A black background with white text

Description automatically generated A logo with blue and black text

Description automatically generated

**Hochschule Flensburg Wind Energy Technology Institude**

University of Applied Science Research on wind Energy

**Wind Farm Project in Gujarat, India**

**Wind Farm Project Development, WiSe 2024/25**

Master’s degree in Wind Engineering, Flensburg, Germany

**Submitted by**

Karan Soni (760153)

Mozafary Mostafa (750247)

Patil Rahul (750532)

**Supervising Professors:**

Dr. Marina Blohm

(Europa-Universität Flensburg)

**Date of issue:**

**Date of submission:**

Table of Contents

[List of Figures iv](#_Toc185938646)

[List of Tables iv](#_Toc185938647)

[1. Abstract 5](#_Toc185938648)

[2. Introduction: Overview of Wind Farm Development in Gujarat 6](#_Toc185938649)

[2.1 The Evolution of Wind energy in India 6](#_Toc185938650)

[2.2 Importance of Wind Energy in Gujarat 6](#_Toc185938651)

[2.3 Objectives of the Report 6](#_Toc185938652)

[2.4 Scope 7](#_Toc185938653)

[3. Literature Review 8](#_Toc185938654)

[3.1 Wind Resource Assessment of Gujarat 8](#_Toc185938655)

[3.2 Review of existing wind energy projects. 8](#_Toc185938656)

[3.2.1 Scaling challenges in Gujarat 8](#_Toc185938657)

[3.2.2 Suzlon secures a repeat order of 193.2 MW in Gujarat 8](#_Toc185938658)

[4. Methodology 10](#_Toc185938659)

[5. Requirement & Criterial to develop wind farm in Gujarat 11](#_Toc185938660)

[5.1 Regional Planning Requirement 11](#_Toc185938661)

[5.2 Guidelines for Micro siting of wind turbines (MNRE) 11](#_Toc185938662)

[5.3 Law & Regulation as well as Park Layout 12](#_Toc185938663)

[5.3.1 Consent to Establish (CTE) from Gujarat State Pollution Control Board (GPCB) 12](#_Toc185938664)

[5.3.2 Permission from Forest Department 13](#_Toc185938665)

[5.4 Eco-sensitive zones 14](#_Toc185938666)

[5.5 NOC from Airports Authority of India (AAI) and Ministry of Defence 15](#_Toc185938667)

[6. Wind Area Selection 17](#_Toc185938668)

[7. Electrical Grid Infrastructure and Cable Routing: Ensuring Connectivity 21](#_Toc185938669)

[8. Project Development Timeline: From Greenfield to Operation 22](#_Toc185938670)

[9. Community Engagement: Strategies for Local Acceptance 23](#_Toc185938671)

[10. Land Leasing and Acquisition: Securing the Site 24](#_Toc185938672)

[10.1 Lease Duration and Terms 24](#_Toc185938673)

[10.2 Eligibility and Allocation 24](#_Toc185938674)

[10.3 Application and Approval Process 24](#_Toc185938675)

[10.3.1 Government land Approval Process: 24](#_Toc185938676)

[10.3.2 Private land Approval Process: 25](#_Toc185938677)

[10.4 Usage and Compliance 27](#_Toc185938678)

[10.5 Financial and Operational Responsibilities 27](#_Toc185938679)

[10.6 Governance and Oversight 27](#_Toc185938680)

[10.7 Provision of Land procurement/ acquisition in Gujarat Wind Power Policy 2016 28](#_Toc185938681)

[11. Addressing Conflicting Interests 29](#_Toc185938682)

[12. Turbine Components: Logistics and Transformation 30](#_Toc185938683)

[13. Profitability Analysis: Calculating the Financial Viability 32](#_Toc185938684)

[14. Long-term Strategy: Wind Energy Development Roadmap to 2030/2050 33](#_Toc185938685)

[15. Barriers and Obstacles to Wind Farm Development 34](#_Toc185938686)

[16. Conclusion: A Strategic Plan for Wind Energy Development in Gujarat 35](#_Toc185938687)

[17. References 36](#_Toc185938688)

[18. Appendices 39](#_Toc185938689)

[6.1 Commissioning all necessary studies 39](#_Toc185938690)

[6.1.1 Environmental Impact Assessment (EIA) 39](#_Toc185938691)

[6.1.2 Social Impact Assessment (SIA) 39](#_Toc185938692)

[6.1.3 Wildlife and Habitat Studies 39](#_Toc185938693)

[6.1.4 Regulatory Compliance 39](#_Toc185938694)

[7.2 Financial Support, Finding Investors and O&M companies 40](#_Toc185938695)

[7.2.1 Financial support by Government 40](#_Toc185938696)

[7.2.2 Financial support by Bank 40](#_Toc185938697)

[7.2.3 Available Investors companies 40](#_Toc185938698)

[7.2.4 Available Operation and Maintenance companies 41](#_Toc185938699)

[7.3 Apply for Auction 41](#_Toc185938700)

[7.4 Construction 42](#_Toc185938701)

[7.5 Testing, Commissioning and Operation 42](#_Toc185938702)

[7.5.1 Testing 42](#_Toc185938703)

[7.5.2 Commissioning 43](#_Toc185938704)

[7.5.3 Operation 43](#_Toc185938705)

[7.6 Official Opening 43](#_Toc185938706)

# List of Figures

[Figure 6. 1: Configured project properties window 18](#_Toc185935793)

[Figure 6. 2: Individual buffers 19](#_Toc185935794)

[Figure 6. 3: Merged no-go area 19](#_Toc185935795)

[Figure 6. 4: Resulting white map area 20](#_Toc185935796)

[Figure 6. 5: The merged wind speed into white map 20](#_Toc185935797)

[Figure 10. 1: Government land approval process for wind farm 25](#_Toc185935890)

[Figure 12. 1: Routes for transporting wind turbine components 31](#_Toc185935943)

# List of Tables

[Table 2. 1: Potential of Energy in Gujarat, India 6](#_Toc185936664)

[Table 5. 1: Forest Clearance Procedure 13](#_Toc185936665)

[Table 6. 1: Specify buffer distances for each feature as per the project guidelines 17](#_Toc185936666)

[Table 8. 1: Project development timeline 22](#_Toc185936667)

[Table 10. 1: Add text 28](#_Toc185936668)

[Table 12. 1: Suzlon wind turbine manufacturing component’s locations and distance from wind farm 32](#_Toc185936669)

# Abstract

This report presents general information on wind farm development in Poladia, Bhuj, Gujarat, India. The project was developed as part of the “Wind Farm Project Development” module within the Wind Energy Engineering Master’s Program at the University of Applied Sciences in Flensburg.

