Taïba Ndiaye Wind Farm

Environmental and Social Impact Study

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Cabinet d'Eco-conseil et d'Etudes

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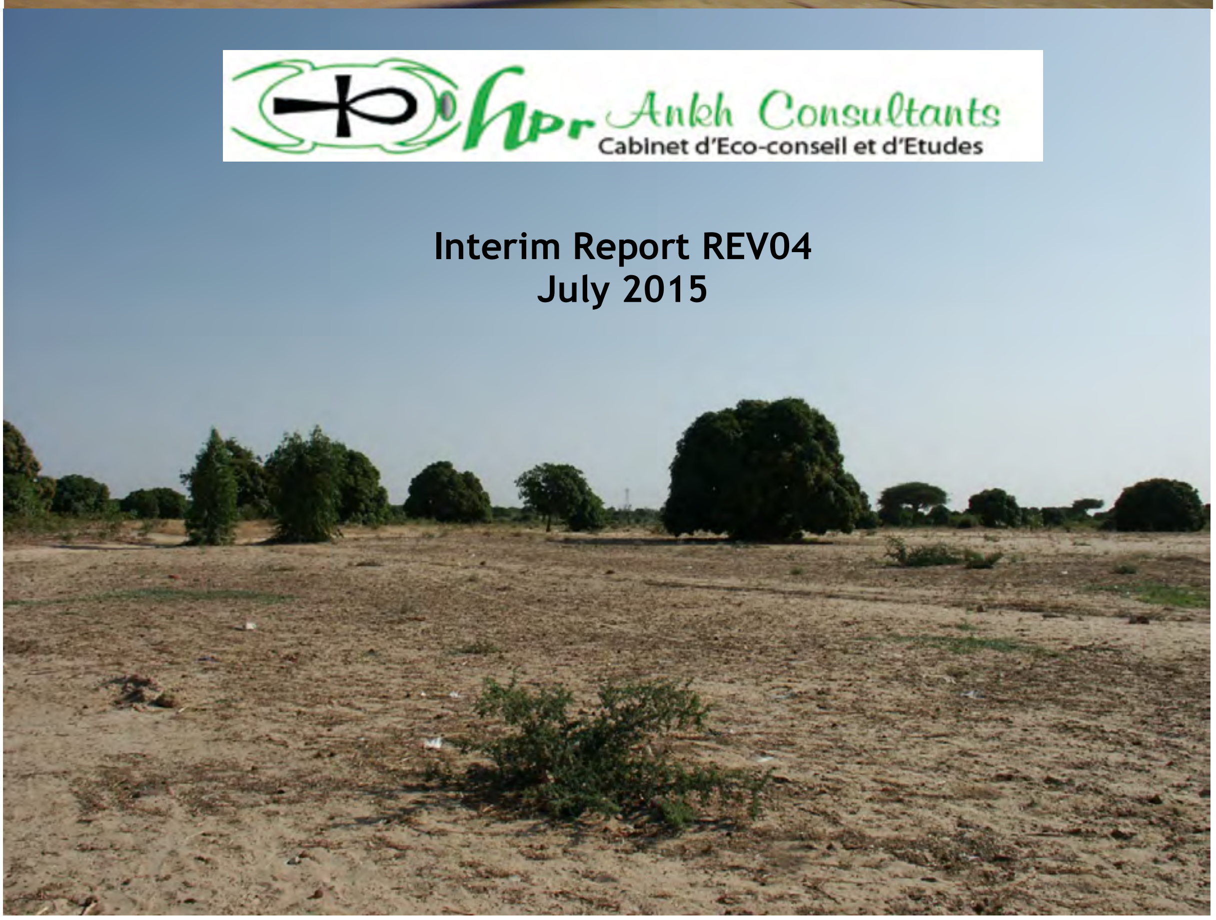

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1 NON-TECHNICAL SUMMARY

1.1 INTRODUCTION

The operating permit request for the wind farm at Taïba Ndiaye is the pretext for this in-depth environmental impact study.

The site which is to host the project covers an overall surface area of approximately 7 ha split into 47 plots of land (46 for the wind turbines and 1 for the technical/operations zone). The administrative information for the work zone is as follows:

Country:	**Senegal**
Region:	Thiès
Department:	Tivaoune
Rural Community	Taïba Ndiaye
Locations impacted by the project	**Ndomor, Keur Malé, Minam, Mbayéne, Keur Birama, Keur Samba Awa, Keur Mbaye Sénoba. Taïba Mbaye, Same Ndiaye, Baïty Ndiaye Baïty Gueye, Keur Madiagne Taïba Santhie, and Keur Assane**

1.2 DESCRIPTION OF THE PROJECT

The project relates to the development, construction and implementation of a wind farm with 46 wind turbines providing power of 3.3 MW per unit, amounting to total power of 151.8 MW.

The project's execution may be split into 5 phases:

Phase 1: The development phase: Impact feasibility studies; in progress

Phase 2: The administrative and contractual phase: Obtaining permits (building permits, operating permits) and purchase contracts for the electricity produced over a period of 20 years; in progress

Phase 3: The construction phase for the first tranche, with the installation of 16 x 3.3 MW wind turbines, providing a total power of 52.8 MW (approximately).

Phase 4: The construction phase for the second tranche, with the installation of 16 x 3.3 MW wind turbines, providing a total power of 52.8 MW.

Phase 5: The construction phase for the third tranche, with the installation of 14 x 3.3 MW wind turbines, providing a total power of 46.2 MW

✓ <u>How a wind turbine works</u>

The main components of a wind turbine are (from bottom to top):

- Foundations that may exceed 400 cubic meters of reinforced concrete,
- A metal tower that is either tubular or made from lattice work. The electric transformer system (alternator) and a ladder for gaining access to the top of the tower can be found inside the base,
- A rotor consisting of a set of blades. These are made from composite materials and there are usually three of them (three-blade system). Sometimes the wind turbine only features two of them (two-blade system),
- A nacelle housing the core of the wind turbine, particularly the electric generator, the gearbox, the braking system, etc.
- A set of equipment and auxiliary instruments: the system for orienting the nacelle (wind vane), devices for measuring the wind speed (anemometer), electronic control devices, etc.

Rotor with a horizontal shaft fitted with three blades

Nacelle

Tower

Whenever the wind picks up (to a speed of about 5 km/h), the blades begin moving solely from the force of the wind. Their movement activates the gearbox and the electric generator.

When the wind is sufficiently strong to overcome friction (at a speed of about 15 km/h), the wind turbine can be coupled to the electrical network. The rotor then spins at a rate of one turn every 4 to 6 seconds. This rotation speed will remain constant throughout the production period so that an alternating current with a constant frequency may be produced.

The generator will then deliver an electric current, the intensity of which varies depending on the wind speed. Thus, when the latter increases, the load bearing on the rotor is accentuated and the power provided by the generator increases.

When the wind reaches about 40 km/h, the wind turbine provides its maximum power level. This power is kept constant using the aerodynamics of the blades.

The anemometer will intervene in relation to extreme wind conditions. In fact, above and beyond a certain wind speed, which varies depending on the models in question, the wind turbine will be "stopped". In concrete terms, when the wind speed exceeds about 90 km/h, the blades are feathered, or placed parallel to the wind direction. The rotor then freewheels, turning slowly, and the wind turbine no longer produces any electricity.

✓ The project's zone of influence

Three (3) study zones were delineated for the purposes of this ESIS (Environmental and Social Impact Study).

☞ **The restricted study zone**

This is a zone inside of which the project is technically feasible with forty-six (46) wind turbines, each taking up 1,400 m^2, making for a total siting of 7 hectares, and on access paths which must have high-voltage cables amounting to a linear distance of approximately 34 km.

☞ **The detailed study zone or the works' direct zone of influence**

This takes into consideration all of the territory disrupted or the work zone. It includes a radius of influence, exceeding five (5) km. It is defined based on the potential impact sources linked to the project's construction phase.

☞ **The expanded or remote study zone**

This relates to the zones of the territory belonging to local entities (the rural community of Diass) covered by the socio-economic analysis. This zone factors in the project's potential effects on the components of the socio-economic and biophysical environment.

☞ **Estimate concerning the settlements closest to the various rows**

Estimating the distance between the wind farm and the various surrounding locations is of paramount importance because it enables identification of the zones which may be adversely affected by the project's impacts (noise pollution, landscape impacts, etc.).

The closest villages (Baïty Guèye, Baïty Ndiaye, Khelcom Diop, Ndombor Diop, Taïba Santhie, Taïba Ndiaye, Maka Gaye Bèye, Diambalo, etc.) are located less than 2 km away from the project.

The locations of the wind turbines closest to the villages are:

Rows or groups concerned	Wind turbine concerned	Distance from buildings (Km)	Village concerned
Row 5	E46	1.27	Baity Ndiaye
	E41	1.07	Maka Gaye Beye

Rows or groups concerned	**Wind turbine concerned**	**Distance from buildings (Km)**	**Village concerned**
	E39	0.95	
	E40	0.95	
Row 4	E31	1.42	Baity Gueye
Row 3	E27	1.27	Khelcom
	E28		
	E18	2.6	Taïba Ndiaye
Row 2	E10	1.75	Ndiombor Diop
	E11	1.07	Khélcom Diop
	E12	1.06	
	E13	1.18	
Row 1	E1	1.4	Diambola

1.3 OVERVIEW OF THE SENSITIVITY OF THE HOST ENVIRONMENT

This entails a scientific assessment of the sensitivity and vulnerability of species of plants and animals, the project's direct areas of influence, and the project's remote and induced effects.

Translating raw environmental data into sensitivity levels is a key stage in the procedure. Defining the various issues involved (landscape, heritage, ecological and other such stakes) enables the sensitivity of the project's sites to be assessed. The environmental data, translated into sensitivity levels, can then be categorized into several levels: low sensitivity, medium sensitivity, high sensitivity, and very high sensitivity.

Assessment of the sensitivity of the various components in the project's environment

THEME	CHARACTERISTICS OF THE PROJECT'S ZONE	STAKES LEVEL	COMPATIBILITY WITH THE PROJECT
Geology	The overall context is linked to that of the Senegal-Mauritanian Basin.	P	A relatively flat area: the altitude levels range from 33 to 60 meters. The local geological context for establishment of Niayes (dune systems): a succession of basins and unconsolidated dunes. A Niayes region with high groundwater.
Pedologic resources	An interesting level of diversity in terms of pedologic resources is noted in the project's zone: Dior soil, Deck-Dior soil, Deck soil, and Dior-Dior soil.	N	The presence of Deck-Dior soil suitable for arboriculture and cash cropping The presence of Deck soils rich in organic materials suitable for market gardening.
Groundwater	The numerous hydrogeological formations are accessed via traditional wells and boreholes.	N	Potable groundwater throughout the villages affected by the project and the environs. High groundwater (between a depth of 17 meters to 66 meters) is exploited via traditional wells: co-operatives, agriculture and livestock rearing. Groundwater held in Lutetian limestone is exploited via boreholes: cooperatives , agriculture and livestock rearing.
Surface water	There are no long-term water supply points at the project's site or in its surrounding environment.	N	No long-term water supply points on-site and/or in the zone of influence. There are numerous temporary pools which become depleted a few months after the last rains. The market garden basins are filled by surface water during the rainy season.
Natural risks	Flooding of basins or low-lying areas.	N	Flooding of basins or low-lying areas (proximity to the high groundwater).

THEME	CHARACTERISTICS OF THE PROJECT'S ZONE	STAKES LEVEL	COMPATIBILITY WITH THE PROJECT
	Crops are attacked. Collapsing sand dunes.		Shifting dunes subject to collapse. Crops are attacked by pests: worms, termites, ants, etc.
Sensitive zones	The only listed area in the project zone is the Pire Gourèye area (listed under Order No. 1857 of 5 May 1946) which brings together nineteen (19) villages.	**P**	No sensitive area has been noted in the immediate zone of influence of the project's sites. The only Protected Forest under the project's influence is that of Pire Gourèye. PF dominated by palmyra groves Existence of a bird migration corridor (between the PNOD (Djodj National Bird Park) and the islands of Sine Saloum).
Flora and vegetation	The species encountered at the site and in the surrounding environment have Sahel-Sudan phytogeographic affinities: falling within the 350 and 600 mm isohyets. The taxonomic spectrum (the site and the surrounding environment) indicates 128 species belonging to 99 genera, split into 41 families. The *Poaceae* (*Graminae*) family is the most diverse one, with 18 species, followed by the *Fabaceae-Faboidae* family which has 17 specific taxa. The *Indigofera* genus is the most diverse one, featuring 7 species.	**N**	Presence of three (3) endemic species (*Crotalariasphaerocarpa, Polycarpaea linearifolia* and *Vernoniabambilorensis*) of Senegalese flora. The presence of three (3) threatened species *(Borassus aethiopum, Adansonia digitata, Faidherbia albida)* or species that may pose a threat to other Senegalese species. The presence of eight (8) species *(Adansonia digitata*, *Borassus aethiopum*, *Elaeis guineensis*, *Faidherbia albida*, *Grewia bicolor*, *Prosopis africana*, *Tamarindus indica* and *Ziziphus mauritiana)* that are partially protected by the Senegalese Forestry Code. The presence of types of trees that have multiple uses *(Adansonia digitata*, *Borassus aethiopum*, *Elaeis guineensis*, *Faidherbia albida*, *Grewia bicolor*, *Prosopis africana*, *Tamarindus indica* and *Ziziphus mauritiana, etc.)* some of which are protected by the Forestry Code and are listed as protected Senegalese flora.

THEME	CHARACTERISTICS OF THE PROJECT'S ZONE	STAKES LEVEL	COMPATIBILITY WITH THE PROJECT
			The presence of a type of tree of proven value to the eco-system.
Fauna	The fauna encountered at the project's site and in the surrounding environment mainly consists of birds or avifauna. The inventory mentions the presence of 25 families split into 39 genera and 39 species. The dominant families are: *Columbidae* (12.82%), *Accipritidae* and *Ploceidae* (7.69 % each). The *Apodidae*, *Coracidae* and *Psittacidae* families each account for 5.13%. The rest of the families inventoried each account for 2.56 %.	**N**	The presence of numerous birds from four species fully protected by the Hunting Code. The presence of three species of mammals listed in Appendix I of the 2011 version of the CITES Convention *(Mungos mungo, Ichneumia albicauda* and *Canis aureus).* The presence of five birds featured in Appendix II (1) (*Milvus migrans, Tockus erythrorhynchus, Tockus nasutus, Bubulcus ibis* and *Poicephalus senegalus*)
Population	The estimated population of the Rural Community (RC) is 24,114 inhabitants; the breakdown for the population of the RC of Taïba Ndiaye is 47.97% males and 52.02% females, with 60% of the population being young people from 0 to 19 years of age. Of the 39 villages comprising the RC of Taïba Ndiaye, 10 villages are affected by the project. The closest housing sites are 1.2 and 1.5 km from the project's sites.	**P**	There are ten (10) villages, the closest of which are 1.2 km to 1.5 km away.
Socio-economic activities	The greatest cash crop continues to be manioc (cassava), which covers nearly 65% of the surface areas, while millet (20% of the cultivated surface areas) and black-eyed peas (5% of the cultivated surface areas) are food crops, followed by market gardening and other seasonal and perennial crops, particularly mangoes. Grazing activities are dominated by semi-intensive grazing.	**N**	Strong presence of agricultural activities: arboriculture, market gardening, rainfall agriculture, etc. Low presence of grazing activities: extensive livestock rearing. The presence of species of plants that have multiple uses and are exploited by the local populations.

THEME	CHARACTERISTICS OF THE PROJECT'S ZONE	STAKES LEVEL	COMPATIBILITY WITH THE PROJECT
	Harvesting activities have been developed with the exploitation and sale of forest products.		
Infrastructure	The only infrastructures at the site and in its immediate surrounding environment consist of the investments made by concessionaries (Senelec (Senegal's national electricity company), SDE (the national water company), and Sonatel (the national telcommunications company)) and a few personal investments in agricultural lands.	**P**	The presence of overhead and underground lines belonging to Senelec.
		N	The presence of numerous concessionaries: Senelec, Sonatel and SDE: overhead and/or underground networks. The presence of boundary hedges established by the operators. The presence of traditional wells (known as "céanes") in market garden basins, set up by farmers.
Transport	The main ways of getting around are sandy rural tracks: main ones and secondary ones.	**N**	The presence of numerous production tracks: main tracks and secondary tracks.
Climatology	The project's zone is located in the Sahel-Sahara climatic area, falling within the 350 and 600 mm isohyets.	**P**	Maximum low wind speed: 2.8 m/s from September to October. Maximum speeds from March (4.1 m/s) to May (4.06 m/s).

1.4 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN AND IMPACTS

The environmental and social management plan enables the mitigation measures listed below to be implemented depending on the potential impacts identified. This plan specifies those responsible for implementation of these measures, as well as the surveillance, inspection and monitoring of them. It also provides methodologies for the implementation of the measures indicated.

The environmental and social management plan features a set of measures for mitigating the negative impacts, set out according to the three key stages of the project - the preparation, operation, and closure/decommissioning of the site.

It also sets out the methods for implementing these measures and features a surveillance and monitoring plan, as well as institutional measures for strengthening the capacity of the parties responsible for its implementation and for informing the local population.

Environmental and Social Management Plan during the wind farm's design and development phase

Potential negative impacts	Mitigation measure	Period	Company in charge	Strategy implemented by the Developer	Indicators	Cost	Monitoring/ Regulatory Inspection
Temporary compacting of the soil	Carrying out soil tests in order to determine the nature of the site.	**Engineering phase**	**PETN**	**Geotechnical studies by an approved laboratory**	**Test results**	**10,000,000**	**PETN RC of Taïba Ndiaye DREEC (Regional Division for the Environment and Listed Establishments)/Thiès and Monitoring Committee**
Ground waterproofing after laying concrete and excavating soil.	Priority reuse for agricultural purposes of the good soil excavated from the paths and from the surface layer for the foundations.	**Development phase**	**PETN**	**Recycling and reuse of the soils**	**The volumes of excavated soil reused**	**Included in the CPTP (Special Works Specifications) for the works**	**PETN DREEC/Thiès, Monitoring Committee Project Manager and landowners**
Soil and groundwater pollution due to accidental seepage of liquid pollutants (worksite or storage machinery:	Storage of hazardous liquid products (oils, fuel, etc.) during construction in a holding tray that can hold the tank's full volume.	**Development phase**	**PETN Works Contractor**	**Making pollution prevention kits available at the worksite**	**The presence of holding trays The number of emergency interventions Technical inspections of heavy machinery**	**Included in the works quotation**	**DREEC/Thiès, Monitoring Committee and Project Manager**

hydrocarbons, hydraulic fluids, lubricants and paints).							
Soil and sub-soil pollution: presence of oils in the wind turbines (approximately 1,500 litres per wind turbine), oil in the transformers.	Placement of equipment items with oils inside them (gearbox, transformers, etc.) in a holding bin that is sufficiently large.	**Engineering phase**	**PETN**	**Giving priority to dry transformers instead of transformers that use oil**	**As above**	**Included in the works quotation**	**DREEC/Thiès, Monitoring Committee and Project Manager**
Reduction of the arable surface areas and a decline in production yields Loss of forestry and agriculture production	Compensate landowners in accordance with a scale that has been jointly agreed to Selection of the site Fair and equitable compensation of the people affected by the project	**Engineering phase** **Development phase**	**PETN**	**Setting up a compensation committee**	**The number of people affected by the project** **The compensation amount** **The number of complaints and claims**	**To be determined with the landowners and the Municipal Council of Taïba Ndiaye**	**DREEC/Thiès, Monitoring Committee** **Rural Council** **Compensation Committee**
Pruning or possible removal of certain trees planted and/or important shrubs along the access paths.	Protection of important species located in the fields and along the access paths.	**Development phase**	**PETN** **IREF**	**Plant trees and shrubs to compensate for this**	**The number of plants** **The linear distance for the trees and shrubs planted**	**10,000,000**	**DREEC/Thiès, Monitoring Committee** **PETN** **Forestry sector**

Adverse effects on stands of heritage species Cutting down trees, clearing land Accidental introduction of invasive species	No soil brought in that is from off-site Putting back removed topsoil with plants after the works Preservation of the crane pad area Protection of habitats highly sensitive to being trampled, informing the public Management of threatened natural environments	**Development phase**	**PETN IREF**	Site selection Checking prior to works that there are no heritage species there	**Heritage species affected Compensatory tree plantings**	**Not given**	**DREEC/Thiès, Monitoring Committee PETN Forestry sector of Tivaouane**
Destruction, loss or deterioration of habitats (sites where nesting or wintering over occurs) Avifauna, chiropterans	Selection of a site that avoids migration paths Selection of the height of the wind turbines Positioning of the wind turbines: outside sensitive zones, parallel to paths that avifauna fly along, spacing rows to facilitate passing through Placing markings on the wind turbines in order to limit the impact on avifauna Maintaining habitats on the edges of the wind farm by managing crop rotation	**Development phase**	**PETN**	**Included in the works quotation**	**The number of deaths due to the wind turbines**	**Included in the works quotation**	**DREEC/Thiès, Monitoring Committee PETN Forestry sector**

Destruction, loss or deterioration of habitats Destruction of specimens that are not very mobile	Check prior to the works that there are no heritage species Rehabilitation or creation of replacement ponds	**Development and engineering phase**	**PETN**		Site selection that avoids sensitive zones	**Not given**	
Noise generated by machinery passing by (trucks, cranes), increase in the number of peak levels per hour.	• Carrying out the work on work days (working on weekends, at dawn and at night-time shall be avoided as much as possible). • Limiting noise levels (do not exceed the values taken into account under the framework of this study).	**Development phase**	**PETN**	**Works Contractor**	**Noise level** **Individual protective equipment allocated to staff** **Complaints and grievances from people living nearby**	**Include in the CPTP**	**DREEC/Thiès, Monitoring Committee** **PETN**
Possible deterioration of the roads and red earth tracks, noise pollution, etc.	Setting up a police escort for a one-off convoy working in collaboration with the company building the wind turbines, the police and local authorities. Wide-load transport permit request	**Development phase**	**PETN**	**Involve Civil Defence**	**% of rotations escorted** **Deterioration of the roads due to axle overloading**	**1,500,000**	**DREEC/Thiès, Security Forces** **Land Transport Directorate** **Sarreole** **DPC (Civil Defence Directorate)**
Disturbances to employees and neighbours Dust being created during earthmoving works	Spraying tracks driven along Planting trees along the tracks to catch dust	**Development phase**	**Works contractor**	**PETN**	- **The presence of water tanks** - **Volumes of water consumed for sprinkling paths** - **The linear**	**Included in the works contractor's offer**	**PETN** **DREEC/Thiès** **Public Health District**

relating to the wind turbines' footprints and tracks Dust thrown up by machinery and heavy vehicles on the red earth tracks					**distance of trees planted to catch dust**		
Natural fire risks due to lightning strikes	Carry out a lightning protection study	**Development phase**	**PETN**	**Involve the DPC**	**46 lightning rods installed**	**Included in the equipment foreseen on each wind turbine**	**PETN** **DPC**
Modification of how the space is organized, introduction of scale ratios Interactions with the landscaping environment (rural, urban, industrial landscape), and with landscape factors	Landscaping project Limitation of visibility of the site Specific operations for returning the site to its original condition	**Development phase**	**PETN**	Site selection and layout variant	**Landscape insertion project proposed**	**Not given**	**PETN** **Borough of Taïba Ndiaye** **DREEC**

Environmental and Social Management Plan during the wind farm's operations phase

Potential negative impacts	Mitigation measure	Period	Company in charge	Strategy implemented by the Developer	Indicators	Cost	Monitoring/ Regulatory Inspection
Negative fiscal impacts Negative tourist impacts	Operational aid for local structures (agricultural, associations, tourist and other structures)	**Operations phase**	**Borough of Taïba Ndiaye**	**Investment in favor of local bodies neighboring the wind farm**	**Borough revenues Subsidies granted to producers' organizations Structural projects that favor the community**	**Not given**	**Municipal Council of Taïba Ndiaye Monitoring Committee**
Soil and groundwater pollution due to accidental seepage of liquid pollutants (worksite or storage machinery: hydrocarbons, hydraulic fluids, lubricants and paints).	Storage of hazardous liquid products (oils, fuel, etc.) during construction in a holding tray that can hold the tank's full volume.	**Operations phase**	**PETN Works Contractor**	**Making pollution prevention kits available at the worksite**	**The presence of holding trays The number of emergency interventions Technical inspections of heavy machinery**	**Included in the works quotation**	**DREEC/Thiès, Monitoring Committee and Project Manager**
Pollution during maintenance work and oil changes.	Carrying out maintenance work according to a well-established schedule and whilst taking the precautions required to avoid any spillage whatsoever of oil or any other liquid substance that is hazardous to the environment.	**Operations phase**	**PETN**	**Emergency measures**	**Holding trays and pollution prevention kits**	**- Included in the operating budget**	**DREEC/Thiès, Monitoring Committee and Project Manager**

Reduction of the arable surface areas and a decline in production yields	Compensate landowners in accordance with a scale that has been jointly agreed to	**Operations phase**	**PETN**	**Setting up a monitoring committee for complaints from people affected by the project** **Allocating an operating budget to the committee**	**The number of complaints and claims** **The disputes resolved**	**1,500,000**	**DREEC/Thiès, Monitoring Committee** **Rural Council** **Compensation Committee**
Trampling of habitats in the vicinity by visitors (indirect effect)	Preservation of the crane pad area Protection of habitats highly sensitive to being trampled, informing the public Management of threatened natural environments	**Operations phase**	**PETN**	Restoring deteriorated environments Stabilizing access paths	**Restored surface areas** **Communication tools developed that are aimed at visitors**	**Included in the works costs**	**DEEC/Thiès, Monitoring Committee** **Research institutes** **PETN** **Forestry sector of Tivaouane**
Risk of bird strikes against moving blades (limited risk); birds of prey are however more sensitive to latticework towers.	Placing markings on the wind turbines in order to limit the impact on avifauna	**Operations phase**	**PETN**	**Setting up research protocols with universities and research institutes** **Monitoring deaths**	**The number of deaths due to the wind turbines**	**7,000,000**	**DEEC/Thiès, Monitoring Committee** **Research institutes** **PETN** **Forestry sector of Tivaouane**

"Bird scarer" effect: risk of disturbing wide avifauna "Barrier" effect Miscellaneous disturbances (for example failed reproduction or lowering of the reproduction rate)	Developing ornithological monitoring in order to assess the impacts of the wind turbines on the avifauna Maintenance of habitats on the edges of the wind farm by managing crop rotation Protecting nesting sites Adapted control of how the wind turbines operate	**Operations phase**	**PETN The Forestry Sector**	**Involve research institutes and universities**	**Direct observation of the rarity of the local fauna The existence of monitoring protocols Monitoring results**	**4,000,000**	**DREEC/Thiès, Monitoring Committee Research institutes PETN Forestry sector**
Noise generated by operating and maintenance vehicles passing by	• Raising the awareness of operating staff about speed limits and instructions for following the road code and road signage • Traffic speed limit in accordance with recommendations • Noise level limit (do not exceed the values factored in within the context of this study).	**Development and dismantling phases**	**PETN**	**Works Contractor**	**Tools for raising awareness developed Complaints and grievances from people living nearby**	**2,000,000**	**DREEC/Thiès, Monitoring Committee Road Safety Authority PETN**
Possible deterioration of the roads and red earth tracks, noise pollution, etc.	Contribute to periodic maintenance of the road Contribution to the budget of the Borough of Taïba Ndiaye for maintaining and rehabilitating tracks	**Operations phase**	**PETN**	**Involve Civil Defence**	**Taxes paid for excess loads Budget allocated to maintaining tracks**	**1,500,000**	**DREEC/Thiès, Security Forces Roads Directorate Land Transport Directorate PETN DPC**

Risk of accidents (broken blades, fallen towers, the rotor catching fire, environment pollution, road transport of the wind turbine components, lightning strikes). Generating infrasonic sounds Shadow casting effect	Site selection (far away from neighboring houses) Informing the public Setting up a POI (Internal Operations Plan) and testing it regularly	**Operations phase**	**PETN**	**Involve the DPC**	**Existence of a POI and testing it** **Campaign for informing the local population and safety rules markings**	**15,000,000**	**DREEC/Thiès, Monitoring Committee Sarreole** **DPC** **Local body of Taïba Ndiaye & neighboring populations**
Risk of collision (foundations, towers), and of becoming snagged (bottom of the blades, cables)	Installing the wind turbines in the direction of traffic flow and the spacing of the machines Audio signal	**Operations phase**	**PETN**		**Incidents log**	**Not given**	**PETN** **DPC** **DREEC**

Noise from the wind turbines Light emissions Radio frequency reception disruptions Disturbances to the neighboring area	Site selection (far away from neighbours) Acoustic optimisation of the wind farm Re-establishing reception quality Curtailing the wind turbines should they exceed noise levels	**Operations phase**	**PETN**	**Public health monitoring protocol with the University of Thiès (Faculty of Medicine)**	**Complaints from neighbours and network operators**	**5,000,000**	**DREEC DPC Social Security University of Thiès Municipal Council of Taïba Ndiaye**
Natural fire risks following a lightning strike	Install lightning rods on the wind turbines	**Operations phase**	**PETN**	**Involve the DPC**	**Number of lightning rods Fires linked to lightning within the footprint of the wind farm**	**Forecast made for each wind turbine**	**DREEC/Thiès, Monitoring Committee PETN DPC**
The frustrations of neighboring villages that are not electrified	Setting up a structure for dialogue between the authorities, the surrounding population, and applicants.	**Operations phase**	**PETN**	**Involve the ASER (Senegalese Rural Electrification Agency) in consultations Contribute to the costs for connecting the villages adopted**	**The number of electrified villages**	**7,500,000**	**DREEC/Thiès, Monitoring Committee PETN ASER Local body of Taïba Ndiaye & neighboring populations**
Bringing the environmental authorities up to speed regarding operation of the wind farm	Organizing study visits and benchmarking	**Operations phase**	**PETN**	**Involve Senelec**	- **The number of participants** - **Travel time and destination**	**10,000,000**	**DEEC/DREEC PETN Borough of Taïba Ndiaye DPC**

1.5 THE COST OF THE ENVIRONMENTAL AND SOCIAL MANAGEMENT AND MONITORING PLAN

The environmental management and monitoring plan includes three categories of measures:

- Technical and/or environmental measures to be included in the call for tenders file as contractual measures and which will not be assessed financially;
- Surveillance and monitoring measures, including measures for boosting capacity, the costs of which will be negotiated and laid down subject to joint agreement with the stakeholders (monitoring actors and service providers);
- Specific measures which will be covered in the development budget.

2 INTRODUCTION AND CONTEX OF THE PROJET

2.1 CONTEXT OF THE STUDY

Population growth, and particularly urban population growth, leads to an increase in energy needs and particularly in renewable energy needs. The traditional local operator, the company Senelec, declared an increase in consumption and an increase in the number of clients at a rate in the vicinity of 10% per year. The bulk of the production is moreover thermal power production (along with the drawbacks related to the petroleum products market in terms of costs, energy dependence, and pollution) or hydro-power production. Under these conditions, it seems opportune to give priority to local renewable energy resources such as solar energy and wind power.

The development of wind power today forms part of the policies for combating the greenhouse effect. The Kyoto (1997) and Buenos Aires conferences concluded that there was a need to limit greenhouse gas emissions. It is the combustion of fossil fuels (fuel oil and coal in particular) which causes most of the world's atmospheric pollution and warming.

In 2010, Senegal's energy supply relied mainly on fossil fuel-based energy sources; oil and its derivatives in particular. The electricity demand is increasing every year and new production capacities will have to be installed.

According to the figures published by Senelec, the national electricity operator, over 87% of electricity production relies on the consumption of imported petroleum products.

Table 1: Breakdown for Senelec's annual electricity production by source: fossil fuel/hydro-power

Annual electricity production (GWh) and % breakdown by source: fossil fuel/hydro-power			
Year	***GWh***	***Fossil fuel portion***	***Hydro-power portion***
2013	2,900	89%	11%
2012	2,787	89%	11%
2011	2,444	91.8%	8.2%
2010	2,499	90%	10%
2009	2,372	89.9%	10.1%

(Source: Senelec business reports 2009 - 2013)

Senegal's social and economic development requires an increase in the production of electrical energy and particularly the creation of an energy mix in which renewable energy sources, contributing to the country's sustainable development and produced locally, will play an increasing role. By 2020, Senegal’s energy policy should enable a 20% renewable energy sources component to be integrated into the national energy mix.

In the years to come, wind power will experience major development within the current context of excessively high fossil fuel costs. Even though this renewable form of energy offers major environmental advantages, it can also entail certain changes and inconveniences.

Therefore it is important to develop quality wind parks that are integrated into their natural and human environment, in the spirit of the Environmental Code (Law No. 2001 - 01 of 15 January 2001), Title I, Chapter III (Instruments for environmental protection), Article L 8 of which states: the national strategy implemented by the United Nations Framework Convention on Climate Change is one of the instruments for environmental protection. Wind power is a form of energy that does not produce greenhouse gases.

The establishment of wind farms, which is a clear symbol of modern dynamism, will be perceived not only as an innovative but also as a highly original demonstration, marking a strong commitment to a sustainable energy policy mindful of the needs of future generations.

2.2 THE PROJECT’S ENVIRONMENTAL STAKES

2.2.1 Objectives

The ultimate purpose of the wind power production program at Taïba Ndiaye is to contribute to the sustainable development of Senegal’s electrical power supply by establishing a wind farm providing major power generating capacity within a sector that is already industrialised and is experiencing a major need in terms of power supply.

2.2.2 The project’s components

This project, which involves a total power of 151.8 MW, and involves the installation of 46 wind turbines with a power per unit of 3.3 MW, will be carried out in 5 phases:

A development phase, involving feasibility and impact studies, forming part of a period lasting about 6 years starting in June 2007, with a budget of approximately € 1,000,000,000.

An administrative and contractual phase, relating to the various permits required (construction permit, operating permits) and the purchase contracts for the electricity produced over a period of 15 to 20 years.

An execution phase, marking the actual installation of the wind turbines, with the execution involving three (3) tranches over 3 years: two (2) 52.80 MW wind turbines and one (1) 46.20 MW wind turbine (approximately). This power level seems to be a critical power level for the construction of a project.Good execution of this phase assumes the establishment of a project that is sufficiently substantial to motivate investors and suppliers of wind turbines in particular, and enables economies of scale to be used in order to share costs (studies, creating access ways and electrical connections, moving construction teams and resources, and erecting the wind turbines).

2.3 THE SCOPE, GOAL AND OBJECTIVE OF THE EIS

The objective of this impact study is to identify the information required in order to assess the environmental impacts of establishing a wind farm within the borough of Taïba Ndiaye.

The study will make it possible to report on all of the components in the natural and human environment likely to be adversely affected by the project.

Such an EIS makes it possible to identify *both the positive and negative impacts* of the project on the biophysical and social environment and to propose measures likely to *mitigate* the negative effects that may arise and optimize the benefits. These measures will be outlined in-depth in an environmental and social management plan that will constitute the environmental specifications for PETN during implementation of the project, should it be granted authorization following the environmental assessment.

Development of the project will inevitably lead to both positive and negative environmental and social impacts. These potential impacts as well as the appropriate mitigation measures are presented in greater detail in Chapters 10 and 11 of this report.

To this end, it should be emphasized that the EIS should thereby enable:

- Better factoring in of the environment from the design of the project onwards;
- Anticipation of any environmental impacts;
- Seeking improvements to the actions envisioned;
- Defining corrective measures or alternative measures.

2.4 METHODOLOGY

The methodology for assessing potential impacts of the Taïba Ndiaye wind park development project was implemented with the assistance of a group of environmental assessment specialists. While targeting the selection of a simple, rigorous method that is comprehensive and is recognized, the additional objective involved in this approach was to opt for a method that was well-suited to the project, or in other words, a method that factors in optimizing the locations of the wind turbines and the potential impacts on the environment.

The goal of analysis of the impacts is to examine both the beneficial and harmful consequences of the project for the environment, as well as to ensure that these consequences are duly considered during the design phase. In other words, the goal of analyzing the environmental impacts is to identify, describe and assess the inter-relations between a project and the physical, biological and human components of the environment affected by the project.

More specifically, the method recommended involves the following main stages.

Stage 1: Determine the inter-relations between the project's components (that are sources of impacts) and the environment's components.

Stage 2: Establish the environmental value of the environment's components.

Stage 3: Assess the importance of the impact based on its intensity, its extent, and its duration, and assess the residual impact following the implementation of particular mitigation measures, where need be.

Stage 4: Make an overall assessment of the project's impacts.

STAGE 1 – DETERMINING THE INTER-RELATIONS

This initial stage consists of properly identifying the project's various components that cause impacts, as well as the environmental component adversely affected by the project. In addition to using the project's technical characteristics and the data gathered concerning the environmental components, establishing the inter-relations was developed in detail based on analysis of similar projects and by benefiting from the knowledge of the various experts involved in the current project. Moreover, determining the inter-relations in question was supplemented by integrating the details contained in the documents available for this type of study.

This detailed stage should enable all the possible impact sources to be identified. It is essential for studying the impacts on the environment, because it makes it possible to ensure that all the factors have been examined, and therefore to avoid any subsequent questions arising.

The factors and the inter-relations between them were grouped together depending on the various phases of the project, namely:

Development phase: The development phase for the infrastructure (paths, wind turbines, etc.).

Operations phase: The effective lifespan as far as energy production by the wind turbines is concerned.

Decommissioning phase: The period required for decommissioning the equipment and cleaning up the sites used.

STAGE 2 – ENVIRONMENTAL VALUE OF THE ENVIRONMENTAL COMPONENTS

The environmental value was established for each of the environment's physical, biological and human components.

For the physical and biological environmental aspects, the environmental value is based on establishing and integrating two factors; namely the ecosystem factor and the social factor. More specifically, the value linked to the ecosystem factor expresses the relative importance of a component depending on its value for the ecosystem it is located in (its function or role, representativeness, frequentation, diversity, rareness or uniqueness) and its qualities (dynamism and potential).

Determining it calls on the judgements of specialists following a systematic analysis of the environment's components. The social value can only increase the environmental value of a component in the natural environment; it will never reduce it.

In the case of the human environment, only the social value is considered for determining the environmental value. The social value states the relative importance assigned by the public, the various levels of government, or any other legislative or regulatory authority to a given environmental component. It indicates popular or political desire or willingness to maintain the integrity and original nature of a component. This willingness is expressed via the legal protection granted to it or via the interest shown by the public at local or regional level. The social value is established depending on the preoccupations of the population concerned by the environmental component. The perceptions and preoccupations that we have gathered from this population during this study are used as factors for establishing this value. The social value assigned to the various environmental components largely stems from the preoccupations indicated during public presentations and consultations held under the framework of this project.

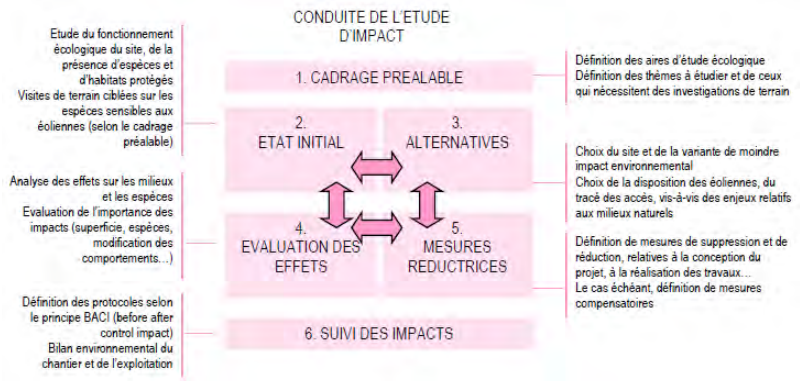
In order to establish the environmental value of the components in the natural or human environments, the first stage involved an individual assessment by each of the specialists associated with the project. Subsequently, a group of specialists compared these assessments in such a way as to ensure uniformity in terms of establishing these environmental values.

In terms of the environmental value assigned to environmental components, we distinguish between three classes:

HIGH: An environmental component has high environmental value when one of the following two conditions is fulfilled:

- The component is protected by a law or forms the subject of special protection measures.
- The protection or preservation of the integrity of the component forms the subject of a consensus between the specialists and administrators or among all the various sectors of the public concerned.

AVERAGE: An environmental component is of average environmental value when one of the following two conditions is fulfilled:



Translation of the above figure:

Study concerning the ecological functioning of the site, the presence of protected habitats and species. Field visits targeting species sensitive to wind turbines (according to the preliminary framework)	CONDUCT OF THE IMPACT STUDY 1. PRELIMINARY FRAMEWORK		Definition of the ecological study areas. Definition of the themes to be studied and of those requiring field investigations.
	2. INITIAL STATE	3. ALTERNATIVES	Selection of the site and the variant with the lowest environmental impact. Selection of the layout of the wind turbines and of the access paths in relation to the stakes relating to natural environments.
Analysis of the effects on the environments and the species. Assessment of the importance of the impacts (surface area, species, changes in behavioural patterns, etc.)	4. ASSESSMENT OF THE EFFECTS	5. REDUCTION MEASURES	Definition of elimination and reduction measures relating to the design of the project, executing the works, etc. Where applicable, defining compensation measures.
Definition of the protocols according to the BACI (Before After Control Impact) principle. Environmental assessment of the worksite and the operation.	6. MONITORING IMPACTS		

Figure 1: Schematic diagram showing the methodological approach for environmental assessment of the impacts

- Preservation or protection of the component's integrity constitutes a matter of lesser concern for the specialists and administrators or for all of the sectors of the public concerned.
- The component constitutes a matter of concern, but does not form the subject of a consensus between the specialists and the administrators or all of the sectors of the public concerned.

LOW: A component in the environment has a low environmental value when preserving it, protecting it, or its integrity are of little concern or are of no concern among the specialists and administrators or all of the sectors of the public concerned.

STAGE 3 - ASSESSMENT OF THE IMPORTANCE OF THE IMPACTS

The methodological approach consists of establishing the importance of the impacts by combining the intensity of the disruption, as well as the extent (the amount of space) and the duration (the amount of time) of the impacts with the environmental value of the environment's components. There are three categories of importance for the impacts, namely high, average and low. For each of them, the type of impact (positive or negative) has to be indicated. The factors determining the importance of the impacts are presented below.

2.4.1 Intensity of the disruptions

Depending on the component considered, the disruption may have positive or negative effects. These effects on the environmental component may also be direct or indirect. Furthermore, you have to take into account the fact that the sum of these effects may increase the level of disruption to an environmental component.

A distinction is drawn between three value classes assigned to the intensity of the disruptions:

HIGH: For a component in the natural environment, the intensity of the disruption is high when it either destroys or has significant adverse effects on the integrity of that component. In other words, a disruption has a high intensity if it is likely to lead to a decline or a major change in the environment as a whole.

For a component in the human environment, the intensity of the disruption is high when it compromises or significantly limits the use of the aforementioned component by the community or a rural population.

AVERAGE: For a component in the natural environment, the intensity of the disruption is average when it destroys or has significant adverse effects on the component to a lesser extent, without undermining its integrity, but in a way that is likely to lead to a limited change of its regional distribution within the environment.

For a component in the human environment, the intensity of the disruption is average when it affects an environmental aspect or when it compromises the use of the aforementioned component by part of the regional population, without however adversely affecting the integrity of the component or undermining its use.

LOW: For a component in the natural environment, the intensity of the disruption is low when it only has slight adverse effects on the component without undermining its integrity or leading to a reduction or to significant changes in its general distribution within the environment.

For a component in the human environment, the intensity of the disruption is low when it has little effect on an environmental aspect or the use of the component without however undermining its integrity or its use.

2.4.2 Extent of the impact

The extent of the impact expresses the scope or spatial influence of the effects stemming from an intervention carried out on the environment. This concept refers either to the distance or to a surface area over which the changes experienced by a component are felt, or to the proportion of a population that will be affected by these changes. A distinction is drawn between three classes that may be assigned to the extent of the impacts:

REGIONAL: The extent of an impact on an environmental component is qualified as "regional" when it adversely affects a huge area or several components over a major distance from the project's site or when it is experienced by all of the population or by a major proportion of that population.

LOCAL: The extent of an impact on an environmental component is qualified as "local" when it adversely affects a relatively limited area or a certain number of components within (for example: a particular ecosystem), either in the vicinity or at a certain distance from the project's site, or when it is experienced by a limited percentage of the population.

SPOT: The extent of an impact on an environmental component is qualified as "spot" when it is felt in a small, restricted area within the environment, whether it adversely affects a small portion or it is only perceptible to a limited group of people (for example: when the impact is felt by a specific environmental feature, such as a plot of land where the hoisting station is installed, a span over a waterway, etc.).

2.4.3 Duration of the impact

The duration of an impact expresses its temporal dimension, namely the period during which the changes to a component are felt. This concept does not necessarily match the period during which the direct cause of the impact acts. It must also take into account the frequency of the impact when it is intermittent.

A distinction is drawn between three classes that may be assigned to the duration of impacts:

LONG: The duration of an impact on an environmental component is qualified as long (generally, greater than 5 years) when it is experienced either continually or intermittently over a sufficiently long time in order to compromise the natural recruitment of a population for more than one generation (for example: the presence of wind turbines). It may include effects considered as irreversible.

AVERAGE: The duration of an impact on an environmental component is qualified as average (generally, from 1 to 5 years) when it is felt either continually or intermittently (for example: rutting of the soil) over a period of time subsequent to the works period.

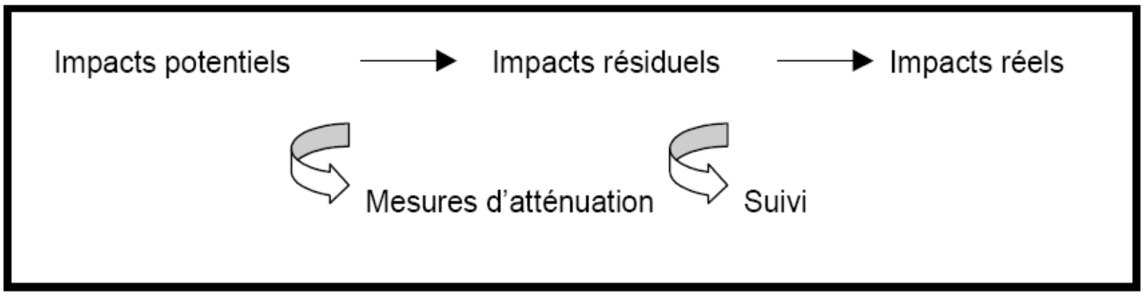
SHORT: The duration of an impact on an environmental component is qualified as short (generally, less than 1 year) when it is felt either continually or intermittently over a limited period of time that may relate to a specific stage of the works (for example: road transport).

2.4.4 Importance of the impact

For the purposes of assessing the importance of environmental impacts, each specialist in the disciplines concerned drew up a list of the components and factors affected (inter-relations) belonging to the physical, biological and human environments.

Each of them drew up and justified their assessments of the value of the components, as well as the intensity, duration and extent of the impacts anticipated. Then, mitigation measures appropriate for reducing the importance of these impacts were proposed. A group of environmental assessment specialists then compared the individual assessments so that a final assessment of the importance of the environmental impacts could be drawn up. Using the grid presented in Table 6.1 makes it possible to systematically establish the importance of the impact anticipated. It should be noted that the impacts deemed to be positive have the (+) sign alongside them in the tables. The group of specialists also assessed the residual impacts following the implementation of standard mitigation measures and, in certain cases, it proposed other mitigation measures aimed at reducing these residual impacts.

Throughout the project's various phases (development, operations and decommissioning), the residual impacts were assessed according to the potential impacts and the effects of the mitigation measures proposed. The actual impacts express the true effect, supported by monitoring of the project, which sometimes may differ from the prior estimates. Figure 2 enables the series of stages involved in assessing impacts to be better understood.



Potential impacts Residual impacts Actual impacts

Mitigation measures Monitoring

Figure 2: Process involved in the detailed assessment of environmental and social impacts

Provision is made for environmental monitoring and inspection measures for properly assessing various parameters of the physical, biological and human components of the environment throughout each of the project's various phases.

2.5 STRUCTURING OF THE REPORT

In addition to an introductory chapter and a conclusion, a description of the main project's activities and installations is provided in Chapter 3, followed by an examination of the legislation and of appropriate policy in Senegal (Chapter 4). Chapter 5 deals with the initial condition of the environment at both of the sites targeted by the project. Chapter 6 tackles the environmental sensitivity of the site. Chapter 6 covers analysis of the variants, which is followed by the results of the public consultation presented in Chapter 8. Chapter 9 identifies and analyzes the environmental and social impacts of the project specifically during each phase; while Chapter 10 assesses the technological and professional risks inherent in the project's activities which potentially pose dangers. The various sections of Chapter 11 relate to the Environmental and Social Management Plan (ESMP), which presents the mitigation measures, the implementation calendar, the costs, the implementation and monitoring responsibilities, and the relevant deadlines. This chapter also deals with monitoring and surveillance, identifying the most relevant factors to be monitored in order to fulfill the environmental and social requirements imposed on the project.

The bibliographic references, the terms of reference, the people consulted and other support documents constitute the appendices.

The environmental and social aspects considered in this ESIS (Environmental and Social Impact Study) comply with the terms of reference validated by the DEEC and appended to this report.

2.6 AUTHORS OF THE ESIS

This study was carried out by Hpr Ankh Consultants which mobilized a multi-disciplinary team consisting of the following people:

Table 2: List of the experts involved in drawing up the study

No.	FIRST NAME AND SURNAME	POSITION/DUTIES
1	Mouhamed Thioye	Electromechanical Engineer specialising in energy
2	Insa Fall	Specialist in Natural Sciences and Environmentalist
3	Mamadou Diédhiou	Sociologist and Environmentalist
4	Oumar Fall	Specialist in Sanitation Engineering and the Environment
5	Bocar Diallo	Geographic Information System Expert
6	Idrissa Guiro	Specialist Geographer, Climatologist
7	Awa Diallo	Chemical Engineer
8	Al Assane Sène	Geographer and Environmentalist

3 DESCRIPTION OF THE PROJECT

3.1 GENERAL POINTS CONCERNING THE PROJECT

Modern wind generators, commonly referred to as wind turbines, have undergone major technological progress made over some years now. They are reliable and efficient and enable decentralized electricity production that is pollution-free and does not create greenhouse gas emissions. It is a **clean**, renewable form of energy that facilitates our country's diversification and energy independence.

3.1.1 The technical components of a wind turbine

By exerting a force on the wind turbine's blades, wind makes them turn. The rotor's spinning then activates an electric generator, with or without the assistance of a gearbox: there is a transfer of the wind's kinetic energy to electrical energy.

The recoverable energy is provided by the **Betz equation**: $P = 0.37*S*V^3$

P: The power recoverable by a wind turbine, in W
S: The surface area swept by the blades, in m^2
V: The wind speed, in m/s

Thus, knowledge of the wind resource is particularly important and for carrying out an on-site measuring campaign it is necessary in order to refine knowledge of the wind strength and wind direction. It should also be noted that a good wind park site will be subject to steady winds rather than extremely strong winds alternating with calm periods.

The first tower, for meteorological measurements, was erected in January 2008 and is 50 m high. The measuring campaign lasted at least 12 months.

3.1.2 Wind turbine

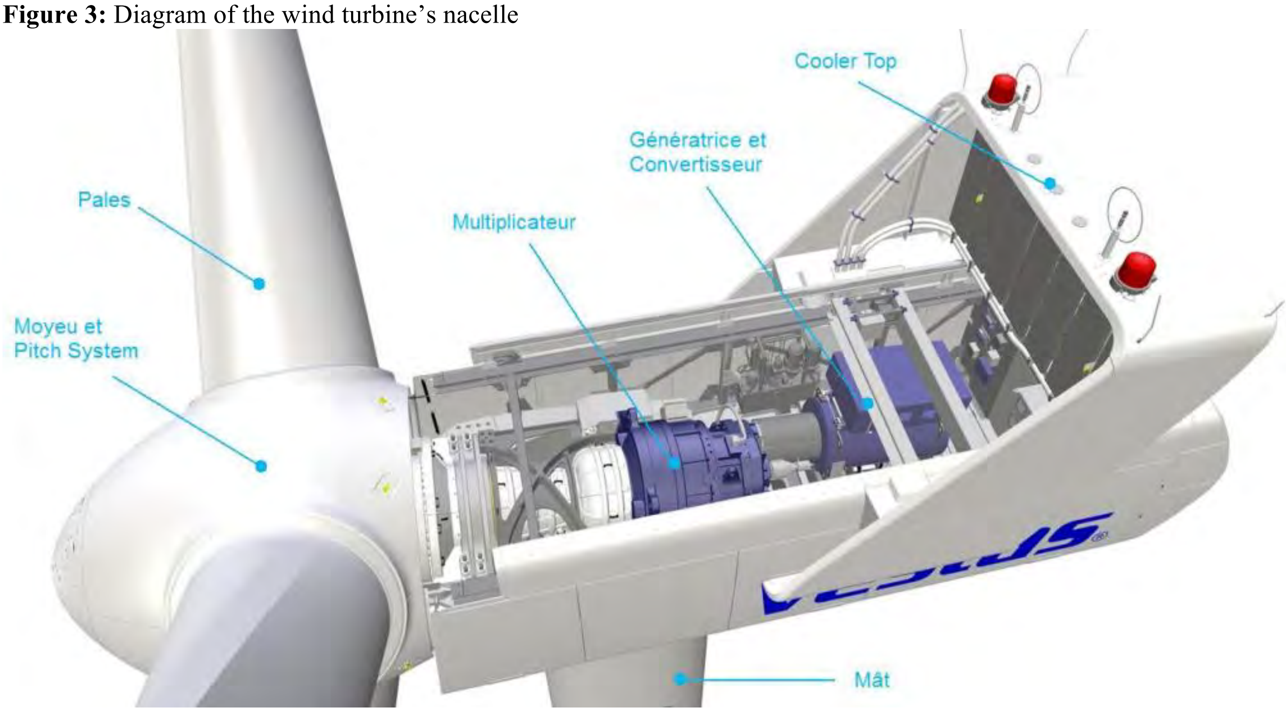
A wind turbine consists of:

- Three blades connected to a hub; the assembly is called a "rotor";
- A nacelle supporting the rotor, in which the technical componentry required to generate electricity is located (a gearbox, generator, etc.);
- A tower on which the nacelle and the rotor are mounted;
- A base providing the foundations for the assembly.

The wind's force causes the rotor to spin, which brings about the rotation of a motor shaft, the speed of which is amplified by a gearbox. Electricity is produced from a generator.

Specifically, a wind turbine begins working whenever the wind speed is sufficient to cause the rotor to spin. The greater the wind speed, the more electricity the wind turbine will provide (until the maximum production threshold is reached).

Figure 3: Diagram of the wind turbine's nacelle



Cooler Top
Generator and converter
Blades
Hub and Pitch System
Gearbox
Tower

Four operating "periods" should be considered for a wind turbine.

- As soon as the wind speed reaches 2 m/s, an automatic controller, which is informed by a wind sensor, commands the slewing motors to position the wind turbine so it is facing the wind. The three blades then start moving solely due to the force of the wind. They in turn cause the gearbox and the electric generator to turn.

- When the wind speed is sufficient (3 m/s), the wind turbine may be connected to the electrical network. The rotor then spins at its rated speed.

- The generator then provides an alternating electrical current with a voltage of 690 volts, the intensity of which varies depending on the wind speed. Thus, when the latter increases, the load borne by the rotor increases and the power provided by the generator increases.

- When the wind speed reaches the value indicated in the table below, the wind turbine will be supplying its maximum power (3,300 kW). This is kept constant through gradual reduction of the load borne by the blades. A hydraulic system regulates the load-bearing by adjusting the angle of the blades by pivoting them on their bearings (each blade can rotate on its own mounting).

Table 3: The rotor speed and the optimal wind speed

	V112 – 3.3 MW	V117 – 3.3 MW	V126 – 3.3 MW
The rotor's rotational speed	6.2 to 17.7 rpm	6.2 to 17.7 rpm	5.3 to 16.5 rpm
The minimum wind speed required for maximum production	14 m/s	13.5 m/s	12.5 m/s

The electricity is routed from the wind turbine directly onto the electrical network. The electricity is not stored.
A wind farm consists of:

- Several wind turbines;
- One or more power sub-stations;
- Electrical links;
- Access paths.

3.1.3 The rotor

Vestas V112/117/126 – 3.3 MW wind turbines are fitted with a rotor consisting of 3 blades and a hub. Each blade comprises an assembly of two shells over a support bar. The general characteristics of the blades are as follows:

Table 4: Characteristics of the wind turbine's blades

	V112 – 3.3 MW	V117 – 3.3 MW	V126 – 3.3 MW
Diameter of the rotor	112 m	117 m	126 m
Surface area swept by the rotor	9,852 m²	10,751 m²	12,469 m²
Length of one blade	55 m	57 m	62 m
Weight of one blade*	12.3 tonnes	13.3 tonnes	11.9 tonnes
The blades' materials	Fibreglass reinforced with epoxy and carbon fibre	Fibreglass reinforced with epoxy and carbon fibre	Fibreglass reinforced with epoxy and carbon fibre

* Optimisation under way; it is likely to be less than this

The blades are relatively lightweight due to a range of new materials being used. For example, carbon fibre – a high-strength, rigid and very lightweight material – was used as a replacement for fibreglass in order to develop the structure bearing the blades' load. Thanks to this fibre's strength, it became possible to reduce the quantity of material used for making the blades and thereby considerably reduce the overall weight as well as the loads.

Moreover, the blades have new-generation aerodynamic profiles enabling energy production to be increased, the impact of roughness on each blade's leading edge to be reduced, and good geometrical continuity to be maintained from one aerodynamic profile and the next. The geometry of these new blades was defined by optimizing the relation between the general impact of the load on the wind turbine and its annual energy production. The aerodynamic profile was developed in collaboration with the Risø National Laboratory, in Denmark. The blade's innovative design improves the wind turbine's performance and makes it possible to increase its output, whilst at the same time reducing the loads transferred to the machine.

3.1.4 The tower

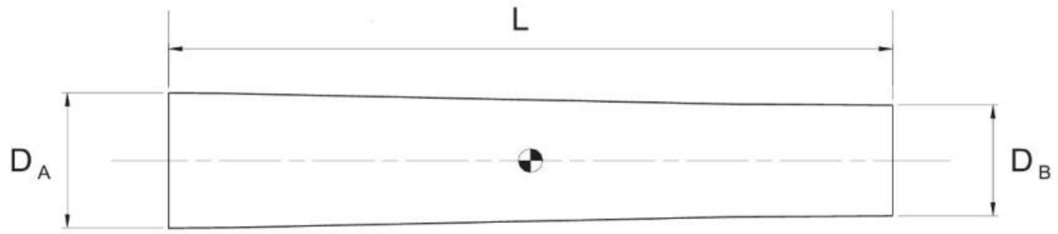
Tubular steel towers, certified in accordance with the standards in force, are available in various standard heights enabling adaptation to the wind classes and the conditions encountered on- site.

Table 5: Characteristics of the tower and wind turbine

	V112 – 3.3 MW		V117 – 3.3 MW		V126 – 3.3 MW	
Description	Conical tube		Conical tube		Conical tube	
Material*	S355 and A709 steel		Steel		Steel	Steel and concrete
Hub heights	84 m	94 m	91.5 m	116.5 m	117 m	137 m
Wind class (IEC)	IEC2A	IEC2A	IEC2A	IEC2A	IEC3B	IEC3A
Bottom diameter section (D_A)	4.3 m	4.3 m	4.3 m		6 m	9.6 m**
Top diameter section (D_B)	3.3 m	3.3 m	3.3 m		3.3 m	3.3 m
Number of sections	3	4	4		6	One part is concrete, with 2 steel sections
Weight*	171 t	228 t			313 t	89 t of steel

* Optimisation in progress; it is likely to be slightly different.
** Value provided as an indication. To be specified depending on the study done by the manufacturer of the concrete tower.

Figure 4: Simplified drawing of the tower



3.1.5 The nacelle

The nacelle's casing is made from fibreglass. The nacelle's frame consists of a metal structure that is used as a support for the nacelle's various main components: the transmission shaft, the generator, the gearbox, the transformer, and the control cabinets. The hatch in the floor makes it possible to hoist up the tools required for maintenance purposes and enables personnel to be evacuated in the event of a fire in the nacelle. The roof windows enable the nacelle to be fastened to a crane so it can be hoisted up onto the tower.

The roof is fitted with wind sensors and a skylight that can be opened from inside the nacelle in order to gain access to the roof. The Vestas Cooler Top™ cooling system is located on top of the nacelle, at the rear end of it.

The nacelle's frame consists of two parts: a front part made from cast steel and a latticework structure at the rear. The front part of the nacelle is used as the base for the power unit by transmitting the rotor's dynamic forces to the motor shaft. The rear part features the control panels, the generator and the transformer.

Table 6: Dimensions of the wind turbine's nacelle

Length	Length without cooler	Length with cooler	Height without cooler	Height with cooler	Weight (with cooler, hub and internal equipment)
12.8 m	4.2 m	5.1 m	3.2 m	8.3 m	157 t

3.1.6 Vestas Pitch system for the blades

Using the Vestas Pitch system, the angle of the blades is adjusted depending on the energy the wind provides for the turbine. The angle of the blades on the hub may therefore be varied using the hydraulic jacks placed along a longitudinal axis in order to optimally benefit from the instantaneous wind. Varying the angle leads either to an increase or decrease in the load borne by the blade, and therefore in the motor torque. A control system makes it possible to determine the optimal position of the blades depending on the wind speed and it commands the hydraulic system so that positioning can be carried out.

This system therefore makes it possible to maximize the energy absorbed by the wind turbine, but it also works as the initial braking mechanism by feathering the blades in the event of strong winds. It is the most efficient system as it enables constant, near-perfect end-of-line control of the generator's rotation, and therefore control of the power.
The blades are controlled by an OptiTip® microprocessor.

Table 7: Characteristics of the wind turbine's control system and hydraulics system

Vestas Pitch system			
	V112 – 3.3 MW	**V117 – 3.3 MW**	**V126 – 3.3 MW**
Angle	From -9º to 90º	From -9º to 90º	From -9.5º to 90º
Type	Hydraulic		
Number	1 hydraulic jack per blade		
Hydraulic system			
Main pump	Internal double pump		
Pressure	260 bars		

3.1.7 The gearbox

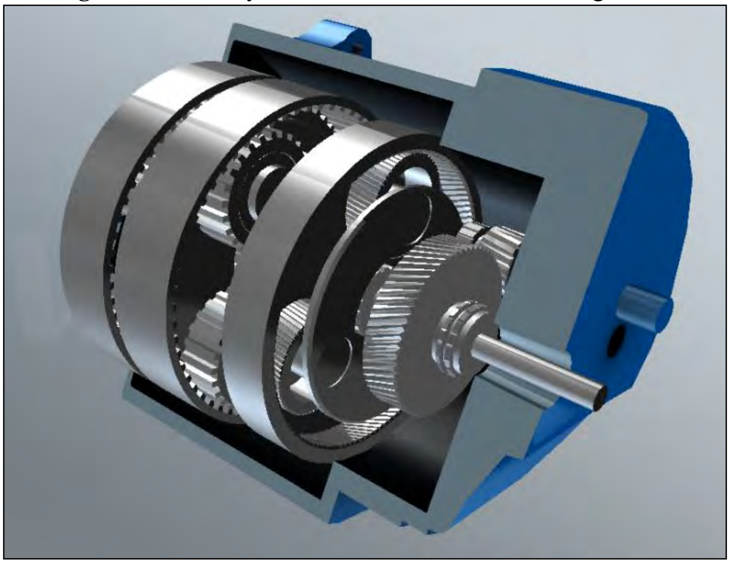
The gearbox is located in-between the rotor and the generator. For technical reasons, the rotor is not linked directly to the generator. Indeed, most generators need to rotate at very high speeds (1,000 to 2,000 rpm) in order to maintain good output. Therefore it is necessary to increase the rotor's rotation frequency before actuating a classic electric generator. This increase is carried out using the gearbox, which consists of a gear train.

The rotor therefore transmits the wind energy to the gearbox via a slow shaft, and the gearbox then leads to a fast shaft (1,000 to 2,000 rpm) and couples itself to the electric generator. A disc brake is mounted directly on the fast shaft. Coupling with the fast shaft is done via two discs made from composite materials, an intermediate tube with two aluminium flanges and a fibreglass tube.

Table 8: Characteristics of the wind turbine's gearbox

Gearbox	
Type	5 stages: - 3 planetary gear stages - 2 helical gear stages
Ratio	Between 1/100 and 1/120 depending on the model of the gearbox
Oil quantity	Between 1,000 and 1,200 litres
Lubrication system	Pressurised oil
Oil cleanliness	-/15/12 ISO 4406

Figure 5: Cutaway view of the V112/V117/V126 gearbox



3.1.8 The electric generator

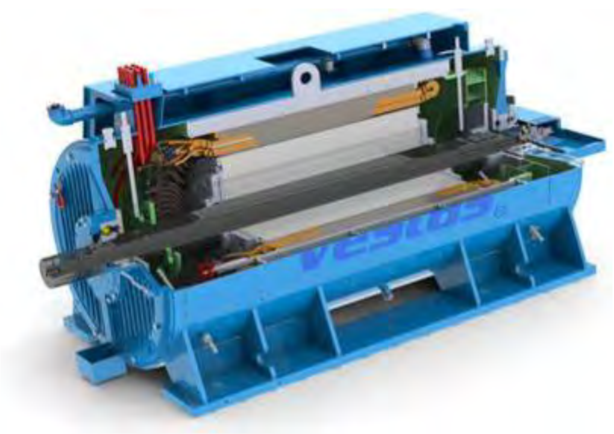
The wind's mechanical energy is transformed into electrical energy by the generator. In the case of Vestas V112/117/126 – 3.3 MW wind turbines, what is involved is a three-phase synchronous generator. The stator is connected to a full-power converter which ensures conversion of all of the energy produced by the generator in order to ensure optimal quality and frequency before delivery to the electrical grid.

The generator is equipped with an internal cooling circuit described in Chapter 1.3.5.1.

Table 9: The main characteristics of the wind turbine's generator

Electric generator	
Description	Three-phase synchronous generator
Rated power	3.3 MW
Frequency	0-200 Hz
Rated voltage of the stator	3 x 710 V
Efficiency (generator)	> 98%
Rated speed	Between 1,450 and 1,550 rpm
Speed limit (according to the IEC)	2,400 rpm
Vibration level	< 1.9 mm/s
Insulation class	F or H

Figure 6: Appearance and location of the generator



3.1.9 The transformer

The transformer is located in a separate padlocked room inside the nacelle, with lightning rods mounted on the high-voltage side of the transformer. The transformer constitutes the electrical component that raises the voltage coming out of the generator in order to enable connection to the distribution network. In the case of Vestas V112/117/126 – 3.3 MW wind turbines, what is involved is a dry three-phase transformer, the characteristics of which are presented below:

Table 10: The main characteristics of the wind turbine's transformer

Transformer	
Type	Dry three-phase transformer
Primary voltage	10-35 kV
Apparent power	3,750 kVA
Secondary voltage	3 x 650 V
Load losses (at the rated power, 120°C)	31.5 kW
Frequency	50 Hz

3.1.10 The other electrical components

Although the generator and the transformer constitute the two main electrical systems involved in the functioning of the wind turbines inside the nacelle, you will find other electrical components in Vestas V112/117/126 – 3.3 MW wind turbines:

- The Vestas Flexpower® **converter** which controls and converts the energy produced by the generator is located in the nacelle;
- The **auxiliary system** which supplies the various motors, pumps, fan units and heating devices in the wind turbine. It is located in the command cabinets in the nacelle;
- The ultrasound **wind sensors** with integrated heating; they measure the speed and the wind direction and are located on the Vestas Cooler Top™;
- The **control system** consists of various processers located in the rotor, in the nacelle and at the foot of the tower;
- The **uninterruptible power supply** which enables the components to be powered in the case of a breakdown is located at the foot of the tower;
- The **high-voltage cables** running from the nacelle to the bottom of the tower.

3.1.11 The cooling system

The cooling system consists of a limited number of components:

- The Vestas Cooler Top™ located on the roof at the back of the nacelle provides cooling of the following 2 systems using natural wind flow:

- A first liquid cooling system, controlled by an electric pump which serves the gearbox and the hydraulic system;
- A second liquid cooling system, controlled by an electric pump, which serves the generator and the converter;

- Cooling of the transformer using forced air, which includes an electric fan unit;
- Cooling of the nacelle using forced air, which includes two electric fan units.

Figure 7: Vestas Cooler Top™

3.1.12 Lubrication

The presence of numerous mechanical components in the nacelle involves lubrication on start-up and during operations in order to reduce the various types of friction and wear between two parts in contact with and which move in relation to each other.

The chemicals and lubricants used in Vestas wind turbines are certified in accordance with the ISO 14001: 2004 standard; among the various chemicals, we note the following:

- Coolant (glycol water);
- Lubricating oils for the gearbox;
- Oils for the hydraulics system for the Vestas Pitch system;
- Various types of grease for lubricating the bearings;
- Various cleaning agents and chemicals for maintenance of the wind turbine.

We will get back to the toxicity of these substances in Chapter 3, which is devoted to this topic.

Altogether a V112/V117/V126 3.3MW wind turbine contains:

- Approximately 600 litres of coolants;
- 1,346 to 1,546 litres of oil;
- Approximately 29 kg of grease

Table 11: The main lubricants, oils and coolants used

Lubrication			
Lubrication points	**Products***	**Quantity**	**Change**
Bearings for the blades	Klüber Klüberplex BEM41-141	Full tank: 15 kg	Every year
Teeth on the slewing ring (pump 1)	Klüberplex AG11-462	Full tank: 2 kg	Every year
Surface of the slewing ring (pump 2)	Shell Gadus S5 T460 1.5	Full tank: 2 kg	Every year
The generator's bearings	Klüber Klüberplex BEM 41-132	2/3 of the tank: 2.4 kg	Every year
Main bearings	SKF LGWM 1	Full tank: 8 kg	Every year
Oils			
Location	**Products***	**Quantity**	**Change**
Hydraulics system	Texaco Rando WM 32/Mobil DTE10-Excel32	250 litres	Depends on analysis
Gearbox	Mobilgear SHC XMP 320	1,000 to 1,200 litres	Depends on analysis
Gear assemblies of the nacelle orientation motors	Shell Tivela S 320	96 litres	Every 10 years
Coolants			
Location	**Products***	**Quantity**	**Change**
Transmission and hydraulic cooling	Texaco Havoline XLC +B -40	200 litres	Every 5 years
Cooling of the generator and the converter	Texaco Havoline XLC +B -40	400 litres	Every 5 years

*** Likely to be slightly different; to be checked by the operator.**

3.1.13 Aviation markings

RAS (Senegalese Aeronautical Regulation) No. 7 Volume 1, Design and Technical Operation of Aerodromes, part 6.2.4 and Table 6-1 of Chapter 6 of RAS 07, describe the marking specifications for wind turbines as well as the characteristics of aviation lights.
The overall height of the obstacle to be considered is the maximum height of the wind turbine, or in other words with a blade in vertical position above the nacelle.

The wind turbines will have to comply with the following provisions:

- In the case of a wind turbine with an overall height exceeding 150 meters, marking using medium-intensity lights is supplemented by low-intensity Type B obstacle lights (32 cd fixed red lights) installed on the tower;
- Acceptable colours for wind turbines: White (cf. in France this includes the following colours: RAL 7035, 7038, 9003, 9010 and 9016);

The day lighting is set as follows:

- Type A medium intensity obstacle lights (20,000 cd white flashing lights);
- 360° visibility of the wind turbine must be ensured.

The night lighting requirements are as follows:

- Type B medium intensity obstacle lights (2,000 cd red flashing lights);
- 360° visibility of the wind turbine must be ensured.

Vestas *V112/117/126* – 3.3 MW wind turbines are fitted with blinking LED obstacle lights featuring Orga L450-63A/63B technology. This system for marking structures posing a potential aviation hazard integrates cutting-edge technologies that are reliable in the long-term and offer low energy consumption.

The characteristics of this marking system are presented in the following table:

Table 12: Characteristics of the aviation marking system

Frequency	40 flashes per minutes at daytime 40 flashes per minutes at night-time
Intensity	20,000 cd at daytime 2,000 cd at night-time
Visibility	360°
Certification	ICAO Annex 14 Volume 1, 4th Edition, July 2004, Chapter 6, Medium Intensity Type A and Type B obstacle light depending on model.

In the case of a wind turbine with an overall height that exceeds 150 m, marking with the medium-intensity lights described above is supplemented by Type B low-intensity lights installed on the tower. One or more new intermediate levels are installed depending on the overall height of the wind turbine, in accordance with the following table:

Table 13: Installation heights of the low-intensity lights

OVERALL HEIGHT OF THE WIND TURBINE	NUMBER OF LEVELS	INSTALLATION HEIGHTS of the Type B low-intensity lights
$150 < h \leq 200$ m	1	45 m
$200 < h \leq 250$ m	2	45 and 90 m
$250 < h \leq 300$ m	3	45, 90 and 135 m
...	...	...
$150 + (n - 1)*50$ m $< h \leq 150 + n*50$ m	n	Every 45 m up to n*45m

3.2 THE PROJECT’S LOCATION

The project is located in the Thiès Region, in the Department of Tivaoune and the borough of Taïba Ndiaye (cf. Map 2).

The project can form part of the contribution to sustainable development of Senegal’s electricity supply through the establishment of a wind farm providing a high power capacity of at least **151.8** MW.

