

Environment and Social Impact
Assessment (ESIA) Report of 4.75
GW Solar/Wind/Hybrid Power project
located at Khavda, Bhuj, Gujarat

Prepared for:

Adani Green Energy Limited

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Executive Summary

Adani Green Energy Limited (“AGEL”) is developing a 4750 MW Renewable Energy Park through various Special Purpose Vehicles (SPVs) near Village Khavda, Taluka Bhuj, District Kutch, Gujarat, over a total land area of approximately 9500 hectares. The proposed development comprises integrated solar and wind power projects aimed at harnessing the region’s renewable energy potential through a Wind-Solar Hybrid configuration to achieve a stable power generation profile.

Development of solar and wind power projects offers several advantages, including shorter establishment periods, lower raw material and consumable requirements, and environmentally sustainable, non-polluting operations. The project is also expected to contribute towards reducing dependence on conventional fossil fuel-based power generation sources. In line with the renewable energy targets of the Government of India, the proposed project supports national commitments towards reduction of Greenhouse Gas (GHG) emission intensity by 33-35% compared to the 2005 baseline levels, thereby contributing to the country’s clean energy transition and climate change mitigation objectives.

To facilitate achievement of renewable energy targets, the Central and State Governments have introduced various policies promoting solar, wind, and wind-solar hybrid projects. Gujarat has emerged as one of the leading states in implementation of large-scale renewable energy projects under these policy frameworks.

AECOM India Private Limited (“AECOM”) was appointed by Adani Green Energy Limited (“AGEL”) to undertake the Environmental and Social Impact Assessment (ESIA) study for the proposed Hybrid (Solar and Wind) Power Project in accordance with IFC Performance Standards, Equator Principles, World Bank Group EHS Guidelines, applicable sector guidelines, and relevant national environmental laws and regulations.

The proposed renewable energy development near Khavda village, Bhuj Taluka, Kutch district, Gujarat, is being implemented in phases through various SPVs under Adani Green Energy Limited (“AGEL”). As part of the ongoing phase, Adani Renewable Energy Fifty-Six Limited (“ARE56L”) is developing a 900 MW Solar Power Project comprising 500 MW and 400 MW capacities. Additional capacities currently under development include 150 MW under ARE48L and 366 MW under AGE26BL, while the balance capacities are proposed to be finalized at a later stage.

The ESIA site visit was undertaken by AECOM in June 2024, during which the project site was observed to be at an early-planning stage with greenfield conditions and no significant on-site activities. The ESIA study has been carried out through baseline surveys, site assessments, document review, desktop analysis, and stakeholder consultations in alignment with IFC Performance Standards (2012), World Bank Group EHS Guidelines, Equator Principles, relevant ILO conventions, and applicable national and state regulatory requirements. The assessment aims to identify and evaluate potential environmental and social impacts associated with the project lifecycle and recommend appropriate management and mitigation measures.

Study Methodology

The aim of the ESIA study is to evaluate environment and social risks and impacts associated with the Project. The ESIA study comprised of a reconnaissance survey, baseline environmental monitoring, primary ecological survey, data analysis and consultations and discussions with relevant stakeholders.

For the ESIA study, the Study Area has been delineated as ‘Area of Direct Influence’ and ‘Area of Indirect Influence’ as defined below.

- a) Area of Direct Influence (Core): The area covering the WTG footprint and solar park is designated as the area under the direct influence of the project for environmental, ecological and social impacts.
- b) Area of Indirect Influence (Buffer): Area outside the direct impact zone of the project, up to a radius of 5 km, is considered as the indirect influence zone for the project for environmental, ecological and social impacts.

All the baseline environmental profiling, including environmental monitoring, biodiversity studies, socio-economic studies, and public consultations, have been carried out within the Aol of 5 km. Note that about 98 percent of the study area of transmission line corridor is overlapped with 5km Buffer of the solar project area.

AECOM team conducted a site survey from June 2024, which included environmental monitoring and baseline data collection, biodiversity assessment and consultations with key stakeholders. Secondary information was collected through literature reviews. Impact identification and prediction were undertaken based on collected environmental and social baseline data.

Impact identification and prediction were undertaken based on environmental and social baseline data collected. The major processes involved are:

- **Identification** - to define the impacts associated with different phases of the project and the activities undertaken.
- **Prediction** - to forecast the nature, magnitude, type, duration, extent, scale, frequency, likelihood and sensitivity of the major impacts identified.
- **Evaluation** - to determine the significance of residual impacts i.e., taking into account how mitigation will reduce a predicted impact.

