensate the owner as per the guidelines by MNRE

## Wind Repowering Project Aggregator (WRPA)

WRPA is a major stakeholder in repowering projects under the aggregator mode. WRPA plays a critical role as an intermediary between the site's existing owners and the Wind Repowering Project Developer (WRPD). This involves convincing and compensating existing turbine owners for repowering, decommissioning, and clearing the site to set up new wind turbines, etc. The roles of WRPA are shown in Figure 6. The following are the defined responsibilities of a WRP.

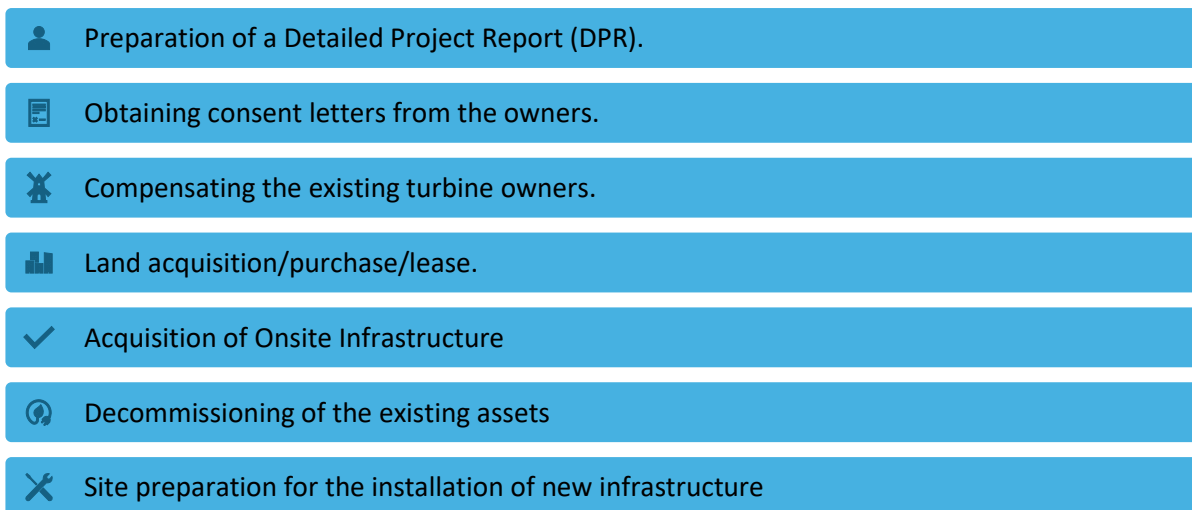


Figure 6: Roles and Responsibilities of WRPA

## Wind Repowering Project Developer (WRPD)

WRPD is one of the key stakeholders for the repowering project. WRPD is responsible for developing the wind site with new turbines and associated transmission infrastructure after the site is handed over by WRPA. WRPD has the following roles:

- i. Development of a site with higher-capacity wind turbine generators.
- ii. Development of transmission infrastructure up to the designated power evacuation point.
- iii. Notify SNA/CAN and DISCOM of the COD date of the repowered project.

- iv. Sale of power as per guidelines

## Indian Renewable Energy Development Agency (IREDA)

IREDA is one of the key stakeholders for repowering projects. As per the Policy for Repowering of the Wind Power Projects, 2023<sup>15</sup>, IREDA will provide a 0.25% rebate on the interest rate for all repowering projects financed by IREDA. Additionally, it will also provide an additional interest rate rebate of 0.25% over and above the interest rate currently available to the new Wind projects being financed by IREDA as an incentive.

For developing WRPA business models, it would be essential to identify the potential candidates for a WRPA role and map those amongst the identified stakeholders, which is provided in section 4.5. For a repowering project in India, there are 7 major candidates mapped for potentially undertaking the WRPA role. The WRPA categories, along with linkages between WRPA selection and NIWE/MNRE, the Role & Responsibility of WRPA, the Scope of WRPA business, and any policy gaps, collectively form the framework for WRPA business models.

Till date, some state governments have also come up with their state policy/orders as follows:

- To motivate wind power developers to refurbish old windmills, the Tamil Nadu state government has circulated the draft Tamil Nadu Repowering and Life Extension Policy for Wind Power Projects - 2024<sup>16</sup> for stakeholder consultation on 2nd January 2024. This policy has ensured the extension of the “wind banking” facility for the repowered project, subject to certain conditions. To incentivize wind energy producers, the policy allows wind banking of up to 50% of additional generation in the month from repowered projects.
- The Gujarat state government came up with the Gujarat Renewable Energy Policy-2023, which includes repowering of wind projects and superseded the Gujarat Repowering of Wind Projects Policy-2018<sup>18</sup> notified vide G.R. dated May 21, 2018. The policy stated that if the wind project developer does not repower their wind turbine generator at the end of the project’s lifespan or the agreed term/extended terms, they will be required to decommission the wind power project and surrender the connectivity. If the wind turbine generator is located on leased land, they will also need to surrender their leasehold rights to the government.
- Karnataka Electricity Regulatory Commission (KERC) has come up with the implementation order<sup>17</sup> on 2nd January 2024, which was in line with the Policy for Repowering of the Wind Power Projects, 2023<sup>18</sup>. The order provided the repowering implementation framework as follows: within a month of the policy’s announcement, the MNRE shall form a monitoring and advisory committee, known as the WRC including the Joint Secretary (wind), MNRE as the Chairman, representatives from IREDA, SECI, CTU, three independent wind experts as members, and a representative from NIWE as the Member Secretary. This formation is in line with the policy’s provisions and is intended to aid the MNRE in implementing the Repowering/Refurbishment Policy. The WRC’s main role shall be to serve as a liaison between industry stakeholders and state/central government organizations, assist the ministry in effectively implementing

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15 Policy for Repowering of the Wind Power Projects | Ministry of New and Renewable Energy | India (mnre.gov.in)

16 draft-repowering-and-life-extension-policy-for-wegs-2024.pdf (indiastpend.com)

17 media\_to\_upload1704359162.pdf (karnataka.gov.in)

18 Policy for Repowering of the Wind Power Projects | Ministry of New and Renewable Energy | India (mnre.gov.in)

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the repowering policy, suggest specific policy/ regulatory changes, and track the progress of projects undergoing repowering/refurbishment.

## 4. WRPA

The Policy for Repowering of Wind Power Projects, 2023, by MNRE defines a well-structured framework for the Wind Repowering Project Aggregator (WRPA), outlining its role and responsibilities. To make stakeholders aware of the potential opportunities and risks associated with WRPA, it's crucial to explore robust business models.

The WRPA model was envisioned to streamline the repowering process for wind power projects with shared infrastructure and multiple owners. Understanding and analyzing the framework elements of WRPA, as illustrated in Figure 7, is essential for developing an innovative and effective WRPA business model.

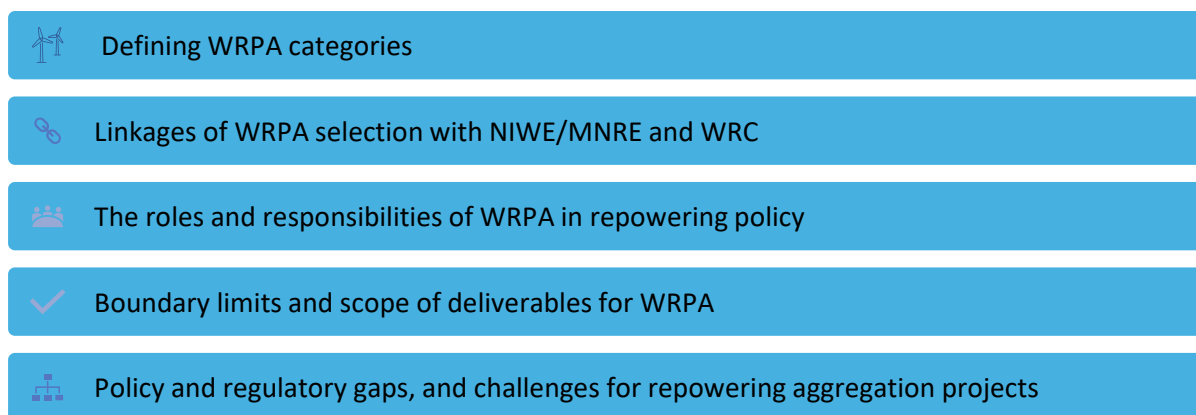


Figure 7: Key WRPA Framework Elements

### 4.1. WRPA Categories

A WRPA entity consolidates ownership of a scattered site and prepares it for repowering. This WRPA may be an asset owner (or a group of owners), an Independent Power Producer (IPP), a developer, an OEM, or a Special Purpose Vehicle (SPV). Table 3 provides more details on WRPA categories and their key drivers.

Table 5: Potential WRPA Categories and Key Drivers for their inclusion

Candidate	Key Driver
Asset Owner/s	Existing turbines, land assets at the site
Developer	Existing land, power evacuation infrastructure, and O&M services
OEM	Future wind farm business
Independent Power Producer (IPP)	Interest in project capacity addition for Captive/PPA use
Independent Service Provider (ISP)	Existing/Potential I&C and/or O&M services
Financial Institution	Project investments for asset acquisition and new project development
Central / State PSU	Access to the site for the new project/Wind RPO compliance

CNA and SNA will oversee repowering activities and policy implementation. Figure 8 outlines potential WRPA categories and demonstrates how both agencies play a crucial role. Entities from different categories may also form Joint Ventures (JV) or Special Purpose Vehicles (SPV) for these activities.

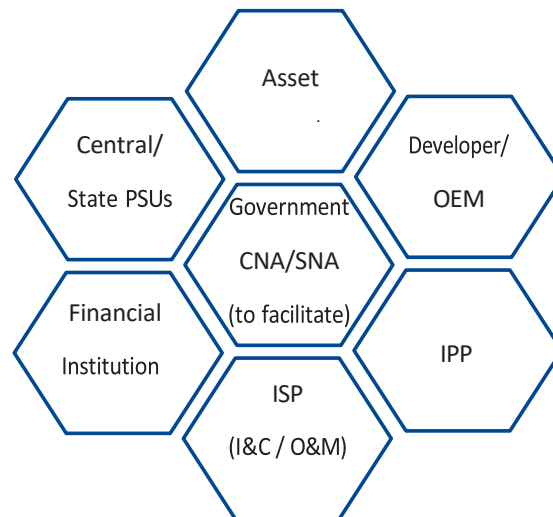


Figure 8: Potential WRPA categories

## 4.2. MNRE/NIWE in WRPA selection

MNRE and NIWE do not play a direct role in WRPA selection, but may be indirectly involved in:

- Identifying aggregation sites for repowering (NIWE)
- Specifying bidding process for WRPA selection (MNRE through WRC)
- Nominating implementing agency (MNRE through WRC)
- Defining the technical and financial eligibility criteria for WRPA selection (NIWE through WRC)

The ‘Policy for Repowering of the Wind Power Projects, 2023’ outlines specific roles for the Wind Repowering Committee (WRC). As mentioned, the WRPA can either be nominated by SNA if it is a Public Sector Undertaking. For other cases, the WRPA will be chosen through a competitive bidding process. While the cost of acquiring the site might be a factor in evaluating bids, WRC will establish the technical and financial criteria for this selection process during its implementation by the designated agency.

## 4.3. Wind Repowering Committee (WRC) in WRPA

The MNRE will establish a national-level Wind Repowering Committee (WRC) to oversee policy implementation, approvals, and coordination. This committee will coordinate with SNAs, NIWE, and a designated “implementation agency” for repowering projects. This committee will undertake the following functions under this policy:

- Approving wind repowering sites.
- Appointing or /nominating an ‘implementation agency’ for aggregation projects.

- Approving feasibility/detailed report for repowering projects.
- Guiding the implementation agency in selecting the Wind Repowering Project Developer (WRPD) for specific project sites.
- Providing overall coordination, monitoring, and guidance for successful repowering.
- Facilitating and monitoring the maintenance of a registry for decommissioned/repowering projects.

The WRC will handle approvals, appointments, guidance, and monitoring as outlined in Figure 9

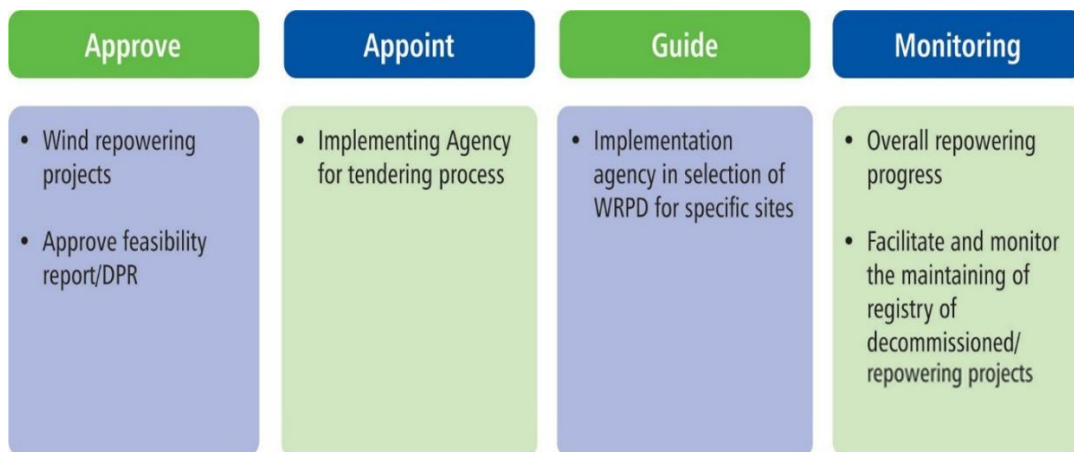


Figure 9: Functions of WRC

#### 4.4. Roles and Responsibilities of WRPA in Repowering Policy

The repowering policy assigns WRPA the role of intermediary between existing owners and WRPD. This agency, which can be a state or central PSE, or even a private entity, is tasked with negotiating with and compensating existing asset owners for repowering their turbines and facilitating the installation of new wind turbines by clearing the land, among other things. A private developer can be selected as WRPA through a transparent process that meets minimal technical requirements and requires consent letters from all recognized turbine owners.