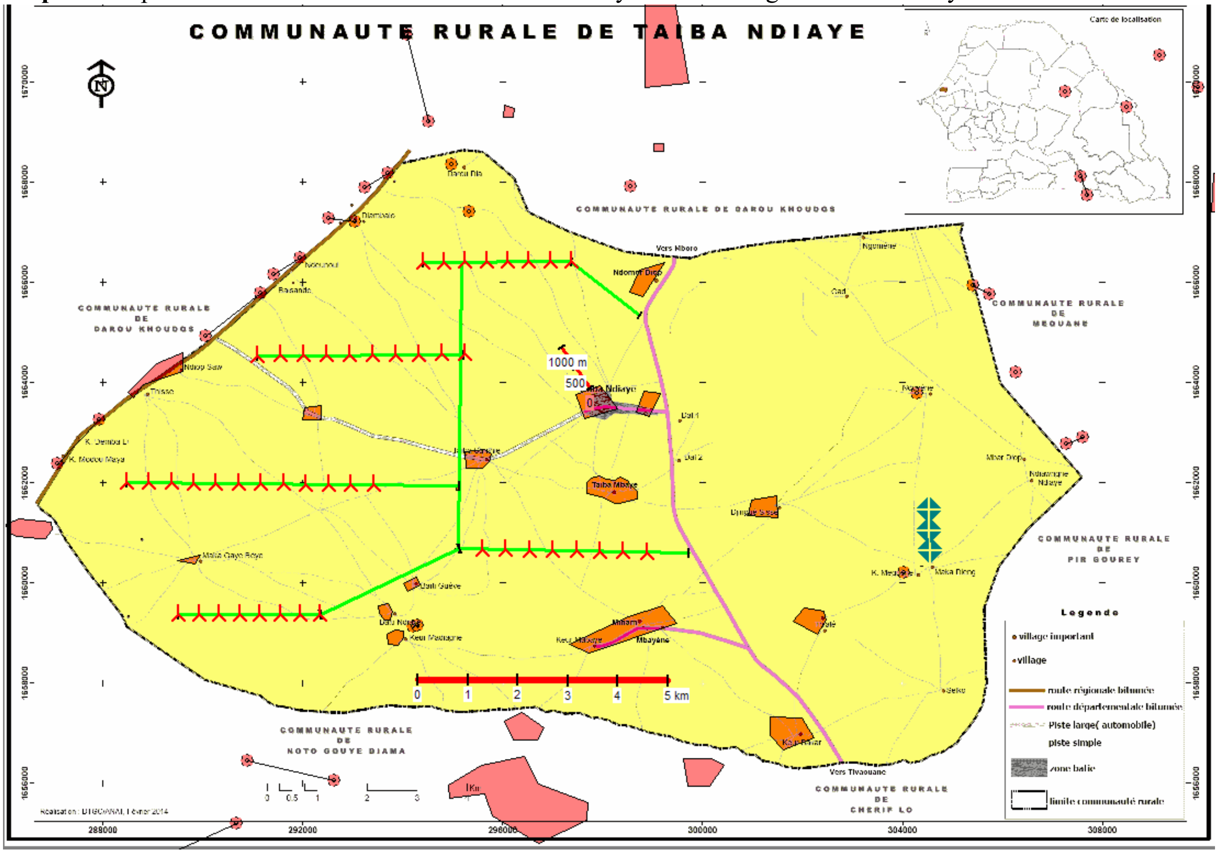
This power will require the establishment of at least **46** wind turbines with a power per unit of **3.3** MW.

<u>NB:</u> The total power of 151.8 MW seems to be a critical power level for the construction of a project. In fact execution of these three (3) phases assumes the installation of a project that is sufficiently substantial to motivate investors and suppliers of wind turbines in particular, and which enables economies of scale to be used in order to share costs (studies, laying down access ways, electrical connections, and moving the equipment and teams for building and erecting the wind turbines).

Map 1: Location of the Taïba Ndiaye wind park project

Establishment zone

Map 2: The precise location of the site within the territory of the borough of Taïba Ndiaye



3.3 DESCRIPTION OF THE CONSTRUCTION AND DEVELOPMENT PHASES

The project's execution may be split into 5 phases:

1. The development phase: Impact studies; in progress
2. The administrative and contractual phase: Obtaining permits (building permits, operating permits) and purchasing contracts for the electricity produced over a period of 15 to 20 years; in progress
3. The execution phase for the first tranche with the installation of 16 x 3.3 MW wind turbines providing a total power of 52.8 MW (approximately).
4. The execution phase for the second tranche with the installation of 16 x 3.3 MW wind turbines providing a total power of 52.8 MW.
5. The execution phase for the third tranche with the installation of 14 x 3.3 MW wind turbines providing a total power of 46.2 MW

3.3.1 The preparatory phase

The preparatory phase will consist of carrying out a series of boring at the locations where the wind turbines are to be sited, in such a way as to specify the nature of the foundations foreseen (geotechnical investigations). If need be, they will be supplemented by tests carried out by the company assigned for the construction and supply of the wind turbines.

Figure 8: The components of a wind farm

The components of a wind farm

Wind measuring tower

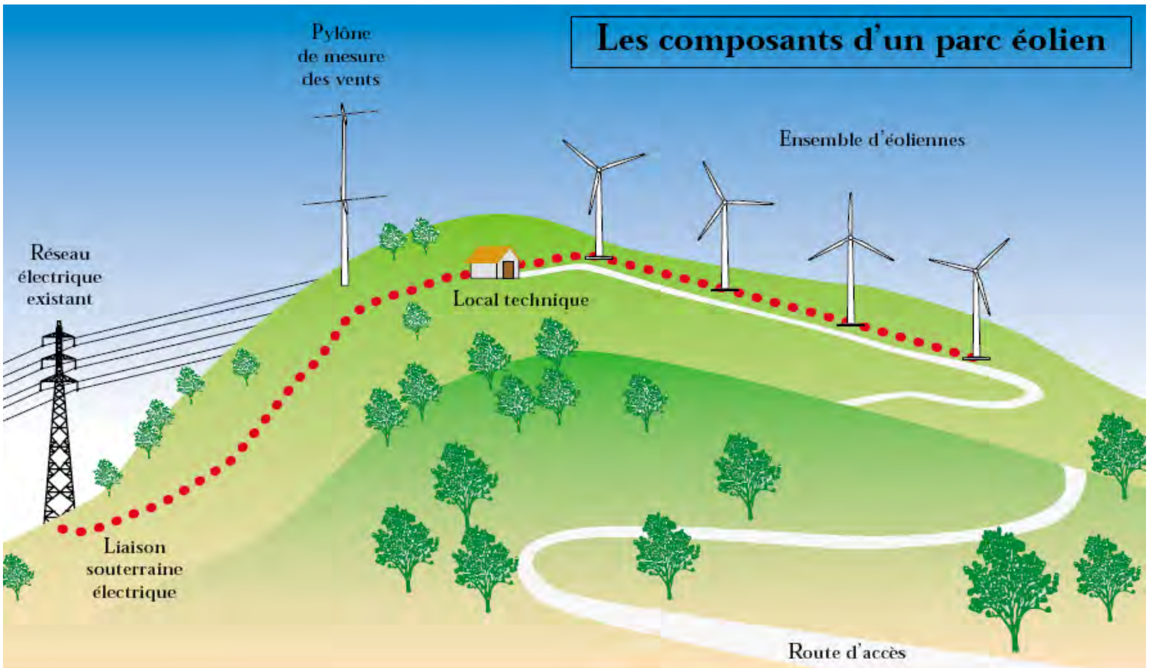
Wind turbines array

Existing electrical network

Technical facility

Underground electrical link

Access road



3.3.2 The construction phase

Implementing the worksite for constructing a wind farm involves a series of major stages. They follow on from each other in a very precise order, determined in concert by the project sponsor, the operators and/or landowners, and the operators of the installation.

3.3.2.1 Preparing the land

The construction of a wind farm, which is a substantial development, requires preparing the land used for establishing the wind turbines and laying access routes to them. Thus, the developments and/or construction of roads and paths will be carried out: levelling of the ground, widening turns, etc.

Figure 9: Preparing the land

The various components comprising wind turbines are heavy and also very large. Section 1.4.3 “Site access” presented the characteristics of a convoy’s load and the sizing of the tracks to be laid as a consequence.

3.3.2.2 Laying the foundations

Laying foundations will only be possible after geotechnical assessments have been carried out. Thus, depending on the characteristics and the special features of the land on which it is envisioned the project will be executed, the dimensions and the type of foundation rebar will be determined.

An excavator will be involved initially in order to dig out a set volume of soil. Then operators will lay out rebar the characteristics of which will be the outcome of the geotechnical analysis. Lastly, concrete mixers will pour the required volumes of concrete.

Then work at the construction site will be suspended for a few weeks to give the concrete time to set.

Figure 10: Preparation of the foundations

3.3.2.3 Storage of the wind turbines' components

The components of the wind turbines (towers, nacelles, blades, etc.) will be trucked to the site. For organizational reasons, each of the components comprising a wind turbine will be unloaded near each of the foundations. Major precautions will be taken in order to avoid any stresses being placed on the components during unloading.

The components will be stored for a short period in order to avoid any deterioration

Figure 11: Storage of the blades on-site before hoisting them

It is foreseen that the nacelle will be unloaded in the vicinity of the platforms, where there will be a specially set-out area so that the truck carrying the nacelle can be maneuvered. The blades will be laid out in an area set aside for that purpose which must be flat, cleared and have its vegetation mown down to ground level as well as being free of any obstacles.

3.3.2.4 Installation of the wind turbines

Wind turbine installation is an assembly operation involving the following stages:

- Preparation of the tower: The surfaces and the platforms of each section of the tower must undergo a visual inspection and the insides of all the sections must also be inspected before lifting them vertically. The tower, which will have been exposed to dust and mud while it was transported, will be cleaned. Tensioning tests will be carried out on the bolts.

Figure 12: Preparation of a blade

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- Assembling the tower: This operation mobilizes two cranes in order to lift a tower section into vertical position. The bottom section of the tower is lifted into vertical position and the magnetic handles are used to bring the tower into position. Once the bottom section is placed in an appropriate position, the fastening bolts will be tightened.

Figure 13: Mounting of the first component of the tower

The next tower sections are then assembled. In principle, mounting of the top section and of the nacelle is planned for the same day. However, if the nacelle cannot be mounted on the same day due to weather or other reasons, the risk of the tower swaying is taken into account and is forestalled by securing the tower using a system of ropes.

Figure 14: Mounting the tower's components

- <u>Hoisting the nacelle onto the tower:</u> As a first stage, the hoisting stirrups must be firmly fastened to the nacelle, along with the guide ropes enabling the operation to be controlled.

Figure 15: Preparation of the nacelle

The nacelle is then hoisted and fastened onto the tower.

Figure 16: Mounting the nacelle on the tower

× Hoisting the hub: Two methods are used depending on the crane's payload:

- The hub may be mounted directly onto the nacelle at ground level. The nacelle and hub assembly is then hoisted and fastened onto the tower;
- The nacelle is fastened onto the tower, the hub is hoisted and fastened onto the nacelle during a second stage.

Mounting the blades: The blades are mounted using a crane and a lift grab.

Figure 17: Lifting a blade

The blade is hoisted to the same level as the hub. Ropes are used to guide the blade to its final position. Two technicians are also required to guide the pins into position, one inside the hub and the other outside the hub.

Figure 18: Assembling a blade onto the hub

After having fastened the blade's pins onto the hub, the hoisting equipment is removed

Figure 19: Holding a blade in position while it is being fastened to the hub

3.3.2.5 Installation of the electrical connection

The wind turbine's output energy will initially be routed to the sub-stations installed on-site (which act as an interface between the electrical network and the energy produced by the wind turbines). Then, electrical cables will be laid (underground) up to the main substation allocated for the connection.

Figure 20: Sub-soil trench digging. The machine used for digging the trench to a depth of approximately 1 m

The connection path between the wind turbine and the delivery stations and the delivery stations and the substation will the project access roads.

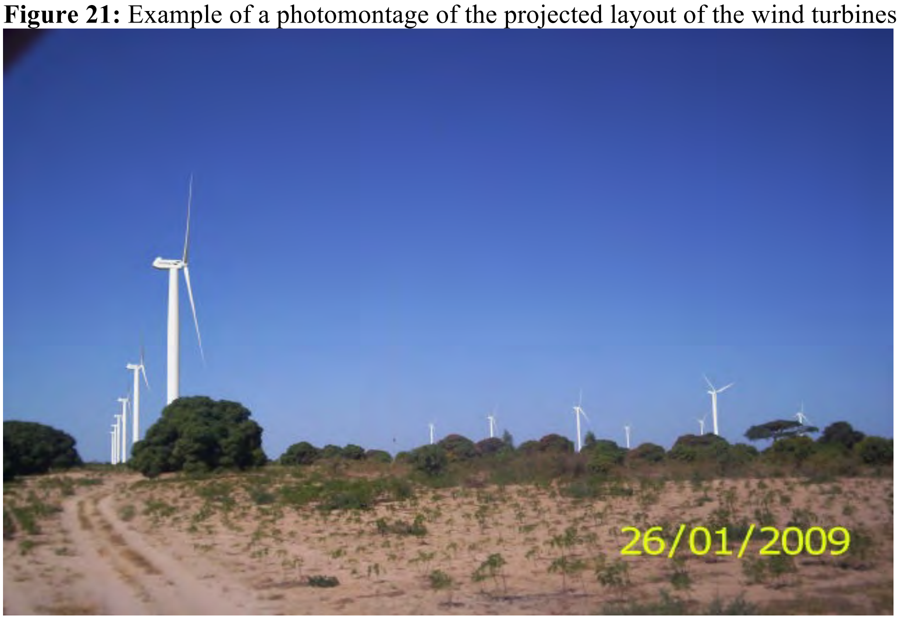
Remark: Each electrical cable used will feature optical fibre. This is why there will be no telephone cabling. Remote management of the wind farm will be ensured via optical fibres.

3.3.3 Site clean-up after construction

This will mainly involve cleaning up the worksite, and completing the final layout of the access roads and paths.

NB: After they are constructed, in no way shall the establishment of the wind turbines in an agricultural zone prevent the continuation of the agricultural reproduction and production activities of the communities living in this area outside the construction area. (See the photomontages below.)

Figure 21: Example of a photomontage of the projected layout of the wind turbines



The photomontages above give an impression of the final layout of the wind turbines at the site.

Several factors point to there not being any major limitations during operation:

- The proximity of an electricity transmission network
- The proximity of roads

Several parameters will have to be checked via sensors in order to optimize the production of electrical energy and make it reliable. All of the various parts of the installation are protected against rust using special coatings.

The structure of the wind turbine and the equipment within it are protected against lightning and overvoltages in accordance with the standards in force.

The maximum electrical power generated by the wind farm as a whole (tranches 1, 2 and 3) is 151.8 MW (46 x 3.3 MW).

Based on the data gathered, we can envisage running at an intermediate power level depending on the power of the wind amounting to 7,000 hours per year (in other words, 80% of the year), which makes for a daily production level equivalent to 6 to 7 hours of rated production (full power) over the whole year.

3.3.4 Decommissioning

3.3.4.1 The decommissioning stages

The various stages involved in decommissioning are as follows:

Table 14: The various stages involved in decommissioning a wind farm

1	Installation of the worksite	Posting the worksite sign, safety arrangements, marking out the worksite around the wind turbines, and the mobilisation, hiring and demobilisation of the work zone.
2	Disconnecting the wind farm	Powering down the wind turbines at the wind farm; making the wind turbines safe by locking their blades; re-establishing the initial distribution network should the operator not wish to retain this network.
3	Disassembling the wind turbines	The opposite procedure to assembly. Possible resale on the second-hand market or to a scrap dealer.
4	Dismantling the foundations	Removal of the foundations to a sufficient depth to enable agricultural machinery to pass over the ground and crops to be grown there.
5	Removal of the substation	Possible resale on the second-hand market.
6	Site clean-up	Removal of the platforms the cranes were mounted on, and of the buried lightning rod system near each wind turbine, and redevelopment of the tracks.

The company Vestas will set up a well-defined project-specific decommissioning process for these wind turbines. Manuals providing recommendations stipulate the existing decommissioning procedure for all models of Vestas wind turbines.

These documents describe the main activities involved in the decommissioning process, ranging from dismantling the turbine through to the preparations for subsequent transport. The decommissioning procedure is set out with the objective of recommissioning the turbine at another site. The instructions therefore aim to keep the components in a reusable state. Consequently, no instructions are provided regarding the disposal of turbine components. Should a turbine have to be destroyed, methods for removing components may be used in order to reduce the workload and the time taken for the decommissioning process, but these methods are neither suggested nor recommended in the aforementioned documents.

Subject to good weather conditions, the estimated time required to decommission a wind turbine is two days.

3.3.5 Noise impacts

3.3.5.1 During the construction phase

During the construction phase, the project manager must take every precaution in order to limit noise, and fulfil the conditions for the use or operation of equipment as well as any municipal orders concerning construction noise. It will be its responsibility to warn the neighboring area of any noise pollution and to organize transport and unloading so that the duration of the noise pollution is reduced.

Initial measures were taken in order to fix the various forms of noise pollution created by construction. Two interministerial decrees dated 11 April 1972 (Official Gazette of 2 May 1972) implemented by the Decree of 18 April 1969 relating to the soundproofing of construction machinery, limit the noise level permitted for some of this equipment.

Of the various sources of construction-related noise pollution, the following items will be noted:

- Civil engineering operations;
- Traffic created by hoisting machines and vehicles (cranes, lorries for transporting the turbine's components and the various equipment items, cars);
- Temporary power supply sources (generator sets);
- Installing and transporting living quarters;
- Movements of people;
- Assembling the wind turbine along with mechanical noises and the use of specific tools (for example: hydraulic fastening tools).

3.3.5.2 During operation of the wind farm

As a matter of fact, all things being equal, a large wind generator is less noisy than a small wind turbine in relation to its size. The main reason for this is the speed at which the blades rotate, which is slower for large wind generators: one rotation takes over three seconds.
The noise emitted by a wind farm does not occur in bursts. It does in fact consist of aerodynamic noise relating to the blades swishing through the air, and a mechanical noise due to the machinery moving inside the nacelle.

Figure 22: Illustration of the source of noises

A wind turbine's noise is the sum of several noises:

Mechanical noise, which is mainly perceptible when the wind turbine begins operating. It is due to the various mechanisms inside the nacelle (the power supply system, rotating components, actuators, etc.);

Aerodynamic noise, which may itself be broken down into two types of noise;

Noise due to the rotation of the blades in the air;

Noise due to the blade passing in front of the tower.

All of these three sources define a theoretical acoustic power that is characteristic of a given wind turbine.

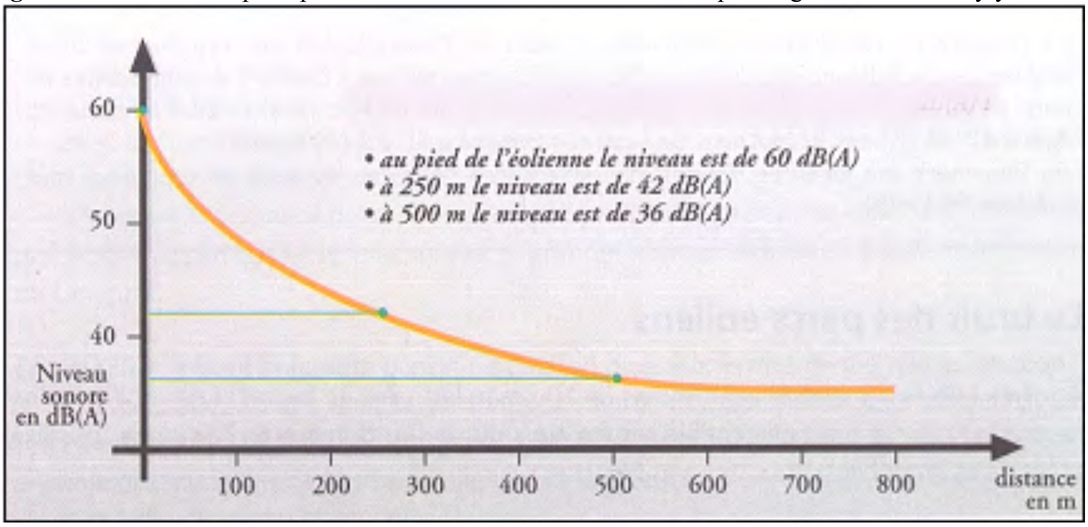
This power depends on the wind speed.

The acoustic power of a wind turbine matches the equivalent noise produced by the machine at the height of the nacelle. The latter factors in air friction on the blades, on the tower, and any mechanical noises, etc. coming out of the nacelle.

Overall, perceptions of the noise from a wind turbine depend on how far away the individual is (cf. the illustration below). It seems that:

- The farther away you are, the lower the noise levels are;
- The noise decrease is greater between a distance of 0 and 150 m away;
- If the noise level at the foot of the wind turbine is approximately 60 dB(A), it will only be approximately 42 dB(A) at 250 m and 36 dB(A) at 500 m.

Figure 23: Decrease in perceptions of the noise of a wind turbine depending on how far away you are



- ***At the foot of the wind turbine, the level is 60 dB(A)***
- ***At 250 m, the level is 42 dB(A)***
- ***At 500 m, the level is 36 dB(A)***

Noise level in dB(A) Distance in m

4 POLITICAL, LEGISLATIVE, REGULATORY AND INSTITUTIONAL FRAMEWORK

The project is conducted under a political, legal and institutional framework that should be presented.

4.1 POLITICAL AND INSTITUTIONAL FRAMEWORK

4.1.1 Analysis of the energy sector

4.1.1.1 Energy policy

Under the framework of the implementation of the energy sector recovery plan, a new sector-based development policy (2007-2012) was drawn up with a view to specifying the objectives and outlining strategic orientations in a set of measures.

The Government of Senegal's new energy policy, which was developed in the policy letter, highlights the following three major objectives:

(i) To ensure the country's energy supply in sufficient quantities, subject to optimal quality and sustainability conditions, and at the lowest possible cost;

(ii) To expand populations' access to modern energy services;

(iii) To reduce the country's vulnerability to foreign fluctuations, particularly due to the global oil market.

Among the various orientations structuring this new energy policy are the following:

- Diversification of the electricity production sources by developing the coal sector, biofuel, wind power, biomass, and other sources;
- Adaptation of the energy infrastructure to meet demand by relying on both the public and private sectors;
- Speeding up access to electricity, particularly through the promotion of rural electrification and the development of energy services for satisfying the needs of production and social activities;
- Keeping a cap on energy demand and improving energy efficiency;
- Consolidating governance of the energy sector;
- Restructuring the electricity sub-sector with a view to greater efficiency and well thought-out involvement of the private sector.

The vision underpinning the objectives pursued falls under the framework of DSRP (Poverty Reduction Strategy Document) II, namely equipping the country with infrastructures that can guarantee urban and rural households access to basic social services, including energy services, by 2012.

4.1.1.2 Institutional arrangements

The Ministry of Energy is responsible for setting out sector-based policy and defining the applicable standards. It alone is empowered to grant licences and concessions which predetermine the right of operators to produce, distribute or sell electricity across Senegal's national territory.

Based on proposals by the CRSE (Electricity Sector Regulatory Commission), the Minister also decides on the pricing conditions applicable to each concession.

The CRSE, which operates as a quasi-judicial administrative tribunal, is responsible for regulating activities relating to the production, transport, distribution and sale of electrical energy in Senegal. It is the body that examines any applications for licences or concessions, and which provides its reasoned opinion to the Energy Minister for decision-making and allocation purposes.

The quite recent creation of the Ministry of Biofuels, Renewable Energy Sources and Scientific Research should also be noted: its purpose is to open up new avenues for research and implementing scientific and technological results for social well-being within a tightly-controlled environment thanks to having a controlled energy sector.

Generally speaking, these two ministries constitute the cornerstone of the institutional framework for the energy sector.

4.1.2 Aspects related to the environmental sector

4.1.2.1 National environmental management policy

In Senegal, environmental management policy is marked by various orientation documents and framework documents for strategic planning, inspired by a mission which forms part of a sustainable development outlook.

Of these orientation documents, the following may be cited:

- ✓ ***The sector-based policy letter***

The overall objective of the environmental sector policy letter adopted in 2004 is to ensure the sustainability of economic and social development with a view to strong growth compatible with preserving natural resources and the environment.

Among other things, the specific objectives pursued by this consist of:

(i) Mitigating the degradation of resources by setting up institutional and regulatory arrangements that are effective, based on international conventions;

(ii) Improving the knowledge base relating to natural resources and the environment with a view to better measuring their loading capacities;

(iii) Improving the planning and coordination capacities of initiatives for preserving the environment within a context involving giving the various actors a greater feeling of responsibility;

(iv) Promoting activities that generate revenue and collective infrastructures that combat both poverty and environmental degradation;

(v) Increasing the network for populations serviced by independent collective sewage works.

The environmental policy letter assigns a central role to taking the environment into account as part of the development approaches for other sectors. As a general rule, primarily infrastructure is scrutinised with regard to harmful impacts on the environment and natural resources, as well as during the construction works for getting this infrastructure up and running.

- ✓ ***PNAE (the National Action Plan for the Environment)***

In terms of environmental planning, the PNAE constitutes the benchmark strategic framework. This planning exercise was undertaken following recommendations made by the World Bank with a view to encouraging countries to improve environmental management in a consistent, co-ordinated way.

Consequently, in February 1995, Senegal initiated a decentralized participatory process which, in 1997, gave rise to the PNAE, which highlights procedures for articulating environmental, institutional and macro-economic issues under the framework of a long-term development strategy.

- ✓ ***PAN/LCD (the National Action Program for Combating Desertification)***

This constitutes an integral part of the PNAE and a major component of it as, in several areas in Senegal, desertification and the degradation of natural resources constitute the most acute environmental issues.

Due to its transverse nature, from the time when it was drawn up, the PAN/LCD has integrated the major orientations contained in the other sector-based exercises such as the livestock rearing action plan, the land action plan, and the forestry action plan.

Of the various causes of desertification, the Plan emphasises deforestation and the clearing of sites allocated for the installation of certain works, as well as the growing pressure created by human settlements.

✓ ***The Biodiversity Conservation Strategy***

Senegal has a biodiversity conservation action plan and strategy. The strategy forcefully emphasises the need to preserve biodiversity sites.

Among the action plan's priority measures is the protection of coastal and marine ecosystems, which are often considered to be sensitive zones.

The works involved in establishing infrastructures along the littoral zone may have negative impacts on biodiversity in terms of degrading or disrupting fragile ecosystems.

✓ ***SNMO (the National Implementation Strategy Regarding Climate Change)***

This strategy is aimed at bedding in a harmonized framework for managing programs relating to climate change. It is understood that the energy sector contributes to a great extent to the emission of greenhouse gases, which play a major part in the process of heating up the planet.

In this regard, it is important to note that warming due to climate change places the communities along the Niayes strip (comprising wetlands) in the forefront, with the site for the wind farm planned for Taïba Ndiaye forming an integral part of this zone.

4.1.2.2 Institutional framework

Due to its complex, strategic nature, in environmental terms, the wind farm development project involves several institutional actors.

Of them, the following key actors may be listed: The Ministry of Environment, and the decentralized local bodies located in the zone where the project is to be established.

The main mission of the Ministry of Environment is to promote rational management of natural resources and to work towards improving the living conditions of local populations, with a view to sustainable development and combating poverty. This mission was reasserted via the sector-based policy letter and the decree setting the Ministry's assigned responsibilities.

More specifically, what is involved is drawing up and implementing environmental policy, the management of which involves many other actors.

In order to successfully complete its mission, the Ministry relies on a certain number of structures, directorates and departments seconded as the case may be.

Within the context of this study, of the Ministry of Environment's structures that are directly involved, the following may be cited:

- **The DEEC (Directorate of the Environment and Listed Establishments)** which is responsible for the implementation of the government's environmental policy, and particularly:

- ✓ Protection of the natural environment and people from various sorts of pollution;
- ✓ Implementation of the specific resources for ensuring prevention and controlling various forms of pollution;
- ✓ Monitoring all of the actions of the various departments and bodies intervening in the environmental sector;
- ✓ Drawing up legislation and regulations concerning the environment;
- ✓ Promoting energy efficiency in order to enable better protection of the environment through rational management of its resources.

The DEEC also ensures the implementation of provisions relating to environmental impact studies. To this end, it conducts end-to-end monitoring of the process for environmental impact studies carried out by approved inspection bureaus, and prepares opinion papers and decision-making recommendations regarding whether or not to accept a project for the Environment Ministry, with the Technical Committee's support.

- **The Technical Committee**

Instituted by Ministerial Order No. 009469 of 28 November 2001, the Technical Committee rules on environmental impact study reports submitted for validation. Its administrative services are carried out by the DEEC. It should be specified that the impact study procedure requires public validation of the impact through public hearings.

- **The Directorate of Water, Forests, Hunting and Soil Conservation**

This Directorate is responsible for the implementation of forestry resource management; soil conservation and wildlife management. Consequently, it has to ensure the conservation of forestry potential and ecological balances. With regard to this, it is involved in the execution and operation of the wind farm.

Without this being an exhaustive list, the following actors are also involved in this arrangement:

- **Local bodies**

Through the powers transferred to them, the boroughs and rural communities are responsible for management of the environment and natural resources, particularly throughout their territories. They have to take care of all the arrangements required for ecologically rational management of the environment. Local bodies offer the advantage of ensuring local management and of constituting priority contacts for local populations.

In this capacity, they must be informed of the projects to be established within their territory, and certain aspects will have to be negotiated with them before the works are actually started in order to avoid conflicts.

Under the framework of exercising their prerogatives, local bodies may receive the support, where need be, of decentralized State services placed under the purview of the Regional Governor through standard agreements set out in the Local Bodies Code.

Within this project, the local bodies involved are: the Department Council of Tivaoune, and the Borough of Taïba Ndiaye.

- **Basic community organizations and non-governmental organizations**

These structures, which are increasingly devoted to the environmental protection sector and improving the living standards of the local populations, also play a major role in terms of promoting citizen control.

4.2 LEGAL FRAMEWORK

In legal terms, it should be pointed out that in its preamble, the Senegalese ***Constitution*** of 22 January 2001 refers to the African Charter on Human and People's Rights adopted in Nairobi in 1981, Article 24 of which enshrines the right of people to a healthy environment.

Within the corpus of basic law, the right of any individual to a healthy environment is guaranteed by Article 8. This constitutionalization of the right to a healthy environment forms the basis of policy for improving living standards.

There are other texts which govern and provide the framework for energy production and infrastructure execution projects, in light of their potential impacts on the environment, safety and the health of local populations.

In this regard, the following will be analyzed: appropriate international conventions, legislation and regulations applicable to the environmental sector (the Law implementing the Environment Code and the various orders supplementing it), as well as the various relevant sector-based Codes.

4.2.1 The relevant international environmental conventions signed by Senegal

The international conventions signed and ratified by Senegal primarily relate to the Rio generation, which are undeniably linked to the execution of infrastructures and energy issues.

As it turns out, what is involved is the United Nations Framework Convention on Climate Change and the Kyoto Protocol relating to greenhouse gas emissions, the Convention on Biodiversity, and the Convention to Combat Desertification.

Other relevant conventions may be added to this list.

A list of the relevant conventions is provided in the table below:

Table 15: International environmental Conventions signed by Senegal

Name of the Convention	The field regulated and the objective	Implementation under the framework of the project
The United Nations Framework Convention on Climate Change (UNFCCC) adopted in Rio on 5 June 1992 and signed by Senegal, ratified on 14 June 1994, and the **Kyoto Protocol**	Management and adaptation to climate change. Stabilizing greenhouse gas concentrations in order to avoid any dangerous disruption to the climate system and so that ecosystems can adapt to climate change.	The existence of industrial activities that constitute greenhouse gas pollution sources (CO_2, SO_2 and NOx emissions in particular).
The Convention on Biodiversity signed by Senegal in June 1992 and ratified on 14 June 1994	Conservation of biodiversity and sustainable use of its elements, as well as fair and equitable sharing of the advantages linked to exploiting genetic resources	Land clearance is possible for developing the site where the project is to be implemented.
The United Nations Convention to Combat Desertification signed in Paris on 14 June 1994 and ratified by Senegal in March 1995	Combating desertification and mitigating the effects of drought.	Land clearance is possible during development operations.
ILO Hygiene (Commerce and offices) Convention No. 120 ratified by Senegal in 1966	Work hygiene and hygiene within infrastructure. This convention governs hygiene in certain infrastructure.	Work hygiene and safety are transverse components in all of the project's activities.
The African Convention on the Conservation of Nature and Natural Resources adopted in Algiers on 15 March 1968 and ratified by Senegal in 1971	Management of natural resources. Protection of wildlife and flora as well as natural resources such as soil and water.	Land clearance is possible during development operations. Destruction and/or contamination of soil; exploitation and/or contamination of water resources.
The Convention Concerning the Protection of the World Cultural and Natural Heritage, adopted in Paris on 16 November 1972, and the **Convention for the Safeguarding of Intangible Cultural Heritage** adopted in Paris on 17 October 2003	Preservation of the cultural heritage.	The project's activities must not cause the destruction of buildings, monuments or other cultural heritage items within the zone.
The Convention for the Protection of the Ozone Layer adopted in Vienna on 22 March 1985 and the **Montréal Protocol** on substances that	Preservation of ozone in the stratosphere. Regulation of activities that may give rise to damaging the ozone layer.	The activities foreseen under the framework of the project must take this international commitment into account.

Name of the Convention	The field regulated and the objective	Implementation under the framework of the project
deplete the ozone layer, adopted in Montréal on 16 September 1987		

4.2.2 The LCE (Law concerning the Environmental Code)

The provisions of Law No. 2001-01 of 15 January 2001 applying the Environmental Code and its Implementation Decree No. 2001- 282 of 12 April 2001 constitute the basic legislative and regulatory framework governing activities with environmental impacts.

The LCE deals with general provisions, preventing and combating various forms of pollution, the protection and development of host environments, and also sanctions and miscellaneous provisions.

In terms of **environmental assessment**, the provisions of Title II, Chapter IV of the LCE institute environmental assessment for any project or activity likely to adversely affect the environment, as well as policies, plans, programs, and regional and sector-based studies.

The objective of the EIS is to take environmental concerns into account from the design phase for projects onwards.

Moreover, the Decree specifies the scope of the environmental impact study. Thus, depending on the potential impact, the nature, the extent and the location of the project, projects are placed into one of the following categories:

- Category 1: The projects are likely to have significant impacts on the environment; an environmental impacts assessment study will enable environmental considerations to be integrated into the project's economic and financial analysis; this category requires an in-depth environmental assessment;

- Category 2: The projects have limited impacts on the environment or the impacts may be mitigated by implementing measures or changes to their designs; this category is subjected to an initial analysis.

The Environmental Code also features provisions specific to **listed installations**.

Indeed, Chapter I of Title II (Prevention and combating various forms of pollution) of the Environmental Code deals with Installations that are listed for environmental protection purposes. These installations fall into two categories (Article 9-11).

Class 1 installations are defined as posing a risk of "serious dangers or inconveniences" relating to "health, safety, public health, agriculture, nature and the environment in general". They are subject to a permits system.

Class 2 installations are considered to pose no threat of major pollution and consequently are subject to less strict controls. These installations are subject to a declarations system.

Above and beyond the provisions referred to above, the Environmental Code covers certain safety aspects by drawing up an emergency plan in order to deal with critical situations that create serious pollution. Such provisions constitute an effective way of implementing a strategy for preventing and combating accidents. In fact, the hazards study constitutes a basic document for designing certain types of projects.

Public participation is an element comprising the environmental impact study (Article L52). Article L53 defines the public's role in the decision-making procedure regarding projects or programs likely to have harmful effects on the environment.

"The participation of populations offers a response to the determination to democratize the decision-making process and it is guaranteed by the State in keeping with decentralization and regionalization." (Article L52)

Also it should be noted that **Prime Minister's Office Circular No. 009 PM/SGG of 30 July 2001** states the need for all development projects or activities likely to be harmful to the environment and the health of local populations to form the subject of a preliminary environmental impact study, in accordance with the procedures defined in the Implementation Decree for the Law applying the Environmental Code.

The range of legal measures relating to environmental assessment is supplemented by **various Orders** which should be noted:

- Order No. 009468 of 28 November 2001 relating to regulating public participation in environmental impact studies;
- Order No. 009469 of 28 November 2001 relating to the organization and functioning of the Technical Committee;
- Order No. 009470 of 28 November 2001 relating to the conditions of granting approval for carrying out activities relating to environmental impact studies;
- Order No. 009471 of 28 November 2001 relating to the content of the terms of reference for environmental impact studies;
- Order No. 009472 of 28 November 2001 relating to the content of the environmental impact study report.

Some of the sector-based legislative texts that apply to implementation of the project include:

4.2.3 The Hygiene Code

Law No. 83-71 of 5 July 1983 concerning the Hygiene Code, which is aimed at regulating hygiene, or in other words all of the rules that have to be complied with by everyone in order to maintain their health. From this perspective, it is aimed at individual hygiene, but particularly public and collective hygiene, and sanitation within the natural environment of such a nature as to facilitate better quality of life in all locations. Among other things, the law precisely defined hygiene regulations in such a way as to enable epidemics to be combated, as well as to ensure good management of the hygiene of homes and industrial installations and the hygiene of public thoroughfares and the packaging of waste.

4.2.4 **General Code of Local Government**

Law No. 2013-10 of 28 December 2013 concerning the General Code of Local Government organizes the framework for implementation of this reform which henceforth retained only two levels of local government in Senegal: the borough and the Department.

The general objective targeted by this reform, which was called "Act III of decentralization", is to organize Senegal into viable regions that are competitive and that foster sustainable development. This reform is taking root in a regional development policy and orients firming up the hopes and aspirations of regional actors, with a view to building up a regional plan. It offers sufficient leeway for laying the groundwork for the regional implementation of public policies.

As stipulated in Article 1 of the General Code of Local Government, local bodies are administered freely by councils elected based on universal suffrage and which have a legal personality and financial autonomy. To do this, they have a budget and their own resources. These resources therefore constitute the central pillar of decentralization, because the first yardstick of the financial autonomy of a local body is having its own resources.

4.2.5 The Water Code

Law No. 81-13 of 4 March 1981 concerns the adoption of this Code. Title II is devoted to water quality protection and makes provision for measures for combating water pollution and for water regeneration, by setting standards to be followed for the various uses. Furthermore, this Title determines events likely to pollute water and the administrative resources for combating pollution.

It was only in 1998 that the first implementation decrees for this code were adopted.

4.2.6 The Forestry Code

Law No. 98-03 of 8 January 1998 concerning the Forestry Code sets out that all activities likely to adversely affect forest formations are prohibited in listed forests unless they are authorized by the Ministry of Water and Forests. The Code specifies that authorization is only granted in light of a file which, among other things, includes an environmental impact study carried out by an approved natural person or legal person.

4.2.7 The Labor Code (Law 97-17 of 1st December 1997) and its implementation decrees

This Code organizes professional relations between workers and employers. The Code regulates the relations system and lays down the principle of respecting their mutual rights and obligations. Among its health-related provisions, Law No. 97-17 of 1st December 1997 concerning the Labor Code sets working conditions, particularly as far as work hours are concerned (which must not exceed 40 hours per week), night work, special regulations for women and children, and the weekly rest period which is obligatory. The text also deals with Hygiene and Safety in workplaces and indicates the measures that any activity must implement in order to ensure the hygiene and safety guaranteeing a healthy environment and safe work conditions. Thus, the project is mainly affected by this Code and its implementation decrees. New Orders have been added to the existing arrangements:

- Decree No. 2006-1249 of 15 November 2006 setting the minimum health and safety requirements for temporary or mobile worksites;
- Decree No. 2006-1250 of 15 November 2006 relating to vehicle and machinery traffic within enterprises;
- Decree No. 2006-1251 of 15 November 2006 relating to work equipment;
- Decree No. 2006-1252 of 15 November 2006 setting the minimum prevention requirements for certain physical environmental factors;
- Decree No. 2006-1253 of 15 November 2006 instituting workplace medical inspection and setting its assigned responsibilities;
- Decree No. 2006-1254 of 15 November 2006 relating to the manual handling of loads;
- Decree No. 2006-1256 of 15 November 2006 setting the obligations of employers in terms of workplace safety;
- Decree No. 2006-1257 of 15 November 2006 setting the minimum requirements for protection against chemical risks;
- Decree No. 2006-1258 of 15 November 2006 setting the missions and organizational and operational rules for Workplace Medical Services;
- Decree No. 2006-1260 of 15 November 2006 relating to the aeration and sanitation conditions of worksites
- Decree No. 2006-1261 of 15 November 2006 setting general hygiene and safety measures within all kinds of establishments

4.2.8 Land law

The Government of Senegal has promulgated several legal texts relating to land ownership, as well as expropriation, compensation and reinstallation procedures. Of these texts, the following may be cited:

- **Law No. 64-46 of 17 June 1964 relating to the national domain**:

The national domain includes all land except lands which fall into the public domain and those which are private property.

The national domain is split into 4 types of zones constituting nearly 95% of the territory. It involves urban zones, rural zones, listed zones, and pioneer zones.

The Law on the National Domain makes the State the guardian of lands and the Authority empowered to organize their rational use. Regarding this topic, it should be noted that domain affairs form part of the powers transferred to local bodies.

- **Law 76-67 of 2 July 1976 relating to expropriation for public purposes and its implementation decree:**

This Law institutes a forced expropriation procedure for public purposes via which the State may, with a view to public utility, and subject to the proviso of providing fair compensation in advance, may force any person to grant it the ownership of a building or of a real property right.

4.3 ENVIRONMENTAL AND SOCIAL COMPLIANCE REQUIREMENTS: THE IFC'S PERFORMANCE CRITERIA

In April 2006, the IFC (International Finance Corporation) published a series of eight PS's (Performance Standards) which have become an international benchmark for the social and environmental assessment process in which the IFC and other international lenders are involved. These standards were revised and the new version came into force in January 2012. Table 16 summarizes these performance standards.

Table 16: The IFC's performance standards

No.	Name	Scope
1	Assessment and Management of Environmental and Social Risks and Impacts	Defines the provisions for succeeding in instituting a suitable environmental and social management policy, including requirements in terms of Environmental and Social Impact Studies.
2	Labor and Working Conditions	Defines the provisions for drawing up and implementing fair recruiting and staff management policies.
3	Resource Efficiency and Pollution Prevention	Defines an approach for rational use of resources and for preventing and combating pollution at project level in compliance with the technologies and practices disseminated internationally.
4	Community Health, Safety, and Security	Defines the provisions for ensuring that the Project's negative impacts on the host community are managed and controlled.
5	Land Acquisition and Involuntary Resettlement	Defines the provisions for managing land ownership and resettling communities under the

		framework of developing projects.
6	Biodiversity Conservation and Sustainable Management of Living Natural Resources	Defines provisions making it possible to ensure that the Project's impacts on nature, ecosystems, habitats and biodiversity are duly managed.
7	Indigenous Peoples	Defines the provisions for ensuring that the rights of indigenous minorities are respected and that indigenous populations will be able to derive benefit from the Project.
8	Cultural Heritage	Defines the provisions for managing the Project's impacts on tangible and intangible heritage assets.

The IFC's Performance Standard 1 establishes the importance of managing social and environmental performance throughout a project's life cycle. It encourages the establishment of a permanent, effective social and environmental management system and real participation by the communities through a good communication policy and consultation of local populations. It also encourages integrated assessment of the impacts, risks and opportunities associated with the project right from its initial development phases, and consequently provides a hierarchy and consistency in order to mitigate and manage risks on an ongoing basis.

Based on the information gathered during the development of the terms of reference as well as the site inspections, it appears that the following IFC[1] Performance Standards are applicable to the wind farm project:

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts;
- Performance Standard 2: Labor and Working Conditions;
- Performance Standard 3: Resource Efficiency and Pollution Prevention;
- Performance Standard 4: Community Health, Safety, and Security;
- Performance Standard 5: Land Acquisition and Involuntary Resettlement;
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources.

IFC Performance Standard 7 concerning indigenous populations will not apply as no indigenous population (as defined in PS 7) has been identified within the project's zone.

The WBG/IFC's Environmental, Health and Safety Guidelines

[1] http: l/www.ifc.or /ifcext/polimeview.nsf/AttachmentsBvTitle/Updated2011/$FILE/UpdatedIFC SustainabilityFrameworkCompounded Augustl-2011.pdf; and
http:/ I wwwl.ifc.org/wps/ wcm I connect/b9dacb004a73e7a8a273fff998895a12/ IFC SustainabilityFramework.p df?MOD=AJPERES

The World Bank Group (WBG) has also published a series of Guidelines for environmental, health and safety management (EHS Guidelines). These guidelines are technical reference documents which present examples of good international practices of a general nature (i.e., the EHS General Guidelines) or concerning a particular business sector (i.e., the EHS Sector Guidelines). .

Under the framework of the Project's development, the EHS Guidelines to be taken into account are:

- The General EHS Guidelines (2007) which presents the environment, health and safety guidelines applicable in all sectors;
- The EHS Guideline for thermal power stations (2007), which presents the good practices to be applied in relation to the various types of power stations depending on the issues highlighted.

These directives may be consulted on the IFC[2] website.

4.4 THE STANDARDS FRAMEWORK

4.4.1 Senegalese standards

There are additional **environmental standards** relating to the protection of air quality, protection against noise, and against the discharge of wastewater.

Prevention against pollution risks in receiving environments such as water and air justifies adopting a standards arrangement that regulates the discharge of wastewater and atmospheric emissions.

The Senegalese Standard NS 05-061 features general provisions applying to wastewater discharges within the country's national territory and provisions concerning the discharge of effluents into a receiving environment. This standard also covers surveillance and inspection of wastewater discharges. To this end, discharge limit values and criteria have been defined, as shown in Tables **5** and **6.**

Along the same lines, Senegalese Standard NS 05-062 concerning air quality sets the limits for establishments' discharge of pollutants into the air (emissions) as well as the permissible pollutants concentration in ambient air (immissions). These limit values are presented in Tables **3 and 4.**

With regard to protection against noise, strictly speaking there are no specific standards governing noise emissions, although the Environment Code stipulates that "The maximum noise thresholds that should not be exceeded without exposing the human body to harmful

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[2] http:// wwwl.ifc.org/wps/wcm/ connect/ topics ext content/ ifc external corporate site/ ifc+sustainability/ sustainabilit y+framework/ environmental %2C +health %2C +and +safety+guidelines I ehs~Widelines french

consequences are fifty-five (55) to sixty (60) decibels per day and forty (40) decibels at night".

Generally speaking, the spirit of these standards does comply with the prevention and precautionary principles which inspired the Law relating to the Environment Code.

Table 17: Standard NS 05-062: Limit values for atmospheric pollutant discharges

Substances	Flow rate	Discharge limit values
Total dust	D <= 1 kg/h D > 1 kg/h	100 mg/m^3 50 mg/m^3
Carbon monoxide The authorization order sets (where applicable) a discharge limit value for carbon monoxide		
Asbestos	D > 100 kg/year	0.1 mg/m^3 for asbestos 0.5 mg/m^3 for total dust
Sulphur oxides (in the form of sulphur dioxide)	D > 25 kg/h	500 mg/m^3
Nitrogen oxides excluding nitrous oxide, in the form of nitrogen dioxide	D > 25 kg/h	500 mg/m^3
Hydrogen chloride and other chlorine gas inorganic compounds (in the form of HCl)	*4.4.1.1.1.1.1 D > 1 kg/h*	50 mg/m^3
Ammonia and ammonium compounds in the form of ammonia	D > 100 g/h	20 mg/m^3
Fluorine, fluorides and fluorinated compounds (gases, droplets and particles)	D > 500 g/h	10 mg/m^3 for gases 10 mg/m^3 for droplets/particles 15 mg/m^3 for manufacturing phosphoric acid, phosphorus and fertiliser
Total discharge in terms of organic compounds, excluding methane and Polycyclic Aromatic Hydrocarbons (PAH)	D > 2 kg/h	150 mg/m^3
Polycyclic Aromatic Hydrocarbons (PAH)	D > 2 kg/h	20 mg/m^3
Discharges of Cadmium, Mercury, and Thallium, and of their compounds (in the form of Cd + Hg + Ti)	D > 1g/h	0.2 mg/m^3
Discharges of Arsenic, Selenium and Tellurium, and of their compounds (in the form of As + Se + Te)	D > 5 g/h	1 mg/m^3
Discharges of antimony, chrome, cobalt, copper, tin, manganese, nickel, lead, vanadium, zinc, and of their compounds (in the form of Sb + Cr + Co + Cu + Sn + Mn + Ni + Pb + V + Zn)	D > 25 g/h	5 mg/m^3
Phosphine, phosgene	D > 10 g/h	1 mg/m^3
Ammonia (for fertiliser units)	D > 100 g/h	50 mg/m^3

Table 18: Standard NS 05-062: Limit values for concentrations of pollutants in ambient air

Substance	Immission limit value	Statistical definition

Sulphur dioxide (SO_2)	50 µg/m^3 125 µg/m^3	Annual (arithmetic) average Daily average
Nitrogen dioxide (NO_2)	200 µg/m^3 40 µg/m^3	Hourly (arithmetic) average Annual average
Carbon monoxide (CO)	30 mg/m^3	Average over 24 hrs; under no circumstances may it be exceeded more than once a year
Ozone (O_3)	120 µg/m^3	Average over 8 hrs (public health)
Suspended dust (PM 10) (aerodynamic diameter less than 10 µg)	80 µg/m^3 260 µg/m^3	Annual (arithmetic) average Average over 24 hrs; under no circumstances may it be exceeded more than once a year
Lead (Pb) in suspended dust	2 µg/m^3	Annual (arithmetic) average
Cadmium (Cd) in suspended dust	1.5 nb/m^3	Annual (arithmetic) average
Total dustfall	200 mg/m^2 x day	Annual (arithmetic) average
Lead (Pb) in dustfall	100 µg/m^2 x day	Annual (arithmetic) average
Cadmium (Cd) in dustfall	2 µg/m^2 x day	Annual (arithmetic) average
Zinc (Zn) in dustfall	400 µg/m^2 x day	Annual (arithmetic) average
Thallium in dustfall	2 µg/m^2 x day	Annual (arithmetic) average

Table 19: Standard NS 05-061: Limit values for the discharge of wastewater into the natural environment

Parameter	Limit value
Total suspended materials	50 mg/l
BOD5	80 mg/l if the permitted maximum daily flow does not exceed 30 kg/day, or go beyond 40 mg/l
COD	200 mg/l if the permitted maximum daily flow does not exceed 100 kg/day; or go beyond 100 mg/l
Total nitrogen	30 mg/l in terms of the monthly average concentration when the maximum daily flow is equal to or greater than 50 kg/day
Total phosphorus	10 mg/l in terms of the monthly average concentration when the permitted maximum daily flow is equal to or greater than à 15 kg/day.
Phenols index	0.5 mg/l if the discharge exceeds 5 g/day
Phenols	0.5 mg/l if the discharge exceeds 5 g/day
Hexavalent chrome	0.2 mg/l if the discharge exceeds 5 g/day
Cyanides	0.2 mg/l if the discharge exceeds 3 g/day
Arsenic and its compounds (in the form of As)	0.3 mg/l if the discharge exceeds 3 g/day
Total chrome (in the form of Cr_3)	1.0 mg/l if the discharge exceeds 10 g/day
Total hydrocarbons	15 mg/l if the discharge exceeds 150 g/day

4.4.2 International standards specific to the business sector

In terms of European standards, standard EN 50 308 *"Wind turbines. Protective measures. Requirements for design, operation and maintenance"* was drawn up under a mandate from the European Commission, in order to provide a "harmonized" standard under the Machinery Directive.

From 1988, standards work concerning wind turbine was undertaken within the International Electrotechnical Commission (IEC), the world organization for standardization in the electricity sector. With regard to safety, of the standards drawn up pursuant to this work, IEC standard 61400-1, entitled "Wind turbines – Part 1: design requirements", was adopted in 1994.

IEC standard 61400-1 sets the requirements relating to the safety of the wind turbine’s structure, its mechanical and electrical parts, and its control system. These requirements relate to the design, manufacturing, installation and maintenance of the machine. The standard also features provisions concerning quality assurance.

A few details of these standards are presented in the appendices.

5 DESCRIPTION OF THE BASELINE ENVIRONMENTAL CONDITIONS

This chapter describes the project's host environment from the perspective of its physical, biological and socio-economic components. Its objective is to characterize the initial state (baseline state) of the site's environment that is to host the project with a view to highlighting the sensitive factors that may be adversely affected by the project.

5.1 GEOGRAPHIC LOCATION AND ADMINISTRATIVE SITUATION OF THE PROJECT'S SITES

From an administrative perspective, the project for establishing the Taïba Ndiaye wind farm falls within the Thiès Region, the Tivaouane Department, an *Arrondissement* of Méouane and the new borough of Taïba Ndiaye (the former Rural Community of Taïba Ndiaye).

5.2 THE PROJECT'S ZONE OF INFLUENCE

Three (3) study zones were delineated for the purposes of this ESIS (Environmental and Social Impact Study).

☞ **The restricted study zone**

What is involved is a zone within which the project is technically feasible for forty-six (46) wind turbines, each of which occupies 1,400 m^2, making a total siting of 7 hectares and involving access tracks which have to host high-voltage electrical cables covering a linear distance of approximately 34 km.

☞ **The detailed study zone or the zone of direct influence of the works**

This takes into account the whole territory impacted or the works zone. It covers a radius as well as an area of influence of over five (5) km. It is defined depending on the potential impact sources linked to the project's construction phase.

☞ **The expanded or remote study zone**

This relates to the territorial zones of the local bodies (Rural Community of Diass) covered by the socio-economic analysis. This zone takes account of the project's potential effects on the socio-economic and biophysical environment.

5.3 ESTIMATE FOR THE SETTLEMENTS CLOSEST TO THE VARIOUS ROWS

The estimated distance between the wind farm in relation to the various surrounding locations is of paramount importance because it will enable the zones that may be adversely affected by the project's impacts to be ascertained (noise pollution, impact on the landscape, etc.).

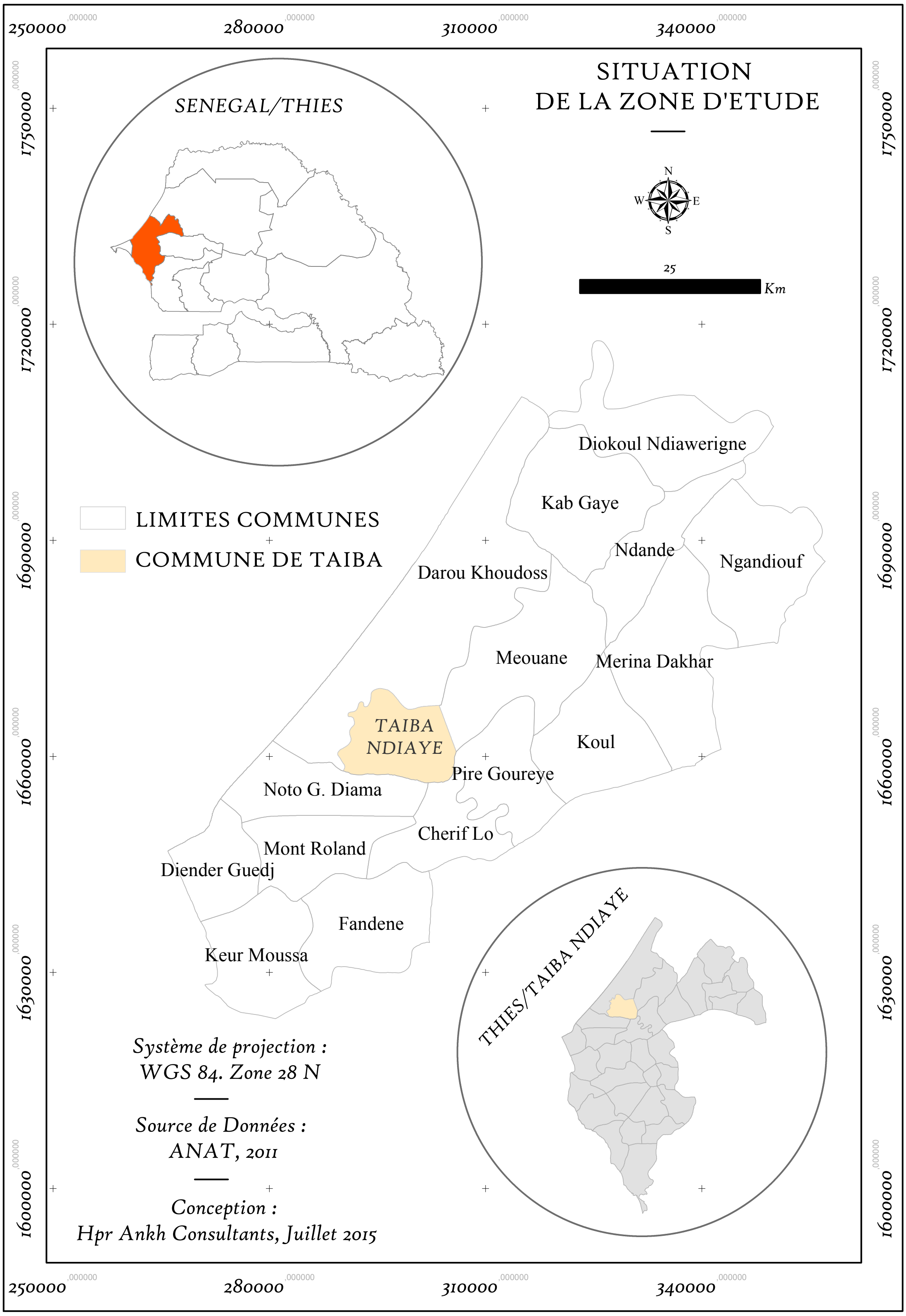
The closest villages (Baïty Guèye, Baïty Ndiaye, Khelcom Diop, Ndombor Diop, Taïba Santhie, Taïba Ndiaye, Maka Gaye Bèye, Diambalo, etc.) are located less than 2 km away from the project.

The locations of the wind turbines closest to the villages are:

Table 20: Summary of the settlements closest to the various lines

Lines or groups concerned	Wind turbine concerned	Distance from buildings (km)	Village concerned
Line 5	E46	1.27	Baity Ndiaye
	E41	1.07	Maka Gaye Beye
	E39	0.95	
	E40	0.95	
Line 4	E31	1.42	Baity Gueye
Line 3	E27	1.27	Khelcom
	E28		
	E18	2.6	Taïba Ndiaye
Line 2	E10	1.75	Ndiombor Diop
	E11	1.07	Khélcom Diop
	E12	1.06	
	E13	1.18	
Line 1	E1	1.4	Diambola

Map 3: Situation and location of the project zone of study



5.4 LAND AND SOIL USE AMONG THE VARIOUS ROWS AND IN THEIR SURROUNDING ENVIRONMENT

Generally speaking, the site that will host the wind farm project is delineated by an agricultural ecosystem. The site is dominated in several locations by plantations of fruit trees, inside of which rainfall related agricultural activities (millet, peanuts, black-eyed peas, etc.) and cash cropping (cassava) are carried out.

However, we did note certain specific features depending on the group considered:

Group 4 will be installed in an area that is mainly dominated by plantations or orchards within which subsistence and cash cropping activities are carried out.

Photo 1: Cash cropping in a palm grove

Photo 2: Mango trees plantation

Groups 5 and 1 will be established within an area, the salient feature of which is that there are no fruit tree plantations. This domain is dominated by rainfall agriculture crops. The presence of a few pockets of land left fallow, with livestock grazing on them, should be noted.

Photo 3: A herd of grazing cows

Photo 4: An old clearing

As far as Group 3 is concerned, what we have is a series of juvenile plantations that are less than five (5) years old. It is a domain that, many years ago, was devoted to rainfall agriculture crops (millet, peanuts, black-eyed peas, etc.) and cash crops (cassava).

Photo 5: A juvenile mango trees plantation

Lastly, Group 2 of E_9 at the village of Baal Diop is dominated by juvenile plantations. After Baal Diop, up to 1.8 km from E_{20}, we find ourselves in an area dominated by rainfall agriculture and cash cropping.

Photo 6: Juvenile plantation with cash crops **Photo 7:** Peanut fields at the end of harvesting

The main groups (1, 2, 3, 4 and 5) described above: plantations of fruit trees, rainfall agriculture and cash cropping are, more often than not, delineated by boundary hedges.

In addition to agricultural activities, the land and soil use of the five (5) groups are dominated by:

Roads: These include main and secondary sandy tracks, a red earth track, and a sealed district road.

Concessionaries: There are networks operated by Senelec, the SDE and Sonatel.

Settlements: There are villages and hamlets within the area of influence of the five (5) groups.

Table 21: Summary of the various forms of land and soil use within the project's zone of influence

Form of land and soil use	Restricted study zone (within the Project's boundary)	Detailed study zone (500 m from the boundary's limits)	Expanded study zone (Borough of Taïba Ndiaye)
Agricultural activities	X	X	
Concessionaries	X	X	X
Settlements			X
Roads	X	X	X
Grazing activities	X	X	X

5.5 THE PHYSICAL ENVIRONMENT

5.5.1 The climatic framework

5.5.1.1 The regional context and seasonal changes

The project's zone belongs to the Sahel-Sudan climate zone. Two basic seasons defined by the criterion of rainfall may be distinguished: A rainy season from June to October and a dry season which takes up the rest of the year.

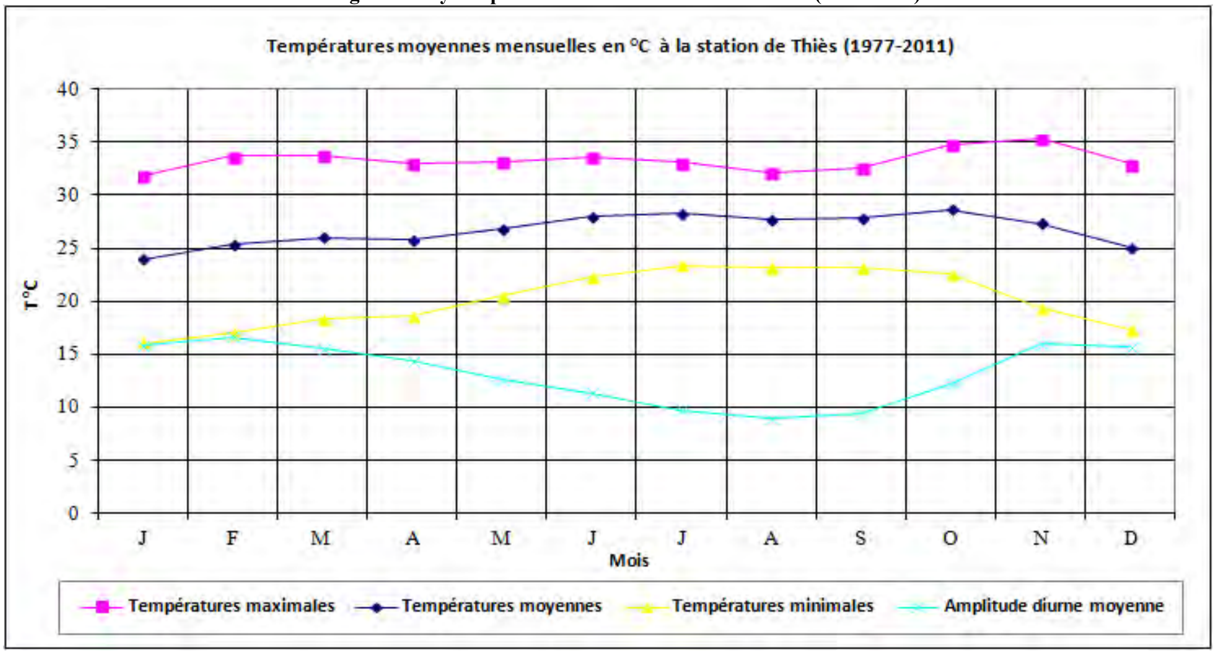
The main climatological characteristics are provided by the tables below.
The data come from the National Meteorological Directorate. The station that is representative of the local climatic conditions is established at Thiès, about 25 kilometers away.

5.5.1.2 Temperature

The average temperature measured over thirty-four (34) years is just over 26 °C. July is the hottest month (28.2 °C), while December and January are the coolest months, with average temperatures of 25.1 °C and 23.9 °C.

Figure 24: Shifts in average monthly temperatures at Thiès from 1977 to 2011

Average monthly temperatures in °C at the Thiès station (1977-2011)



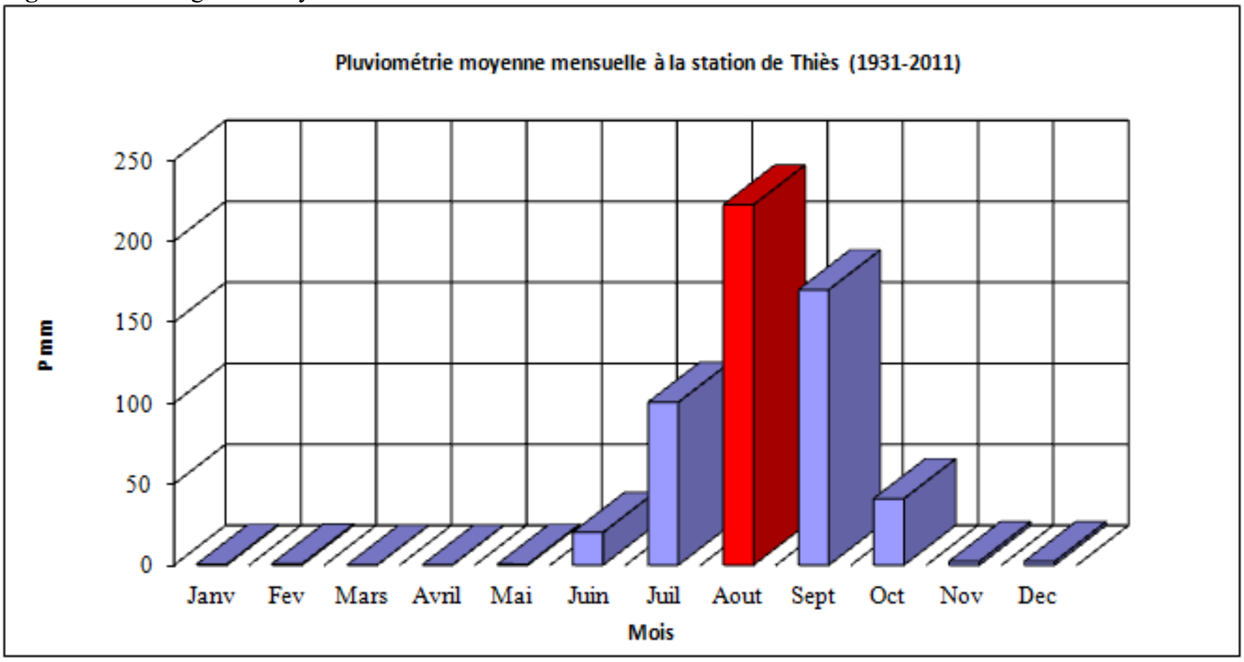
Maximum temperatures **Average temperatures** **Minimum temperatures** **Diurnal temperature range**

5.5.1.3 Rainfall

The average quantity of water collected from 1930 to 2011 is 587.6 mm at the Thiès station. Rains do not fall throughout the year. The maximum rainfall is observed in August and September. The rainfall totals vary greatly from one year to the next.

The rainfall regime is characterized by medium to thick clouds and moderate to high rains and stormy downpours (Sérigne Faye, UCAD (Cheik Anta Diop University), 1995).

Figure 25: Average monthly rainfall at the Thiès station from 1930 to 2011



5.5.1.4 The wind regime

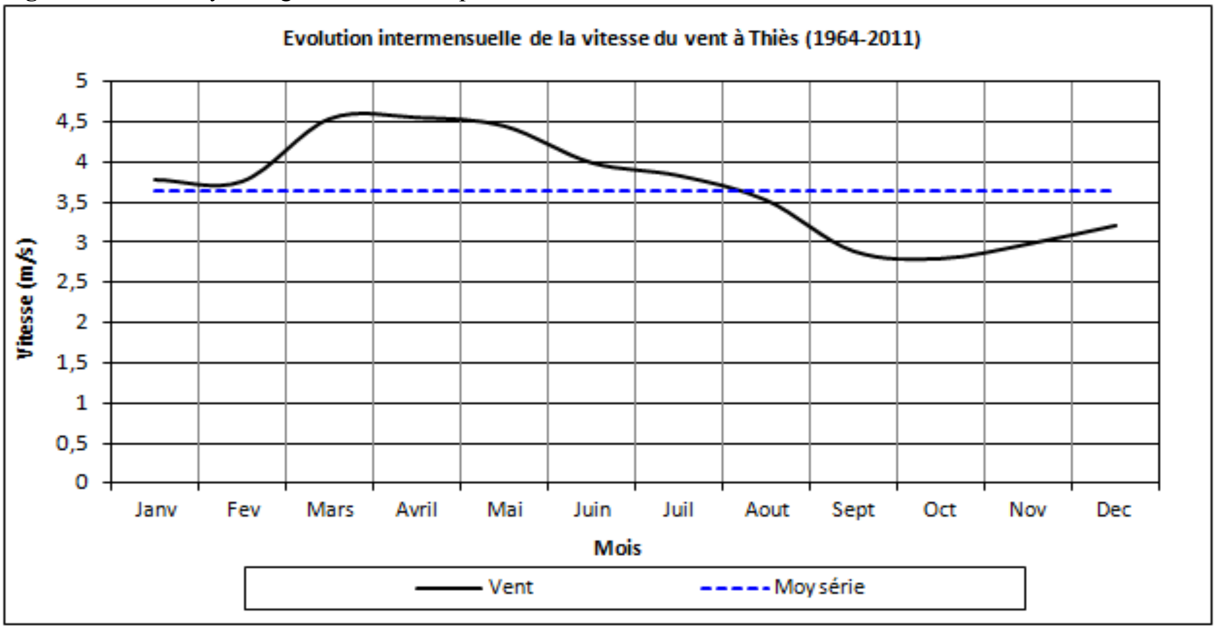
Wind data (concerning wind direction and wind speeds) are essential under the framework of a project for establishing a wind farm; they predetermine the project's technical feasibility.

The wind regime in the zone enables two (2) wind turbine seasons to be distinguished:

- One season, running from October to May, with predominantly Northerly and North-Easterly winds;
- A second season running from June to September, when Southerly to Westerly winds greatly predominate in terms of frequency.

As the table below shows, although they vary throughout the year, wind speeds are high and remain either higher than or equal to 2.7 m/s. The maximum speeds are recorded from March (4.1 m/s) to May (4.06 m/s). It is only in August, September and October that the speeds are relatively low, with the minimum being reached from September to October with 2.8 m/s. The annual average is 3.5 m/s.

Figure 26**:** Monthly changes in the wind speed at Thiès from 1964 to 2011



Speed (m/s)

Wind Series average

5.5.1.5 Study carried out by the Developer

Compared to carrying out measurements at the site using a weather tower, simulation offers several advantages:

- It enables a more extensive zone to be tested than can be covered by a measuring tower and therefore enables the layout of the wind turbines to be optimized;
- It enables you to avoid erecting several measuring towers, which may have an impact on the landscape;
- It enables winds to be simulated at greater heights than what is technically possible using a tower;
- It does not require a town and country planning permit (building permit).

Under the framework of this project, wind speed simulations have been carried out since 2008. Anemometers were placed on a tower at various altitudes (30 meters, 48.5 meters and 50 meters). In August 2010, a second measuring tower that was 100 m high was installed approximately 5 km away in the northern part of the site, in the vicinity of the location of wind turbine E18. The results of the measuring campaigns are confidential so only the results for the period from 1 February 2008 to 1 June 2008 at an altitude of 50 meters are available to us.

Table 22: Average monthly simulated wind speed at the site in 2008 at an altitude of 50 meters

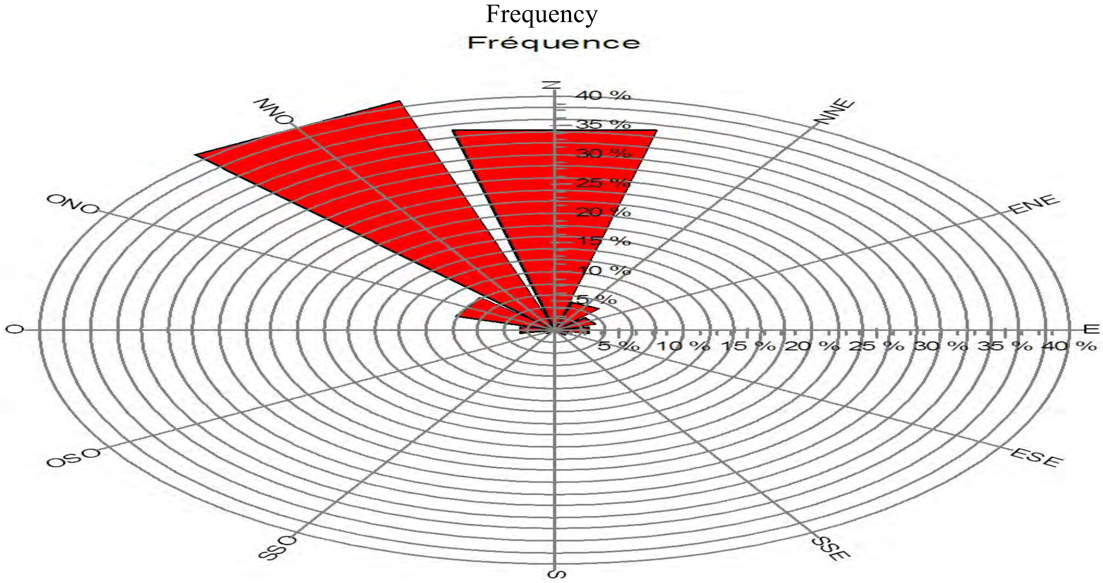
Month	February	March	April	May	June	Average
Average speed (m/s)	6.4	6.0	6.7	6.1	3.0	5.64

Source: Technical study for the project for establishing the Taiba Ndiaye wind farm

The Table above indicates that, at a height of 50 meters, the average wind speeds that may be expected are, on average, 5.64 m/s, or 20.3 km/h.

The wind rose below was compiled based on data from these results and tests. It is characterized by North-North-West (NNW) to Northerly winds (N). It shows that 40 % of the time, the wind is blowing from the NNW, and for 35 % it is Northerly.

Frequency



[clockwise from "O":] W WNW NNW N NNE ENE E ESE SSE S SSW WSW

Figure 27: Summary wind rose for Taïba Ndiaye with frequencies in % at an altitude of 50 meters

5.5.2 Geomorphology and topography

The study zone forms a homogeneous geomorphological unit. The relief is flat and consists of fixed sand dunes of maritime or continental origin. Both the nearby and expanded study zones are located inland, to the east of the Northern littoral.