Subsequently, the Environmental and Social Management Plan (ESMP) has been prepared, delineating the roles, responsibilities and timeline for implementing mitigation measures to prevent the significant impacts arising from activities during different phases of the project.

Project Categorization

For project categorisation, a screening exercise was undertaken considering the project's characteristics, scale, location sensitivity, local issues and potential environmental and social impacts. The screening exercise was supported by a reconnaissance survey, data validation and ground truthing.

Based on the available primary and secondary data, the proposed project is anticipated to have limited, site-specific, and largely reversible environmental and social impacts that can be effectively managed through mitigation measures. No protected areas, eco-sensitive zones, or Important Bird Areas (IBAs) are located within 10 km of the site. Further, given the project's location within a restricted Border Security Force jurisdiction and the absence of settlements within 30 km, significant social impacts are not anticipated. Accordingly, the proposed 4.75 GW Hybrid Power Project may be classified as '**Category B**' in line with IFC Environmental and Social Sustainability criteria.

Resource Requirement

Land Requirement

Land requirement for the proposed project shall be sufficed through long-term lease arrangements of 25-29 years and direct purchase from willing landowners. The total land requirement includes 9,312.32 hectares for the Solar Power Project, 12 hectares for the Pooling Substation (PSS), and 175.68 hectares for the Wind Power Project, including a WTG footprint area of 1.44 hectares.

Manpower Requirement

The manager, mechanical, electrical, Control and instrumentation team will work in general shift. All other operation personnel would work on three shift basis. Manpower for shift personnel managing key areas has been generally done taking into several O&M activities scheduled for the shift and considering leave reserves and personnel training periodic sessions.

Water Requirement

Water for site construction may be delivered from authorised bore wells outside the plant area although the water quality may need to be assessed by the developer for construction use. In case, Groundwater is used then prior approval from the appropriate Government Water supply authority shall be considered. Water can also be made available by tankers and open reservoirs, though the authorized water suppliers. Additionally, plant may also develop its own internal water harvesting system as feasible after the topography study to elevate the Groundwater level in the area.

Environment Baseline Data Collection

Environmental baseline information was collected through primary monitoring and reconnaissance surveys of the study area (5 km distance from the project boundary). The baseline study covered the following thematic areas:

- The primary environmental baseline data were collected with respect to groundwater (02 locations), ambient air quality (AAQ) (02 locations), ambient noise level (02 locations), soil quality(02 locations), and socio-economic profile. The ecology and biodiversity data were also collected as part of the primary data collection.

- The GIS mapping of the study area was done to present details on land use patterns, forest/ vegetation cover, settlements, water bodies, drainage pattern and contours.
- Information on geology, meteorological conditions, water and ecological resources, socio-economic status, etc., was collected from secondary sources.

Natural Hazards

Earthquake Hazard

The project site is situated in Zone V, classifying it as a very high damage risk zone concerning earthquake occurrences

Wind Hazard

The Project site is located in an area that experiences high wind velocities $V_b = 47$ m/s and the zone is classified as High damage risk zone for wind hazard

Flood Hazard

The Project area is not located in the area liable to river floods. However, a significant amount of land of the proposed project site remains inundated during and after the monsoon.

Biodiversity Baseline

As per classification of Indian Biogeographic zones published by Wildlife Institute of India (Rodgers, et al. 2002), the project site falls under Biogeographic Zone 8A West Coast. Globally, the region falls in Indo- Malay Realm and Deserts and Xeric Shrublands Biome represents a large expanse of scattered dry forest.

The project site does not overlap with any protected areas such as National Parks, Wildlife Sanctuaries, Tiger Reserves, Reserved Forests, Protected Forests, Conservation Reserves, Community Reserves, or Eco-Sensitive Zones. However, one National Protected Area/Ramsar Site and three Important Bird and Biodiversity Areas (IBA/KBA) are located within a 50 km radius of the site. The Rann of Kutch Wildlife Sanctuary, which is also designated as a Ramsar Site and IBA/KBA, is located approximately 6.5 km from the northern boundary of the project site within Pakistan territory. Other nearby biodiversity-sensitive areas include Flamingo City IBA (~36.98 km), Banni Grassland and Chhari Dhand Conservation Reserve (~22.16 km), Kutch Desert Wildlife Sanctuary (~28.55 km), and its Eco-Sensitive Zone (~27.3 km). Shakoor Lake, known for supporting avifaunal species, is located approximately 25 km from the project site.