##### WRPA's Role and Responsibilities include

###### 1. Preparation of a detailed project report (DPR)

WRPA will conduct a comprehensive study of the potential repowering site. This includes evaluating the existing wind farm's location, topography, wind resource, and land availability. The findings will be used to prepare a Detailed Project Report (DPR). Based on the DPR and the wind farm owner's consent letter, SNA/CNA will provide its approval for repowering.

###### 2. Obtaining consent letters from the existing owners

WRPA is responsible for securing approval from wind turbine owners for repowering. This entails discussing all aspects of repowering (including its benefits), addressing financial and ownership concerns, and ensuring fair compensation in accordance with market standards and MNRE guidelines.

### **3. Land acquisition/purchase/lease**

New wind turbines often require specific layouts (e.g., 5D x 7D, 4D x 8D, 3D x 5D). WRPA will make the appropriate arrangements, such as land acquisition, to erect new, higher-capacity turbines. The repowering ratio is an important parameter considered in repowering. If a repowering project requires additional land to meet the important minimum repowering ratio set by SNA, WRPA will be responsible for acquiring it.

### **4. Acquisition of site infrastructure**

WRPA is responsible for acquiring all repowering infrastructure, including new wind turbines, generators, motors, power cables, and any necessary upgrades to handle increased power transmission. This includes power evacuation rights and internal transmission infrastructure, especially if existing turbines supply a specific site rather than the general grid. WRPA will also compensate asset owners for any financial losses incurred during the repowering phase, including lost generation revenue, in accordance with the methodology outlined in the **National Repowering & Life Extension Policy for Wind Power Projects – 2023**<sup>19</sup>. This ensures owners are fairly compensated for the entirety of their lost income potential.

### **5. Decommissioning of existing assets**

To facilitate the installation of new wind turbines, WRPA must decommission the existing ones. This includes dismantling wind turbine generators, blades, towers, foundations, and metal bodies. All project assets, functional and non-functional, will be appraised in accordance with industry standards (valuation methods provided in the policy document). WRPA is responsible for obtaining the necessary clearances and ensuring the proper disposal of turbine blades in accordance with the regulations of CPCB, SPCB, and MoEFCC (certificate required). Revenue generated from scrap sales will help offset decommissioning costs.

### **6. Site preparation for installation of new infrastructure**

WRPA must prepare the decommissioned site for new infrastructure. This involves returning the land to its original or predetermined condition, which includes removing scrap materials, controlling erosion, and reclaiming the ground. WRPA should also address any potential obstacles to repowering the site, such as:

- i. Land availability.
- ii. Transportation access for large infrastructure, like turbine blades.
- iii. Securing the local community's cooperation for site development

## **4.5. Boundary and Scope of Deliverables for WRPA**

The repowering policy clearly outlines WRPA's responsibilities. To establish WRPA as a distinct entity with a clear business model, we need to define its operational boundaries and deliverables.

WRPA's work commences upon SNA's selection for the repowering project and upon execution of the contract between CNA/SNA and WRPA. The contract, in accordance with existing guidelines and the repowering policy,

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<sup>19</sup> Policy for Repowering of the Wind Power Projects | Ministry of New and Renewable Energy | India (mnre.gov.in)

will define WRPA’s terms and conditions as set by CNA/SNA. Site clearance is WRPA’s final step before handing the cleared site to SNA or WRPD for the repowering project

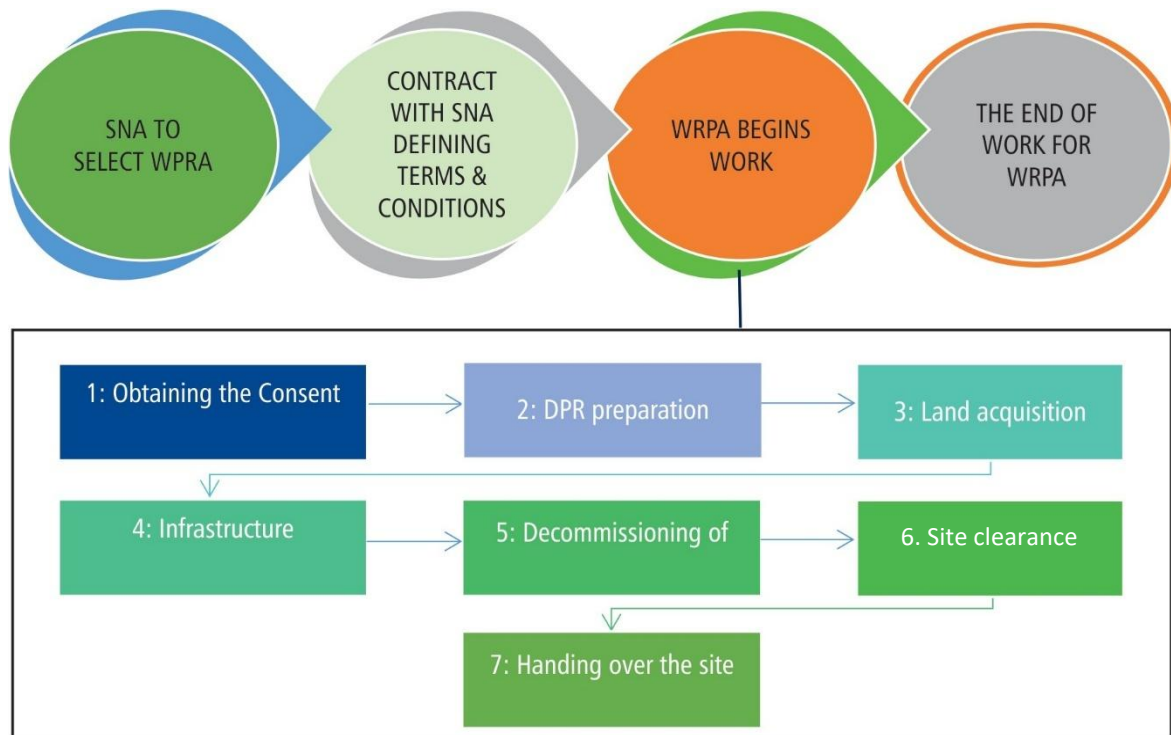


Figure 10: Scope of WRPA Business

To develop the WRPA business model (see Figure 10), a clear understanding of WRPA’s scope of work and deliverables is crucial. These elements will significantly impact the cost structure of a WRPA business. Table 6 outlines the activities that fall within and outside WRPA’s scope of work for further clarity.

Table 6: Scope of WRPA

<b>SCOPE for WRPA (as an individual entity)</b>
Getting consent from owners
Compensating existing owners
Decommissioning assets
Site clearance
DPR preparation
Land acquisition/lease
Site handover to CNA/SNA /WRPD
<b>BEYOND WRPA’S SCOPE (as an individual entity)</b>
Identification of old turbines/sites for repowering
Upgrading transmission infrastructure for repowered turbines

Planning for a temporary supply of power during repowering

Installation of new turbines

Database management of the repowering project

## 4.6. Policy and Regulatory Gaps, and Challenges for Repowering in Aggregation Projects

The challenges to wind repowering in India (see Figure 11) include multiple and fragmented land ownership, compensation to existing owners, evacuation infrastructure, decommissioning of old turbines and blades, and modifications to PPA.

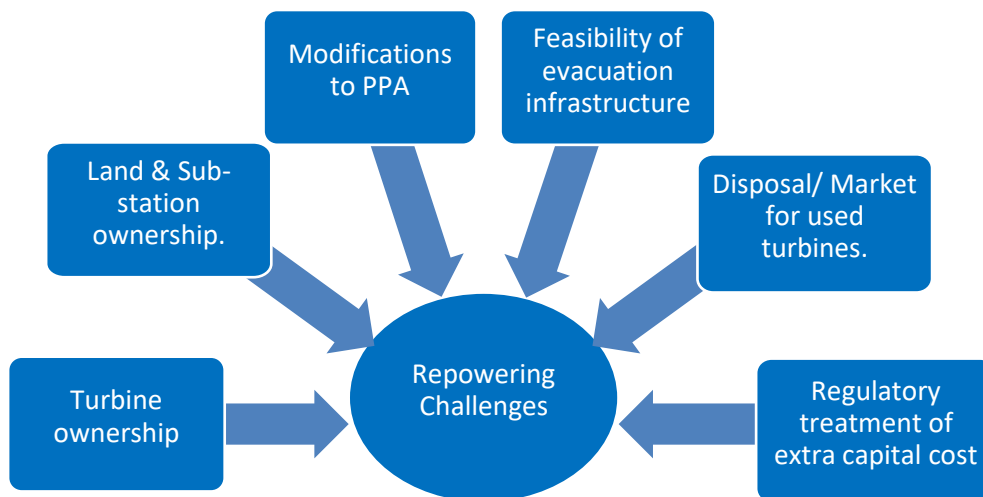


Figure 11: Repowering Challenges in India

Table 7 describes key issues and potential challenges for repowering in aggregation projects

Table 7: Repowering Challenges for the Indian Wind Sector

Issue	Key Challenges
<b>Ownership</b>	<ul style="list-style-type: none"> <li>Multiple owners of wind turbine farms.</li> <li>All parties/WTG owners may not be willing to choose repowering.</li> </ul>
<b>Evacuation</b>	<ul style="list-style-type: none"> <li>Most of the old wind projects are connected to the 11 kV line (particularly in TN), which poses a major hurdle for any repowering initiative.</li> </ul>
<b>Land and Substation ownership</b>	<ul style="list-style-type: none"> <li>Multiple wind farm ownership and substation ownership with developers/OEMs poses another challenge to repowering projects.</li> <li>Optimal micro-siting of a repowered site requires unhindered access and planning flexibility on the land site.</li> </ul>

Issue	Key Challenges
<b>Off-take arrangement</b>	<ul style="list-style-type: none"> <li>Retaining earlier off-take arrangements (DISCOM or captive sale) and identifying off-takers for excess generation.</li> </ul>
<b>Tariff &amp; incentives</b>	<ul style="list-style-type: none"> <li>Existing tariff is too low considering the PPAs are over 20 years old with no termination clause, making it unviable for repowering projects.</li> </ul>
<b>Utility</b>	<ul style="list-style-type: none"> <li>Utility companies are in a secure PPA with the developer benefitting from a much lower tariff, thus making them reluctant to early termination of PPAs to facilitate repowering.</li> </ul>
<b>Wind measurements</b>	<ul style="list-style-type: none"> <li>Non-availability of long-term wind resource measurements at 100+ meter hub heights in potential repowering sites.</li> </ul>

Conducive policy and regulatory measures are key to the successful implementation of repowering projects. It is essential to address state-specific policy and regulatory gaps arising from variations in regulatory frameworks across states. This study focuses on policy and regulatory gaps for repowering projects in two key states: Tamil Nadu and Maharashtra.

## Policy and regulatory gaps for repowering projects in Tamil Nadu (TN)

As per the draft policy findings, Tamil Nadu has the highest number of turbines that need to be repowered, thus it is of prime concern that the states tackle all the regulatory challenges to ensure repowering

### Absence of a dedicated state policy on wind repowering

A comprehensive state policy provides structure and guidelines for repowering activities, ensuring all stakeholders share a vision and cooperate.

### Power evacuation infrastructure augmentation

Upgrading power evacuation infrastructure is essential to accommodate the increased generation capacity of repowered turbines because most turbines currently have capacities below 2 MW. However, after repowering old turbines, power production is likely to increase, rendering the existing transmission lines insufficient and underscoring the need for an augmented power evacuation infrastructure.

### Feed-in-Tariff less than PPA Tariff

The current Feed-in Tariff (FIT) of ₹ 2.80 per unit in Tamil Nadu may be less attractive than the Power Purchase Agreement (PPA) tariff (or Open Access Tariff) that existed before 2009, which was around ₹ 2.75 or ₹ 2.90 per unit. This lower FIT discourages turbine owners from repowering their projects.

### Absence of a satisfactory incentive scheme

Unlike some countries, such as Denmark, which offered incentives like “Repowering Certificates” for phased repowering with increased tariffs, India lacks similar schemes. Such incentives make larger turbine installations financially viable. Implementing phase-wise repowering with attractive incentives could significantly benefit the state.

## **Some WTGs work efficiently even after completing design life (25 years)**

**The National Repowering & Life Extension Policy for Wind Power Projects – 2023** focuses on wind turbines that have completed their designated lifespan, typically 25 years, as defined by the Tamil Nadu Electricity Regulatory Commission (TNERC). However, some turbines remain functional even beyond this period. Owners of such operational turbines may be hesitant to repower due to the upfront costs involved.

- **Land availability**

Repowering projects often require different layout configurations, leading to additional land requirements. This can be a significant hurdle, especially if acquiring additional land for the repowered turbines and associated transmission infrastructure proves difficult.

## **Policy and Regulatory Gaps for Repowering Projects in Maharashtra (MH):**

Maharashtra has a vast repowering potential of 3431 MW, which is impeded by the following policy and regulatory gaps:

- **No proper allocation of stakeholders and tasks in the state policy**

The Maharashtra Unconventional Energy Generation policy 2020 mentions that “all existing non-conventional energy projects will be encouraged to increase their generating capacity. This can be achieved by either installing new equipment at the same source, increasing efficiency, or hybridizing it with other unconventional sources.” However, it is not stated which agency would be responsible for repowering.

Insufficient guidelines on repowering WTG capacity State policy generally states that projects will undergo capacity expansion until targets are met. However, there are no clear guidelines on whether old turbines can be replaced with new, higher-capacity ones. Many aging turbines produce significantly less power than they could if repowered.