The geomorphology presents a dune-based model which becomes increasingly accentuated as you get closer to the littoral dunes. The Southern part of the project's zone is located both in interior or Ogolian dunes and on a plateau. On the other hand, the Northern part is located in the coastal dunes.

The relief of the Rural Community is relatively flat, apart from some uneven ground at certain spots resulting either from the wind or from tailings from mining operations. This relates to a monotonous plateau tilting slightly to the West. It is covered with old Ogolian ergs (fixed dunes) from the Cayor period, concealed in places by a ferruginous duricrust (red earth).

The altitudes observed in the zone increase very slightly along the Mboro-Tivaouane axis (from the North-West to the South–East) but they are still not much higher than sea level. They are relatively low and, overall vary from 33 to 60 meters.

5.5.3 Pedology

The pedologic map highlights three (3) types of soils where the Rural Community of Taïba Ndiaye is located. There are:

- Dior soils, which are slightly bleached ferruginous soils that constitute about 70 % of its surface area;
- Deck Dior soils, which are clay and sand soils that account for 15 % to the West of the Rural Community;
- Deck soils, which account for 15 % of the Rural Community’s soils, are found in the extreme North-West in zones where there are hollows. These are bleached tropical ferruginous soils. They are hydromorphic, with a clay texture.

5.5.3.1 The nature and agricultural potential of the soils

According to the pedologic map, in the Southern part of the project’s zone, the soils are tropical ferruginous types that are unbleached or are only slightly bleached in the eastern and central part, while there are red tropical or lithosol soils in the western part, and slightly bleached soils in the Northern. On the other hand, in the Northern part of the project’s zone, all the soils are slightly bleached ferruginous soils.

The November 2008 soil analysis results are entered in the Table below. According to these results, the soil where these sites are located is sandy (pure sand) with a sand content percentage of 90.9 %. These results are corroborated by the textures triangle.

Table 23: Soil analysis results at the wind farm project's sites

Physical and chemical characteristics (particle size as a %)					Chemical fertility (soil content in g/kg)				
C	**FL**	**CL**	**FS**	**CS**	**Available phosphorus**	**Exchangeable cations**			
					P_2O_5	**K**	**Mg**	**Ca**	**Na**
3.5	**1.1**	**4.6**	**38.2**	**52.7**	**0.16**	**0.03**	**0.09**	**0.54**	**0.0**

Source: Wind farm project document

Abbreviations: C = Clay, FL = Fine Loam, CL = Coarse Loam, FS = Fine Sand, CS = Coarse Sand

The Rural Community's Deck Dior soils are very suitable for arboriculture. Crops of peanuts, millet and cassava are grown there.

Deck soils, which are rich in organic materials, are suitable for fruit and vegetable cultivation and arboriculture (particularly mango trees and cashew trees).

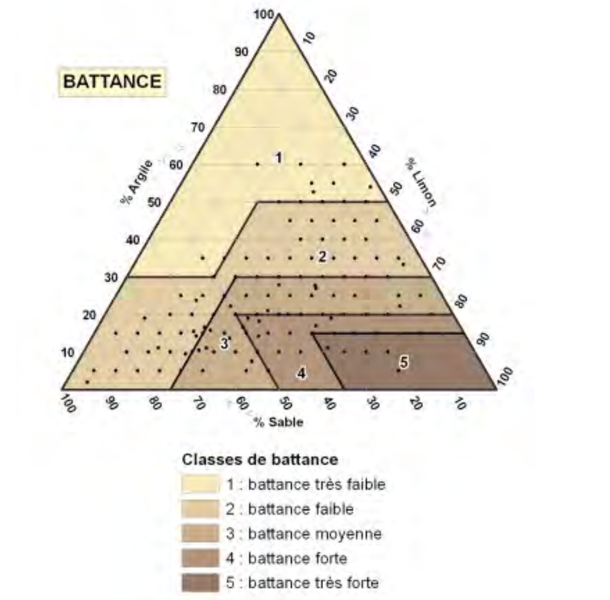
5.5.3.2 Soil stability

In the fall of 2014, Esteyco was commissioned to perform a complete geotechnical evaluation of the site and the 46 locations of the wind turbines in order to determine the ground's load-bearing factor and to provide the necessary data to design the wind turbine foundations. The study is the subject of a report dated December 12, 2015.

The location of each turbine was subject either to a borehole and/or a cone penetration test. A total of 31 boreholes, 22 cone penetration tests, 10 pit tests and 2 resistivity tests were performed together with laboratory testing. Esteyco concluded that the soil has the minimum geotechnical characteristics for a spread style foundation without any requirement for pilings.

The particle size measurement carried out by the SADEF laboratory in France for the project makes it possible to assess the soil's structural stability and particularly the risks of soil slaking, depending on what proportions of clay and loam there are in the soils. Structural stability refers to the firmness of the soil's structure and its ability to withstand agents that may cause degradation to it. Soil slaking refers to the soil's sensitivity to the formation of a surface crust with a lamellated structure that is continuous, consistent and clogs the soil's surface. According to the Figure below, we can conclude that the risk of soil slaking where the sites are is low because over 90 % of the soil consists of sand.

Figure 28: Triangle for determining soil slaking depending on the soil texture



SOIL SLAKING

Clay %

Loam %

Sand %

Soil slaking classes
1: Very low level of soil slaking
2: Low level of soil slaking
3: Medium level of soil slaking
4: High level of soil slaking
5: Very high level of soil slaking

The susceptibility to erosion entails an estimate of the capacity of each soil type to withstand erosion, more often than not based on its physical characteristics.

In relation to erosion due to water and wind turbines, their rate and extent depend on:

- The intensity of rainfall and run-off;
- The soil texture;
- The soil structure;
- Plant cover;
- The gradient and slope of the ground;
- etc.

The low level of soil slaking in the project's zone, along with relatively gentle slopes, confirms that these soil types withstand erosion caused by water. Moreover, the relatively substantial permanent plant cover in certain locations means that the erosion caused by wind turbines will be low, particularly in the Southern part of the project's zone.

5.5.4 Geological context

In geological terms, there is no high groundwater. Only the water infrastructure along the road linking Tivaouane, in the South-East, to Mboro in the North-West, and which pass less than one kilometer away from the site, enable the zone's geology to be specified.

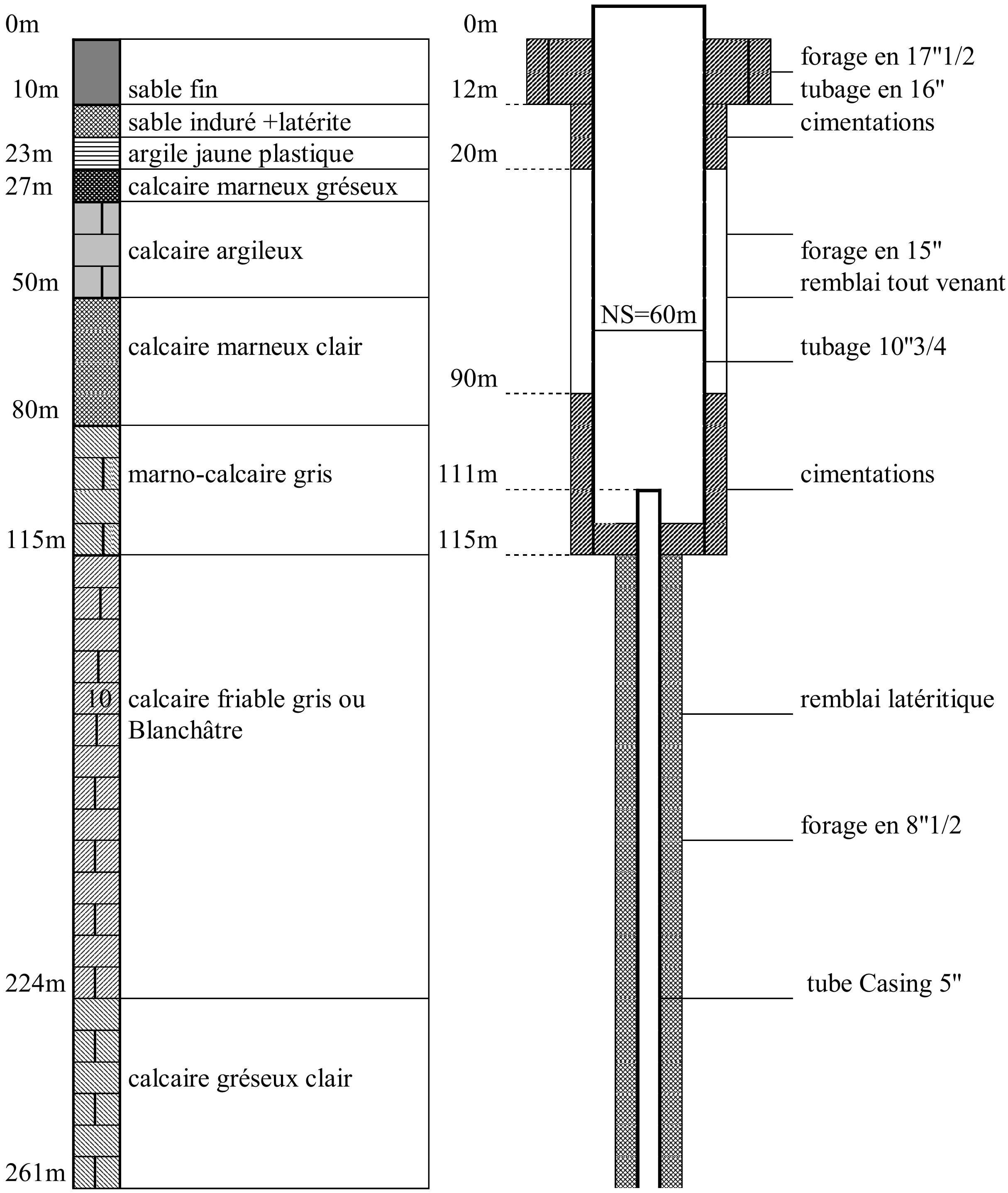
Quaternary sand dunes constitute the zone's surface formation. Their thickness increases slightly from the North-West to the South-East. It varies from 17 meters, according to the Keur Bocar piezometer (located approximately 4 km South-East of the site), to 66 meters at the Keur Malé well.

The Taïba Ndiaye piezometer enabled a good knowledge to be obtained of the lithology of the Quaternary sands. From the bottom to the top, it shows alternating yellow and orange sand, beige sand, yellow sand with red clay, yellow clay sand, and fine white sand at surface level (Water Resources Management and Planning Directorate, 1987).

This sand formation, comprising fixed dunes, rests on Lutetian limestone. The Taïba Ndiaye borehole, which is 380 meters deep, enables the following layers from top to bottom to be noted beneath the Quaternary sands (Diwi Walter International, 1986):

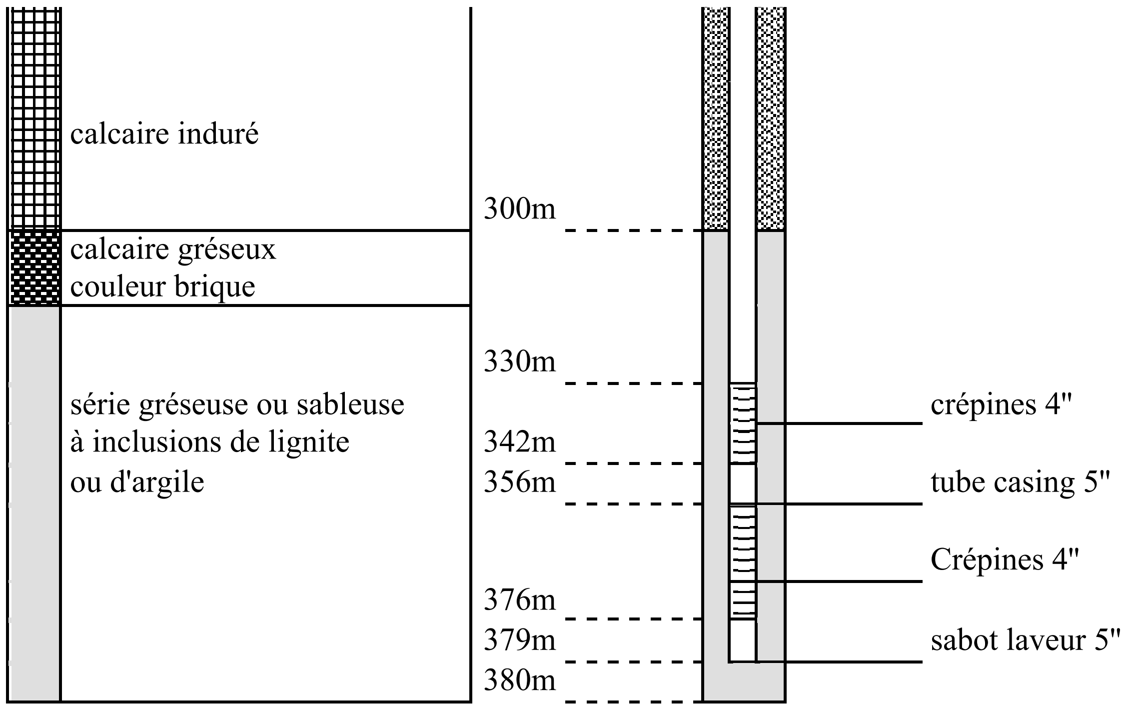
- Lutetian (57 meters thick): Alternating limestone with gritty marl, limestone with clay and limestone with light marly limestone;
- Ypresian (144 meters thick): Alternating grey marly limestone, and grey or whitish crumbly limestone;
- Palaeocene (99 meters thick): Alternating light gritty limestone, indurated limestone and red brick gritty limestone; and lastly;
- Maastrichtian, the aquifer used by this borehole; it was only drilled to a depth of 57 meters and shows a gritty or sandy facies with lignite and clay inclusions.

Figure 29: Geological section and catchment of the Taïba Ndiaye borehole [see below for translation]



Fine sand	17½" borehole
Indurated sand/laterite	16" tube
Plastic yellow clay	Cement
Limestone with gritty marl	

Limestone with clay Light gritty limestone Grey marly limestone Grey or whitish crumbly limestone Light gritty limestone	15” borehole Backfill featuring unsorted waste 10¾” borehole Cement Laterite backfill 8½” borehole 5” casing tube



Indurated limestone Brick-coloured gritty limestone Gritty or sandy series featuring lignite and clay inclusions	 4” strainers 5” casing tube 4” strainers 5” washover shoe

5.5.5 Groundwater

5.5.5.1 Regional hydrogeology

The studies carried out in the Thiès region have enabled three (3) major series of hydrogeological formations to be identified. These are, from the bottom to the top:

- The lower series, consisting of the Maastrichtian sands aquifer;
- The intermediate series, which features limestone or marl and marl and limestone formations from the Palaeocene and the Eocene and, lastly;
- The upper series, consisting of sand and sand and clay formations sometimes featuring laterite from the “Continental Terminal” and Quaternary Periods.

The Maastrichtian aquifer, with permeability varying from $3.8*10^{-4}$ to $1.7*10^{-6}$ m/s, is heavily exploited via water boreholes. The aquifer is held captive or semi-captive by the clay or marl and sand clay formations at the top of the Maastrichtian layer. At Thiénaba, the oil boreholes sunk by Petrosen passed right through it from depths of 255 m to 700 m.

The Palaeocene aquifer, with permeability varying from $1.3*10^{-2}$ to 10^{-4} m/s, with marl and clay from the Lower Eocene on top of it, is a captive aquifer. However, the marl and clay’s level of karstification make it a large reservoir.

The Eocene aquifer, with permeability varying from $7.4*10^{-3}$ to 10^{-6} m/s, has a top consisting of sands and clay sands from the Quaternary and the “Continental Terminal” Period which is free or semi-captive.

5.5.5.2 The local hydrogeology and groundwater capture

The Maastrichtian aquifer is captured by two (2) Taïba Ndiaye boreholes, the first of which is called No. 1 (which is non-operational), which was drilled in 1976 and the second, called No. 2, which was drilled in 2001. These provide a water supply to the local populations. This operational borehole, sunk to a depth of 420 meters, has a flow rate of $45m^3/h$. Its water tower has a height of 17 meters and a volume of 150 m^3 and is connected to the one for the first borehole upon shut-off at a volume of 100 m^3, supplying twenty-nine (29) villages out of the thirty-nine (39) comprising the Rural Community de Taïba Ndiaye, with a total of over 1,500 private users. In addition to these private users, this borehole also supplies water to local populations via thirty or so public fountains and 45 public taps. To the contrary, the villages of Keur Bocar, Djingué, Thiallé and Selco are supplied from Guiers Lake.

The village wells reach down to the Continental Terminal layer, which has sandstone containing water tables at depths of 8 to 50 meters (8 meters near Darou Dia and Ballé Guèye, and 50-60 meters at Taïba Ndiaye, Taïba Mbaye, Djingué, Thiallé, etc.).

In these four (4) villages near the project’s zone, the local populations have indicated that when their wells were sunk, they noticed that the Quaternary sands’ water table was at a depth of 40 to 50 meters and was not very productive.

This justifies firstly continuing to sink wells down to the Lutetian limestone at depths of 56 to 70 meters and, secondly, explains why there is a lack of fruit and vegetable cultivation activity in this zone.

It should however be emphasized that, in the project's near to wider zones, the data available from piezometers and boreholes, the information gathered from local populations, and the various studies carried out by the Water Infrastructure Ministry's Water Resources Management and Planning Division, as well as the thesis studies conducted by university students on the Northern littoral, show that in this zone, there is no clear, separate boundary between the two geological and hydrogeological series consisting of Quaternary sands and Lutetian limestones.

Where such a separation does exist, it is infrequent and lenticular, and therefore discontinuous. This enables the good hydraulic continuity between these two formations to be explained (cf. **J. Puttalaz**, 1962, and **Ch. H. Kane**, 1995)[3].

Rainwater seepage contributes to supplying the aquifer in the Quarternary sands, which in turn plays a part in replenishing the Lutetian limestones aquifer.

The piezometric map thereby drawn up shows that the project's zone is located in a piezometric dome: the Taïba Ndiaye dome to the south.

The presence of a piezometric dome means that the aquifer system's direction of flow is radial (like a centrifuge).

The Taïba Ndiaye piezometric dome shows a pronounced slope to the North-West, towards Mboro and the ocean. This entails a slower flow, as if the water was encountering an obstacle; which assumes mediocre permeability.

Conversely, in the direction of the project's zone, the slope is gentler which allows easier flow, and therefore greater permeability, or the capacity to let water seep through it.

5.5.5.3 The groundwater quality

For the study, three (3) wells were sampled and analyses were carried out in the hydrochemistry laboratory at the Geology Department in the Faculty of Science and Technology at Cheikh Anta Diop University in Dakar.

The study related to the following works: (1) The works (traditional wells) capturing a fairly high groundwater aquifer at Ndomor Diop and Baity Guèye and (2) the works (a traditional well) at Taïba Ndiaye which also captures high groundwater.

The first two works at Ndombor Diop and Baïty Guèye are located in the water's flow direction, while the one at Taïba Ndiaye was used as a reference.

The analytical parameters are the ones adopted by a classic analysis and the results are provided in the Table below. The values of the parameters measured were compared to the

[3] Cf. the Bibliography

maximum permissible values defined by the World Health Organization (WHO standards) for drinking water.

Table 24: Results of classic chemical analyses of the groundwater in the vicinity of the sites

	In-situ parameters		**Cations**					**Anions**						**Other**	
	pH	**Cond. (µS/cm)**	**Na^+**	**K^+**	**Mg^{2+}**	**Ca^{2+}**	**Total Fe**	**HCO_3^-**	**CO_3^{2-}**	**Cl^-**	**NO_3^-**	**SO_4^{2-}**	**F^-**	**Dry solids content**	**Total hardness (French degrees)**
Baity Guèye well	5.95	590	62.57	3.79	9.60	44.30	0.09	36.60	0	107.72	117.19	18.76	0.23	424	15°F
Taïba Ndiaye borehole	5.64	189	22.94	1.52	2.31	12.14	0.27	18.30	0	25.81	18.30	6.90	0.06	140	15°F
Ndomor well	6.23	490	40.03	3.84	9.59	44.28	0.18	67.10	0	86.07	50.23	26.84	0.18	352	4°F
WHO standards	6.5 – 8.5	1,500	200	12	30	100	0.30	-	-	250	50	400	1.50	1,000	-

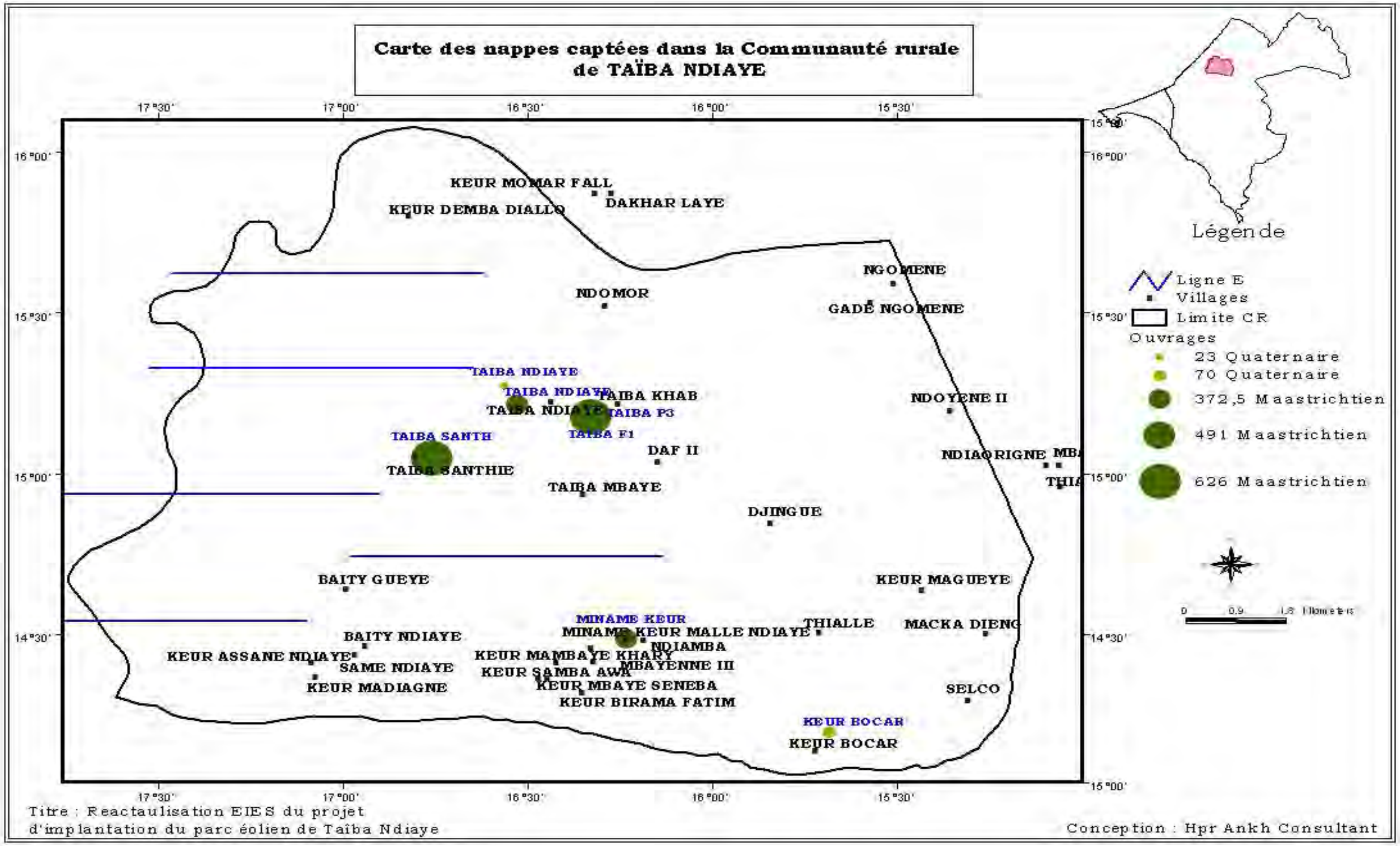
Source: Results of the analyses by the hydrochemistry laboratory at the Geology Department, UCAD, December 2012

The results of classic analyses of the groundwater in the project's sector show two different aquifers due to their hydrochemical characteristics. The analysis results show that the water from the Taïba Ndiaye well is characterized by a low electrical conductivity value of 189 $\mu S.cm^{-1}$ and its chemical facies are dominated by bicarbonates and chlorides in the case of the anions, and sodium and calcium in the case of the cations. For the Ndomor and Baity Guèye aquifers, the water's mineralisation varies greatly. Overall, this aquifer is not very mineralised, with electrical conductivity values lower than 1,000 $\mu S.cm^{-1}$.

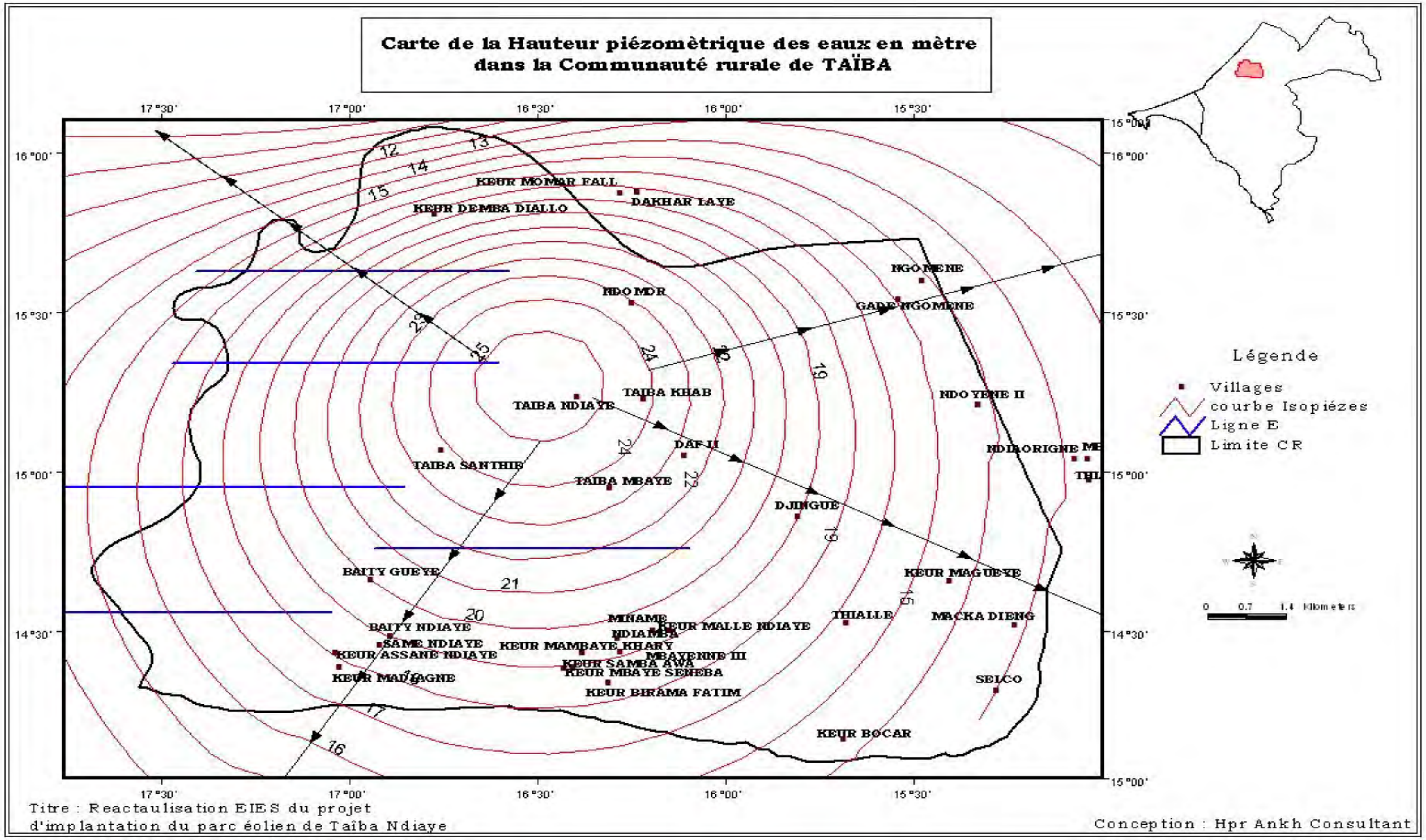
As far as the potability of the groundwater is concerned, a comparison of the chemical analysis results for the water from these aquifers with the WHO's potability standards shows that the groundwater captured by traditional wells in the project's sector is potable. What should be pointed out is that the high groundwater contains a greater quantity of dry solids content than what was observed at Taïba Ndiaye. This implies higher hardness values for the aquifer where the villages of Ndomor and Baity Guèye are than what is found at Taïba Ndiaye.

This comparative study of the current state of the resource made it possible to show that there is no source of contamination. Consequently, the project's site has copious quantities of groundwater that fulfil WHO standards for the elements analyzed. The pH level revealed is also slightly acidic. The WHO standard does not provide values for carbonated substances, probably due to the harmlessness of these elements, although the European standard does make provision for a guideline value of 25 mg/l.

Map 4: Map of the hydrogeological units and of the depths of the captured water in the Taïba Ndiaye zone and the surrounding villages



Map 5: Piezometric map of the Northern Littoral aquifer system



5.5.6 Surface water

Within the project's immediate and extended zones, within a radius of at least 10 km around the site, there are no standing bodies of water.

There is no standing surface water within the Rural Community of Taïba Ndiaye, or in the Rural Community of Méouane, apart from the artificial water sources created due to mining operations.

On the other hand, further south of the project's zone, from Cayar to Mont Rolland, and further to the north, from Léona and Potou on the same latitude as Louga, as far as Le Gandiolais, in the vicinity of Saint-Louis, this strip of the northern littoral or of the Niayes is the leading fruit and vegetable cropping zone in Senegal. During the rainy season, surface water replenishes the aquifer, which rises near the surface through "Céanes" (traditional wells that are 1 to 5 meters deep). During the dry season, these "Céanes" become wells 10 to 20 or even 30 meters deep, depending on the zones.

5.5.7 The landscape

In order to take better account of land use within the Rural Community of Taïba Ndiaye, within the project's zone and surrounding area, we based our observations on field data and maps.

The sites where the future wind farm will be established belong to the Rural Community of Taïba Ndiaye. These sites are moreover near the Mboro zone, which is located in the Niayes nature zone, the relief of which is characterized by a series of dunes and hollows.

The Southern zone where the wind farm is to be established can be accessed by driving along Department Road 702 and by carrying on along a red earth track which crosses a series of villages, after which you take a sand track. The project's Northern zone can also be accessed via Department Road 702 as well as via Regional Road 70.

In the vicinity of the project's Southern zone, there is a series of villages including Keur Mallé Ndiaye, Miname, Mbayène, Keur Mambaye, and Keur Mbaye to the South-East, which constitute a linear cluster of locales after the Department Road 702 crossroads, with Baïty Guèye to the East and Taïba Mbaye to the North-East.

The boundaries of these village units are not clear in the case of the first five (5) villages referred to because they are all in line and the road network is quite sparse, frequently of middling quality, and with verges in-between the villages that quite often are built-up. All these factors do not contribute to structuring the landscape.

Compared to the morphology of the village habitats, for the most part the houses are well structured. Almost all of them are made of brick and they are all one-story structures, apart from a few mosques. The various neighborhoods comprising the villages all have broad thoroughfares. The villages are also connected to the electrification network.

The villages are generally surrounded by crops as well as areas of land left fallow and these are often not very far from houses. The agriculture is mixed (arboriculture, mainly with orchards featuring mango trees within the area taken up by the project in its Southern zone, crops of cassava which occupy vast expanses of land within the area taken up by the project's Northern zone, and rainfall agriculture crops). There are also lands left fallow.

Apart from the Taïba-ICS mine (operated by the company Industries Chimiques du Sénégal) which straddles the rural communities of Taïba Ndiaye, Darou Khoudoss and Méouane, located about 6-7 kilometers away, currently there is no industrial infrastructure within the vicinity of the project's zone.

However, three (3) GSM towers belonging to the mobile telephone operators Orange, Tigo and Sudatel are visible in the Taïba Ndiaye zone, and numerous power pylons are visible that carry power for Senelec from the high voltage (90 and 225 kV) transformer sub-station at Tobène, about 1 km South of wind turbine No. 42. This transformer sub-station, which is not far from the project's site, constitutes an advantage for the project's electrical connection.

It will be noted that the project's region has a few landscape zones of public interest. These zones comprise agricultural zones, dune zones (in the Northern zone) and a zone with a grove of palms (in the Southern zone).

At the local level, the wind farm study site is basically located in an agricultural zone. Currently, the sites are almost exclusively occupied by orchards of mango trees, cashew trees and fields of cassava. In the Southern part, near Group 5, there is a savannah with scrub that predominantly consists of *Combretaceae*.

There are no roads within the area taken up by the project, although there are sand tracks which are generally only used by local populations for gaining access to the various fields of cassava and to the orchards, and which therefore do not have a visual impact on the landscape.

No town and country planning requirements exist either at the site or in its immediate vicinity. Indeed, the Rural Community of Taïba Ndiaye does not have town and country planning regulations or a POAS (Land Use and Allocation Plan).

The Rural Community of Taïba Ndiaye occupies a total surface area of approximately 148 km^2 (or 14,800 ha) almost all of which has no buildings on it. These zones are assigned to the following uses: agricultural land (with crops of cassava occupying 65 % of the land), orchards, grazing lands, woods, fallow and waste land, and other uses. It should be pointed out that the areas with buildings mainly have houses in them.

The surface area taken up by the project features 46 wind turbines, symbolically split into five (5) rows. The surface area taken up by a wind turbine is approximately 1,400 m^2, which constitutes a total surface area of 7 hectares. The sub-station accounts for 150 m^2, representing an additional surface area of 2.25 ha.

5.6 PLANT BIODIVERSITY

5.6.1 Description of the natural habitats

A natural habitat is a "homogeneous space due to its ecological conditions, its vegetation (arborescent, herbaceous plants, and shrubs), which shelters a certain fauna, with species that carry out some or all of their living activities within this space".

Within the project's zone, natural habitats are very rare due to the artificial nature of the landscape and the amount of distance from the environment's natural state.

Two categories of criteria may be used in order to assess the level of the artificial nature of the environment where the project for the construction of the thermal power station is to be established:

Flora and vegetation: Among the site's various types of flora, natural (spontaneous) species may be distinguished, along with species whose presence is due to mankind. These species were identified during inventories of flora. The vegetation characteristic of wooded savannah in the Northern zone is very artificial due to fruit trees being grown there. In the Southern part (Group 5), it involves scrubby savannah predominated by *Combretaceae* with rainfall agriculture crops. The remaining woody vegetation spared in the fields where cassava, black-eyed peas and peanuts are planted, as well as in the orchards of mango trees, is mainly dominated by the apple-ring acacia (*Faidherbia albida*).

Farming: The main types of farming carried out at the site involve rainfall agriculture and arboriculture. The farming is intensive because it involves high, constant pressure on the environment (for example: frequent cutting at the bases of mango trees).

5.6.2 Plant diversity

5.6.2.1 Methodological approach

The agricultural vocation of the zone that is to host the wind farm project should be correlated with the cultivation and ploughing activities etc. These various activities lead to both degradation and disruption of the herbaceous layer.

However, we did note that there were pockets of herbaceous vegetation scattered around the site that were preserved to a greater or lesser extent. Therefore, the spatial heterogeneousness of the vegetation (or in other words of the undisrupted zones associated with the disrupted zones due to cultivation and ploughing work). We opted to work with the best-preserved pockets of vegetation. For the purpose of characterising the herbaceous layer, we are going to consider the vegetation pockets or mosaics to be homogeneous.

The choice of methodology is guided by the local context that we described above. Consequently, concerning the remnant woody species and the layer, the various methodological approaches used for characterization purposes are presented below.

- **Study of the woody plants**

This was tackled using the method involving wandering around and taking readings, as set out by Chevallier (1948) and Aubreville (1959). This methodology involves walking the site in all directions, noting all the species of plants encountered.

- **Herbaceous plants study**

In the methodological part, we adopted the random sampling espoused by Orloci & Kenkel (1985). It consists of walking the site and inventorying the vegetation mosaics (herbaceous plants) which are homogeneous floristically and selecting the most interesting ones in terms of homogeneousness. The phytosociological readings are carried out according to the Braun-Blanquet method (1932). Plots measuring 10 m x 10 m covering a surface area of 100 m^2 are laid in order to carry out an inventory of the herbaceous layer.

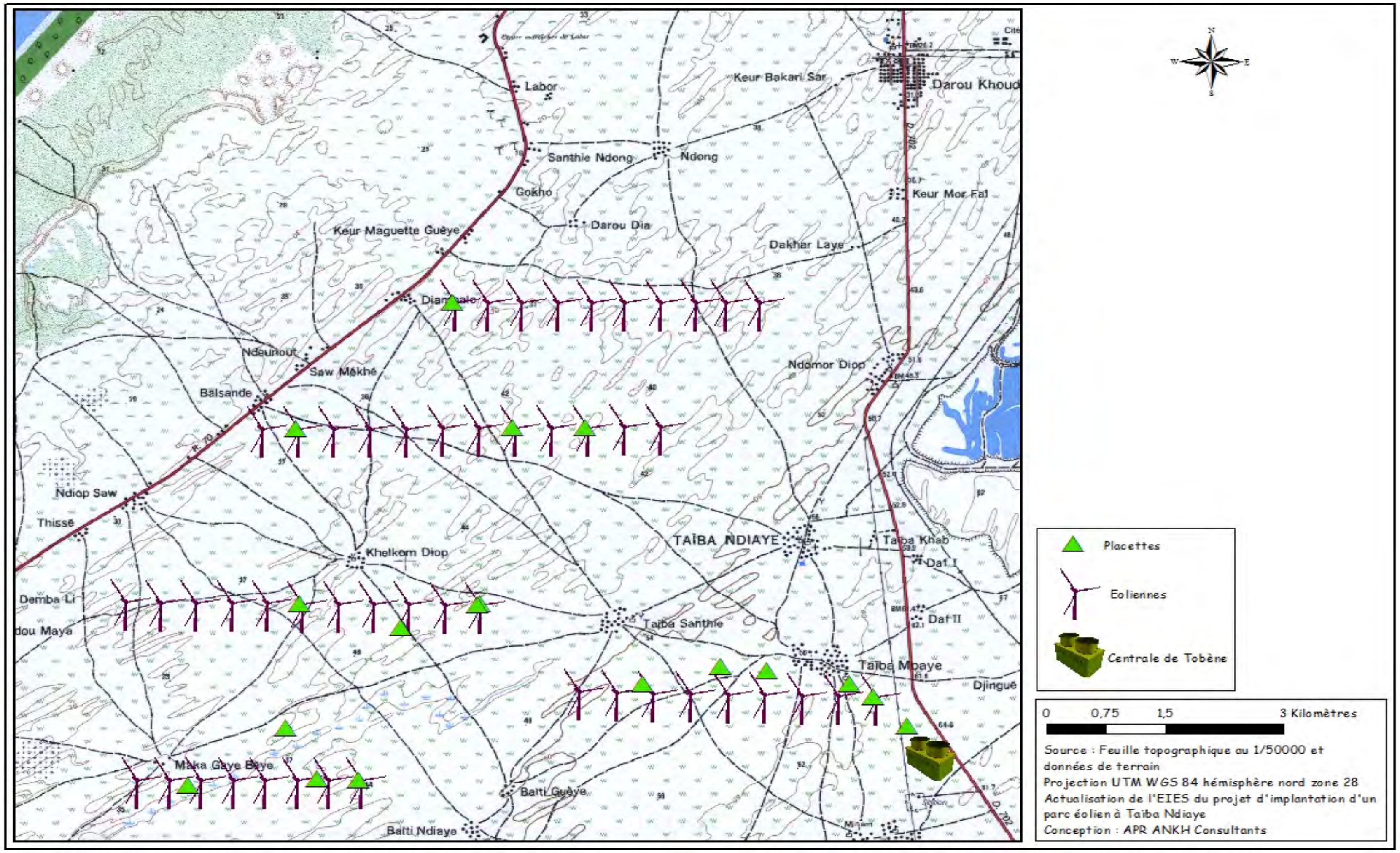
In addition to the species inventoried in the plots, a list mentioning the various sorts of trees encountered in the vicinity and which are not featured in the plot (measuring 10 m×10 m) is started. Likewise, the woody species omitted from the readings taken by wandering around will be added as you go.

Lastly, some disputed samples, recognition of which posed problems out in the field, were gathered and compared with other samples. Identification by comparison was carried out with the help of the Dakar Herbarium in the Plant Biology Department at Cheikh Anta Diop University.

- **Flora inventory**

A flora list was drawn up after a systematic census of all the species observed. The various works consulted for identifying their nomenclature are: Berhaut, J. (1967); Berhaut, J. (196-196); Lebrun, J. P. & Stork, A. (1996-1997); Mabberley, D. J. (1997); Poilecot, P. (1999); Berghen, C. V. (1988).

Map 6: Location of the plant species inventory plots



5.6.2.2 Results

The inventory enabled us to draw up a flora list of the plant species carried out at the project site and in its environs. A list of the plant species encountered is provided in the Table below:

Table 25: Taxonomic spectrum

FAMILIES	SPECIES
Acanthaceae	*Monechma ciliatum* (Jacq.) Milnc-Redh..
Aizoaceae	*Gisekia pharnacioides* L.
	Limeum diffusum (Gay) Schinz
	Limeum viscosum (Gay) Fenzl
	Mollugo cerviana (L.) Seringue
Amaranthaceae	*Achyranthes aspera* L.
	Pupalia lappacea (L.) A. Just.
	Amaranthus graecizans L.
Anacardiaceae	*Anacardium occidentale* L.
	Mangifera indica L.
Annonaceae	*Annona glauca* Schum. & Thonn.
Arecaceae (Palmae)	*Borassus aethiopum* Mart.
	Phonix reclinata Jacq
	Elaeis guineensis Jacq.
Asclepiadaceae	*Calotropis procera* (Ait.) R. Br.
	Leptadenia hastata (Pers.) Decne
	Pergularia daemia (Forssk.) Chiov.
Asteraceae	*Blainvillea gayana* Cass.
	Centaurea perrottetii DC.
	Conyza aegyptiaca (L.) Ait.
	Vernonia ambigua Kotschy & Peyr.
	Vernonia bambilorensis Berh.
Balanitaceae	*Balanites aegyptiaca* (L.) Del.
Bignoniaceae	*Stereospermum kunthianum* Cham.
Bombacaceae	*Adansonia digitata* L.
Boraginaceae	*Heliotropium ramosissimum* (Lehm.) DC.
Capparacea	*Boscia senegalensis* (Pers.) Lam. ex Poir.
	Capparis tomentosa Lam.

	Cleom viscosa L.
Caryophylaceae	*Polycarpaea linearifolia* (DC.) DC.
Celastraceae	*Maytenus senegalensis* (Lam.) Excell
Combretaceae	*Combretum aculeatum* Vent.
	Combretum micranthum G. Don
	Guiera senegalensis J. F. Gmel.
Commelinaceae	*Commelina benghalensis* L.
	Commelina forskaolaei Vahl
Convolvulaceae	*Jacquemontia tamnifolia* (L.) Griseb.
	Ipomoea asarifolia (Desr.) Roem. & Schult.
	Ipomoea kotschyana Hochst. ex Choisy
	Ipomoea pes-tigridis L.
	Ipomoea vagans Bak.
	Merremia tridentata subsp. Angustifolia (Jacq.) van Ooststr.
	Merremia pinnata (Hochst.) Hall.
Cucurbitaceae	*Coccinia grandis* (L.) Voigt
	Cucumis melo var. agrestis Naud.
	Momordica balsamina L.
Cyperaceae	*Cyperus esculentus* L.
	Cyperus rotundus L.
	Fimbristylis exilis (Kunth) Roem. & Schult.
Euphorbiaceae	*Chrozophora senegalensis* (Lam.) A. Juss. ex Spreng.
	Croton lobatus L.
	Euphorbia balsamifera Ait.
	Euphorbia hirta Linn.
	Jatropha curcas L.
	Manihot esculenta Crantz
	Phyllanthus pentandrus Schum & Thonn.
Fabaceae-Caesalpinioidae	*Cassia obtusifolia* L.
	Cassia occidentalis L.
	Dialium guineense Willd.
	Parkinsonia aculeata L.
	Tamarindus indica L.
	Alysicarpus ovalifolius (Schum.) Léo.
	Arachis hypogaea L.
	Crotalaria arenaria
	Crotalaria perrottetii
	Crotalaria sphaeocarpa

Fabaceae-Faboidae	*Indigofera astragalina* DC.
	Indigofera berhautiana
	Indigofera bracteolata
	Indigofera diphylla Vent.
	Indigofera pilosa Poir.
	Indigofera secundiflora
	Indigofera tinctoria L.
	Stylosanthes fruticosa (Retz.) Alston
	Stylosanthes erecta P. Beauv.
	Tephrosia linearis
	Tephrosia purpurea
	Zornia glochidia
	Vigna unguiculata (L.) Walp.
Fabaceae-Mimosoidae	*Acacia nilotica subsp. Adstringens* (Schum. & Th.) Roberty
	Acacia pennata (L.) Willd.
	Dichrostachys Cinerea (L.) Wight & Arn.
	Faidherbia albida (Del.) A. Chev.
	Prosopis africana (Gui. & Perr.) Taub.
	Prosopis glandulosa Torrey
Lamiaceae	*Hyptis suaveolens* Poit.
Malvaceae	*Hibiscus asper* Hook. f.
	Sida rhombifolia L.
Meliaceae	*Azadirachna indica* A. Juus.
Menispermaceae	*Cissampelos mucronata* A. Rich.
Moraceae	*Ficus platyphylla* Del.
	Ficus sycomorus L.
Moraceae	*Eucalyptus camaldulensis* Dehn.
Pedaliaceae	*Ceratotheca sesamoides* Endl.
	Sesamum alatum Thonn.
Poaceae	*Andropogon gayanus* Kunth
	Aristida sieberiana Trin.
	Aristida stipoides Lam.
	Brachiaria lata (Schmach.) C. E. Hubb.
	Brachiaria xantholeuca (Schinz) Stapf
	Cenchrus biflorus Roxb.
	Chloris pilosa Schmach.
	Cynodon dactylon (L.) Pers.
	Dactyloctenium aegyptium (L.) Willd.
	Digitaria ciliaris (Retz.) Koeler
	Digitaria honrizontalis Willd.
	Echinochloa colona (L.) Link.

	Enteropogon prieurii (Kunth) Clayton
	Eragrostis gangetica (Roxb.) Steud.
	Eragrostis pilosa (L.) P. Beauv.
	Panicum laetum Khunth
	Pennisetum pedicellatum Trin.
	Pennisetum violaceum (Lam.) Rich.
Polygalaceae	*Polygala irregularis* Boiss.
	Securidaca longipedunculata Fres.
Rhamnaceae	*Ziziphus mauritiana* Lam.
Rubiaceae	*Kohautia grandiflora* DC.
	Mitracarpus villosus (Sw.) DC.
	Spermacoce radiata (DC.) Hiern
Sapindaceae	*Aphania senegalensis* (Juss. ex Poir.) Radlk.
Solanaceae	*Datura fastuosa* L.
Solanaceae	*Waltheria indica* L
Tiliaceae	*Corchorus tridens* L.
	Grewia bicolor Juss.
	Triumfetta pentandra A. Rich.
Tribulaceae	*Tribulus terrestris* L.

The taxonomic spectrum indicates 128 species belonging to 99 genera, covering 41 families. The *Poaceae* (*Graminae*) family is the most diverse one, with 18 species, followed by the *Fabaceae-Faboidae* family, which has 17 specific taxa. The *Indigofera* genus is the most diverse one, with 7 species.

- **Flora composition**

Table 26: List of the families along with the name of the genus and species

FAMILY	NUMBER OF GENERA	NUMBER OF SPECIES
1. Acanthaceae	1	1
2. Aizoaceae	4	4
3. Amaranthaceae	3	3
4. Anacardiaceae	2	2
5. Annonaceae	1	1
6. Arecaceae (Palmae)	3	3
7. Asclepiadaceae	3	3
8. Asteraceae	4	6
9. Balanitaceae	1	1
10. Bignoniaceae	1	1
11. Bombacaceae	1	1
12. Boraginaceae	1	1

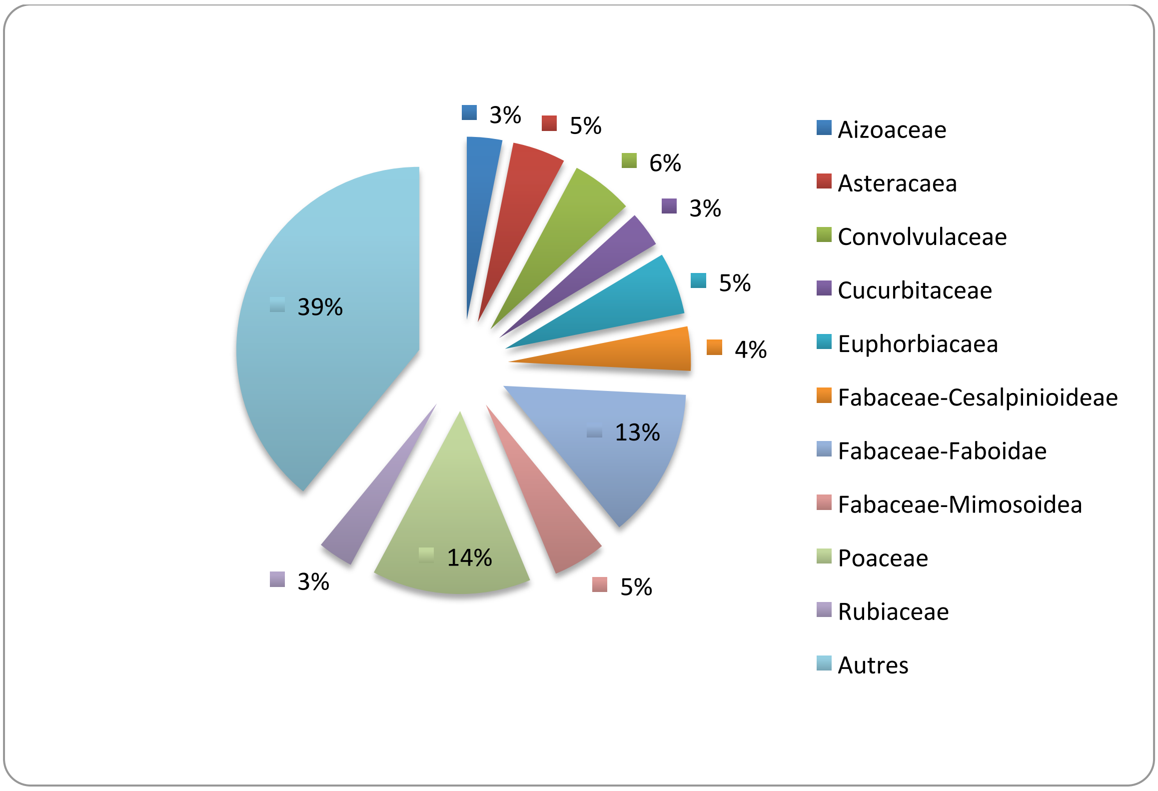
13. Capparaceae	3	3
14. Caryophylaceae	1	1
15. Celastraceae	1	1
16. Combretaceae	2	3
17. Commelinaceae	1	2
18. Convolvulaceae	3	7
19. Cucurbitaceae	4	4
20. Cyperaceae	2	3
21. Euphorbiaceae	6	7
22. Fabaceae-Caesalpinioideae	4	5
23. Fabaceae-Faboidae	8	17
24. Fabaceae-Mimosoideae	4	6
25. Lamiaceae	1	1
26. Malvaceae	2	2
27. Meliaceae	1	1
28. Menispermaceae	1	1
29. Moraceae	1	2
31. Myrtaceae	1	1
32. Pedaliaceae	2	2
33. Poaceae	13	18
34. Polygalaceae	2	2
35. Rhamnaceae	1	1
36. Rubiaceae	3	4
37. Sapindaceae	1	1
38. Solanaceae	1	1
39. Sterculiaceae	1	1
40. Tiliaceae	3	3
TOTAL	**99**	**128**

- **Most prevalent Species**

Overall, the most representative families are the *Poaceae* (14%), followed by the *Fabaceae-Faboidae* (13 %). A long way behind them are the *Aizoaceae*, the *Asteraceae*, the *Convolvulaceae*, the *Cucurbitaceae*, the *Euphorbiaceae*, etc. The other families with less than 2 species account for 39 %.

In terms of the woody plants component, the *Mimosaceae* (06), the *Cesalpiniaceae* (05) and the *Euphorbiaceae* (07) predominate over the others. The other families with fewer than two (2) species are grouped together in the Others category. The herbaceous component is largely dominated by the *Poaceae* (18), the *Fabaceae* (17), and the *Cucurbitaceae* (4).

Figure 30: Spectrum of families of species



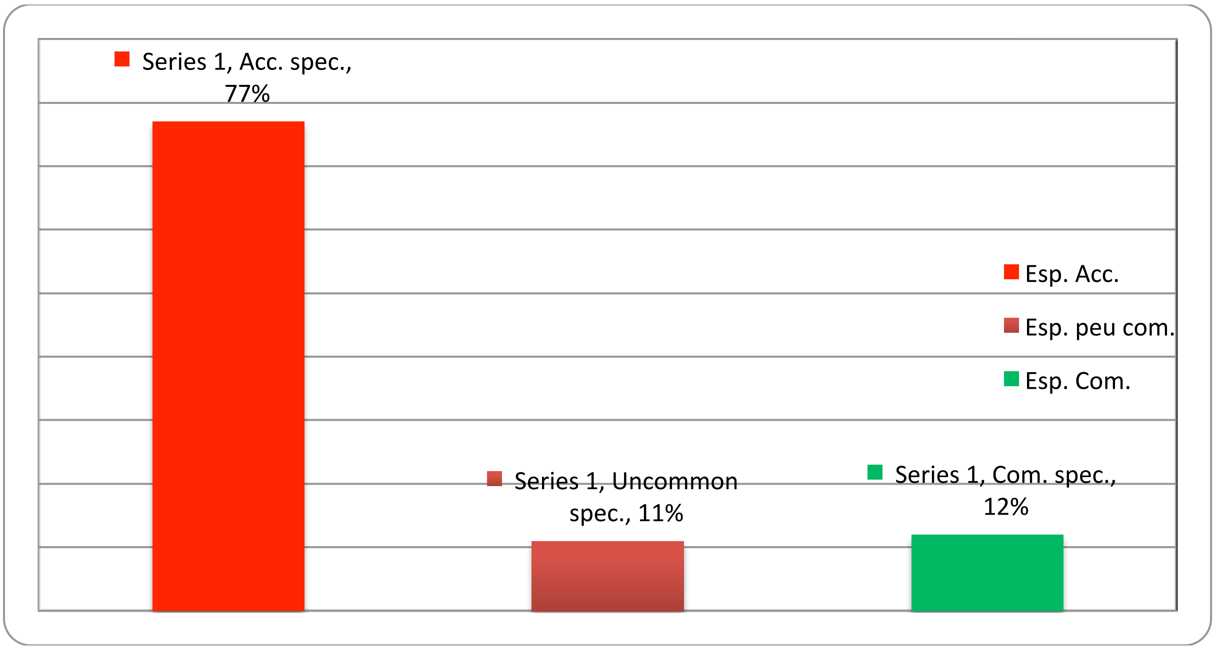
Autres = Others

- **Frequency**

How frequently a species occurs is the ratio stated as a percentage of the number of samples where this species is noted out of the total number of samples taken, as per **Tatien *et al.* (2010)**. In this case, in terms of being constant, we have identified three (3) groups:

- The species in the first group are qualified as constant (common species) when they are found in 50 % or more of the samples taken within the same community;
- The species in the second group are ancillary as they are only found in 25 to 49 % of the samples and, lastly
- The accidental species have a frequency of occurrence that is less than 25 %.

Figure 31: Spectrum of frequency of occurrence



Accidental species
Uncommon species
Common species

The Figure above shows that most of the species (83) are accidental because they are to be found in fewer than 25 % of the readings.

Twelve (12) species, or 11%, are infrequent, including *Indigofera puchra*, *Momordica balsamina*, *Cassia obtusifolia* and *Sesbania pachycarpa*, which are to be found in 40 % to 42 % of the samples. The other infrequent species are *Eragrotis ciliaris* (29 %), *Merremia tridentata* (33 %), *Pergularia daemia* (33 %), *Tephrosia linearis* (33 %), *Comelina Forskalaei* (38 %), *Indigofera berhautiana* (38 %), *Monechma ciliatum* (38 %) and *Sparmacoce stachydea* (38 %).

Thirteen species are frequent (found in at least 50% of the samples) at the site and in its vicinity. This group includes *Cenchrus biflorus* (75 %), *Indigofera astragalina* (75 %), and *Mitracarpus villosus* (79 %).

This breakdown of the species depending on their frequency shows that a low proportion of the species is widely distributed (13 %) - 13 species within the study zone, whereas a large number is not widespread, or even accidental (77 %).

5.6.2.3 Uses made of the species

This part reports on the uses made by the local populations of the plant species. The possibilities for using the various types of agriculture, fruit and forestry trees may be summarized as follows:

- Species from rainfall agriculture with subsistence crops (millet, maize, etc.) and cash crops (cassava, peanuts, etc.);
- Forest species used in the pharmacopoeia, as foods, and for other purposes (*Leptadiana hastata, Momordica balsamina, Boscia senegalensis*, etc.) by the local populations and sold at markets;
- Exotic species providing high added value (mango trees, cashew trees, etc.) which form orchards and, lastly,
- Species used as boundary hedges (*Euphorbia balsamifera; Jatropha curcas* and *Parkinsonia aculeata)* which delineate properties as well as preventing livestock from wandering off.

The Table below lists the agricultural, forestry and fruit species that are used by local populations.

Table 27: List of the plant species used by local populations

Vernacular names	Scientific names	Uses
Balsam pear	*Momordica balsamina*	Pharmacopoeia
Thieukheute*	*Leptadiana hastata*	Fodder for livestock
Balsam spurge	*Euphorbia balsamifera*	Hedge
Apple-ring acacia	*Faidherbia albida*	Fodder for livestock - Organic fertiliser
Mango	*Mangifera indica*	Food
Cashew tree	*Anacardium occidentale*	Food
Barbados nut	*Jatropha curcas*	Hedge
-	*Parkinsonia aculeata*	Hedge
Hanza	*Boscia senegalensis*	Food
Peanut	*Arachis hypogea*	Food
Manioc	*Manihilot esculenta*	Food
Black-eyed pea	*Vigna unguiculata*	Food
Millet	*Pennisetum typhoides*	Food
Maize	*Zea mays*	Food
Dogoor*	*Annona glauca*	Pharmacopoeia
Soloom*	*Cretevia bicolor*	Food

* No known English name; the Latin name is commonly used.

5.7 ANIMAL BIODIVERSITY

5.7.1 Methodology

The method of wandering around and taking readings, combined with station-based observations, was adopted. It consisted of going through the zone to be occupied by the project. The points geo-referenced for the wind turbine installations were considered to be observation stations while the distances separating them were considered to be a transect. In terms of the points adopted for the wind turbine installations (stations), ten (10) minutes were devoted to recording all the avian fauna and mammals moving around. The distance separating two (2) points was crossed as a transect in order to identify the fauna. In addition to this direct counting method, the indirect method was used for certain species using their presence indices.

5.7.2 The current state of the site's fauna diversity

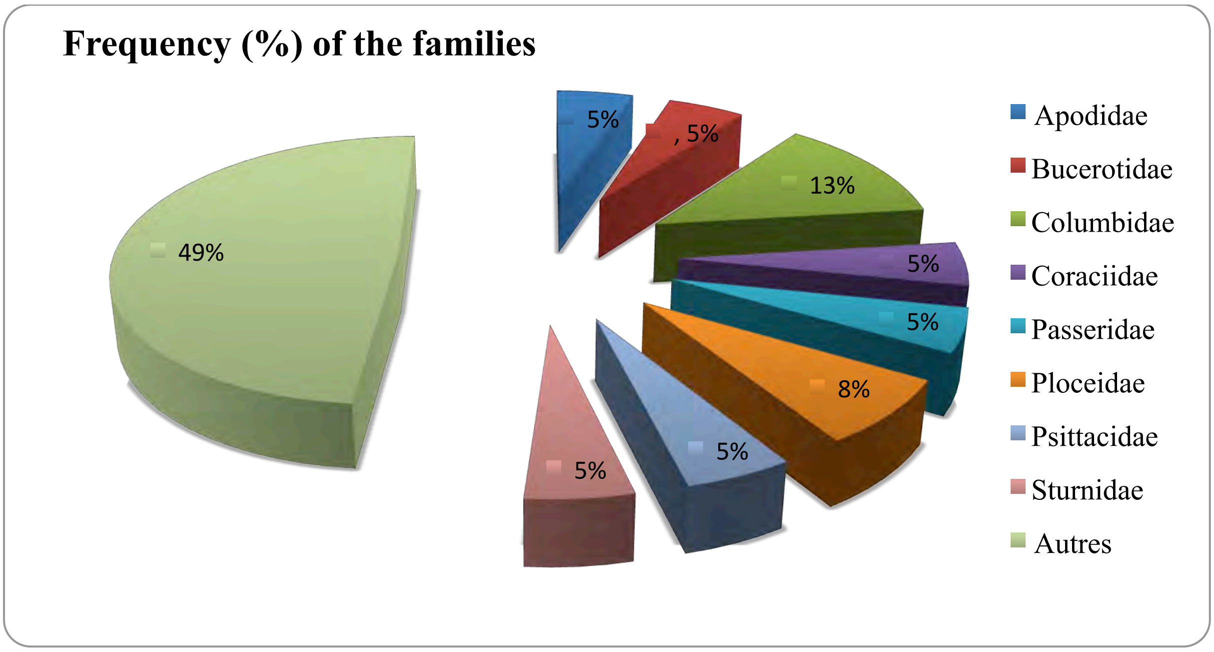
The results compiled in the Table below provide an idea of the diversity of avian fauna in December 2012. Reading the Table, it may be said that the avian fauna at the Taïba Ndiaye site is relatively diverse. The presence of 25 families with 39 genera and 39 species was noted. In terms of importance for avian fauna (cf. Figure 50), the dominant families are: *Columbidae* (12.82%), *Accipritidae* and *Ploceidae* with 7.69 % each. The *Apodidae*, *Coracidae* and *Psittacidae* families also each account for 5.13 %. The rest of the families inventoried each account for 2.56 %.

Table 28: Diversity of the avian fauna in the Taïba Ndiaye zone

Avian fauna within the project area

Family	Genus	Species	Family %
Accipitridae	3	3	7.69
Apodidae	2	2	5.13
Ardeidae	1	1	2.56
Bucerotidae	2	2	5.13
Burhinidae	1	1	2.56
Charadriidae	1	1	2.56
Columbidae	5	5	12.82
Coraciidae	2	2	5.13
Corvidae	1	1	2.56
Cuculidae	1	1	2.56
Estrildidae	1	1	2.56
Falconidae	1	1	2.56
Malaconotidae	1	1	2.56
Muscicapidae	1	1	2.56
Musophagidae	1	1	2.56
Nectariiniidae	1	1	2.56
Passeridae	2	2	5.13
Phasianidae	1	1	2.56
Ploceidae	3	3	7.69
Psittacidae	2	2	5.13
Pteroclidae	1	1	2.56
Pycnonotidae	1	1	2.56
Pteroclidae	1	1	2.56
Sturnidae	2	2	5.13
Upupidae	1	1	2.56
Total = 25	**39**	**39**	**100.00**

Figure 32: Spectrum of bird families



Autres = Others

5.7.3 The abundance of avian fauna and mammals

In terms of the abundance, within the zone to be taken up by the project, in total 965 birds were counted. The dominant species are: the alpine swift (*Tachymarptismelba*) 23.83 %, the red-eyed dove (*Streptopelia semitorquata*) 18.03 %, and the cattle egret (*Bubulcus ibis*) 8.81 %. Alpine swifts are only there during the day for feeding purposes and are birds of passage. However the other species nest in the area.

As far as mammals are concerned, the cape ground squirrel (*Xerus inauris)* is the most commonly observed species within the zone: eight (8) were observed. The other species (the Gambian sun squirrel, the jackal, the civet and the bat) are only observed via indications of their presence recorded out in the field. As the zone is used for arboriculture, the surveys conducted of the populations in the zone reveal a high presence of bats, which are nocturnal mammals. A serious study should be carried out within this context as this is the species that may possibly collide with the wind turbines.

All the species from the *Falconidae* (*Falco tinnunculus*), *Accipritidae* (*Melieras metabates* and *Accipiter brevipes* and *Milvus migrans*) families are birds of prey.

All the species observed are diurnal because the recordings were carried out during the daytime. However, bats and mongooses are nocturnal mammals.

Table 29: The abundance of the species of avian fauna encountered in the Taïba Ndiaye zone

Species observed	Family	Scientific name	Total number	% of total number per species
Black scrub robin	*Muscicapidae*	*Cercotrichas podobe*	2	0.21
Dark chanting goshawk	*Accipitridae*	*Melieras metabates*	1	0.10
Common bulbul	*Pycnonotidae*	*Pycnonotus barbatus*	32	3.32
African grey hornbill	*Bucerotidae*	*Tokus nasutus*	22	2.28
Red-billed hornbill	*Bucerotidae*	*Tokus erythrorhyncus*	39	4.04
Cape crow	*Corvidae*	*Corvus capensis*	75	7.77
Senegal coucal	*Cuculidae*	*Centropus senegalensis*	7	0.73
Levant sparrowhook	Accipitridae	*Accipiter brevipes*	1	0.10
Greater blue-eared starling	*Sturnidae*	*Lamprotornis chalybaeus*	12	1.24
Common kestrel	*Falconidae*	*Falco tinnunculus*	5	0.52
Double-spurred francolin	*Phasianidae*	*Francolinus bicalcaratus*	17	1.76
Yellow-throated sandgrouse	*Pteroclidae*	*Pterocles gutturalis*	2	0.21
Black-headed gonoleck	*Malaconotidae*	*Laniarius erythrogaster*	2	0.21
Cattle egret	*Ardeidae*	*Bubulcus ibis*	85	8.81
Hoopoe	*Upupidae*	*Upupa epops*	2	0.21
Alpine swift	*Apodidae*	*Tachymarptis melba*	230	23.83
African palm swift	*Apodidae*	*Cypsiurus parvus*	2	0.21
Greater blue-eared starling	*Sturnidae*	*Lamprotornis chalybaeus*	22	2.28
Black kite	*Accipitridae*	*Milvus migrans*	10	1.04
Senegal thick-knee	*Burhinidae*	*Burhinus senegalensis*	2	0.21
House sparrow	*Passeridae*	*Paser domesticus*	26	2.69
Senegal parrot	*Psittacidae*	*Poicelaphus senegalus*	2	0.21
Rose-ringed parakeet	*Psittacidae*	*Psittacula krameri*	4	0.41
House sparrow	*Passeridae*	*Paser domesticus*	26	2.69
Speckled pigeon (palmyra)	*Columbidae*	*Columba guinea*	16	1.66
Abyssinian roller	*Coraciidae*	*Coracias*	6	0.62

Species observed	Family	Scientific name	Total number	% of total number per species
		abyssinicus		
Purple roller	*Coraciidae*	*Coracias naevius*	3	0.31
Western bluebill	*Estrildidae*	*Spermophaga haematina*	2	0.21
Splendid sunbird	*Nectariiniidae*	*Cinnyris coccinigastrus*	10	1.04
Black-winged red bishop	*Ploceidae*	*Euplectes hordeaceus*	2	0.21
Village weaver	*Ploceidae*	*Ploceus cucullatus*	59	6.11
Vieillot's black weaver	*Ploceidae*	*Ploceus nigerrimus*	27	2.80
Western plantain-eater	*Musophagidae*	*Crinifer piscator*	4	0.41
Red-eyed dove	*Columbidae*	*Streptopelia semitorquata*	13	1.35
Ring-necked dove	*Columbidae*	*Streptopelia capicola*	2	0.21
Laughing dove	*Columbidae*	*Streptopelia senegalensis*	174	18.03
Mourning collared dove	*Columbidae*	*Streptopelia decipiens*	9	0.93
Black-headed lapwing	*Charadriidae*	*Vannellus tectus*	10	1.04
Total species observed			**965**	**100**

5.7.4 Number of avifauna species

The majority of the species inventoried within the zone are small in number. However, certain species such as the black kite and the cattle egret are numerous.

5.7.5 The existence of a migration corridor for avifauna

The birds use the zone for resting and feeding. Those birds that leave Djoudj park in order to fly to the Saloum Delat pass through the littoral zone where there is a belt of casuarina trees about 5 km from the project's zone.

5.8 STATUS OF THE SPECIES AND SPACES

5.8.1 Status of the plant species

In this section, we are going to conduct an analysis of the legal status of the plant species encountered at the project's site and in the vicinity. The purpose of this section is to see which of the species encountered at the site are the source of conservation concerns (because they are rare, endemic, threatened, etc.).

Firstly, we are going to see the positions of the species in the IUCN Red List in terms of conservation concerns set out in a section entitled ***Rarity status***.

The second and last section, entitled ***Protection status***, will tackle everything relating to the national legislation (the Forestry Code) and international legislation (CITES) applicable to these species.

Rarity status

In this part of the analysis, we are going to see the rarity status of the species inventories at regional level or, in other words, in terms of the eco-geographical region where the project is located. As a reminder, the site that is to host the project belongs to the Sahel-Sudan area. What is involved is the eco-geographic zone within the 350 and 600 mm isohyets.

A comparative analysis of the flora list and a list of the endemic and threatened species in the Senegalese Sahel-Sudan area was carried out. No endemic or threatened species were identified at the site.

The project's site does not feature any species belonging to the Sahel-Sudan area that are listed as being endemic and/or threatened.

- ***Threatened plant species***

The following species are featured in a list of species that are either threatened or that may pose a threat to other species in Senegal.

Moreover, from a regulatory perspective, these three species benefit from partial protection. A chapter deals with issues relating to the protection status of the plant species encountered at the site and in its vicinity.

- ***Endemic species***

An endemic plant species is a species with a distribution area limited to one country or region. Herbaceous species predominate where there are endemic species.

Of the one hundred and twenty-three (123) species inventoried at the project's site and its vicinity, three (3) (*Crotalariasphaerocarpa, Polycarpaea linearifolia* and *Vernoniabambilorensis*) feature among Senegal's endemic flora species.

Protection status

In Chapter 5 of the Implementation Decree for the Senegalese Forestry Code concerning protected forestry species, Article R.63 lists the forestry species that are protected in Senegal.

From a legislative and regulatory perspective, the eight (8) following species: *Adansonia digitata*, *Borassus aethiopum*, *Elaeis guineensis*, *Faidherbia albida*, *Grewia bicolor*, *Prosopis africana*, *Tamarindus indica* and *Ziziphus mauritiana* are encountered at the project's site and in its vicinity, which form part of the species partially protected by the Senegalese Forestry Code. This involves obtaining prior authorization from the relevant authorities before taking any action (cutting down trees, chopping off branches, clearing tree stumps, etc.).

With regard to species fully protected by the Forestry Code, none of the species inventoried fall into this category.

Nor were any species featured in the CITES[4] in Appendices I, II or III (2012 edition) inventoried and identified at the site or in its vicinity.

5.8.2 Status of the animal species

Analysis of the status of fauna species encountered at the project site and in its vicinity is dealt with in Appendix B. None of the species inventoried is considered by the IUPN to be threatened either at national or international level.

Four species of birds that are fully protected under Senegalese regulations (Article R-59 of the Hunting and Fauna Protection Code) were also inventoried. They are *Milvus migrans* and *Bubulcus ibis*, with the natural habitat found at the zone where the project is to be established not offering any characteristics favorable for their reproduction; the individuals observed were therefore either birds of passage or were looking for food. As far as the two species of hornbills (*Tockus erythrorhyncus* and *Tockus nasutus*) are concerned, what is involved are birds that only use hollows in old trees for nests. The study zone, which features several old trees, therefore constitutes a potentially favorable zone for the reproduction of hornbills.

Lastly, there were no animal species that are protected under the 25 September 2012 version of the CITES[(2)] Convention. Three species of mammals were however listed in Appendix I[(3)] of the previous version of the CITES Convention (*Mungos mungo, Ichneumia albicauda* and *Canis aureus*) while five birds belonged to Appendix II[(1)] (*Milvus migrans, Tockus erythrorhynchus, Tockus nasutus, Bubulcus ibis* and *Poicephalus senegalus*). Only the latest version of the Convention was taken into consideration for determining the threatened status of the species in this ESIS; the old statuses are however presented in Appendix 4.