Socio Economic Baseline

The socio-economic assessment of the proposed 4.75 GW Hybrid Solar and Wind Power Project at Khavda was undertaken based on site observations, Google Earth imagery, and secondary demographic data from the Census of India 2011. No inhabited settlements or villages are located within 34 km of the project site. The nearest villages include Khavda, Kuran, Dhrobana, and Dinara in Kutch district, Gujarat, which were considered for the socio-economic baseline assessment.

Demographic Profile

The four nearby villages considered for the socio-economic assessment have a combined population of 20,916 with 4,490 households and an average household size of 4.6. The male and female population constitute approximately 51.4% and 48.6%, respectively, with an average sex ratio of 946. The total child population is 4,987, with an average child sex ratio of 956.

Vulnerable Groups

The Scheduled Caste (SC) population across the four villages constitutes 8.2% of the total population, while the Scheduled Tribe (ST) population is negligible at 0.3%. The proportion of ST population in the study area is comparatively lower than the corresponding Taluka, district, and state averages.

Literacy Level

As per Census 2011 data, the average literacy rate in the study area is 42.5%, which is lower than the literacy rates at the Taluka (73.18%), district (70.59%), and state (69.14%) levels. The average male and female literacy rates in the study area are 53.9% and 30.5%, respectively, indicating a literacy gap of 23.4%.

Workforce Participation

As per Census 2011 data, the Working Participation Rate (WPR) in the study area is 32.8%, which is lower than the WPR at the Taluka (35.4%), district (36.6%), and state (40.98%) levels. Of the total working population, males and females constitute 48.4% and 16.4%, respectively, while the non-working population accounts for 67.2%, including 51.6% males and 83.6% females.

Among the total workers, 72.8% are main workers and 27.2% are marginal workers. Male workers constitute a higher proportion of main workers (87.8%), whereas female workers account for a higher proportion of marginal workers (73.9%). The workforce is predominantly engaged in agricultural labour activities, with 55.2% of main workers and 67.7% of marginal workers dependent on agricultural labour, followed by engagement in other work categories, cultivation, and household-based activities.

Social and Physical Infrastructure

The nearby villages have limited infrastructure and basic civic amenities. Water supply is primarily dependent on untreated groundwater, handpumps, dug wells, and government tanker supply, with no drainage systems or nearby surface water sources. Educational facilities are limited to government schools, with no colleges available within the villages, requiring students to travel to Bhuj for higher education. Healthcare infrastructure is also limited, with only basic primary and community health facilities available, and residents depend on Bhuj for advanced medical services. Electricity supply is available through the grid, with approximately 24-hour domestic supply and around 8-hour supply for agricultural and commercial use.

Shadow Flicker and Sensitive Receptors

Shadow flicker impacts associated with wind turbines are not anticipated to be significant, as the project site is located on barren land and the nearest habitation is approximately 34 km away. Accordingly, no sensitive receptors are present within the project footprint or surrounding buffer area that would be affected during the operational phase.

Environmental and Social Impacts

The key potential environmental and social impacts of the project are summarized as follows:

Air Quality: During construction, short-term and localized impacts on air quality are anticipated due to fugitive dust emissions from earthworks, access road development and increased vehicular movement. With the implementation of standard dust suppression measures and good construction practices, the overall impact is expected to be low and temporary. No significant air emissions are anticipated during the operational phase.

Noise and Vibration: Construction activities will cause a temporary increase in ambient noise levels due to the operation of machinery and movement of construction vehicles, which may add to background noise. However, no sensitive receptors are present within the project footprint or surrounding buffer area so the overall noise impacts are anticipated to be minor and manageable.

Wastewater: Wastewater during construction and operation phase mainly consist of domestic sewage from site offices and labour camps. Drainage systems with soak pits and septic tanks will manage waste with periodic removal by disposal trucks. Operational-phase wastewater generation will be minimal.

Solid and Hazardous Waste: Construction and operation phase activities would generate construction and demolition waste, domestic waste, packaging materials, debris and scrap. Such waste should be segregated, re-used and non-recyclables should be handed to authorized agencies. Hazardous waste, including used oil, rags, e-waste and batteries will be safely stored and disposed of through authorized recyclers.

Shadow Flicker: Shadow flicker occurs when turbine blades cast moving shadows, and is most pronounced at sunrise, sunset, and during higher wind speeds. However, no sensitive receptors are present within the project footprint or surrounding buffer area so the overall impact is non significant.