The report discusses the selection of suitable areas using white map criteria specific to Gujarat's requirements. Subsequently, it considers the installation of six (2.1 MW) wind turbines from Suzlon and details the wind farm layout, total energy yield, and the calculation of CAPEX and OPEX. The analysis employs two main software tools: QGIS and WindPro.

The selection of Suzlon turbines is justified based on their efficiency, reliability, and suitability for the region. The report also addresses regulatory, environmental, and logistical challenges encountered during development and highlights the project's alignment with Gujarat's renewable energy goals and India's wind energy roadmap.

# Introduction: Overview of Wind Farm Development in Gujarat

## 2.1 The Evolution of Wind energy in India

India has made significant wind energy farm over the past few decades, becoming Globally, India ranks fourth in terms of installed wind power capacity. The journey began in the 1980s with small-scale wind energy projects. The first wind farm was established in 1986 in coastal Gujarat. India has developed several large wind farms, particularly in states like Tamil Nadu, Gujarat, and Maharashtra. The growth of the wind industry has created a strong support system, improved project management skills, and built a manufacturing capacity of around 15,000 MW per year. [1] [2]

## 2.2 Importance of Wind Energy in Gujarat

[As of May 2024, Gujarat has an impressive 11,823 MW of installed wind power capacity](https://www.thehindubusinessline.com/economy/gujarat-bags-award-for-highest-wind-power-installed-capacity/article68292944.ece). [This makes it the leading state in India for wind energy, surpassing Tamil Nadu, which has 10,743 MW](https://www.thehindubusinessline.com/economy/gujarat-bags-award-for-highest-wind-power-installed-capacity/article68292944.ece). [3] Its growth has been significantly influenced by a dedicated wind and land policy, which is further explored in a later section of this report.

|  |  |  |  |
| --- | --- | --- | --- |
| No | State | Wind Potential at 120 m (GW) | Wind Potential at 150 m (GW) |
| 1 | Andhra Pradesh | 70.90 | 123.3 |
| 2 | Gujarat | 142.56 | 180.8 |
| 3 | Karnataka | 124.15 | 169.3 |
| 4 | Madhya Pradesh | 15.40 | 55.4 |
| 5 | Maharashtra | 98.21 | 173.9 |
| 6 | Rajasthan | 127.75 | 284.2 |
| 7 | Tamil Nadu | 68.75 | 95.1 |
| 8 | Telangana | 24.83 | 54.7 |
| 9 | Other | 18.95 | 27.1 |

Table 2. : Potential of Energy in Gujarat, India [1]

## 2.3 Objectives of the Report

* To analyse the growth and current status of wind energy installations in Gujarat, India.
* Design and analyse of Wind Farm using GIS and Wind Pro software
* To examine the policies and regulations that have supported the development of wind energy in Gujarat
* To identify the key drivers and barriers to the expansion of wind energy in Gujarat, India, including infrastructure, financing, and policy support.
* Making schedule and timetable for wind Farm development project in Gujarat, India.

## 2.4 Scope

* **Geographic Advantage**: Gujarat’s long coastline and favourable wind conditions make it an ideal location for both onshore and offshore wind projects. [4]
* **Government Support**: The state government offers various incentives, including subsidies, tax benefits, and streamlined approval processes, to encourage investment in wind energy.
* **Economic Impact**: Wind energy projects create jobs, boost local economies, and contribute to sustainable development goals.

# Literature Review

## 3.1 Wind Resource Assessment of Gujarat

The wind resource estimates in this study highlight regions with average annual wind speeds above 8 m/s, mainly in the Gulf of Kutch and the southern coast. Similar to past research, our 2011 analysis confirms the highest wind potential in the northwestern Gulf of Kutch, with comparable potential found along the southern coastline. While the International Renewable Energy Agency agrees on high wind speeds in these areas, they report higher speeds of 9 m/s in the Gulf of Khambhat, exceeding our estimates. [4]

Wind speeds in Gujarat peak from May to August, reaching over 10 m/s, particularly along the coast, and are lowest in October and November, averaging below 7 m/s. Gujarat has a tropical and subtropical steppe climate, with occasional cyclones, droughts, and floods. The state experiences three main seasons: winter (November-March), summer (March-June), and monsoon (June-September). The northern region is dry, while the southern part is humid, with coastal winds influenced by sea breezes. [4]

## 3.2 Review of existing wind energy projects.

### 3.2.1 Scaling challenges in Gujarat

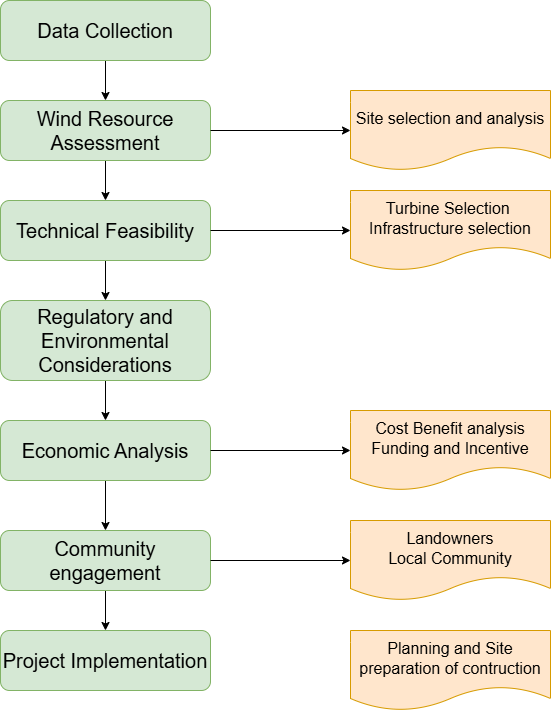
Renewable energy development, particularly large-scale wind farms, faces multifaceted challenges (Land Acquisition and local engagement, Logistical Challenges, Grid Integration, Regulatory and Environmental Hurdles, Financial and Contractual Risks, Stakeholder Coordination) that can significantly impact project timelines, costs, and outcomes. The experiences of hypothetical projects like Adani Wind Energy’s 300 MW wind farm in India’s coastal region highlight key obstacles that often arise during such ventures.Successful wind energy projects, such as those proposed by Adani Wind Energy, provide valuable lessons for future initiatives in the renewable energy sector. [5]