5.8.2.1 Status of the spaces: sensitive and/or protected areas

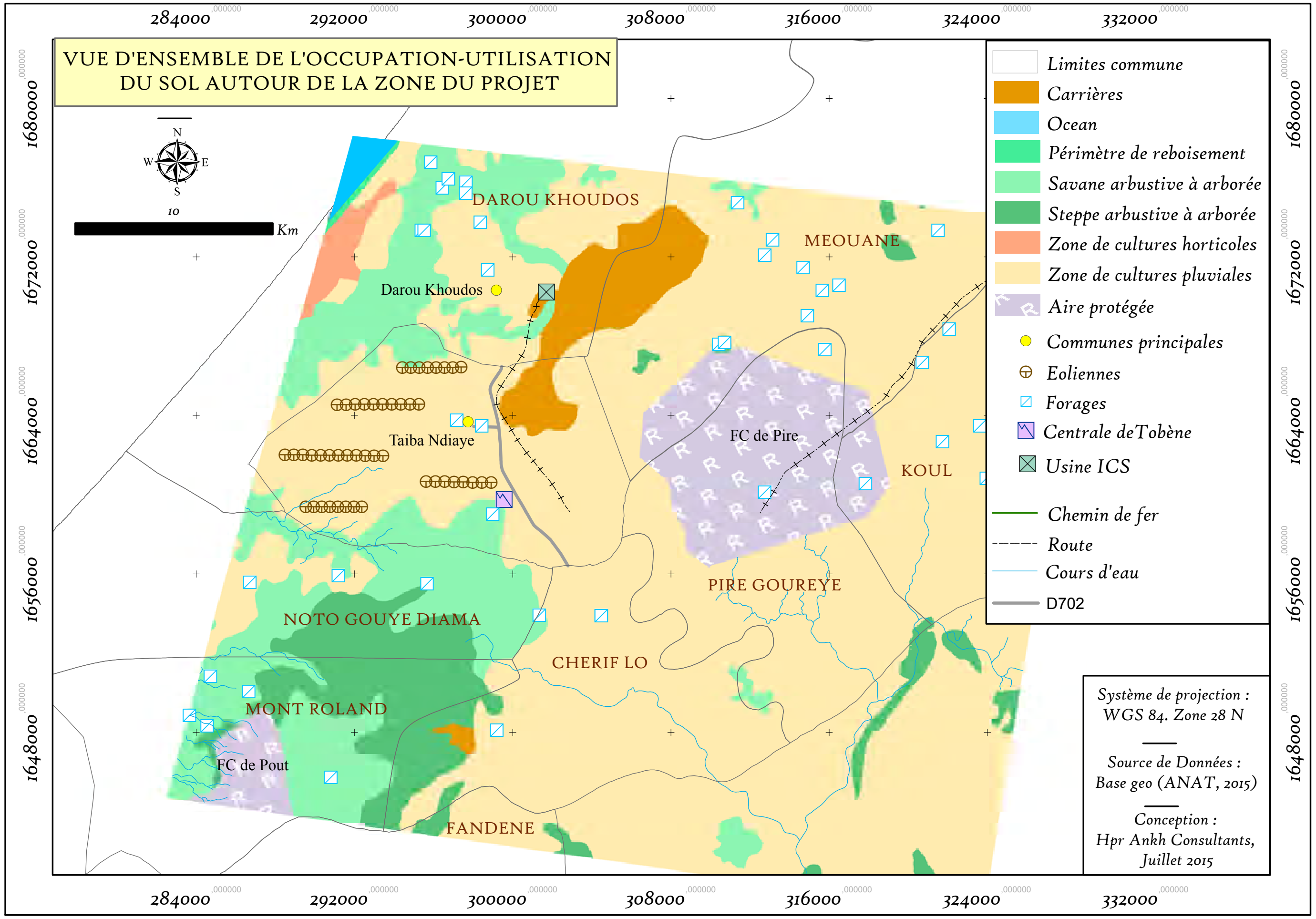
The only listed area within the project's zone is the Pire Gourèye area (cf. Figure 18). It was listed by Order No. 1857 of 5 May 1946 and features nineteen (19) villages. It is mainly populated by palms (*Borassus aethiopum*).

[4] Convention on International Trade in Endangered Species.

Table 30: Summary of the sensitive spaces within the area of influence of the project's site

Name	Distance and direction in relation to the project (No. of km N, S, E, or W)	Area (km^2)	Protection level (use the local terminology & IUCN codes)	Sensitivity (what are the habitats and protected species concerned – brief summary)
FC of Pire Gourèye	7.5 km East of the site	92.50	Managed	Palm grove

Map 7: Map of the protected areas within the project's expanded zone



5.9 SERVICES RENDERED BY THE ECOSYSTEMS

This part reports on the uses the populations make of the plant species, and fauna to a lesser extent. It is based on the IFC's performance criteria.
The services rendered by the ecosystems entail interactions between the natural environment and the human environment. The study of the services rendered by the ecosystems is based on the importance of the components reused:

- Geology and soils;
- Biodiversity;
- Water;
- Cultural heritage;
- Land use and subsistence resources;
- The health of local populations;
- etc.

The following Table outlines the services rendered by the ecosystems at the project site and in its vicinity.

Table 31: Summary of the services rendered by the ecosystems

Service categories	Services
Supply	<u>**Energy source**</u> ☞ Gathering up dead wood; ☞ Cutting down trees and chopping off branches at the base of trees (fruit tree species and stumps of trees). Photo 8: Bundle of dead wood tied up using *Leptadiana hastata* vines   Photo 9: Pruning the side branches from mango trees

Service categories	Services
	  **<u>Service and the local economy</u>** ☞ Exploitation of forestry products: the leaves from *Leptadiana hasta* or Thieukheute, the leaves from *Sena tora* or Mboum Ndour for food, the fruit from *Boscia senegalensis* (hanza) for food, palm leaves for making containers for storing foods, the palm trunk for making poles, the bark from the confetti tree for rope-making; ☞ Exploitation of fruit trees: mango trees, cashew trees, lemon trees, palms, leaves from *Boscia senegalensis,* the leaves from *Leptadiana hastata*, etc. Photo 10: Looking for sap in the base of a palm in order to make wine Photo 11:Gathering palm leaves

Service categories	Services
	  Photo 12: Base of *Boscia senegalensis* beside E23 Photo 13: Bade of *Leptadiana hastata* beside E18   **<u>Livestock feed</u>** ☞ Exploitation of fodder from overhanging tree branches: apple-ring acacia pods, the leaves and fruit from Tahitian lime trees, Néew fruit, etc.

Service categories	Services
	☞ Exploitation of herbaceous plants for fodder. ☞ Exploitation of products remaining from harvests: peanuts, manioc, millet, and market garden products generally
Cropping	**The intrinsic value of biodiversity**: ☞ Partially protected species: plant and animal species. The plant species offer various cultural services. Take palms for example; several cultural services derived from the various parts of the plant can be listed. For example: ☞ Palm leaves are used on the roofs of huts to provide protection against lightning ☞ Palm leaves are used for making cooking utensils and containers for storing foods and foodstuffs ☞ Palm sap is used for making local wine ☞ Etc. Photo 14: Hut roof based on palm leaves Photo 15: Framework for a hut made with palm stems

Service categories	Services
	  Photo 16: A fence made from palm leaves 
Regulation	**Combating erosion caused by wind and water:** ☞ Ground cover provided by plants preventing erosion caused by wind and water; ☞ Numerous hedges have been grown (which prevent erosion caused by wind) and low stone walls Photo 17: Low stone wall Photo 18: Wind break

Service categories	Services
	 **Water cycle** ☞ Surface bodies of water contribute to replenishing the high groundwater Photo 19: Standing bodies of water on line 3 

5.10 THE HUMAN ENVIRONMENT

The purpose of this section is to present a description of the socio-economic environment for the project in its initial state. In particular, it relates to a demographic, social and economic characterization of the study zone based on primary and secondary data. The methodology adopted in order to fulfil this specification relies on making use of documents drawn up at national and local level. Particularly the Economic and Social Policy Document (DPES 2011-2015), the Local Development Plan for the borough of Taïba Ndiaye, and calculations carried out based on data drawn from these various documents, as well as the results of the streamlined households survey conducted in the villages neighboring the project zone, which was carried out by a multi-disciplinary team and related to a random sample of 66 households.

This chapter describes the administrative, demographic, economic, social and agricultural contexts of the town and country planning and housing situation, land use and ownership, the employment situation, social services and infrastructures.

5.10.1 Administrative context

Upon achieving independence, Senegal opted for a cautious, progressive and irreversible decentralization policy. This option was confirmed during the various phases that marked this policy.

The first major reform in 1972 laid down the groundwork with greater local freedoms, the creation of rural communities, the promotion of devolution, and planning regionalization.

The second major reform, carried out in 1996 "with a view to increasing the State's local services and the responsibilities of local bodies", enshrines regionalization, particularly through establishing the region as a local authority, and creating district boroughs.

However, in spite of the progress made, a good many weaknesses and constraints still weigh on the implementation of the decentralization policy. The context and weakness of the development policies and strategies applied hitherto require, as a consequence, the initiating of alternatives likely to make up for shortcomings and at the same time achieve significant progress at national level and harmonious local development.

With a view to this, the option adopted was, under the framework of consensus-based and forward-looking dialogue, to lay the building blocks for the State's renewal and modernization through decentralization that is consistent in its principles, and which offers high-performance implementation.

Thus, the Government envisages a major reworking of the State's regional action through the project of reforming decentralization.

The general objective targeted by this reform, called "Act III of decentralization", is to organize Senegal into viable regions that are competitive and promote sustainable development.

This reform has its roots in a true regional development policy and orients firming up the aspirations and hopes of regional stakeholders with a view to putting together a regional plan. It offers sufficient room to lay the groundwork for the regional implementation of public policies.

It takes the form of four basic objectives:

- Bedding in regional consistency in order to achieve a renovated administrative structure;
- Clarification of the powers of the State and local authorities;
- Development of contractual arrangements between the two decision-making levels;
- Modernization of regional State-sector management, with a reform of local finances and sustained promotion of the quality of human resources.

In light of its complexity and its decisive nature for the future of our country, Act III of decentralization will be implemented gradually and will be carried out in two phases.

The first phase will involve:

- Eliminating the regional local authority;
- Establishing Departments as local authorities;
- Carrying out the full establishment of a boroughs structure by setting up rural communities and Arrondissement boroughs as boroughs;
- Creating towns with a view to sharing the powers of the boroughs comprising them;
- Allocating the nine areas of authority transferred to date between the two levels of local authorities, consisting of the Departments and boroughs.

The first phase must be carried out in accordance with the current regional boundaries of the administrative entities concerned.

The borough of Taïba Ndiaye is one of the oldest local authorities in the country. It was created as part of the second regional reform initiated by Law No. 72-25 of 25 April 1972. Administratively, it is subordinate to the Arrondissement of Méouane which is located in the Department of Tivaouane, in the Thiès Region. Taïba Ndiaye has 39 villages, over ten of which are located near the project's zone.

5.10.2 Local governance and organizational dynamics

Local governance refers to forms of coordination including multiple stakeholders. Local public-sector action is no longer the prerogative of a single authority but instead involves non-State sector stakeholders in decision-making processes.

In Senegal, the emergence of local governance is closely linked to the decentralization reforms instituted in 1996. Indeed, the transfer of the 9 areas of authority to local authorities enabled the latter to achieve truly autonomous management. The centralized State no longer appears to be a suitable instrument for ensuring development at ground level.

Article 3 of Law No. 96-06 of 22 March 1996 concerning the Local Authorities Code stipulates that: “The mission of local authorities is to come up with, schedule and implement actions for economic, educational, social and cultural development of regional, borough or rural interest. (…). Where applicable, they involve community movements and groups in the execution of economic, educational, social and cultural development projects”.

Taïba Ndiaye, following the example of all the other rural communities, is administered by a rural council consisting of male and female councillors elected by direct universal voting for a 5-year term of office. The executive organ is still its Chair, who is the moral authority and is elected by the councillors for the same term of office as the council, and is in charge of ensuring the local authority’s administrative policy in accordance with the provisions of the laws and regulations in force as well as having the mission of implementing the areas of authority transferred which are health, education, the environment, housing, town and country planning, agriculture, youth, sport and cottage industries. Under the framework of its operations, the rural council is assisted by specific commissions.

The organizational dynamic – which must support the rural council – has to be characterized both by its quantitative scope and by its diversity. The dynamism of the OCBs (Basic Community Organizations) has to be the guarantor of rural areas’ socio-economic development.

The OCBs mainly consist of Dahiras, GPFs (Groups for Promoting Women), ASCs (Sports and Cultural Associations) and, on an ancillary basis, GIEs (Public Interest Groupings) in the borough of Taïba Ndiaye or specifically in villages neighboring the project’s site. The Dahiras are the most important organizations in terms of numbers. They have real mobilisation capabilities, but for the time being their actions are oriented solely towards religious worship. The proximity of the religious town of Tivaouane has a determining influence on the profusion of this type of organization.

The GPFs, which are quite numerous, are the most dynamic organizations in economic terms. Their dynamism is mainly the result of supervision by technical and financial partners. As a matter of priority, generally the areas of support mainly concern literacy, micro-credits and employment, among other aspects.

The other OCBs are generally oriented towards carrying out for-profit community activities or the maintenance and upkeep of certain community assets. The OCBs which involve themselves in the maintenance and upkeep of community infrastructure are APEs, health committees, and borehole management committees.

5.10.3 Demographic context/Housing

Senegal’s estimated population was slightly over 13 million people in 2012. Fifty-two percent of the population is female, and it is also characterized by its extreme youth, with about 60% of Senegalese being under the age of 20. Demographic growth, which is considered to be nearly 2.7% on average annually, is higher in urban areas, where it has reached nearly 4%, than in rural areas. In spite of this rapid urbanisation, over 60% of the population still lives in country areas.

Women still marry early; 50% of them get married before they are 17 years old. The average fertility rate is about 6 children for women at the end of their childbearing years, and is one and a half times higher for rural women than it is for urban women. In terms of family responsibilities, surveys show that nearly 82% of the heads of households are men and only 18% are women. However, it is in towns where women constitute the largest proportion as heads of families (25.7%), as opposed to 13.1% in rural areas. The major demographic pressure and the youthfulness of the population explain why the economic dependence rate is very high, being 1.03. The working population, from 15 to 64 years old, is growing at a rate of 4% on average.

The population in the Thiès region grew 8.30% from 2009 to 2012, making for an annual increase of 2.69%, which is near the annual average. Indeed, it went from 1,610,052 inhabitants in 2009 to 1,743,707 inhabitants in 2012. Women account for 50.1% of that figure, which is slightly less than the national average.

The estimated population of the borough of Taïba Ndiaye is 24,114 inhabitants, comprising 47.97% men and 52.02% women, with about 60% of the population being young people under the age of 20. For over 10 years now, its natural growth rate has been around 3% annually. The majority of the inhabitants of this location are Muslims (99%) and Wolofs (99%). The working population constitutes 45.17% of the total population, with 85% being farmers, 4% graziers, 5% craftsmen, 3% manual laborers working in the industrial sector, and 3% are shopkeepers and State employees.

The information gathered during surveys polling households in villages neighboring the project's zone indicates a young population, which is in line with regional and national data. Young people under the age of 15 constitute 42.15% of the population, with 60.34% of them being boys. Paradoxically, in this zone, men outnumber women, who only constitute 47.6% of the sample population. Only 30.46% of the population is of working age, 31.65% of whom are women. Another ambiguity that should be emphasized in this sample is that, of the 27.4% comprising people who are 65 years of age or over, approximately 78% are women. Young people and old people constitute 69.54% of the population and constitute the non-working population, making for a dependence rate of 2.28, which is far higher than the national average. This excessively high rate of economic dependence may have a huge influence on the earning capacity of households along the fringes of the project's zone. Under these conditions, their incomes may experience a certain degree of depreciation due to the excessively large number of mouths to feed and point to concerns in terms of financial access to basic social services.

Table 32: Structure of households in villages neighboring the project's site

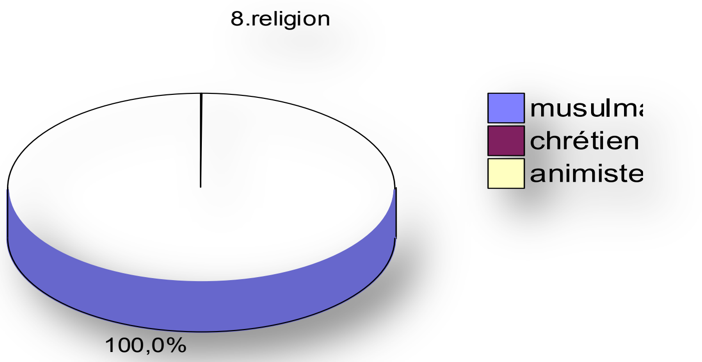
AGE STRUCTURE	SEX				TOTAL percentage	TOTAL numbers
	Male		Female			
	%	n	%	n		
Under the age of 1	7.4	72	2.6	25	10	97
1 to 5 years old	6.8	66	4.6	45	11.4	111
6 to 14 years old	11.3	110	9.5	93	20.8	203
15 to 64 years old	20.8	203	9.6	94	30.4	297
65 years or over	6.1	59	21.3	208	27.4	267
TOTAL	52.4	510	47.6	465	100	975

Source: Household survey results, December 2012

5.10.3.1 Ethnic and religious situation

In this region, the most commonly spoken languages are Wolof, Peulh and Bambara. The Wolofs form the majority and constitute 89.4% of the population, Peulhs constitute 9.1% and Bambaras account for 1.5%. The zone's population is 100% Muslim.

Figure 33: Breakdown by religion



Muslim
Christian
Animist

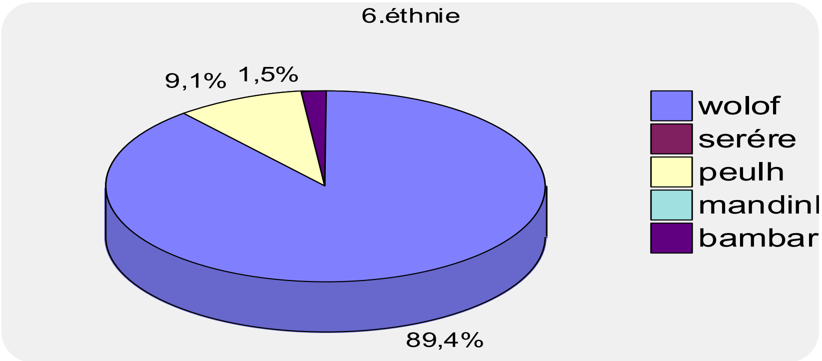
Source: Household survey results, December 2012

Figure 34: Breakdown of the ethnic groups of the households neighboring the site

6. Ethnic groups

9.1% 1.5%

Wolof
Serére
Peulh
Mandinka
Bambara



89.4%

Source: Household survey results, December 2012

External and internal migration movements are frequent within this borough. Young boys and girls are the most involved in this rural exodus because women are busy for a good part of the year. Girls head off to search for domestic work during the dry season in towns like Tivaouane, Thiès and Dakar in particular, and boys head to certain fishing towns in the Thiès region.

5.10.3.2 Town and country planning and housing

With the advent of decentralization in Senegal, town and country planning and housing were transferred to local authorities. Unfortunately, due to a lack of financial resources, these local institutions are experiencing major difficulties with developing their respective rural lands. This is the reason for the development of squatter housing and recurring conflicts between users, particularly between producers. However, the State is attempting to support these local bodies by helping them to develop and diversify the offer of low-cost public housing by reinforcing programs for planned development zones and as part of drawing up and implementing land regularization strategies.

The quality of rural housing in Senegal has improved considerably, particularly in the north and north-eastern zone of the country. Like many rural communities, the households in many villages in Taïba Ndiaye near the project's zone are increasingly abandoning thatch and straw and are adopting galvanized steel, concrete, tiles or slates. Housing and the spatial configuration run parallel to roads and follow destructured community reasoning. The houses of villages close to the project's zone are modern and semi-modern (77.3% and 22.7% respectively).

5.10.3.3 Property

The level of land-owning in Senegalese rural households is 84.90 % of the national level. However, the figures vary slightly depending on the eco-geographic zones. The ownership rates are highest in zones where there is a low demographic density. It is 93.33% in the regions of Tambacounda and Kédougou, 92.91% in the Casamance region, and 84.62% in the forestry and grazing zone. The rates are comparatively lower in the Senegal River Valley (80.16%), in the Niayes (80.13%) and in the Peanut Basin (79.91%) where the high densities often entail a higher level of pressure on land. The latter two zones are characterized respectively by the increasing establishment of agro-industry and speculation linked to the major demand for housing land.

In the various eco-geographic zones, inheritance, bequests, donations and loans stand out as the main methods of gaining access to land. These types of access, which precede the law on the national domain (allocation) still retain great social legitimacy. It is widely accepted that access to land resources greatly depends on the social status of individuals (their ethnic group, social class, etc.) and their family status (the particular position that men and women hold within the household). 94.53% of households that own land have a man as the head of the household and 5.47% have a woman as the head of the household.

Access by women to land varies depending on the eco-geographic zones. In the Casamance region, over 60% of women have access to land, while in the Tambacounda and Kédougou regions, nearly 70% of women have access to land. Within the zones of Le Ferlo, the River Valley and the Niayes, the percentages vary from 20 and 30%. Women often have access to land through their families and GPFs. On a priority basis, women refer to their families in order to gain access to land, with married women acting through their husbands. The reason for this is that land is considered to be a family asset.

Access to land resources may differ depending on the matrimonial situation, offspring, age, and the rank of the spouse within a polygamous marriage. Due to various power relations, the logic underpinning family management of production would have that the relations women have with land be limited to the possibility of exploiting but not appropriating land. It is the man, who is the head of the household, who manages and controls land. As the head of the family, he has decision-making powers, as well as power over the production and distribution of resources.

In villages near the project's site, 98.5% of the households polled as part of the land surveys had owned land, almost all of which is in rural zones, or in other words in the National Domain governed by Law No. 64-46 of 17 June 1964. Indeed, 92.4% of the households surveyed obtained these fields through custom rights, with them being passed on from father to son, from one generation to the next.

5.10.3.4 Soil use

The lands comprising the National Domain are the property of the nation and the State holds them with a view to ensuring rational use and development of them, in accordance with the various development plans and programs. Management powers are transferred to local authorities.

Land is not only agricultural, it is also used for grazing, and also encompasses all the activities relating thereto.

Generally, the lands in the National Domain are intended for raising livestock and agriculture, activities which employ 70% of the working population, and which have the greatest economic potential.

In rural zones, where you find over 75% of the female population, 80% of women take part in agricultural work.

Agriculture in Senegal is traditional and extensive in nature, and contributes very little to the GDP. The majority of the people involved are small farmers who only cultivate surface areas less than 5 hectares.

The Thiès region is considered to be a major agricultural production hub where the farmers in particular devote their efforts to food crops (particularly perennial ones), to the detriment of cash crops, particularly peanuts, whose surface areas sown have considerably diminished. Overall, surface areas sown increased 46.67% from 1997 to 2008, particularly due to cereal crops and tubers, especially cassava. Indeed, the surface areas devoted to these cash crops have increased 353% to 85,641 ha, with a 4.5 times increase for cassava; 37.25% for black-eyed peas, 14% for millet and 37.93% for sorghum over that period. The production of these various crops has increased spectacularly. It has multiplied around tenfold, going from 84,091 tonnes to 838,259 tonnes. In particular, this remarkable increase is due to the production of cassava, which increased 17.59 times, going from 40,963 tonnes to 720,628 tonnes, marking an increase of 1,659%. In addition to the substantial shifts in the surface areas cultivated, the second main reason for the increase in these food crops is the extraordinary increase in their productivity per hectare. As a matter of fact, yields increased by about 248% over this period, or 3.48 times. The cassava yield went from 2,169 kg/ha to 8,415 kg/ha, or a growth of 287.9%.

In the borough of Taïba Ndiaye, the production system was marked by repeated seasonal crops that are highly dependent on rainfall levels. Now the most important cash crop is cassava with nearly 65% of the surface areas being sown with cereals – which has become the main source of income for households – and thereby offers producers in that locale an alternative to cultivating peanuts, which is handicapped by a lack of quality seed and a lack of rainfall. Millet (20% of the cultivated surface areas) and black-eyed peas (5% of the cultivated surface areas) are food crops, with the bulk of the production being consumed by the growers. Fruit and vegetable cultivation is also practiced within the borough, but the surface areas are negligible compared to the other seasonal and perennial crops, particularly mangoes.

In addition to cassava, the producers in the borough of Taïba Ndiaye also work in the mango sector, where involvement of a substantial number of women was noticed. The new agricultural dynamism and the emergence of a new economy in this locale are naturally caused by the crisis in the peanuts sector, which reoriented producers towards arboriculture, tubers and fruit and vegetable cultivation providing them with more long-term income than growing peanuts does. Unfortunately, like other Senegalese producers, 60% of the households in these villages near the project farm surface areas less than 5 ha, mainly due to the land issue.

Livestock rearing is semi-intensive. People opt for this as a secondary activity. The overall number of all sorts of livestock is very low compared to other grazing zones. The lack of grazing lands is prompting graziers to graze animals in the vicinity of their homes, particularly cattle and sheep.

Forestry operations have developed within this local community. Except that land clearance for mining operations and the extension of zones where perennial crops are grown along with housing areas are threatening this sub-sector, which provides substantial income to local populations.

5.10.3.5 Conflicts and tension

Even though land management is one of the powers transferred to local authorities, in practice this is giving rise to management methods that are a mix of traditional and modern methods. Most of the lands farmed by families are subject to a range or rights and access rules particular to their circumstances. Land transactions involve several levels of responsibilities and prerogatives ranging from the individual to the community, both informally (management within families) and formally (positive rights granted by the law concerning the National Domain). Open conflicts over land seem to be rare and the land boundaries between private individuals and between villages are well-known and fixed within this long-settled area, where there is next to no itinerant grazing. On the other hand, there are boundaries for the borough where Peulhs live, who are cattle owners. But this livestock rearing is not of such a scope as to give rise to conflicts between sedentary inhabitants and nomads because these stakeholders are also involved in agriculture and market gardening thereby takes up a substantial proportion of their livestock rearing activities. Yet it is important to take a livestock rearing zone into account within the context of preparing and planning the works involved in installing wind turbines. The reason for this is that the latter may come up against a livestock grazing corridor, with this giving rise to tensions if the graziers have to seek an alternative corridor.

5.10.4 Economic context

5.10.4.1 General context/economic activities

Since the devaluation of the CFA franc, which was decided on in January 1994 by the Member States of the WAMU, growth has been sustained by the secondary and tertiary sectors, and particularly the construction and public works sector, telecommunications, agrofood industries and commerce, to the detriment of agriculture in the broader sense, which is not very productive and is barely competitive due to difficulties accessing production factors, the high dependence on rainfall agriculture crops, inherent problems relating to seed quality, and access to land and to local and international market openings, although it does however still employ over half of the working population.

The primary sector's contribution to GDP grew 20% annually from 1980 to 1993 and only 14.6% from 1993 to 2008, marking a relative decrease of 6 points, settling at a level of 17.2% in 2011. The secondary sector's contribution increased relatively by 3.5 points. As a matter of fact, its contribution went from 16.5% in 1980 to 20% in 2008, reaching a level of 18.8% by 2011, marking a fall of about 1 point. On the other hand, the portion taken by the tertiary sector in the broadest sense over the same period was on average 51.2%, increasing by just 0.4 percentage points in 2011, amounting to 51.6% (ANSD (National Statistics and Demography Agency): Senegal's Economic and Social in 2011). The informal sector makes a major contribution to the national economy. It constitutes over 40% of GDP.

The Senegalese economy was hit hard by the repercussions of internal and external impacts relating to the food, energy and financial crises that marked the decade running from 2000-2010. Economic activity slowed down substantially during the period from 2006 to 2009, particularly due to a lack of rainfall, with an average growth rate of 3.3% in spite of an average annual increase in national wealth of 6% during the 2003-2005 period, marking a fall of approximately 3 points. The real GDP growth rate then settled at 4.1% in 2010, in spite of persistent difficulties being noted, particularly in electricity supply and subject to the international environment's unfavorable conditions. Among other things, the energy sub-sector is marked by a weak offer, and the low quality provided by the electricity service, along with both recurring and unforeseeable load shedding that hinders the performance levels of economic activity.

Exports of goods and services increased relatively by 1.2 points between the 2000-2004 and 2004-2010 periods. In fact, respectively, they went from 5.6% to 6.8% annually. However, in spite of this positive export trend, Senegal's trade balance remained in the red during this period. The trade balance deficit, due to the rising prices of imported products, entailed a substantial deterioration of the current account deficit, which amounted to 6.4% of GDP from 2009 to 2010. The trade balance and current account deficits were respectively estimated to amount to 978 billion CFA francs and 388 billion CFA francs in 2010.

The Senegalese economy suffers from shortcomings in terms of the quality and quantity of infrastructures, the weakness of its industrial network, and a level of private investment that is still not very high, particularly in the production sectors. However, with the major increase in budget resources and the substantial contribution made by public development aid, the investment rate more or less doubled over the 1986-2010 period. It reached 22.7% of GDP which, for some economists, constitutes the prior condition for moving towards economic emergence. Direct Foreign Investment experienced a resurgence of interest during the 2005-2009 period, but on average only constitutes 2.8% of Gross Fixed Capital Formation, which is one of the various investment factors. Private investments were very dynamic over the 2004-2010 period in the secondary and tertiary sectors, particularly in telecommunications, mining and tourism.

Final consumption regularly increased over the last decade. Over the 2006-2010 period, it increased 7.3%. The domestic savings rate went from 11.2% in 2000 to 7.0% in 2010, amounting to a decrease of 4.2 percentage points. However, the national savings rate increased approximately 4 points in terms of relative value over the same period, going from 13.4% in 2000 to 17.3% in 2010, which was caused by transfers of funds by expatriate Senegalese workers.

Overall, inflation is under control. It does however feel the influence of fluctuations in the world exchange rates for food products and energy sources. Indeed, the average variation of the HICP (Harmonized Index of Consumer Prices) went from 1.5% between 2000 and 2006 to nearly 6% between 2007 and 2008, feeling the effect of the food and energy crises. However, facilitating the easing observed in international rates, domestic prices returned to more moderate growth rates. Thus, in 2010, they experienced a 1.2% increase after the 0.9% fall posted in 2009. In the long term, inflation should be kept below the community ceiling set by the WAEMU (3%).

The total government debt outstanding, which varied from 21.3% in 2006 to 34.4%% in 2010, amounting to an increase of just over 13 percentage points, and remained substantially higher than the community ceiling set (by the WAEMU) at 70% of GDP. In terms of budgetary management, the State has kept a cap on public expenditure, whilst at the same time maintaining social expenditures, in spite of a drop in revenue due to the downturn in economic activity. However, the public deficit went from 2% of GDP to 4.5% of GDP from 2001 to 2010. (Source: Economic and Social Policy Document - DPES 2011-2015).

5.10.4.2 Employment and training (national context)

Within the economic sectors, employment shows geographic and gender disparities. Within rural zones, women are mainly involved in agriculture and livestock rearing and they carry out nearly 82.6% of the work, as opposed to 79.4% in the case of men. In the urban environment, women consider the informal sector to be a worthwhile alternative because it requires fewer skills and less specialization, as well as being more flexible and better adapted to their financial capacities and their schedules. Consequently they continue to have a low level of involvement in the formal sector. On the whole, women are under-represented in qualified professions in that 75% of them are in unqualified occupations, as opposed to a figure of 33% for men.

The labor offer has increased at a sustained rate over the last few years in Senegal, as the growth rate for the working population of 15 to 64 years of age has increased 4% per annum since 1988, which is approximately 1.6 percentage points more than for the population as a whole. Due to migration flows, this rate is faster in towns (5.5%) than in rural areas (3%). The average unemployment rate has increased 4.5 points annually from 2000 to the present day. Over the last decade, informal enterprises were the main job providers, both in country areas and in towns, while formal employment has more or less stagnated. 18.8% of young people in the 15 to 29 year-olds age group are unemployed. In the rural environment, urban drift by young people and women of working age is certainly the most obvious sign of the lack of productive jobs.

Employment characteristics vary enormously depending on the residential environment (whether it is rural or urban). The rural employment market appears to be relatively homogeneous. The population employed in the rural environment constitutes approximately 41.5% of people of working age in the country, 23.9% of whom are women. Within this zone, laborers work for a longer period than in towns, particularly young people. Employment is focused on the primary sector, in small farms. Approximately 80% of workers have their primary occupation in agriculture, livestock rearing or forestry. Employment conditions are extremely precarious. While the activities rates are, on average, higher in country areas – the rate is 35.8% in towns – the majority of laborers are seasonal and only 25% of them have permanent full-time work. The qualification levels of these laborers is very low as over 70% of people (over the age of 15) do not yet know how to read, and this includes practically 90% of women. The vulnerability of the workforce, which is partially unemployed and constitutes 4.7% of working people, is accentuated by the low levels of their qualifications.

Employment characteristics in the urban environment differ from those in the rural environment. Employment there no longer seems as homogeneous as there is a greater diversification of occupations. Unlike the rural sector, where the primary sector accounts for almost all of the jobs, the main occupations in the urban environment are in commerce, which accounts for approximately 34% of jobs, and this is where 60% of women are employed out of an employed female population of 22%. In decreasing order of importance, commerce is followed by the other market services, agriculture, livestock rearing, transport and communication and the construction and public works sector which, overall, account for approximately 60% of the jobs in the urban environment. The employment structure is more or less the same in Dakar and the other towns in Senegal, with the exception of the weight of the public administration, which accounts for approximately 8% of the total number of jobs in the capital, while it is negligible in Senegal's other towns.

In Senegal, the State remains the main source of financing for education and vocational training expenditures. For over 10 years now, the State has devoted nearly 40% of its budget to overcoming the lack of educational infrastructure by creating primary schools, middle schools and secondary schools providing general education and technical and vocational training at local level throughout national territory. Only financial accessibility poses a problem for certain levels of the population, particularly rural ones, due to the high cost of education and training borne by parents (enrolment costs, and purchasing textbooks and stationery, among other things).

5.10.4.3 Employment and training (PAP - Priority Action Plan)

Like other local rural communities, the villages neighboring the borough of Taïba Ndiaye show the traits characteristic of a country economy that is highly dependent on agriculture in the broad sense of the term. They do not depart from the homogeneous nature of employment in rural areas, which is focused on the primary sector. 89.4% of the households surveyed are in paid employment. Agriculture remains the dominant activity for households affected by the project, with 54.5% of them working in this sector. Major shopkeepers constitute 21.20% of the households. 10.60% are craftsmen and have small businesses. 18.20% offer transport services. Within the project's zone, women have a greater presence in agriculture (5%), commerce (5%) and in cottage industries and small businesses (4.7%). Men have a greater presence in these sub-sectors and are also employed in the transport service. About 4 men out of 10 are in employment and only slightly more than 2 women out of 10 work, making for respective workforce participation rates of 40% and 20.21%. The overall employment participation rate (30.46%) of the villages near the project is very low compared to the level for the whole of the borough of Taïba Ndiaye (45.17%).

The producers in these locales mainly derive their incomes from producing cassava and mangoes. Arboriculture, the production of tubers (which have become perennial crops), and fruit and vegetable cultivation, have relegated growing peanuts and millet to being second-tier cropping activities.

Incomes are relatively low in these villages near the project's site. Over half, or approximately 60% of the households surveyed, have a monthly income (derived from their main employment activities) of less than 150,000 CFA francs. Only 10% of them manage to earn more than 150,000 CFA francs. Concerning secondary employment activities, 54.54% of the households earn less than 120,000 CFA francs and 14% earn more than 120,000 CFA francs. The reason for this situation is either the number of fields farmed and the varying proportions of the harvests sold, or the declared incomes being under-estimated by the people who were surveyed. In fact, 67.0% of the households use less than 3 fields for perennial crops and 77.30% of them use less than 2 fields for seasonal crops, the surface areas of which seldom exceed 3 ha. Concerning sales, 45.45% of households sell their production from perennial crops and 60% of them market their harvests from seasonal cash crops, generally at the farm gate, with prices exceeding 250 CFA francs per kilogram for mangoes in particular.

Concerning expenditures, 57.57% of the households use 60% of their income for food, which is characteristic of poor countries.

The school infrastructure available for households in the borough of Taïba Ndiaye are within a reasonable radius. Education is offered. Indeed, there are day-care structures for preschoolers, primary schools in the majority of the villages in the borough, local middle schools, and literacy schools. However the enrolment percentage is very low in this locale compared to the regional rate and even the national rate, which is over 75%. It barely exceeds 50%. Yet there is a potential demand. Indeed, in 92.42% of the households polled, there were 2 to 10 children of school age and, in 95.45% of the households, there were 2 to 10 children attending school.

Paradoxically, 30.3% of the households have children who have received no education; 12.1% have children who attend primary school; 9.1% of the households have children who are at secondary school; 1.5% have children who have reached university, and 47.0% of the households send their children to Koran schools.

By way of an explanation for this state of affairs, 92.4% of the households surveyed preferred to give no response; 3.0% of the households thought it was due to financial constraints, and

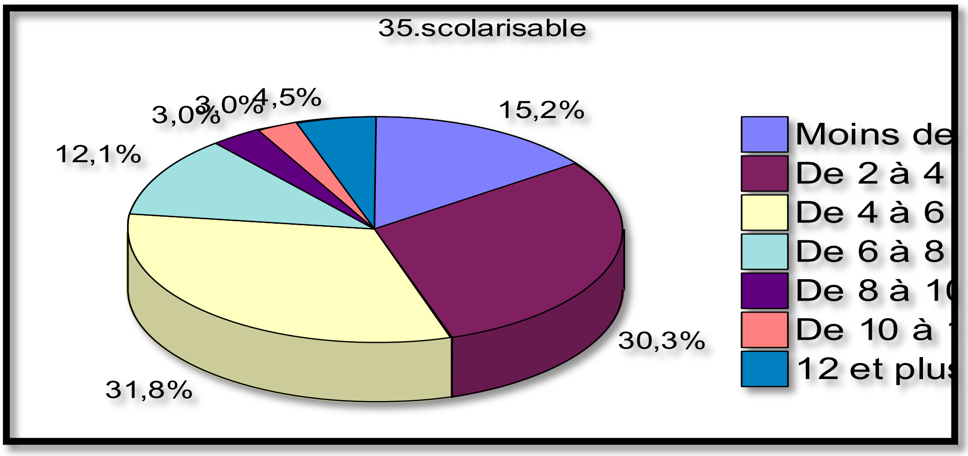
4.54% of them held that it was due to dropping out of school or because of having TV at home, or they preferred their children to attend courses for studying the Koran.

Figure 35: Breakdown of children of school age

35. Of school age
12.1% 3.0% 3.0% 4.5% 15.2%

31.8% 30.3%

Under the age of 2
2 to 4 years old
4 to 6 years old
6 to 8 years old
8 to 10 years old
10 to 12 years old
12 or more years old



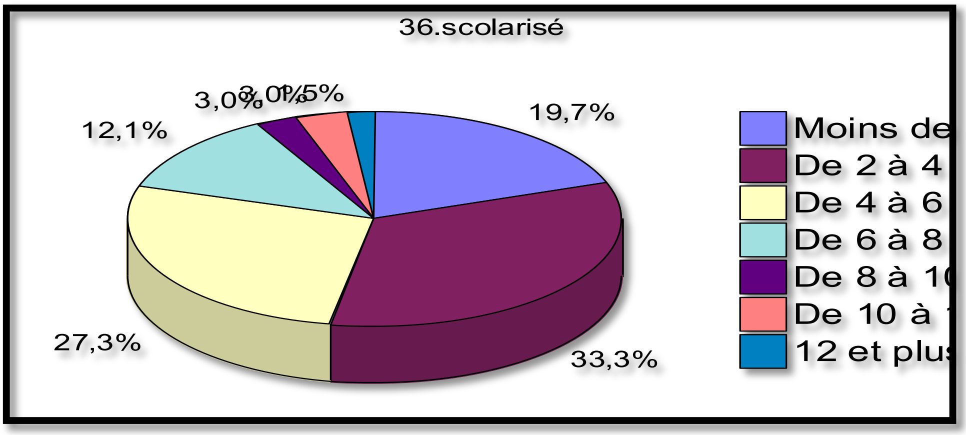
Source: *Household survey results,* ***December 2012***

Figure 36: Breakdown for children attending school

35. Attending school
12.1% 3.0% 3.0% 5% 19.7%

27.3% 33.3%

Under the age of 2
2 to 4 years old
4 to 6 years old
6 to 8 years old
8 to 10 years old
10 to 12 years old
12 or more years old



Source: *Household survey results,* ***December 2012***

5.10.4.4 Public health context

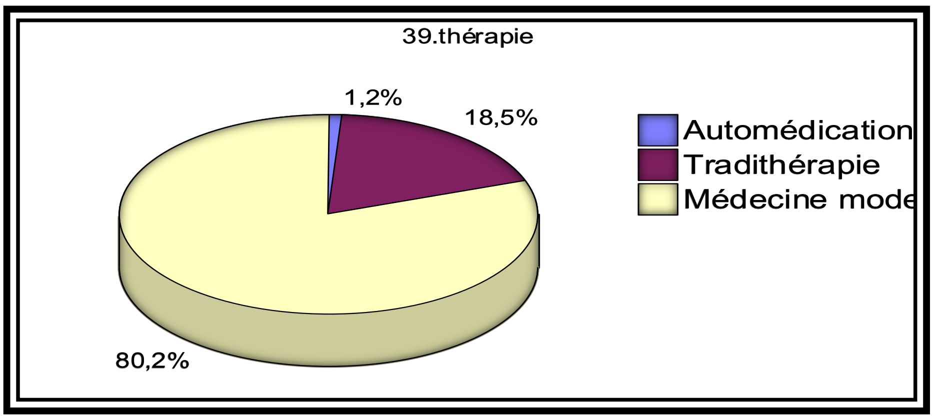
The borough of Taïba Ndiaye does not have enough public health structures of an acceptable level. Indeed, it only has health centres and health huts that are under-equipped and yet 80.2% of the households in this zone state that they regularly frequent public health structures; 18.5% do however prefer to consult traditional healers and only 1.2% practice self-medication. Approximately 41% of these households travel from 3 to over 7 km in order to gain access to a public health institution of an acceptable level, and 21.2% of them travel 1 to 3 km in order to receive medical care. Some even travel as far as 15 km away in order to reach a health centre that is of a higher level than a local health clinic or health hut.

Figure 37: Breakdown of the households' therapy choices

39. Therapy
1.2% 18.5%

80.2%

Self-medication
Traditional therapy
Modern medicine



Source: *Household survey results,* ***December 2012***

At this level, it should be specified that the 18.5% who resort to traditional therapy only take this treatment when modern medicine does not provide effective results. So it therefore constitutes an alternative solution.

Health expenditures are too low in this locale; those households that spend more than 120,000 CFA francs annually constitute over 41% of the households surveyed. This expenditure constitutes nearly 7% of the income of 60% of the households that earn less than 150,000 CFA francs per month.

Malaria, flu and nervous stress are the three main illnesses that most affect the populations of these villages adjoining the project's zone, followed by diabetes and gastric illnesses.

5.10.4.5 Infrastructure and services

The borough of Taïba Ndiaye is not isolated. It has a tarred road and red earth tracks for agricultural produce which are in good condition and link practically all of the villages under the local authority. In all seasons, the locale is serviced by intercity transport along the tarred road that passes from the north to the south in-between the two cities in the Department, namely from Tivaouane to Mboro.

All of Taïba Ndiaye's villages are covered by the network run by the three telcommunications operators established in Senegal.

The water network consists of boreholes and sheltered wells. Many villages are served by piped water networks, either run by the Senegal Water Company (SDE) or the firm ICS. The access rate to potable water supplies is nearly 70%, which is much lower than the figure set by the 2015 MDG (Millennium Development Goals), which is 82%.

The households in the villages neighboring the project have very easy access to potable water. The households that have one tap in the home constitute 87.9% of the sample; 12.1% of the households get their water from public taps, and only 3% of them draw water from wells. The cost of water is relatively low for 63.63% of the households, which pay 1,000 CFA francs to 6,000 F. CFA every two months. Only 15.2% spend more than 6,000 CFA francs per month.

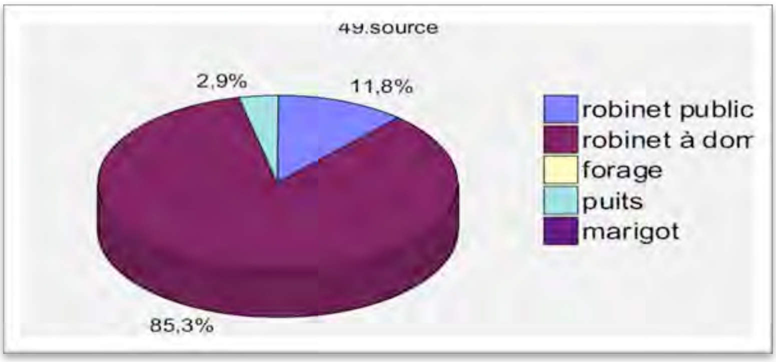
Figure 38: Breakdown of the potable water drinking supply sources

49. Source

2.9% 11.8%

85.3%

Public tap
Home tap
Borehole
Well
Stream



Source: *Household survey results,* ***December 2012***

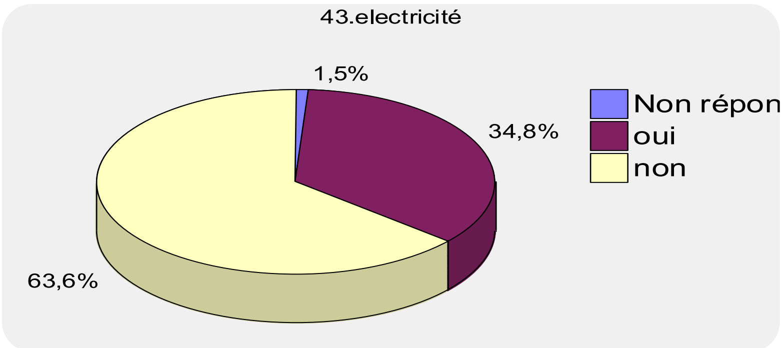
In spite of the proximity of the ICS's Taïba installations and the rural electrification program, many households in the borough do not have access to electricity, particularly those neighboring the project's zone. Indeed, 63.6% of the households surveyed use candles (25.8% of the households), oil lamps (6.1%), solar energy (4.5%) or torches (62.1%). Those households that have electricity only constitute 34.8% of the sample. For cooking purposes, firewood remains the most widely used energy source for 98.5% of the households. Those households that use charcoal or butane constitute 7.6% and 37.9% respectively.

Figure 39: Breakdown of the households that have electricity

43. Electricity
1.5% 34.8%

63.6%

No answer
Yes
No



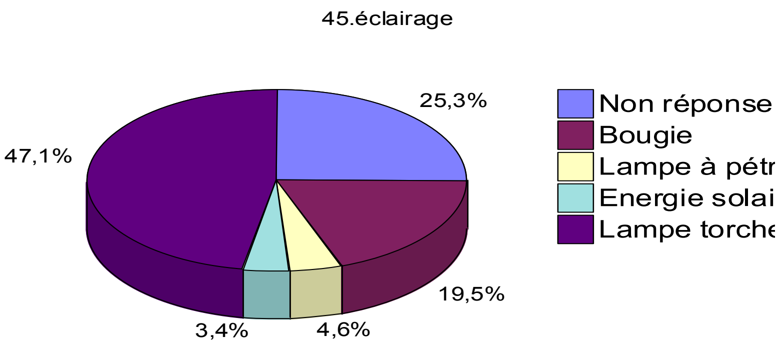
Source: *Household survey results,* ***December 2012***

Figure 40: Breakdown for household lighting methods

45. Lighting
47.1% 25.3%

3.4% 4.6% 19.5%

No answer
Candle
Oil lamp
Solar energy
Torch



Source: *Household survey results,* ***December 2012***

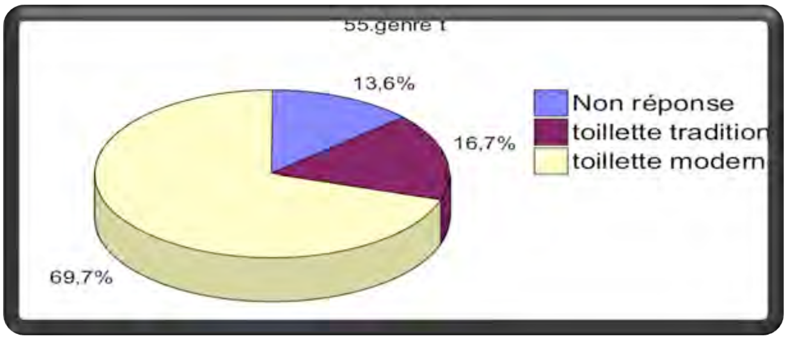
Of the households in the villages neighboring the project's site, 87.9% have latrines (69.7% of the households have modern latrines and 16.7% have traditional latrines). The villages have not set up an organized night soil collection system. Of the households polled, 81.8% stated that they dump their waste at illegal tips; 10.6% incinerate it; and 25.8% throw the waste out the back of their homes. It is estimated that 4.5% of the households bury their waste.

Figure 41: Breakdown for the types of toilets in households

55. (**mot illisibe**)
13.6%
16.7%

69.7%

No answer
Modern toilet
Traditional toilet



Source: *Household survey results,* ***December 2012***

Sewage in this zone poses a real public health issue. Most of the households in this zone either dump wastewater in the street (65.2%) or behind their homes (30.3%). There are no authorized waste collection companies in these locales.

5.10.4.6 Standard of living

The populations living in these various villages have diverging assessments of their living standards. Those who consider their living conditions to be average or low are the most numerous. They constitute at least 98% of the households polled.

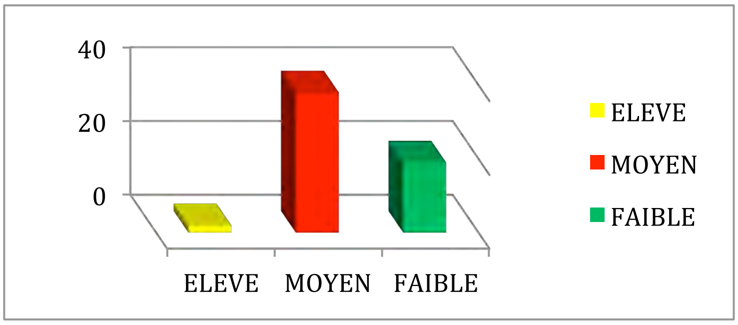
The results of the surveys perfectly demonstrated this. Given that some households use 60% their income on food, and 7% of their income to deal with their health needs (not forgetting education-related costs), there are not many remaining financial resources left over for any improvement whatsoever of their living standards.

Generally, in addition to access to productive resources like land, which has become an intractable issue in this zone, the level of training and access to basic social services are perceived by the local populations as being priority indicators of their well-being. The survey results showed that these populations encounter difficulties when it comes to sufficiently farming fields in order to improve their incomes, which verge on being inadequate. Nearly 60% of the households polled earn less than 150,000 CFA francs.

Figure 42: Households' assessment levels for their living conditions

HIGH
MEDIUM
LOW

HIGH MEDIUM LOW



Source: *Household survey results, December 2012*

5.11 NOISE ENVIRONMENT: NOISES AND VIBRATIONS

5.11.1 Methodology

Under the framework of this study, the approach adopted is based on two major stages:

- ✓ **Document-based research**
  <u>*Consultation of documents on the noise impacts of wind farms*</u>

The review of the documentation was structured based on two types of documents:

- ✓ Documentation on the noise impacts of wind farms which enabled firstly the types of noise sources related to wind turbine installations to be identified and secondly the potential impacts. It contributed to a better understanding of the phenomenon of noise generated by wind turbines.
- ✓ Documentation on regulations providing the framework for assessing and dealing with noise pollution linked to wind turbines. This stage is devoted to identifying all the requirements and other legal requirements applicable to the noise aspects of wind turbines.
- ✓ Drawing up equal-loudness contour charts.

5.11.2 General points

The measurements were carried out using a calibrated Voltcraft SL-451 sound meter in Slow mode, with the Min./Max. functions deactivated. Generally speaking, the measurements were carried out instantaneously with a view to monitoring the environment. For this reason, certain climatic factors including wind were considered at a relatively low speed reference level in order to avoid causing disturbances to the sound meter’s microphone as much as possible.

Due to the objectives assigned to the study, no listing was made of the equipment items. Consequently, the approach consists of defining the general ambient environment in terms of noise pollution at the time the study was carried out and of making projections based on the noise emergence levels of the wind turbines to be installed.

5.11.3 Noise measurements

The noise measurements were carried out on 5, 6 and 7 December 2012. The noise measurements carried out do in fact just relate to assessing noise pollution with a view to compiling a noise map. The approach consists of identifying the closest houses, or in other words, the ones that are most susceptible to, or are even exposed to, the impacts of noise pollution linked to operating a wind farm. What is also involved is determining the impact of the wind and the topography on exposure to noise. This approach makes it possible to draw up the initial acoustic state in order to determine the potential situation of the future installation. To sum up, the measuring campaign features three main stages:

- ✓ Identifying the closest houses, or in other words, the ones that are the most exposed and susceptible;
- ✓ Calculating the noise levels based on reducing the impacts as a function of doubling the distance.
- ✓ Analyzing the noise emergence, which makes it possible to compare the residual noise levels and the noise levels calculated to determine the installation’s noise emergence.

5.11.4 Mapping approach

Drawing up the noise maps in accordance with the reference terms was carried out in 4 stages:

- Stage 1. GPS readings;
- Stage 2: Data processing;
- Stage 3: Exporting and digitization of a background image;
- Stage 4. Actually drawing up the maps.

5.11.4.1 The GPS readings

The GPS readings were carried out at the same time as the noise measurements in order to indicate the precise locations where they were conducted. We were able to reference fifty or so waypoints, covering nearly all of the surface area of the power station. Tracks were also recorded via GPS in order to delineate the property boundaries.

5.11.4.2 Data processing

The data gathered were then processed using GPS processing software (Easy GPS). The waypoints and tracks were then converted into Kml format, Google Earth format, and Shapefile format, which is the format recognized by mapping software.

5.11.4.3 Exporting and digitization of a background image

The data processed were then displayed on Google Earth to check that they appear at the right locations on the Google image for the zone. Then the image was exported so it could be used as a map background so that the land-use details could be digitised (locations of the wind turbines, village housing boundaries, etc.). After this digitization stage, we drew up the noise maps.

5.11.4.4 Actually drawing up the maps

Drawing up noise maps is based on the noise measurements carried out. Firstly, we carried out an interpolation according to the Nearest Neighbor method. The result obtained is an image covering the whole of the study zone, upon which you can read a noise value at any point.

These values were then sorted using the **Manual** classification method. This method enabled us to define the intervals and to extract the four (4) noise levels matching the colour codes. Then, we did the layout for the various maps.

5.11.4.5 The equipment used and the human resources

The equipment used for making readings consisted of one (1) Garmin GPSMap 60 Cx with an accuracy of 3 m.

ArcGIS software was used for making the maps. It is modern software that is widely used in the field of cartography. It features all of the Cartographic and Geographic Information System (GIS) functions.

5.11.4.6 Cartographic tools execution

This entails making maps and illustrations in the form of buffers.

- ✓ A map of the footprints/space requirements
- ✓ A map showing the spatial distribution of the wind turbines at ground level
- ✓ A summary map illustrating the impact of the vegetation and relief on noise pollution;
- ✓ A general summary map for the whole of the wind farm.

Buffers were used in order to firm up the “safety distances” separating the most susceptible/exposed houses and the installation reference points for the wind turbines. There were two types of buffers:

- ✓ Initial acoustic state buffers
- ✓ Buffers illustrating the potential noise levels after the wind farms have started up their activities.

5.11.5 Difficulties

Constraints were noted in the waypoint readings even though they had no major impact on the results. To a great extent, they were to do with difficulties in gaining access to certain parts and also to do with disruptions in noise levels due to cultural events being held in certain villages.

5.11.6 Regulatory framework

Due to the nature of the future activities and the specific nature of the technology, various regulatory reference levels in terms of assessing and managing the noise risk were considered under the framework of this study. Analysis of the regulatory framework is based on:

- ✓ Identifying the national legal requirements applicable to the wind farm project;
- ✓ Identifying other international legal requirements applicable to noise pollution linked to wind turbines.
- ✓ Identifying other requirements in the form of good practices in terms of taking into account the effects of noise under the framework of wind farm projects.

5.11.6.1 The Senegalese regulatory framework

Analysis of the national regulatory framework specific to noise pollution linked to wind farms shows that there are next to no regulations in this field. Given that the work consists of carrying out an environmental and social impact study of the wind farm project, several levels may be considered depending on the various stages of the project.

✓ *Worksite installation and construction phases*

5.11.6.2 Workplace Health and Safety

This regulation is based on the Workplace Health and Safety aspects. The Senegalese regulations in terms of work station exposure, and particularly Decree **No. 2006-1252 of 15 November 2006** sets the minimum prevention requirements for certain physical environmental factors;

Article 14 (Chapter IV, Noise) of Decree **No. 2006-1252 of 15 November 2006 states that** "The daily noise exposure level experienced by a worker throughout his working day must not exceed eighty-five (85) A-weighted decibels (dB(A)).

If it is not technically possible to reduce the daily noise exposure level below 85 dB(A), the employer must make suitable individual protection equipment available to employees. The employer must also make sure that this equipment is actually used.

This limit of 85 dB(A), which is required for the use of individual protection equipment, may be lowered depending on the nature of work (intellectual or other sorts of work) "requiring concentration".

Article 13 states that "The noise exposure level must be as low as possible and remain within an intensity limit that does not run the risk of adversely affecting the health of workers, and particularly their hearing".

✓ *During the operational phase*

The regulatory references for property boundaries as defined by the Environmental Code will be taken into account. Thus, on property boundaries, for round-the-clock exposure (24 hours a day), the regulations, referring to the Environmental Code, Article R 84, Title IV, require that the maximum thresholds must not exceed 55 to 60 dB during the daytime and 40dB at night-time. The property boundaries concept refers to the closest houses or the houses that are most susceptible/exposed.

To sum up, it should be noted that the specific regulatory framework for noise pollution from wind farms is next to non-existent. For this reason, the French regulations concerning neighborhood noises, based on the concept of the noise emergence value, are also considered with the context of this project, but as a "good conduct" code rather than as a set rule.

5.11.6.3 The French regulatory framework

Due to the fact that there are next to no regulations on wind farms in Senegal, the French regulatory framework was used within the context of this study. Moreover, the French legislation concerning wind turbines is governed by the common system of "neighborhood noises" based on the concept of noise emergence levels.

Section 3 of the Public Health Code defines the minimum requirements for taking "neighborhood noise" into account. Article R1334-31 emphasises the need to ensure that the surrounding neighborhood is quiet for any type of project: "Due to its duration, repetition or its intensity, no particular noise should disturb the peace and quiet of the neighborhood or human health either in a public or private location, whether a person is himself the source of it or the noise is made via the intermediary of a person, a thing that he has in his keeping, or an animal that he is responsible for". Article R1334-32 introduces the concept of emergence noise by setting the following thresholds for characterising neighborhood noise. These emergence noise threshold limits are 5 dB(A) during the day, in other words from 7 am to 10 pm, and 3 dB(A) during the night (10 pm to 7 am); a corrective term of a psychological nature in decibels is added to these thresholds, depending on the total period over which a particular noise arises.

5.11.6.4 Effects on health

- ✓ Noise

Noise is likely to lead to disturbances for subjects regularly subject to high noise levels. Normally, two types of effects are distinguished:

- General effects: These manifest themselves in increased stress levels, nervous tension, and insomnia. A rise in blood pressure and a faster pulse rate have also been noted, as well as digestive disorders;
- The effects specifically on the hearing of the people subject to the noise. Temporary hearing loss (a warning sign) or permanent hearing loss (irreversible deafness) have been diagnosed.

These effects only occur when the "daily noise dose" over 8 hours (LEP'd - daily noise exposure level) is higher than 85 dB(A). It was demonstrated that the level of 65 dB(A) (at daytime) is often considered to be a threshold for discomfort and fatigue. But the discomfort felt will depend on the location you are in (you are more likely to tolerate a noisy environment in a public place than in a bedroom for example), the noise source, and the individuals involved.

For the wind turbines project at hand, the noise levels likely to be perceived by people living nearby are at low levels. They are 40 dB(A) depending on the intensity of the wind, a low value in relation to the value of 65 dB(A); which corresponds to a "calm" level and provides "the possibility of carrying out a conversation where you are speaking normally".

The Environment and Health Ministries called on Afsset (the French Agency for Social Security, the Environment and Labor) to conduct a critical analysis of the report by the National Academy of Medicine assessing the repercussions of operating wind turbines for human health: its conclusions were published in March 2008.

It seems that "the noise emissions from wind turbines are not sufficient to generate direct public health consequences as far as the effects on hearing are concerned". No available public health data has made it possible to observe any effects linked to exposure to low frequencies and infrasound generated by these machines. Inside homes, with the windows closed, you either do not note any disturbance or their consequences are unlikely given the noise levels perceived.

Concerning outdoor exposure, Afsset's conclusions are as follows: "these noises may, depending on the circumstances, cause discomfort, which is sometimes exacerbated by factors other than noise factors that have an influence on the acceptance of wind turbines (their aesthetic appearance, landscape development, etc.)".

- ✓ The case of infrasound

The effects resulting from a sound wave depend both on the power of the noise level (in dB(A)) and its frequency (in Hertz). It will be recalled that a frequency entails a certain number of oscillations per second.

The human ear can only perceive noise events within a frequency range and noise levels that are well-defined. For a young, healthy individual, this range is between 20 and 20,000 Hertz. Below 20 Hz is the infrasound range, which is not usually audible to humans; however, infrasounds may be perceptible under certain conditions.

Typical sources of infrasounds are wind noises, storms, large items of industrial machinery, urban traffic, aircraft, and numerous other items forming part of our daily lives. Wind turbines undoubtedly produce infrasound, as the emission sources are aerodynamic (the most important ones) and they are mechanical in nature.

Pursuant to a request from the APSA (Association for the Protection of Les Abers) made to the French Ministry of Health and Solidarity, the National Academy of Medicine studied whether there was a harmful effect by wind turbines on health, and particularly infrasound. In its report dated February 2006 entitled "The Repercussions of Operating Wind Turbines on Human Health", the Academy held that "the production of infrasounds by wind turbines is, in their immediate vicinity, well analyzed and very moderate, posing no danger to people. Above and beyond a few meters away from the machines, the infrasound produced by wind turbines quickly becomes inaudible and has no impact on human health."

- ✓ During maintenance

Maintenance activities also generate one-off noises. However, these are more of concern to the maintenance workers (see Appendix I: Hygiene and Safety Instructions) than to people living near the wind farm. Noise measurements were carried out by the Épinal & Greater Regional Association of Workplace Health (an unaccredited body according to the terms of Article 3 of the Order of 19 July 2006), in order to:

- Carry out an assessment of maintenance workers' exposure to the "noise" risk;
- Assess the harmfulness of noise for workers;

- Orient employers towards collective prevention measures and, failing that, individual ones in order to eliminate or reduce the “noise” risk.

The measurements were carried out on Thursday 8 October 2010, during maintenance of a wind turbine, using an exposimeter placed on a worker’s body. The measurements made it possible to determine the daily noise exposure level (what is involved is the weighted average during the noise exposure time over a nominal working day lasting eight hours) (LEX,d) the peak acoustic pressure level, which is the level of the maximum value of the instantaneous acoustic pressure, measured with the C frequency weighting C. (Lpc).

In accordance with Article R4431-2 of the Labor Code, the exposure limit values for these two variables are as follows:

- 87 dB(A) for the daily noise exposure level;
- 140 dB(C) for the peak acoustic pressure.

The daily noise exposure level measured during maintenance was 86.6 dB(A), with a peak acoustic pressure of 131.4 dB(C).

By way of a conclusion, the noise exposure level linked to maintenance is lower than the acoustic power of the Vestas V112/117/126 – 3.3 MW wind turbines when they are running, and consequently this activity will not cause any noise pollution for people living nearby.

5.11.7 Noise pollution assessment

5.11.7.1 Gathering noise data: reporting and database

Before tackling the aspects involved in gathering, analyzing and interpreting data, under the framework of a project like this, it is important to establish a typology of wind turbine noise sources. Indeed, the documentation review makes it possible to distinguish two noise sources.

- ✓ **Noises of mechanical origin,** entailing marked noises downwind from the wind turbine but which are practically inaudible upwind at distances exceeding 200 meters;
- ✓ **Noises of aerodynamic origin,** which primarily relate to the swishing of the blades as they spin in front of the tower.

Moreover, it should be noted that these two types get mixed up the further you get away from the wind turbine. In light of the average distance to the houses, which is greater than 1,000 meters (with one exception: the western zone of Maka, which is about 975 m to the north – and is therefore not downwind – of wind turbine E39), we will not make any distinction between the two types of sources under the framework of this study. The analysis will focus on characterising noise due to operating a wind farm.

For the purpose of gathering the noise data itself, several types of reading points were identified. What is involved are:

1. Property boundaries at the Tobène station;
2. Reference points at the ends of each row of wind turbines;
3. Points 100m away from each reference point;
4. Points at the houses that are most exposed or susceptible;

Table 33: Noise data at the property boundaries of the Tobène station

Zones/Reference points	GPS co-ordinates		Noise levels in dB(A)
	X	Y	
Property boundaries at the Tobène power station	291103	1664552	48.8
	299623	1659761	54.4
	299625	1659712	
	299630	1659668	
	299633	1659634	
	299633	1659611	52.2
	299352	1659585	50.3

Table 34: Noise data at the reference points (mild wind)

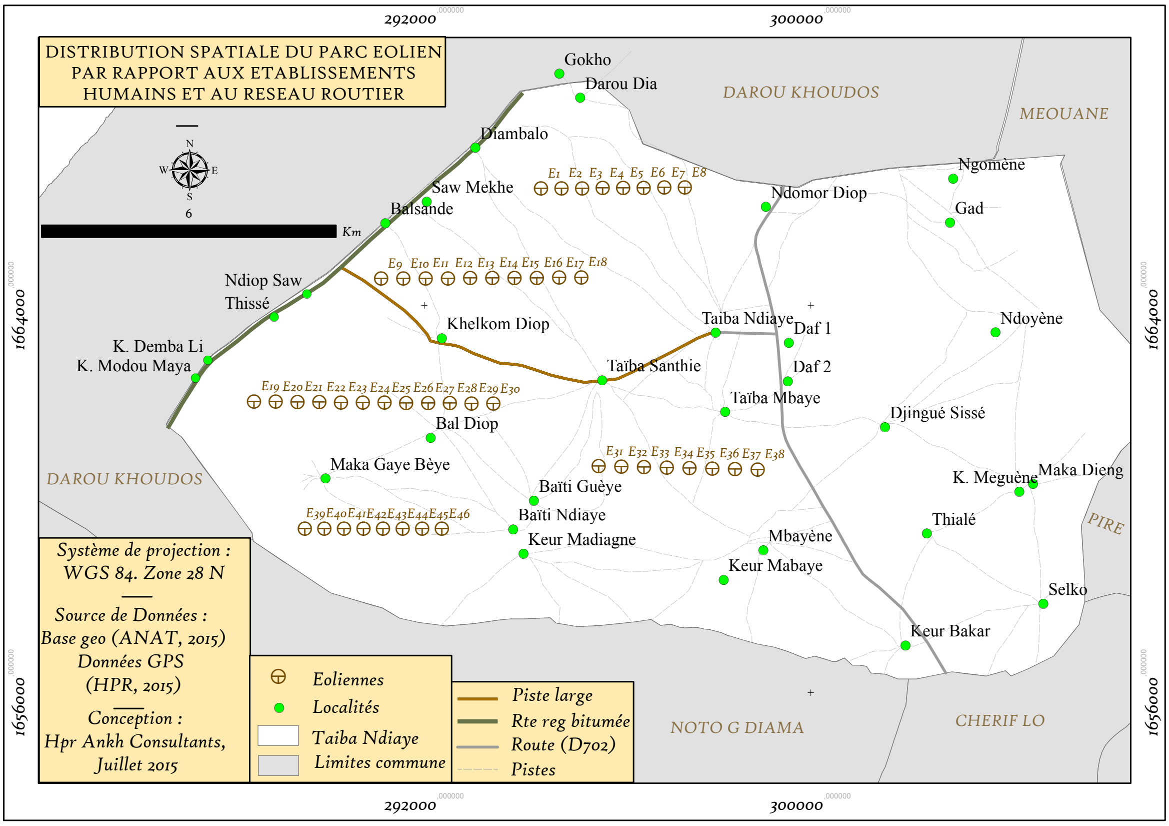
Zones/Reference points	Day co-ordinates		Noise levels in dB(A) - daytime	Night co-ordinates		Night-time noise levels in dB(A)
	X	Y		X	Y	
E 38	298895	1660615	48.4			
100m E 38	298896	1660583	38.8			
Minam (the closest/most exposed/most susceptible houses E38)	299032	1659486	36.6	299032	1659486	37.8
E 31	295134	1660691	46.4			
100 m E 31	300477	1666364	52.1			
Baïty Gueye[5](the closest/most exposed/most susceptible houses E31)	294362	1660022	45.5			
E 39	289523	1659390	42.1			
100 m E 39	282391	1659384	42.5			
Baïty Ndiaye[6] (the closest/most exposed/most susceptible houses E39)	293678	1659550	46.8			
Maka Gaye Bèye (the closest/most exposed/most susceptible houses E43)	289937	1660431	42.5	289937	1660431	39.2
E 30	293875	1661969	41.6			
100 m E 30	293893	1661993	41.9			
Taïba Santhie (the	295504	1662215				

[5] No night-time measurements could be taken due to religious events.
[6] No night-time measurements could be taken due to religious events.

closest/most exposed/most susceptible houses E33)			40.7	295504	1662215	39.0
E 19	289373	1662008	42.1			
100 m E19	289410	1661983	41.9			
Xelcom Diop (the closest/most exposed/most susceptible houses E23)	292206	1663228	41.7	292206	1663228	39.2
E 18	296166	1664586	40.3			
100 m E 18	296141	1664573	42.3			
Taïba Ndiaye (the closest/most exposed/most susceptible houses E22)	297985	1664166	40.7	297985	1664166	39.0
Diambalo (the closest/most exposed/most susceptible houses E01)	293196	1667168	41.5	292922	1667231	39.2
E 01	2935559	1666412	41.5			
100 m E 01	293853	1666300	41.7			
Balsande (the closest/most exposed/most susceptible houses E11)	291009	1665528	41.9	291005	1665541	39.2
E 09	296166	1664586	41.8			
100 m E 09	297985	1664166	41.4			
Ndomor (the closest/most exposed/most susceptible houses E08)	299161	1666473	39.0	299161	1666473	38.4
Taïba Mbaye[7]	298302	1661495	39.8			

Map 8: Presentation of the polarised zone

[7] No night-time measurements could be taken due to religious events.



5.11.8 Supports

Summary of the French regulatory requirements

1. The measurements are carried out in terms of the weighted equivalent continuous acoustic pressure;
2. The neighborhood noise regulation is based on the concept of the emergence noise value. According to this regulation on neighborhood noises, there is no violation when:

   - ✓ The ambient noise providing a backdrop to the particular noise incriminated is less than 30 dB(A) on the premises of the neighbour in question;
   - ✓ For an ambient noise greater than 30 dB(A) on the premises of the neighbour, the emergence of the incriminated noise is less than 5dB(A) at daytime (7 am - 10 pm) and 3dB(A) at night-time (10 pm - 7 am).

This second condition will be considered, given that the ambient noise is greater than 30 dB(A) in the initial state before the project. This means that the potential noise levels will be calculated in order to determine the emergence noises and thereby assess the level of regulatory compliance.

The Senegalese property boundary regulation specified in the Environmental Code considers 55 to 60 dB(A) at daytime and 40 dB(A) at night-time.

For these regulatory references, the following example provides an illustration in terms of orders of magnitude, enabling positioning of the noise levels likely to be perceived by the houses most exposed and even those that are most susceptible.

Table 35: Orders of magnitude of the noise levels likely to be perceived by neighbours

Wind turbine's electric power	dB(A) reference acoustic power	Potential noise level at 100 m dB(A)	Potential noise level at 500 m dB(A)	Potential noise level at 1,000 m dB(A)
1MW	105	55	40	32
		The equivalent of a normal spoken conversation	A living room where the people are reading	A bedroom where people are resting

Source: Guide for the wind farms environmental impact study

5.11.9 Interpretation of the results

5.11.9.1 Initial acoustic state

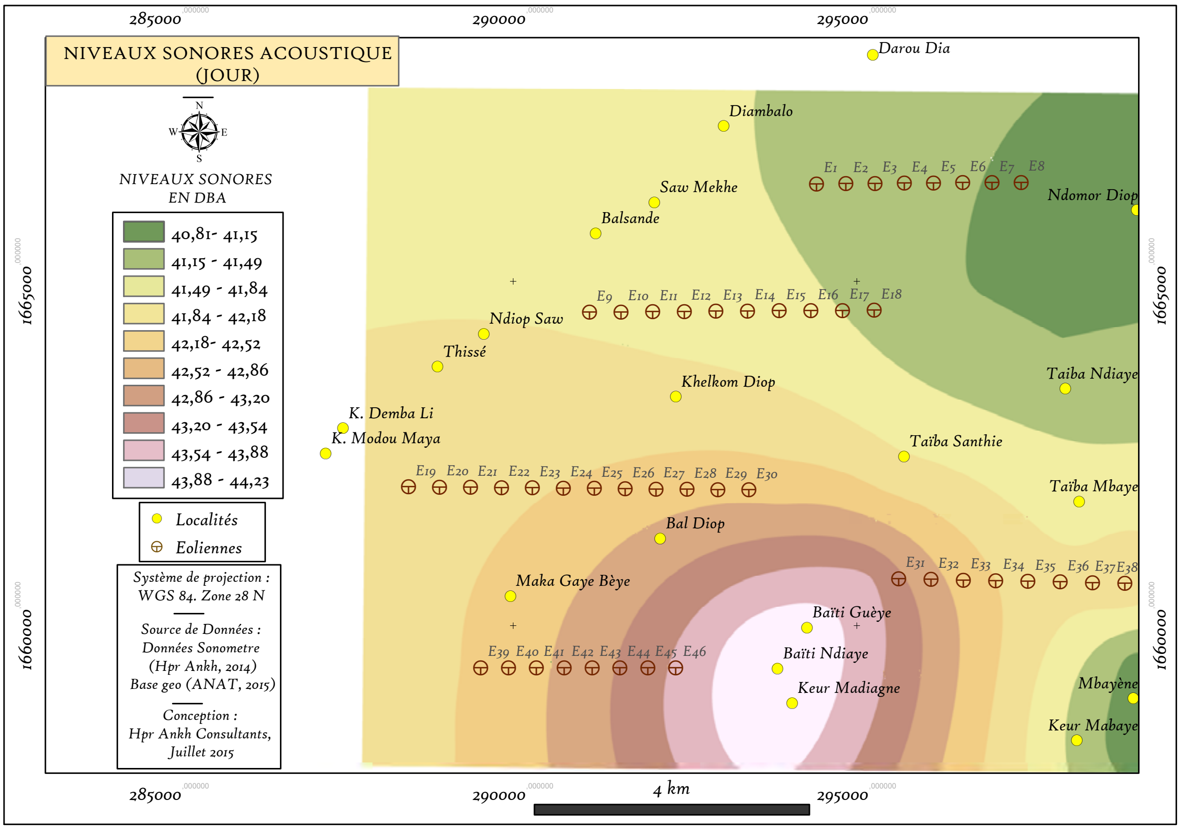
Establishing the initial acoustic state is based on identifying the points that are most susceptible or even exposed. It enables a reference situation to be drawn up for these various reference points.