Biodiversity: Land clearance and construction activities may disturb local ecology and biodiversity, primarily within the Project footprint, including WTG sites, solar park and access roads.

Occupational Health and Safety (OHS): Workers may be exposed to electrical hazards, falls from height, mechanical vibrations, noise and risks related to turbine or transformer failure. Unsafe act and unsafe condition have potential to cause injury, death, loss of man-days and may cause site emergency.

Community Health and Safety: The civil works and influx of workers may cause several negative impacts, including social conflict, the spread of communicable diseases, inefficient disposal of solid waste and improper sanitary conditions at labour camps, which may lead to pollution and inconvenience for local communities.

An Environmental and Social Management and Monitoring Plan has been proposed to ensure that social and environmental impacts, risks and liabilities identified during the ESIA process are effectively managed during the operation and closure of the project. The ESMP delineates the monitoring and management measures to avoid and/ or minimize the identified impacts by allocating management responsibility and suggesting skill requirements for the implementation of these measures.

Key Environment and Social Management Plan Aspects

Sl. No.	Aspect	Potential Impact	Mitigation and Management Measures
1	Ambient Air Quality	<ul style="list-style-type: none"> Fugitive dust emissions during construction (earthworks, vehicle movement) Exhaust emissions from construction machinery and DG sets 	<ul style="list-style-type: none"> Implement dust suppression measures such as regular water sprinkling on access roads, foundations and material storage areas, particularly during dry periods. Cover trucks carrying soil, sand and construction materials to prevent spillage and dust dispersion. Ensure construction machinery and vehicles are well maintained and comply with applicable emission norms. Restrict vehicle speeds on village roads and internal project roads. Use DG sets with acoustic enclosures and comply with CPCB emission standards. Conduct periodic ambient air quality monitoring during construction at representative locations.
2	Ambient Noise Levels	<ul style="list-style-type: none"> Noise generation due to construction activities and operation of WTGs affecting nearby sensitive receptors 	<ul style="list-style-type: none"> Conduct periodic noise monitoring during construction and operation phases. Regular Maintenance of construction equipment and WTGs to minimise mechanical noise generation. Implement a Grievance Redress Mechanism (GRM) to address noise-related complaints promptly.
3	Natural Hazards	<ul style="list-style-type: none"> Potential risks include damage to infrastructure, safety hazards for workers and communities and disruption to operations. 	<ul style="list-style-type: none"> Conduct site-specific hazard risk assessments and integrate findings into project design. Ensure all structures comply with applicable safety codes for wind and seismic resilience. Install lightning protection systems on turbines and key infrastructure. Develop and implement an Emergency Preparedness and Response Plan (EPRP) covering extreme weather events and natural disasters. Train workers in emergency response procedures and conduct regular drills.

Sl. No.	Aspect	Potential Impact	Mitigation and Management Measures
			<ul style="list-style-type: none"> Maintain coordination with local authorities for early warning systems and disaster response.
4	Soil and Land	<ul style="list-style-type: none"> Soil erosion due to excavation and grading Soil compaction and contamination from oil spills Loss of topsoil from agricultural land 	<ul style="list-style-type: none"> Strip, store and reuse topsoil separately for site restoration and plantation activities. Implement erosion control measures such as bunds, silt traps and proper drainage at excavation sites. Restrict vehicle movement to designated routes to minimise soil compaction. Provide spill kits at fuel storage and maintenance areas and ensure immediate clean-up of any oil or chemical spills. Restore temporarily disturbed areas post-construction to near-original conditions.
5	Waste Management (Solid & Hazardous)	<ul style="list-style-type: none"> Generation of construction debris and domestic waste Generation of hazardous waste such as used oil, grease, oily rags and batteries 	<ul style="list-style-type: none"> Segregate waste at source into biodegradable, recyclable and hazardous waste categories. Dispose of construction debris through authorised vendors or reuse where feasible. Collect domestic waste from labour camps and dispose through local-authority-approved or authorised agencies or bio-compositing at the sight. Store hazardous waste (used oil, lubricants, oily waste) in designated, banded areas with proper labelling. Dispose hazardous waste only through State Pollution Control Board authorised recyclers/ vendors and maintain waste manifests and records. Prohibit open burning or indiscriminate dumping of waste within the Project area.
6	Occupational Health and Safety (OHS)	<ul style="list-style-type: none"> Electrocution risks Fire due to short circuits Falls from height Occupational illness and injuries Heat stress 	<ul style="list-style-type: none"> Implement an OHS Management System aligned with IFC EHS Guidelines. Conduct job-specific safety training including electrical safety and working-at-height procedures. Implement Lock-Out/ Tag-Out (LOTO) procedures during maintenance works. Provide and enforce use of appropriate PPE including helmets, harnesses, gloves, safety shoes and arc-flash protection. Equip electrical installations and transformer yards with fire-fighting systems and emergency response equipment. Maintain incident, accident and near-miss reporting and investigation records.
7	Biodiversity and Avifauna	<ul style="list-style-type: none"> Habitat disturbance Avifauna mortality due to collision, electrocution, and barotrauma 	<ul style="list-style-type: none"> Improve turbine blade visibility (e.g., painting one blade black) to reduce bird collision risk. Install line markers (bird flight diverters) on transmission lines, in consultation with relevant experts and the Central