### 3.2.2 Suzlon secures a repeat order of 193.2 MW in Gujarat

Suzlon Group, a leading renewable energy solutions provider, has secured a repeat order from The KP Group for a wind energy project in Gujarat. This collaboration underscores the private sector's commitment to sustainable growth, supported by Gujarat's favourable policy environment for renewable energy development. Suzlon's wind turbines, featuring the advanced Doubly Fed Induction Generator (DFIG) technology, efficiently integrate with utility networks to meet grid requirements. The company's R&D focuses on increasing turbine performance, optimizing energy capture from low wind sites, and reducing energy costs. Suzlon’s commitment to **"Aatmanirbhar Bharat"** is evident through its domestically manufactured turbines, contributing to India's self-reliance in the renewable energy sector.

Gujarat's conducive policy environment for renewable energy development, along with Suzlon’s technological expertise and KP Group's commitment, makes the state an ideal location for expanding renewable energy infrastructure. The partnership supports India's net-zero goals while promoting economic progress through clean energy. [6]

# Methodology



# Requirement & Criterial to develop wind farm in Gujarat

## 5.1 Regional Planning Requirement

To promote the healthy and structured growth of the wind power sector in India, the Ministry of New & Renewable Energy (MNRE) introduced guidelines for wind power project development in July 1995, which have been periodically updated (Last updated 2024). Considering advancements in technology, new regulations, and the need for accelerated growth in the sector, the MNRE has recognized the importance of issuing comprehensive guidelines for wind power project development in collaboration with various stakeholders.

The process of wind power project development starts with site selection. Identification of suitable sites depends upon land use permission, availability of wind resource, technically and commercially feasible grid connectivity, transport logistics and environmental acceptability.

* Land use permission
* Availability of wind resource
* Technically and commercially feasible grid connectivity
* Transport logistics
* Environmental acceptability

## 5.2 Guidelines for Micro siting of wind turbines (MNRE)

Micro siting is the optimization of energy production through the correct placement of wind turbine generators in the wind farm area, considering all physical constraints of the area.

Micro siting criteria are prescribed as under.

Developer(s) shall optimise the wind turbine locations within their land using appropriate wind flow modelling and optimisation tools (linear and Nonlinear)/techniques subject to site assessment as per IEC 61400-1 standard for turbine safety considering extreme wind, flow inclination, vertical wind shear, and turbulence with added wake effects and corrections for terrain complexity etc.

Developer(s) shall maintain a distance of (D-Rotor Diameter) distance perpendicular to the predominant wind direction and distance in the predominant wind direction from the boundary line of each adjoining land of other developer(s) with appropriate offset.

Developer(s) shall maintain a wake loss (in terms of energy) of 10% between wind turbines with appropriate offset for wind turbines sited on a footprint basis.

Developer(s) shall maintain a distance of (Hub Height+ Half Rotor Diameter +5 meters) from Public Roads, railway tracks, highways, buildings, public institutions and EHV lines.

Developer(s) shall not site wind turbines within 500 m of any living places for the mitigation of noise. ‘dwelling’ shall mean at least 15 inhabited buildings. [7]

## 5.3 Law & Regulation as well as Park Layout

### 5.3.1 Consent to Establish (CTE) from Gujarat State Pollution Control Board (GPCB)

#### 5.3.1.1 Consent to Establish (CTE)

Required to obtain CTE under section 21(1) of the Air (prevention and control of pollution) Act, 1981. Also, CTE under section 25/26 of the Water Act is required in case of discharge of sewage or trade effluent in a stream or a well or a sewer or a lake. [section 21(1) of the Air (prevention and control of pollution) Act, 1981]

#### 5.3.1.2 Consent to Operate (CTO)

Prior to commercial generation, it is obligatory to apply for CTO under section 21 of the Air (P & CP) Act 1981, with respect to ambient air quality related to noise. [ section 21 of the Air (P & CP) Act 1981,]

#### 5.3.1.3 Apply for Hazardous Waste Authorisation

wind power projects use different types of fluids for the smooth operation of the WTG. Primarily, three main types of fluid are used: First, Generator cooling fluid is used as coolant (a mixture of glycol and water, similar to what is used in automobile radiators). Second, Lubricating oil is used in the gearbox (synthetic oil). Third, Hydraulic oil for operating the blade pitch system, yaw mechanism and brakes. To protect transformers from heating, mineral oil (transformer oil) is used as coolant. [8]

## 5.3.2 Permission from Forest Department

Under Rule 6 of the Forest (Conservation) Rules, 2003, any project that intends to use forest land for non-forest purposes must submit a proposal using the prescribed forms included in the rules.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Advising/ Recommending body | Route | Final clearance Authority |
| < 1 hectare | - | - | State Government (Principle Secretary of Forest) |
| 1 – 5 hectares | State forest department | State government to regional office of MoEF | Regional office MoEF |
| 5 – 40 hectares | State Advisory group | State Government to regional office of the MoEF; then to the MoEF with state advisory group recommendations | MoEF |
| > 40 hectares | Forest Advisory Committee | State government to MoEF | MoEF |

Table 5. : Forest Clearance Procedure [9]

The forest clearance process begins with the project proponent submitting an application to the nodal officer of the state forest department. The application is forwarded to the district-level field office, where an inspection of the proposed land is conducted. After this evaluation, the application is sent back through the forest department hierarchy to the Principal Secretary of Forests. The final approval authority depends on the extent of forest land to be diverted: the proposal may either be approved by the Regional Office of the Ministry of Environment, Forest, and Climate Change (MoEFCC) or by the Secretary, at the regional or central level, based on the project's scale and requirements. [9]

Further, the forest guidelines also specify certain criteria for the setting-up of a development project, which states that no projects should be in the vicinity of the following:

* National Parks, Wildlife Sanctuaries and Core areas of the Biosphere Reserves.
* Scenic landscapes, areas of geo-morphological significance, unique and representative biomes and eco-systems, heritage sites/structures and areas of cultural heritage and importance.
* Fragile eco-systems such as mountains; areas rich in coral formations as well as marine, coastal, desert, wetland, riverine and island eco-systems. Areas rich in biological diversity, gene pool and other natural resources.