Table 36: Level of regulatory constraint for each exposed point

Reference points	Villages concerned	Daytime noise level	Night-time noise level
E38	Minam	36.6	37.8
E31	Baïty Gueye	45.5	39.0
E39	Maka Gaye Bèye	42.5	39.6
E46	Baity Ndiaye	46.8	39.0
E31	Taïba Santhie	40.7	39.0
E27	Xelcom Diop	41.7	39.5
E18	Taïba Ndiaye	40.7	39.0
E01	Diambalo	41.9	39.2
E08	Ndomor Diop	39.0	38.4
E09	Balsande	41.9	39.2

Analysis of the initial acoustic state shows that the zone polarised by the wind farm project is not noisy because the values recorded match the profile for a "living room where the people are reading" in term of the orders of magnitude during both the daytime and night-time. Thus, for regulatory compliance of the wind farm project, the noise emergence level must not exceed 5 dB(A) during the daytime and 3 dB(A) at night-time. As the night-time constraint is tighter, the study will be devoted to that.

Map 9: Breakdown of the noise levels for the initial acoustic state



CAPTION => specify the (dB(A)) unit in the Table and round it to 0.1 dB(A).

5.11.10 Determining the potential noise level

Assessment of the potential noise levels is based on two stages:

1. Assessment of the safety distances: this consists of determining the distance separating each reference point with a reference wind turbine point.
2. Calculating the potential noise levels is done based on technical specifications concerning noise pollution laid down by the manufacturer. The approach consists of considering the technical specification concerning noise and applying the reduction according to the distance away. These data, combined with the safety distances, make it possible to assess regulatory compliance.

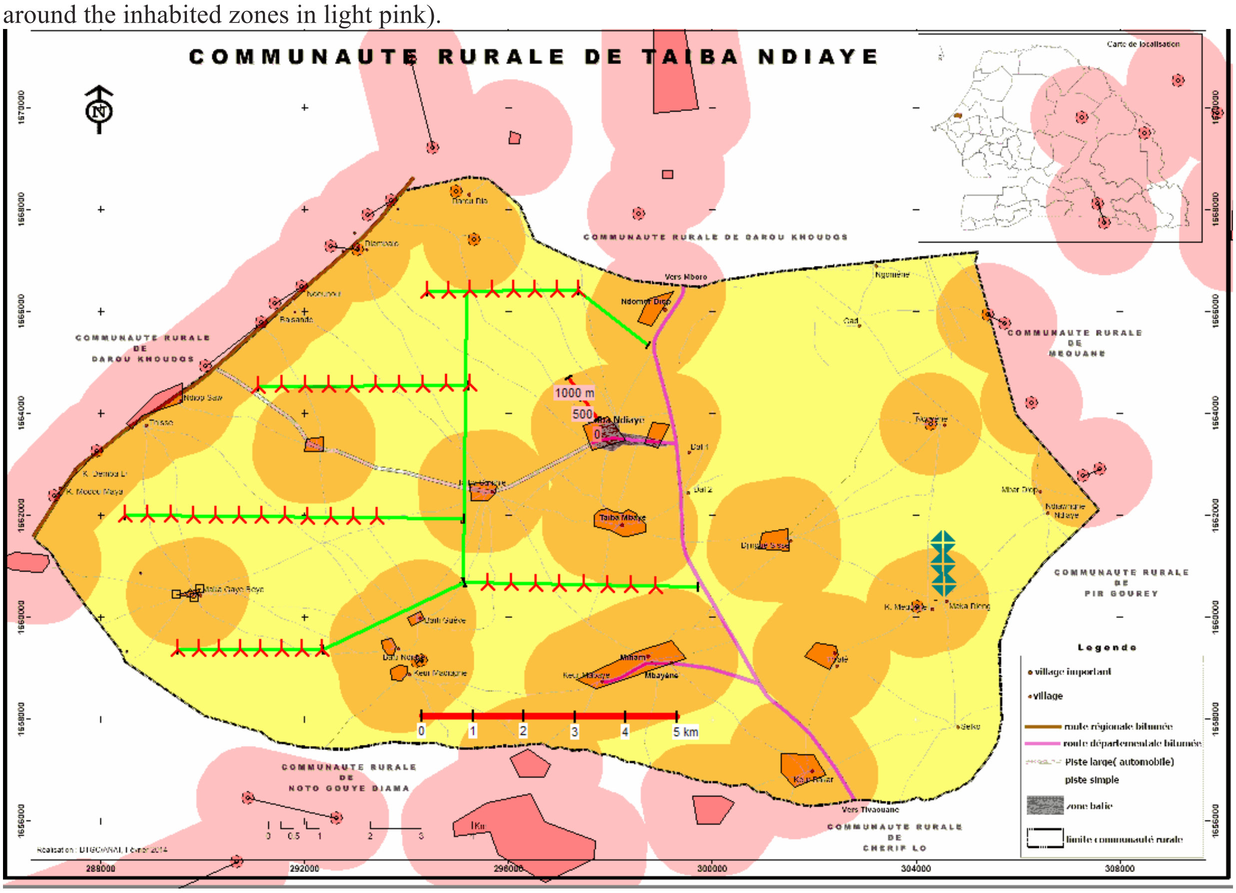
5.11.11 Assessment of the setback distances

Table 37: Level of regulatory constraint for safety distances

Reference points	Sensitive points	Distance in m	
E1	Diambalo	1,410	

E10	Ndomor Diop	1,475	
E11	Balsande	1,280	
E11 (E13)	Khelcom Diop	1,343	
E23 (E29)	Khelcom Diop	1,250	
22	Taïba Ndiaye	1,866	
E23 (E24)	Maka Gueye Bèye	1,576	
E43 (E44)	Maka Gueye Bèye	1,041	
E33 (E34)	Taïba Santhie	1,568	
E35	Taïba Santhie	1,538	
E34	Baity Gueye	1,020	
E42	Minam	1,137	
E50	Baity Ndiaye	1,327	

Map 10: Location of the wind turbines in relation to inhabited zones (a setback boundary of 1,000 m was drawn around the inhabited zones in light pink).



However, the effects of noise pollution can be reduced via the following technical aspects of the project:

- ✓ The distance between two wind turbines is approximately 450 m.

- ✓ The technical characteristics of the wind turbines[8];
- ✓ The local climatic factors, particularly the wind speeds, with the average wind speed being around 5.6 m/s at ground level, and particularly the technical characteristics intrinsic to the type of wind turbines to be installed under the framework of the project;
- ✓ The method used for occupying the relatively spread-out space.

All of these considerations may bring the neighborhood noise levels down within the regulatory ranges.

5.11.12 Potential noise pollution assessment

Assessment of the noise pollution in operational situations is carried out based on technical specifications concerning the operational characteristics and the data concerning sound emissions. The following data enable this noise pollution to be assessed.

5.11.12.1 Operational characteristics

- ✓ Rated power: 3,300 kW
- ✓ Minimum wind speed: 3 m/s
- ✓ Nominal wind speed: 13 m/s
- ✓ Shut-off wind speed: 22.5 m/s
- ✓ Restart speed: 20 m/s

Under the framework of this assessment, the average wind speed is considered to be approximately 5.6 m/s, which is rounded to 6 m/s.

Table 38: Average monthly wind speeds at the site in 2008 at an altitude of 50 meters

Month	February	March	April	May	June	Average
Average speed (m/s)	6.4	6.0	6.7	6.1	3.0	5.64

Source: National Meteorology Division

These wind data will be combined with the sound emissions of the project's wind turbines and the data concerning the orders of magnitude for noise levels likely to be perceived by the neighbours.[9]

5.11.12.2 Acoustic emissions according to Vestas (V126 HH117 m, Noise Mode 0)

- ✓ 3 m/s 94.7 dB(A)

[8] The technical characteristics will be adopted in the potential noise pollution assessment.

[9] Guide de l'étude d'impact sur l'environnement des wind farms, Ministère dudevelopment Durable et de l'Ecologie en France. cf. rappel sur les exigences réglementaires au point II.2.1

- ✓ 4 m/s 98.6 dB(A)
- ✓ 5 m/s 103.0 dB(A)
- ✓ 6 m/s 106.7 dB(A)
- ✓ 7 m/s 107.4 dB(A)
- ✓ 8 m/s 107.5 dB(A)

Under the framework of this assessment, the wind data at 6m/s approximately match an acoustic power of 107 dB(A).

Vestas V126 – 3.3 MW wind turbines have the following acoustic power levels:

Summary:

The wind speed considered: 6m/s

Reference acoustic power: 105 dBA

Potential noise level at 100m = 55 dBA; the equivalent of a conversation where people are speaking normally

Potential noise level at 500 m = 40 dBA; the equivalent of a living room where people are reading

Potential noise level at 1000 m = 32 dBA; Refers to a bedroom

Table 39: Noise level of the wind farm as a function of the safety distances

Reference points	Villages concerned	Minimum distance to the closest wind turbine in m	Daytime noise level measured (dB(A))	Night-time noise level measured (dB(A))
E1	Diambalo	1,410	41.5	39.2
E8	Ndomor Diop	1,475	39.0	38.4
E9	Balsande	1,280	41.9	39.2
E12	Khelcom Diop North	1,075	>41	39.0
E27	Khelcom Diop South	1,250	41.7	39.5
E18	Taïba Ndiaye	2,620	40.7	39.0
E22	Maka Gueye Bèye	1,160	>41	39.0
E39	Maka Gueye Bèye	975	42.5	39.6
E30	Taïba Santhie	2,030	40.7	39.0
E31	Taïba Santhie	1,530	40.7	39.0
E31	Baity Gueye	1,380	45.5	
E42	Minam	1,175	>40	37.8
E46	Baity Ndiaye	1,300	>40	39.0

The impact of the noise levels linked to the wind turbines at the points/houses that are most susceptible or exposed is insignificant. Even if you apply the principle of breaking down the equipment items' noise levels, the thresholds to be reached will be substantially lower than the limits relating to the French regulation on "neighborhood noise" or the property boundaries under the Senegalese Environmental Code. Also, still taking the noise levels breakdown phenomenon into consideration, you realise that the emergence noise levels are lower than 5 dB(A) in daytime and 3 dB(A) at night-time.

5.11.13 Recommendations

In terms of recommendations, two major actions must be implemented.

During the worksite installation and construction phases:

- ✓ Follow the regulations relating to dealing with work station noise risks;
- ✓ Inform worksite staff and raise their awareness about the hearing and other impacts of using certain worksite machinery within the context of such a project;
- ✓ Provide all workers with appropriate hearing protection.

During the operational phase:

- ✓ Check the noise environment around the wind farm.

5.11.14 Conclusion

Generally speaking, implementing the wind farm will have very little impact in terms of noise pollution on the houses that are most exposed and/or susceptible. By comparing the technical specifications of the wind turbines in terms of noise pollution to the advantages provided in improving the living standards of the local populations, we may consider such a project to be quite innovative in terms of the development of wind production technologies.

6 ASSESSMENT OF THE ENVIRONMENT'S SENSITIVITY

Converting raw environmental data into sensitivity levels is an essential stage in the procedure. Defining the various stakes involved (landscape, heritage sites, ecological and other such stakes) enables the sensitivity of the project's sites to be assessed. The environmental data, translated into sensitivity levels, can then be categorized into several levels:

- low sensitivity
- medium sensitivity
- high sensitivity,
- very high sensitivity.

Table 40: *Assessment of the sensitivity of the various components in the project's environment*

THEME	CHARACTERISTICS OF THE PROJECT'S ZONE	STAKES LEVEL	COMPATIBILITY WITH THE PROJECT
Geology	The overall context is linked to that of the Senegal-Mauritanian Basin.	P	A relatively flat area: the altitude levels range from 33 to 60 meters. The local geological context for establishment of Niayes (dune systems): a succession of basins and unconsolidated dunes. A Niayes context with high groundwater.
Pedologic resources	An interesting level of diversity in terms of pedologic resources is noted in the project's zone: Dior soil, Deck-Dior soil, Deck soil, and Dior-Dior soil.	N	The presence of Deck-Dior soil suitable for arboriculture and cash cropping The presence of Deck soils rich in organic materials suitable for market gardening.
Ground-water	The numerous hydrogeological formations are exploited via traditional wells and boreholes	N	Potable groundwater throughout the villages affected by the project and the environs. High groundwater (between a depth of 17 meters to 66 meters) is exploited via traditional wells: DWS, agriculture and livestock rearing. Groundwater held in Lutetian limestone is exploited via boreholes: DWS, agriculture and livestock rearing.
Surface water	There are no long-term water supply points at the project's site or in its surrounding environment.	N	No long-term water supply points on-site and/or in the zone of influence. There are numerous temporary pools which become depleted a few months after the last rains. The market garden basins are filled by surface water during the rainy season.
Natural risks	Flooding of basins or low-lying areas.	N	Flooding of basins or low-lying areas (proximity to the high groundwater). Shifting dunes subject to collapse.

THEME	CHARACTERISTICS OF THE PROJECT'S ZONE	STAKES LEVEL	COMPATIBILITY WITH THE PROJECT
	Crops are attacked. Collapsing sand dunes.		Crops are attacked by pests: worms, termites, ants, etc.
Sensitive zones	The only listed area in the project zone is the Pire Gourèye area (listed under Order No. 1857 of 5 May 1946) which brings together nineteen (19) villages.	**P**	No sensitive area has been noted in the immediate zone of influence of the project's sites. The only PF under the project's influence is that of Pire Gourèye. PF dominated by a palmyra grove. Existence of a bird migration corridor (between the PNOD (Djodj National Bird Park) and the islands of Sine Saloum).
Flora and vegetation	The species encountered at the site and in the surrounding environment have Sahel-Sudan phytogeographic affinities: falling within the 350 and 600 mm isohyets. The taxonomic spectrum (the site and the surrounding environment) indicates 128 species belonging to 99 genera, split into 41 families. The *Poaceae* (*Graminae*) family is the most diverse one, with 18 species, followed by the *Fabaceae-Faboidae* family which has 17 specific taxa. The *Indigofera* genus is the most diverse one, featuring 7 species.	**N**	Presence of three (3) endemic species (*Crotalariasphaerocarpa, Polycarpaea linearifolia* and *Vernoniabambilorensis*) of Senegalese flora. The presence of three (3) threatened species *(Borassus aethiopum, Adansonia digitata, Faidherbia albida)* or species that may pose a threat to other Senegalese species. The presence of eight (8) species *(Adansonia digitata*, *Borassus aethiopum*, *Elaeis guineensis*, *Faidherbia albida*, *Grewia bicolor*, *Prosopis africana*, *Tamarindus indica* and *Ziziphus mauritiana)* that are partially protected by the Senegalese Forestry Code. The presence of types of trees that have multiple uses *(Adansonia digitata*, *Borassus aethiopum*, *Elaeis guineensis*, *Faidherbia albida*, *Grewia bicolor*, *Prosopis africana*, *Tamarindus indica* and *Ziziphus mauritiana, etc.)* some of which are protected by the Forestry Code and are listed as protected Senegalese flora. The presence of a type of tree of proven value to the eco-system.
Fauna	The fauna encountered at the project's site and in the surrounding environment mainly consists of birds or avifauna. The inventory mentions the presence of	**N**	The presence of numerous birds from four species fully protected by the Hunting Code. The presence of three species of mammals

THEME	CHARACTERISTICS OF THE PROJECT'S ZONE	STAKES LEVEL	COMPATIBILITY WITH THE PROJECT
	25 families split into 39 genera and 39 species. The dominant families are: *Columbidae* (12.82%), *Accipritidae* and *Ploceidae* (7.69 % each). The *Apodidae*, *Coracidae* and *Psittacidae* families each account for 5.13%. The rest of the families inventoried each account for 2.56 %.		listed in Appendix I of the 2011 version of the CITES Convention *(Mungos mungo, Ichneumia albicauda* and *Canis aureus).* The presence of five birds featured in Appendix II [(1)] (*Milvus migrans, Tockus erythrorhynchus, Tockus nasutus, Bubulcus ibis* and *Poicephalus senegalus*).
Population	The estimated population of the Rural Community is 24,114 inhabitants; the breakdown for the population of the RC of Taïba Ndiaye is 47.97% males and 52.02% females, with 60% of the population being young people from 0 to 19 years of age. Of the 39 villages comprising the RC of Taïba Ndiaye, 10 villages are affected by the project. The closest housing sites are 1.2 and 1.5 km from the project's sites.	**P**	There are ten (10) villages, the closest of which are 1.2 km to 1.5 km away.
Socio-economic activities	The greatest cash crop continues to be manioc (cassava), which covers nearly 65% of the surface areas, while millet (20% of the cultivated surface areas) and black-eyed peas (5% of the cultivated surface areas) are food crops, followed by market gardening and other seasonal and perennial crops, particularly mangoes. Grazing activities are dominated by semi-intensive grazing. Picking activities have been developed with the exploitation and sale of forest products.	**N**	Strong presence of agricultural activities: arboriculture, market gardening, rainfall agriculture, etc. Low presence of grazing activities: extensive livestock rearing. The presence of species of plants that have multiple uses and are exploited by the local populations.
Infrastructures	The only infrastructures at the site and in its immediate surrounding environment consist of the investments made by concessionaries (Senelec (Senegal's national electricity company), SDE (the national water company), and Sonatel (the national telco) and a few personal investments in agricultural lands.	**P**	The presence of overhead and underground lines belonging to Senelec.
		N	The presence of numerous concessionaries: Senelec, Sonatel and SDE: overhead and/or underground networks. The presence of boundary hedges established by the operators.

THEME	CHARACTERISTICS OF THE PROJECT'S ZONE	STAKES LEVEL	COMPATIBILITY WITH THE PROJECT
			The presence of traditional wells (known as "céanes") in market garden basins, set up by farmers.
Transport	The main ways of getting around are sandy rural tracks: main ones and secondary ones.	**N**	The presence of numerous production tracks: main tracks and secondary tracks.
Climatolog y	The project's zone is located in the Sahel-Sahara climatic area, falling within the 350 and 600 mm isohyets.	**P**	Maximum low wind speed: 2.8 m/s from September to October. Maximum speeds from march (4.1 m/s) to May (4.06 m/s)

Key:
P: Positive
N: Negative

High

Medium

Low

7 VARIANTS ANALYSIS

Adopting a classic operational and design approach, the execution of this project at a pre-selected site calls on standard techniques both in terms of equipment and how it functions.

To achieve this, the study's immediate focus was on developing a single variant adopted beforehand.

This variant will be dealt with in greater detail in the following sections.

8 PUBLIC CONSULTATION AND PARTICIPATION

Public consultation is aimed at ascertaining the points of view and opinions of the neighboring communities, particularly those that will be affected by the project. It enables any conflicts with the public to be avoided, helps identify innovative solutions, and helps increase the public's trust in the developer.

Likewise, consultation of the stakeholders enables better acceptance of the project, improving the benefits, and reducing its negative consequences.

8.1 THE METHODOLOGICAL APPROACH

8.1.1 The principle of the consultation and of its objective

Consulting the public plays a part in Environmental and Social Impact Studies aimed at involving the public in the decision-making process by involving institutional stakeholders like technical departments and local elected officials as well as members of the general public and key stakeholders in ground-level communities, whether individuals or groups.

The objective targeted is to integrate their perspectives before the event, along with their concerns and recommendations as a part of decision-making and in the procedures for implementing a project.

It seeks to create a dynamic involving the exchange of views in order to make the project viable in the long-tern by being inclusive of the knowledge and experiences of various categories of social stakeholders. On the one hand, it makes it possible to ensure a project's viability, and on the other hand it ensures its social acceptability.

8.1.2 The methodology and implementation of the consultation

As a part of this dynamic, the methodological approach adopted in this study concerning the establishment of a wind park in the Rural Community of Taïba Ndiaye by the company Sarreole is qualitative. Indeed, the qualitative approach is better adapted to enabling an understanding of the dynamics of the sentiments and statements made by the stakeholders regarding the project.

With a view to this, the technique used is an interview-based survey which, through the exchanges that it establishes, enables in-depth, detailed exploration of the questions asked. These interviews were conducted based on a ***semi-directive interview guide***. Indeed, this tool, which uses themes and questions, identifies the guiding thread for the discussion between the researcher and the stakeholders and provides an intermediary for exchanges.

8.1.3 The stages involved in the consultation:

While carrying out this mission from 22 to 28 December 2012, between Dakar and Thiès, the following stakeholders were consulted:

- The National Technical Directorates, namely:

    - The Directorate of the Environment and Listed Establishments;
    - The Civil Defence Directorate;
- The technical services of the Thiès Region, namely:
    - The Regional Division of the Environment and Listed Establishments;
    - The Regional Directorate for Rural Development;
    - The Regional Water and Forests Inspectorate;
    - The Regional Development Agency;
    - The Regional Development Directorate;
- The Sub-Prefect of Ouadiour;
- The Borough of Taïba Ndiaye;
- The populations of the villages of Diambalo, Balsande, Taïba Ndiaye, Taïba Mbaye, Baïty Ndiaye, Baïty Guèye, Minam Diop, Mbayène, Khelkom Diop, Taïba Santhie, Maka Gaye Bèye and Ndomor Diop.
- Two people claiming ownership of land at the site where the unit will be established.

8.2 NATIONAL TECHNICAL SERVICES

8.2.1 Perception of the project

The national services consulted did not raise any limitations that might prevent completion of the wind farm. This is due to the fact that the environmental impact study had been carried out and all the major aspects had already been identified and handled. For the DEEC "Along with the length of the supports and the blades, there have been changes in the positioning of the wind turbines so that the local populations will experience impacts different from what was initially measured". On the other hand, the distance of the wind turbines from the houses does not exempt the developer from implementing measures for managing the possible impacts. Indeed, as the socio-economic situation shows, the majority of the population living in the borough of Taïba Ndiaye work in the agricultural sector, which implies regular foot traffic in the fields where the rows of wind turbines are located. However, there is much more to it than that. Following on in this line of thinking, it is absolutely essential to boost vigilance and strengthen safety by stressing prevention measures. This measure will be implemented just as much for construction as for operational purposes. This is why the Civil Defence Directorate deems it necessary to "… also offer a reminder that the local populations do not necessarily have any knowledge of this type of installation: hence the need for caution both whilst carrying out the work and during the operational stage." Likewise "The depth at which the cables will be buried is good (1.80-2.00 m) because that way there can be no possible direct contact with members of the public, in addition to which there is no fire risk or risk of starting a bush fire along the line". But this does not mean that the buried cables should be neglected given that they may be adversely affected by stormwater run-off.

Along other lines, they mentioned the minor risks entailed and the advantages of such a project. Indeed, operating this type of installation does not generate atmospheric pollution, although there is noise as a result of the blades spinning. Each time the blades go past the tower, they make a "whooshing" noise. Significant impacts are expected during the execution of the works. The DEEC offers the following reminder: "Concerning the impacts of the execution of the works on the environment, everything will depend on the period, depending on whether it is in the rainy season or in the dry season." As mentioned above, the reason for this is agricultural activities (perennial crops, seasonal crops) which bring people out to the fields. Consequently, various sorts of obstructions along the usual corridor should be expected. These may cause disruptions to the local seasonal calendar and adversely affect production. Payment and the effect of expenses[10] will then depend on the period involved in the installation activities: hence the impacts of a socio-economic nature.

To the contrary, positive social stakes are expected through the jobs that will be generated by the project. It was recognized that: "It is an important project that may help public institutions in the locale, such as the community hotel, schools, health structures, cultural centres, etc. to have free electricity."

8.2.2 Expectations of the national services consulted and their recommendations

– ***Safety-related aspects of the installation works***

- Reinforcing protection of the buried cables in order to avoid them rapidly becoming worn out from rainwater;
- Placing indicator plates so that people using the tracks are informed that there are underground cables there, as is done for pipelines;
- Installing lightning rods in order to prevent lighting strikes, even if this is not easy to ascertain;
- Marking out work zones with fluorescent strips while the installations are being installed;
- Making personal protective equipment available to each employee.

- ***Following legal procedures***

- Following regulatory procedures;
- Sending the Environmental Directorate the new terms of reference for validation, which will not be complicated provided that the key work has been done;
- Taking account of the fact that there must be different management measures in place for each technical change.

- ***Support measures for the construction and operational phases***

- Adapting the nature of the installation activities to the season as, after all, the payment of expenses stemming from them will depend on it;
- Committing to a good awareness-raising and communication strategy because the local populations are not familiar with these installations.

- ***Social measures***

- Employing local labor;
- Supplying free electricity to local public structures.

[10] An "effect" understood to be a loss of assets caused by the project. These assets may be high-value and depend on their profitability.

8.3 STAKEHOLDERS AT GROUND LEVEL

8.3.1 The stakeholders' perception of the project:

The assessment that the stakeholders have of the project for the establishment of a wind farm in the Borough of Taïba Ndiaye is positive overall. Indeed, understanding of it follows on directly from the efforts to be made by public authorities and the private sector in order to reduce the electricity shortage, the economic and social consequences of which cannot be ignored by anyone. Certain points of view stated regarding this issue point towards an analysis highlighting the energy crisis context, which calls for a diversification of supply sources, as is apparent in the following statements:

- "*My opinions remain unchanged regarding the work carried out. Overall, I believe that this is a good project that will help solve problems within Senelec, which is experiencing some difficulties. We must assist Sarreole, which is a partner of the State, in taking up the challenge of providing a good electricity supply*." (The Sub-Prefect of Méouane)

- "*As an economic and social development actor, we are aware that only renewable energy sources can get Senegal out of certain difficulties, but it took us a long time to work this out... We do no have oil or gas, so if we are offered wind energy, that is excellent news, even though I would have preferred solar energy. This means that people have become aware of the fact that the future lies in renewable energy sources*." (Director of the Regional Development Agency).

- "*We think that it is an excellent project insofar as it involves making up for the energy shortage in Senegal. Establishment of the project in our borough is a point of pride for the local population*." (An inhabitant of Minam Diop)

Although this view is very widespread among the stakeholders, we do, however, note a certain degree of disappointment among certain residents in the locales concerned. This is due to the fact that the existence of this wind farm in their Borough does not guarantee them access to the electricity service. This point of view, stated by a number of stakeholders from villages in the project's zone of influence but which are not electrified, is sustained by the following view: *"Producing electricity in our borough and reselling it to other people without it serving us is abnormal..."*. In reality, electrification is felt to be a pressing need and some people think that this project should constitute an opportunity for fulfilling it.

Furthermore, the other factor which places a damper on this approval of the project without undermining its social acceptability is the fact that the project will have an impact on socio-economic activities, particularly food production and sources of income from growing fruit trees and gathering agro-forest products. Indeed, the total estimated space requirement for the wind turbines is 7 hectares, on top of which there is the length of the tracks, which is about 35 km, which, according to all of the stakeholders, constitute a loss of earnings for the people affected by the project and the surrounding area in general. The person who illustrated this position the best was the Regional Director of Rural Development when he stated: "*We are particularly worried about the land aspect with the increase in the surface area allocated to the project even though these spaces are occupied by fields and orchards... We are fearful of* *a decline in production... these populations generally earn around 2 million annually by harvesting whereas the compensation amounts only cover one year's harvest.*"

Moreover, the consequences of the presence of the wind turbines and the development of tracks on the configuration of the ecosystem in general constitute another source of concern for the stakeholders.

For all these reasons, they recommended a range of measures that may enable better management of the project in order to facilitate its integration into the environment:

8.3.2 The concerns about the project:

As was mentioned in the part devoted to acceptance of this project, even though it has a good level of social acceptability, it has, however, raised fears and concerns regarding balances in the natural and human environments. Indeed, the establishment of 46 wind turbines and nearly 35 km of red earth tracks is raising concerns. Generally speaking, as it turns out, these concerns are on several levels:

- Risks relating to the adverse effect on the natural environment, and particularly:

- Pollution with liquid wastes like dead oil, and particularly PCBs and grease;
- Noise and olfactory pollution through the sounds and unpleasant odours created by the wind turbines, which may have an impact on insects carrying out pollination;
- Atmospheric pollution from the dust kicked up from the red earth during the phase involving laying of the tracks and their use;
- Increased pollution due to the chemicals from the Taïba ICS site;
- The loss of plant cover due to fruit trees, scrub, and protected species like the Alida acacia being cut down;

- Risks linked to the disruption of socio-economic activities and living conditions, such as:

- A loss of agricultural production and income due to the colonisation of lands used for growing crops, with all this occurring within a context where there is great pressure on land in the Rural Community of Taïba Ndiaye, accentuated by the presence of ICS and MDL;
- Impoverishment of the local populations due to a poor compensation policy for the losses brought about by the project involving either insignificant compensation amounts or due to the volatile nature of money, which places local populations in vulnerable situations;
- The risk of single-crop farming becoming generally established with mango trees due to the gap in the method of compensation for fruit trees and bare land (land that is lying fallow or land where harvests have already been completed)
- A fall in the productivity in the areas around the paths due to the dust kicked up during construction or due to vehicle traffic;
- The generation of waste along the edges due to tailings being deposited in fields outside the area taken up by the wind turbines and the tracks;
- Obstruction of farmers' movements during the phase when the tracks are laid;

- An adverse effect on human health due to the hazards attributed to living alongside wind turbines;
- The risk of accidents due to falling towers, blades breaking off, or even becoming detached from their rotors;

8.3.3 The expectations and recommendations made by the stakeholders

The expectations and recommendations made by the stakeholders provide guidelines with a view to mitigating the impacts identified or compensating for them fairly and equitably. But they are also motivated by the desire to see the local populations really derive benefit from the presence of these infrastructures intended for harnessing wind energy. Consequently, according to the two categories of impacts feared, the suggestions are structured based on the following two main avenues:

- ***Orientations intended to reduce or provide compensation for the impacts on the natural environment:*** The measures recommended are mainly aimed at re-establishing plant cover. What will be involved is:

- Fulfilling the administrative formalities which regulate cutting down trees and particularly permits for protected species and paying taxes;
- Thinking about revegetating while delineating the land taken up by the wind turbines by using rows of replanted trees that do not excessively get in the way of their operations;
- Planting neem trees or gmelina trees on both sides of roads and tracks at regular 15 meter intervals in order to keep the environment intact: this belt of trees could protect the local population from dust.

Other aspects come into play in relation to this category of impacts and in particular relate to pollution risks due to dead oil and PCBs. With a view to this, the Head of the Regional Division of the Environment and Listed Establishments informed us that these aspects were discussed during validation of the first study and that adequate proposals were made with a view to getting these issues under control.

- ***Measures intended to mitigate the impacts on living conditions, limit the impacts on socio-economic activities, restore subsistence resources, and support the communities with a view to furthering their social progress:***

With a view to mitigating the impacts on the standard of living, it was recommended that:

- The negative and positive effects be compared and that the local populations should have their awareness raised about the impacts;
- The expansion of villages should be taken into account by allowing for a greater distance from man-made structures (1,500 m for example);
- Roads be developed along the routes of the tracks in order to limit the dust raised;

With a view to preventing people from being placed in vulnerable situations, it was suggested that:

- Discussions should be held with the people affected by the project in order to find common ground for satisfactory compensation;
- The scale be raised substantially;
- What should be envisioned is establishing market garden boundaries that are in particular equipped with water infrastructures and splitting up the land into different plots with a view to sharing it out among the various people affected by the project;
- Farmers should be helped to intensify production by boosting capacities in terms of cropping techniques and production resources (inputs);
- Production should be secured by setting up processing units;
- Sources of income should be diversified by promoting activities that generate income;
- Nurseries should be established, working in collaboration with the Water and Forests services and groups of women, in order to replace the trees cut down with a view to correcting this imbalance, particularly by planting fruit trees;

Here the main stake relates to the annexing of spaces enabling the local populations to ensure their subsistence and derive income. This issue was particularly well articulated by an elected official from the Rural Community of Taïba Ndiaye, who put it in these terms: "*We have worries about fair and equitable compensation of the local populations who annually earn 50,000 to 100,000 francs CFA per mango tree, whereas the compensation allocated generally only covers one year's harvest*".

Lastly, with a view to supporting the communities via social support measures enabling the positive impact of the presence of this project to be felt, the following orientations are set out:

- Help the local authority to reduce social demand;
- Recruit local labor while giving priority to the families of people adversely affected by the project;
- Strengthen the capacities of staakeholders regarding follow-up actions and particularly training in professions related to wind turbines;
- Think of training local craftsmen to carry out certain sub-contracting activities and thereby enable them to derive benefit from the project;
- Envisage electrification of the borough's villages that do not have access to this service;
- Assist villages by building schools, classrooms, health structures, water infrastructures, commercial infrastructures, and maintaining and refurbishing places of worship;
- Help people to cover the energy bill for boreholes;
- Help women to purchase millet mills;
- Support female entrepreneurial activities;
- Facilitate access to credit by supporting the microfinance Economic Interest Grouping.

8.4 COMMENTS AND CONCLUSION CONCERNING THE PUBLIC CONSULTATION

The opinion shared by the various stakeholders regarding the project for establishing a wind farm in the Borough of Taïba Ndiaye is that it will enable a substantial improvement of electricity production in Senegal, with a contribution of 153.75 MW annually being foreseen. Although certain inhabitants of the Rural Community were upset by the fact that their villages cannot benefit from this long-awaited service, there is an understanding of the project's objective, which is to contribute to reducing the electricity supply shortage which is severely hampering the nation's economic and social life.

In terms of impacts, the stakes linked to the implementation of the project have not changed regarding the issues raised. Firstly, what is involved is the allocation of economic resources to ground-level communities by annexing lands used for subsistence crops and as sources of income from growing cash crops and picking produce enabling the households to ensure their survival. With a view to this, the gap between the losses brought about and the small amounts of the sums paid by way of compensation constitute the main grievance in relation to the compensation efforts. Thus, what is hoped for is a reassessment of the rates applied for covering people adversely affected by the project in addition to support measures aimed at enabling the people affected to escape from the trap of becoming impoverished; these are the strong expectations expressed by the stakeholders.

In addition to which, the presence of the wind turbines is fuelling fears regarding health and safety impacts on local populations in the project's zone of influence. However, an improvement in relation to the project's layout plan entails an increase in the wind turbines' setback distances in relation to the closest villages by about 500 meters. In spite of everything, the Head of the Regional Division of the Environment and Listed Establishments suggested improving the distance between them and the latter houses by at least another 500 meters, making provision for the future growth that the human settlements will surely experience in the medium and long term, establishing them at least 1,500 meters away.

The presence of red earth tracks also constitutes another concern due to the risk of generating dust which will adversely affect the environment, living conditions, and the well-being of local populations. In response to this issue, what is recommended is planting a green belt to act as a screen along the roads, which may help to contain the dust kicked up. The paths along which cables are buried will have to be clearly marked. These rows will also make it possible to forestall the safety risks which may be increased by houses being too close to the rows of wind turbines. From another perspective, the execution period for the works will be the determining factor for reducing socio-economic impacts. The reason for this is the harvesting period and the extent to which seasonal crops have grown.

Moreover, the safety of the local populations and animals may be compromised during the works execution phase. For those populations, fluorescent strips should be set up. But for animals, monitoring will be necessary, which at the same time involves raising the awareness of local populations.

Lastly, the creation of the wind farm is prompting concerns regarding the loss of plant cover and management of hazardous waste such as PCBs, which are the main sources of impacts on the natural environment. To this end, basically what is recommended is revegetating the zone by targeting forestry species and maintaining the procedures approved for managing dead oil at the time of the initial studies, which proposed satisfactory solutions enabling revalidation by the technical committee.

Table 41:**Summary of the concerns of the various staakeholders and the state of management in the description of the project or the ESMP (Environmental and Social Management Plan)**

N	Fears/Concerns	Stakeholders		Factored in (Yes/No)	Level to which they are factored in (Description of the project or ESMP)	Details of the response (Response made to the concern)
		Technical Services	*Local communities /Elected officials and populations*			
1	The risk of a lowering and loss of agricultural production and income due to the colonisation of land used for growing crops, particularly within a context where there is pressure on land in the Rural Community of Taïba Ndiaye, accentuated by the presence of ICS and MDL.	YES	YES			
2	The risk of impoverishment and food insecurity stemming for a poor compensation policy giving priority to fruit trees such as mango trees, to the detriment of food crops which, in the long term, would give rise to the development of single-crop farming.	YES	YES			
3	The risk of conflict that may result for not factoring in damage along boundaries committed to farms owned by third parties during construction or operations.	----------------	YES			
4	The risk of obstructing the movements of farmers during the track laying phase					
5	Risks of accidents for the local populations frequenting the zone where the wind	YES	----------------			

N	Fears/Concerns	Stakeholders		Factored in (Yes/No)	Level to which they are factored in (Description of the project or ESMP)	Details of the response (Response made to the concern)
		Technical Services	*Local communities /Elected officials and populations*			
	turbines are established and where the underground electric cables are due to their proximity to their farms, with this applying both during construction and operations.					
6	The risk of accidents due to towers falling, blades breaking or even becoming detached from rotors	YES	YES			
7	The risk of pollution with liquid waste such as dead oil, and particularly PCBs or grease.	YES	------------------			
8	The risk of underground cables becoming worn due to contact with run-off.	YES	------------------			
9	The risk of noise pollution and olfactory pollution due to the sounds and unpleasant odours caused by the wind turbines which may have an impact on human health or on insects performing pollination.	YES	------------------			
10	The risk of atmospheric pollution due to laying and using red earth tracks.	YES	YES			
11	The risk of a loss of plant cover due to cutting down fruit trees, scrub, and protected species like the Alida acacia.	YES	------------------			
12	Risks of lightning-related incidents.	YES	-----------------			
13	Risks of accidents to employees during the construction phase as well as due to maintenance activities.	YES	-----------------			

9 POTENTIAL ENVIRONMENTAL ISSUES AND IMPACTS OF THE PROJECT

9.1 ENVIRONMENTAL ISSUES

Wind energy is one of the cleanest of existing forms of energy sources. It produces no atmospheric emissions.

Nevertheless, wind energy is associated with environmental impacts given that the execution of any project affects the environmental and human spheres.

9.1.1 Renewable energy production

The option of producing wind energy to build up the electric power production capacities testifies to the desire of the Senegalese authorities to promote the diversification of energy sources and reduce the country's dependency on fossil energies.

It is therefore clear that the advent of the wind turbine in the energy gap reduction strategy is a huge step towards adopting clean energies. This demonstrates, if this was indeed necessary, a strong commitment to a sustainable energy policy concerned about protecting the environment and future generations.

9.1.2 Denaturation of landscaped areas

Although the aesthetics of a wind turbine is a matter of taste that cannot be decided objectively, local residents normally fear visual degradation to the sites in question.

A wind turbine or a wind farm located in a landscape never leaves someone indifferent. This monumental scale contrasts with the human scale of elements already in the landscape.

The visual impact of a wind farm on the landscape will often be linked to:

- the size of wind turbines;
- their number;
- the meteorological conditions;
- the distance between the observer and the wind turbines;
- the visual obstacles.

The wind project should define the best landscape scheme and combine with the farming landscape of the Taiba Ndiaye area **to help it gain acceptance.**

9.1.3 Noise exposure

One of the greatest myths about wind turbines is the noise they generate. Wind turbines make a noise, however not very much.

The audible noise is caused by the wind sliding along the blades and by the generator. Nevertheless, new blade and generator technologies have reduced noise levels significantly.

It is therefore possible to stand at the foot of a wind turbine tower and carry on a normal conversation without raising one's voice.

9.1.4 Wildlife and birdlife and their habitat

The two wind farms could disturb the wildlife in a variety of ways, mainly the populations of reptiles and other small rodents found in this sector and the herpetofauna[11]. These animals are therefore likely to be disturbed when the wind farm is being erected. However, functioning wind turbines should not cause significant disturbance in the operating phase.

Wind turbines cause very few bird deaths compared with several other mortality factors. Most birds avoid the turbines according to existing studies.

9.1.5 Land use

The land of the Taiba Ndiaye rural community and the environmental impact zone of the project is mainly used for agricultural-pastoral and arboricultural purposes. The installation of a 46-generator-strong wind farm will certainly disturb the spaces given over to production activities by the local populations.

9.1.6 Local and regional economy

The implementation of various phases in the project to install a wind farm with 151.8 MW power will without doubt increase commercial transactions, all the more so that the site and requirements of the operations will necessitate the purchase of goods and services as well as the hiring of labor and staff accommodation sites. To this end, it is to be hoped that the villages polarised by the wind farm - especially those of Mbayène, Baïty, Guèye, Taiba Ndiaye and Same Ndiaye - will benefit from the first economic impact from this project. Beyond that, new trades linked to the manufacture of wind turbine components can be anticipated in the Thiès region.

9.2 SOURCES OF IMPACT

An onshore wind farm comprises the following components: a set of wind turbines and their foundations, an access route and an inter-turbine service track, an underground cable network, a power sub-station, a transformer unit inside or outside each wind turbine and a connection cable to the grid.

[11] Amphibians (frogs, toads and salamanders) and reptiles (snakes, etc.).

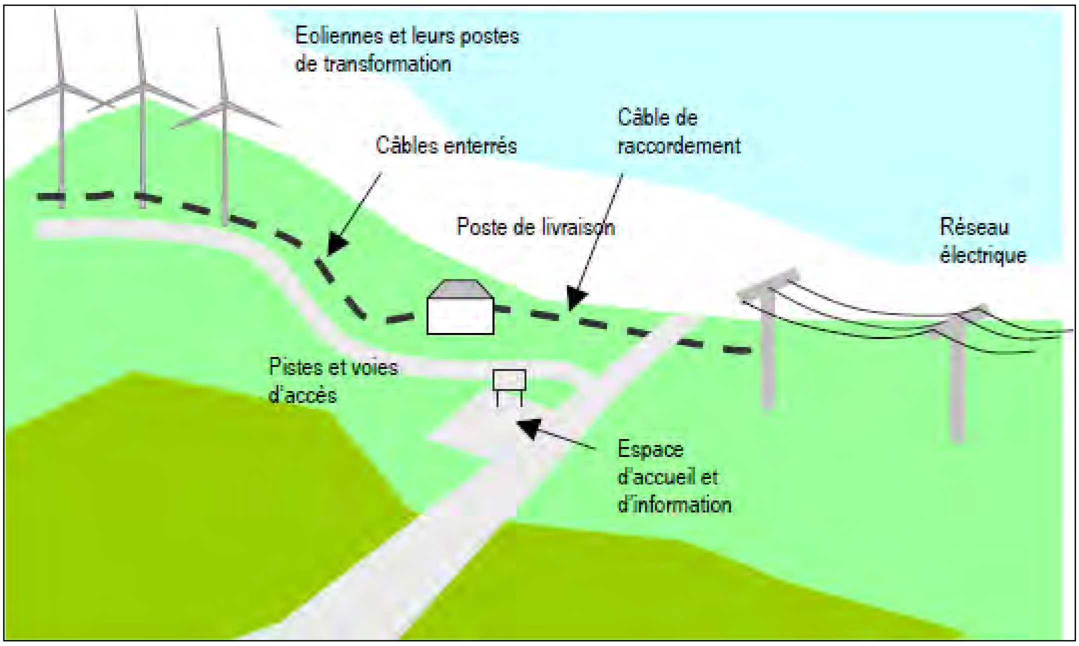


Figure 43: Descriptive diagram of an onshore wind farm (scaling ratios not representative)

Determining sources of impact will involve identifying and defining the activities of the project to install two tranches totaling 46 wind turbines likely to alter the physical environment or have an impact on the components of the biological and human environments.

This determination is based on the technical description of the project and knowledge of the environment. They are also drawn from documentary research into similar wind projects executed elsewhere (benchmarking) in the world (i.e. Europe and North America).

The sources of impact under this study are classified under erection, operating and decommissioning phases.

9.2.1 Erection phase

The sources of impacts during the erection phase relate basically to the following activities:

- work to prepare two sites accommodating 46 wind generators and the plant;
- opening up access roads to the mast installation sites;
- civil engineering works, mainly excavations, foundations, etc.;
- assembly of wind generator components;
- construction of sub-stations;
- car and construction equipment traffic; and
- commercial activities of purchasing goods and services.

9.2.1.1 *Preparatory work*

Expropriation works (access roads and wind farm plinths) of the fifty or so wind turbines will mean clearing trees and undergrowth (about fifteen acres per machine, i.e. slightly less than 7 ha for 46 wind turbines with technical rooms) and will inevitably disturb the surrounding ecosystems, mainly the biodiversity and biophysical environments.

9.2.1.2 *Opening up access paths and power line trenches*

Existing rural roads will be widened or rerouted to facilitate the transport of wind turbine equipment to the various areas of the wind farm and allow smooth progress of site activities, mainly:

- preparing hoisting and lifting platforms and site traffic areas;
- tree clearance,
- levelling work (cut and fill), installation of draining ditches;
- foundations on the ground;
- access tracks and roads to be constructed based on needs to adapt to the configuration of the Taiba Ndiaye area;
- preparing cabling network footprints;
- etc.

The table below gives an idea of the spaces required to install wind generators.

Table 42: Orders of magnitude of footprints for an onshore wind farm

Description	**Onshore wind farm**
Hoisting and lifting platform surface area	About 1000 m^2 per wind turbine
Ground surface area for foundations	About 300 m^2 per wind turbine
Access track and road characteristics (to be created based on pre-existence of tracks and roads)	About 5 m wide, minimum bend radius of 30 m
Cabling footprint	About 60 cm wide and 1 m deep

Excavation and foundations

Preparing the wind turbine plinth and foundation and burying the cable network will involve excavating foundations wide enough to accommodate the concrete casting that will keep the towers stable. In the same order, trenches should be excavated for the underground cable network.

This construction work will disturb soil stability and water drainage slightly.

9.2.1.3 Raise wind turbines

Raising a wind turbine is a long operation that can take more than three months. In addition to foundations, the wind turbine constituent components have to be brought on site, the mast and nacelle assembled and the rotor fitted. This is a huge operation necessitating the use of sturdy machinery.

Figure 44: Assembling the nacelle

Figure 45: Fitting the rotor (formed by the hub, the cone and three blades).

9.2.1.4 Construction of sub-stations

When connecting to the high-voltage grid (HTB), a high-voltage transformer unit (or source unit) is required at the foot of the high-voltage line. The wind farm can also have related components such as a meteorological measurement mast, material and tool storage area, technical room, car park with reception and information area, etc.

9.2.1.5 Transport and traffic

The preparation activities inevitably result in increased numbers of humans directly in the area of influence and far away from the wind farm project. As stated above, the roll-out of the site logistics and the transport for equipment and personnel specific for the works will mean an increase in lorry traffic, especially on departmental road 702 and the roads linking the 46 wind generators.

Purchase of goods and services: One of the direct impacts of the erection of the wind farm will be seen in the local and regional economy through increased trading and commercial activities. Immediate benefits are anticipated for the local surrounding populations and the supplies of goods and services in the Thiès region.

9.2.2 Operating phase

The sources of impacts during the operating phase of the 46-generator-strong wind farm are as follows:

9.2.2.1 Impact of the operation of wind turbines on the ambient noise level

Given the sound levels of modern wind farms (about 60 dB at the foot of a wind turbine, 45 dBA 300 m above the ground), no impact on the hearing system is envisioned. It is nowadays agreed that no health impacts from infrasounds have to date been shown in humans (even at high exposure levels), that the exposure "of the population to the noise of wind turbines is comprehensively below the threshold of 70-80 dB" and that "no risk of direct harm to hearing is envisioned".

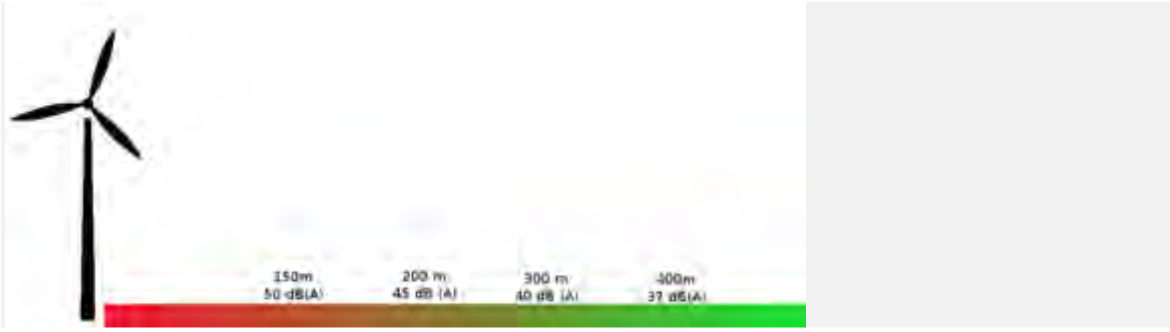


Figure 46: Mitigation of the noise according to the distance away from the wind turbine

In addition, the noise of the wind turbine and its perception depend on several factors:

- intrinsic, linked to the wind turbine and its acoustic power, the size of the farm, etc.;
- dependent on the topography, soil type, geometry of the wind turbine and the "receiving" location;
- dependent on the weather (wind, hygrometry) encouraging the propagation of the sound;
- relating to the surroundings (vegetation, rocky substrate, earth, etc. which absorbs or reflects the noise in varying degrees);

In practice, it is difficult to perceive the noise of a wind farm more than 500 meters away, but the annoyance exists, nevertheless. This annoyance is explained only very partially by the acoustic factors (about 30 to 40%); the non-auditory effects that can be envisioned are basically psychological.

Still according to the French Agency for Environmental and Occupational Health Safety (AFSSET), the noise level is (in 2007):

- near wind turbines: in the range of noise levels of land transport infrastructures
- away from sources: in the range of residual (or background) noise levels and partly in the infrasounds, including a low frequency proportion. Psycho-acoustic laboratory studies on the description of the noise emitted by wind turbines show that whistling and effects of beating to be the most disturbing, above all if they are perceived as bursts of noise; the annoyance could also be generated or increased by subjective factors, including the feeling of lack of information and consultation and/or a lesser

acceptance of the presence of the wind turbine deemed a blot on the landscape or a disturbance to birds. Research into how to make wind turbines less noisy is on-going. The simulations for "particularly prejudicial emission and propagation conditions" show a relatively low noise compared with the natural background noise as soon as there is sufficient distance from the source and major variations according to the scenario chosen. AFSSET therefore concluded that a minimum regulatory distance was not relevant and that the problem should be dealt with case by case through impact studies.

Thus, the sound impact of wind turbines is an offshoot of different factors, including the acoustic power of wind turbines, their arrangement, their technological choices, their number and their operating modalities. Their foundations, the distance between them and the nearest buildings and the background noise level also play a significant role.

Experience shows that the noise is not excessive when the dwellings are located more than 300 meters from the nearest turbine. Several countries, including Sweden, have adopted certain standards:

- 45 dB (A) maximum at an isolated country house.
- 40 dB (A) maximum in an urban area.
- 45 dB (A) maximum 400 meters from the turbine.

9.2.2.2 Impact of the presence and operation of wind turbines on birdlife and wildlife

The impacts from wind farms on the biodiversity mainly affect birds and bats and vary according to the species, seasons, environments, the size of the wind farm and wind farmers that can impact on:

- **mortality**

Depending on the configuration, the location of farms and methods used, between zero and forty birds and bats are killed per wind turbine per year.

- **disruption**

The wind farm is likely to disrupt the operation of an environment and reduce its attraction for certain species. During migrations, the presence of wind turbines in the migratory path normally causes by-pass reactions, which increase the difficulty of the journey.

- **loss of habitat**

Birds from open environments avoid approaching the wind farms. This avoidance distance increases with the size of the farm. Intense, repeated disturbance can cause a lasting loss of habitat. For some species, the presence of numerous wind farms cause total desertion of the area.

9.2.2.3 Impact of the presence of wind turbines on the landscape

Although the aesthetics of a wind turbine is a matter of taste that cannot be decided objectively, local residents normally fear visual degradation to the sites in question.

A wind turbine or a wind farm located in a landscape never leaves someone indifferent. To overcome all subjectivity, the wind turbine must be considered as a new form of extremely large building, therefore visible from afar. Each installed wind turbine will be 125 to 150 m tall maximum, made up of a tower 80 to 100 m tall and blades 50 m long. This monumental scale contrasts with the human scale of elements already in the landscape.

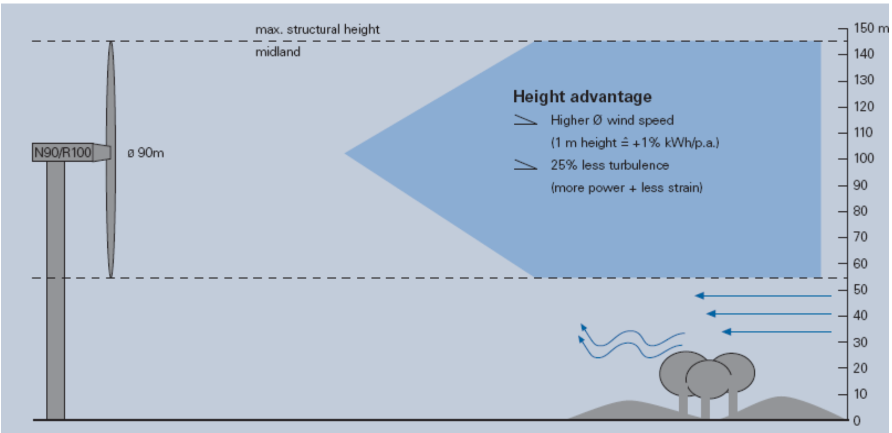


Figure 47: Representation of a wind turbine in the landscape

The visual impact of a wind farm on the landscape is linked to:

- the size of wind turbines
- their number
- the meteorological conditions
- the distance between the observer and the wind turbines
- the visual obstacles

The risk of alteration to land habitats from the construction and operation of onshore wind turbines is limited given their low ecological footprint. The main visual impact will mainly come from an alteration to the natural landscape.

9.2.2.4 Impact of maintenance work to the wind farm

Routine maintenance work to the wind farm and motors could occasionally pollute the soil through spillage of hydrocarbons. A VESTAS wind turbine contains about 1000 l oil in its gearbox and about 140 l oil for the various components requiring lubrication.

It goes without saying that an accidental leakage of this significant amount of oil could cause substantial soiling in line with the masts as well as runoff and contamination of bodies of water and/or underground resources when the oils are discharged after their final use.

Thankfully, recovery systems (containment systems and catchers) are planned in these same wind turbine parts, thereby avoiding soiling of soils following occasional spillages. The highest risk will be during wind turbine maintenance and oil draining operations.

9.2.2.5 Impact of the presence of sub-stations

Given the size of wind generators and electricity pylons, the advent of new power lines will have a relatively low visual impact insofar as they will be integrated with the hoisting areas.

9.2.2.6 Electromagnetic interference and radiation

The low frequencies generated by a wind turbine are the result of the interaction of the aerodynamic pressure on the Blades and the atmospheric turbulence in the wind. The random nature of air turbulence has a bearing on the low frequency emissions. It seems that the low frequency sounds are less likely to generate nuisances that the less random bursts of sound. Low frequency emission involved the downwind wind turbines above all (when the wind turbine tower is between the wind and the rotor), but all wind turbines today are upwind.

Although little information exists on infrasounds, foreign studies do not find any effect on health. According to the Swedish Environment Agency, the infrasound levels emitted by the wind farms are so low that they have no detrimental effect on health. Similarly, according to the National Academy of Medicine, once a few meters away, the infrasounds from the noise of wind turbines are very quickly inaudible and therefore do not affect human health.

The acoustic annoyance of the sound produced by the wind turbines is above all induced by the infrasounds (very low frequencies < 20 Hz) that are inaudible to the human ear but dangerous for the organism. Animals are extremely sensitive to them and inexplicable changes in behavior are noted in wild species when infrasounds are present.

9.2.2.7 Public access

As special and relatively imposing installations, there is a fear that the curiosity sparked by the sheer size of the wind farm can raise a few safety concerns. Numbers of people at production spaces.

9.2.3 Decommissioning phase

The impacts during the decommissioning phase relate to the following activities:

9.2.3.1 Dismantling of equipment

Dismantling of equipment is taken to mean the dismantling of wind turbines (towers, nacelles, hubs and blades) and their concrete plinth, power lines (buried wires), the sub-station and related installations. The access roads are left in place.

9.2.3.2 Transport and traffic

The dismantling and transport of imposing constituent parts of wind generators will mean rolling out logistics similar to those used during the installation phase, but also increased load on internal and regional traffic routes.

9.2.3.3 Soil rehabilitation

The restoration of soils formerly dedicated to foundations will necessitate before any regeneration a meticulous study to detect any contamination and determine the best rehabilitation methods.

9.3 IDENTIFICATION, PROMOTION AND ANALYSIS OF ENVIRONMENTAL IMPACTS

The methodology presented previously in § 1.3 of this document uses the concepts of ecosystem and social value as a basis for assessing the magnitude of impacts and their significance. In this context, the human and natural components of the environment found in the study area or likely to be affected by or other of the forecast interventions have obtained an environmental value matching their relative importance in the said area.

The impact analysis of the landscape scheme for the Taiba Ndiaye wind farm relies on the description of the project, the knowledge of the environment, the ecological context and the environmental issues. This analysis is segmented according to acknowledged repercussions on the natural (physical and biological) and human environments of the wind farm's erection, operating and decommissioning phases.

The affected components (significant impacts) are dealt with in depth. Those suffering impacts deemed negligible to zero are described more succinctly.

The acknowledged impacts for each component dealt with are assessed using the methodology described in Chapter 1.0.

It is important to underline that the impacts have been determined by considering that all current mitigation measures (best practices) described in section 2.0 (project description and components) are an integral part of the project. This approach reduces both the number and significance of impacts at the same time.

9.3.1 Positive impacts

The Taiba Ndiaye wind farm project will have a positive effect on global pollution (greenhouse gas emissions and radioactive waste avoided) and on local development. Thus, the maintenance of the wind farm and the access roads will have a direct impact on the local and regional economy.

The wind farm may also contribute indirectly to creating or attracting related industries, particularly as the gearbox oil is checked and changed if necessary every six months. A work team of fifteen to twenty people will have to be created to check and maintain the wind turbines. Half of these will be hired in the neighboring villages or in the region.

The next table summarizes the anticipated beneficial effects of the Taiba Ndiaye wind farm project.

Table 43: Summary of the anticipated beneficial effects of the wind farm project

Environmental component	Sample effects
Physical environment	
Climate	Helping to control the greenhouse effect
Natural environment	
Biodiversity	Preserving the biodiversity (by helping to control the greenhouse effect) Improving knowledge of the biodiversity and its protection Improving knowledge of the ecological integration of human activities
Human environment	
Local economy and sustainable development	Fiscal impacts for the Taiba Ndiaye municipality Revitalizing local employment Impact on tourism Creating local sustainable development dynamics
Macro-economy	Contributing to the diversification of electricity generation Reducing the level of energy dependence on fossil energies in Senegal Creating direct jobs in the renewable energy sector Creating indirect jobs (design offices, maintenance, component manufacture, public works, rural

Environmental component	Sample effects
	craftsmen, etc.)
Public health and safety	Energy without producing waste CO_2 emissions avoided Reversible installations

9.3.2 Negative environmental impacts

9.3.3 Negative environmental impacts on the physical environment

The physical environment elements likely to be affected by the project are:

- the geotechnical characteristics of substrates,
- soil quality,
- water resources, mainly the surface water drainage pattern and the surface water and groundwater quality.

9.3.3.1 Impacts on the geotechnical properties of substrates

The resistance of the sub-soil materials is of prime importance as it guarantees the stability of structures supporting the wind generators. Given that the wind turbines are installed on summits, with few significant geotechnical constraints, the indication is that the environmental value relating to substrate stability can be qualified as low.

9.3.3.1.1 Impacts forecast in erection phase

No substrate instability was has been noted in the footprint of the fifty or so (46) wind generators, where the vast majority (more than 90%) of the earth is made up of sands characterized by a relatively low risk of surface sealing.

The localized nature of specific wind turbine foundations reduces hugely the impact of necessary excavation work on the substrates.

Thus, the magnitude of the impact is qualified as low. Its scope is limited. The impact duration will be moderate, as the erection work could last for more than a year. Thus, the significance of the impact is qualified as low.

9.3.3.1.2 Impacts forecast in operating phase

The operation of the wind farm of 46 wind generators should not increase the load on the sub-soil nor threaten soil stability for either the access roads or the surfaces carrying the wind turbines themselves.

The host substrate on which the wind generator units are erected is kept solid by pouring a concrete plinth, itself combined with the weight of the wind turbine. Thus, in the absence of extraordinary phenomena, there is nothing to fear from the risks of settling or weakening of the host substrate. In addition, the geotechnical studies prior to the installation of each wind turbine will be used to optimize the nature of the plinth with the specific type of substrate.

There is little impact from the operation of wind generators on the stability of host substrates.

9.3.3.1.3 Impacts forecast in decommissioning phase

No impact on the stability of substrates is anticipated during the wind farm equipment decommissioning phase. Only the substrates already developed (access roads, areas laid out for the wind turbines, etc.) will be subject to the effects of construction equipment and human numbers and no other substrate will be affected by the decommissioning work.

Once the equipment has been dismantled, the upper portion of the wind turbine concrete plinths will be razed and covered with contaminant-free sediments. The access roads will remain as is.

The Developer undertakes upon expiry of the lease that the deep anchorings are stripped to less than 0.80 m of the natural soil before the work in order to restore the original agricultural land and landscape.

Table 44: Summary of the impact of the wind farm on substrate quality

Phase	Activity	Nature of the impact	Scope	Period	Magnitude	Significance of the residual impact
Development of plinths and access roads	Preparing foundations Clearing trees for roads Excavation work Raising wind turbines	Negative	Local	Temporary	Intermediate	Low
Operation of wind generators, technical room, etc.	Optimum operation of wind generators Electric power generation and transport	Negative	Local	Permanent	Intermediate	Low
Dismantling of the wind farm	Regeneration of substrates	Positive	Local	Permanent	High	High

9.3.3.2 Impact on the soil quality

As a rule, except for cultivated land, the soils in the study area are natural and free of any human-source contamination. The environmental value for soil quality can therefore be qualified as high.

9.3.3.2.1 Impacts forecast in erection phase

Accidental spillage of petroleum products seems to be the most likely impact to affect the texture and horizons of soils. These petroleum products would come from the operation of construction equipment and any leaking lubricants. The production of so-called sterile waste is to be expected; this would come from trench digging (sub-soiling) and preparing for wind turbine foundations. The inter-wind turbine connection route to the power sub-stations and from the power sub-stations to the source unit will following existing roads.

Figure 48: Machine for digging the trench about 1 m deep

Nevertheless, given the eminently agricultural nature of the wind turbine influence area, recycling the stripped earth should not be difficult in this rural area.

The soils in the study area are agricultural or natural and have therefore been granted huge environmental value. The magnitude of the disturbance has been qualified as moderate. Even taking into account all sites used or developed for the project, the scope of the impact remains limited and short-lived, given the rapid elimination of any possible accidental spillage. Due to the rigor that will be applied to managing waste, hydrocarbons, machine servicing and appropriate measures in the event of accidental spillage of contaminants, the significance of the residual impact is qualified as low.

9.3.3.2.2 Impacts forecast in operating phase

The operating phase will be regulated by the operation of the wind turbines and the maintenance of the machinery. This will involve motor vehicles and operating personnel frequenting the site.

The risks of soil pollution or denaturation would therefore come mainly from oil or fuel leaking accidentally from the machinery or maintenance vehicles on the site. The machinery maintenance and draining systems are designed not to attack the environment. Specific and appropriately-equipped lorries will drain the oil. In addition, as the area below the nacelle is made up of the concrete plinth, accidental spillages of petroleum by-products are unlikely to occur.

Overall, the magnitude of the impact is qualified as moderate. Its scope remains limited and short-lived, given the preventive monitoring by the maintenance team. The residual impact is therefore qualified as low.

9.3.3.2.3 Impacts forecast in decommissioning phase

The soils could be soiled during decommissioning operations by an accidental spillage from construction equipment. As the machinery is in principle in good working order, a spillage is highly unlikely and the magnitude of the impact can be qualified as moderate. Its scope remains limited and short-lived due to the rapid elimination of accidental spillages.

Table 45: Impacts of the wind farm on soil quality

Phase	Activity	Nature of the impact	Scope	Period	Magnitude	Significance of the residual impact
Development of plinths and access roads	Excavation work Circulation of machinery Raising wind turbines	Negative	Local	Temporary	Intermediate	Low
Operation of wind generators, technical room, etc.	Optimum operation of wind generators Maintenance of wind turbines and energy transport infrastructures	Negative	Local	Temporary	Intermediate	Low
Dismantling of the wind farm	Regeneration of substrates	Negative	Local	Temporary	Intermediate	Low

9.3.3.3 Impact on surface water resources

Over and beyond temporary bodies of water formed around old phosphate quarries, the influence area of the future Taiba Ndiaye wind farm does not incorporate major surface water. The result is a relatively low environmental value for this component.

9.3.3.3.1 Impacts forecast in erection phase

Given that long-term surface water does not exist in the project area, the acknowledged global impact is therefore insignificant.

9.3.3.3.2 Impacts forecast in operating phase

The arrangements made to optimize the operation of the wind generator farm (access roads, wind turbine bases, etc.) and the clearing of trees from wind turbine installation points will not alter significantly the runoff water pattern.

9.3.3.3.3 Impacts forecast in decommissioning phase

Given the above and the low value of the "surface water resources" component, the decommissioning phase will have no impact on runoff water drainage. The access roads will in all likelihood be kept, with all suitable arrangements to control the surface water properly.

Table 46: Impact of the wind farm on surface water resources

Phase	Activity	Nature of the impact	Scope	Period	Magnitude	Significance of the residual impact
Development of plinths and access roads	Excavation work Circulation of machinery Raising wind turbines	Negative	Local	Temporary	Intermediate	Low
Operation of wind generators, technical room, etc.	Optimum operation of wind generators Maintenance of wind turbines and energy transport infrastructures	Negative	Local	Temporary	Intermediate	Low
Dismantling of the wind farm	Reinstatement of soils and excavations	Negative	Local	Temporary	Intermediate	Low

9.3.3.4 Surface water quality

Given that the water in bodies of water in the study area are recognized as unfit for drinking, the value relating to this quality can even be qualified as low.

Nevertheless, special attention will be given to the installations used for irrigation and draining of farmland.

9.3.3.4.1 Impacts forecast in erection phase

It is acknowledged that waste from excavations required for the foundations will be generated as sterile soils. These can be carried into the runoff water and thus be suspended in the temporary ponds used for irrigation and watering the herd. Added to this, the leaching water from farming plots adjacent to the wind turbines could be loaded with pesticide residues.

Note, however, that the erection options recommend not installing wind turbines near these temporary bodies of water, which suggests that their residual impact will be of little significance. The magnitude of this impact will therefore be low and the scope limited and will be restricted to water points or near wind turbine raising areas. It will be short-lived and limited to the construction period. Overall, this impact is therefore qualified as low.

9.3.3.4.2 Impacts forecast in operating phase

The operation itself, which basically calls on the wind turbine component, will have no notable environmental impact on water quality.

9.3.3.4.3 Impacts forecast in decommissioning phase

As stated previously, no erection is planned near temporary water points, which minimizes the environmental risks for the aquatic component when dismantling the entire wind farm.

For all these reasons, the magnitude of acknowledged disturbances in the water points is qualified as low. The scope remains limited and short-lived.

Table 47: Impact of the wind farm on surface water quality

Phase	Activity	Nature of the impact	Scope	Period	Magnitude	Significance of the residual impact
Development of plinths and access roads	Excavation work Circulation of machinery Raising wind turbines	Negative	Local	Temporary	Intermediate	Low
Operation of wind generators, technical room, etc.	Optimum operation of wind generators Maintenance of wind turbines and energy transport infrastructures	Negative	Local	Temporary	Intermediate	Low
Dismantling of the wind farm	Reinstatement of soils and excavations	Negative	Local	Temporary	Intermediate	Low

9.3.3.5 Groundwater quality

Groundwaters can represent a source of drinking water for the inhabitants of a locality or as irrigation water for market gardens in the area. Any alteration to the groundwater quality will therefore have a direct impact on the food chain and drinking water supply. Given that the groundwater in the study area is recognized as good quality, the value relating to this quality can even be qualified as high.

9.3.3.5.1 Impacts forecast in erection phase

Considering the position of wind turbines on the top of dunes and their distance from the groundwater sources, the acknowledged impact on groundwater quality is very low.

Only a major hydrocarbon spillage is likely to affect the quality of the water table, but given the proposed mitigation measures, the magnitude of the impact is deemed low. Remember that the drinking water wells listed in the Taiba Ndiaye area are 8 to 50 m deep.

The magnitude is high, the scope is limited and short-lived, leading to an impact of little importance.

9.3.3.5.2 Impacts forecast in operating phase

During the operating phase, no impact is acknowledged on groundwater quality.

9.3.3.5.3 Impacts forecast in dismantling phase

Apart from a major spillage of hydrocarbons from construction equipment, no activity during the dismantling phase is likely to affect the groundwater quality when dismantling the wind farm.

Table 48: Impact of the wind farm on the groundwater

Phase	Activity	Nature of the impact	Scope	Period	Magnitude	Significance of the residual impact
Development of plinths and access roads	Excavation work Circulation of machinery Raising wind turbines	Negative	Local	Temporary	Intermediate	Low
Operation of wind generators, technical room, etc.	Optimum operation of wind generators Maintenance of wind turbines and energy transport infrastructures	Negative	Local	Temporary	Intermediate	Low
Dismantling of the wind farm	Reinstatement of soils and excavations	Negative	Local	Temporary	Intermediate	Low

9.3.3.6 Potential negative environmental impacts on the biological environment

The components of the biological environment likely to be affected by the installation of these 46 wind generators are the vegetation, wildlife, birdlife and herpetofauna.

9.3.3.7 Impacts on the terrestrial vegetation and the habitats

The vegetation is a major element both aesthetically and for its biological value. As the study area does not include an exceptional forest ecosystem or natural community reserves, but does have floral species with precarious status (at least four partially-protected species that may be affected), the environmental value of the vegetation can be qualified as moderate to high.

9.3.3.8 *Impacts forecast in erection phase on the plant cover and habitats*

The Taiba Ndiaye wind project is proposing to install a maximum of 46 wind turbines. Each wind turbine requires a working space of about 0.15 ha so that masts and turbines can be raised and assembled. The project also provides for the installation of technical rooms that require no additional tree clearance.

Access roads will be necessary for the passage of the machinery and the transport of wind turbine components in erection phase. Some of these roads exist already and will require relaying and improvement work. Other roads are, however, planned under the project and will have to be built. They will also be used by the local populations to travel to the cultivation areas.

The surface footprint inside which are represented symbolically the wind turbines split into five rows is a rectangle of 11 km from East to West and 7.5 km from North to South. Nevertheless, as the surface taken up by a wind turbine is about 14.4 acres (i.e. 1440 m2), this represents a total surface area of 6.62 hectares for a total of 46 wind turbines provided for under the project. A 0.8 hectare plot is planned to house technical components (control post and transformers).

✓ **Plant cover**

The vegetation is a major element both aesthetically and for its biological value. However, the study area does not include an exceptional forest ecosystem or natural community reserves but does have plant species of varying degrees of ecological importance in terms of the biodiversity. The same applies to species at the endemic state, partially protected or protected under the Convention on International Trade in Endangered Species (CITES).

- ***threatened plant species, comprising Borassus aethiopum, Adansonia digitata and Faidherbia albida,***
- ***endemic species, including*** **three** (*Crotalaria sphaerocarpa, Polycarpaea linearifolia* and *Vernonia bambilorensis*) that figure among the endemic species of the flora of Senegal. But the project site does not include species belonging to the list of West African rare and/or endemic species and
- ***Eight species*** partially protected by the Senegal Forest Code, as follows: *Adansonia digitata*, *Borassus aethiopum*, *Elaeis guineensis*, *Faidherbia albida*, *Grewia bicolor*, *Prosopis africana*, *Tamarindus indica* and *Ziziphus mauritiana* are found on the project site and its surroundings and are part of species. This involves acquiring prior authorization from the competent departments before any action (cutting, delimbing, grubbing, etc.).

Added to this, the agro-forestry activity of the Taiba Ndiaye area places the tree at the heart of agricultural activities. It must therefore be said that fruit arboriculture will be highly affected by the wind turbine preparation and installation activities. The potential effects on the habitats and flora can vary, shown by:

- dust deposits during work;
- surface consumption following expropriation;
- land clearance, but cutting isolated trees;
- alteration to habitats;
- the trampling of surrounding habitats (works, foot traffic) and too many people in the environments;
- increased risks of fire;
- the introduction of invasive exogenous species;
- the destruction of protected species (in this case, a dispensation submission for the destruction of a protected species must be prepared);
- the attack on heritage and/or decisive species stands.

These impacts will be more or less marked depending on the nature of the plant cover on the installation site of each of the five groups.

Thus, group 4 that will be installed in an area basically dominated by plantations or orchards will be the most affected. And to a lesser extent:

- group 3, dominated by a succession of young plantations less than five years old and lastly

- group 2 from E11 to the village of Baal Diop, dominated by young plantations. After Baal Dip until 1.8 km of E22 we are in an area dominated by rainfed and cash crops.

The magnitude of the impact from loss of vegetation can be qualified as high, the scope is limited and long-lived, since the tree clearance will be felt for more than five years. Overall, the significance of the impact is qualified as moderate.

The farming focus of the area home to the wind farm project must be correlated with the maintenance and cultivation activities, etc. These various activities both degrade and disturb the herbaceous layer.

9.3.3.9 Impacts of erection on animal habitats

Given the lack of remarkable animal habitats likely to be disturbed by the planned erection, the preparation of the wind generator sites and the wind farm commodities (control post and transformer) will not have a negative impact on the opportunistic wildlife found in the cultivation lands. The access roads that will have potentially to be created will also be located outside the most interesting biological areas.

The impacts on the habitats will be restricted at most to a disturbance of the noise exposure and the settling of soils, given the transport and storage activities of the site logistics and wind turbine components.

9.3.3.9.1 Impacts forecast in operating phase

The automation of the wind farm means that the wind generators can function autonomously without being disturbed by machinery inspections and routine maintenance. During these inspections, the personnel and the machinery used for the maintenance will take the roads cleared for inter-wind turbine connection.

Thus, no significant impact is anticipated to the vegetation during the operating phase except for probable soiling during maintenance of the sub-station and access roads. This maintenance involves regular cleaning to keep minimum surfaces free of plant cover for access and maintenance reasons. In addition, no herbicide will be used.