- **Existing PPAs hinder owners from reaping the benefits of repowering**

The MH state policy states that a wind project with an existing PPA with DISCOM may undergo capacity expansion only after the PPA term expires. On the contrary, the National Repowering & Life Extension Policy for Wind Power Projects – 2023 allows existing PPAs to continue after repowering. The national policy also allows the sale of excess power to DISCOMs or third parties, as per WRPD regulations.

- **Extra capacity will not qualify for associated incentives.**

Under the state policy, the additional power generation after repowering may not receive the same incentives as the original capacity. This additional power would be subject to a separate regulatory or selling framework. Additionally, owners might not benefit from schemes such as the green tariff, which could limit their profit margins. Additionally, the policy restricts the sale of excess power generated after repowering to only

DISCOMs. There's no mention of selling to third parties or participating in competitive bidding for excess generation. Modifying existing PPAs to accommodate these changes could lead to longer implementation times.

## 5. WRPA Business Models

The Policy for Repowering of Wind Power Projects, 2023, by MNRE defines a well-structured framework for the Wind Repowering Project Aggregator (WRPA), outlining its role and responsibilities. To make stakeholders aware of the potential opportunities and risks associated with WRPA, it's crucial to explore robust business models.

The role of WRPA is critical for repowering projects under the Aggregation mode. Hence, it's imperative to discuss various options or models for the WRPA business. A well-structured WRPA business model is key to accelerating repowering under the aggregation model.

The WRPA business models discussed here aim to create a value proposition for aggregating old wind turbines, which is critical to repowering. Different business models help illustrate the roles of various stakeholders in the aggregation business. The basis for different WRPA business models is as follows:

- i. Implementation pathway,
- ii. Key driving entity,
- iii. Finance mechanism,
- iv. WRPA as a separate entity and WRPA & WRPD as the same entity, etc.

### 5.1. Brief Overview of Business Models

Under the current study, three (3) viable WRPA business models have been proposed as illustrated in Figure 12. The models differ in the mode of implementation. These models are built on the analysis that a WRPA entity can generate revenue from i) the handover of a cleared site, ii) the sale of scrap, and iii) government incentives, if any. Two of the business models (Model -1 and Model -2) are based on WRPA being a separate entity, and one of the business models (Model – 3) is based on WRPA and WRPD being the same entity. In the case of WRPA and WRPD being the same entity, a model has been developed to calculate the additional levelized cost for WRPA activities. WRPA costs will vary from project to project. Two case studies, one for Maharashtra and one for Tamil Nadu, have been developed based on Model-3.

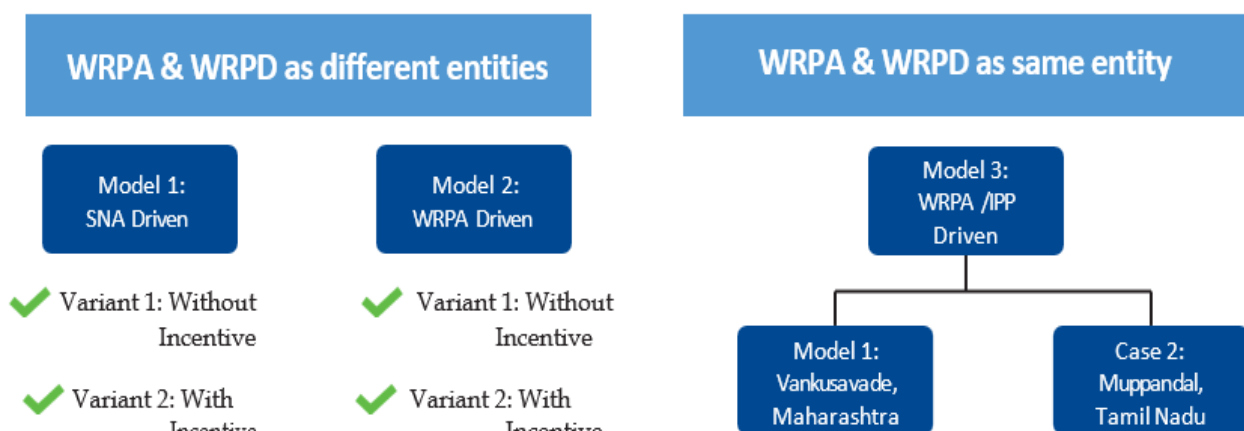


Figure 12: Different types of WRPA Business Model

The development criteria for Models 1 and 2 differ from those for Model 3. In the case of Model-1 & Model-2, the implementation criteria and the driving entity differ. It can be inferred that Model-1 is driven by SNA, Model-2 by WRPA, and Model-3 by WRPD. In these cases, the driving entity initially bears the financial burden of aggregation. Ultimately, the financial burden of aggregation gets transferred to WRPD. Figure 13 highlights the basis of the WRPA business model development.

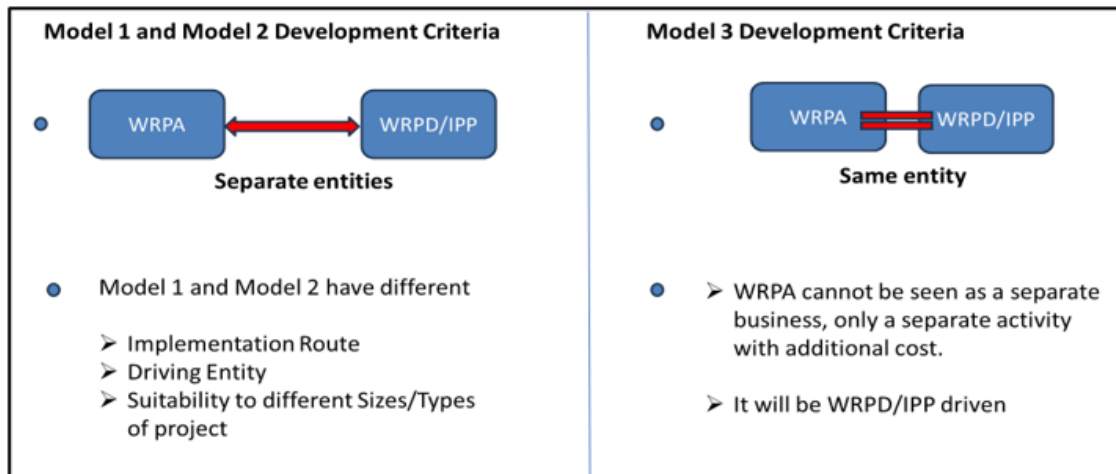


Figure 13: Basis of WRPA Business Model Development

### Business Model-1: SNA Driven

Business Model-1 is SNA-driven and built around SNA's selection of WRPA for aggregation at selected sites for repowering. In Business Model-1, the SNA invites bids to select WRPA for the identified sites (with possible capping of WRPA costs as per Model-1 estimates). The WRPA pre-qualification can be done as per the minimum qualification criteria notified by SNA, and WRPA can be selected through a competitive bidding process. SNA shall provide a consent letter, terms and conditions, and contract to the selected WRPA. Figure 14 describes WRPA Business Model 1.

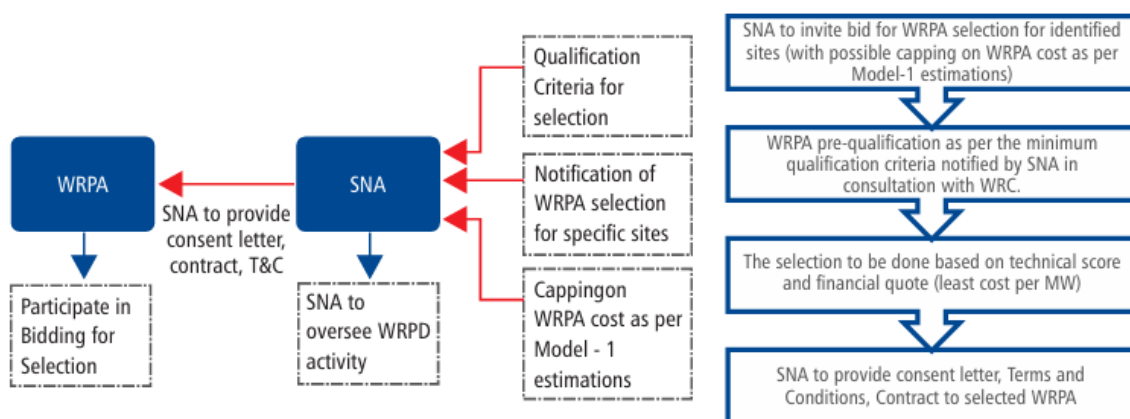


Figure 14: WRPA Business Model-1

### Advantages and Challenges for WRPA Business Model-1

The Model-1 for WRPA Business is SNA-driven. The SNA has the flexibility to choose the project's size and scale. Payment to the WRPA entity will be made by SNA as per the contract. The SNA can recover its

expenses from WRPD as a site allocation fee. The WRPA and WRPD activities can occur in parallel, as both entities shall be selected by SNA. The major challenge for Model-1 is that it requires state policy/regulation to empower SNA in selecting WRPA and WRPD. Table 8 illustrates the advantages and challenges of Model-1 for the WRPA business.

Table 8: Advantages and Challenges of Model-1 for WRPA Business

Advantages	Challenges
<ul style="list-style-type: none"> <li>• SNA has the flexibility to select the scale and size of the project.</li> <li>• WRPA cost is secured.</li> <li>• Payment to WRPA is guaranteed.</li> <li>• WRPA and WRPD activities can occur in parallel after the clearing of some sites.</li> <li>• SNA can select WRPD and recover the WRPA cost as a site allocation fee</li> </ul>	<ul style="list-style-type: none"> <li>• Requires state policy/regulation to empower SNA for selection of WRPA.</li> <li>• Payment guarantees burden falls upon SNA, which might limit the scale and size of projects undertaken.</li> <li>• May cause bureaucratic delays due to process centralization</li> </ul>

## Business Model-2: WRPA Driven

The Business Model-2 is WRPA-driven and built around WRPA's core capabilities in aggregation and repowering. In Business Model-2, WRPA will establish a designated site with the consent of at least 25% of asset owners. The WRPA pre-qualification can be done as per the minimum qualification criteria notified by SNA. The SNA shall provide the consent letter and Terms and Conditions to the WRPA. The WRPA can hand over the site to the WRPD of its choice, subject to the WRPD's quoted Site-handover fee. Figure 15 describes the WRPA Business Model-2.

## Advantages and Challenges for WRPA Business Model-2

The Model-2 for the WRPA business is WRPA-driven and requires minimal regulation. The WRPA has the flexibility to select the project's size and scale. Also, the WRPA will bear the aggregation cost upfront. It will generate revenue from scrap sales and site handover to WRPD. The major challenge for Model-2 is that it may lead to fragmented aggregation. Table 9 illustrates the advantages and challenges of Model-2 for the WRPA business.

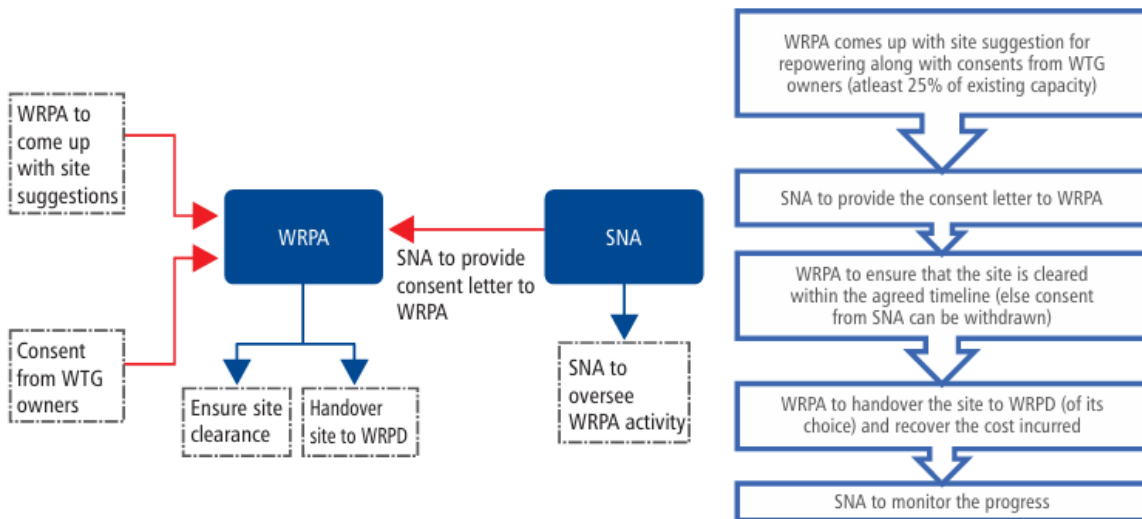


Figure 15: WRPA Business Model -2

Table 9: Advantages and Challenges of Model-2 For WRPA Business

Advantages	Challenges
<ul style="list-style-type: none"> <li>• It can be of any scale and size.</li> <li>• Minimal requirement of policy/guideline</li> <li>• Empower existing asset owners or groups of owners to form WRPA.</li> <li>• Facilitates faster adoption due to decentralized processes.</li> <li>• SNA to oversee the process of aggregation</li> </ul>	<ul style="list-style-type: none"> <li>• Financial burden is on WRPA.</li> <li>• May facilitate fragmented aggregation.</li> <li>• Additional land requirement needs may arise.</li> <li>• May lead to inflation in land price and hence an increase in WRPA cost</li> </ul>

### Business Model 3: WRPD Driven

Business model-3 is WRPD-driven because in this case WRPA and WRPD are the same entity. In business model 3, WRPD may establish a demarcated site with the consent of at least 25% of asset owners. The WRPA pre-qualification can be done as per the minimum qualification criteria notified by SNA. The SNA shall provide the WRPD with a consent letter and Terms and Conditions. In this case, the WRPD shall bear the cost of aggregation. Figure 16 describes the WRPA business model 3.