## 5.4 Eco-sensitive zones

In 2002, the MoEF decreed that an area of 10 km around national parks and sanctuaries should be assigned as an eco-sensitive zone, with restrictions on development.

Any project including wind power projects that fall inside the zone have to seek approval from the National Board for Wildlife (NBWL). The NBWL may conduct a study if it believes the project may have large-scale impact.

**Wildlife Board’s guidelines on linear intrusion:**

* The guidelines are extensive and focus firstly on how to avoid the need for new roads and powerlines in natural areas. Only after avoidance is ruled out, do the guidelines go into details of how roads and powerlines should be built to minimize and mitigate damage.
* Keep construction phase as short as possible, avoid night-time work as it disturbs animals.
* When one linear intrusion has been made, new projects should align with it so as not to cause further destruction
* According to the guidelines, roads should be no wider than 12.5 m for primary roads and 8.5 m for secondary roads.
* To avoid electrocution of elephants powerlines should be a minimum of 6.6 m above ground on level terrain and a minimum of 9.1 m above ground on steeper terrain.
* Maintaining 1.5 m spacing between energized components, cover and insulate energised hardware, include reflectors and perch deterrants. Install underground cables. Monitor effectiveness of measures.
* Structures, such as retaining walls that can act as barriers to animal movement should not be installed along roads, especially in hilly terrain. [10]

## 5.5 NOC from Airports Authority of India (AAI) and Ministry of Defence

Aircraft Act, 1934 empowers the Central Government to impose restriction on the construction of buildings and other structures within a radius of 20 Km from ARP of all aerodromes.

No Wind Turbine Generators (WTGs) shall be installed up to 10 Km from the Radar Antenna of all Static Air Defense Radars and up to 8 km from ATS Radar antenna/VOR.

**Colour Coded Zoning Maps (CCZMs):**

* CCZMs have been formulated for all IAF aerodromes and handed over to Local Municipal Authorities (LMAs). Area in the center of CCZM of 4 Km radius around threshold of an IAF aerodrome is marked in Red. For all proposed constructions falling in Red Grid/Zone, it shall be mandatory for an applicant, to submit application in specified format and obtain NOC from IAF as per existing procedures/guidelines.
* Area beyond 4 Km from threshold has been demarcated in various zones with different Color Coding on the CCZM. Local Municipal Authorities (LMAs) can approve any building/infrastructure plans only up to maximum elevation specified in the respective zones as depicted on CCZM without referring the case to IAF.
* Under GSR 751 (E), the area marked in ‘Green’ is beyond 20 Km from Aerodrome Reference Point of an IAF airfield and is outside the purview for issuance of NOC by IAF. Hence, for any construction/proposal in areas marked in ‘Green’, the applications are not required to be processed for infrastructure up to a max height of 150 m AGL above aerodrome elevation. [11]
* No Objection Certificate (NOC) from State Electricity Board
* Land Allotment Letter
* NOC from the District Level Industrial and Revenue (DLIR) Department
* NOC from Mining Department
* NOC from Village Panchayat
* Power Purchase Agreement (PPA)

# Wind Area Selection

To analyse wind farm suitability by integrating wind speed data at 100m height with geographical and infrastructural constraints.

**Steps Involved in the Analysis:**

**Step 1: Data Preparation**

* Wind speed data at 100m height. [12]
* GIS layers for: Buildings, Forests, Military areas, Railways, Industrial, Roads, Airports, Airfields, Rivers. [13]
* Import all provided data layers.

**Step 2: Project Properties Setup**

* Set the correct CRS (Coordinate Reference System) as per the dataset. [See Fig. 6.1]

**Step 3: Create Buffers**

* Use the Buffer tool to create exclusion zones around:

|  |  |
| --- | --- |
| GIS Layers | Distances [m] |
| Buildings | 250 |
| Forests | 10,000 |
| Military Areas | 10,000 |
| Railways/ Industrial | 250 |
| Roads | 250 |
| Airports/ Airfields | 20,000 |
| Rivers | 250 |

Table 6. : Specify buffer distances for each feature as per the project guidelines

**Step 4: Merge Buffers into No-Go Areas**

* Combine all individual buffer layers into a single "No-Go Area" layer. [See Fig. 6.2 for individual buffers and Fig. 6.3 for the merged No-Go Area.]

**Step 5: Identify Suitable Areas Using Difference Tool**

* Use the Difference tool to subtract the "No-Go Area" layer from the total study area.
* The output is a "White Map" layer highlighting areas suitable for wind farms. [See Fig. 6.4]

**Step 6: Integrate Wind Speed Data**

* Overlay wind speed data onto the White Map layer. [See Fig. 6.5]
* Use the Clip Raster by Mask Layer tool.

A screenshot of a project

Description automatically generated

Figure 6. : Configured project properties window

A screenshot of a computer

Description automatically generated

Figure 6. : Individual buffers

A map of a city

Description automatically generated

Figure 6. : Merged no-go area

A map of a country with dots

Description automatically generated

Figure 6. : Resulting white map area

A map of different colored areas

Description automatically generated

Figure 6. : The merged wind speed into white map

# Electrical Grid Infrastructure and Cable Routing: Ensuring Connectivity

# Project Development Timeline: From Greenfield to Operation

|  |  |  |
| --- | --- | --- |
| Phases | Descriptions | Timeline |
| 1 | Study Laws and Regulations |  |
| 2 | Site Assessment |  |
| 3 | Land Leasing |  |
| 4 | Planning |  |
| 5 | Permitting |  |
| 6 | Financing |  |
| 7 | Constructions |  |
| 8 | Commissioning |  |
| 9 | Operations |  |

Table 8. : Project development timeline

# Community Engagement: Strategies for Local Acceptance

**Community Meetings**:

Organize meetings with community members to explain the benefits of the project, such as job creation, infrastructure development, and clean energy. Address any concerns and answer questions.

**Engage Local Leaders**:

Work with local leaders and influential community members to gain their support. Their endorsement can help in building trust and acceptance within the community.

**Transparency**:

Maintain transparency throughout the process by sharing project details, timelines, and potential impacts. This can help in building trust and reducing resistance.

**Benefit Sharing**:

Propose benefit-sharing, such as community development funds, scholarships, or infrastructure improvements, to ensure that the community also gains from the project.