9.3.3.9.2 Impacts forecast in decommissioning phase

No negative impact is forecast to the vegetation during the decommissioning work. On the contrary, efforts will be made to replant cleared areas in a process to boost the agro-forestry heritage of the Taiba Ndiaye municipality.

The impact expected here should result in a regreening of the palmyra grove.

Table 49: Environmental impacts per wind turbine on the vegetation

Phase	Activity	Nature of the impact	Scope	Period	Magnitude	Significance of the residual impact
Development of plinths and access roads	Preparing foundations Clearing trees for roads Excavation work Raising wind turbines	Negative	Local	Temporary	Intermediate	Average
Operation of wind generators, technical room, etc.	Optimum operation of wind generators Electric power generation and transport	Negative	Local	Temporary	Intermediate	Low
Dismantling of the wind farm	Boosting of the agro-forestry heritage	Positive	Local	Permanent	High	High

9.3.3.10 Environmental impacts on the fauna

The area being studied is not potentially frequented significantly by large mammals, be it for feeding or reproduction purposes. The environmental value of this element is therefore deemed low.

In terms of abundance, a total of 965 birds have been counted in the project's footprint. The dominant species are: Alpine Swift (*Tachymarptis melba*) 23.83%, Red-eyed Dove (*Streptopelia semitorquata*) 18.03% and Cattle Egret (*Bubulcus ibis*) 8.81%. The Alpine Swifts only stop there for a day to feed on their way north or south. The other species are nesting birds, on the other hand.

In terms of mammals, the Cape Ground Squirrel (*Xerus inauris*) is the species seen most in the area: eight have been observed. The other species (Gambian Sun Squirrel, Jackal, Civet and Bat) are only identified through signs of their presence recorded in the field.
As the area is wooded, surveys of populations in the area reveal a strong presence of bats which are nocturnal mammals. **A serious study should be conducted in this context as it remains the species that could potentially collide with the wind turbines**.

All species in the families: *Falconidae* (*Falco tinnunculus*), *Accipritidae* (*Melieras metabates* and *Accipiter brevipes and Milvus migrans*) are birds of prey.

All the species noted are diurnal as the sightings took place during the day. However, the bats and mongooses that are mammals are nocturnal.
Birdlife refers mainly to the birds likely to frequent the sectors affected by the works during migration or nesting. Given that no birdlife acknowledged as significant exists, the environmental value of the birdlife must be qualified as low.

9.3.3.11 Impacts to the terrestrial wildlife

The occupancy of the site by the terrestrial wildlife must be analyzed to take into account all local ecological components, even if the issues are theoretically minor in relation to the specific wealth. Lastly, this analysis will ensure that the functionality of existing biological corridors is maintained.

9.3.3.11.1 Impacts forecast in erection phase

The erection of the wind farm will have an impact on the habitats (alteration, destruction) of small, less mobile species or those dependent on very local ecological nests in line with access roads or in the wind turbine footprint.

The herpetofauna (reptiles and amphibians) appear to be the most sensitive group of species in terms of their protection and conservation status, behavior and the specific habitats they occupy (rockfalls, dry grassland, temporary ponds, etc.).

The site activities will bring a risk of direct destruction of individuals in a protected species or its specific habitat. The largest and/or most mobile species, like the large mammals that roam vast habitats, will be less sensitive, even if the works must be deemed as a nuisance period.

They can affect the terrestrial wildlife directly by the installation of wind turbines, loss of habitat and increased accessibility to the region.

The impact from loss of habitat is all the more significant if quality habitats are rare in the sector or if the infrastructures are installed in critical habitats. There are none in the Taiba Ndiaye rural community.

During the erection phase, the lorry traffic, noise from construction equipment and increased human presence are likely to temporarily disturb the wildlife near the work areas. Clearing trees and laying out forest roads will fragment the habitat of some species and reduce its area. Remember that the Taiba Ndiaye project will require trees cleared from nearly 7 ha, i.e. only 0.35% of the study area, which is relatively little. Part of this cleared land will also be recolonized by early-successional species in the short and medium term. The magnitude of the disturbance is therefore deemed low. The scope of the disturbance is limited to the study sectors, more especially to the lands adjacent to the work areas, and short-lived. Given the low proportion of land affected compared with the land available for terrestrial wildlife, the inconvenience caused by the works will have a negligible impact on the wildlife inside the study sector, mainly because it can adapt easily to the human activities.

9.3.3.11.2 Impacts forecast in operating phase

During the operating phase, the most likely acknowledged impact is linked to the inconvenience to the wildlife from the operation of the wind turbines (blade noise and movement, maintenance work, etc.). Experience shows no loss of habitat or fragmentation of lands in the vicinity of wind turbines and phenomena of becoming accustomed to the sound emissions or the shade created.

Thus, the magnitude of the disturbance is qualified as low. As its scope is limited and long-lived, the significance of the impact is qualified as low.

To limit potential disturbances to the terrestrial wildlife from the presence of wind turbines, the following measures could be introduced:

- restricting the free area around the wind turbines;
- limiting access by wind farm employees to the wind turbine sites;
- speed limits on the roads.

9.3.3.11.3 Impacts forecast in decommissioning phase

The decommissioning activities could disturb the terrestrial wildlife. Nevertheless, the magnitude of the impact has been qualified as low, given the huge spaces where the wildlife can shelter during the works. As its scope is limited and short-lived, the significance of the impact is qualified as low.

9.3.3.12 Birdlife

Most of the species identified in the area are small. However, some species like the Black Kite and Cattle Egret are large.

The birds rest and feed in the area. Birds leaving the Djoudj Park for the Saloum Delta follow the strip of casuarinas in the coastal area. This is located some 5 km from the project area. It is therefore possible that the area is a migration corridor for birdlife. **However, observations must be carried out to identify the species passing through these corridors.**

9.3.3.12.1 Impacts forecast in erection phase

The birdlife is highly sensitive to all the types of work that will be undertaken in the area near to the wind farm. This is especially true for the nesting birds that risk being disturbed by the sound emissions of both personnel and machinery. The noise can cause stress in these animals and temporary displacement from nesting sites. It can also disturb the activities (hunting, fleeing from predators, communication between individuals), where natural sound signals are important.

However, this upheaval will be insignificant given that it is intermittent, short-lived and of limited scope.

In total, the impact of preparatory activities on the birdlife in the Taiba Ndiaye area will be of little significance.

9.3.3.12.2 Impacts forecast in operating phase

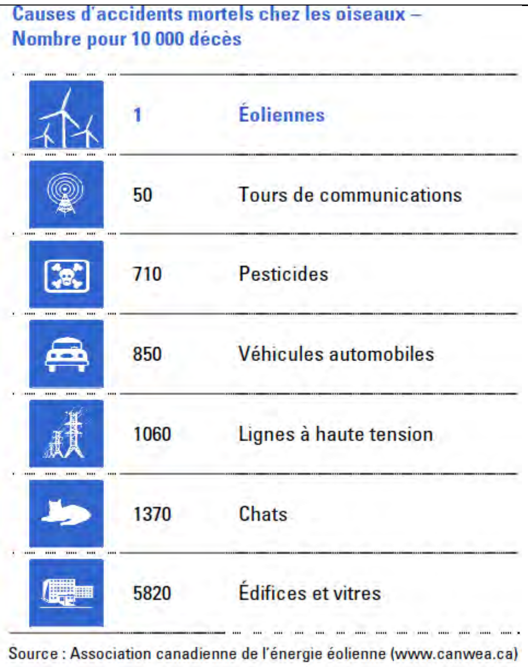
The risk of collision and the "barrier" effect (diversion of migratory trajectories) are the main impacts anticipated for birds.

Collisions occur normally because the birds do not sense the movement of the blades and hit them (direct collision with the wind turbine).

But lessons learned from miscellaneous observations (monitoring mortality, flight altitudes, avoidance tactics, etc.) of wind projects show that far fewer bird deaths are caused by colliding with the wind generator blades than by the common infrastructures or facilities (i.e. electric pylons of the Tobène plant or telecommunication installations in the municipality's region.

The following figure illustrates this assertion clearly.

Figure 49: Causes of fatal accidents listed in birds



Causes d'accidents mortels chez les oiseaux – Nombre pour 10 000 décès

1	Éoliennes	Wind turbines
50	Tours de communications	Communications towers
710	Pesticides	Pesticides
850	Véhicules automobiles	Automobiles
1060	Lignes à haute tension	High tension transmission lines
1370	Chats	Cats
5820	Édifices et vitres	Building Windows

Source : Association canadienne de l'énergie éolienne (www.canwea.ca)

Given that there is no bird migration corridor within the perimeter of the wind farm, the risks of diversion of migratory corridors is highly reduced.

It can therefore be said that the impact of the operation of 46 wind generators making up the Taiba Ndiaye wind farm will be negligible.

9.3.3.12.3 Impacts forecast in decommissioning phase

Despite a noisy ambience during dismantling and transfer of the wind farm equipment, no significant disturbance should be feared for the birdlife. The nuisances caused would be negligible. The disturbance can thus be qualified as low. It is short-lived and of local scope, which results in a global impact of little significance.

9.3.3.13 Impacts on the chiroptera

The importance of fruit arboriculture in the Taiba Ndiaye area confirms the surveys of populations in the area relating to the presence of bats which are nocturnal mammals. A serious study should be conducted in this context as it remains the species that could potentially collide with the wind turbines. [in progress]

9.3.3.13.1 Impacts forecast in erection phase

The cutting of trees to make way for access roads and the installation of wind generators will result in a direct loss of shelter for the bats that roost in the trees. Similarly the civil engineering and hoisting activities could generate passing trauma in bat populations. The rest or reproduction shelters, movement corridors and hunting environments may be destroyed or disturbed during the works phase and land clearance, excavation, earthworks, creation of

access roads or cable laying operations may diminish feeding patterns and the raising of young around installations.
Thankfully, the temporary nature of preparatory activities means that the impact will be of limited scope and will render the disturbance near work areas low.

9.3.3.13.2 Impacts forecast in operating phase

The main impact to be feared for the bat populations is the risk of mortality. Although it is still not entirely clear why bats hit the wind turbines, they can be killed following direct collisions with the blades or barotraumas, i.e. internal injuries caused by abrupt variations in pressure.

The other factors in impacts on the bats are still hypothetical and will required scientific validation before they can be considered objectively in this impact study. This involves the "barrier effect" on the displacement channels of resident species, the indirect attraction (currently not demonstrated) by the insects hunted by the bats, themselves attracted by the heat from the nacelle or the site lighting. Likely to be affected are the assumed curiosity of pipistrelles, the possible confusion between wind turbines and trees and the use of wind turbines during reproduction behavior.

On the other hand, the wind plays an important role in bat activity. Their activity normally drops significantly in wind speeds above 6 m/s (the activity level is reduced by 95%). The activity is concentrated in periods of no wind or very low wind speeds. Given the high speeds (40 km/h) required for the wind turbines to function, low bat mortality can be predicted at the foot of wind turbines in operation, with a low impact of the operation of wind generators on global bat mortality.

The inter-relations between the chiroptera and the wind turbine transport/traffic and maintenance activities are insignificant, as for the birds, in terms of disturbance by the workers, as only about twenty workers will be required to circulate in the wind farm area for maintenance.

9.3.3.13.3 Impacts forecast in dismantling phase

The dismantling of equipment that has recently killed and disturbed chiroptera populations would only be beneficial in the sense that the tree stratum will be recomposed by planting activities. It is therefore new habitats and new biotopes favorable to the development of this wildlife.
In addition, the work will be less substantial than in the construction phase (no road construction or improvement). Lastly, the vehicles will travel at reduced speed on the roads and mainly during the day.

Table 50: Impacts of the wind farm on the terrestrial wildlife and birdlife

Phase	Activity	Nature of the impact	Scope	Period	Magnitude	Significance of the residual impact
Development of plinths and access roads	Preparing foundations Clearing trees for roads Excavation work Raising wind turbines	Negative	Local	Temporary	Intermediate	Average
Operation of wind generators, technical room, etc.	Optimum operation of wind generators Electric power generation and transport	Negative	Local	Temporary	Intermediate	Low
Dismantling of the wind farm	Decoupling the farm Removing the wind turbines Dismantling the foundations Withdrawing the power sub-station Reinstating the site	Positive	Local	Permanent	High	High

9.3.3.14 Environmental impacts on the human environment

The components of the human environment with an environmental value likely to be impacted by the installation of the Taiba Ndiaye wind farm can be summarized around the following impacts:

- ecological benefit,
- repercussions on the local and national economy,
- land use,
- infrastructures and services,
- archaeology,
- visual environment,
- acoustic environment,
- public safety,
- quality of living environment,
- stroboscopic effects,
- electromagnetic impacts and low frequencies.

9.3.3.15 Ecological impact

The generation of electric power due to the gradual installation of the 46-generator-strong wind farm will constitute a clean project that will make a significant contribute to reducing anthropic greenhouse gas emissions in a global context of adapting to climate change.

As such, the advent of a power plant of 151.8 MW using wind power signals strongly the desire of the Senegal government authorities to campaign for renewable energy sources and introduce the "energy mix" into the electric power generation process to break from the weight of fossil energy in the trade balance. In addition, the proximity of the power plant to Tobène, installed in fact in an energy-consuming industrial mining environment (ICS), could be an outlet. In addition, wind power produces no greenhouse gas.

Thus, the annual production of the wind farm for eight to nine hours of production equivalent to the rated power of machines for about 365 days of operation would represent an estimated total of at least 467,000 MWh/year for the entire project.

Compared with identical electricity generation of a traditional plant, the wind farm envisioned in the Taiba Ndiaye location will prevent waste production, atmospheric emissions, fossil fuel combustion, taking surface water and groundwater and thermal and chemical discharges in natural outfalls.

In addition, the project is going to participate in avoiding each year about 4305 tons CO2 per wind turbine compared with a traditional thermal production of the same power. These CO2 savings will be promoted in CDM projects with an envisionedenvisioned price of more than 1,000 CFA francs per ton of CO2.

The eligibility of the Taiba Ndiaye wind project for the UNFCCC's Clean Development Mechanism (CDM) is a long process that has taken more than thirty months.

The Developer hired the company ESBI as a carbon consultant in Autumn 2009. ESBI is a subsidiary of ESB, the Irish Electricity Supply Board, which will support it in the various CDM development phases. UNFCCC approved the project on 29 February 2012.

Table 51: Comparison of emissions of different electric power generation modes

Parameters	Quantities of waste for	Specific emissions*	Annual savings for 46 wind turbines

		(2002)		
TRADITIONAL	Industrial waste production	2,539 tons	0.186 g/kWh	50 tons
	Fly ash			
	Production	202,747 tons	14.85 g/kWh	215,200 tons
	Power sales	219,950 tons	16.11 g/kWh	
NUCLEAR	Waste production	56.52 m^3	4.14 m^3/TWh	1.1178 m^3

9.3.3.16 Socio-economic impacts

The potential economic benefits (local taxes, labor, supply of goods and services, etc.) anticipated from the wind farm installation and operations give it huge environmental value; it could boost both the local and regional economy.

9.3.3.16.1 Impacts forecast in erection phase

The execution of the Taiba Ndiaye wind farm project would inject more than €270 million for the construction of the 151.8 MW wind farm and 110 billion CFA francs into the Senegalese economy, in addition to the jobs (temporary and permanent) created. Over one thousand jobs are anticipated (about ten jobs per MW according to the European Wind Energy Agency).

Specialized equipment and workers will be needed to transport and raise the wind turbines and the activities relating to the excavation, levelling and transport of granular materials will no doubt necessitate hiring local and regional workers with fewer qualifications or local populations with no qualifications at all. It goes without saying that where costs and skills are equal PETN will ideally privilege employing local workers.

Beyond that, the municipality of Taiba Ndiaye has an opportunity here to broaden its tax base by collecting taxes to be paid by PETN for construction permits and other miscellaneous taxes.

The installation work of the wind generator farm will bring in their wake:

- a boom in small trader activity in the Mboro area, through retail trading stalls, accommodation and catering for local workers and those from outside the locality.

- the advent of SME and SMI and sub-contractors orbiting around the wind industry, thereby consolidating several jobs in the Thiès region.

The impact of the project is positive in terms of economic consequences. Its magnitude has been qualified as high, its scope is local and regional and it is short-lived. Overall, the significance of the impact is qualified as **high and positive.**

9.3.3.16.2 Impacts forecast in operating phase

The operational phase (power generation and maintenance) of the 46-generator-strong wind farm will be run by fewer staff than the installation phase but is important for the local economy. As for the erection phase, local and regional purchases of goods and service are a considerable financial godsend for the local authorities, populations and service providers. Its magnitude has been deemed moderate given the number of jobs created considered to be more modest. Its scope is local and long-lived. Therefore, the significance of the impact is **high and positive.**

During operation, the company will pay all legitimately due taxes to the tax authorities; in particular, a local tax, the "Patente" will be paid annually to the Taiba Ndiaye rural community. This tax is estimated to be about 2.5 million euros (more than 1,9000,000,000 CFA francs) a year and represents an amount corresponding to more than twelve times the current annual budget of the Taiba Ndiaye rural community.

9.3.3.16.3 Impacts forecast in decommissioning phase

The dismantling of the Taiba Ndiaye wind turbine complex will have a dual repercussion on the economy.

Firstly, the specific decommissioning activities will lead to not insignificant, but positive economic consequences. The impact will be short-lived and the work will require hiring people from the locale and the region. The significance of the residual impact therefore remains low and positive.

The second dimension of the impact will be negative, in the sense that the dismantling could be synonymous with job and income losses for people drawing all or part of their income from the operation and maintenance of the wind farm. The magnitude will be considered moderate and the scope local and short-lived, as the people involved could potentially find a job given the promising future of clean, renewable energy production methods in Senegal. The importance of the global impact is therefore qualified as moderate and negative. It must be stated that at the end of the life cycle (in about 25 years), nothing will prohibit reconstructing the site with new wind turbines.

9.3.3.17 Impacts on land use and services offered by the ecosystems

The wind farm footprint is basically given over to agro-forestry (agriculture, market gardening and gathering. Expert assessments and the perception of the public, mainly the local populations and elected representatives, and the decentralized State structures indicate that the environmental value varies depending on the demographic weight, but that in general it can be qualified as high.

9.3.3.17.1 Impacts forecast in erection phase

- ✓ **Exploitation of land and natural resources**

The crisis in the peanut sector due to low yields of soils has turned the populations in the Taiba Ndiaye locality towards more lucrative crops such as fruit arboriculture, tubers and market gardening in family holdings of about five hectares on average.

Activities to prepare the 46-generator-strong wind farm will no doubt hinder farming and market gardening activities in the villages of Ndomor, Keur Malé, Minam, Mbayéne, Keur Birama, Keur Samba Awa, Keur Mbaye Sénoba, Taïba Mbaye, Same Ndiaye, Baïty Ndiaye Baïty Gueye, Keur Madiagne and Taïba Santhie and Keur Assane.

This hindrance to the activities is relative considering that the surfaces to be developed will only cover 7.5 ha, i.e. only 0.1% of the study area. This is fairly insignificant even when pointing out the presence of species with high commercial value that constitute the main sources of income for the farmers: mango trees, cassava, cash crops, marketing gardening, etc.

However, the loss of use and profits drawn from operating ecosystems and the services they provide should not be overshadowed. Arboriculture, agriculture, picking, pharmacopoeia, construction and crafts represent substantial sources of income and also miscellaneous services and uses for the populations owning the lands affected by the wind farm footprint.

In addition, the installation of wind turbines in farming areas, despite not being in any way a hindrance to production and services beyond the footprint limits after their construction, the fact remains that a shortfall will persist due to the restriction in accessing and using resources.

Appropriate scheduling of works and installing suitable signs will facilitate the sequence of activities with the other users of the site.

This will mitigate the magnitude of the impact, thus deeming it as low, for only the increased number of workers and traffic in the farming and marketing gardening lands will affect the exploitation of natural and land resources. The scope of the impact will be limited and short-lived. Thus, the significance of the impact is qualified as low.

- ✓ **Road transport and traffic**

The erection work could cause impacts to the areas surrounding the wind turbine installation areas. Vehicle and machinery traffic to transport the wind turbine components may have an impact on the safety in terms of accident risks of road users (Tivaouane-Mboro) and production tracks (Taiba Ndiaye - Niayes and Djingué area - Mboro road) and the longer journey time given the circulation of large carriers on these main access roads to the various sites.

The most significant sources of impact on traffic relate to:

- The needs of the site's living quarters and earthworks machinery;

- The arrival of heavy equipment used for the construction: flattening the land, levelling high spots, widening bends and creating foundations;
- The delivery on large carriers of wind turbine components (tower, nacelles, blades, etc.). They will be brought to the site by lorry, requiring several convoys and turnarounds given the size of constituent wind generator components;
- The delivery of construction materials, mainly concrete, cement and sand required for the wind turbine plinths. About 400 to 450 m^3 will be required for each foundation, which means on average sixty to seventy concrete mixer trucks per foundation.

- The arrival of workers in the morning and their departure in the evening.

The transport on site of wind generator components will require wide loads. This implies extra load on the axle likely to impact the state of roads and tracks taken by the numerous HGV turnarounds between Dakar and Taiba Ndiaye.

Over and above this extra load, the size of convoys could cause a disturbance by slowing down traffic between Dakar and Tivaouane.

Overall, the magnitude of the impact on road transport linked to the erection of the wind farm is deemed moderate with regional and short-lived scope.

9.3.3.17.2 Impacts forecast in operating phase

- ✓ **Exploitation of land and natural resources**

During the wind farm operating period, there will be no significant negative impact on the exploitation of natural resources and agricultural activities, all the more so that the agricultural areas will be accessible provided there is no infringement on the footprint allocated to each wind turbine.

- ✓ **Road transport**

The road traffic attributable to the 46-generator-strong wind farm will be substantially reduced in that it will only involve light vehicles transporting the machinery monitoring and maintenance personnel. "Escorted" large carriers will only be mobilized for a relatively short time for major repairs requiring replacement of components (blades, turbine, etc.) or engine oil changes. Their impact on the transport of necessary equipment would be minor and short-lived.

- ✓ **Air transport**

The project area has no airport infrastructures but during the wind farm operating phase, in addition, compliance with minimum flying altitudes in the region, miscellaneous measures applied for the wind farm will ensure the safety of aircraft travelling this region of the Niayes, which has benefited from several projects. Let us state also that the wind farm will be signed in accordance with ICAO standards.

In short, no impact is forecast on air traffic, all the more so that there are no aeronautical constraints in the area of influence of the Taiba Ndiaye wind farm.

9.3.3.17.3 Impacts forecast in decommissioning phase

- ✓ **Exploitation of land and natural resources**

The decommissioning phase of a 46-generator-strong wind farm will certainly mean increased local and regional traffic.

This phase will necessitate the following activities:

- Installing the site which will involve mobilising construction machinery;
- Decoupling the farm;
- Dismantling of wind turbines with the hoisting equipment and storing them, which will necessitate a large amount of space;
- Transporting spare parts from the wind farm to a dedicated site;
- Dismantling the foundations;
- Withdrawing the power sub-station.

However, considering the limited and short-lived scope of the said works, the magnitude and significance of the impact are qualified as low.

- ✓ **Road transport**

The dismantling of the wind farm equipment and infrastructures will cause disturbances and potential impacts to the safety of road users. The number of journeys required to transport the various sections of 46 wind turbines will be the same as required for the erection phase, except for the concrete mixer trucks. The magnitude of the disturbance is deemed moderate, with a regional and short-lived scope. Thus, the significance of the impact is qualified as moderate.

9.3.3.18 Impact on the basic infrastructures

The basic infrastructures (tracks, roads, base equipment, public buildings, socio-cultural infrastructures, buildings, etc.) do not have legal environmental protection and the social value remains relatively low. This element of the human environment has therefore been deemed as having a low environmental value.

On the other hand, the environmental value of public roads providing access to the study area is qualified as moderate.

- ✓ **Air transport**

The wind farm decommissioning phase will have no impact on air traffic and flyover.

9.3.3.18.1 Impacts forecast in erection phase

- ✓ **Drinking water supply**

The likelihood of soiling the populations' drinking water supply network is minimal, all the more so that the two drinking water reservoirs of Taiba Ndiaye are not located in the wind farm footprint. The only fear could be accidental pollution of the water table captured by the two boreholes following an accidental spillage of hydrocarbons from construction machinery on the two host sites. The magnitude of such an impact is qualified as moderate. Its scope would be local and short-lived. In addition, the measures taken to contain and eliminate the contaminants could be applied rapidly.

- ✓ **Road infrastructures**

The heavy loads on the axles of lorries transporting the materials and equipment required to erect the wind farm could contribute to the wear on the surface layers of the departmental road 702 as well as the other access roads to Taiba Ndiaye. The transport of wind turbine components, earthworks and civil engineering materials and wind turbine superstructures could cause deterioration of the road network and degrade the surrounding tracks.

Given the relatively poor state of roads and surrounding tracks, the impact of the transports on the road network will be moderate. The use of multi-axle trailers appropriate for the load will reduce the damage to the road network considerably. The scope of the impact is qualified as regional, as it is above all the transport of concrete and wind turbine components that should have an impact on the road network. The duration of the impact is qualified as moderate, as the possible damage could last longer that the transport operations themselves. Nevertheless, the significance of the residual impact remains low.

A network of new, stabilized tracks will have to be built to provide access to the wind turbines. This will cover about 35 km for a width of 5 m on straight lines and about 8 to 10 m when changing direction. These new roads are going to reduce the cultivated plots marginally, but they will however remain open and available. This will make it easier for the farmers to reach their cultivated land.

The presence of a cemetery has been taken into account during the access road identification phase and the access road passing nearby will make a substantial detour.

- ✓ **Grid**

The existing grid should not suffer from operations relating to the installation of wind generators. At most temporary inconveniences should be expected when connection the generation from the park to the Tobène grid. It is planned to connect sub-stations at the foot of wind turbines to the Tobène station underground. The benefit hoped for, to increase the production capacity and electric power supply to populations, is disproportionate to the occasional temporary inconvenience of work on connecting the two networks. Senelec should perform this activity and will schedule the distribution of power as a result so as to lessen the risks of load shedding.

The impact on the grid and the power distribution will be considered as low.

- ✓ **Telecommunications**

The infrastructures dedicated to the telecommunications found in the Taiba Ndiaye municipality will not be impacted by the erection of the wind farm. The telephone network should not be unduly disturbed.

- ✓ **Air transport**

The wind farm erection phase will have no impact on air traffic.

9.3.3.18.2 Impacts forecast in operating phase

- ✓ **Drinking water supply**

Maintaining and inspecting the correct operation (sub-station, access roads and wind turbines) of the wind generators are the main activities during operation of the wind farm and are not a notable source of nuisances for the water supply network and quality intended for drinking. Any hydrocarbon spill will be quickly contained. Thus, the significance of the impact in question is qualified as low.

- ✓ **Road infrastructures**

The road and tracks will carry less load during the commissioning of wind turbines. Only maintenance vehicles (vans) will circulate on the access roads (departmental road 702) to access the wind farm. Limited heavy loads could occur in the event of extraordinary breakdowns justifying the replacement of a blade or turbine. During these events, the transport of components will cause a low magnitude and short-lived disturbance.

Thus, the significance of the envisioned impact is qualified as low.

- ✓ **Grid**

The distribution network may experience some disturbance during commissioning of the wind farm that will alter the management of certain high voltage lines. This is to take account of the new generation from the wind turbines.

All these minor disturbances will be short-lived. The residual impact is therefore negligible.

- ✓ **Telecommunications**

The electric cable network used will be equipped with fibre optics. There will therefore not be a telephone cable. The wind farm will thus be managed remotely via fibre optics. It is difficult at this stage to state the potential interference with the telecommunication operator network.

On this point, a sectorial study on the telecommunications systems should be conducted to eliminate all the possible conflicts with the microwave connections exploiting this site and thus protect the miscellaneous mobile radio systems installed in this structure. Feedback until now on the sites constructed elsewhere has revealed no impact on the transmission of radio telephone systems.

Thus, the magnitude is perhaps qualified as low, the scope is local and long-lived leading to a residual impact of little significance.

9.3.3.18.3 Impacts forecast in decommissioning phase

- ✓ **Drinking water supply**

When dismantling the wind farm, all the special precautions and interventions faced with any fuel spilling accidentally from site vehicles will be highlighted. Thus, even the installation of new drinking water taps over the next few years will not affect the water supply. The importance of the forecast impact is therefore qualified as low.

- ✓ **Road infrastructures**

During the decommissioning phase, the transport of different components could cause deterioration of the road network. The magnitude of this disturbance has been qualified as moderate, as the regulations in force at that time will apply. Its scope is regional and short-lived, which means that the residual impact has been qualified as of little significance.

- ✓ **Grid**

No specific impact will affect the grid during the decommissioning phase.

- ✓ **Telecommunications**

No specific impact will affect the telecommunications during the decommissioning phase.

9.3.3.19 Impacts on the cultural heritage

Archaeology, which is linked to the heritage, has a legal connotation in addition to its importance for many people. Investigations of the land have not shown up any archaeological remains and the environmental value for archaeology has therefore been qualified as low.

9.3.3.19.1 Impacts forecast in erection phase

The survey work and public consultation did not list the existence of remains or sites of historical and cultural interest throughout the study area. But places of worship (mosques) and graves in the area away from the farm have been listed. No negative impact on the cultural and religious heritage is therefore noted.

9.3.3.19.2 Impacts forecast in operating phase

The commissioning of 45 wind generators will have no effect on the religious heritage of the Taiba Ndiaye municipality.

9.3.3.19.3 Impacts forecast in decommissioning phase

No potential negative impact on the places of worship and cemeteries in the municipality is anticipated during the dismantling of the wind farm.

9.3.3.20 Impact on the landscape

The rural landscapes, whether natural or developed, are often a cause for concern. Although different people view their significance differently, their environmental value has been qualified as high.

Creating and altering existing roads and creating roads intended for the operation, maintenance or, if appropriate, discovery of wind turbines can cause various consequences on the site:

- potentially too many visits due to opening up new access or altering existing roads;
- conflicts of newly-juxtaposed practices due to easier access for motorized vehicles;
- site abandoned by some of its users following the installation of wind turbines.

The works have direct and indirect effects on the nearby landscape. Building or widening access roads, earthworks, grubbing out trees, compacting the soil, destroying low walls or weeds appearing due to earth being brought in from outside all have diverse consequences:

- destruction of the existing vegetation and opening up of views;
- alteration in the color and plant appearance of the site;
- partial or total land take of the site (roads, banks, areas without plants, etc.).

The problem for the project is in the visible dimension of proposed equipment combined with an agricultural environment relatively valued for its landscapes. It is difficult to conceal the telecommunications and HV electric power transmission infrastructures in the landscape. They have in no way denatured the agrarian landscape of the municipality of Taiba Ndiaye. Although larger, the wind generator towers should not create visual pollution.

The wind farm should therefore integrate well with this panorama that is already familiar to the populations in the locality of Taiba Ndiaye. The project has also been designed in a spirit of structuring and arranging the landscape by creating straight lines of wind turbines. The alterations in the landscape (linked to the perception of fifty or so wind turbines in the background) will be felt for the lifetime of the wind turbines.

The significance of the impact is deemed average given that the area affected by the impact is large.

9.3.3.21 Impact on noise exposure

9.3.3.21.1 Impact in erection phase

During the site phase, the noise exposure in the footprint of the future wind farm will rise substantially. The soil characterization preparatory work (surveys and geotechnical tests) and the construction of the wind farm which is a huge development will mobilize heavy machinery for arranging and/or construction roads and inter-wind turbine roads: flattening the land, levelling high spots, widening bends, etc.

Table 52: Sound levels of construction machinery at variable distances

Sound level expressed in dB (A) (Leq (1-h)) depending on the distance						
Equipment	**15 m**	**76 m**	**152 m**	**305 m**	**762 m**	**1,524 m**
Bulldozer	85	71	65	59	51	45
Crane	88	74	68	62	54	48
Loader	85	71	65	59	51	45
Generator	81	67	61	55	47	41
Grader	85	71	65	59	51	45
Shovel	82	72	62	56	48	42
hydraulic						
Lorry	88	74	68	62	54	48

Source: **US Department of the Interior, 2005**

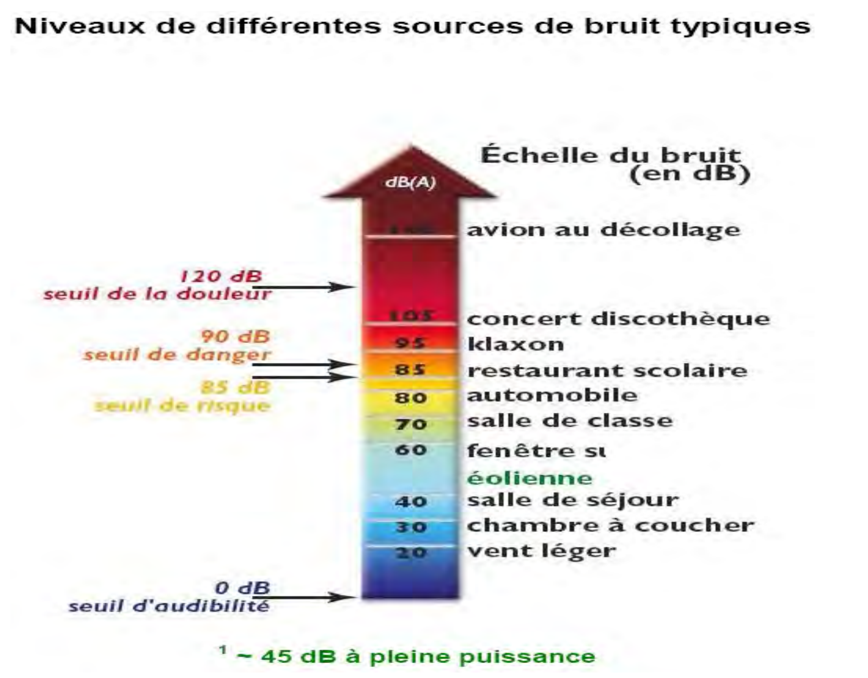
There are many sources of noise in wind power sites, the main ones being pneumatic drills, engines and reversing beepers of transport or hoisting machinery, etc. Acoustic levels can exceed the exposure thresholds stipulated by the regulations and cause damage to personnel and local residents.

Apart from injury to the hearing system (hearing loss, tinnitus, etc.), the ambient noise can cause inconvenience or stress with psychic disorders and pathologies that harm not only the health of workers but also safety through a drop in vigilance.

Given the limited scope of works and protective measures (PPE) that will be made available to the personnel, the impact and potential damage can be considered as moderate.

9.3.3.21.2 Impact in operating phase

One of the greatest myths about wind turbines is the noise they generate. Wind turbines make a noise, however not very much.



Noise levels from different sources

Noise levels

Airplane take off

Discoteque music
Horns
School restaurant
Automobiles
Classroom
Wind turbines
Living room
Bedroom
Light wind

Figure 50: Levels of various typical sources of noise

The audible noise is caused by the wind sliding along the blades and by the generator. Nevertheless, new blade and generator technologies have reduced noise levels significantly.

It is therefore possible to stand at the foot of a wind turbine tower and carry on a normal conversation without raising one's voice.

Simulations based on wind blowing at 5 to 8 m/s and illustrated on the following maps confirm the statements below.

Within this range of wind speed, the contribution to the background noise of the wind farm is significantly less than 40 dB (A) (living room noise) within the proximity of any dwellings on the project site (max. about 36-37 dB (A)).

It is reminded that the Taiba Ndiaye wind farm is mainly erected in an agricultural and semi-industrial environment (ICS mines) on private land

For information, the wind turbines positioned closest to Villages are as follows:

ID	Village	Closest Wind Turbine	Distance in Km	Municipality	Status
1	Diamballo	E01	1,4	Darou Khoudoss	without PAP
2	Keur Saliou BA	E01	1,6	Taiba NDIAYE	without PAP

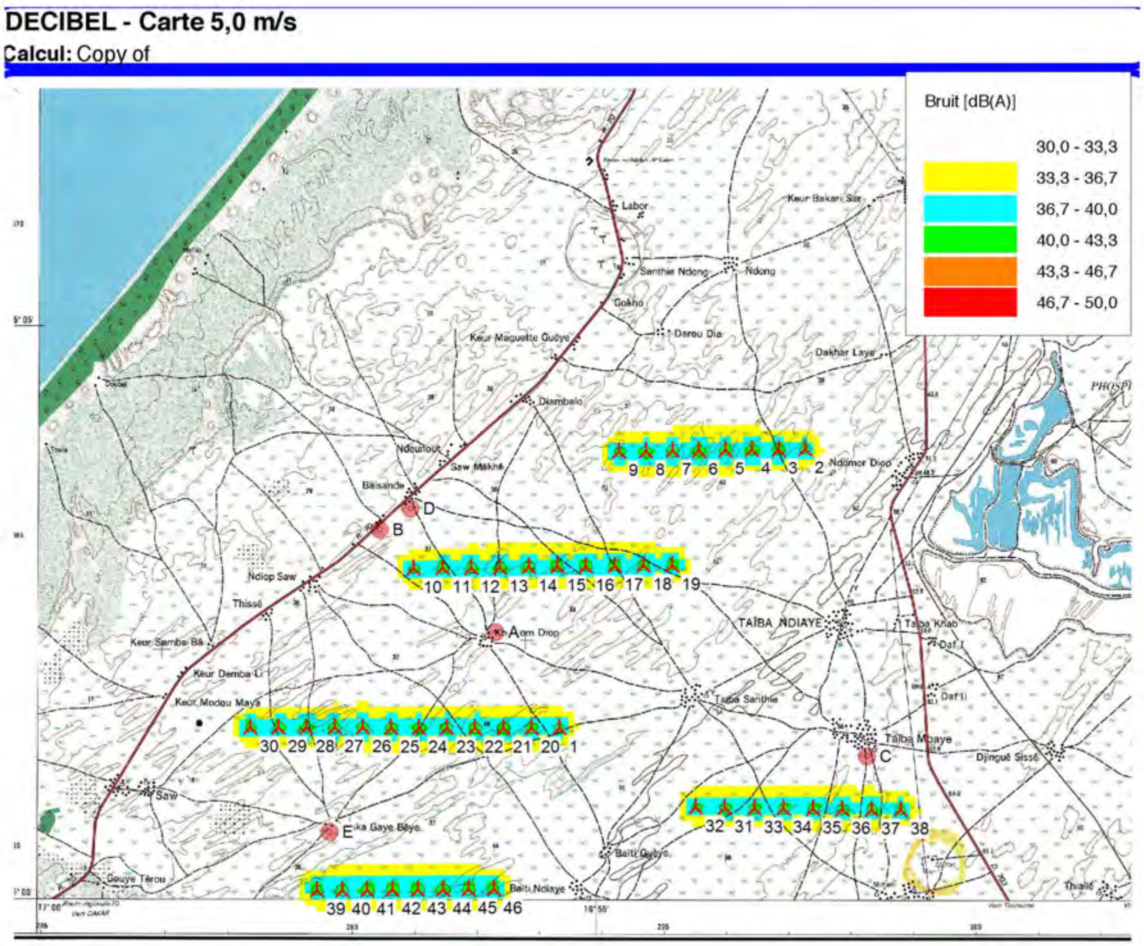
ID	Village	Closest Wind Turbine	Distance in Km	Municipality	Status
3	Ndeunoute	E01	1,7	Darou Khoudoss	without PAP
4	Keur Demba Diallo	E03	1	Taiba NDIAYE	with PAP
5	Darou Dia	E03	1,8	Taiba NDIAYE	with PAP
6	Ndomor	E08	1,5	Taiba NDIAYE	without PAP
7	Taiba Khab	E38	3	Taiba NDIAYE	with PAP
8	Balsande (Bal Samb)	E09	0,96	Darou Khoudoss	with PAP
9	Mourdjiguène	E09	0,826	Darou Khoudoss	with PAP
10	Baal Gueye	E09	1	Taiba NDIAYE	with PAP
11	Ndiop Sao	E09	1,2	Darou Khoudoss	with PAP
12	Thieno Ndiaye	E10	1,3	Taiba NDIAYE	without PAP
13	Sao Mékhé 1	E10	1,6	Darou Khoudoss	without PAP
14	Sao Mékhé 2	E11	1,7	Darou Khoudoss	without PAP
15	Taiba Ndiaye	E18	2,6	Taiba NDIAYE	with PAP
16	Mérina Samb	E19	1,8	Taiba NDIAYE	with PAP
17	Sao2	E19	1,7	Darou Khoudoss	without PAP
18	Thissé III	E19	1,8	Taiba NDIAYE	with PAP
19	Khelcom (Baal Diop)	E12	1,04	Taiba NDIAYE	with PAP
20	Baity Guèye	E31	1,4	Taiba NDIAYE	with PAP
21	Taiba Santhie	E31	1,4	Taiba NDIAYE	with PAP
22	Baity Ndiaye	E31	1,9	Taiba NDIAYE	with PAP
23	Taiba Mbaye	E37	0,86	Taiba NDIAYE	with PAP
24	Ndiamba	E37	1,6	Taiba NDIAYE	without PAP
25	Macka Gueye Beye	E40	0,96	Taiba NDIAYE	with PAP
26	Keur Mallé Ndiaye	E38	1,2	Taiba NDIAYE	with PAP
27	Miname	E38	1,2	Taiba NDIAYE	without PAP
28	Daf2	E38	1,8	Taiba NDIAYE	without PAP
29	Daf1	E38	1,9	Taiba NDIAYE	without PAP
30	Djingue	E38	2,5	Taiba NDIAYE	with PAP
31	Keur Assane Ndiaye	E46	1,2	Taiba NDIAYE	with PAP
32	Keur Madiagne	E46	1,7	Taiba NDIAYE	with PAP
33	Same Ndiaye	E46	1,9	Taiba NDIAYE	with PAP

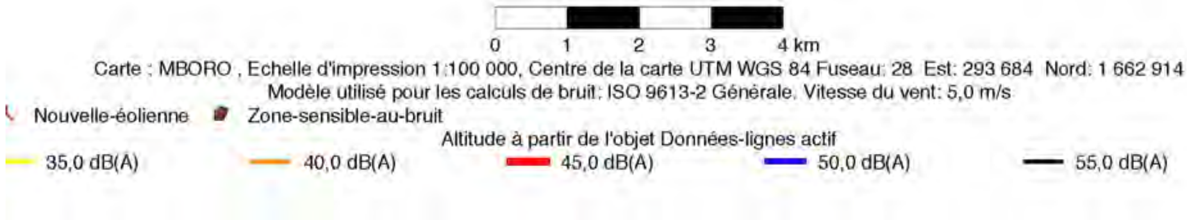
It therefore appears that the human settlements which are located on average more than 1250 m from any single wind turbine (the nearest) and more specifically those within 1000 m (in particular the dwelling closest to a turbine in the village of Balsande (Bal Samb) is 960 m from wind turbine E09; the dwelling closest to a turbine in the village of Morudiguene is 826 m from wind turbine E09; the dwelling closest to a turbine in the village of Taiba Mbaye is 860 m from wind turbine E37; and the dwelling closest to a turbine in the village of Macka Gueye Beye is 960 m from wind turbine E40) will not be subjected to any particular sound nuisance.

Also in the study area can be found farm and forestry workers near the wind turbines thus activities are conducted in open areas.

To summarize, the magnitude will be low, the scope will be limited and short-lived, which results in a moderate impact on the sound environment.

Map 11: Map of estimated equal loudness curves for wind conditions of 5 m/s





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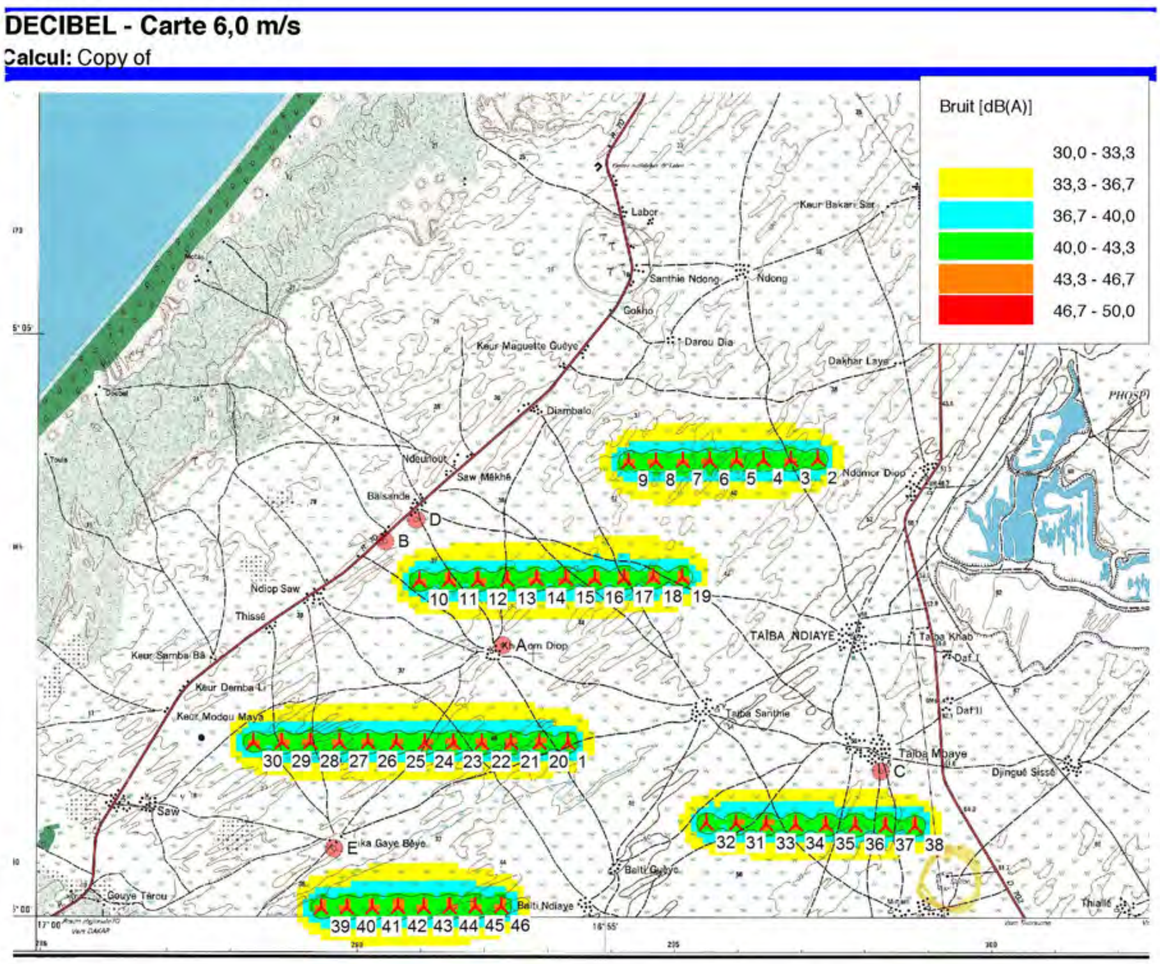
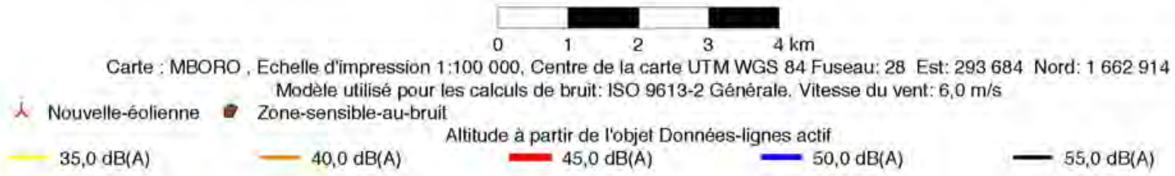
The design notes illustrated below are based on:

- *A hypothesis of an increase in sound level according to the conservative local wind speed (+2 or +3 dB(A) per m/s above 5.0 m/s);*
- *A hypothesis of noise propagation with mitigation of agricultural land, without however taking account of the plant cover.*

Map **12** Map of estimated equal loudness curves for wind conditions of 6 m/s

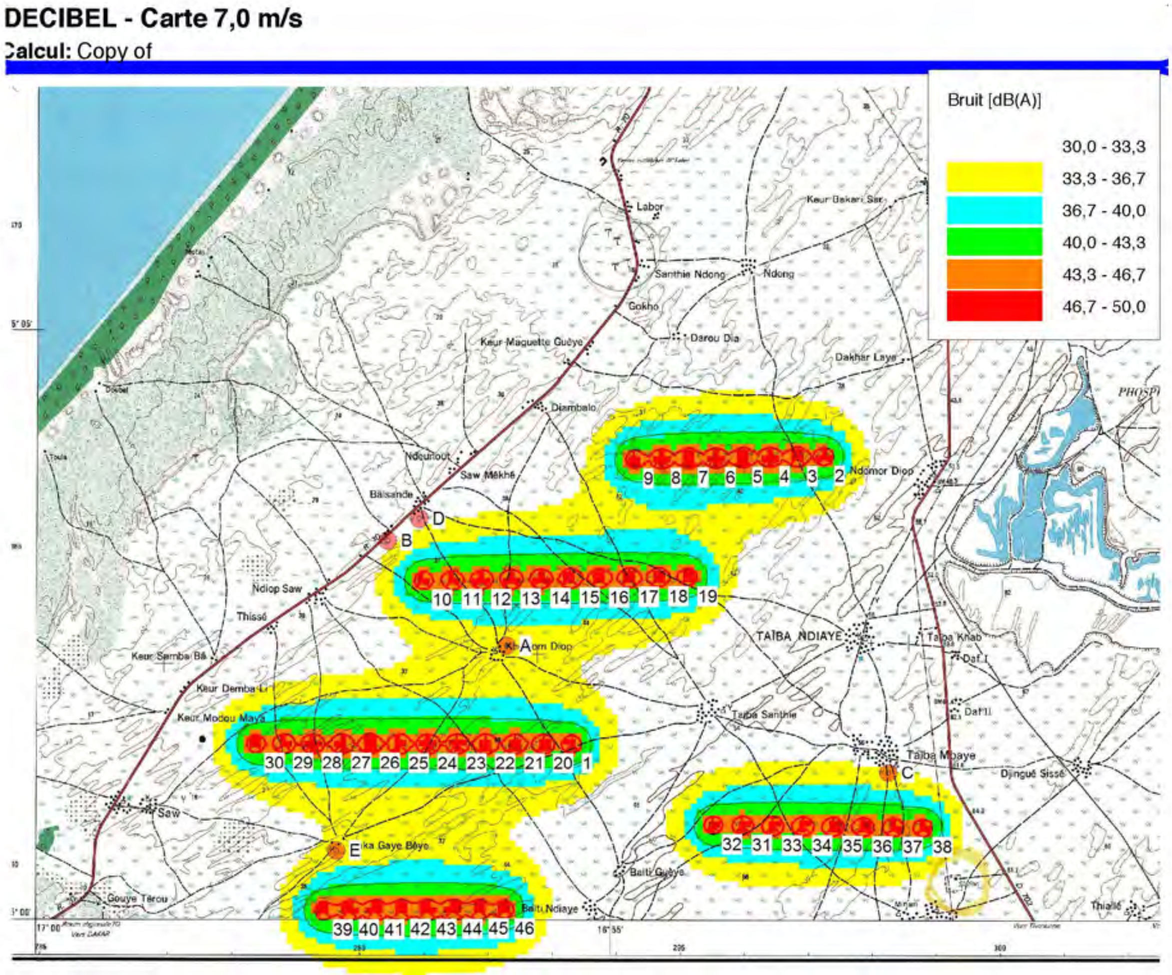


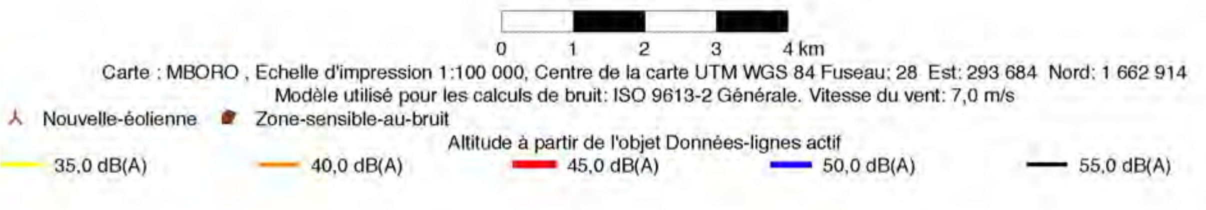


The design notes illustrated below are based on:

- *A hypothesis of an increase in sound level according to the conservative local wind speed (+2 or +3 dB(A) per m/s above 6.0 m/s);*
- *A hypothesis of noise propagation with mitigation of agricultural land, without however taking account of the plant cover.*

Map 13 Map of estimated equal loudness curves for wind conditions of 7 m/s

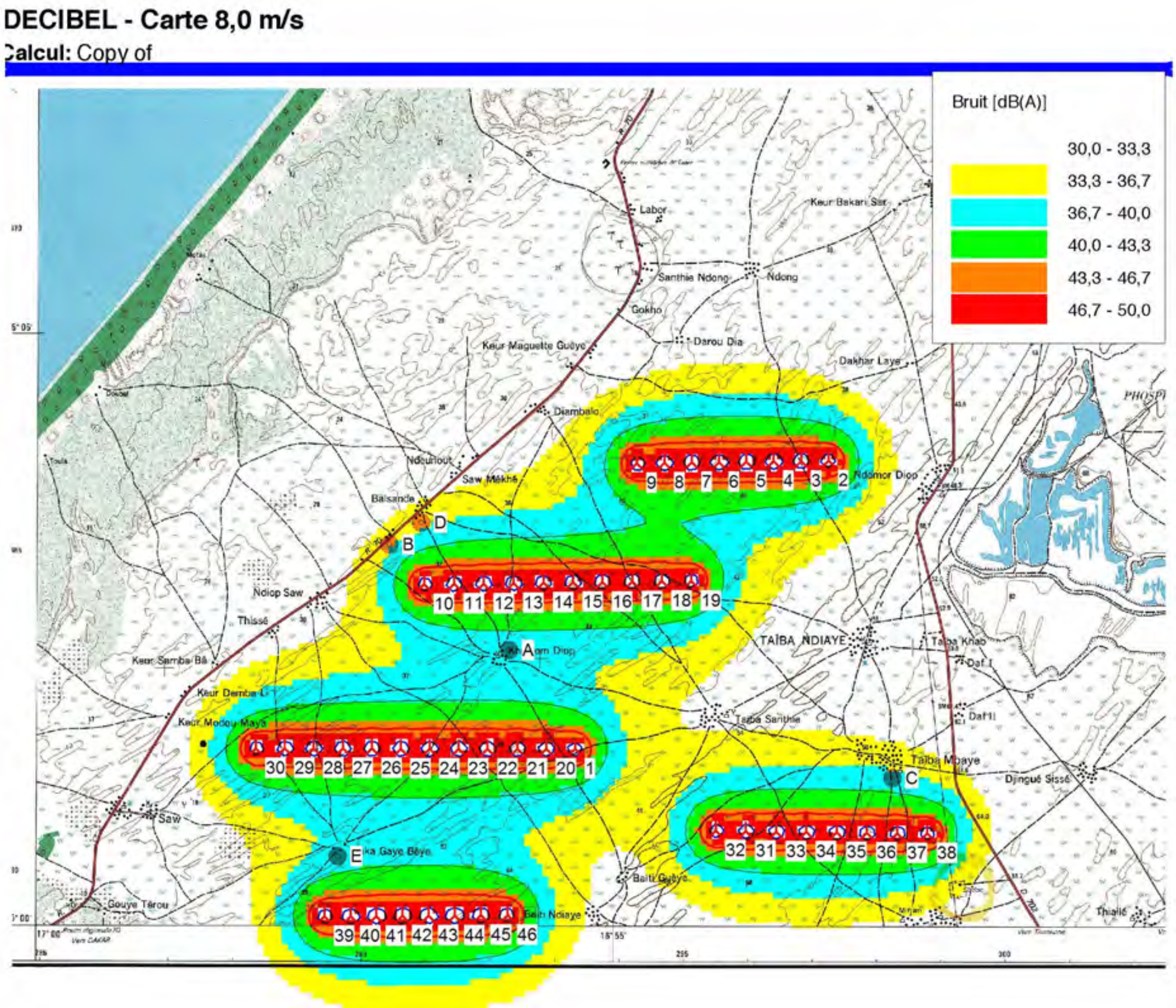


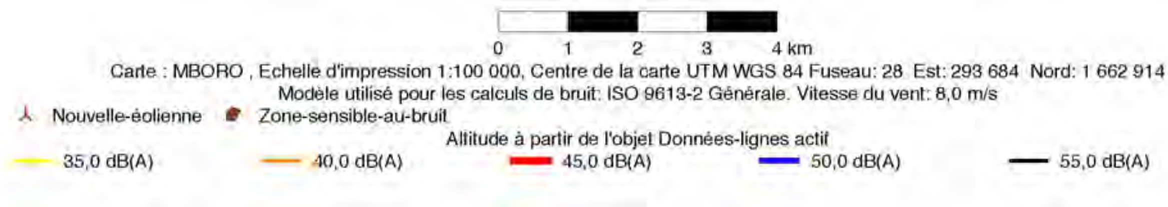


The design notes illustrated below are based on:

- *A hypothesis of an increase in sound level according to the conservative local wind speed (+2 or +3 dB(A) per m/s above 7.0 m/s);*
- *A hypothesis of noise propagation with mitigation of agricultural land, without however taking account of the plant cover*

Map 14 Map of estimated equal loudness curves for wind conditions of 8 m/s





The design notes illustrated below are based on:

- *A hypothesis of an increase in sound level according to the conservative local wind speed (+2 or +3 dB(A) per m/s above 8.0 m/s);*
- *A hypothesis of noise propagation with mitigation of agricultural land, without however taking account of the plant cover.*

Figure 51: Design note of the estimated onset of sound [5.0 - 10.0 m/s] - villages of Kelkhom Diop, Mourdjiguène, and Taiba Mbaye

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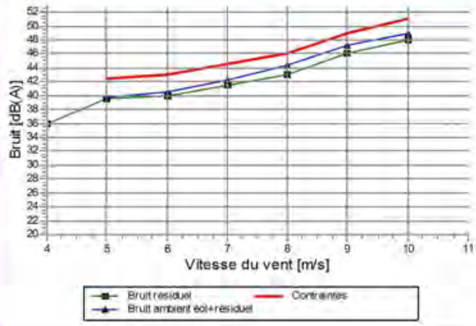
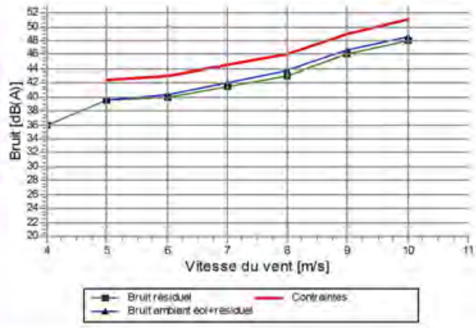
Calcul: Copy of **Modèle utilisé pour les calculs de bruit:**ISO 9613-2 Générale

Kelkhom Diop (A)



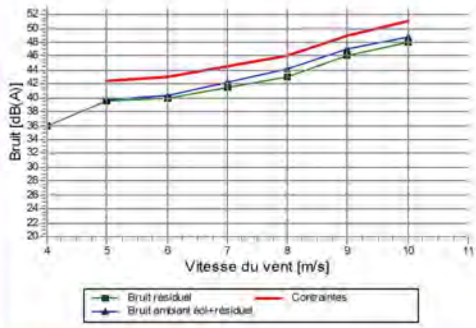
	Contraintes	Niveaux sonores		Résultats	
Vitesse du vent	Bruit résiduel	Emergence max. permise	Bruit éoliennes	Bruit ambiant éol+résiduel	Emergence	Contrainte respectée ?
[m/s]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	
5,0	39,5	3,0	27,7	39,8	0,3	Oui
6,0	40,0	3,0	30,6	40,5	0,5	Oui
7,0	41,5	3,0	34,6	42,3	0,8	Oui
8,0	43,0	3,0	38,3	44,3	1,3	Oui
9,0	46,0	3,0	41,1	47,2	1,2	Oui
10,0	48,0	3,0	41,7	48,9	0,9	Oui

Mourdjiguène (B)



Vitesse du vent	Bruit résiduel	Contraintes: Emergence max. permise	Niveaux sonores: Bruit éoliennes	Niveaux sonores: Bruit ambiant éol+résiduel	Résultats: Emergence	Contrainte respectée ?
[m/s]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	
5,0	39,5	3,0	25,3	39,7	0,2	Oui
6,0	40,0	3,0	28,2	40,3	0,3	Oui
7,0	41,5	3,0	32,2	42,0	0,5	Oui
8,0	43,0	3,0	35,9	43,8	0,8	Oui
9,0	46,0	3,0	38,7	46,7	0,7	Oui
10,0	48,0	3,0	39,3	48,6	0,6	Oui

TaibaMbaye (C)



Vitesse du vent	Bruit résiduel	Contraintes: Emergence max. permise	Niveaux sonores: Bruit éoliennes	Niveaux sonores: Bruit ambiant éol+résiduel	Résultats: Emergence	Contrainte respectée ?
[m/s]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	
5,0	39,5	3,0	27,1	39,7	0,2	Oui
6,0	40,0	3,0	30,0	40,4	0,4	Oui
7,0	41,5	3,0	34,0	42,2	0,7	Oui
8,0	43,0	3,0	37,7	44,1	1,1	Oui
9,0	46,0	3,0	40,5	47,1	1,1	Oui
10,0	48,0	3,0	41,1	48,8	0,8	Oui

Figure 52: Design note of the estimated onset of sound [5.0 - 10.0 m/s] - villages of Bal Samb and Moka Gueye Beye

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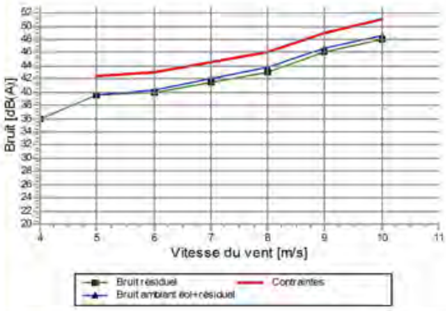
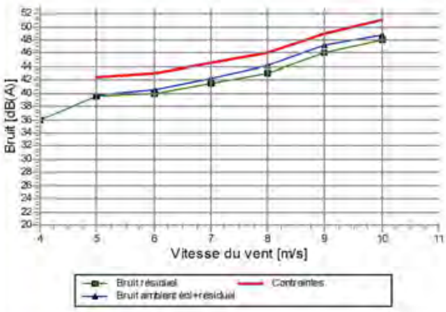
Calcul: Copy of **Modèle utilisé pour les calculs de bruit:**ISO 9613-2 Générale

Balsanbe (Bal Samb) (D)



		Contraintes	Niveaux sonores		Résultats	
Vitesse du vent	Bruit résiduel	Emergence max. permise	Bruit éoliennes	Bruit ambiant éol+résiduel	Emergence	Contrainte respectée ?
[m/s]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	
5,0	39,5	3,0	25,3	39,7	0,2	Oui
6,0	40,0	3,0	28,2	40,3	0,3	Oui
7,0	41,5	3,0	32,2	42,0	0,5	Oui
8,0	43,0	3,0	35,9	43,8	0,8	Oui
9,0	46,0	3,0	38,7	46,7	0,7	Oui
10,0	48,0	3,0	39,3	48,5	0,5	Oui

Macka Gueye Beye (E)



		Contraintes	Niveaux sonores		Résultats	
Vitesse du vent	Bruit résiduel	Emergence max. permise	Bruit éoliennes	Bruit ambiant éol+résiduel	Emergence	Contrainte respectée ?
[m/s]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	[dB(A)]	
5,0	39,5	3,0	27,5	39,8	0,3	Oui
6,0	40,0	3,0	30,4	40,4	0,4	Oui
7,0	41,5	3,0	34,4	42,3	0,8	Oui
8,0	43,0	3,0	38,1	44,2	1,2	Oui
9,0	46,0	3,0	40,9	47,2	1,2	Oui
10,0	48,0	3,0	41,5	48,9	0,9	Oui

9.3.3.21.3 Impact in dismantling phase

The impacts anticipated during the preparation phase are virtually the same. The sound disturbances will be attributable mainly to the specific machinery used for site installation, dismantling wind turbine components, transporting dismantled equipment and withdrawing from the site. The sound levels will annoy both the personnel carrying out the dismantling and to a lesser extent the populations of Taiba Ndiaye and the localities crossed by the transport lorries. Should the personnel be wearing suitable PPE and the noisy works will be carried out essentially in farmland, the residual impacts will be moderately felt.

9.3.3.22 Public safety

The environmental value allocated to the safety of local residents and people transiting through the wind farm footprint (work areas and journeys undertaken for the transport of materials and wind turbine components) is qualified as high.

9.3.3.22.1 Safety of persons during the works phase

In site phase, personnel, trained and accredited for a site of this size, are far more exposed to the risk of accidents than the local populations. The notion of public safety is implicitly and closely linked to the presence of human activities in the study area. The wind turbine installation sites will be easy to access given the access roads constructed under this project.

However, a site of this size, moreover in a rural environment, will attract large numbers of curious outsiders, who will actually be taking a risk despite the site being prohibited. As these outsiders are not kept away from the site boundaries, they are exposed to certain hazards (trench not filled in or signed, unprotected spiky concrete reinforcing rods, etc.).

The risk is however mitigated by the introduction of a special safety plan for persons and property so that the accident risk is reduced to zero.

The wind farm site will have signs warning of the hazards present on the site (falling objects, electrical risk, construction machinery traffic, etc.) and prohibiting access. These signs will be put up at the site entrance and at each storage and lifting platform.

Similarly, when raising the wind turbines which will be an impressive operation, suitable measures will be taken to lead any unauthorized persons on the site to risk-free areas. Compliance with basic safety measures, such as wearing a helmet, is essential during organized visits.

Public safety will only be threatened during the erection phase should an accident, (*i.e.,* an unforeseeable event) occur. Any threat to public safety therefore lies in an unexpected even and calls on the notion of risk which will be expanded further in the next chapter.

Overall, the magnitude of potential impacts in relation to the project seems low, given the genuine risk that such events produce.

9.3.3.22.2 Safety of persons in operating phase

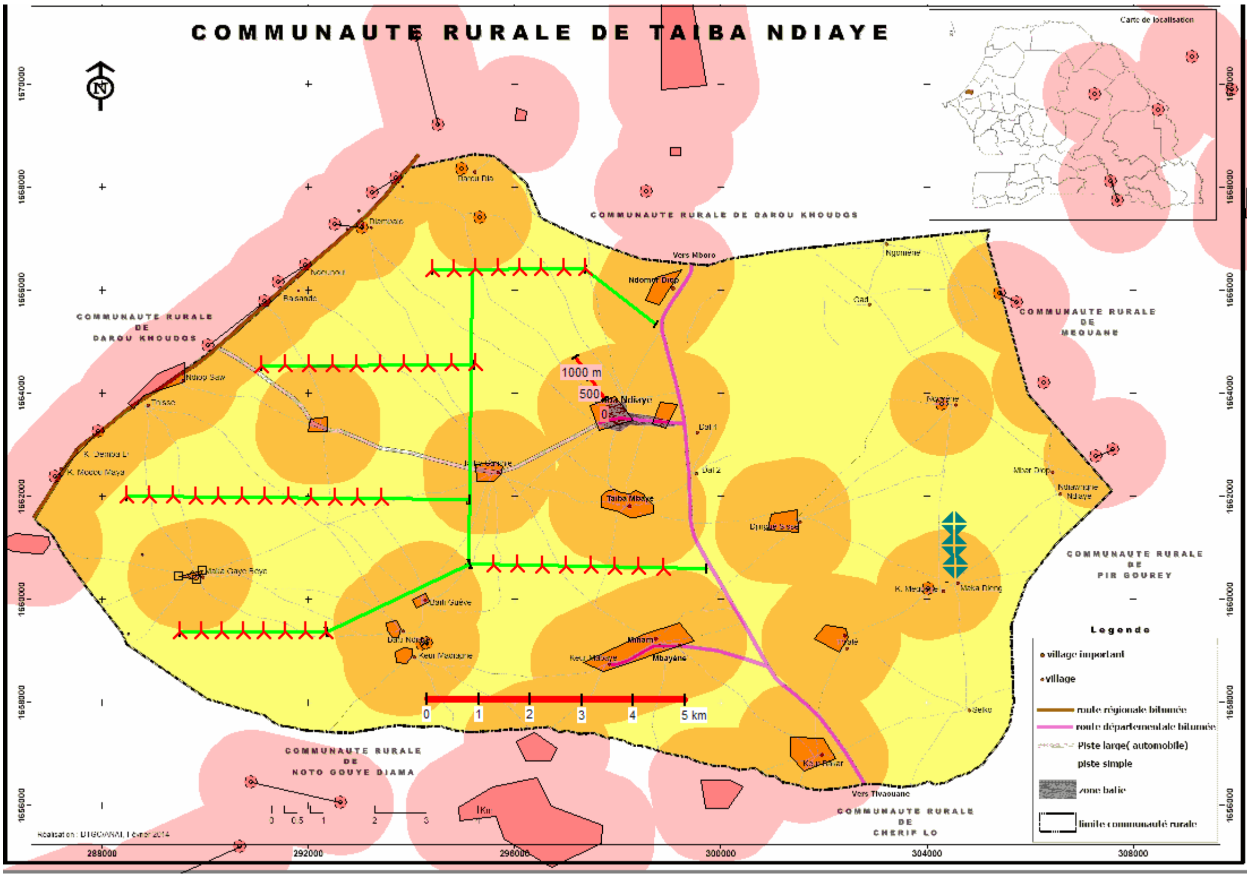
Like any human activity, zero risk does not exist when operating a wind farm. The main risk factor here comes from moving mechanical components. The resulting risk of an accident for a third party is, therefore, minimal.

During operating periods, the potential impacts on public safety relate to the risk of accidents from breaking wind turbine blades and collapse of the tower, the risk of fire around step-up stations and wind turbines and lightning strikes. These events are, however, unexpected in all circumstances.

The likelihood of a wind turbine incident like rupture or ejection of a blade or total destruction of the wind turbine causing a serious accident to the property or health of a third party is very low *(according to data from the Renewable Energy Syndicate).*

The annual likelihood of a blade (for a hub 65 m high) reaching a distance of 215 m would be in the order of 5.10 -7. This likelihood of a component of a 2 MW wind turbine being thrown through the air in a 40-meter radius (i.e. under the wind turbine footprint) would be in an order of magnitude of 10-5 and 10-6 of it falling (one chance in a million) in a radius slightly more than 100 meters.

Map 15: Project installation map in the territory of the municipality of Taiba Ndiaye with theoretical withdrawal perimeter of 1000 m



The hazard study (see § 9) shows that the future 46-generator-strong wind farm of Taiba Ndiaye has mainly risks of components being thrown through the air and, to a lesser extent, fire. The calculated effect areas, corresponding to the distances reached by different sizes of breaking blades ejected at maximum speed, can be up to a radius of 798 m. The effects of these hazardous phenomena would be collision with human targets, structures and/or protected species.

The low likelihood of calculated targets being reached also argues in favor of these levels of acceptable risk for the project.

Lastly, note that the risks associated with a breaking blade or collapse of a tower feared in the operating phase are especially low for the local populations and infrastructures.

9.3.3.22.3 Impacts forecast in decommissioning phase

During the decommissioning phase, there is no particular impact to point out in terms of risks of breakage or fire. The only risks come from an unexpected accident affecting the workers on the site at this time.

9.3.3.23 Impacts on public health and quality of life

Quality of life is taken to mean the quality of the air and the absence of sound or visual nuisances. The agricultural and forest land in the study area does not have major industrial infrastructures and is used principally for farming and forestry activities. The quality of life in this area is deemed to be excellent.

This section analyzes the potential effects of the Taiba Ndiaye wind farm on public health and neighborhood convenience. There is no need for an advanced analysis of these items under the impact study, given the low risk levels for the local residents, but nevertheless have to be mentioned for information purposes. There is no village center in the study area.

9.3.3.23.1 Impacts forecast in erection phase

Impacts from noise and on air quality

During the erection phase, the acknowledged impacts are basically associated with sound nuisances and the dust generated by the machinery. Noise-related impacts have been addressed in the previous sections.

As all the work will take place in agricultural and rural areas, far from built-up areas and large concentrations of housing, the erection phase should not cause a significant impact on the quality of life of most of the citizens of Taiba Ndiaye.

Nevertheless, a considerable increase in lorry transport on the roads around the installation site is predicted. The repeated passing of lorries and machinery could inconvenience the residents with dwellings near the roads taken by the construction workers. In terms of the dust raised during the works, dust control systems are included in routine mitigation measures and will lessen the associated nuisances.

Considering the low population density and the fact that the wind farm is erected exclusively in agricultural areas, the impacts on the population in the study area will be minor. In addition, remember that no wind turbine will be installed less than 900 m from any housing unit.

The magnitude of the disturbance has been qualified as low, given the distance from access roads and wind turbine installation sites (900 m from housing units). The scope is qualified as limited and short-lived. Thus, the significance of the global impact is qualified as low.

9.3.3.23.2 Impacts forecast in operating phase

Impacts relating to noise and air quality

In operating phase, there is no actual impact on the quality of life. The noise-related nuisances have been discussed in detail above as have the alterations to the landscapes caused by the installation of wind turbines.

Remember also that each individual has his own perception of a wind turbine and it is therefore difficult to rule on its impact on the quality of habitats.

9.3.3.23.3 Impacts forecast in decommissioning phase

During the decommissioning phase, the works are likely to cause similar impacts as in the erection phase. The magnitude of the disturbance has been qualified as low, given the general distance from access roads and wind turbine installation sites. The scope is qualified as limited and short-lived. The significance of the impact is thus qualified as low. In terms of the dust raised during the works, dust control systems are included when needed in routine mitigation measures.

9.3.3.24 Stroboscopic effects and reflection of the sun's rays

When the sun passes behind the wind turbine, the rotation of the blades interrupts the sunlight periodically. This is called "stroboscopic effect". This phenomenon can be a problem when the wind turbines are located near residential areas and can be more or less disturbing depending on the orientation of housing areas with respect to the wind turbines.