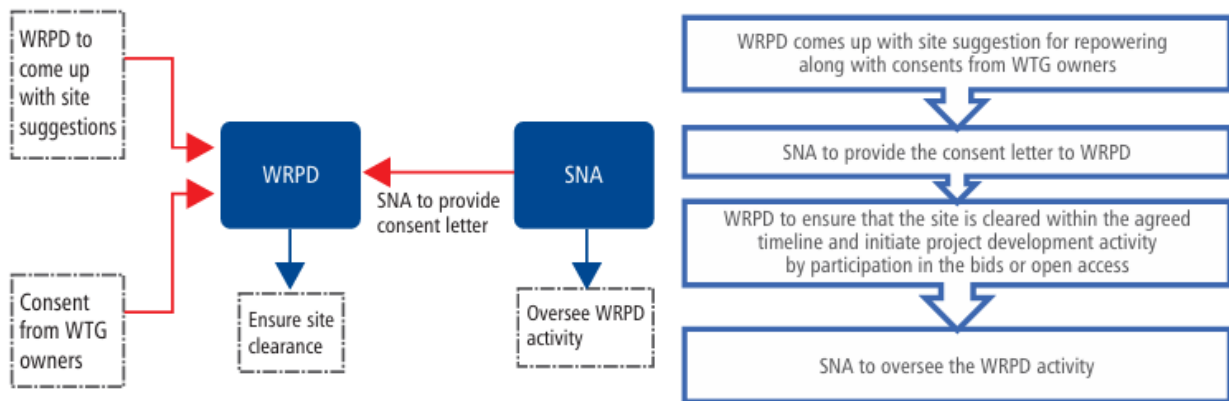


Figure 16: WRPA Business Model-3

### Advantages and Challenges for WRPA Business Model-3

The Model-3 for WRPA Business is WRPD-driven and requires minimal regulation. It is suitable for large-scale repowering projects. Also, project delays can be avoided because WRPA and WRPD are single entities. The major challenge for Model-3 is that it must compete with greenfield projects and will need additional incentives/ revenue as per Model-3 calculations. Table 10 illustrates the advantages and challenges of Model-3 for the WRPA business.

Table 10 : Advantages and Challenges of Model-3 for WRPA Business

Advantages	Challenges
<ul style="list-style-type: none"> <li>• Suitable for large-scale projects</li> <li>• Eliminates the need for upfront payment to WRPA.</li> <li>• Minimum Policy/Regulation needed.</li> <li>• It can avoid project delays as WRPA and WRPD are the same entity.</li> <li>• SNA to oversee the process of aggregation</li> </ul>	<ul style="list-style-type: none"> <li>• WRPD must compete with greenfield projects, which may be less viable without incentives or a price markup for repowered projects</li> <li>• Regulatory overnight WRPD activities to avoid the block of sites.</li> </ul>

### 5.2. Cost assumptions for the WRPA business model

The overall capital cost for the WRPA business depends on the year of operation for the wind turbine/project/site for which repowering is done, as per the Policy for Repowering of the Wind Power Projects<sup>20</sup>.

It must be noted that PPAs for wind power projects are generally signed for long periods (20/25 years) or renewed on a short-term basis (1 or 2 years). In such cases, existing owners who choose to repower may lose future revenue from their projects. Such potential financial loss needs to be compensated by WRPA.

<sup>20</sup> Policy for Repowering of the Wind Power Projects | Ministry of New and Renewable Energy | India (mnre.gov.in)

In addition, WRPA would incur costs for decommissioning and disposal of the old Wind assets. The said cost may be partially offset by income from the sale of scrap material.

Accordingly, the following equations may be considered for 'Repowering Site Preparation Cost (RSPC).

**RSPC = Terminal Valuation + Decommissioning Cost – Income from sale of scrap material**

Where:

**Terminal Valuation = PPA Value + PPA Termination Incentive**

"PPA value" can be estimated as an amount equal to the Net Present Value (NPV) of net revenue from the anticipated generation in the remaining years (as per PPA).

$$\text{PPA value} = \text{NPV of } \sum_{\kappa=0}^n [(t * G\kappa) - (OM\kappa)]$$

Where,

**t = Tariff** as per PPA in case of sale to DISCOM or third party. In case of captive consumption, the tariff as per the tariff order(s) of the appropriate commission for the year of the project's commission may be considered. In the absence of both the PPA and the tariff order, a nominal tariff, such as the state's concerned APPC, may be considered for the project.

**G= Average annual generation**, which may be calculated using the energy delivered at the delivery point (as defined in the PPA) or the PSS level data for the last 3 years.

**OM= Annual O&M** cost may be considered as per SERC/CERC tariff orders. In case of absence of the appropriate SERC/CERC tariff orders, O&M expenses for the first year of the control period shall be 2% of the wind turbine's original capital cost (CAPEX) and shall be escalated at the rate of 5% per annum over the tariff period.

**n** = No of remaining years for completion of PPA  $\kappa = 1, 2, 3, \dots, n$

PPA Termination Incentive = 5% of PPA Value

PPA Termination Incentive means the incentive provided to the asset owner more than the PPA value. The incentive will be up to 5% of the PPA Value. Decommissioning costs would include dismantling Wind turbines, site clearance, and disposal of blades.

**Decommissioning cost = DS + SC + DB**

Wherein.

**DS** = Cost incurred for dismantling wind turbine **SC** = Cost incurred for clearing the site

**DB** = Cost incurred for disposal of blades.

Income from the sale of scrap material may be considered based on SERC/CERC tariff orders. In case of the absence of an appropriate order, the income shall be assumed to be 10% of the capital cost.

Apart from the above cost items, WRPA shall incur additional costs for conducting a study to prepare the DPR, purchasing or leasing additional land, and handling paperwork for the owner's consent. All the cost components are listed in Table 11.

Table 11: Cost Components of WRPA Business

Cost Components	
Owner's consent + Paperwork	Included
Land Lease Cost (May vary as per state)	Included
Additional Land Area	Optional
Study Cost (Preparation of DPR)	Included
Asset Acquisition Cost	Included
Decommissioning Cost	Included

## WRPA Cost Calculation Methodology

In the context of WRPA business models, the Internal Rate of Return (IRR) varies across Models 1, 2, and 3. In Model-1, the IRR is fixed at 16%, and financial viability is assessed by the revenue gap between total WRPA costs and the earnings from scrap sales, plus the additional revenue required to achieve the fixed IRR. The NPV and IRR for different years of operation per MW are calculated using the Discounted Cash Flow (DCF) method, providing insights into the economic feasibility of Model-1. For Model-2, the IRR varies with cash flows over three years, and the NPV and IRR are calculated using the discounted cash flow method. The results indicate that the IRR increases with the number of years of operation for repowering turbines, and the model is deemed viable even without government incentives. In Model-3, the IRR is calculated based on the levelized cost of WRPA activities over the entire 25-year repowered project. The results of the economic viability analysis for different turbine operating years indicate varying IRR percentages, with the model designed to ensure the sustainability of the WRPA business.

The cost calculations have been done based on the indicative valuation model provided in the **Policy for Repowering of the Wind Power Projects, 2023**<sup>21,22</sup>. The asset acquisition cost, decommissioning cost, and total WRPA capital cost have been calculated and presented in Table 12 for different years of operation for the wind turbine/project/site undergoing repowering.

Table 12: WRPA cost per MW for different years of WTG Operation considered for Repowering

Remaining PPA/OA Years	10	9	8	7	6	5	4	3	2	1	
Yr. of Operation from COD	16	17	18	19	20	21	22	23	24	25	After 25 Yrs.
Asset Acquisition cost	87.39	78.58	69.93	61.5	53.36	45.61	38.33	31.64	25.66	20.53	16.4

<sup>21</sup> Policy for Repowering of the Wind Power Projects | Ministry of New and Renewable Energy | India (mnre.gov.in)

<sup>22</sup> Model, Costs, and calculations are indicative only and may not be considered as a benchmark.

Remaining PPA/OA Years	10	9	8	7	6	5	4	3	2	1	
(₹ Lakh/MW) <sup>23</sup>											
Decommissioning cost (₹Lakh/MW)	25	25	25	25	25	25	25	25	25	25	25
Additional Land (₹Lakh/MW)	1										
DPR cost (₹Lakh/MW)	1										
Owner's consent + Paperwork(₹Lakh/MW)	1										
Total WRPA cost (₹Lakh/MW)	115.39	106.58	97.93	89.5	81.36	73.61	66.33	59.64	53.66	48.53	44.4

### 5.3. Key Features of WRPA Business Models

As discussed earlier, 3 different WRPA business models have been developed and have been found to be suitable for WRPA business. These have been discussed below.

#### Key features of WRPA Business Model-1

Model-1 is SNA-driven. In this model, WRPA may act as a separate entity and shall be selected by the SNA or CNA through a transparent process, with the SNA monitoring the aggregation work under a contract. A period of three years has been taken for the aggregation process. The following are the data input and assumptions for model 1 as given in Table 13

Table 13: Data Input & Assumptions for WRPA Business Model-1

WRPA Capital Expenditure (Total WRPA COST)	Varies with different years of operation as provided in Table 8
Period (Years)	03
Term Loan Interest Rate (%)	10
Discount Rate (%)	10
ROE (%)	20
Debt: Equity	70:30
Scrap value per MW (₹ Lakh)	50
Gap after the sale of scrap	Revenue gap for 16% IRR in 3 years, after the sale of scrap.

<sup>23</sup> Annexure of Policy for Repowering of the Wind Power Projects 2023.

Model-1 is a simple model in which SNA shall select WRPA through competitive bidding, as per the calculations provided in Model-1. The WRPA will generate its revenue through the handover of cleared sites and the sale of scrap. The following are the salient features of Model-1 as illustrated in Figure 17.





-  Under Model-1 After WRPA is selected, WRPA will incur cost for acquiring wind assets and other tasks for aggregation.
-  Time period for repowering has been assumed to be 3 years. WRPD activity can be started in parallel based on WRPA work plan.
-  The site once cleared by WRPA will be handed over to SNA.
-  Model-1 has two revenue streams  
1. Sale of Scrap and 2. Hand over of site

Figure 17: Salient Features of WRPA Business Model-1

### Process Flow of WRPA Business Model-1 for 1 MW

The process flow of Model-1 captures the flow of cost components for WRPA, and the flow of revenue for any operation years in which repowering is done. It can be with or without government incentives, as illustrated in Figures 18 and 19. The SNA can recover the site handover cost from WRPD while allocating the site to WRPD.

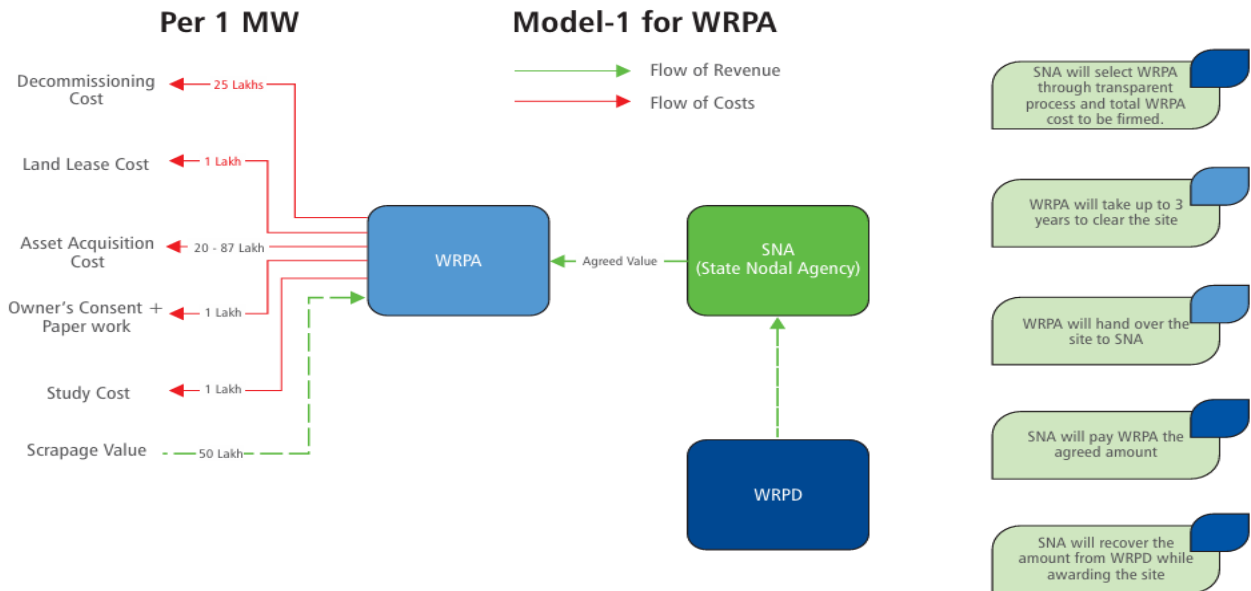


Figure 18: Process flow for Model 1 (without Govt. Incentive)