**Regular Updates**:

Keep the community informed about the progress of the project through regular updates and open communication channels.

# Land Leasing and Acquisition: Securing the Site

Policy 2023 aims to facilitate the leasing of government fallow land in Gujarat for the establishment of green hydrogen production facilities. These facilities will utilize non-conventional renewable energy sources such as solar, wind, and hybrid wind-solar energy. [14]

## 10.1 Lease Duration and Terms

* Lease Period: 40 years
* Annual Rent: ₹15,000 (€ 150 – €170) per area, subject to a 15% increase every three years.
* Advance Payment: Annual rent and applicable taxes must be paid in advance. Late payments integrate 12% simple interest after 90 days.
* Security Deposit: Applicants must provide a deposit equivalent to one year’s rent, a 1% service charge, and necessary stamp duty upon land possession. [14]

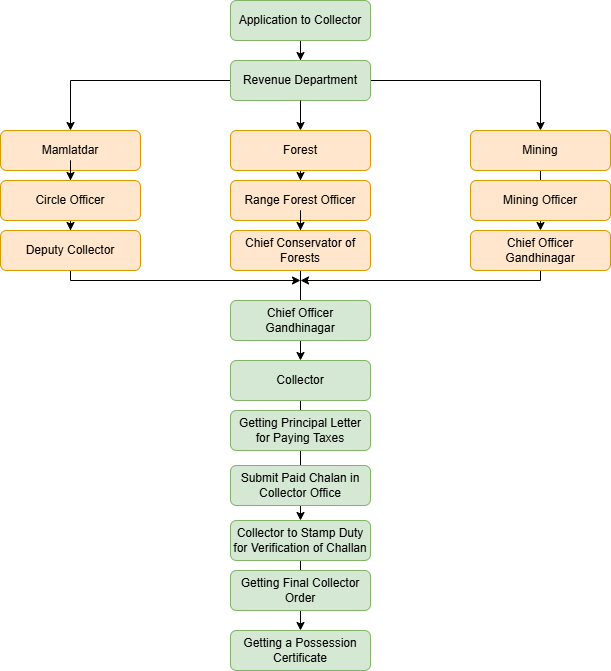
## 10.2 Eligibility and Allocation

* Criteria: Includes financial stability (minimum net worth of ₹1200 crore (€130.44 million)), experience in renewable energy generation (minimum 500 MW).
* Land Allocation Limits: One applicant or their partners can only lease enough land to produce 30 lakh metric tonnes () of green hydrogen each year. This means they can't lease more land than what is necessary for that amount of production. [14]

## 10.3 Application and Approval Process

* Pre-Feasibility Report: Applicants must submit a preliminary report demonstrating their capability to produce green hydrogen.
* Review Committees: A Committee of Experts evaluates the applications, followed by the High-Power Committee for final recommendations. [14]
* Tripartite Agreement: Upon approval, a tripartite agreement is signed between the Collector, the nodal agency (GPCL), and the applicant. [14]

### 10.3.1 Government land Approval Process:

****

Application to collector

Figure 10. : Government land approval process for wind farm [15]

### 10.3.2 Private land Approval Process:

**Step 1:** Title Clearance

* The first step involves ensuring that the title of the land is clear. This includes:
* Checking all historical ownership records.
* Ensuring there are no disputes, encumbrances, or legal issues associated with the land.
* Reviewing registered documents with the Sub-Registrar's office.

**Step 2:** Agreement to Sell (ATS) and Sale Deed

* Agreement to Sell (ATS):
* The developer enters into a formal agreement with the landowner, documenting the agreed price, terms of payment, and timelines for the transaction.
* The ATS may involve an advance payment.
* Sale Deed:
* Once the terms in the ATS are fulfilled, a sale deed is executed.
* The sale deed is then registered with the Sub-Registrar’s office, completing the legal transfer of ownership to the developer.

**Step 3:** Application and Obtaining 89A Permission from revenue department

* Purpose of 89A Permission:
* Under Section 89A of the Gujarat Land Revenue Code, this permission is required to formally register the land transaction.

**Step 4:** Conversion to Old Tenure Land & Payment of Premium

* Understanding Land Tenure:
* Land in Gujarat is often classified as "new tenure" (with restrictions on sale or use). Developers must convert it to "old tenure" to remove restrictions.

**Step 5**: Apply and Obtain 65 Kh Permission (Non-Agricultural or NA Use)

**Purpose of 65 Kh Permission:**

* Land classified as agricultural must be converted to non-agricultural (NA) for setting up infrastructure like wind turbines.

**Application Process:**

* The developer applies to the District Collector or Revenue Department with relevant documents (title clearance, sale deed, and tenure conversion approval).
* The Collector grants permission, officially converting the land use to NA, allowing construction to proceed. [15]

## 10.4 Usage and Compliance

Dedicated Use: Leased land must be exclusively used for green hydrogen production.

Development Timeline: Projects must develop infrastructure and achieve 50% capacity within 3 years and full capacity within 8 years.

No Subleasing: The leased land cannot be subleased to third parties. [14]

## 10.5 Financial and Operational Responsibilities

Infrastructure Development: Applicants are responsible for all infrastructure, including power transmission, roads, water supply, and security.

Energy Usage: Generated renewable energy must primarily be used for green hydrogen production within Gujarat. Excess energy sales are subject to government discretion.

Charges and Taxes: All applicable taxes, licensing fees, and GST must be borne by the lease agreement. [14]

## 10.6 Governance and Oversight

Nodal Agency (GPCL): Manages land allocation, application processing, and project monitoring.

High Power Committee (HPC): Sets parameters for equipment and production standards, and prioritizes applications based on predefined criteria.

Revenue Department: Ensures land allocation aligns with state requirements and oversees final approvals. [14]

## 10.7 Provision of Land procurement/ acquisition in Gujarat Wind Power Policy 2016

The Gujarat Energy Development Agency (GEDA) will act as the State Government's Nodal Agency for implementing and facilitating the Gujarat Wind Power Policy-2016. GEDA will support project developers by assisting with the following activities to achieve the policy's objectives:

**Project Registration**: Ensuring wind power projects are properly registered.

|  |  |  |
| --- | --- | --- |
| S.No | Department | Designation |
| 1 | ACS/PS/Secretary (CCD) | Chairman |
| 2 | AS/JS/Deputy Secretory (EPD) | Member |
| 3 | Chief Electrical Inspector & Collector of Elect.  Duty | Member |
| 4 | General Manager (Comm), GUVNL | Member |
| 5 | Respective District Collector | Member |
| 6 | Director, GEDA | Member Secretary |

Table 10. : Add text [16]

**Developer Assistance**: Addressing queries and resolving issues faced by wind power project developers.

**Accreditation**: Facilitating the accreditation and recommending wind power projects for registration with the Central Agency under the Renewable Energy Certificate (REC) mechanism.