Sl. No.	Aspect	Potential Impact	Mitigation and Management Measures
		<ul style="list-style-type: none"> Increased human presence and vehicle movement associated with project activities may pose a risk to herpetofauna (Indian Flapshell Turtle) in the surrounding area. Potential risk of poaching and hunting of resident and migratory species by migrant workers during the construction phase. 	<p>Electricity Authority, to reduce bird fatalities.</p> <ul style="list-style-type: none"> Minimise artificial lighting by using low-intensity, downward-directed, hooded fixtures to reduce attraction of night-flying birds. As a best industry practice, enable temporary turbine shutdowns during periods of high bird activity or seasonal migration to further reduce avian mortality. Regularly monitor and remove carcasses from the site to avoid attracting scavenging raptors. Implement a long-term monitoring programme for bird and bat activity around WTGs and transmission lines, maintain a faunal mortality log, and generate baseline data to assess and manage collision risks. Control vehicle movement, restrict worker access to sensitive areas, and implement awareness measures to minimise risks to herpetofauna species. Enforce a strict no-hunting and no-poaching policy for all project personnel, supported by worker awareness programmes, controlled site access, and coordination with the Forest Department. After 2 years of operation phase the present bird mitigation measures will be updated, if required, by consultation with the wildlife department and experts based on the bird hit monitoring report as per SOP of AGEL, Incident register report and initial baseline monitoring report.

Key Findings:

Based on the criteria set forth in the IFC Policy - Environmental and Social Sustainability, the project is classified as '**Category B**'. Available primary and secondary data indicate that the environmental and social risks and impacts associated with project allied activities are expected to be limited, generally site-specific, largely reversible and can be readily managed through appropriate mitigation measures.

1. The project site is located in Khavda Village in Bhuj Taluka. Land for the proposed development has been taken on lease from Government of Gujarat on lease agreements ranging from 25 to 30 years. No Private revenue land has been procured. The overall land allocation comprises 9,312.32 hectares for the solar facilities, 12 hectares for the Pooling Substation (PSS), and 175.68 hectares for the wind power component, including a WTG footprint area of 1.44 hectares.
2. During the site visit, no residential or commercial structures were observed on the identified private land. Accordingly, no physical displacement is anticipated as a result of land procurement.
3. The proposed project site does not overlap with any protected areas or eco-sensitive zones; however, biodiversity-sensitive areas including the Rann of Kutch Wildlife Sanctuary/Ramsar Site, Flamingo City IBA, Banni Grassland and Chhari Dhand Conservation Reserve, Kutch Desert Wildlife Sanctuary, and Shakoor Lake are located within a 50 km radius of the site.

4. The project site falls within Seismic Zone V, categorized as a very high earthquake risk zone, and is also located in a high wind hazard area with design wind velocities of 47 m/s. While the site is not prone to river flooding, parts of the project area remain inundated during and after the monsoon season.
5. The concentrations of all ambient air quality parameters (PM10, PM2.5, SO2, NO2, and CO) at the monitoring stations were found to be within the National Ambient Air Quality Standards (NAAQS) 2009. It is also found that daytime and nighttime noise levels are well within CPCB limits specified for Residential area as per Noise Pollution (Regulation and Control) Rules, 2000. Analysis of groundwater samples indicates that the groundwater quality in the region is generally unsuitable for drinking purposes.
6. A site-specific Grievance Redressal Mechanism (GRM) should be implemented by the Client to overcome public inconvenience (if any) during the O&M phase.
7. The Project to ensure that all applicable environmental and social regulatory approvals and permits are obtained in accordance with statutory requirements.

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