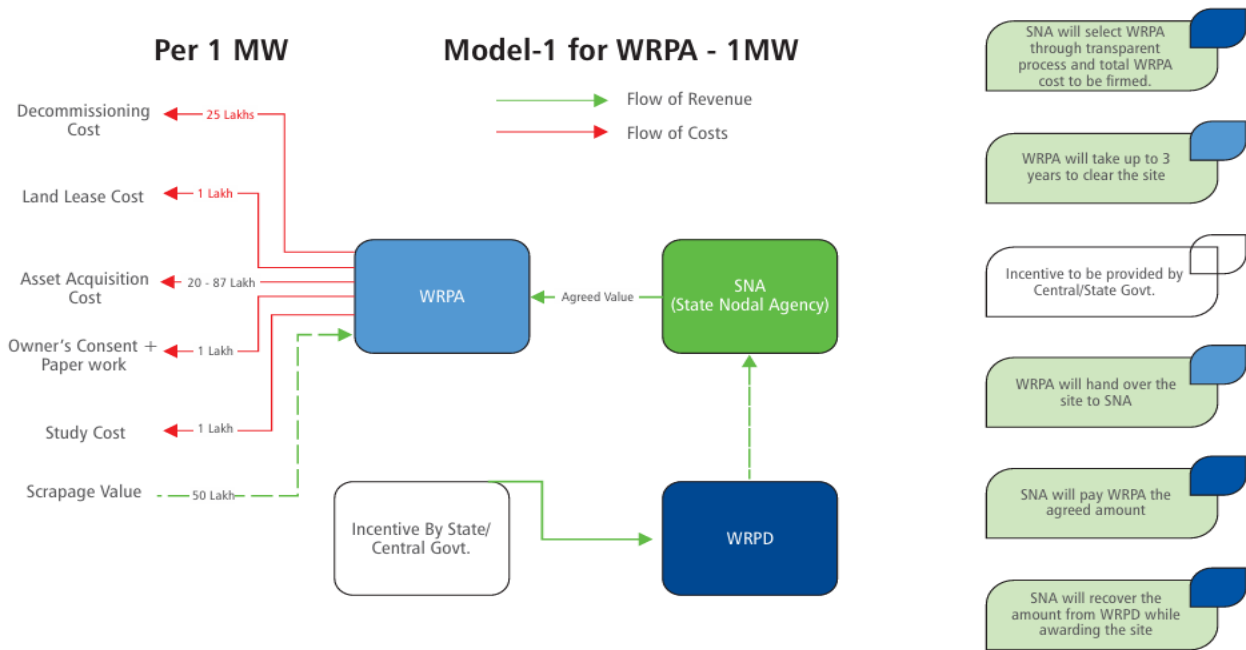


Figure 19: Process flow for WRPA Business Model-1 (with Govt. Incentive)

### Model – 1 Calculation

The Model-1 of the WRPA business model calculates the revenue gap between total WRPA costs (spending on Aggregation activities over 3 years) and the earnings from the sale of scrap, with an IRR of 16% for the WRPA entity. This revenue gap shall act as the capping for SNA to calculate the total gap amount for a site and accordingly invite bids from WRPA entities. The qualified WRPA entities with the lowest bid shall be selected for aggregation under Model-1. The steps shown in Figure 20 were used to calculate the revenue gap for any year of WTG operation.

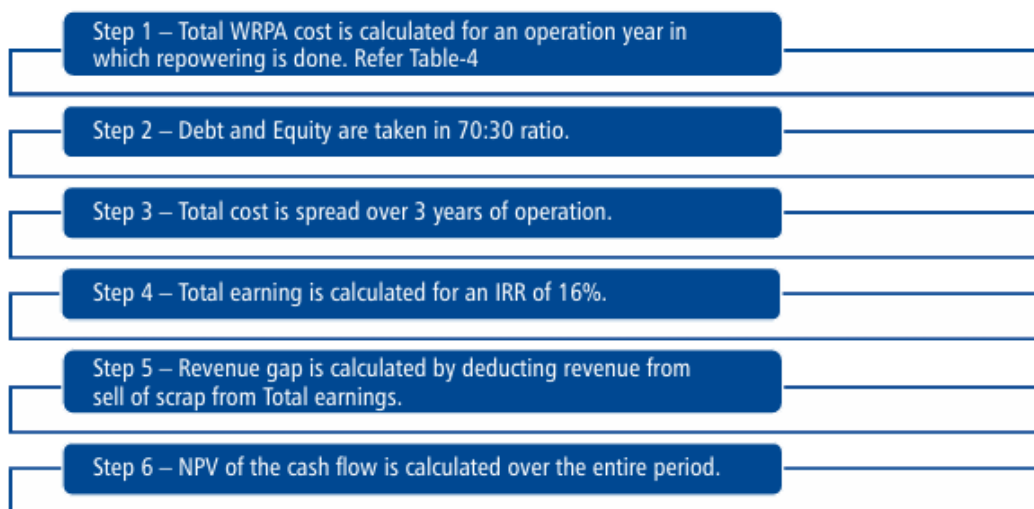


Figure 20: Model-1 Calculation

The calculation sheet for a particular WTG operation year (in this case, 21 years) in which repowering is done is given in Table 14.

Table 14: WRPA Model-1 Calculation Sheet (without Incentive)

For 3-year period (21st Year of WTG Operation) 1MW			
WRPA Business Model -1	1	2	3
WRPA Cost (₹ Lakhs)	73.61	0.00	0.00
Debt (₹ Lakhs)	51.53	0.00	0.00
Equity (₹ Lakhs)	22.08	0.00	0.00
Principal Amt (₹ Lakhs)	17.18	17.18	17.18
DEBT Outstanding (₹ Lakhs)	51.53	34.35	17.18
Interest Rate (%)	10		
Interest Amt (₹ Lakhs)	5.15	3.44	1.72
To Bank (₹ Lakhs)	22.33	20.61	18.89
ROE (%)	20		
Return On Equity	4.42	4.42	4.42
Cost (₹ Lakh)	48.83	25.03	23.31
NPV of Cost (₹ Lakh)	82.59		
Discount Rate (%)	10		
Revenue			
Sale of Scrap (₹ Lakhs)	0.00	0.00	50.00
Cash flow for 16% IRR (₹ Lakhs)	-48.83	-25.03	95.00
<b>Gap (₹Lakh/MW)</b>		<b>68.31</b>	
<b>NVP of cashflow (₹ lakhs)</b>	<b>6.30</b>		
IRR (%)	16		

The proposed Model-1 for the WRPA business requires no incentives. However, it is an additional cost for WRPD to acquire such sight. Thus, WRPD shall require additional revenue/incentive to compete with other greenfield projects. In the case of repowering projects, it is also necessary to keep in mind that the additional power generated after repowering is not guaranteed offtake under a PPA.

### Key features of WRPA Business Model-2

The Model-2 is WRPA-driven. In this model, WRPA will act as a separate entity and identify the selected site, with consent from at least 25% of the asset owners. SNA will monitor the aggregation work. A period of three years has been taken for the aggregation process. In Model-2, instead of handing over the site to SNA, WRPA

will hand it over directly to WRPD, which was selected for having the highest quoted site acquisition fee. The SNA will monitor the handover of the site in accordance with the contract T&Cs.

The WRPA input cost and assumptions are the same as given in Table 15. The following are the data input and assumptions for Model 2.

Table 15: Data Input & Assumptions for WRPA Business Model-2

WRPA Capital expenditure (Total WRPA COST)	Varies with different years of operation as provided in Table 8
Period (Years)	03
Term Loan Interest Rate (%)	10
Discount Rate (%)	10
ROE (%)	20
Debt: Equity	70:30
Scrap value (₹Lakh/MW)	50
Site handover value	NPV of total WRPA cost

As illustrated in Figure 21, the following are the salient features of Model-2.





-  Under Model-2 WRPA selects site. SNA gives consent. WRPA will incur cost for acquiring wind assets and other tasks for aggregation.
-  WRPD to be chosen by WRPA based on quoted site acquisition fee by WRPD.
-  The site once cleared by WRPA can be handed over to WRPD. WRPA & WRPD activity can go in parallel
-  Model-2 has two revenue streams. 1. Sale of Scrap and 2. Hand over of site to WRPD

Figure 21: Salient Features of WRPA Business Model-2

## Process Flow of WRPA Business Model-2 for 1 MW

The Process flow of Model-2 captures the flow of cost components for WRPA and the flow of revenue for any operation years in which repowering is done. It can be with or without government incentives, as shown in Figures 22 and 23. WRPA will recover the aggregation cost from WRPD while allocating the site to WRPD.

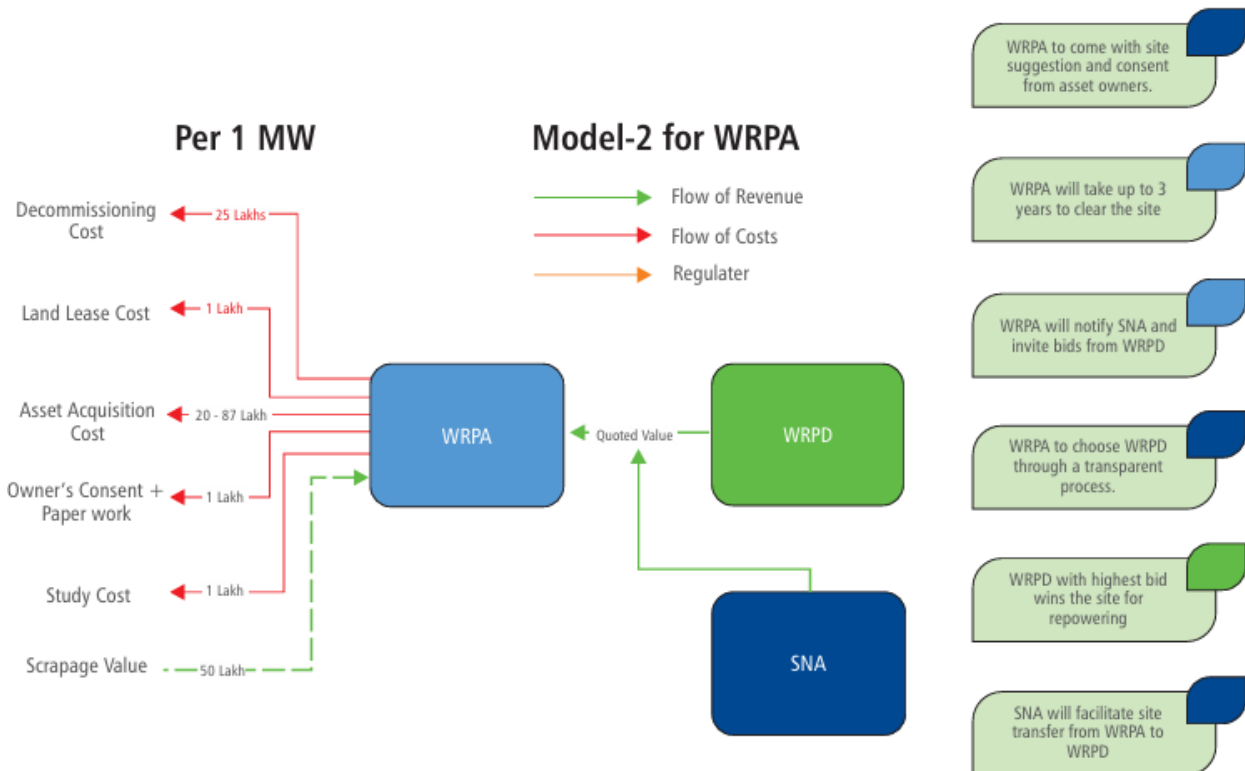


Figure 22: Process Flow for WRPA Business Model-2 (without govt incentive)

Under Model-2, the WRPA business is lucrative and has the potential to generate decent returns. The WRPA entity might not need any government incentive under Model-2, but the WRPD, due to additional site acquisition costs, will need a generation-based incentive (GBI) to compete with other greenfield projects.

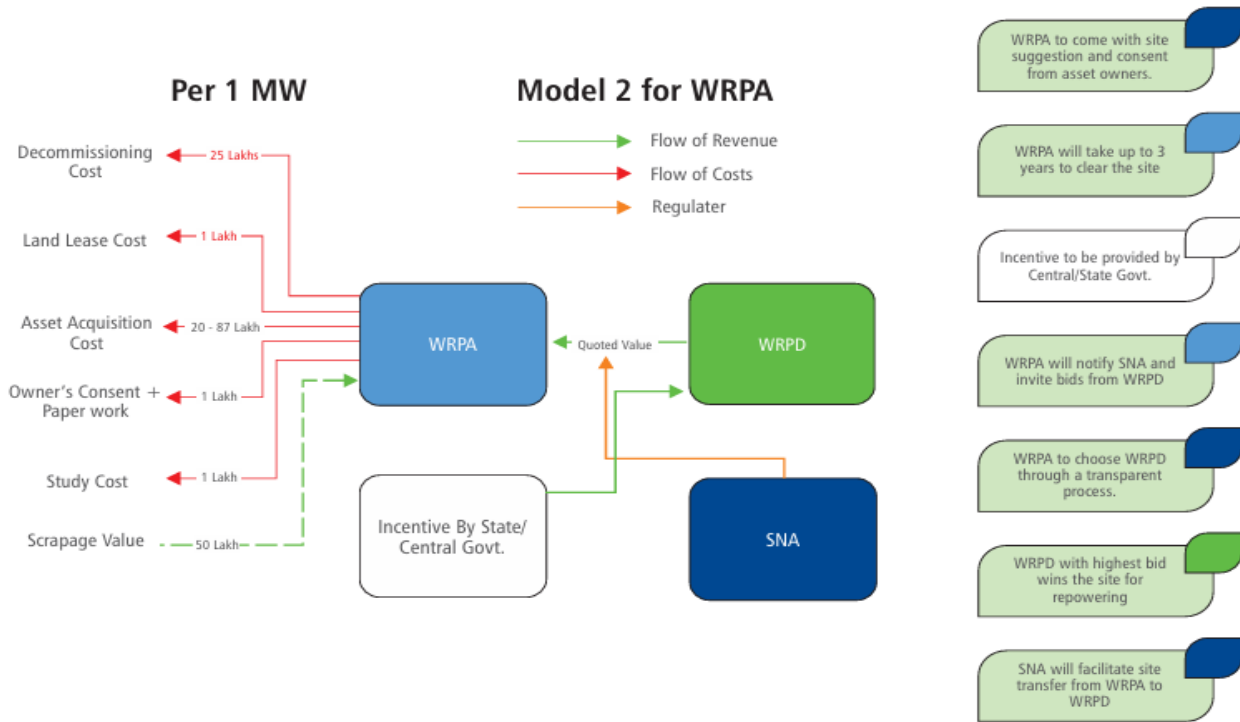


Figure 23: Process flow for WRPA Business Model-2 (with govt. incentive)

## Model-2 Calculation

WRPA drives the proposed Model-2 of the WRPA business model. The WRPA incurs the cost of aggregation upfront and prepares the site for the WRPD of its choice. It earns revenue by handing over the site to WRPD. The revenue for the site handover can be calculated as the NPV of all costs. The other source of revenue is from the sale of scrap. Thus, Model 2 has higher revenue and earning potential than Model 1. For Model 2, the NPV and IRR calculations for 3 years of cash flows are presented. The following steps, as shown in Figure 24, were used to calculate the NPV and IRR for any year of WTG operation.