Wind Turbine Generators (WTGs) can be established on private land, revenue wasteland allotted by the State Government, or land owned by GEDA (if available). The allocation of GEDA-owned land on lease requires the approval of a Coordination Committee, as detailed in the policy's framework. Additionally, this committee is responsible for resolving issues beyond land allotment, such as interpreting specific provisions of the policy.

# 11. Addressing Conflicting Interests

# 12. Turbine Components: Logistics and Transformation

There are four locations: Daman, Vadodara, Gandhidham, and Bhuj (refer to Figure 12.1). Previously, we have selected a wind farm site located in Poladia, Gujarat, India. We had discussed that we chose Suzlon company wind turbines because they are manufactured in Gujarat, India. One of the key advantages is the ease of transportation. The government provides incentives if we select “Made in India” products, it is second key advantages.

A map of the world

Description automatically generated

NH48

NE4

754k

NH27

NH64

4

3

2

1

NE1

Figure 12. : Routes for transporting wind turbine components

You can see Table 12.1, which shows the different turbine component manufacturing locations and the distances to the wind farm. Additionally, in Figure 12.1, the National Highway (NH), National Express Highway (NE), and Sub National Highway (754K) are represented. These are the best routes for transporting wind turbine components

|  |  |  |
| --- | --- | --- |
| Wind Turbine Manufacturing components | Manufacturing Locations | Distance between Manufacturing location to Wind farm [km] |
| Nacelle | Daman, Gujarat, India | 743 |
| Nacelle Cover | Daman, Gujarat, India | 743 |
| Hub | Daman, Gujarat, India | 743 |
| Rotor Blades | Bhuj, Gujarat, India | 57 |
| Tower | Gandhidham, Gujarat, India | 136 |
| Electrical | Vadodara, India | 544 |

Table 12. : Suzlon wind turbine manufacturing component’s locations and distance from wind farm [17]

# 13. Profitability Analysis: Calculating the Financial Viability

**Income:**

**Operating costs:**

Inflation: 6.20 % (for India); Start first year value 1.

The total operating cost includes under a full maintenance contract, lease costs, annual financial statements and tax advice, insurance, and operational management. Additionally, it covers dismantling guarantee reserves, own consumption, and miscellaneous expenses. Agricultural impacts, such as hamster management and yield loss compensation for farmers growing wheat and barley, are also accounted for.

**EBITDA: Earnings before Interest, Taxes, Depreciation and Amortization:**

**Depreciation and Amortization:** It refers to the reduction in the value of an asset over time, typically due to wear and tear, usage, or obsolescence. We have considered value of **7,61,341 euro** until 14 years.

**EBIT: Earnings before Interest and Taxes:**

**Net Financial Income:**

# 14. Long-term Strategy: Wind Energy Development Roadmap to 2030/2050

The state of Gujarat has good potential for wind energy development, which can significantly contribute to India's renewable energy goals.

**Vision and Goals:**

**By 2030:**

* Achieve an installed wind energy capacity of 15 GW.
* Increase the share of wind energy to 20% of the state's total energy mix.
* Launch the first phase of offshore wind projects. [7]

**By 2050:**

* Establish Gujarat as a global leader in wind energy.
* Fully integrate smart grid solutions for efficient energy distribution.
* Achieve a 50% reduction in carbon emissions from energy production. [7]

To achieve long-term wind energy goals, Gujarat will improve policy support, adopt advanced turbine technologies, and upgrade infrastructure. By integrating smart grids and encouraging community engagement, the state aims to significantly reduce carbon emissions. Government and company will spend more money in research and development of wind turbine and energy storage system. This comprehensive approach ensures sustainable and efficient wind energy development, positioning Gujarat as a leader in renewable energy.

# 15. Barriers and Obstacles to Wind Farm Development

**High Initial Costs**:

The setup and installation of wind turbines and related infrastructure require significant upfront investment.

**Land Use Conflicts**:

Large-scale wind farms can lead to land acquisition issues and conflicts with local communities.

**Environmental Concerns**:

Wind turbines can impact local wildlife, particularly birds and bats, and may cause noise pollution.

**Maintenance Issues:**

Challenges in maintaining and servicing of Wind Turbine, leading to operational inefficiencies.

**Grid Integration**:

Integrating wind energy into the existing power grid can be challenging due to the need for stable and reliable energy supply.

**Standardization and Quality Control:** Lack of standardized practices and quality control measure for wind turbine.

**Limited Awareness:** Low awareness among potential users and stakeholders about the benefits and applications of wind turbine.