Certain residents, farmers or market gardeners may be disturbed occasionally by the stroboscopic effects.

The sun's reflection on the blades or the mast can have particularly inconvenient effects for the neighboring populations when the blades are directed so that they send the sun's rays towards the residential areas. This is, nevertheless, a transient phenomenon caused by new wind turbines only and disappears after a few months once the blades are dirty and no longer reflect the sunlight.

Considering the tranquility of the habitat in the study area, the environmental value of this component is qualified as moderate.

9.3.3.24.1 Impacts forecast in erection phase

In the erection phase, the wind turbines will not be operational and there will therefore be no risk linked to the stroboscopic effects.

9.3.3.24.2 Impacts forecast in operating phase

When the sun is shining, a wind turbine projects a shadow on the land around it like any other tall structure. From time to time the blades cross the sun's rays, triggering what is called a stroboscopic effect (Danish Wind Industry, 2003) or **shadow flicker effects.**

The shadow flicker of moving wind turbine blades can create unpleasant stroboscopic effects for nearby dwellings.

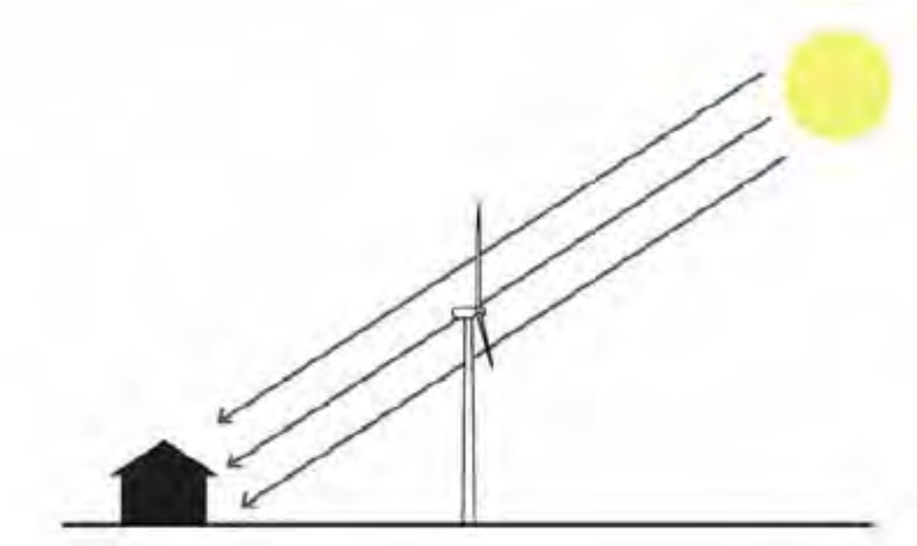


Figure 53: Illustration of the stroboscopic effect phenomenon

Several parameters play a part in this phenomenon:

- the size of wind turbines;
- the position of the sun (the effects vary depending on the day of the year and the time of day);
- the existence of sunny weather;
- the characteristics of the façade in question (orientation);
- whether or not there is visual masking (relief, vegetation);
- the orientation of the rotor and its relative angle to the dwelling in question;
- whether or not there is any wind (and therefore whether or not the blades are rotating).

The risk of epilepsy crises following this phenomenon is sometimes wrongly raised. The human body can only react if the blinking speed is more than 2.5 Hertz, which would mean for a three-blade wind turbine a rotation speed of 50 rpm. Current wind turbines rotate at 9 to 19 rpm, i.e. well below these frequencies.

The phenomenon of stroboscopic shadow can be experienced by a static observer, for example inside a dwelling. This experience quickly becomes impossible for a moving observer, for example inside a vehicle.

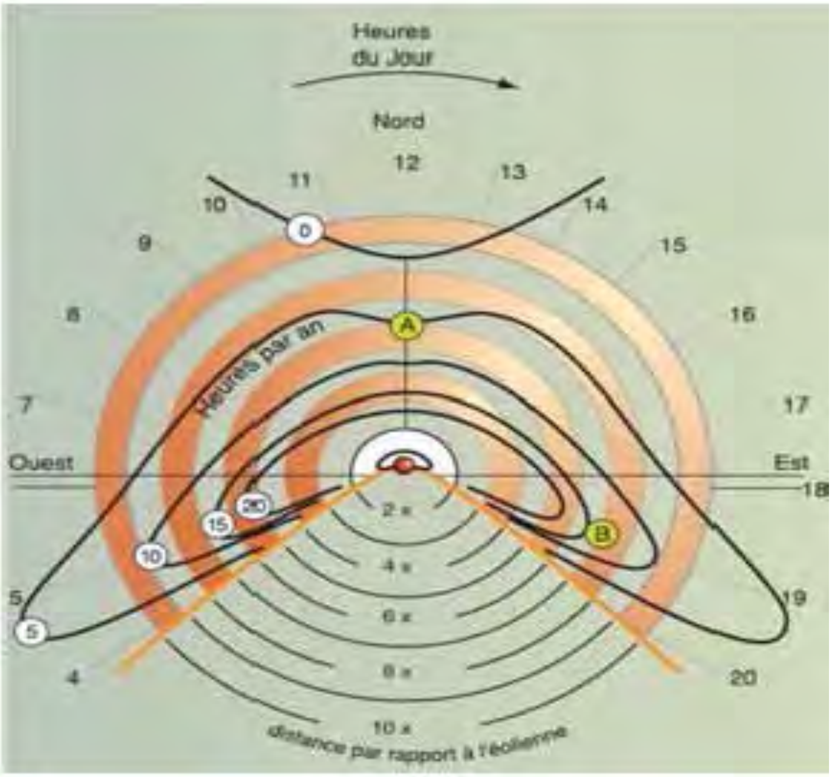


Figure 54: The periodic masking of the sun by the moving blades (source: ADEME**)**

The dwellings located to the east and west of wind turbines are more likely to be concerned by these phenomena than those located to the north or south. These annoying phenomena diminish fairly rapidly as you move away (they decrease according to a hyperbolic curve). Specific software programs can be used to state the potential periods of annoyance and produce maps indicating the number of shadow hours per year.

The stroboscopic effect appears when the sun is low in the sky and the sky is cloudless. It only occurs when the following conditions appear together (Walloon Government, 2002):

1. clear weather (sunny);
2. wind (blades rotating);
3. orientation of the sun in relation to the wind turbine sending its shadow onto a dwelling or place of work;
4. orientation of windows of the place in question towards the wind turbine.

We note that under this project, the study area is in a sector with a low population density, mainly due to the agricultural and rural land on which the wind turbines are installed. They will be installed on the summit of dune plateau, out of reach of man-made infrastructures. The sectors occupied by a permanent population are located above all inside village centers.

A minimum distance of 826 m (in only one case) separates every wind turbine from one of the dwelling boundaries, no matter the row of turbines. According to the Ministry of Health and Social Services (MSSS), the possibility of psychic or even neurological consequences (epileptic seizure) of the strobe effect which is caused by sustained observation of the rotating blades, especially if this is in the direction of a sun low on the horizon, is apparently NOT supported by any successful case study (MAMR, undated). The specialized literature points out that shadow casting (strobe effect) can only be seen near wind turbines and generates no risk for the population (ADEME, 2004). Thus, wind turbine shadow is negligible on the human environment, as on average its influence goes no further than 250 to 300 m.

Calculation of strobe effects :

The software Windpro can simulate projected shadows / strobe effects by wind turbines within their vicinty ; the module « Shadow » for example, is often used for these simulations.

Two methodes of calculation are used :

1. The Worse Case Scenario Method ; a method which takes into consideration scenarios which are only slightly realistic assuming that:
   a. Wind turbines fonction all year long ;
   b. The sun shines all year long ;
   c. The turbine blade is always perpendicular to the rays of sunshine;
   d. The minimal hight of the sun is 3 degrees above the horizon;
   e. The maximum distance of the shadow projection corresponds to 10 times teh diameter of the rotor (i.e. 1260m).
2. The most likely Scenario Method which takes into account :
   a. The acutal fonctioning of the wind turbines according to the the statistiques measure by the wind mast. (see below table)

Tableau 53 : **Number of hours per year of estimated production of the wind park (based on the the data of the 100 m meaurement mast installed on site at Taiba Ndiaye.**

Wind Direction	N	NNE	ENE	E	ESE	SSE	S	SSO	OSO
hours / year	2625	665	476	272	158	156	156	194	315

Direction	O	ONO	NNO
Heure / an	601	1057	1908

b. The sun shines in accordance with statistiques of sunshine of the nearest meteorological site ; in this case, the meterological station of LOUGA (See below table)

Tableau 54 : **Probablity of sunshine (average hours of sunshine per day]** [LOUGA]

Month	JAN	FEV	MAR	AVR	MAI	JUIN	JUIL	AOUT	SEPT
Hours / day	7,50	7,89	8,59	8,94	8,80	8,04	8,04	8,18	7,63

Month	OCT	NOV	DEC
Hours / day	8,38	8,64	7,67

c. The roto is always perpendicular to the rays of light
d. The minimum height of the son is 3% above the horizon
e. The maximum distance of the shadow projection is 10 times teh diameter of the rotor (i.e. 1260 m).

Prinicipal Simuations :

In the first case, receivers (vertical windows of 1 m x 1 m place at a height of 1 m from the ground and oriented towards a row of turbines permits the possibility to simulate the strobe effect which results in virtual environment of the project in area which is populated and/or are are suceptible to the strobic impacts by a shadow projection ; these 17 receivers are identified by the letters A-Q. The coordinates of these receivers are also registered in the table of the summary of results.

In the second case, for each of the two scenarios, the softoware Shadow Windpro calculates :

- The number of hours of exposition per year for each receiver ;
- The number of hours/minutes of exposition per day.

- The number of days per year where an event of exposition which lasts a minimum of 2 is likely to occur;
- The turbine or turbines responsible for the strobe effect ;
- Maps representing the rasters or surfaces with a 10 m x 10 m resolution are produced and permit to illustrate a zone around the turbines being simulated for strobe effect.

Results :

The following table illustrate the results of 17 virtual receivers.

Tableau 55 : **Summary of Strobe Effects**

Receivers					Coordinates of Receivers		Worse Case (Hours : Minutes) total per year	Worse Case (Hours : Minutes) maximum per day	Most likely case - Nombre (Hours : Minutes) total per year	Wind Turbines responsible for strobe effect
A	Taïba	Santhie	sud		295 517	1 662 305	00:00	00:00	00:00	
B	Taïba	Mbaye			297 979	1 661 704	00:00	00:00	00:00	
C	Taïba	Santhie	nord		295 517	1 662 626	00:00	00:00	00:00	
D	Taïba	N'Diaye	Nord	Ouest	297 496	1 663 781	00:00	00:00	00:00	
E	Djambalo	sud	est		292 955	1 667 119	00:00	00:00	00:00	
F	Khelkom	Diop	Nord	Est	292 268	1 663 526	00:00	00:00	00:00	
G	Baïti	Ndiaye			293 611	1 659 420	07:37	00:19	02:51	E46
H	Maka	Gaye	Bèye		289 784	1 660 486	00:00	00:00	00:00	
I	Khelkhom	Diop	Sud		292 232	1 663 304	00:00	00:00	00:00	
J	Ndomor	Diop	Nord	Ouest	298 753	1 665 902	00:00	00:00	00:00	
K	Balsande	SE			291 151	1 665 663	00:00	00:00	00:00	
L	Saw	Nord	Est		286 960	1 661 187	00:00	00:00	00:00	
M	Mbayène	Nord			298 720	1 659 429	00:00	00:00	00:00	
N	Baïti	Guèye	NE		294 231	1 660 142	00:00	00:00	00:00	
O	Keur	Modou	Maya	SE	287 119	1 662 549	00:00	00:00	00:00	
P	Ndiop	Saw	E		289 580	1 664 277	00:00	00:00	00:00	
Q	Balsande	II	SE		290 238	1 664 929	36:29:00	00:33	17:15	E10

An analysis of the strobe effects confirms that only 2 villages would be affected (i.e. 2 inhabited areas) are susceptible of receiving projections of shadows in these scenarios with a maximum of 17 hours and 15 minutes per year in the most likely scenario and in teh worse case scenario 36 hours and 29 minutes per year.

Tableau 56 : **Identification of Sources and timing of potential strobe effects**

Wind Turbine Responsible for Effect	Wind Turbine Coordinates		Period during the year	
E46	291 103	1 664 55	**1st period of the year** Between April 12 and April, at the rate of 6 - 19 minutes per day(worse case)	**2nd period of the year** Between the 18th and 30th of September around 7 :30 pm at a rate of 2 -19 minutes per day (worse case)
E10	292 360	1 659 389	Betwee the 9th of November and the 4th of Februay ; from 8-33 minutes maximum per day including 2 12-day periods where in teh worst case, can be as much as 31-33 minutes per day.	

The two wind turbines potentially responsable for the strobe effects are turbine E46 and E10 ; the times of year where the strobe effect can be expected are indicated in the table above.

The following figures present « rasters » calculated for the worse and most likely cases et ; « raster » in number of hours per years and the maximum amount of minutes per day.

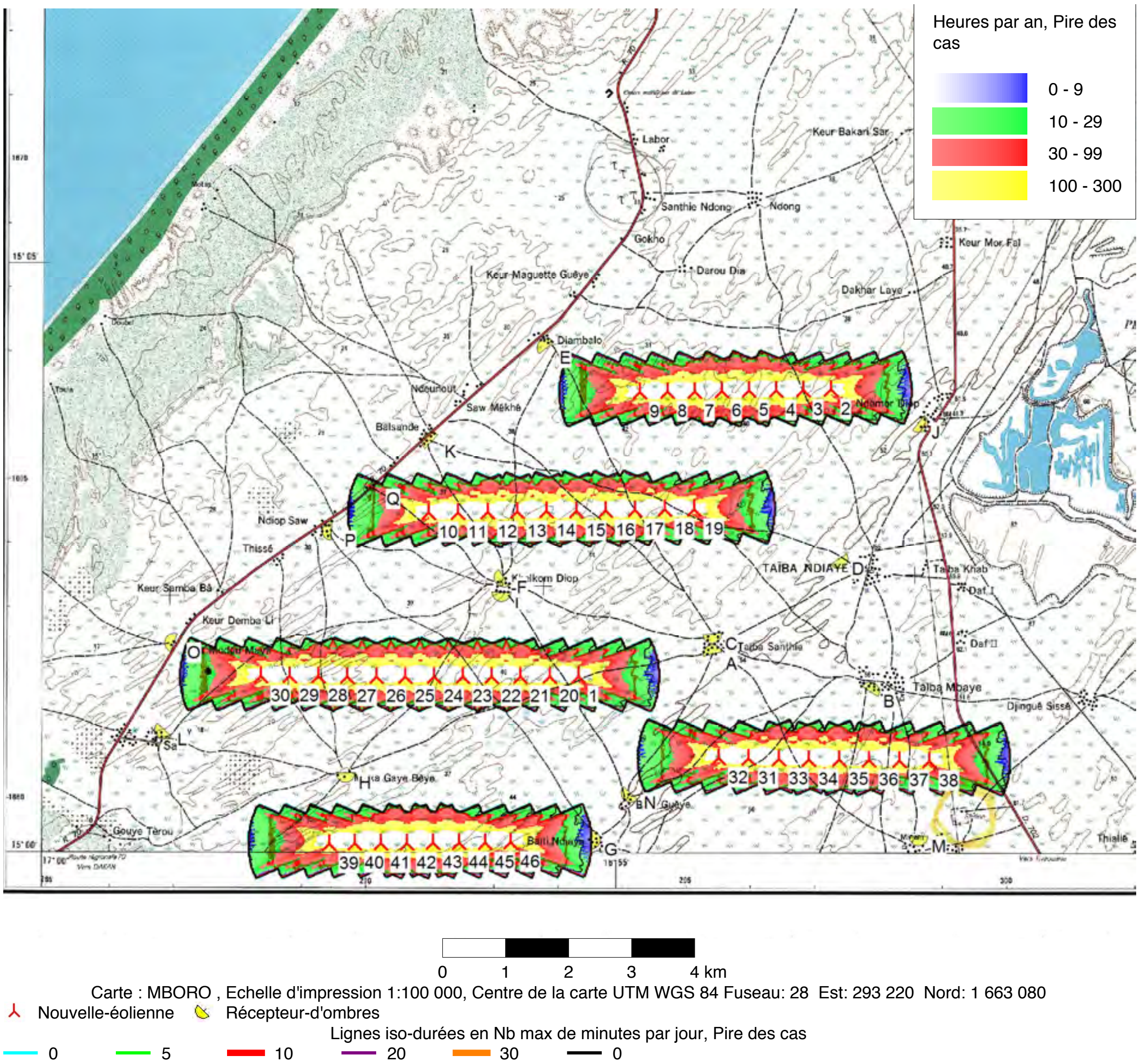
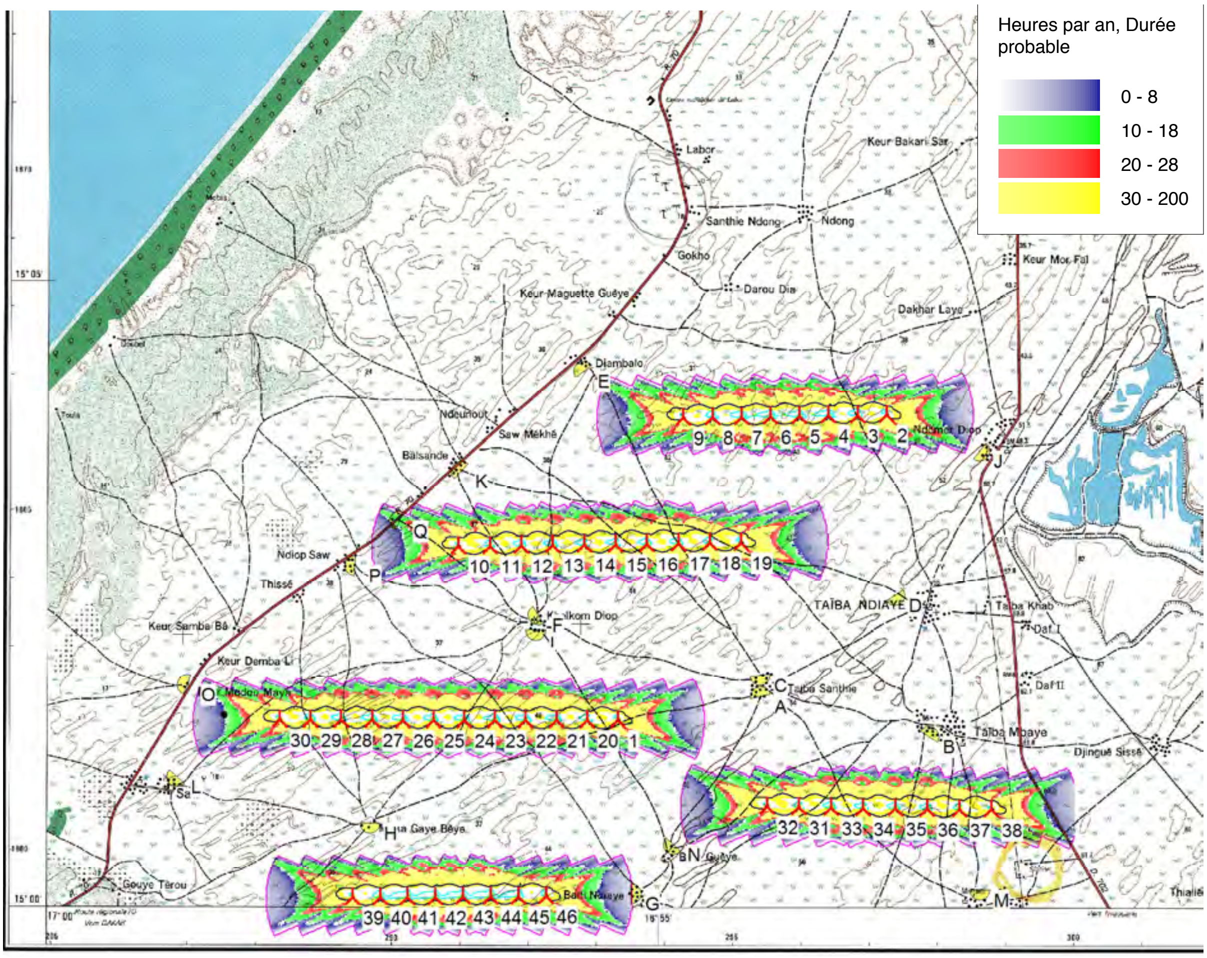


Figure 55 : **Projection of Shadows - Strobe Effet - [Worse Case] - number of hours per year**



0 1 2 3 4 km

Carte : MBORO , Echelle d'impression 1:100 000, Centre de la carte UTM WGS 84 Fuseau: 28 Est: 293 100 Nord: 1 663 080

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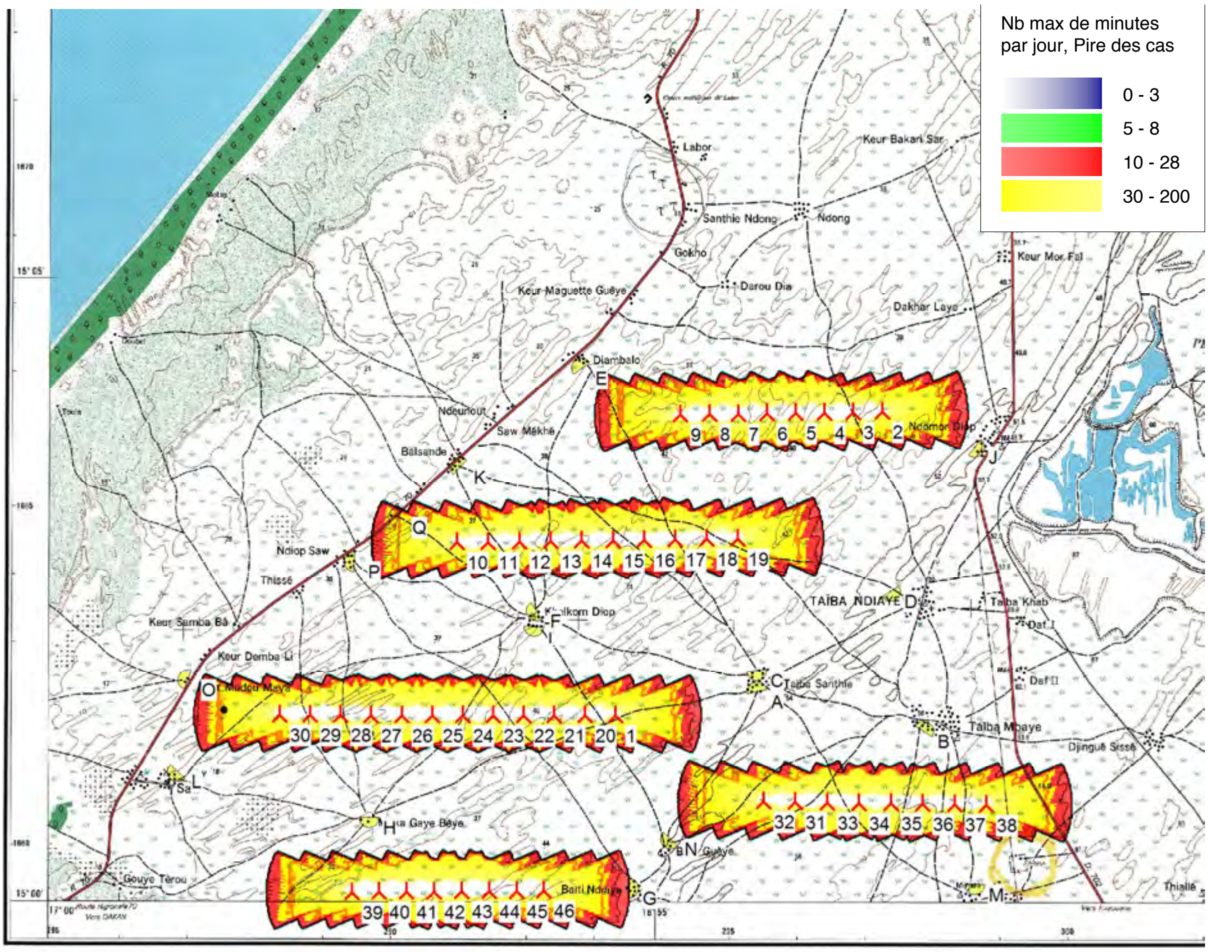
Lignes iso-durées en Nb max de minutes par jour, Durée probable

0 60 120 180 240 300

Figure 56 : **Projection of Shadows - Strobe Effet - [Most Likely Case] - number of hours per year**



0 1 2 3 4 km

Carte : MBORO , Echelle d'impression 1:100 000, Centre de la carte UTM WGS 84 Fuseau: 28 Est: 293 220 Nord: 1 663 080

Nouvelle-éolienne Récepteur-d'ombres

Lignes iso-durées en Nb max de minutes par jour, Pire des cas

0 5 10 20 30 0

Figure 57 : **Projection of Shadows - Strobe Effet - [Worse Case] - number of minutes per day**

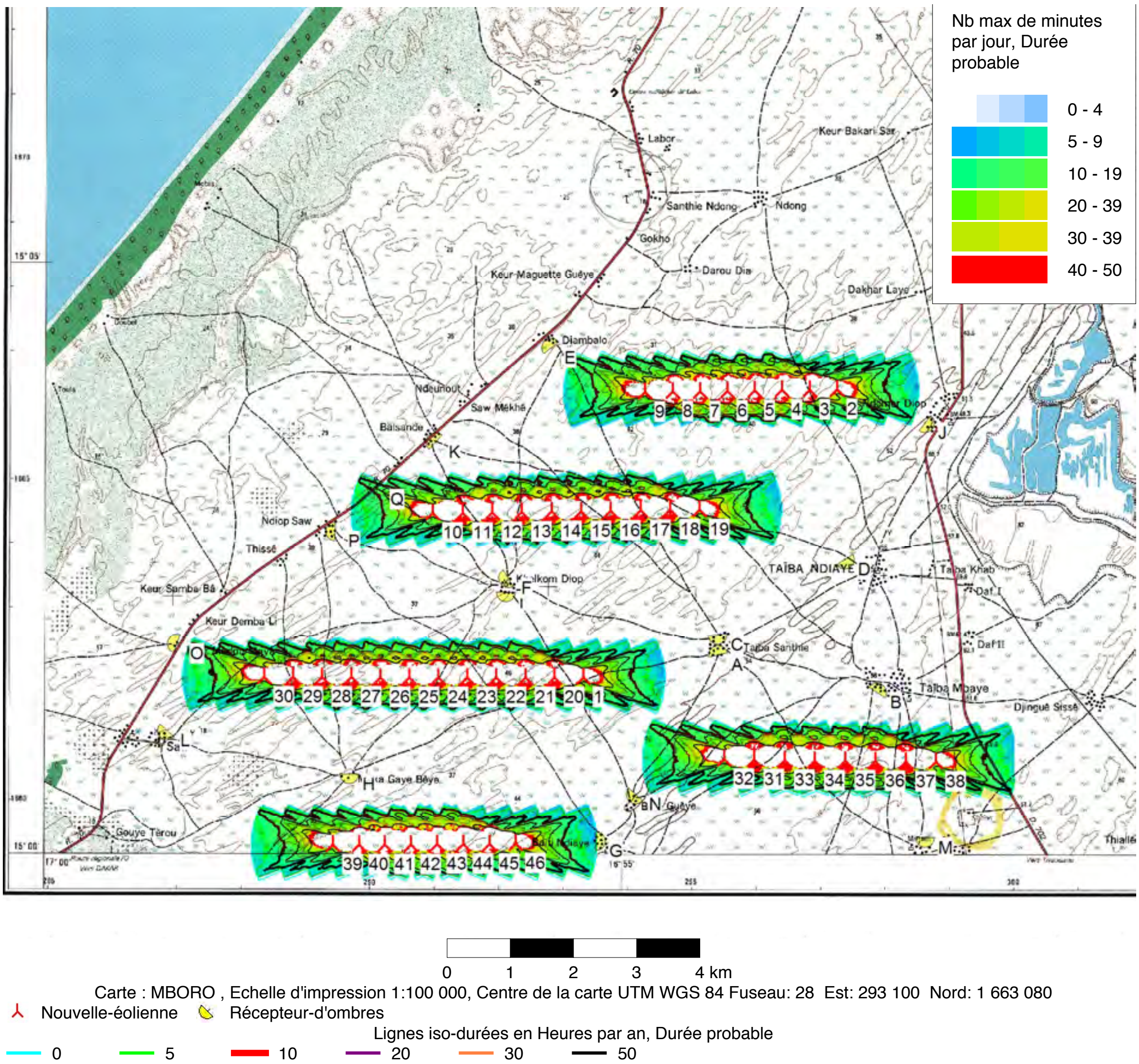


Figure 58 : **Projection of Shadows - Strobe Effet - [Most Likely Case] - number of minutes per day**

Conclusion:

Considering these factors, the magnitude of the disturbance will be low, its scope limited and long-lived, due to the operating period of the wind farm. The importance of the impact will therefore be low. The developer has included a shadow casting map and calculated statistical tables in his application for planning permission showing no particular nuisance to the populations.

9.3.3.24.3 Impacts forecast in decommissioning phase

During the decommissioning phase, there is no possible risk from stroboscopic effects.

9.3.3.25 Effects of electromagnetic fields

Electromagnetic impacts may be emitted into the environment by the wind turbine generators, transmission lines and sub-station. For an electric voltage output of 30 kV max. from step-up voltage transformers and transit currents of 500 A approximately per underground cable in addition, the induced electromagnetic fields will be very low.

The environmental value of this component is qualified as low.

9.3.3.25.1 Current conditions

Considering that there is no wind turbine inside the study area, no electromagnetic impact is currently experienced in the region from this type of installation.

We do, however, point out the existence of electricity transmission lines (Tobène HV line) and telecommunications infrastructures belonging to the three national telephone operators.

9.3.3.25.2 Impacts forecast in erection phase

In the erection phase, the wind turbines will not be operational and there will therefore be no risk linked to the electromagnetic fields.

9.3.3.25.3 Impacts forecast in operating phase

The wind turbines are intended to generate electricity and can thus generate an electromagnetic field. This field is made up of an electric field and a magnetic field.

There are two possible sources of electromagnetic fields:

- natural sources: these generate static fields, like the earth's magnetic field and the atmospheric static electric field (low in good weather, in the order of 100 V/m, but very high in stormy weather (up to 20000 V/m);
- sources linked to electrical applications, be they domestic equipment of sub-stations.

The following tables compare the electric and magnetic fields produced by some household equipment and electric line conductors, which will also be compared with underground cables.

Thus, the small motors and transformers on domestic equipment form local magnetic field sources far greater than their electric cables.

Table 57: Electromagnetic cables of some household equipment, electric cables and underground cables

Source	Champ électrique (en V/m)
Rasoir électrique	Négligeable
Micro-ordinateur	Négligeable
Grille-pain	40
Téléviseur	60
Chaîne stéréo	90
Réfrigérateur	90
Lignes 90 000 volts (à 30m de l'axe)	180
Lignes 400 000 volts (à 100 m de l'axe)	200
Couverture chauffante	250

Source	Champ magnétique (en µT)
Réfrigérateur	0,30
Grille-pain	0,80
Chaîne stéréo	1,00
Lignes 90 000 volts (à 30m de l'axe)	1,00
Lignes 90 000 volts (à 30m de l'axe)	1,20
Micro-ordinateur	1,40
Téléviseur	2,00
Couverture chauffante	3,60
Rasoir électrique	500
Liaison souterraine 225 000 V (pose de câbles : en trèfle – en nappe)	6 – 20 (à l'aplomb)
	1 – 4 (à 5 m de l'axe)
	0,1 – 0,3 (à 20m de l'axe)
Liaison souterraine 63 000 V (pose de câbles : en trèfle – en nappe)	3 – 15 (à l'aplomb)
	0,4 – 3 (à 5 m de l'axe)
	Négligeable – 0,2 (à 20m de l'axe)

The electromagnetic fields from wind farms are mainly from the power sub-station and underground cables. The radial-field cables, commonly used in wind farms, emit electromagnetic fields that are very low and even negligible as soon as you move away.

The World Health Organization (WHO) believes that from 1 to 10 mA/m^2 (induced by magnetic fields greater than 0.5 mT82 and up to 5 mT at 50-60 Hz, or 10-100 mT at 3 Hz) minor biological effects are possible. The electromagnetic fields to which the populations are normally exposed therefore do not affect their health.

However, these currents are far lower than those produced naturally by brain, nerves and heart and there is no known risk for health.

Electromagnetic impacts may come from four sources in a wind farm: connection to the power transmission line, the wind turbine generators, the electric transformers and the underground cabling to the sub-station. Standards apply to the cables connecting the power transmission line. The generator winding is insulated, which prevents virtually all electromagnetic fields. In addition, remember that the nacelle is some 117 m above the ground, which makes any propagation even more unlikely. The impact of electromagnetic fields produced by the wind farm has already been discussed above, with no effect on the populations.

Considering the low population density in the study area, the magnitude of the impact is qualified as low and its scope is limited and long-lived, due to the operating period of the wind farm. The result is insignificant impact.

During the decommissioning phase, there is no possible risk for the population from electromagnetic impacts.

9.3.3.26 Low frequencies

Wind turbine operation is likely to emit infrasounds into the environment. The infrasounds can be perceived as a risk for the population in the study area near the wind turbines. In France, the report from the Academy of Medicine dated 14 March 2006 demonstrated that the infrasounds emitted by the wind turbines were extremely low and without special impact on public health. A moderate value is attributed to this component.

9.3.3.26.1 Current conditions

As there are no wind turbines inside the study area, the low frequencies on the site are anthropic (potentially motorized movements) or natural (wind movements, rumbling of thunder, noise from the sea, etc.)

9.3.3.26.2 Impacts forecast in erection phase

In the erection phase, the wind turbines will not be operational and there will therefore be no risk linked to the low frequencies and infrasounds.

9.3.3.26.3 Impacts forecast in operating phase

The noises are cyclic fluctuations of the air pressure, which can be characterized by their intensities, expressed in decibel (dB), and by their tones, which then involves the notion of frequencies, where the units are the Hertz (1 cycle per second = 1 hertz (Hz)). It is generally agreed that the response from the human ear covers the sounds with a frequency of between 20 Hz (low-pitched sounds) and 20000 Hz (high-pitched sounds). Infrasounds and ultrasounds define the sounds outside this range, either below 20 Hz for the infrasounds and above 20000 Hz for the ultrasounds. Although the low frequencies can propagate quite far, their intensity diminishes rapidly with distance. The propagation of the noise far away depends on several factors, including climate conditions, the topography and the environment specific to each site.

There are several parameters that make a noise harmful: the quality of the noise, the purity of the sound, the intensity of the noise, the onset and rhythm of the noise, the exposure time and individual vulnerability (AFSSET, 2008). Firstly, at equal intensity, high-pitched noises cause more harm than low-pitched ones. Similarly, a pure sound, at narrow frequency, is more traumatic than a broad-spectrum noise, The intensity of the noise represents the sound level. All very intense audible noises can cause functional ear disorders and lesions. But such intensities do not occur in a wind farm, even just a few meters away from a wind turbine.

As in other types of equipment, the wind turbines produce low frequencies and infrasounds. The medium-frequency, broadband noise of these wind turbines (unlike a noise with tonalities) is produced mainly by air friction around the blades. The intensity of this noise increases momentarily every time a blade passes in front of the tower supporting the nacelle. Typically, a blade passes in front of the tower once every second, which gives a rhythm of about 1 Hz.

The noise generated by a blade passing in front of the tower, causing air compression and an associated noise, which is more or less audible depending on the operating condition, is not a 1 Hz infrasound but more a low frequency noise (around < 100 Hz); its intensity increases momentarily and is accompanied by inaudible sound emissions of a frequency close to 1 Hz. Despite this confusion over the type of noises produced by the wind turbines, sound readings with a sound level meter demonstrate that there are indeed infrasounds generated when a wind turbine is operating.

For the moment, the scientific community agrees to state that the infrasounds have no impact on human health.

The most recent document on the subject is Health Impact of Wind Turbines written by Chatham-Kent Public Health Unit in Ontario (2008). Having examined fully the available documentation, the authors draw the conclusion that the harmful effects for the health of the citizens of Chatham-Kent are negligible and that there is no evidence that the wind turbines can have potentially harmful effects on health. The risks associated with the low frequencies are a complex, poorly-understood element. Remember, however, that the low frequencies diminish less quickly when moving away from sources that the higher frequencies. For this reason, it is occasionally possible to perceive low frequency sounds several hundred meters from wind turbines, without the intensity of corresponding sounds being inevitably high; it is a peculiarity of the onset of sound. The impact can therefore be qualified as low intensity, the scope will be limited and long-lived, resulting in an insignificant impact.

9.3.3.26.4 Impacts forecast in decommissioning phase

During the decommissioning phase, there is no risk from infrasounds or low frequencies.

9.3.3.27 Waste production

9.3.3.27.1 Impacts of the wind farm footprint in erection phase

Workers on the site are going to produce household waste and waste comparable to household waste.

At the same time, the waste produced by the contractors covers, for example:

- production offcuts,
- offcuts from storage or handling breakages,
- waste from using materials and equipment,
- packaging waste.

Three types of waste will be singled out in order of increasing nuisance:

- inert waste,
- common industrial waste and
- special industrial waste

- ***Inert waste***

This waste is:

- concrete and stones,
- roof and ceramic tiles,
- bricks,
- glass,

- unpolluted earth, aggregates and rubble,
- bituminous asphalt, without tar.

- ***Common industrial waste***

This category of waste generated on site will include:

- wood, paper and cardboard waste that has not been treated with hazardous substances
- plastic, metal and scrap or glass waste.

- ***Special industrial waste***

Common industrial waste or inert wasted must be considered as hazardous waste when soiled by hazardous substances. For example, this applies to packaging or material waste soiled by oil or paint containing hazardous substances.

9.3.3.27.2 Impacts on production in operating phase

Given that the wind farm operates independently and there are no living quarters for the workers employed to maintain the wind generators, there will not be a great deal of domestic waste.

Nevertheless, the machinery and equipment maintenance operations may create soiled items and generate waste, especially oils and greases. To ensure optimum operation of the blades and prevent premature wear of constituent parts of the wind turbine machinery, these items are greased at start up and in operation.

The draining operations involve wind generators each containing about 1500 liters of oil and 29 kg of grease.

For the full wind farm, this is nearly 70,000 liters of oil to be drained potentially plus 1,300 kg of grease. Thankfully, the chemical substances and lubricants used in the Vestas wind turbines are certified to ISO 14001 standards. In addition, the maintenance and draining operations will follow a strict protocol designed to prevent leaking oil and grease.

As the use of PCB was immediately banned right from the design of the transformer unit, there is no fear of the risk of this highly toxic product spreading into the wind farm substrates.

Relatively low negative impacts can therefore be predicted from the production of common or special waste.

9.3.3.27.3 Impacts on production in dismantling phase

The types of waste will be comparable to those found in the works phase (common waste, excavated topsoil, concrete, scarp, etc.) and also during operation, mainly the risks of leaking fluids (coolants, oils) and greases.

This waste will result from the different phases planned for the dismantling of equipment and installations, especially:

- The installation of the site and living quarters for employees allocated to decommissioning works;
- The decoupling and removal of wind turbine components;
- The dismantling of iron- and concrete-based foundations;
- The transport of wind generator component frames.

10 RISK ASSESSMENT

10.1 INTRODUCTION

In accordance with Senegal's **"hazard study methodological guide"**, we are going to identify the hazardous elements of the wind farm installation and operation in the Taiba area in order to (i) describe the malfunctions that could generate a risk of significant consequences for the environment (natural and human), (ii) justify the measures taken and (iii) limit the effects.

10.2 ACCIDENT RISK ASSESSMENT

The aim of the hazard study is to identify the hazardous elements of a company, describe the malfunctions that could generate a risk of significant consequences for the environment (natural and human), then to justify the measures taken and lastly limit the effects.

The methodology used for this hazard study complies with that proposed by Senegal's **"hazard study methodological guide"**

10.3 PRELIMINARY RISK ANALYSIS

10.3.1 Hazards from substances used

This involves qualifying the hazards (flammability, explosiveness, toxicity, etc.) shown by the products or substances that will be used.

The majority of input products are lubricants so that the machinery works properly. They are not classed as flammable products but nevertheless remain combustible.

- ***Lubricating oil hazard analysis***

- **Product description**

The lubricating oils for rotating parts are made up of heavily-refined mineral oils and additives where the polycyclic aliphatic hydrocarbons (carcinogenic) of the mineral oils is less that 3% or constituted of paraffin hydrocarbons.

- **Incompatibility, stability and reactivity**

No specific study has been performed to date on the stability and reactivity of the oils and lubricants used.

- **Fire/explosion risk**

This oil has no special risk of ignition or explosion under normal conditions of use. Nevertheless, an explosive mist can form in particular temperature and pressure conditions. A reminder of ignition conditions for the lubricating oil is given below.

Table 58: Fire/explosion risk from the lubricating oil

Product	Fire risk
Lubricating oil	Boiling point: data not available - Flash point: 210°C - Vapour pressure: data not available self-igniting temperature: 250°C - LEL (Lower Explosive Limit) 45 g/m3 (oil mist) - UEL (Upper Explosive Limit): data not available

- **Toxic risk - Acute toxicity - local effects**

Although classed as non-hazardous to humans, this product can nevertheless have toxic characteristics. These characteristics are given below.

Table 59: Acute toxicity of the lubricating oil

Product	Acute toxicity - local effects
Lubricating oil	- Contact with the eyes or skin can cause irritation (burning sensation, redness) - Ingestion of large quantities can cause nausea or diarrhoea - Complete or incomplete combustion of the lubricating oil produces soots and gases with varying degrees of toxicity such as carbon monoxide, carbon dioxide, hydrogen sulphide, phosphorous oxides, nitrogen oxides, sulphur oxides, aromatic amines, etc. Inhalation is a considerable hazard.

- **Ecotoxic risk**

As the ecotoxic risk of the oil ISO 320 has not been addressed in the material safety data sheet, other material safety data sheets describing the ecotoxic effects of similar products have been studied.

Table 60: ecotoxicity of the lubricating oil

Product	Ecotoxicity
Lubricating oil	- The lubricating oil is very slowly biodegradable in the air, - The product spreads over the surface of the water thereby disturbing the transfers of

	oxygen to aquatic organisms. - Given its physico-chemical characteristics, the product does not normally move very much in the soil, - The new product is not considered as hazardous for land plants, - it is considered as slightly hazardous for aquatic organisms. LD50 in rats > 2000 mg/kg

10.3.2 Equipment-related risks

All equipment with risks are described and detailed in this section.

- ***Wind turbines***

The wind turbine itself is an assembly of several components with miscellaneous functionalities: generation of electricity, conversion of kinetic energy into electric power, transmission of the electric power, structure support, etc. **The various components are sub-divided into** mechanical and electric **components.**

The mechanical parts rotated by the wind can reach excessive speeds causing runaway with material being thrown through the air. They can also suffer natural aggressions that cause the structure to collapse.

The electric part made up of an alternator is driven; it provides high electric voltage that is a source of electrocution or a short-circuit potentially causing a fire.

Strain on this equipment can potentially generate a risk of overheating.

The main hazards feared and summarized in the table below are therefore:

- collapse of the wind turbine;
- equipment ruptures with falling objects;
- the entire blade or a piece of blade falling or flying through the air following its rupture;
- Fire linked to electrical equipment and certain combustible materials;

Table 61: Equipment-related hazards

Installation or System	Function	Feared phenomenon	Potential hazard
Rotor	Electricity generation	Excess speed	Overheating of mechanical parts
Blade	Convert wind power into mechanical energy	Broken blade	Kinetic energy of blades
Power sub-station	Grid	Internal short-circuit	Thermal effect

Installation or System	Function	Feared phenomenon	Potential hazard
			Toxic/impenetrability effect of smoke from fire Effects of soil and sub-soil pollution by extinguishing water
Global machine	Generate electricity	equipment completely ruined	Collision with people, structures or protected species
Foundation	Wind turbine support and anchoring	Collapse	Collision with people, structures or protected species
Mast	Nacelle and rotor support	Entire or part of the mast falling Fire	Thermal effect Toxic/impenetrability effect of smoke from fire Effects of soil and sub-soil pollution by extinguishing water

➢ ***Transformer***

A transformer is equipment intended to alter the electric voltage of the current. It can raise the voltage, for example at the generation unit output to make the electricity capable of being transmitted over long distances by limiting the electrical losses (joule effect). It can also lower the voltage in successive stops depending on the end user and his electricity needs.

The transformers contain high voltage electricity and the possibility of fire-related incidents is always present. Due to the fire risks and the important role played by the electric transports in supplying the community with electricity, this equipment must be fitted with an appropriate fire protection system.

We normally have two types of transformer: the transformer in a dielectric fluid (oil) of the so-called "dry" transformer with windings enveloped by epoxy resin.

If set on fire, the transformer can empty, dispersing the dielectric fluid (sometimes containing PCB - polychlorinated biphenyls). The products created through the degradation of the PCB are to be feared more than the PCB themselves that are deemed toxic for humans. From 500°C and when oxygen is present, they can release highly toxic compounds when decomposing such as dioxins and furans.

10.3.3 Environmental hazards

➢ ***Hazards from natural conditions***

Natural conditions are understood to mean all events not controlled by human activity. These elements can be a notable risk to installations in certain conditions. The meteorological conditions can attack the installations.

➢ ***Lightning***

There is a substantial risk of lightning in the areas exploited. A lightning strike is a known ignition source. It can trigger an electrical fire, releases of hazardous or polluting materials, an explosion or equipment falling or flying through the air.
Lightning is a phenomenon produced by the electric potential of certain clouds. The lightning risk is due the electric current associated with it. This is pulsed and has very steep intensity pulse edges. The effects vary according to the electrical characteristics of conductors taken by the current.

The following effects are therefore possible:
- thermal effects (heat released),
- rises in potential of earths and priming,
- induction effects (electromagnetic field),
- electrodynamic effects (appearance of forces potentially causing mechanical deformations or ruptures),
- electrochemical effects (electrolytic decomposition),
- acoustic effects (thunder).

A full lightning strike normally lasts between 0.2 s and 1 s and has four partial discharges on average. A low current of around a hundred or a thousand amps continues to flow by the ionised channel between each discharge. The median value of the intensity of a lightning strike is around 25 kA.

Lightning rods on each wind turbine would help to minimize the risks of fire caused by lightning.

The main equipment concerned by lightning is listed in the next table

Table 62: Lightning hazards

Installation	Function	Feared phenomenon	Potential hazard	Comments
Rotor	Electricity generation	Internal short-circuit	Overheating of mechanical parts, fire	Retained for the preliminary risk analysis despite the storm risk being deemed as low on the site of interest.
Mast	Rotor support	Collapse	Fire, Kinetic energy of the assembly	
Blade	Conversion of wind power into mechanical energy	Falling blade	Kinetic energy of the blade	

Installation	Function	Feared phenomenon	Potential hazard	Comments
Nacelle	Rotor support	Falling nacelle	Kinetic energy of the nacelle, fire, pollution	

- ***rainfall***

As the Taiba sites are not located on floodplains, no flood hazard has been noted.

However, the geotechnical and reinforced concrete studies will allow the inclusion of any soil settling with a potentially detrimental effect on the stability of the wind turbines. The underground cables will be buried at the regulatory distance and chosen between other criteria depending on the nature and constraints of infiltrations.

- ***Wind and storm hazards***

The storm hazards are as follows:

Table 63: Wind and storm hazards

Installation	Function	Feared phenomenon	Potential hazard	Comments
Rotor	Electricity generation	Runaway	Overheating of mechanical parts - fire	Retained for the preliminary risk analysis despite the storm risk being deemed as low on the site of interest.
Mast	Rotor support	Collapse	Fire, kinetic energy of the assembly	
Blades	Convert wind power into mechanical energy	Broken blade	Kinetic energy of blades	
Nacelle	Rotor support	Falling nacelle	Kinetic energy of the nacelle, fire, pollution	

- ***Risks relating to the human environment***

- ***Human error***

Human error is one risk that has to considered in any company. Despite automated operations, all the activities are performed or supervised by the personnel. As such, it is important to review the operations likely to be hazardous due to the nature of:

- ✓ The activity,
- ✓ The equipment,
- ✓ The product,
- ✓ Other.

These include, among others:

- ✓ Maintenance operations,
- ✓ Various works,
- ✓ Handling of machinery,
- ✓ Remote operation of wind turbines.

➢ ***Hazards from malicious acts***

The wind turbines are usually easily accessible, with no anti-intrusion system, and installed in isolated sites with little policing.

At the date of writing this document, a single incident of this type has been noted: two wind turbines in the Roquetaillade (Aude, France) wind farm suffered a criminal arson attack in the night of 18 to 19 November 2006. The criminals forced the door to two machines and set fire to them, virtually destroying them. No claim or explanation has been provided to this day.

A malicious act can stem from several origins:

- Degradation of equipment: in this case, the risk area relates to the inside of installations, accessible by maintenance workers, but inaccessible to the public due to locked doors;
- Fire: depending on the type of fire caused, the worst-case scenario relates to fire in one or more wind turbines. In this case, the risk area covers the footprint of the wind turbines, i.e. a perimeter of 150 meters around them. To a lesser extent, the ancillary installations can catch fire: transformation units, source units, etc.

Given the exceptional nature of a malicious act, this risk can be considered as highly unlikely. Given the installation of the wind turbines more than 500 meters from dwellings, the risk can be considered as extremely low.
Thus, the low probability of this phenomenon, the virtual absence of such acts in the feedback and the anti-intrusion system on the wind turbine mast doors, the scenarios relating to the malicious acts are not considered in this guide.

10.3.4 Risks from lack of utilities

➢ ***Loss of electric power***

The turbine is shut down automatically if there is a loss of general power supply from the grid. Loss of electric power causes the operating system to feather the blades. The equipment required to maintain the installation totally safe is backed-up by inverters.
In this, it is important to make sure that:
- the inverters are working properly;
- the fire detections powered electrically have sufficient autonomy in a power cut (via the emergency battery).

- ***Loss of the cooling system***

When the cooling circuits are unavailable for a long time (loss of water circulation, leak in the circuit, loss of gearbox oil circulation, fan stopped), the equipment in question is shut down automatically (fault detection, high temperature detection) to avoid damaging overheating of the equipment and its potential indirect consequences, to protect the environment and the safety of persons.

10.4 STUDY OF THE ACCIDENT RATE

The reason behind studying accidents occurring in similar installations is to prepare the risk analyzes for the installation and operation. The study defines precisely the causes and consequences of failures studied.

An international inventory of accidents is compiled, as this gives a far wider field of survey, all the more so that this type of operation is relatively similar throughout the world.

The research is based on the ARIA database at the Risk and Industrial Pollution Analysis Bureau, attached to the Industrial Environment Department of the French Ministry of Ecology and Sustainable Development and also the database of the Caithness Windfarm Information Forum (CWIF) for accidents occurring in Europe, United States, Canada, Australia and China.

The analysis of past accidents highlights:

- The type of events that could release potential hazards;
- The consequences of feared events;
- The relevance of safety barriers that can prevent, detect or control the appearance of hazardous phenomena or reduce their consequences.

10.4.1 Selected accidents

As the accident rate of installations in operation is very limited, the accident rate is also based on similar equipment sometimes coming from similar sectors.

The accident inventory in the ARIA database compiles all the accidents identified in France or abroad actually of involving a wind farm installation; it lists a considerable number of accidents.
However, the study selected the most instructive accidents.

Table 64: Summary of the accident rate (source ARIA)

No.	Accident	Equipment/Installation	Cause	Consequence
1	**N° 38999-19/09/2010 ROCHEFORT-EN-VALDAINE (26)**	Fire in two wind turbines 45 m high and 3 km apart.	malfunctioning of automatic hydraulic brakes on two wind turbines - runaway and fire	One broke up and sent debris flying through the air causing two wildland fires over 3500 and 1500 m^2
2	**N° 37601 30/10/2009 FREYSSENET(07): EOLIENNEVESTAS**	**Fire at the top of a rotor on a wind turbine 70 m high, commissioned in 2005**	**short-circuit following a maintenance operation**	**The carbon fibre and glass material melted in the heat, releasing smoke and generating odour nuisances detectable in the Ouvèze Valley.**
3	**N° 34340-10/03/2008DINÉAULT (29):**	One of four wind turbines installed in the 2000s became uncontrollable	Power cuts due to storm force winds of over 100 km/h damaged the automatic shut down system for the blades provided for in the event of too strong winds	One of these blades started to fold
4	**N° 29385 22/12/2004 MONTJOYER-**	smoke and unaccustomed noise on a wind turbine	malfunction in the braking system	Three blades broken (two disintegrated and fell to the ground and the third broke and stayed hanging) and outbreak of fire in one wind turbine
5	**ROCHEFORT (26)**	Collapse of a mast of one of nine wind turbines in service	wind	a wind turbine fell, with the mast and part of its foundation that had been torn up, following the break up of the nacelle, rotor and blades
6	**N° 29388 20/03/2004LOON PLAGE -**	One wind turbine amount four wind generators 60 m high inaugurated in May 2002 broke during the night	defective tightening of bolts connecting two mast sections (maintenance failure)	the generator and three 25 m bales fell from the rotor.

Table 65: Summary of the accident rate (source ARIA)

Type of accident	Year	Description	Number
Maintenance/Construction	1975 - 2011	Accidents to third parties, site accidents, dragging in the rotating mechanisms, electrocution, falling	149

Type of accident	Year	Description	Number
		from a great height (simple injuries to fatalities)	
Blade ruptures	1975 - 2011	Broken blades that can fly through the air for up to 1300 m	203
Structural problems	1975 - 2011	Falling rotors, nacelles, collapse of the wind turbine	112
Fires	1975 - 2011	Due to overheating and motor runaway problems, to lightning and even in very few cases to malicious acts.	158
Transport	1975 - 2011	Section of wind turbines falling from the carrier, hitting obstacles near the carrier/road accident	70
Environmental impacts	1975 - 2011	wind turbines causing death or injury to the surrounding wildlife (including protected species)	86
Other	1975 - 2011	accidents caused by particular circumstances: floods, lightning, problems with the issuing of planning permission for areas too close to dwellings, lack of machinery maintenance	185

Conclusion

It appears that the majority of accidents involving wind turbines occur during unsettled meteorological conditions and in most cases result in rupture blades or collapse.

10.4.2 Feedback on accident causes

There are frequently many causes of an industrial accident that are difficult to establish. In addition, their correct identification normally assumes advanced investigations that are only systematically undertaken for serious accidents or those theoretically providing useful pointers. Lastly, there is usually a broad margin of interpretation in classifying causes.
The main causes identified are therefore:

- Equipment failure,
- Human failure,
- Malice,
- Insufficient intervention,
- Outside accident.

Figure 59: Distribution of number of accidents noted in wind turbines by type of accident

Although the next table is not exhaustive, it highlights the events to be feared:

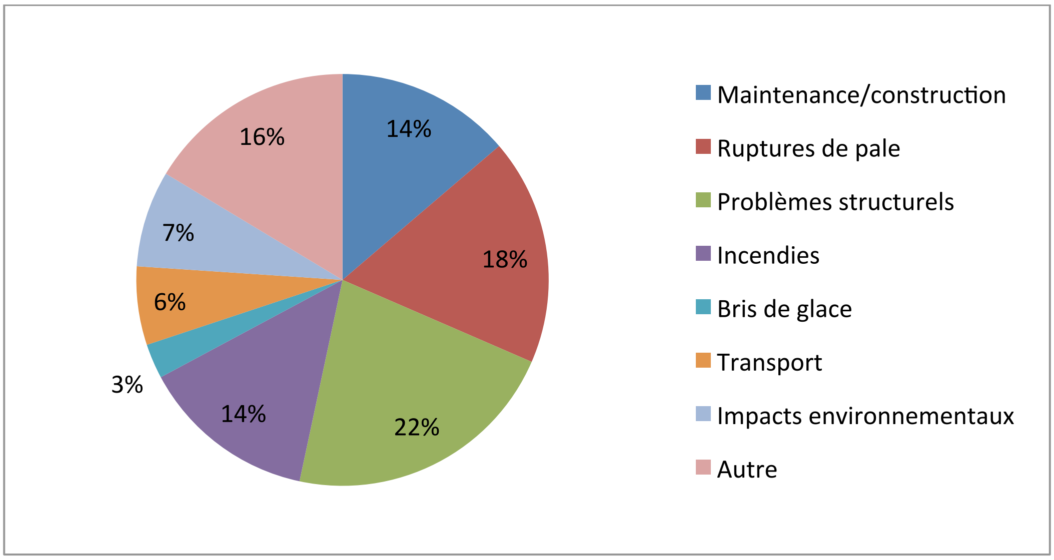


Table 66: Summary of feared events

Area of effect	Source of potential hazard	Initiating event	Feared event
Distance around the wind turbine equivalent to its total height	Lightning	Collapse of the wind turbine	Fire in the rotor and blades
Distance around the wind turbine equivalent to its total height	Lightning	Collapse of the wind turbine	Generalised fire and collapse of the wind turbine
Distance around the wind turbine equivalent to its total height	Storm	Kinetic energy of the wind	Fire in the nacelle
Distance around the wind turbine equivalent to its total height	Storm	Kinetic energy of the wind	Generalised fire and collapse of the wind turbine
Radius of one kilometer around the wind turbine	Storm	Kinetic energy of the wind	Breaking blade/Ejection of blades
Radius of one kilometer around the wind turbine	Lightning	Collapse of the wind turbine	Broken blade
Distance around the wind turbine equivalent to its total height	Flooding	Kinetic energy of the water	Collapse of the wind turbine
Distance around the wind turbine equivalent to its total height	Flooding	Saturated ground	Weakening of the soil around the base, collapse of the wind turbine
Distance around the wind turbine equivalent to its total height	Storm	Kinetic energy of the wind	Base torn out and collapse of the wind turbine
Distance around the wind turbine equivalent to its total height	Storm	Kinetic energy of the wind	Runaway of the rotor
Distance around the wind turbine equivalent to its total height	Storm	Kinetic energy of the wind	Falling nacelle
Radius of one kilometer around the wind turbine	Snowy weather	Inertia of the rotor then moving again	Formation of ice stalactites then ejection when the rotor starts up again

Area of effect	Source of potential hazard	Initiating event	Feared event
No particular area	Inattention	Transport	Wind turbine sections hanging out of the lorry and hitting nearby obstacles
rotor diameter	Environmental disturbance	-	Collision between the blades and the local wildlife (bats, birds of prey, etc.)
rotor diameter	Third parties	Poor meteorological conditions	Collision between parachutist and rotor
rotor diameter	Third parties	Inattention	Collision between aeroplane and wind turbine
Distance around the wind turbine equivalent to its total height	Poor maintenance	Maintenance	Objects falling on the technicians --> injuries
Distance around the wind turbine equivalent to its total height	Uncontrolled restarting	of the rotor Maintenance Technician falling	Technician falling
rotor diameter	Uncontrolled restarting	of the rotor Maintenance Technician falling	Limb dragged into the machinery
Wind turbine interior	Uncontrolled restarting	of the rotor Maintenance Technician falling	Technician falling in the nacelle
Wind turbine interior	Failure to comply with safety instructions	Maintenance	Electrocution and burns of the technician
Construction materials unloading area	Failure to comply with safety instructions	Construction	Section of mast falling on technicians
Construction area	Failure to comply with safety instructions	Construction	Objects falling on the technicians --> injuries
Distance around the wind turbine equivalent to its total height	Poor maintenance	Maintenance	Undetected oil leak --> Environmental pollution
Distance around the wind turbine equivalent to its total height	Lightning	Collapse of the wind turbine	Oil spreading around the wind turbine in a collapse

10.4.3 Risk analysis

Approach

This stage consists of systematically studying all the scenarios, looking for their causes and identifying the associated preventive measures.

In addition, it reviews the possible consequences and identifies control measures.

Lastly, it can define the severity and probability level of each scenario and deduce its risk level.

Presentation of severity and probability scales

The scales used to estimate the probability and severity levels are taken from Senegal's hazard study methodological guide.

Assessing the risk level consists of considering it as being the product of two factors, namely the probability of occurrence P and the importance of the severity S.

Risk = Probability x Severity

The appearance probability levels can go from improbable to frequent and the severity levels from negligible to catastrophic (see next table).

Table 67: Levels of factors (P, 2) in preparing a risk matrix

Probability scale (P)		**Severity scale (S)**	
Score	**Meaning**	**Score**	**Meaning**
IP = improbable	• Never seen with this type of installation; • Almost impossible with this type of installation.	**IS = negligible**	• Minor impact on the personnel • No operation shutdown • Few environmental effects
P2 = rare	• Already encountered in this type of establishment; • Possible in this establishment	**S2 = minor**	• Medical care for the personnel • Minor damage • Small loss of products • Minor environmental effects
P3 = occasional	• Already encountered in this type of installation; • Occasional, but can sometimes happen with this type of installation	**S3 = significant**	• Personnel seriously injured (extended time off work) • Limited damage • Partial shutdown of the operation • significant environmental effects
P4 = frequent	Happens two or three times in the establishment	**S4 = critical**	• Handicapping injury for life (1 to 3 deaths) • Major damage • Partial shutdown of the operation

Probability scale (P)		Severity scale (S)	
Score	**Meaning**	**Score**	**Meaning**
			• significant environmental effects
P5 = constant	Happens several times a year with the installations (more than three times a year)	**S5 = catastrophic**	• Several deaths • Very extensive damage • Long production shutdown

By combining the two levels (P, S) we form a matrix of risks deemed acceptable or not. We have simply produced an assessment grill of the risk level in operating the establishment by allocating a colour code from green to red (Table 62).

Table 68: Risk level matrix

	S5	S4	S3	S2	S1
P5	**55**	**54**	**53**	**52**	**51**
P4	**45**	**44**	**43**	**42**	**41**
P3	**35**	**34**	**33**	**32**	**31**
P2	**25**	**24**	**23**	**22**	**21**
IP	**15**	**14**	**13**	**12**	**11**

Meaning of the colours:

- A very limited **risk** (tolerable) will be considered as **acceptable** and will be coloured **green**. In this case, no action is required;
- **Yellow** means a **significant risk.** In this case, a reduction plan must be implemented in the short, medium and long term;
- While an **unacceptable risk level** is going to need a detailed study of major accident scenarios. The site must have immediate reduction measures by setting up prevention and protection means. It is represented by the colour **red.**

Unacceptably high risk level

Significant risk level

Acceptable risk level

10.4.4 Presentation of risk analysis tables

The risk analysis is prepared using HAZOP tables. The HAZOP method (HAZard OPerability) was developed by Imperial Chemical Industries (ICI) in the early 1970s. Since then it has been adapted by miscellaneous activity sectors.

HAZOP considers the potential deviations of the main parameters in operating the installation. It therefore focuses on the operation of the process.
The next tables summarize the analysis results and risk levels of different scenarios:

Table 69: Summary analysis and presentation of initial risk levels

Hazardous events	Causes	Consequences	IP	IS	Initial risk level
Igniting of fire in the inside sections of the wind turbine	Humidity, Lightning, electrical malfunction	Fire in all or part of the wind turbine Outbreak of fire	P3	S3	32
Overheating of mechanical parts	Misalignment of the generator, defective part, defective lubrication	Fire in all or part of the wind turbine Outbreak of fire	P3	S3	33
Rotor overspeed, defective pitch, overheating of mechanical parts and ignition of fire	Strong wind, lightning	Fire in all or part of the wind turbine Outbreak of fire	P3	S3	33
Defective cell protection creating an overvoltage	Climatic conditions, rodent	Fire in all or part of the wind turbine Outbreak of fire	P3	S3	33
Flow outside the nacelle and along the mast, then on the soil with infiltration	Leaking lubrication system	Environmental pollution	P4	S3	43
Accidental spillage of hazardous products during maintenance operations	Spilling of fluids	Environmental pollution	P4	S3	43
Flow of fluids outside the wind turbine and soil pollution	Leaking converter	Environmental pollution	P4	S3	43
Significant crack(s), damage to/brittleness of the fixing devices.	Structural fatigue, corrosion	Falling element/part of element of the wind turbine with risk of impact on the target	P3	S3	33
Brittleness of the blade, damage to the blade structure	Lightning	Falling element/part of element of the wind turbine with risk of impact on the target	P3	S3	33

Hazardous events	Causes	Consequences	IP	IS	Initial risk level
Structural fault in the blade	Manufacturing fault in the blade or dimensioning error	Falling element/part of element of the wind turbine with risk of impact on the target	P2	S3	33
Brittleness of the nacelle fixings	Faulty nacelle fixing	Falling element/part of element of the wind turbine with risk of impact on the target	P3	S3	33
Significant crack(s)	Brittleness of the blade, wear on the blade, fatigue, degradation of the blade due to difficult climatic conditions, corrosion	Projection of a blade fragment when the wind turbine is moving and risk of impact on the target	P4	S3	43
Too much stress applied to the blades	Strong winds	Projection of a blade fragment when the wind turbine is moving and risk of impact on the target	P4	S3	43
Faulty fixing of blades to the hub	Inappropriate tightening or loosening of blade dowels	Projection of a blade fragment when the wind turbine is moving and risk of impact on the target	P4	S3	43
Damage to the devices fixing blades to the hub, damage to the blade structure	Fire in the nacelle (electrical malfunction, overheating due to a technical fault in the braking system)	Projection of a blade fragment when the wind turbine is moving and risk of impact on the target	P3	S3	33
Major damage to the blade structure	Blade struck by lightning	Projection of a blade fragment when the wind turbine is moving and risk of impact on the target	P3	S3	33
Manufacturing fault in the blade or dimensioning error	Structural fault in the blade	Projection of a blade fragment when the wind turbine is moving and risk of impact on the target	P3	S3	33

Hazardous events	Causes	Consequences	IP	IS	Initial risk level
Stress (e.g. strong winds) applied to the machine exceeding the assumptions made in the dimensioning	Error in dimensioning the foundation	Projection/falling of fragments and falling of the mast	P3	S3	33
Brittleness of the tower (fixing to the foundations, junction of tower sections) by the stress applied to the tower	Strong winds/Fatigue	Projection/falling of fragments and falling of the mast	P3	S3	33
Brittleness of the wind turbine structure or certain of its components (foundation)	Impact between the wind turbine mast and a fire vehicle	Projection/falling of fragments and falling of the mast	P3	S3	33

10.4.5 Detailed study of scenarios retained

Under the hazard study regulations, only the scenarios retained for their potential impact on human targets will be subjected to a detailed analysis of risks presented. The others will, however, be subject to additional measures.

The causes retained that may have consequences potentially impacting human targets are as follows:

- Brittleness of the blade (wear on the blade, fatigue, degradation of the blade due to difficult climatic conditions, corrosion, etc.)
- Inappropriate tightening or loosening of blade dowels, etc.
- Dimensioning error, mechanical shocks, unfavorable climatic conditions, etc.

These conditions culminate in scenarios with flying fragments and/or collapse of the wind turbine.

Also, the scenarios retained for their potential impact on the environment are:

Flow outside the nacelle and along the mast, then on the soil with infiltration
Accidental spillage of hazardous products during maintenance operations
Flow of fluids outside the wind turbine and soil pollution

10.4.6 Analysis by the "bow-tie" method

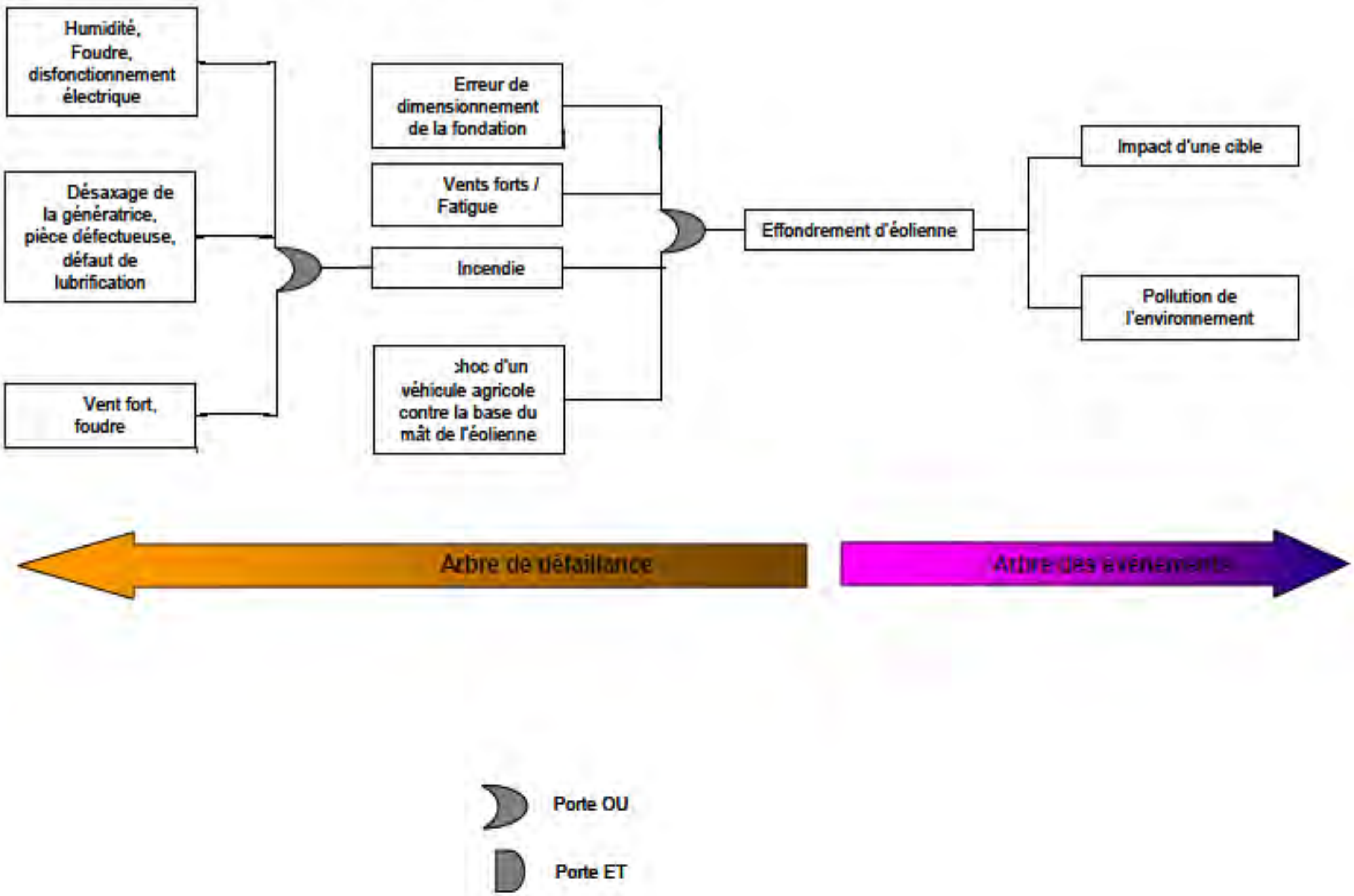
To study in detail the conditions of occurrence and the possible effects of hazardous phenomena and to demonstrate more accurately the control of scenarios causing them, it may be necessary to develop an additional approach to the method used in the preliminary risk analysis and visualise the possible accidental sequences using a representation called ***"bow-tie".***
The use of such a tool based on tree methods like the fault tree and/or the event tree describes the scenario better and also provides valuable elements in demonstrating the control of each scenario.

In concrete terms, it is used to:

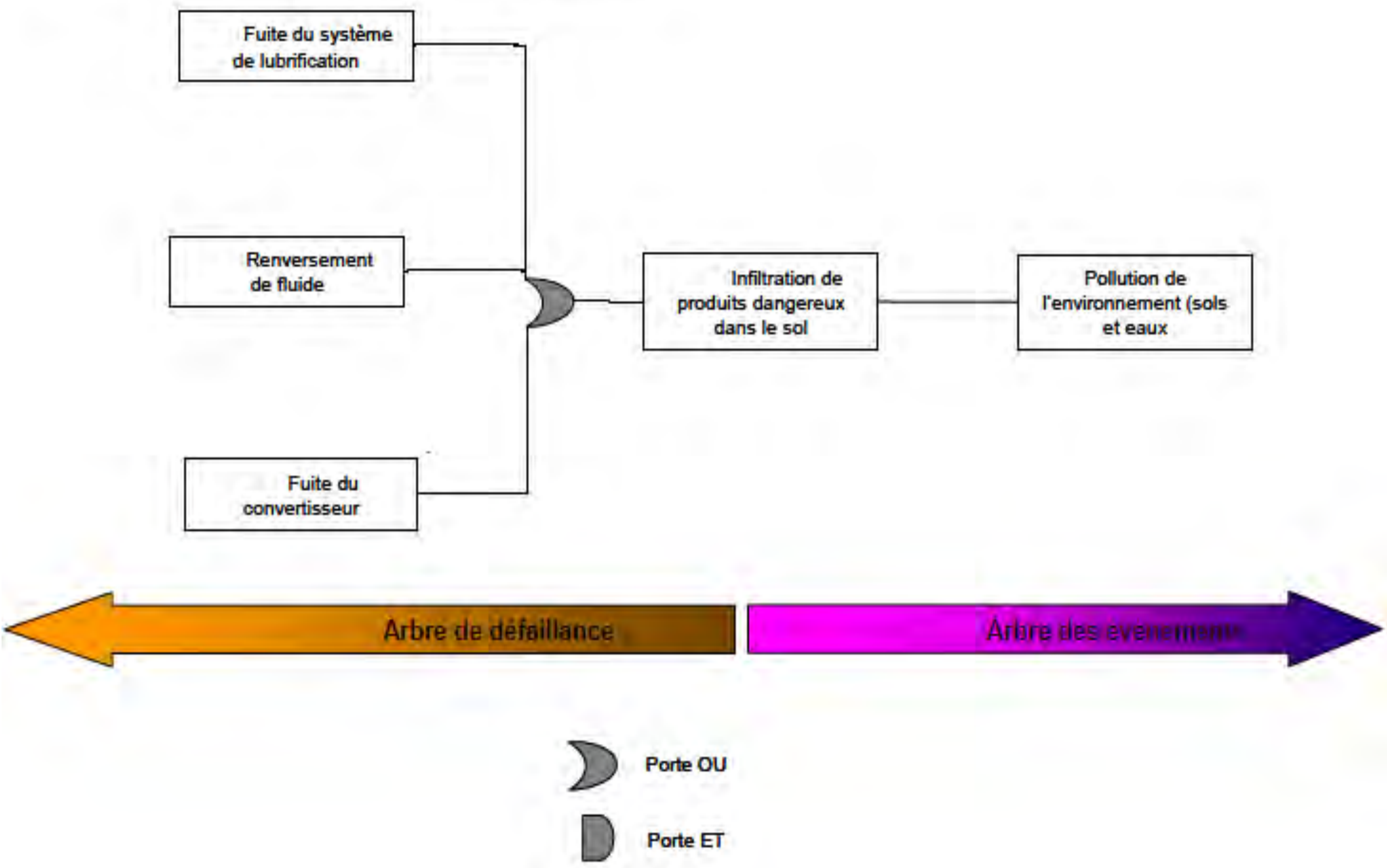
- represent all the combinations of causes (identified during the preliminary risk analysis phase) that could lead to the hazardous phenomenon studied;
- position the safety barriers set up on each "branch";
- determine the probability of the phenomenon studied qualitatively and quantitatively if the available data allows this (confidence level even failure rate on barrier loading, frequencies of initiating events, etc.).