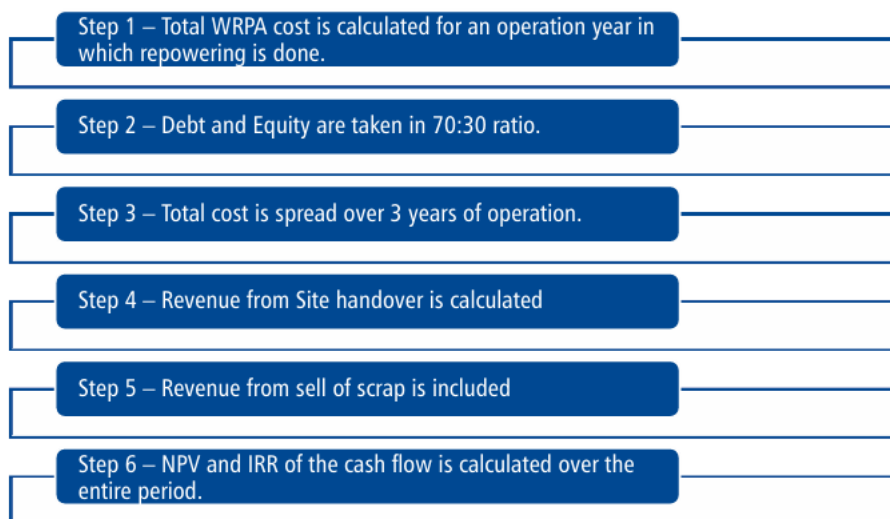


Figure 24: Model-2 Calculation

The calculation sheet for a particular WTG operation year (in this case, 21 years) in which repowering is done is given in Table 16.

Table 16: WRPA Model-2 Calculation Sheet

For 3-year period (21st Year of WTG Operation) 1MW			
WRPA Business Model -1	1	2	3
WRPA Cost (₹ Lakhs)	73.61	0.00	0.00
Debt (₹Lakhs)	51.53	0.00	0.00
Equity (₹Lakhs)	22.08	0.00	0.00
Principal Amt (₹Lakhs)	17.18	17.18	17.18
DEBT Outstanding (₹Lakhs)	51.53	34.35	17.18
Interest Rate (%)	10		
Interest Amt (₹Lakhs)	5.15	3.44	1.72
To Bank (₹Lakhs)	22.33	20.61	18.89
ROE (%)	20		
Return On Equity	4.42	4.42	4.42
Cost (₹Lakh)	48.83	25.03	23.31
NPV of Cost (₹Lakh)	82.59		
Discount Rate (%)	10		
Revenue			
Sale of Scrap (₹Lakhs)	0.00	0.00	50.00
Cash flow for 16% IRR (₹Lakhs)	-48.83	-25.03	95.00
<b>Gap (₹Lakh/MW)</b>		<b>68.31</b>	
<b>NPV of cash flow (₹Lakhs)</b>	<b>6.30</b>		
IRR (%)	16		

The WRPA cash flow for 3 years for the above WTG (21st Year of WTG Operation) of 1 MW under Model-2 is given in Figure 25.

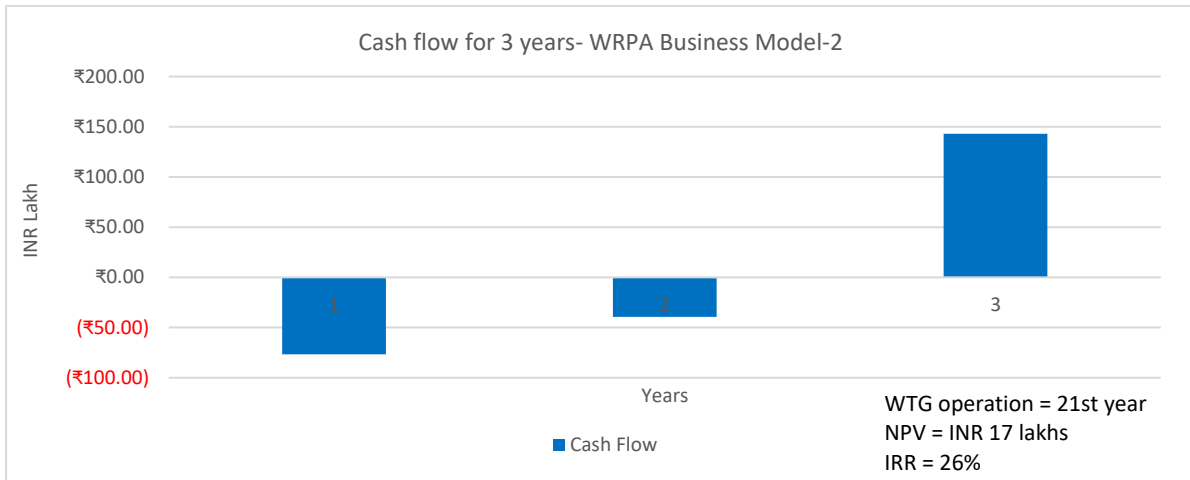


Figure 25: Cash flow for WRPA business model-2 per MW (21st year of WTG Operation)

### Difference between WRPA Business Model-1 & Model-2

Model-1 and Model-2 differ in their implementation. Model-1 is an SNA-driven process, while Model-2 is a WRPA-driven process monitored by SNA—the basic difference between Model-1 and Model-2 is given in Figure 17.

Table 17: Process flow for WRPA Business Model-2 (With Govt. Incentive)

Model-1	Model-2
<ul style="list-style-type: none"> <li>SNA has the primary responsibility to compensate WRPA as per the agreement between them.</li> <li>SNA will come up with sites and select WRPA based on competitive bidding</li> <li>Suitable for low to medium capacity sites driven by SNA</li> </ul>	<ul style="list-style-type: none"> <li>WRPD has the primary responsibility to compensate WRPA as per the quoted fee.</li> <li>WRPA will come up with site suggestions Suitable for any capacity sites, driven by WRPA</li> </ul>

### Key features of WRPA Business Model-3

In Model-3, the WRPA and WRPD are considered a single entity and can be selected by either SNA or CNA through a transparent process, or the WRPA/WRPD can propose a site with the consent of at least 25% of the asset owners. SNA will monitor the aggregation work. Three years have been assumed for the aggregation process under Model-3. Since it's a WRPD-driven model, WRPA activity has been treated as an additional cost in the overall repowering business. Thus, it's necessary to understand the impact of the WRPA cost. In Model-3, the levelized WRPA cost over the entire 25-year repowered project period has been calculated and presented.

## Difference between WRPA Business Model-1 & 2 and Model-3

The Model-1 and Model-2 WRPA and WRPD are different entities, whereas in Model-3, WRPA and WRPD are the same entity. Models 1 and 2 are designed to explore business cases for WRPA as a separate entity. The Model-3 is designed to calculate the levelized total WRPA cost for the repowering project. The basic difference between Model-1 and 2 and Model-3 are given below.

Table 18: A comparison of different WRPA Business Models

Model-1 and Model-2 are developed based on the following criteria:	Model-3 is based on the following criteria:
<ul style="list-style-type: none"> <li>• WRPA &amp; WRPD are different entities</li> <li>• Model 1 and Model 2 have different               <ul style="list-style-type: none"> <li>– Implementation Route</li> <li>– Driving Entity</li> <li>– Suitability for different Sizes/Types of projects</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• WRPA &amp; WRPD are the same entity.               <ul style="list-style-type: none"> <li>– WRPA cannot be seen as a separate business, only a separate activity with additional cost.</li> <li>– It will be WRPD driven</li> </ul> </li> </ul>

A summary of differences for all the 3 models, i.e., Model 1, Model 2, and Model 3, is shown in Table 19:

Table 19: Differences in Model 1, 2, and 3

Aspect	Model-1	Model-2	Model-3
Driving Entity	SNA	WRPA	WRPD
Selection Process	SNA or CNA through transparent process	WRPA comes up with selected site and consent	SNA or CNA through transparent process or WRPA/WRPD comes up with selected site and consent
Aggregation Work Monitoring	SNA through a contract	SNA	SNA
Ownership Consent	0%	25 % number of owners	25 % number of owners
Entity Relationship	WRPA and WRPD act as a separate entity	WRPA and WRPD acts as a separate entity	WRPA and WRPD are considered as one entity
Financial Burden of Aggregation	Initially borne by driving entity, transferred to WRPD	Initially borne by WRPA, transferred to WRPD	Borne by WRPD
Period for Aggregation Process	3 years	3 years	3 years

Aspect	Model-1	Model-2	Model-3
Revenue Streams	Revenue from handover of cleared site and sale of scrap	Sale of scrap and handover of site to WRPD	Revenue from handover of cleared site and sale of scrap
Additional Cost for WRPD	–	Requires generation-based incentive to compete with greenfield projects	Requires generation-based incentive to compete with greenfield projects
Advantages and Challenges	Suitable for different type/size of project.	<ul style="list-style-type: none"> <li>• Suitable for different type/size of project.</li> <li>• Facilitates faster adoption, may lead to inflation in land price, SNA oversight</li> </ul>	Suitable for large-scale repowering projects, may need generation-based incentive, avoids project delays
Challenges	Requires State policy/Regulation to empower SNA for selection of WRPA and WRPD. Payment guarantee burden falls upon SNA which might limit the scale and size of projects undertaken	Additional land requirement need may arise.	Must compete with greenfield projects and shall need generation-based incentive
Risk	High for Government	High for WRPA & WRPD	Low for all stakeholders

Under the Model –3, two case studies have been developed. Case 1 is from the Vankusawade site in Maharashtra, and Case 2 is from Muppandal, Tamil Nadu. In Model-3, calculating the total WRPA cost is very important, as there may be wind turbines with different capacities and years of operation. The other important aspect is determining repowered capacity based on micro-siting results and AEP based on simulated CUF. Calculations and results for both case studies are discussed below.

### Case-1 (Vankusawade, Maharashtra)

The following is the current distribution of wind turbines at the Vankusawade site, as shown in Table 20.

Table 20: Distribution of Wind turbines at the Vankusawade site

Vankusawade - Repowering (Sale to Utility + OA)								
Number of Turbines and no of remaining years of PPA								
Turbine capacity (kW)	6 years of PPA	5 years of PPA	4 years of PPA	3 years of PPA	2 years of PPA	1 year of PPA	Total Turbines	Total Capacity (MW)
230	0	0	0	0	2	5	7	1.61

Vankusawade - Repowering (Sale to Utility + OA)								
350	50	20	0	23	138	202	433	151.55
500	0	0	0	0	0	0	0	0
600	0	0	0	0	0	6	6	3.6
750	0	0	0	0	0	0	0	0
800	0	0	0	0	0	0	0	0
1000	0	0	0	0	0	2	2	2
<b>Total</b>	<b>50</b>	<b>20</b>	<b>0</b>	<b>23</b>	<b>140</b>	<b>215</b>	<b>448</b>	<b>158.76</b>

The total WRPA cost for the above distribution has been calculated as per the evaluation model. Table 21 shows the total WRPA cost calculation for the Vankusawade site.

Table 21: Total WRPA cost calculation for the Vankusawade site

Total WRPA cost calculation for the Vankusawade Site										
Remaining PPA/OA Years	10	9	8	7	6	5	4	3	2	1
Year of Operation from COD	16	17	18	19	20	21	22	23	24	25
Capacity to be powered (MW)					17.5	7	0	8.05	48.76	77.45
WRPA cost per MW (₹ Lakhs)	115.3 9	106.5 8	97.9 3	89.5	81.36	73.61	66.33	59.64	53.66	48.53
WRPA Cost (₹ Lakhs)					1423. 8	515.2 7	0	480.1 0	2616. 46	3758.65
Total Site WRPA Cost (₹ Lakhs)										<b>8794.28</b>

## Case – 1 Calculation Sheet

The following steps were used to calculate the LCOE of the WRPA cost for Case-1 under Model-3.

Step 1 – The total WRPA cost was calculated for the entire site. Step 2 – Debt and Equity are taken in a 70:30 ratio.

Step 3 – Total cost and generation are calculated for 25 years of operation.

Step 4 – All financial parameters were considered in accordance with MERC or CERC guidelines.

Step 5 – The levelized cost of WRPA was calculated.

## Case-2 (Muppandal, Tamil Nadu)

The following is the current distribution of wind turbines with  $\leq 1000$  kW capacity at the Muppandal site<sup>24</sup>, as shown in Table 22.

Table 22: Distribution of Wind turbines at the Muppandal site

Sr.	Turbine Capacity (kW)	No. of Turbines	Total Installed Capacity (MW)
1	300	6	1.8
2	320	6	1.92
3	350	54	18.9
4	400	23	9.2
5	410	147	60.27
6	500	213	106.5
7	600	210	126
8	750	124	93
9	800	3	2.4
10	950	3	2.85
11	1000	12	12

The total WRPA cost for the above distribution has been calculated as per the evaluation model described in the cost calculation section, as illustrated in Table 23.