**Preference for Solar Energy:** Higher preference for solar energy over wind energy due to various factors. [18] [19]

# 16. Conclusion: A Strategic Plan for Wind Energy Development in Gujarat

# 17. References

|  |  |
| --- | --- |
| [1] | “MINISTRY OF NEW AND RENEWABLE ENERGY,” 01 2024. [Online]. Available: https://mnre.gov.in/wind-overview. [Accessed 2024 10 02]. |
| [2] | “A Deep Dive into Wind Energy Farms in India: Tapping into the Power of the Breeze,” Green Energy, 23 01 2024. [Online]. Available: https://powerefficiency.com/wind-energy-farms-in-india/. [Accessed 02 10 2024]. |
| [3] | “gujarat-bags-award-for-highest-wind-power-installed-capacity,” thehindubusinessline, 15 06 2024. [Online]. Available: https://www.thehindubusinessline.com. [Accessed 2 10 2024]. |
| [4] | A. P. Z. P. C. Draxl, “Wind Resource Assessment,” NREL National Renewable Energy Laboratory, July, 2014. |
| [5] | M. Gupta, “Scaling Challenges In Gujarat: Adani’s 300 MW Wind Farm Project And Its Journey Through Regulatory And Logistical Hurdles,” WINDINSIDER EMPOWERING THE WIND SECTOR, 13 05 2024. [Online]. Available: https://windinsider.com. [Accessed 10 10 2024]. |
| [6] | Suzlon Group, “Suzlon secures a repeat order of 193.2 MW from The KP Group in Gujarat,” 21 December 2023. [Online]. Available: https://www.suzlon.com. [Accessed 13 10 2024]. |
| [7] | MINISTRY OF NEW AND RENEWABLE ENERGY, “Clarification to the ‘Guidelines for Development of Onshore Wind Power Projects’ and amendments,” Government of India, 18 12 2024. [Online]. Available: https://mnre.gov.in/en/document/clarification-to-the-guidelines-for-development-of-onshore-wind-power-projects-and-amendments/. [Accessed 15 11 2024]. |
| [8] | thc.nic.in, “THE HAZARDOUS WASTES (MANAGEHANDLING AND TRANSBOUNDARY MOVEMENT) RULES, 2008,” Official Gazeette, MARCH, 2010. |
| [9] | Forest Clearance, “Forest Conservation Rules,” 2003. [Online]. Available: https://forestsclearance.nic.in. [Accessed 17.11.2024]. |
| [10] | National Board for Wildlife, Ministry of Environment and Forest, India, “Guidelines for linear infrastructure intrusions in natural areas: roads and powerlines,” 10 Octomber 2011. [Online]. Available: https://moef.gov.in. [Accessed 25 11 2024]. |
| [11] | India Air Force, “GUIDELINES FOR ISSUE OF NOC FOR CONSTRUCTIONS AROUND INDIAN AIR FORCE AERODROMES,” 12 2021. [Online]. Available: https://indianairforce.nic.in. [Accessed 11 11 2024]. |
| [12] | DTU, “GLOBAL WIND ATLAS,” DTU, ESMAP, WORLD BANK GROUP, VORTEX, [Online]. Available: https://globalwindatlas.info. [Accessed 24 11 2024]. |
| [13] | GEOFABRIK, “OpenStreetMap Data Extracts,” [Online]. Available: https://download.geofabrik.de/. [Accessed 25 11 2024]. |
| [14] | Government of Gujarat, “Policy-2023 for leasing the government fallow land for green hydrogen production using non-conventional energy sources such as solar, wind, wind solar hybrid energy.,” 08 May 2023. [Online]. Available: https://www.eqmagpro.com. [Accessed 13 10 2024]. |
| [15] | ARCADIS India Pvt. Ltd., “ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT: 250 MW Wind Power Project in Kutch district, Gujarat,” ARCADIS, Kutch, 2017. |
| [16] | Gujarat Goverment , “policy\_files,” 2016. [Online]. Available: https://geda.gujarat.gov.in. [Accessed 28 11 2024]. |
| [17] | suzlon, “supply-chain-management-and-manufacturing,” 2024. [Online]. Available: https://www.suzlon.com. [Accessed 12 12 2024]. |
| [18] | M. B. Arshi Banu P S, “Wind energy feasibility and wind turbine selection studies for the city Surat, India,” *Clean Energy,* vol. 8, no. 3, pp. 166-173, 2024. |
| [19] | L. C. a. A. B. Vaisakh Suresh Kumar, “Scaling up small wind turbines in India (Barriers and options for the way forward),” WRI-INDIA.ORG and CLEAN , Delhi, 2024. |
| [20] | Nature India, “Is the drive for clean energy throwing environmental caution to the wind?,” *NEWS FEATURE,* 16 June 2019. |
| [21] | P. C. Abhishek Gawande, “Environmental and social impacts of wind energy: a view point with reference to India,” Indian Institute of Forest Management, Bhopa, 2019. |
| [22] | EU-INDIA CLEAN ENERGY & CLIMATE PARTNERSHIP, “About the partnership,” European Union , 30 March 2016. [Online]. Available: https://www.cecp-eu.in. [Accessed 13 10 2024]. |
| [23] | V. Shah, “India Sets Sail on 1 GW Offshore Wind Energy Projects in Gujarat, Tamil Nadu,” goodreturns, 19 June 2024. [Online]. Available: https://www.goodreturns.in. [Accessed 22 10 2024]. |
| [24] | Editorial Team, “Gujarat: Pioneering Sustainable Wind Power Generation in India,” SSMB.IN, 19 September 2024. [Online]. Available: https://ssmb.in/2024/09/19/gujarat-pioneering-sustainable-wind-power-generation-in-india/. [Accessed 22 10 2024]. |
| [25] | GE VERNOVA, “GE acquires 49% stake in Continuum onshore wind farm in support of the energy transition in India,” GE, [Online]. Available: https://www.gevernova.com. [Accessed 22 10 2024]. |
| [26] | Gujarat Urja Vikas Nigam Ltd, “REQUEST FOR SELECTION (RfS),” 10 07 2023. [Online]. Available: https://jmkresearch.com. [Accessed 20 10 2024]. |
| [27] | Wind farm BoP, “Wind farm testing and commissioning,” 2017, [Online]. Available: https://www.windfarmbop.com/. [Accessed 22 10 2024]. |
| [28] | A. P. a. Z. P. . Draxl, “Wind Resource Assessment,” National Renewable Energy Laboratory (NREL), 2014. |
| [29] | R. m. https://www.mercomindia.com/gujarat-land-policy-solar-wind-projects, “Gujarat's New Land Policy for Solar, Wind Projects to Make Developers More Accountable,” MERCOM, Clean Energy Insights, 17 September 2020. [Online]. Available: https://www.mercomindia.com/gujarat-land-policy-solar-wind-projects. [Accessed 05 10 2024]. |
| [30] | D. M. Blohm, *Lecture Notes on Wind Farm Development,* Flensburg, 2024. |
| [31] | Gujarat Energy Development Agency, Gujarat Government, [Online]. Available: https://geda.gujarat.gov.in. [Accessed 22 10 2024]. |

# 18. Appendices

## 6.1 Commissioning all necessary studies

### 6.1.1 Environmental Impact Assessment (EIA)

While wind energy is a greener choice compared to fossil fuels, it has some environmental challenges. One major issue is that birds, especially predators like raptors, can accidentally fly into the spinning turbine blades, leading to injuries or deaths. These impacts interrupt local ecosystems, as seen in reduced raptor populations leading to increased numbers of prey species, such as the fan-throated lizard. Noise from turbines and habitat disruption during construction can further affect wildlife. [20]

In India, even though environmental impact assessments (EIA) are not required for wind farms, the wind energy sector still must follow certain guidelines from the Ministry of Environment and Forests (MoEF). If a wind power project is located in a forest, national park, or wildlife sanctuary, it must get approval from the State Forest Board, the State Pollution Board, and the National Board for Wildlife. Additionally, if the land is home to scheduled tribal communities or traditional forest residents, the project must comply with the Scheduled Tribes and Other Forest Dwellers Act, 2006.6.1.2 Geophysical and Geo-Technical Studies. [20]

### 6.1.2 Social Impact Assessment (SIA)

**Impact on Livelihoods**: Assess how the project might affect local livelihoods, such as agriculture and fishing, while identifying potential benefits like job creation and infrastructure improvements.