Table 23: Total WRPA cost calculation for the Muppandal site

Total WRPA cost calculation for the Muppandal Site										
Remaining PPA/OA Years	10	9	8	7	6	5	4	3	2	1
Year of Operation from COD	16	17	18	19	20	21	22	23	24	25
Capacity to be powered (MW)					0	0	0	0	0	804.9
WRPA cost per MW (₹ Lakhs)	115.3	106.5	97.9	89.5	81.36	73.61	66.33	59.64	53.66	48.53
	9	8	3							

<sup>24</sup> Muppandal Repowering study report by NIWE

Total WRPA cost calculation for the Muppandal Site										
Total WRPA Cost (₹Lakhs)					0	0	0	0	0	39061.8
Total Site WRPA Cost (₹Lakhs)										<b>39061.8</b>

#### Case – 2 Calculation Sheet

The following steps were used to calculate the LCOE of the WRPA cost for Case-2 under Model-3: Step 1 – Total WRPA cost was calculated for the entire site.

Step 2 – Debt and Equity are taken in a 70:30 ratio.

Step 3 – Total cost and generation are calculated for 25 years of operation. Step 4 – All financial parameters were considered in accordance with CERC guidelines. Step 5 – The levelized cost of WRPA was calculated.

## 6. Financial Viability and Risk Analysis of Proposed Business Models

The financial viability of the WRPA business models discussed depends on the cash flow they generate, the net present value (NPV), and the internal rate of return (IRR). The Discounted Cash Flow (DCF) method was used to calculate the NPV for the WRPA business model-1 for an operational year in which repowering with a fixed IRR of 16% was considered. For Model 2, NPV and IRR were calculated based on cash flows over 3 years. For Model 3, the levelized cost of WRPA activities has been calculated for the cases discussed.

### 6.1. Financial Viability of Model-1

In Model-1, the revenue gap is calculated as the difference between total WRPA costs (spending on Aggregation activities over 3 years) and the earnings from the sale of scrap, plus additional revenue, to achieve an IRR of 16% for the WRPA entity. **This gap forms the basis for the SNA's selection of WRPA.** The calculation of this revenue gap using Model-1 enables SNA to determine how much additional revenue, beyond revenue from scrap sales, is required for the WRPA to achieve an IRR of 16%. The total WRPA cost, revenue gap, NPV, and IRR for different years of operation per MW are presented in Table 24 and Figure 26.

Table 24: Economic Viability of Model-1

Turbine Operation Year (FY)	Total WRPA Cost (₹Lakh/MW)	Gap after Sale of Scrap (₹Lakh/MW)	NPV (₹Lakh/MW)	IRR (%)
16	115.39	135.54	9.94	16
17	106.58	121.75	9.46	16
18	97.93	107.1	8.09	16
19	89.5	93.34	7.28	16
20	81.36	80.76	6.96	16
21	73.61	68.31	6.3	16
22	66.33	56	5.22	16
23	59.64	45.89	5.13	16
24	53.66	35.99	4.4	16
25	48.53	27.87	4.06	16

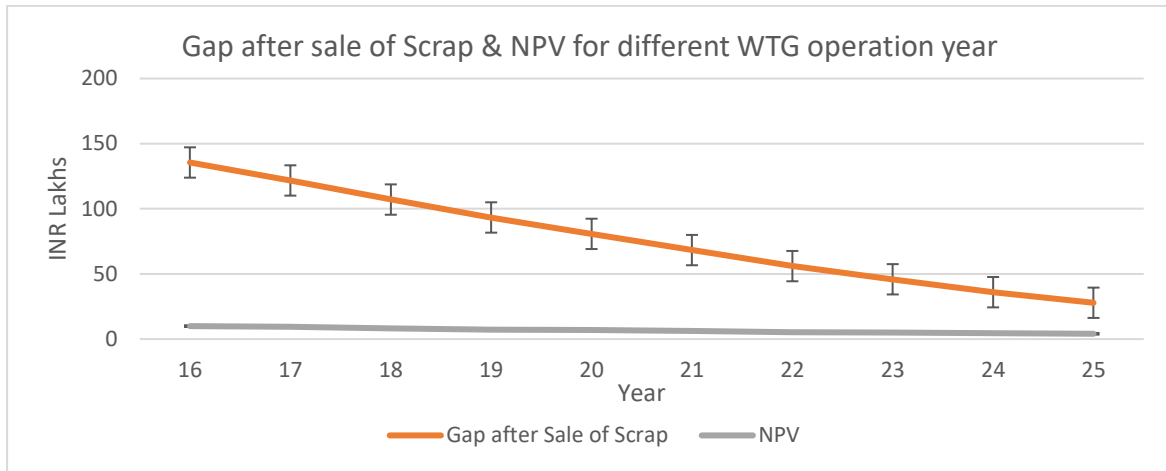


Figure 26: Revenue Gap and NPV under model-1 per MW for different years of WTG operation

## 6.2. Financial Viability of Model-2

In Model 2, cash flow was calculated from input costs and revenue generated each year. The NPV and IRR were then calculated using the discounted cash flow method. The NPV in these models is positive, indicating the viability of these business models. The IRR and NPV for different years of WTG operation are presented in Table 25.

Table 25: Economic viability of Model-2

Turbine Operation Year (FY)	Total WRPA Cost (₹Lakh/MW)	NPV (₹Lakh/MW)	IRR (%)
16	115.39	5.37	13
17	106.58	7.83	15
18	97.93	10.24	18
19	89.5	12.59	20
20	81.36	14.87	23
21	73.61	17.03	26
22	66.33	19.06	30
23	59.64	20.93	34
24	53.66	22.59	38
25	48.53	24.03	43

The results of the economic viability analysis for different years of WTG operation are shown in Figure 27. The scrappage value, which is considered revenue, is set at ₹50 lakh/MW<sup>25</sup> for any turbine operation year. The scrappage value is critical to the overall cash flow. It is important to understand that the presented models are designed to sustain the WRPA business. The following is a comparison of the WRPA cost and NPV for different years of WTG operation under Model-2 of the WRPA business.

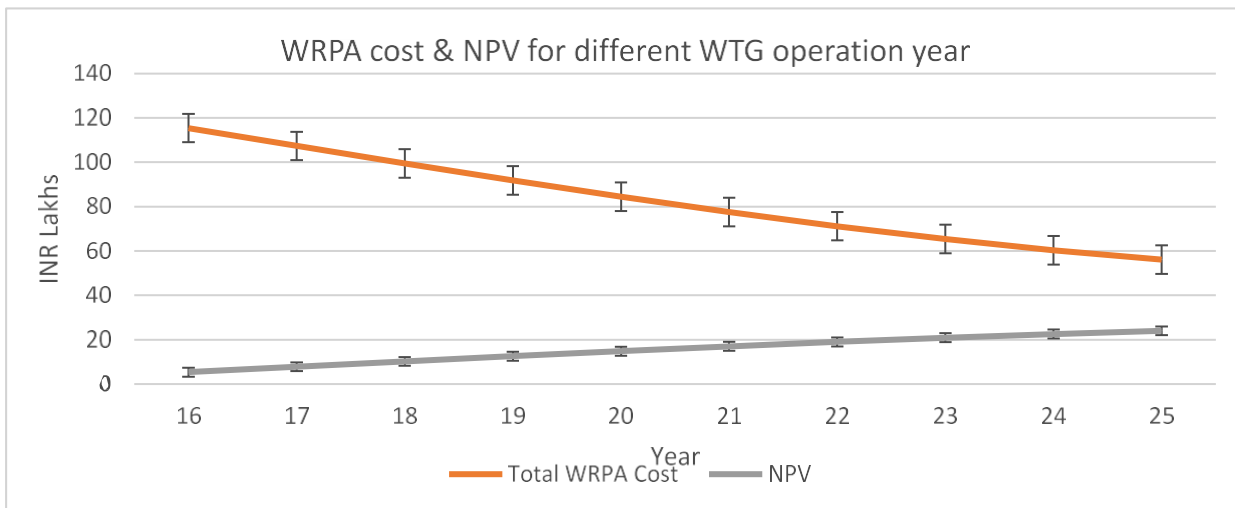


Figure 27: Total WRPA cost and NPV under Model-2 per MW for different years of WTG operation

### Analysis of results

- For Model-2 WRPA, the cost is decreasing with an increase in the years of operation (operational life) for the turbine for which repowering is done.
- NPV and IRR are increasing with an increase in the years of operation for the turbine for which repowering is done.
- Repowering from the 21st year onwards makes a lot of sense from the WRPA business point of view.
- The revenue source for WRPA in the 3rd year is from the sale of scrap and the handover of the site.
- Revenue from scrappage can have a significant impact on the cash flow for the WRPA business. Anything less than 50 Lakhs per MW will affect the NPV and IRR negatively.
- For WRPA business, Model -2 is viable even without any Government incentive. But for WRPD to compete with tariffs from greenfield projects, the government. Incentives are needed.
- NPV is positive for wind turbines in the 16th year of operation and increases with longer operating periods due to lower asset acquisition costs.
- In Model-2, WRPA can sell the site to its choice of WRPD. So, Model 2 is less regulated and yields higher IRR and NPV.

<sup>25</sup> [https://mnre.gov.in/img/documents/uploads/file\\_f-1666005996212.pdf](https://mnre.gov.in/img/documents/uploads/file_f-1666005996212.pdf)

### 6.3. Financial Viability of Model-3

The economic viability of Model-3 will depend on the levelized cost of WRPA activity. This will be the additional cost that must be added to the expected tariff for the WRPD to recover the WRPA cost. For the model to be viable, the Levelized cost of WRPA should be within 5% of the existing PPA tariff.

#### Case-1- Vankusawade site

For the Vankusawade site, the levelized cost of WRPA activity was calculated to be 0.09 ₹/kWh, with a repowered capacity of 353 MW at a repowering ratio of 2.2. The CUF has been taken as 35% of Annual Energy Production (AEP). For the total WRPA cost of ₹879.43 Mn, the levelized cost of WRPA is shown in Table 26.

Table 26: Levelized cost of WRPA for Vankusawade site

WRPA Cost	Unit	
Interest on term loan Per Year (levelized)	₹ Mn.	62.8
Return on Equity Per Year (levelized)	₹ Mn.	36.9
<b>Total WRPA Cost per year</b>	<b>₹Mn.</b>	<b>99.7</b>
<b>Levelized tariff corresponding to 25 Years</b>		
Per Unit Cost of Generation	Unit	Levelized Cost Impact
<b>Int. on term loan</b>	₹/kWh	0.06
<b>RoE</b>	₹/kWh	0.03
<b>Total Levelized WRPA cost</b>	₹/kWh	0.09
<b>Levelized Tariff</b>	₹/kWh	<b>0.09</b>

If we consider the PPA tariff to be 3.00 ₹/kWh, then the additional cost from WRPA of 0.09 ₹/kWh is 3% of the PPA cost. Thus, Model 3 seems viable for the Vankusawade site.

#### Analysis of results

The Model-3 calculation for Case-1 is subject to various assumptions. The most critical factors are Repowering Ratio and CUF, which directly impact Annual Energy Production. These two factors are site-specific. Hence, the Levelized cost of WRPA was calculated for different repowering ratios, keeping the CUF constant, and for different CUF, keeping the repowering ratio constant. The results are discussed in Table 27.

Table 27: Levelized cost of WRPA for Vankusawade site with different Repowering Ratio and 35% CUF

Repowering Ratio	Levelized cost of WRPA (₹/kWh)	Repowered Capacity (MW)	Levelized cost of WRPA as % of PPA tariff of 3.00 ₹/kWh
0.75	0.27	119.07	9
1.00	0.2	158.76	7
1.25	0.16	198.45	5.3
1.5	0.14	238.14	4.7
1.75	0.12	277.83	4
2	0.1	317.52	3.3
2.25	0.09	357.21	3.0
2.5	0.08	396.90	2.7
2.22	0.09	353	3

### Sensitivity Analysis

The sensitivity of the levelized WRPA cost to different repowering ratios has been analyzed and calculated using Model-3 for the Vankusawade site, as shown in Figure 28.

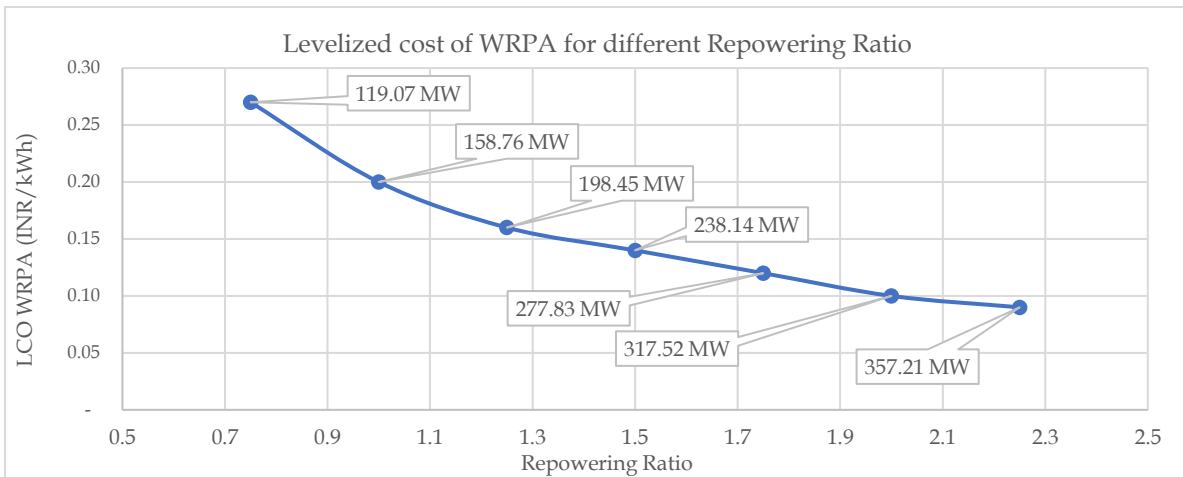


Figure 28: Levelized cost of WRPA for different repowering ratios at the Vankusawade site

The sensitivity of the levelized WRPA cost to different CUFs has also been calculated under Model-3 for the Vankusawade site, as presented in Table 28 and Figure 29.

Table 28: Levelized cost of WRPA for Vankusawade site with different CUF

CUF (%)	Levelized cost of WRPA (₹/kWh)	Repowered Capacity (MW)	Levelized cost of WRPA as percentage (%) of PPA tariff of 3.00 ₹/kWh
24	0.14	353.00	4.7
26	0.13	353.00	4
28	0.12	353.00	4
30	0.11	353.00	3.7
32	0.102	353.00	3.3
34	0.097	353.00	3.3
36	0.090	353.00	3
38	0.086	353.00	3

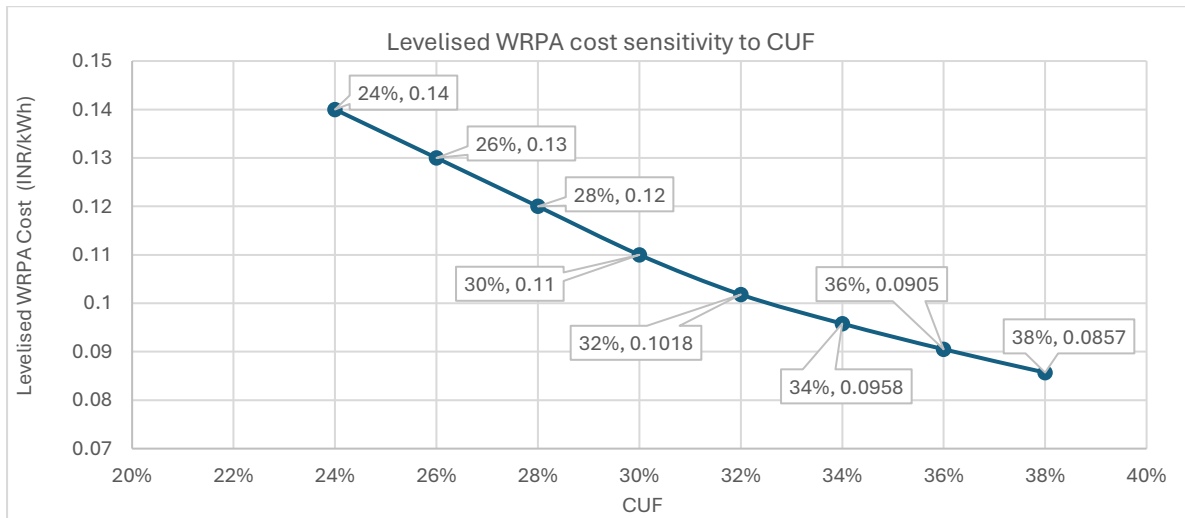


Figure 29: Levelized WRPA cost for different CUF for the repowering of the Vankusawade site

## Case-2 - Muppandal site

For the Muppandal site, the levelized cost impact of WRPA activity was calculated to be 0.07 ₹/kWh, assuming a repowered capacity of 2,100 MW at a repowering ratio of 2.61. The CUF has been taken as 35% for the AEP calculation. For a total WRPA cost of ₹3,906.18 Mn, the levelized cost of WRPA is ₹0.07/kWh, as shown in Table 29.

Table 29: Levelized cost of WRPA for Muppandal site

WRPA Cost	Unit	Levelized
Interest on term loan Per Year (levelized)	₹ Mn.	278.8
Return on Equity Per Year (levelized)	₹ Mn.	164.1
<b>Total WRPA Cost per year</b>	<b>₹Mn.</b>	<b>442.4</b>
<b>Levelized tariff corresponding to 25 Years</b>		
Per Unit Cost of Generation	Unit	Levelized
Int. on term loan	₹/kWh	0.04
RoE	₹/kWh	0.03
<b>Total COG</b>	<b>₹/kWh</b>	<b>0.07</b>
<b>Levelized Tariff</b>	<b>₹/kWh</b>	<b>0.07</b>

If we consider the PPA tariff to be 3.00 ₹/kWh, then the additional cost from WRPA of 0.07 ₹/kWh is 2.3% of the PPA cost. Thus, Model-3 seems viable for the Muppandal site.

### Analysis of results

The Model-3 calculation for Case-2 is subject to various assumptions. The most critical factors are Repowering Ratio and CUF, which directly impact Annual Energy Production. These two factors are site-specific. Hence, the Levelized cost of WRPA was calculated for different repowering ratios, keeping the CUF constant, and for different CUFs, keeping the repowering ratio constant. The results are presented in Table 30.

Table 30: Levelized cost of WRPA for Muppandal site with different Repowering Ratio and 35% CUF

Repowering Ratio	Levelized cost of WRPA (₹/kWh)	Repowered Capacity (MW)	Levelized cost of WRPA as % of PPA tariff of 3.00 ₹/kWh
0.75	0.24	603.68	8
1.00	0.18	804.90	6
1.25	0.14	1006.13	4.7
1.5	0.12	1207.35	4
1.75	0.10	1408.58	3.3
2	0.09	1609.80	3.0

Repowering Ratio	Levelized cost of WRPA (₹/kWh)	Repowered Capacity (MW)	Levelized cost of WRPA as % of PPA tariff of 3.00 ₹/kWh
2.25	0.08	1811.03	2.7
2.5	0.07	2012.25	2.3
2.61	0.07	2100	2.3

### Sensitivity Analysis

The sensitivity of the levelized WRPA cost to different repowering ratios has been analyzed and calculated using Model-3 for the Muppandal site, as shown in Figure 30.

The sensitivity of the levelized WRPA cost for different CUF has also been calculated under Model-3 for the Muppandal site, as presented in Table 32 and Figure 31.

Table 31: Levelized WRPA cost with different CUF for the Muppandal site

CUF (%)	Levelized cost of WRPA (₹/kWh)	Repowered Capacity (MW) with 2.61 RR	Levelized cost of WRPA as percentage (%) of PPA tariff of 3.00 ₹/kWh
24	0.13	2100	4.3
26	0.12	2100	4
28	0.11	2100	3.7
30	0.11	2100	3.7
32	0.10	2100	3.3
34	0.09	2100	3
36	0.09	2100	3
38	0.08	2100	2.7

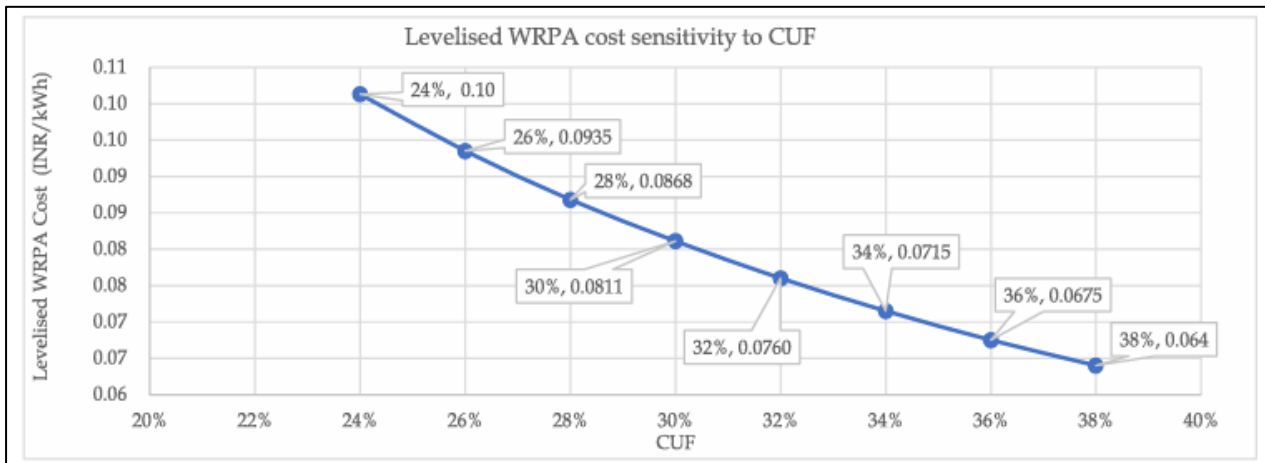


Figure 31: Levelised WRPA Associated risks with various WRPA Business Models

The proposed models for WRPA business have been developed to ensure profitability and sustainable cash flow for the aggregator. However, the models rely on multiple variable parameters, which may lead to different results in real-world applications.

It is therefore necessary to identify those variables and address the associated risks. The risks can be categorized into four categories: Business risk, Regulatory risk, Financial risk, and Environmental risk, as shown in Figure 32.



Figure 32: Possible Types of Risks in WRPA Business

### Associated Risks with WRPA Business Models 1, 2, and 3

There are multiple stakeholders in the WRPA business; therefore, the various types of risks discussed above will affect them differently. The stakeholders in this case are the WTG asset Owner, WRPA, WRPD, and Government agencies. A few stakeholders might remain immune to certain risks, while others may remain exposed to those risks. The risk categories are explained below.

- **Business Risk**

For various stakeholders, business risk might be defined as how the WRPA business is going to affect the business of other stakeholders and their independent operation of the business.

- **Regulatory Risk**

Regulatory risks primarily stem from the regulatory support required across different WRPA business models.

- **Financial Risk**

Financial risks for the WRPA business arise from the very nature of WRPA business and the lack of any case examples to support financial decisions.

- **Environmental Risk**

Environmental risk arises from WRPA's business of decommissioning old turbines, given the disposal methods used and the percentage of raw materials that can be recovered through recycling. In WRPA business models 1, 2 & 3, the perceived risks are as shown in Table 32

Table 32: WRPA business risk for different proposed models

		Low	Moderate	High
<b>Model-1</b>	<b>Business Risk</b>			
	<b>Regulatory Risk</b>			
	<b>Financial Risk</b>			
	<b>Environmental Risk</b>			
WTG Owner				
WRPA				
WRPD				
Govt.				
<b>Model-2</b>	<b>Business Risk</b>			
	<b>Regulatory Risk</b>			
	<b>Financial Risk</b>			
	<b>Environmental Risk</b>			
WTG Owner				
WRPA				
WRPD				
Govt.				
<b>Model-2</b>	<b>Business Risk</b>			
	<b>Regulatory Risk</b>			
	<b>Financial Risk</b>			
	<b>Environmental Risk</b>			
WTG Owner				
WRPA				
WRPD				
Govt.				

### Risk Analysis of Model-1

In Model-1, Regulatory Risk is high for WRPA and WRPD due to the changes needed to the existing PPA. New provisions must be made to enable SNA to select sites for aggregation and repowering in accordance with the state's policies and regulations.

- Financial risk is high for the Government in Model-1 because SNA must ensure upfront payment.
- WRPA must adhere to Environmental norms for decommissioning.
- WRPD has no environmental risk in Model 1 because it will get a cleared site.

### **Risk Analysis of Model-2**

- In Model -2, Regulatory Risk is high for WRPA and WRPD due to the changes needed in the existing PPA.
- Financial risk is there for WRPD due to the additional cost of site acquisition.
- WRPA under Model-2 must adhere to Environmental norms for decommissioning.
- WRPD has no environmental risk under Model 2 because it will get a cleared site.

### **Risk Analysis of Model-3**

- WRPA & WRPD, being the same entity, must ensure safe disposal and must adhere to Environmental norms for decommissioning.
- Financial risk for all stakeholders is at a minimum.
- Financial risk is there for WRPD due to the additional cost of site acquisition, resulting in a higher levelized cost of electricity.

**Conclusion:** WRPA Business Model-1, which SNA drives, can be suitable for aggregation projects on government-owned lands or selected sites, where the State wants to go for repowering at the earliest. The risks in this model include the initial financial burden on the SNA and the regulations required to empower the SNA to conduct such activities.

WRPA Business Model-2, which is WRPA-driven, can be suitable for aggregation sites identified by SNA, subsequently selected by WRPA, and subject to WRPA having the required consent from the current asset owners. The risk in this model lies with WRPA.

WRPA business Model-3, which WRPD drives, can be suitable for aggregation sites identified by SNA, subsequently selected by WRPD, and subject to WRPD having the required consent from the current asset owners. The risk in this model lies with the project developer.

## 7. Conclusions and Recommendations

### **The conclusion of the study for WRPA is as follows:**

This study encompasses the development of three viable WRPA business models, each with distinct characteristics and implementation modes. It focuses on identifying innovative business models for WRPA and conducting risk analysis for these models. It has also addressed various aspects crucial to the effective implementation of aggregation projects, such as WRPA selection, the bidding process, approvals, and intimation to the SNA/CNA regarding WRPA project development, WRPD selection, and decommissioning and site clearance. It aims to bring convergence to the existing National Wind Repowering Policy, 2023, and to provide indicative guidance for each business model, acknowledging the potential impact of future interventions and the MNRE's policy outlook.

Furthermore, the study has emphasized the economic viability and associated risks of the proposed business models, addressing diverse aspects of these models, the various stakeholders directly or indirectly involved in wind repowering projects, and the roles and responsibilities within them. The study has culminated in the preparation of implementation guidelines for aggregation projects and WRPA, providing a comprehensive framework for the successful implementation of Wind Repowering in India.

This study discusses these models to address the challenges and opportunities associated with repowering old wind turbines in aggregation mode. Model-1 involves the state/central government's role in selecting WRPA through a bidding process; Model-2 places the onus of identifying a selected site and obtaining consent from asset owners on WRPA; and Model-3 treats WRPA and WRPD as the same entity. The financial viability and risk analysis of each model are evaluated based on the cash flow it can generate, the net present value (NPV), and the internal rate of return (IRR).

### **The recommendations are as follows:**

The three models should be tested across various geographical locations and project scales.

For the WRPA concept and its associated business model to be implemented, Capacity building and handholding for SNA is important.

A comprehensive awareness program for a broad range of stakeholders is essential for the WRPA and its related business model.





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