**Health and Safety**: Evaluate possible health and safety impacts, including noise pollution and environmental changes that could affect the community.

**Cultural and Heritage Impact**: Examine the impact on cultural heritage sites, traditional practices, and local customs to ensure the project does not harm these aspects.

**Economic Impact**: Analyse economic benefits and costs to the local community, such as changes in property values and opportunities for local businesses. [21]

### 6.1.3 Wildlife and Habitat Studies

### 6.1.4 Regulatory Compliance

Ensure that the project complies with all relevant local, state, and national regulations and standards. [22]

## 7.2 Financial Support, Finding Investors and O&M companies

### 7.2.1 Financial support by Government

* **Viability gap funding (VGF) scheme:** The government provides VGF to support the development of wind projects, reducing the financial burden on developers. The Union Cabinet has sanctioned amounting to Rs 7,453 crore (€820 million). [23]
* **Tax Incentives and Subsidies**: The Gujarat government has introduced supportive policies aimed at attracting investments in wind energy, such as tax breaks, subsidies, and the development of necessary infrastructure. These initiatives create a favourable environment for both local and foreign investors to engage in the state's wind energy sector. [24]

### 7.2.2 Financial support by Bank

* **GE Energy Financial Services**: GE Energy Financial Services invested in the Major Wind Power Project in Gujarat through a structured preferred equity solution. This project, developed by Continuous Green Energy, has capacity of 148.5 MW.
* **State Bank of India (SBI)**: SBI has been actively financing renewable energy projects, including wind farms, in Gujarat. They offer project financing, corporate loans, and working capital loans to support the development and operation of wind farms.
* **ICICI Bank**: ICICI Bank provides financial support for renewable energy projects, including onshore wind farms. They offer loans and structured finance solutions to help developers secure the necessary capital.
* **Axis Bank**: Axis Bank also supports renewable energy projects in Gujarat by providing project financing and working capital loans. They collaborate with developers to ensure the successful implementation of wind farm projects. [25]

### 7.2.3 Available Investors companies

There are more investor companies involved in onshore wind farms in Gujarat, but include some important companies names:

* Continuum Green Energy
* Morgan Stanley Infrastructure
* Siemens Gamesa
* GE Energy Financial Services
* Tata Power
* Adani Green Energy
* ReNew Power
* Enercon

### 7.2.4 Available Operation and Maintenance companies

Here are some companies that provide operation and maintenance (O&M) services for wind farms in Gujarat:

* KP Energy Ltd
* Suzlon Energy Ltd
* Aditya Birla Renewable Energy
* GE Renewable Energy
* ReNew Power

## 7.3 Apply for Auction

* **Tender Issuance**: The Gujarat Urja Vikas Nigam Limited (GUVNL) or the Solar Energy Corporation of India (SECI) issues a Request for Selection (RfS) document. This document outlines the project details, eligibility criteria, and bidding process.
* **Pre-Bid Meetings**: Pre-bid meetings are held to clarify any queries from potential bidders and provide additional information about the project.
* **Bid Submission**: Interested bidders submit their technical and financial bids by the specified deadline. The technical bid includes details about the bidder's qualifications and project plan, while the financial bid includes the proposed tariff for the electricity generated.
* **Bid Evaluation**: The bids are evaluated based on technical and financial criteria. The bidder with the lowest tariff often wins the project, but other factors like experience and project feasibility are also considered.
* **Reverse Auction**: A reverse auction process is conducted where bidders lower their tariffs in subsequent rounds until the best price is determined.
* **Power Purchase Agreement (PPA)**: The winning bidder enters a PPA with GUVNL or SECI, which outlines the terms of electricity purchase, tariff, and project milestones. [26]

## 7.4 Construction

After finishing Auction process, starting Construction process. Construction is doing by same company or may be new one.

* **Site Preparation**: Clearing the site, levelling the ground, and preparing the foundation for the wind turbines.
* **Foundation Construction**: Building the foundations for the wind turbines.
* **Transport and Installation of Turbines**: Transporting the wind turbine components to the site and assembly.
* **Electrical Infrastructure**: Installing the electrical infrastructure, including cables, transformers, and substations to connect the wind farm to the grid.

## 7.5 Testing, Commissioning and Operation

* **Testing, Commissioning and Operation**: Once the project is completed, it is testing and commissioning and begins generating electricity, which is connecting to the local electricity to start delivering power.

### 7.5.1 Testing

Basically, there are three types of testing:

1. **Factory Tests (FAT)**

These tests are carried out during the manufacturing stage of WTGs and other key components to ensure quality and compliance with specifications. On the WTGs side, the most usual one are Test on Tower, Electrical and mechanical components.

1. **Site Acceptance Tests (SAT)**

Conducted on-site, these tests ensure that the equipment is installed correctly and functioning as intended.

1. **Performance Tests**

These tests evaluate the overall performance of the wind farm to ensure it meets operational and regulatory standards. The performance phase includes. [27]

### 7.5.2 Commissioning

### 7.5.3 Operation

## 7.6 Official Opening

* **Ribbon-Cutting Ceremony:** Provides a formal touch and a symbolic start to the wind farm's operation, while engaging local leaders and stakeholders.
* **Community Engagement:** The open house and tours offer transparency, allowing residents to see the project firsthand and learn about its benefits.
* **Educational Workshops:** Address any questions or concerns, educate attendees on renewable energy, and inspire future green initiatives.
* **Cultural Program:** Celebrates local cultural program with local community, which is increasing relationship.
* **Refreshments and Networking**: Keeps the atmosphere relaxed and enjoyable, providing informal opportunities for discussion and building connections.