The various bow-ties of different scenarios are thus represented:

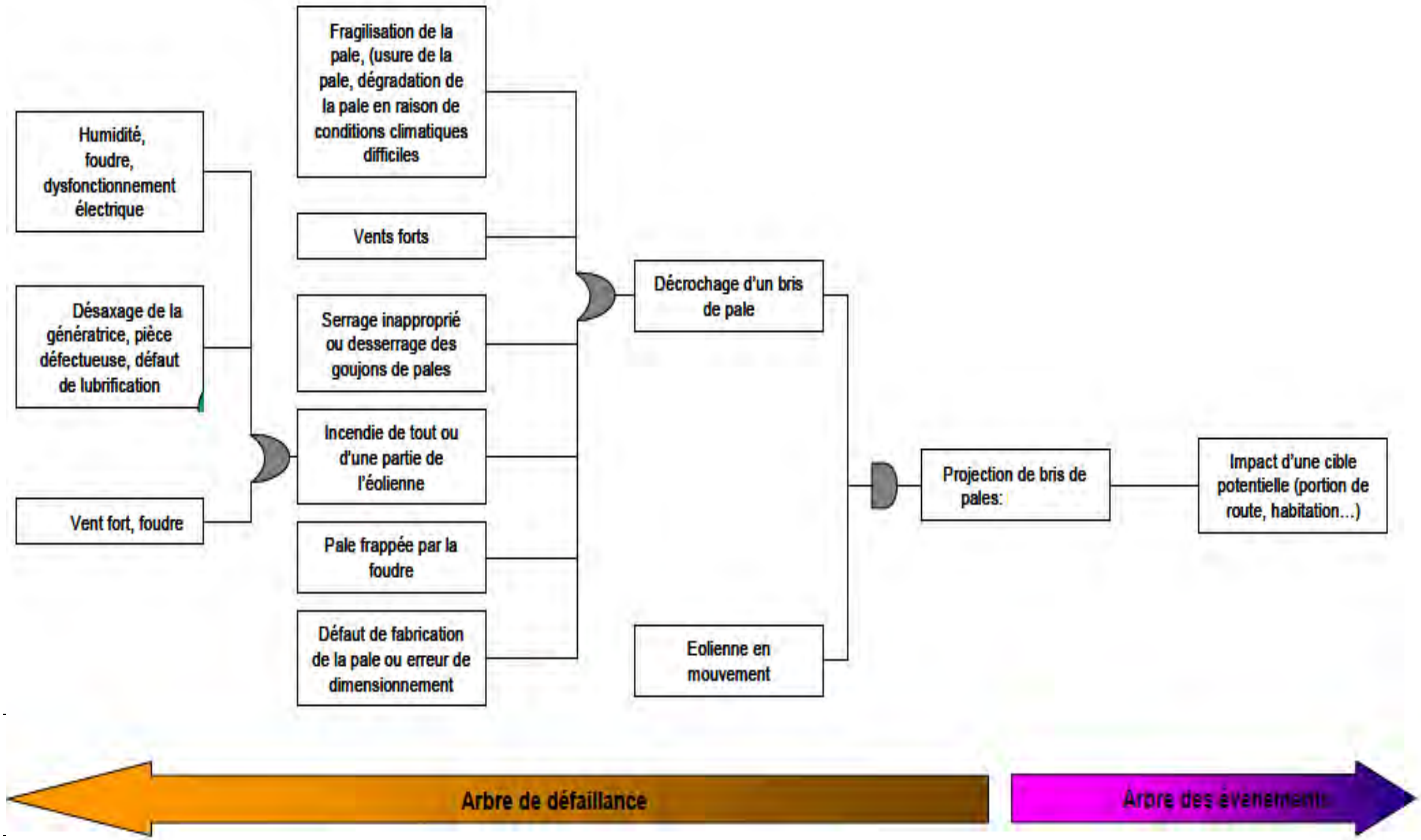
Noeud 1: Effondrement d'éolienne



Noeud 2: Pollution de l'environnement



Noeud 3: Projection de bris de pales



10.4.7 Implementing safety measures

Beacons on the wind turbines makes them stand out more easily both during the day and at night and prevent collisions.

Regular maintenance can prevent accidents such as broken blades and falling objects.

Wearing suitable PPE (and work clothes) and complying with safety rules during interventions on site are defined and must be followed to avoid accidents such as electrocution and falling from a great height.

Safety training for technicians working on the site will be monitored regularly. Note also the presence on site of a first aid kit, anti-noise protection and emergency lighting system.

Fall arrestor systems and anchoring points will be fitted.

Constant surveillance via sensors placed on the wind turbine can detect operating deviations in the system.

In terms of fires, the majority of materials used in the wind turbines are fireproof.

Maintenance will also be able to identify and contain (if necessary) lubricant leaks. Extinguishers are available in each wind turbine.

The access roads will be maintained regularly to facilitate the passage of fire engines (and local residents).

Note also the presence of extinguishers and detection and firefighting protection systems.

Regarding the rotor runaway risks in strong winds/storms: the wind turbines are fitted with a safety system and vibration sensors that block their operation in strong winds.

In addition, as the weather forecasters announce storms in advance, the operation could shutdown the wind turbines remotely.

Regarding the lightning hazards, internal internal and external (lightning rod) lightning arrestors are planned for each wind turbine.

In addition, the entire installation is earthed (network of underground cables connecting all the wind turbines) and each wind turbine will be connected to the earth by a downwards lightning rod cable located at the end of the earthed nacelle.

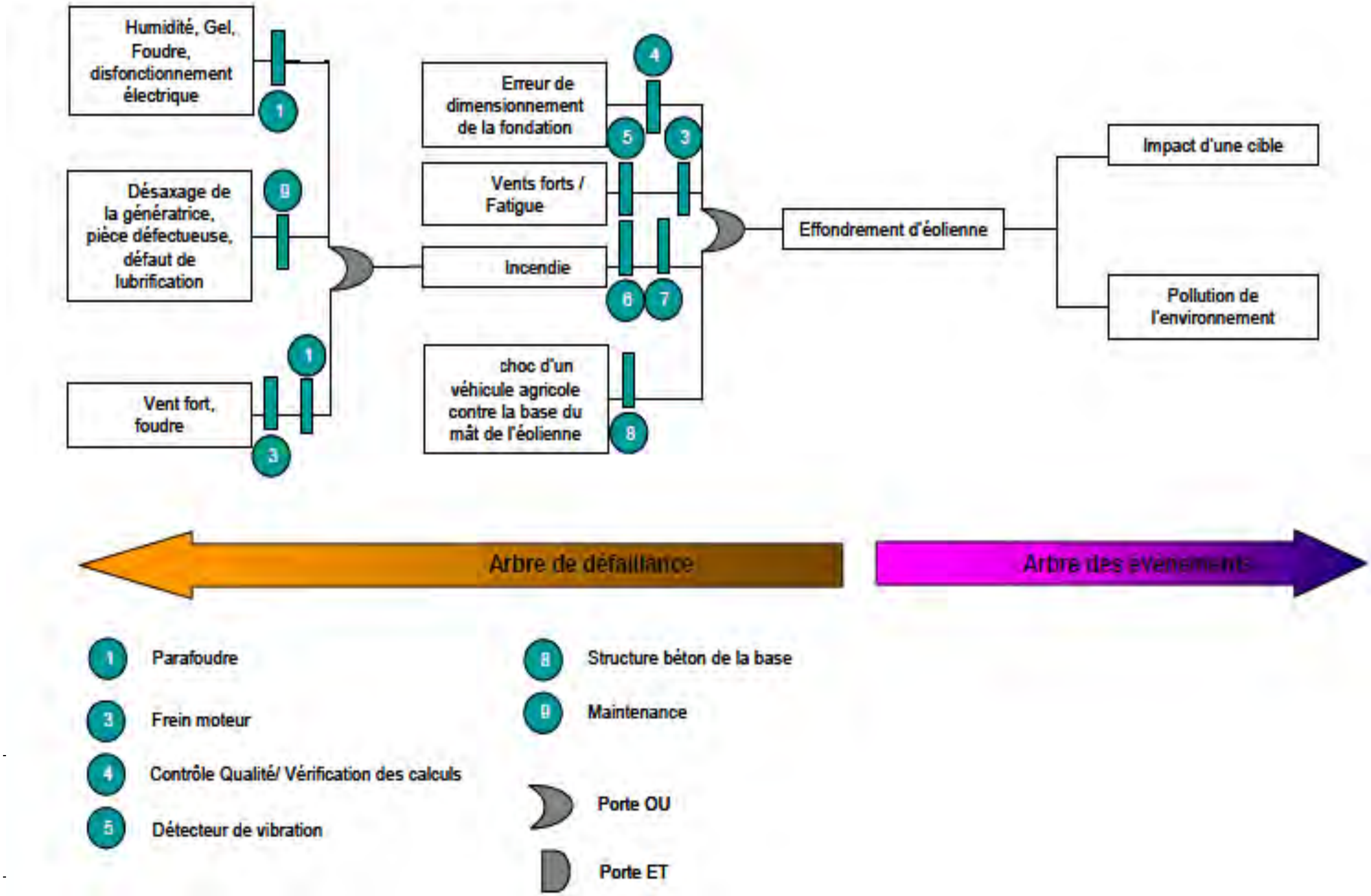
No measure to reduce the special hazard has been introduced for natural phenomena as these risks are considered as low in this region.

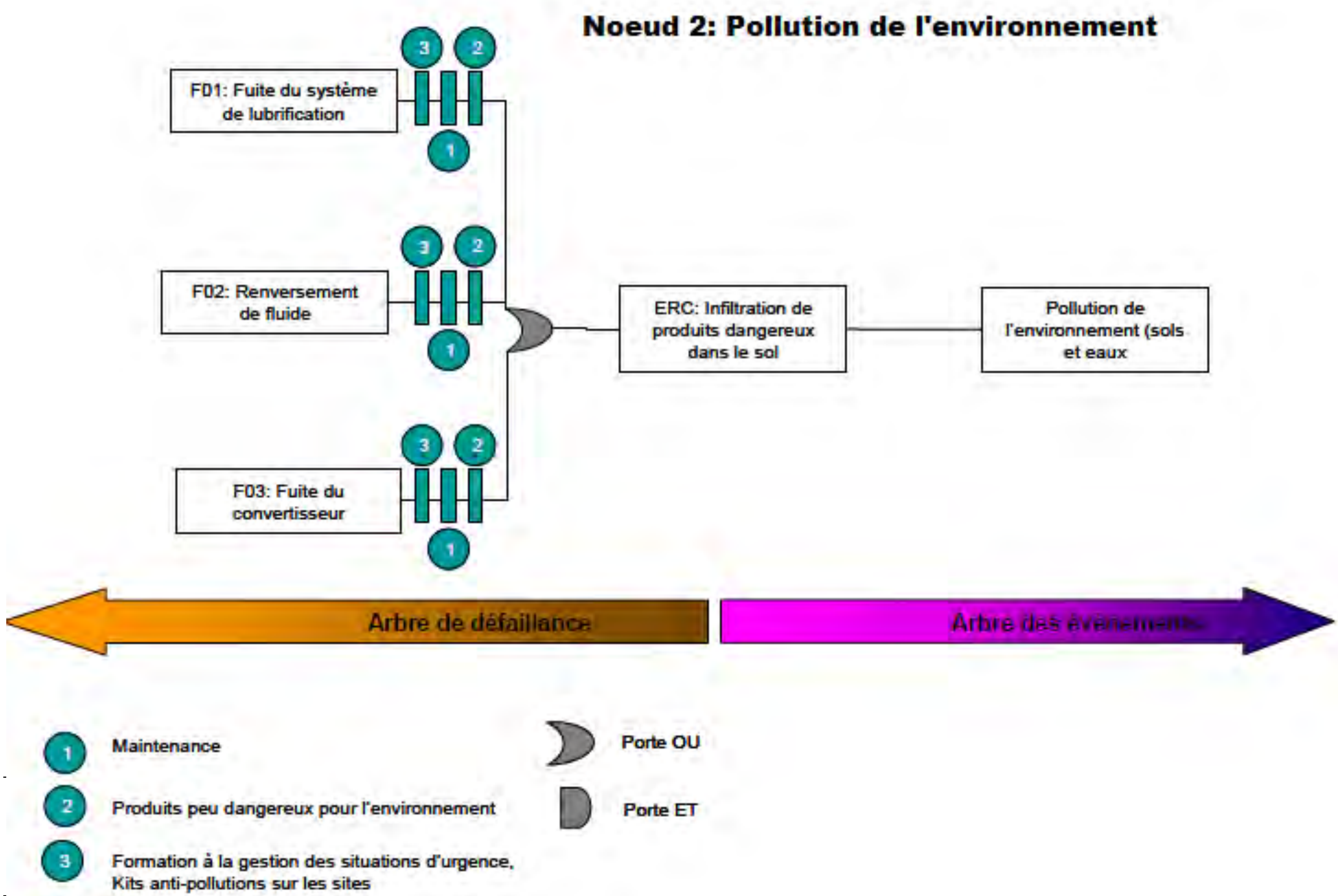
Table 70: Summary of barriers to prevent and mitigate consequences

Prevention measures	**Measures to mitigate the consequences of an accident**
1. Preventive maintenance and inspection of installations	**1.** Scheduling of activities around the wind turbine installation area.
2. Compliance with maintenance and operating procedures	**2.** Setting up a correctly dimensioned network of extinguishers: approach companies specialising in the distribution and installation of extinguishers.
3. Physical and remote surveillance of the site and beacons delimiting the area.	**3.** Have an **Internal Operation Plan** (POI) in accordance with the interministerial order on the POI.
4. Protection against the direct and indirect effects of the lightning (lightning arrestor, lightning rod)	
5. The electrical installations must be checked and inspected every year by an approved body.	
6. Training of personnel (in extinguishing a fire and first aid).	
7. Test of safety devices according to the manufacturer's stipulations	
8. Earthing and lightning arrestor	

Implementing safety barriers culminates in the bow-ties below:

Noeud 1: Effondrement de l'éolienne





Noeud 2: Pollution de l'environnement
F01: Fuite du système de lubrification
F02: Renversement de fluide
F03: Fuite du convertisseur
ERC: Infiltration de produits dangereux dans le sol
Pollution de l'environnement (sols et eaux
Arbre de défaillance
Arbre des événements
Maintenance
Produits peu dangereux pour l'environnement
Formation à la gestion des situations d'urgence, Kits anti-pollutions sur les sites
Porte OU
Porte ET

Table 71: Summary analysis and presentation of final risk levels

Hazardous events	Causes	Consequences	IP	IS	Risk level I	Prevention	FP	Controlling the consequences	FS	FL	Residual risks
Igniting of fire in the inside sections of the wind turbine	Humidity, lightning, electrical malfunction	Fire in all or part of the wind turbine Outbreak of fire	P3	S3	32	Non-flammable materials lightning arrestor, Lightning rod detection of temperature, 24H surveillance	P2	Fire extinguishing Introduction of a rapid evacuation plan Limiting the presence of the personnel in the installation	S2	22	Loss of equipment
Overheating of mechanical parts	Misalignment of the generator, defective part, defective lubrication	Fire in all or part of the wind turbine Outbreak of fire	P3	S3	33	Imbalance detection, temperature sensor, maintenance	P2	Fire extinguishing Introduction of a rapid evacuation plan Limiting the presence of the personnel in the installation	S2	22	Loss of production
Rotor overspeed, defective pitch, overheating of mechanical parts and ignition of fire	Strong wind, lightning	Fire in all or part of the wind turbine Outbreak of fire	P3	S3	33	Overspeed detector	P2	Fire extinguishing Introduction of a rapid evacuation plan Limiting the presence of the personnel in the installation	S2	22	Loss of production
Defective cell protection creating an overvoltage	Climatic conditions, rodent	Fire in all or part of the wind turbine Outbreak of fire	P3	S3	33	Maintenance, alert system	P2	Fire extinguishing Introduction of a rapid evacuation plan Limiting the presence of the personnel in the installation	S2	22	Loss of production
Flow outside the nacelle and along the mast, then on the soil with infiltration	Leaking lubrication system	Environmental pollution	P4	S3	42	- Checking oil levels during maintenance operations	P3	- Provisional area as a retention tank - Provisional collection floor drain	S3	33	Pollution

Hazardous events	Causes	Consequences	IP	IS	Risk level I	Prevention	FP	Controlling the consequences	FS	FL	Residual risks
Accidental spillage of hazardous products during maintenance operations	Spilling of fluids	Environmental pollution	P4	S3	43	- Procedure for managing emergencies. - Protecting the environment in the event of a leak using anti-pollution kits	P3	- Regular monitoring by an operator	S3	33	Pollution
Flow of fluids outside the wind turbine and soil pollution	Leaking converter	Environmental pollution	P4	S3	43		P3		S3	33	Pollution
Brittleness of the blade, damage to the blade structure	Lightning	Falling element/part of element of the wind turbine with risk of impact on the target	P3	S3	33	Preventive maintenance (prevent the degradation of the state of equipment)	P2	Infrastructures away from the wind farm Evacuation of the personnel	S2	22	Loss of equipment
Structural fault in the blade	Manufacturing fault in the blade or dimensioning error	Falling element/part of element of the wind turbine with risk of impact on the target	P2	S3	23	Manufacturing quality control, preventive maintenance (blade inspection)	P2	Infrastructures away from the wind farm Evacuation of the personnel	S2	22	Loss of equipment
Brittleness of the nacelle fixings	Faulty nacelle fixing	Falling element/part of element of the wind turbine with risk of impact on the target	P3	S3	33	Application of assembly instructions, preventive maintenance	P2	Infrastructures away from the wind farm Evacuation of the personnel	S2	22	Loss of equipment
Significant crack(s)	Brittleness of the blade (wear on the blade, fatigue, degradation of the blade due to difficult climatic conditions, corrosion)	Projection of a blade fragment when the wind turbine is moving and risk of impact on the target	P4	S3	43	Preventive maintenance (regular blade inspection)	P3	Infrastructures away from the wind farm Evacuation of the personnel	S3	33	Loss of equipment

Hazardous events	Causes	Consequences	IP	IS	Risk level I	Prevention	FP	Controlling the consequences	FS	FL	Residual risks
Too much stress applied to the blades	Strong winds	Projection of a blade fragment when the wind turbine is moving and risk of impact on the target	P4	S3	43	Automatic shutdown above a wind speed fixed by the type of machine	P3	Infrastructures away from the wind farm Evacuation of the personnel	S3	33	Loss of production
Faulty fixing of blades to the hub	Inappropriate tightening or loosening of blade dowels	Projection of a blade fragment when the wind turbine is moving and risk of impact on the target	P4	S3	43	Application of assembly instructions, preventive maintenance	P3	Infrastructures away from the wind farm Evacuation of the personnel	S3	33	Loss of production
Damage to the devices fixing blades to the hub, damage to the blade structure	Fire in the nacelle (electrical malfunction, overheating due to a technical fault in the braking system)	Projection of a blade fragment when the wind turbine is moving and risk of impact on the target	P3	S3	33	Fire detection, preventive maintenance	P2	Fire extinguishing Introduction of a rapid evacuation plan Limiting the presence of the personnel in the installation	S2	22	Loss of equipment
Major damage to the blade structure	Blade struck by lightning	Projection of a blade fragment when the wind turbine is moving and risk of impact on the target	P3	S3	33	Lightning protection installation	P2	Infrastructures away from the wind farm Evacuation of the personnel	S2	22	Loss of production
Manufacturing fault in the blade or dimensioning error	Structural fault in the blade	Projection of a blade fragment when the wind turbine is moving and risk of impact on the	P3	S3	33	Manufacturing quality control, preventive maintenance (blade inspection)	P2	Infrastructures away from the wind farm Evacuation of the personnel	S2	22	Loss of equipment

Hazardous events	Causes	Consequences	IP	IS	Risk level I	Prevention	FP	Controlling the consequences	FS	FL	Residual risks
		target									
Stress (e.g. strong winds) applied to the machine exceeding the assumptions made in the dimensioning	Error in dimensioning the foundation	Projection/ falling of fragments and falling of the mast	P3	S3	33	Application of manufacturer's specifications, technical inspection of the construction	P2	Infrastructures away from the wind farm Evacuation of the personnel	S2	22	Loss of equipment
Brittleness of the tower (fixing to the foundations, junction of tower sections) by the stress applied to the tower	Strong winds/Fatigue	Projection/ falling of fragments and falling of the mast	P3	S3	33	Preventive maintenance of the tower	P2	Infrastructures away from the wind farm Evacuation of the personnel	S2	22	Loss of equipment
Brittleness of the wind turbine structure or certain of its components (foundation)	Impact between the wind turbine mast and a fire vehicle	Projection/ falling of fragments and falling of the mast	P3	S3	33	Low kinetic energy of farm vehicles, few visits Use of non-flammable materials for the tower (steel or concrete)	P2	Infrastructures away from the wind farm Evacuation of the personnel	S2	22	Loss of equipment

10.5 DETAILED STUDY OF BLADES FLYING THROUGH THE AIR

These incidents have been considered in the preliminary risk analysis as critical scenarios and should thus be the subject of a detailed risk analysis according to the installation retained.

To assess the increasing risks, we use the ballistic method to check for an acceptable risk level for each scenario for all potential targets identified in the areas surrounding the wind turbines.

The probability of the risk must be below the level of acceptability considered for it to be deemed acceptable. Thus, a probability calculation will determin the probabilities of a complete blade or blade fragments flying through the air onto a potential target considered in our case as suffering significant lethal effects. In this case, the risk index can be assimilated with the probability of collision between a flying object and a target.

10.5.1 Thresholds

For information, regarding the values for the effect thresholds relating to the impact of a flying object, the French standards state that "Given the limited knowledge in determining and modelling effects of flying objects, the assessment of these effects of a hazardous phenomenon requires, if appropriate, a case-by-case analysis, justified by the operator".

The effects thresholds proposed characterize hazardous phenomena where the intensity is applied in all directions around the origin of the phenomenon and decreases based on the distance (for example a fire or explosion).

Three thresholds are required for each type of effect (overpressure, toxic and thermal): threshold of significant lethal effects, thresholds of lethal effects and thresholds of irreversible effects.

These thresholds define areas in which people exposed will suffer a more or less high risk:

- People in the area of significant lethal effects will be exposed to a risk of lethality of 100% to 5%;
- People in the area of lethal effects will be exposed to a risk of lethality of 5% to 1%;
- People in the area of irreversible effects will be exposed to a risk of irreversible injury.

In the case of scenarios involving wind turbine components flying through the air, the notion of "effect threshold" is not applicable: the intensity of the phenomenon does not decrease based on the distance but is applied in a well-delimited area at a constant intensity (at the area of impact of the wind turbine component).

It is proposed here that this intensity corresponds to a lethality of 5% to 1% in the impacted area (i.e. the level of threshold of lethal effects)).

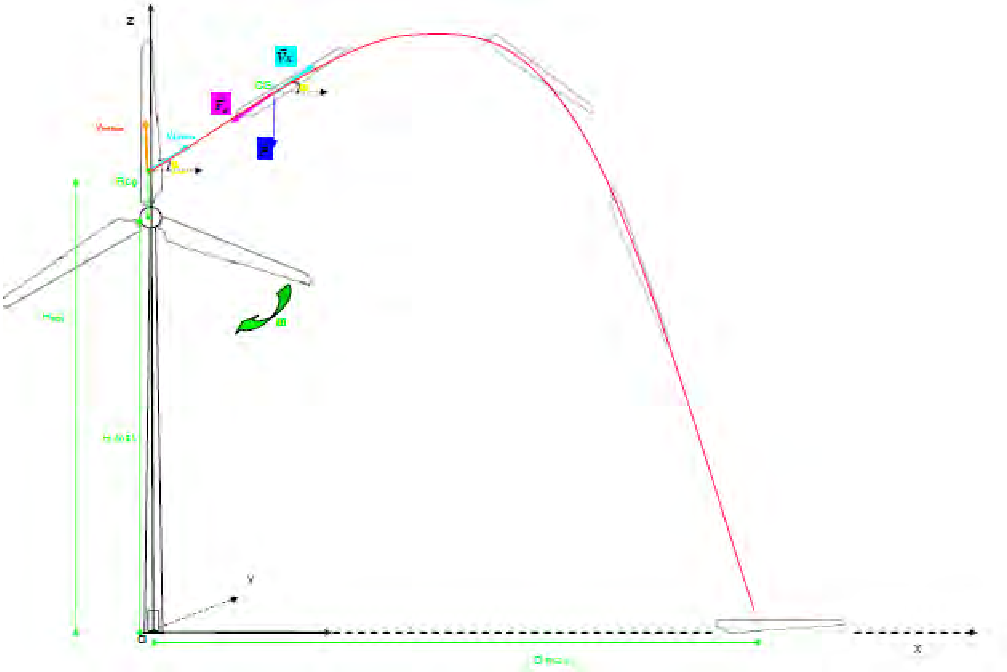
10.6 DETAILS OF CALCULATIONS OF SCENARIOS OF WIND TURBINE FRAGMENTS FLYING THROUGH THE AIR

Given the presence of rural roads, several pedestrian tracks and power sub-stations near the wind generators, a ballistic study has calculated the maximum range of any fragments should a blade accidentally rupture totally or partially.

The impacted area is considered to correspond to a lethality of 5% to 1% covering a circular area with a maximum radius to determine around each wind turbine.

10.6.1 Ballistic study of broken blades: Description of scenarios

The principle of the trajectory and input data for the modelling is according to this diagram:



Three scenarios have been retained for each wind turbine:

- rupture of an entire blade;

- rupture of the end quarter of a blade (25% of the total length);

- rupture of the tip of a blade (5% of the total length).

The study is conducted for each base scenario for the maximum rotating speed that shuts the turbine down in the event of overspeed.

10.6.2 Calculation methodology and assumptions

1. The ballistic calculations were performed using a model developed by our firm.

2. Air resistance was taken into account as a linear function of the square of the speed of the flying object.

2. The resulting differential equation is solved by separation of variables.

3. The rebound effect of the flying object once falling to the ground will not be taken into account to model the physical phenomenon. In addition, we shall assume that the flying object takes an ordered flight path and does not turn off an axis.

4. The model's input data are:
- the fragment mass **m** in (kg);
- the height of the mast **Hmast** (m)
- the initial speed of the fragment **V0** (m/s); this involves the linear speed of the centre of gravity (**V0**) of the fragment when the blade ruptures, where **V0** = 2pi*N with N: rotor rotating speed (rpm) and RG: position of the centre of gravity of the fragment in question (m);
- the angle of departure of the fragment **Alpha0** (°);
- the initial position of the fragment **RG** in (m);
- the initial height of the fragment **L** in (m);
- the mean maximum cross section or thrown surface of the fragment **S** (m^2);
- the coefficient of drag (dimensionless) taken as equal to 0.5 (value for a sphere (envelope));
- the maximum distance reached **Xmax** in (m);
- the maximum height reached (m);
- the flight time **tflight** in (s);
- the speed of impact on the ground (m/s).

5. The results from the software relate to:
- the maximum distance reached (m);
- the maximum height reached (m);
- the flight time (s);
- the speed of impact on the ground (m/s).

6. Under this study, only the results relating to the maximum distance reached will be exploited.

7. The assumptions retained for broken blades are:

- the rotor turns correctly despite the fact that the blades are damaged;

- the fragment in question breaks off cleanly without being held.

8. In addition, conservatively, any obstacles or characteristics on the ground that could hinder the trajectory of blade fragments are not taken into account.

NB:
- The principle of ballistic calculations is presented in the annex.

- The detailed characteristics of the wind turbine that are required for the calculations are provided in the annex.

10.6.3 Principle of ballistic calculations

The initial speed of the flying object (bit of blade) $Vo = 2\pi\ Ncrit \times RG$

Ncrit – critical rotating speed of the wind turbine that causes it to shut down through overspeed.

RG - initial position of the centre of gravity of the fragment in relation to the rotating axis of the blades.

The speed is broken down according to the Z axis and the X axis:

Therefore, $Voz = Vo \sin\alpha$

$Vox = Vo \cos\alpha$

α- Angle of detachment of the bit of pole with respect to the horizontal.

Fundamental relation of the dynamics: $\sum \vec{F} = m\ \vec{c}$ (1)
(1) flying through the air following the x and z axes gives:

$$\begin{cases} m\ (dVx / dt) = -(1/2)\ .\rho o\ .Cdlong\ .S.Vx^2 & (1.a) \\ m\ (dVz / dt) = -mg - (1/2).\ \rho o\ .Cdlong.\ S.Vz^2 & (1.b) \end{cases}$$

This gives $k = ((1/2)\ .\rho o\ .Cdlong\ .S\ )/m$

NB:
(1) The written model takes account here of the air resistance as proportional to the square of the speed of the flying object.

Equations (1.a) and (1.b) then become:

$$\begin{cases} (dVx / dt) + k.Vx^2 = 0 & (2.a) \\ (dVz / dt) + k.Vz^2 = 0 & (2.b) \end{cases}$$

The integration of each differential equation by the variable separation method gives: Vx = Vx(t) et Vy = Vy (t).
The parametric equations of the movement: (X = X (t) et Z = Z (t)) are obtained by the formulae:

$$\begin{cases} (dVx / dt) = Vx^2 & (3.a) \\ (dVz / dt) = Vz^2 & (3.b) \end{cases}$$

The system above gives tflight and Xmax simultaneously (flight time and maximum range). These parameters cannot be calculated explicitly. The system of differential equations (I) must be solved numerically (by software or iterations), with Vox, Voz as parameters.
The restrictions to be imposed for the resolution are:

$$\begin{cases} X\ (tflight) = Xmax \\ Z(tflight) = 0 \end{cases}$$

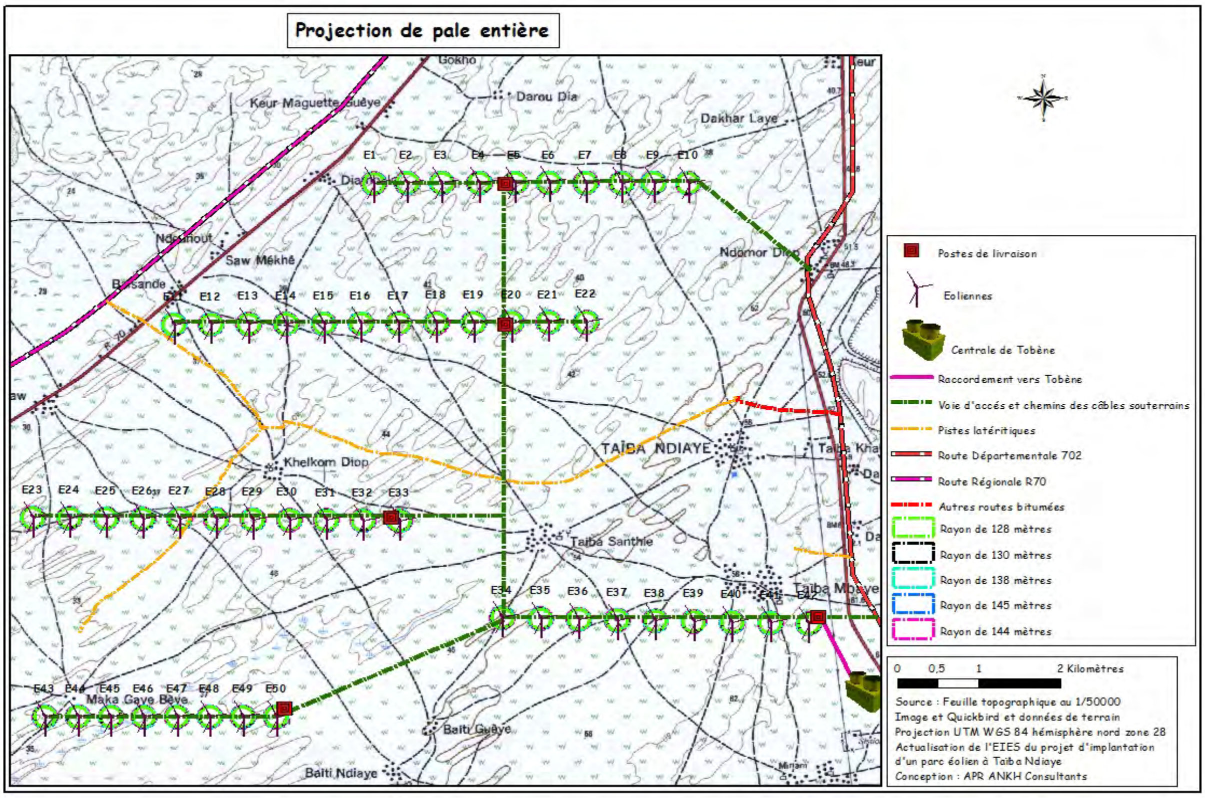
10.6.4 Calculation results and graphic representation of distances of effects.

We present below the results of the ballistic calculation for different angles of projection and the associated graphic representation.

☞ **Entire blade flying through the air**

Table 72: **Calculation results for an entire blade flying through the air**

Hmast (m)	119	119	119	119	119
Blade length (m)	54.65	54.65	54.65	54.65	54.65
Ncrit (rpm)	17.66	17.66	17.66	17.66	17.66
Rho (kg/m3)	1.225	1.225	1.225	1.225	1.225
Cd_long	0.5	0.5	0.5	0.5	0.5
S (m2)	4.9	4.9	4.9	4.9	4.9
m (kg)	11000	11000	11000	11000	11000
K	0.00013642	0.00013642	0.00013642	0.00013642	0.00013642
Alpha(0) (degree)	***0***	***20***	***25***	***38***	***45***
W (rad/s)	1.84935088	1.84935088	1.84935088	1.84935088	1.84935088
RG(m)	13.6625	13.6625	13.6625	13.6625	13.6625
V(0) (m/s)	25.2667563	25.2667563	25.2667563	25.2667563	25.2667563
Vz(0) (m/s)	0	8.64173962	10.6781926	15.5557685	17.8662947
C1	0	0.88060652	1.087926	1.58393016	1.81854527
tflight (s)	***5.2***	***6.1***	***6.4***	***7.0***	***7.3***
CGz(tflight) (m)	9.8197E-09	1.3646E-08	1.577E-08	4.878E-08	6.5164E-08
Vx(0) (m/s)	25.2667563	23.7429845	22.899458	19.9104757	17.8662947
Xmax (m)	***130***	***144***	***145***	***138***	***129***



Map 16: Distances of effect for an entire blade flying through the air

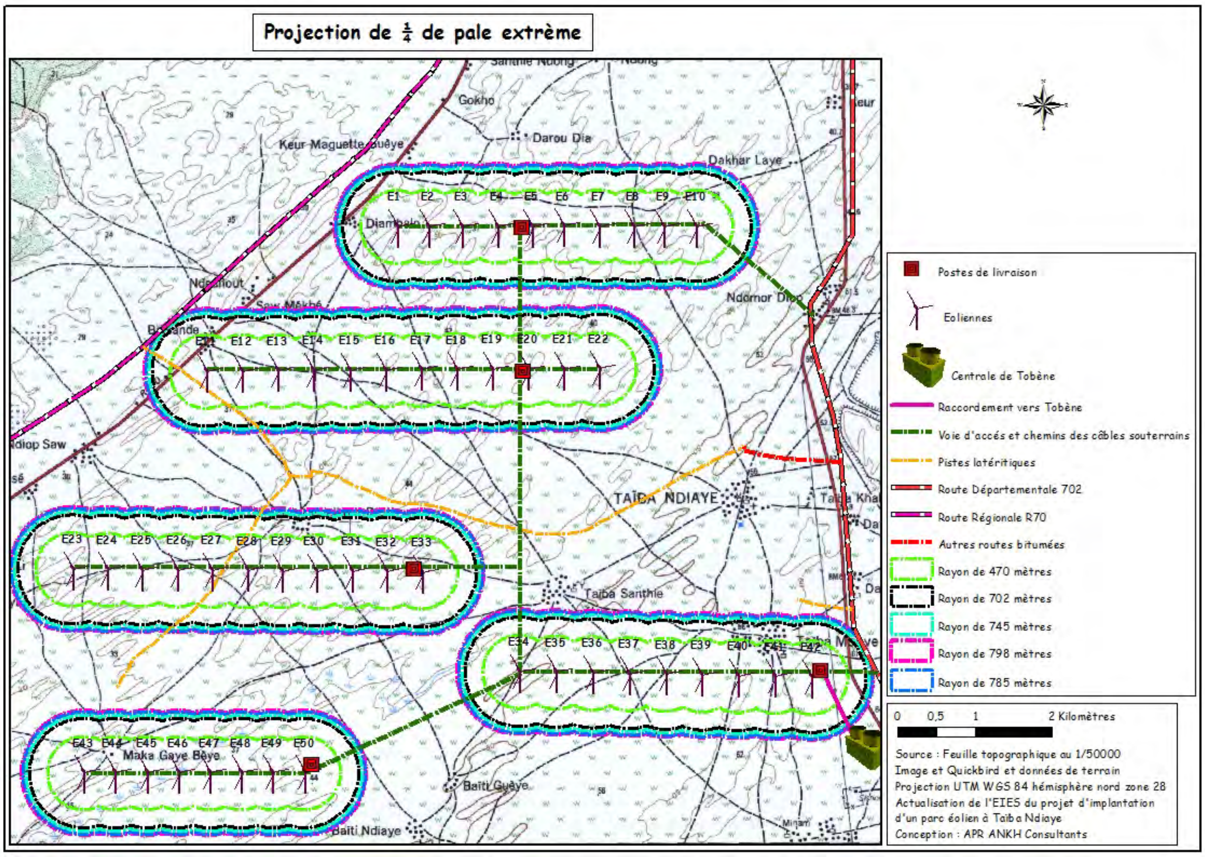
☞ <u>**End quarter of a blade flying through the air**</u>

Table 73: Calculation results for an end quarter of a blade flying through the air

Hmast (m)	119	119	119	119	119
Blade length (m)	13.6625	13.6625	13.6625	13.6625	13.6625
Ncrit (rpm)	17.66	17.66	17.66	17.66	17.66
Rho (kg/m3)	1.225	1.225	1.225	1.225	1.225
Cd_long	0.5	0.5	0.5	0.5	0.5
S (m2)	0.76	0.76	0.76	0.76	0.76
m (kg)	675	675	675	675	675
K	0.00034481	0.00034481	0.00034481	0.00034481	0.00034481
Alpha(0) (degree)	***0***	***20***	***25***	***38***	***45***
W (rad/s)	1.84935088	1.84935088	1.84935088	1.84935088	1.84935088
RG(m)	47.81875	47.81875	47.81875	47.81875	47.81875
V(0) (m/s)	88.4336472	88.4336472	88.4336472	88.4336472	88.4336472
Vz(0) (m/s)	0	30.2460887	37.3736742	54.4451897	62.5320316
C1	0	3.0507656	3.7491791	5.36843389	6.10422639
tflight (s)	***5.8***	***9.6***	***10.6***	***13.2***	***14.4***

CGz(tflight) (m)	8.2454E-07	-1.1278E-07	-1.823E-07	2.5562E-07	-4.0495E-08
Vx(0) (m/s)	88.4336472	83.1004457	80.1481031	69.686665	62.5320316
Xmax (m)	***470***	***702***	***745***	***798***	***785***

Map 17: Distances of effect for an end quarter of a blade flying through the air



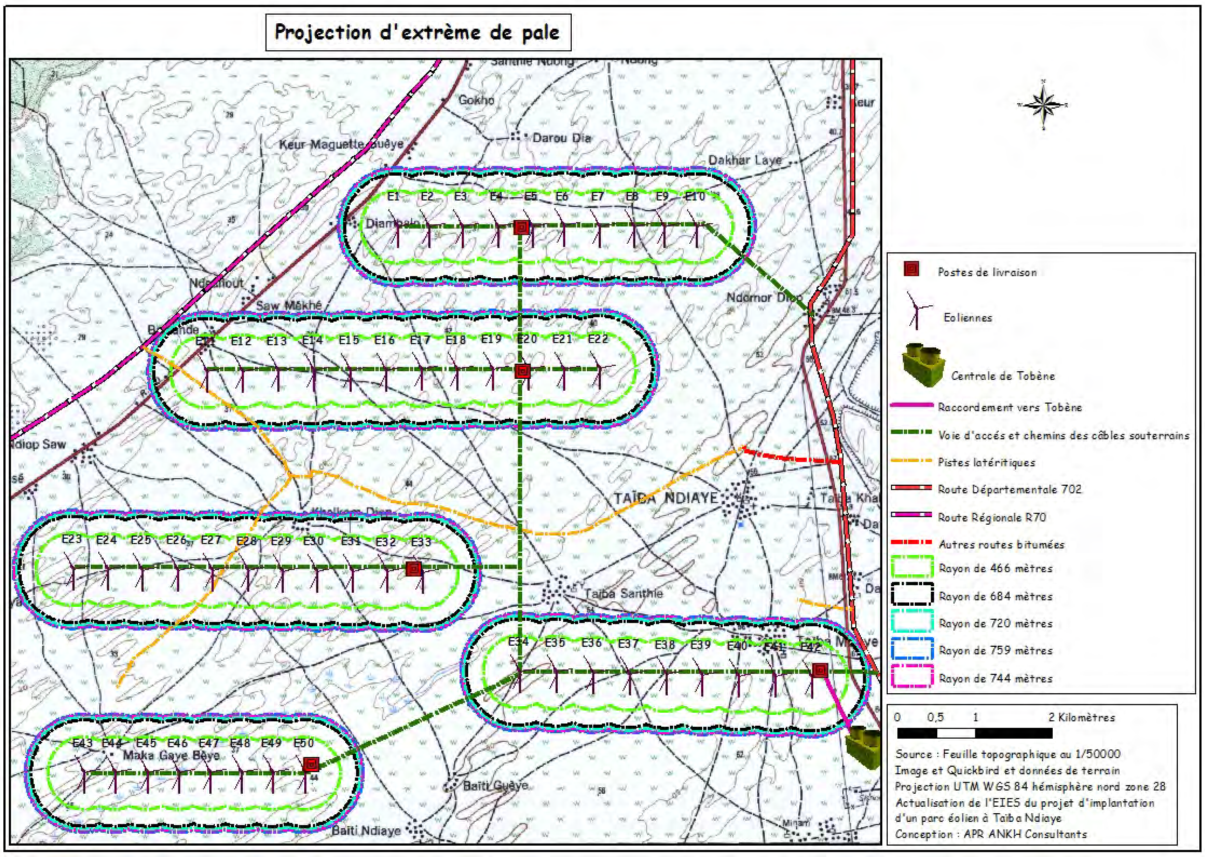
☞ **<u>Tip of a blade flying through the air</u>**

Table 74: Calculation results for the tip of a blade flying through the air

Hmast (m)	**119**	**119**	**119**	**119**	**119**
Blade length (m)	2.24	2.24	2.24	2.24	2.24
Ncrit (rpm)	17.66	17.66	17.66	17.66	17.66
Rho (kg/m3)	1.225	1.225	1.225	1.225	1.225
Cd_long	0.5	0.5	0.5	0.5	0.5
S (m2)	0.14	0.14	0.14	0.14	0.14
m (kg)	56	56	56	56	56
K	0.00076563	0.00076563	0.00076563	0.00076563	0.00076563
Alpha(0) (degree)	***0***	***20***	***25***	***38***	***45***
W (rad/s)	1.84935088	1.84935088	1.84935088	1.84935088	1.84935088
RG(m)	52.41	52.41	52.41	52.41	52.41

V(0) (m/s)	96.9244794	96.9244794	96.9244794	96.9244794	96.9244794
Vz(0) (m/s)	0	33.1501243	40.962055	59.672668	68.5359566
C1	0	3.28729559	4.00638074	5.59794997	6.28203689
tflight (s)	***5.8***	***9.9***	***10.9***	***13.5***	***14.6***
CGz(tflight) (m)	-2.2641E-07	6.4546E-07	-1.3553E-07	3.5452E-07	-1.2017E-07
Vx(0) (m/s)	96.9244794	91.079218	87.8434104	76.377532	68.5359566
Xmax (m)	***466***	***684***	***720***	***759***	***744***

Map 18: Distances of effect for the tip of a blade flying through the air



10.6.5 Summary of results obtained

We present below the results of the ballistic calculation for different angles of projection:

Table 75: Calculation results for an entire blade flying through the air

Type of fragment	Maximum distances in m				
Angle of projection in degrees	**0**	**20**	**25**	**38**	**45**
Entire blade	**130**	**144**	**145**	**138**	**129**
End quarter of a blade	**470**	**702**	**745**	**798**	**785**

Tip of a blade	**466**	**684**	**720**	**759**	**744**

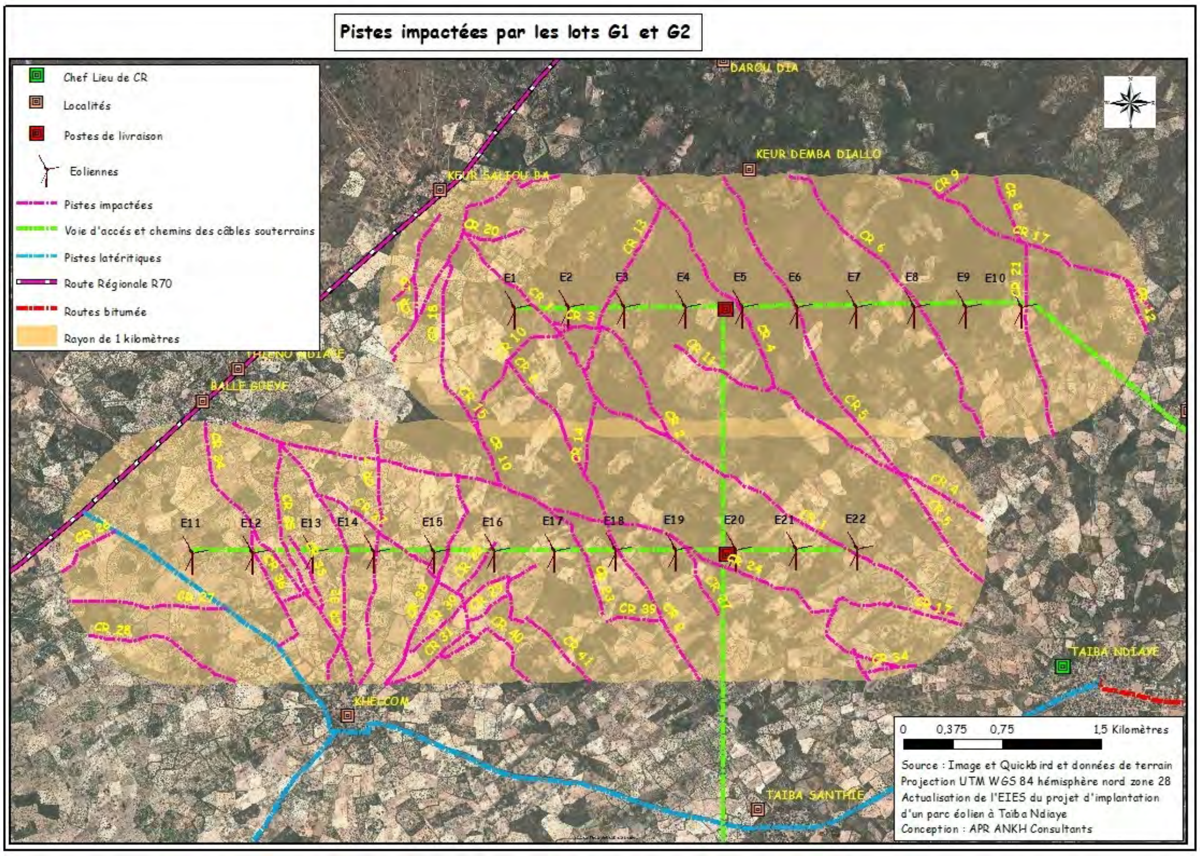
- ❖ We have the maximum distances with an angle of projection of 38°.
- ❖ The maximum distance retained is 759 m. It will be used to calculate probabilities of reaching potential targets with even an overestimation up to 1 km (1000 m).

10.6.6 Identifying targets

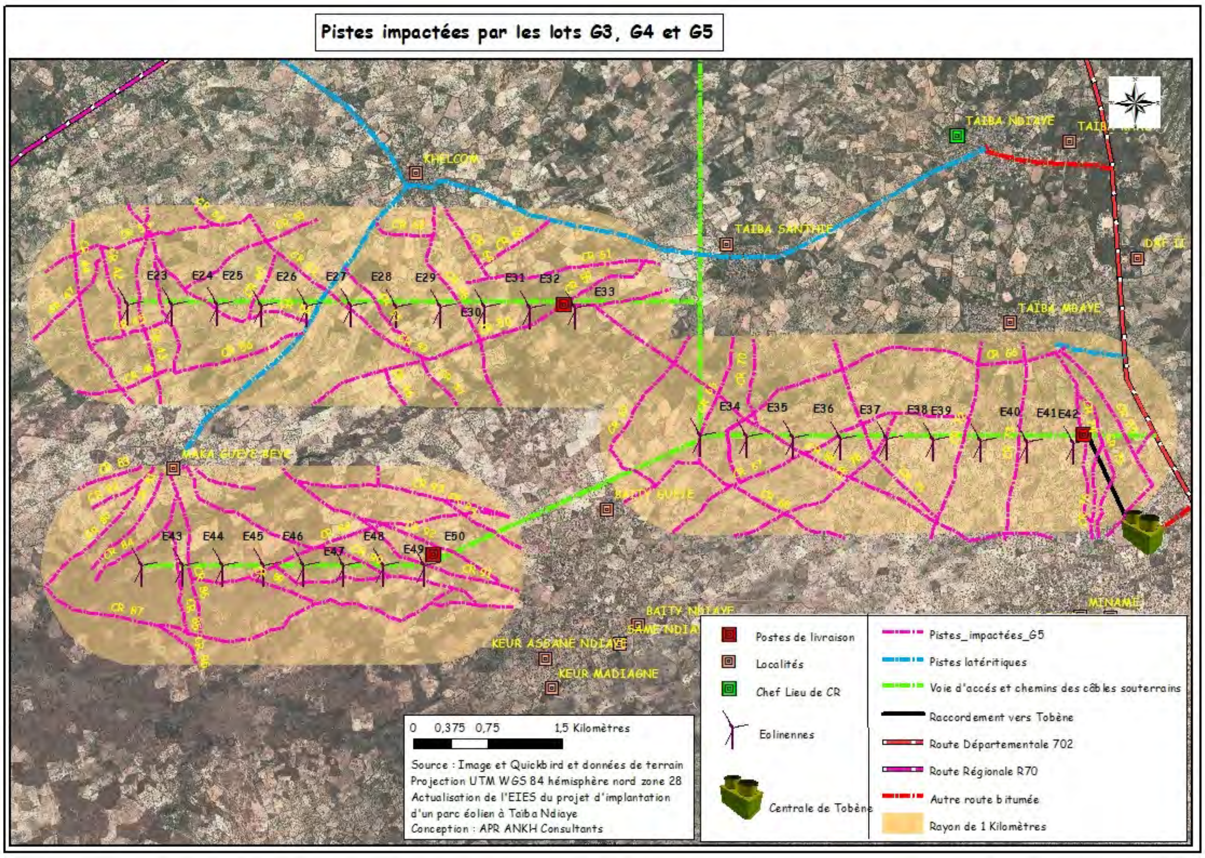
The targets identified below in a radius of 1 km around the wind turbines are likely to be influenced by the ballistic calculation.

The targets likely to be influenced are listed in the next map with two groups of ten wind turbines, i.e. groups (G1 and G2) and (G3, G4 and G5).

Map 19: Identification of targets influenced for groups G1 and G2



Map 20: Identification of targets influenced for groups G3, G4 and G5



The next tables summarize the maps above with the actual distances indicated in yellow in the tables:

Table 76: Distance between the targets and group 1 of the wind turbines

	CR1	CR2	CR3	CR4	CR5	CR6	CR7	CR8	CR9	CR10	CR11	CR12	CR13	CR14	CR15	CR16	CR17	CR18	CR19	CR20	CR21
E1	171	403	312	> 1 km	> 1 km	> 1 km	645	> 1 km	247	> 1 km	690	> 1 km	> 1 km	546	870	540	778	971	698	755	> 1 km
E2	225	299	138	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	857	298	711	> 1 km	948	> 1 km	691	716	610	> 1 km	> 1 km	> 1 km
E3	547	240	240	676	> 1 km	> 1 km	> 1 km	> 1 km	442	464	132	701	> 1 km	> 1 km	> 1 km	961	905	366	> 1 km	> 1 km	> 1 km
E4	900	528	665	281	852	> 1 km	> 1 km	> 1 km	> 1 km	290	535	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	535	> 1 km	> 1 km	> 1 km
E5	> 1 km	> 1 km	> 1 km	20	> 1 km	421	> 1 km	> 1 km	> 1 km	> 1 km	900	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	903	> 1 km	> 1 km	> 1 km
E6	> 1 km	> 1 km	> 1 km	413	2	948	> 1 km	> 1 km	> 1 km	624	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km
E7	> 1 km	> 1 km	> 1 km	684	453	494	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km
E8	> 1 km	> 1 km	> 1 km	> 1 km	935	50	> 1 km	> 1 km	806	> 1 km	> 1 km	> 1 km	798	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	808
E9	> 1 km	> 1 km	> 1 km	> 1 km	> 1 KM	334	> 1 km	656	> 1 km	> 1 km	> 1 km	> 1 km	622	> 1 km	855	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	462
E10	> 1 km	> 1 km	> 1 km	> 1 km	502	735	> 1 km	> 1 km	875	> 1 km	> 1 km	> 1 km	490	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	37

Table 77: Distance between the targets and group 2 of the wind turbines

	CR 1	CR 2	CR 4	CR 5	CR 7	CR 22	CR 23	CR 24	CR 25	CR 26	CR 27	CR 28	CR 29	CR 30	CR 31	CR 32	CR 33	CR 34	CR 35	CR 36	CR 37	CR 38	CR 39	CR 40	CR 41	PL 1	R 70
E 11	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	604	411	664	> 1 km	460	> 1 km	> 1 km	814	504	737	460	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	780
E 12	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	464	927	> 1 km	> 1 km	> 1 km	731	373	153	262	20	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km
E 13	> 1 km	> 1 km	> 1 km	> 1 km	461	961	> 1 km	> 1 km	> 1 km	> 1 km	778	> 1 km	> 1 km	> 1 km	> 1 km	272	86	308	185	405	444	978	> 1 km	> 1 km	> 1 km	778	> 1 km
E 14	> 1 km	> 1 km	> 1 km	> 1 km	25	540	> 1 km	> 1 km	710	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	939	190	567	589	681	792	160	532	803	933	> 1 km	> 1 km	> 1 km
E 15	> 1 km	> 1 km	> 1 km	> 1 km	443	222	> 1 km	> 1 km	373	> 1 km	> 1 km	> 1 km	582	458	658	649	961	961	> 1 km	> 1 km	103	126	460	707	605	> 1 km	> 1 km
E 16	> 1 km	918	> 1 km	> 1 km	922	487	> 1 km	> 1 km	39	> 1 km	> 1 km	> 1 km	347	232	636	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	487	816	220	582	220	> 1 km	> 1 km
E 17	> 1 km	> 1 KM	> 1 km	> 1 km	> 1 km	> 1 km	218	> 1 km	447	> 1 km	> 1 km	> 1 km	472	> 1 km	893	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	170	775	393	> 1 km	> 1 km
E 18	951	30	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	774	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	605	> 1 km	827	> 1 km	> 1 km
E 19	846	418	> 1 km	> 1 km	> 1 km	> 1 km	475	76	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km
E 20	379	920	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	65	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km
E 21	195	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	494	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km
E 22	25	> 1 km	789	610	> 1 km	> 1 km	> 1 km	943	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km

Table 78: Distance between the targets and group 3 of the wind turbines

	CR 42	CR 43	CR 44	CR 45	CR 46	CR 47	CR 48	CR 49	CR 50	CR 51	CR 52	CR 53	CR 54	CR 55	CR 56	CR 57	CR 58	CR 59	CR 60	CR 61	CR 62	CR 63	CR 64	PL 2
E 23	80	120	479	335	441	479	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	605	605	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km
E 24	527	329	906	103	172	926	828	> 1 km	> 1 km	> 1 km	> 1 km	211	201	> 1 km	863	> 1 km	> 1 km	> 1 km	819	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km
E 25	977	764	> 1 km	553	519	> 1 km	575	> 1 km	> 1 km	> 1 km	775	282	24	> 1 km	455	> 1 km	> 1 km	> 1 km	366	> 1 km	> 1 km	> 1 km	> 1 km	820
E 26	> 1 km	> 1 km	> 1 km	> 1 km	956	> 1 km	395	> 1 km	> 1 km	> 1 km	619	582	72	> 1 km	167	> 1 km	> 1 km	> 1 km	86	> 1 km	> 1 km	> 1 km	> 1 km	570
E 27	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	847	> 1 km	850	> 1 km	247	748	141	728	273	> 1 km	> 1 km	> 1 km	535	> 1 km	> 1 km	> 1 km	> 1 km	132
E 28	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	708	> 1 km	25	930	436	278	541	913	> 1 km	> 1 km	985	> 1 km	811	> 1 km	> 1 km	436
E 29	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	686	588	948	699	> 1 km	873	172	957	613	> 1 km	> 1 km	> 1 km	751	725	988	> 1 km	699
E 30	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	236	452	716	> 1 km	> 1 km	> 1 km	582	> 1 km	568	> 1 km	> 1 km	> 1 km	368	726	616	> 1 km	> 1 km
E 31	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	211	304	730	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	822	> 1 km	842	> 1 km	341	899	430	> 1 km	996
E 32	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	586	164	979	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	672	358	> 1 km	300	> 1 km	631	> 1 km	893
E 33	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	523	31	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	223	99	> 1 km	419	> 1 km	> 1 km	> 1 km	722

Table 79: Distance between the targets and group 4 of the wind turbines

	CR 58	CR 65	CR 66	CR 67	CR 68	CR 69	CR 70	CR 71	CR 72	CR 73	CR 72	CR 73	CR 74	CR 75	CR 76	CR 77	CR 78	R 702	PL 3
E 34	463	5	266	593	272	690	600	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km
E 35	149	465	156	404	517	> 1 km	162	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km
E 36	114	833	288	186	744	> 1 km	363	703	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	680	> 1 km	> 1 km
E 37	314	> 1 km	458	35	938	> 1 km	825	261	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	361	> 1 km	> 1 km
E 38	512	> 1 km	657	260	> 1 km	> 1 km	> 1 km	172	782	> 1 km	570	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	21	> 1 km	> 1 km
E 39	793	> 1 km	830	241	> 1 km	> 1 km	> 1 km	637	309	> 1 km	310	864	> 1 km	> 1 km	> 1 km	> 1 km	480	> 1 km	> 1 km
E 40	999	> 1 km	772	259	> 1 km	> 1 km	> 1 km	> 1 km	163	862	165	392	> 1 km	> 1 km	> 1 km	> 1 km	970	> 1 km	> 1 km
E 41	918	> 1 km	920	618	> 1 km	> 1 km	> 1 km	> 1 km	635	79	635	80	574	> 1 km	729	> 1 km	> 1 km	> 1 km	> 1 km
E 42	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	547	> 1 km	540	130	574	273	636	> 1 km	875	959

Table 80: Distance between the targets and group 5 of the wind turbines

	CR 80	CR 81	CR 82	CR 83	CR 84	CR 85	CR 86	CR 87	CR 88	CR 89	CR 90	CR 91	CR 92	CR 93	CR 94	CR 95
E 43	504	362	741	936	155	43	331	569	522	682	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km

E 44	796	691	924	> 1 km	392	448	736	643	164	288	678	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km
E 45	> 1 km	> 1 km	> 1 km	> 1 km	690	853	> 1 km	755	167	187	541	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km
E 46	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	574	45	295	338	878	> 1 km	917	> 1 km	> 1 km
E 47	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	408	130	463	200	818	749	839	> 1 km	> 1 km
E 48	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	358	277	768	125	490	500	796	> 1 km	878
E 49	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	457	379	> 1 km	70	209	387	794	922	664
E 50	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	> 1 km	378	435	> 1 km	153	15	235	687	661	618

10.7 CALCULATIONS OF PROBABILITIES OF IMPACTS OF MAJOR ACCIDENTS

The targets identified above in a radius of 1 km around the wind turbines are likely to be influenced by the ballistic calculation.

Those further away than the maximum range of a blade fragment have been removed from the study as they could not be influenced.

10.7.1 Probability class

Annex I of the Order of 29 September 2005 defines the probability classes that must be used in the hazard studies to characterize the major accident scenarios:

Table 81: Probability classes of major accidents

LEVELS	Qualitative scale	Quantitative scale (annual probability)
A	*Common:* Has occurred on the site in question and/or can occur several times during the lifetime of installations, despite potential corrective measures	$P > 10^{-2}$
B	*Probable:* Has occurred and/or can occur during the lifetime of installations	$10^{-3} < P \leq 10^{-2}$
C	*Improbable:* Similar event already encountered in the activity sector or in this type of organization somewhere in the world, without any corrections made since guaranteeing a significant reduction in its probability	$10^{-4} < P \leq 10^{-3}$
D	*Rare:* Has already occurred but has undergone corrective measures reducing the probability significantly	$10^{-5} < P \leq 10^{-4}$
E	*Extremely rare:* Possible but not encountered worldwide. Is	$\leq 10^{-5}$

LEVELS	Qualitative scale	Quantitative scale (annual probability)
	not impossible in the light of current knowledge	

10.7.2 Probabilities of ejection of a broken blade

Data on the probabilities of a wind turbine blade breaking are available in the expert assessment document no. 19003, rev. 6 "Wind turbines near protected objects; indications of minimum distances" from the company Veenker (Germany).
Wind turbines are often near protected objects when being installed (buildings, rural roads and tracks in this study). These protected objects are subject to the risks of a potential ejection of rotor blades or bits of rotor blades, ejection of the nacelle or rupture of the mast. In this study, we shall only consider the ejection of blades.

The studies suggest a probability of occurrence of 6,1.10-4 per year for the ejection of a rotor blade or bits of rotor blade. This probability incorporates the various operating modes of the wind turbine.

The ejection usually involves entire blades or small bits. The proportion is given in Table 19.

Table 82: Distribution of the size of fragments

Size of the ejected object	Proportion
Entire blade	0.4
End quarter of a blade	0.2
Tip	0.4

- The frequency of occurrence of loss of the **entire blade** is therefore **2,44.10-4** (6,1.10-4 * 0.4) **per year** for one year for one wind turbine.
- The frequency of occurrence of loss of the **end quarter of a blade** is therefore **1,22.10-4** (6,1.10-4 * 0.2) for one year for one wind turbine.
- The frequency of occurrence of loss of the **tip of a blade** is therefore **2,44.10-4** (6,1.10-4 * 0.4) for one year for one wind turbine.

NB: ***For the risk to be considered acceptable, its probability should be less than 10-5 to be deemed "extremely rare" or between 10-5 < P ≤ 10-4 to be classed in the "rare" cases (See Table 78).***

10.7.3 Probability of reaching a target

The probability of reaching a target depends on wind frequency and direction and fragment trajectories, calculated during the ballistic study and of the frequency of broken blades.

Remember that three conditions must be met for a vehicle to be reached:

1- Failure of a wind turbine (broken blade) - Pproj
2- Broken bits reaching the road - Ps
3- Presence of a vehicle on the section ....- Pveh

The probabilities of broken blades are given in the report. The value 2,44 10-4 will be taken for a blade tip per year.
Therefore **Pproj = 2,44 10-4**
Ps = ∑ Psi with
Psi = ((frequency Wind1)/100)*(N.angle1/360) + ((freq.Wind2)/100) * (N.angle2/360)
where FrequencyWind1/FrequencyWind2 (see Wind rose)
N.angle1 = N.angle2 = 1° (this is the angle that allows the road to be reached)
NB:
The angles will be taken small to have small road sections.
Pveh = (L/V)*(Nv/(3600.24)) with L = length of the section studied (m)
V = average speed of vehicles (70 km/h)
Nv = daily traffic (number of veh/day)
The probability of reaching a target is the sum of three probabilities.
Preach = Pproj + Ps + Pveh
The approach is similar for people on a track, with:
Ppers = (L/V)*(Nv/(3600.24))

10.7.4 Calculation results

- VEHICLE TARGET: ROAD 798 m FROM THE NEAREST WIND TURBINE

Table 83: Probability of risks
Assumptions:
It will be assumed, in the extremely unfavorable case, that a row of ten wind turbines runs parallel to the road. This distance will be equal to the footprint length of ten wind turbines aligned and equal to 5100 m.

Sectors Si of length Xmax*(π*D/360) will be taken

D being the angle for reaching the road (°)

Three conditions must be met for a vehicle to be reached:

1. Failure of one wind turbine out of the ten facing the road with a probability called **Pprojection**
2. Broken bits reaching the road with a probability called **Ps**
3. Presence of a vehicle on the section with a probability called **Pveh**

We assume that in this case the vehicle is reached and we therefore increase the probability by calculating the total probability.

This will then give:

Preach = Ps * Pveh * Pprojection

The other notations used are:

Lsi = length of the sector Si;
Freq wind1 = Wind frequency in direction 1 (wind rose);
Freq wind2 = Wind frequency in direction 2 (wind rose);
Lsection – length of the road section (m) equal to 5100 m;
Vm vehicles – Mean speed of vehicles (km/h) taken at 70 Km/h;
Nv – Number of vehicles per day on the section in question with ten vehicles/hour, i.e. 240 vehicles/day;

Results

Lsi	6.885323899
Freq wind1	0.4
Freq wind2	0.35
Number of angle/road	1
Psi	0.044861111
Ps	***0.448611***

Lsection (m)	5100
Vm vehicles (km/h)	70
Nv (veh/d)	240
Pveh	***0.202381***

Blade flying through the air	***0.00122***

Preach	***1,11E-05***

Conclusions
The simulation gives a probability level D. Therefore it is "rare" that a vehicle will be reached by broken blades.
This calculated value is all the more reassuring as in reality the roads are not parallel to the row of ten wind turbines.

- HUMAN TARGET: PERSON STANDING 798 m FROM THE NEAREST WIND TURBINE

The same approach as used for the vehicles gives:

Lsi	6.885323899
Freq wind1	0.4
Freq wind2	0.35
Number of angle/road	1
Psi	0.044861111
Ps	***0.448611***

Lsection (m)	5100
Vm persons (km/h)	3.5
Np (pers/d)	6
Ppers	***0.10119***

Pprojection blade	***0.00122***

Preach	***5,54E-06***

Conclusion
The simulation gives a probability level E. Therefore it is "extremely rare" that people will be reached by broken blades.

10.7.5 CONCLUSIONS

The hazard study of the Taiba wind farm project has identified:
- the risks from the products and processes used,
- the effects of accidents likely to occur on the site,
- existing or envisionedenvisioned measures to reduce the probabilities of occurrence (prevention) and the effects (protection) of the main feared events.

The future wind farm mainly shows risks of flying objects and, to a lesser extent, fire.

The Preliminary Risk Analysis identified, by examining feared events, the environmental consequences and the prevention and protection measures introduced to avoid or limit these events. Several accident scenarios were selected from these feared events identified in the Preliminary Risk Analysis to determine the distances of effect relating to different sizes of broken blades.

The calculated effect areas, corresponding to the distances reached by different sizes of broken blades ejected at maximum speed, can be up to a radius of 798 m. The effects of these hazardous phenomena would be collision with human targets, structures and/or protected species.

It is important to note that in a major accident, mainly a fire that cannot be controlled, specific emergency and alert means would be triggered.

Thus, overall, the risks of major accidents arising from the activities in the future wind farm can be considered as sufficiently controlled.

In addition, for each envisioned scenario, analyzed safety barriers exist for all initiating events (organizational measures, prevention, protection and intervention means identified systematically under the study).

In particular, the maintenance and surveillance of installations, training of personnel and safety, servicing and work procedures are essential elements for the safety and smooth operation of the wind farm and ensure the acceptability of risks at tolerable levels.

The low probabilities of calculated targets being reached also argue in favor of these levels of acceptable risk for the project.

11 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

The environmental and social management plan makes it possible to implement the mitigation measures listed below in the light of the potential impacts identified. This plan specifies those responsible for implementing these measures, their supervision, control and monitoring. It also contemplates the means of implementing the indicated measures.

The environmental and social management plan comprises a set of measures to mitigate the negative impacts that are defined according to the three key phases of the project, namely the preparation, the operating and termination / refurbishment phases.

It also provides details of the methods of implementing these measures and contains a supervision and monitoring plan, as well as institutional measures to build the capacity of those responsible for putting it into action and information for local communities.

The goals of the environmental management plan (EMP) are:

- to ensure that the project's activities are undertaken in accordance with all the legal requirements arising from the project's environmental authorization process;
- to ensure that the installations will be designed and erected in such a way that the environmental performance levels forecast in the impact study are achieved and even exceeded, if possible;
- to ensure that the project's environmental commitments are well understood by the site and operating personnel, including subcontractors:
- to ensure that Senegal's environmental policy (see Chapter 3) is adhered to throughout the project.

The environmental and social management plan (ESMP) also helps to:

- implement the developer's commitments to the environment and the Taiba Ndiaye municipality;
- clarify the environmental issues relating to the preparation and operating phases of the project and to develop a plan and procedures to deal with these issues specifically;
- determine the responsibilities of each stakeholder, including the project developer, with regard to the EMP;
- inform the government authorities and citizens concerned about the information resulting from the EMP;
- establish corrective actions to be introduced if necessary.

The ESMP will be reviewed as needed in order to ensure its relevance and effectiveness. The proposed amendments will be discussed with the relevant government authorities.

The following sections present the mitigation actions to be implemented, the administrative organization which allows the mitigation actions, as well as the main supervision and relevant monitoring activities, to be effectively implemented.

11.1 IMPACT MITIGATION PLAN

Two types of mitigation measures will be planned to reduce the expected impacts during the implementation of the various components and activities planned within the scope of this project:

- prescriptive measures which must be followed by the developer and its contractors.
- specific mitigation actions relating to the reduction of the expected negative effects on the environmental and social components which are sensitive to the project's activities.

The aim of these measures is to ensure the environmental balance of the project and that there is no overall loss of biodiversity. They must be adapted to the impacts identified.

11.1.1 Prescriptive measures

The aim is to ensure that the project complies with applicable regulations, in particular:

11.1.1.1 Conformity with the agreement to grant the site reservation

The implementation of the ESMP is subject to compliance with the agreement entered into with the Taiba Ndiaye municipality in accordance with the local authorities code and with land law. The agreement addresses issues such as the safety of people and property, which the owner must guarantee, fees and rent, as well as compensation and rent to be paid to those entitled to them.

Taking into account the review of the initial version, the necessary adjustments should be made concerning the increase of the land tax base to be assigned to PETN.

11.1.1.2 Compliance with environmental regulations

PETN must also ensure compliance with regulations on classified installations. To this end, all of the documents required to make up a permit dossier should be gathered together and made available to the competent authorities, in particular the department of classified establishments of the Directorate for the Environment and Classified Establishments (DEEC).

This detailed impact study report on the installation of the wind farm is an integral part of it.

11.1.1.3 Compliance with forestry regulations

The carrying out of the activities planned for the project is subject to adherence to forestry regulations. For this purpose, clearing of trees must comply with the procedures established in the Forest Code. The areas to be cleared must be indicated in the form of a plan.

The Forestry Sector of Tivaouane will be consulted in order to fulfil the land clearing and felling tax obligations. In the same respect, an inventory of plant species likely to be cut down will be approved by the head of the forestry sector before paying the forestry taxes.

Removal of materials (wood, lumber, etc.) must also be authorized by the Forestry Sector. The start-up of any activity that may affect vegetation must first comply with all the procedures established by the Forest Code and with forestry guidelines.

This coordination with the forestry services will also be important during the reinstatement of the wind generator farm's footprint when the farm is dismantled.

11.1.2 Specific impact mitigation measures

The specific measures were proposed to mitigate the various impacts expected during the implementation of the different project components.

- **The elimination measures** help to prevent the impact starting from the project design phase (for example, the change in location to avoid a sensitive environment). They reflect the project owner's choices in the design of a lower-impact project.
- **Reduction or reductive measures** aimed at reducing the impact. They concern, for example, the decrease or increase in the number of wind turbines, the change in the spacing between wind turbines, the creation of openings in the row of wind turbines, the distance away from houses, the regulation of the operation of wind turbines, etc.
- **Compensation and compensatory measures** aimed at broadly maintaining the environments' initial value, for example by reforesting plots to maintain the quality of afforestation when land clearing is necessary, by purchasing plots in order to ensure management of the natural heritage, by implementing measures to protect species or natural environments, etc. They have an effect on the residual impact once the other types of measures have been implemented. A compensation measure must be related to the nature of the impact. It is implemented outside the project site.
- The **project support measures,** often of an economic or contractual nature and aimed at facilitating its acceptance or implementation, for example the launch of social projects for local inhabitants or the community. They are also aimed at assessing the real impacts of the project (nature and social monitoring, etc.) and the effectiveness of the measures.

The table below lists the various measures to be introduced.

Table 84: Measures to mitigate environmental and social impacts

Potentially sensitive environmental component	Critical phase	Potential negative impacts	Mitigation measure
Soil and sub-soil	**Construction phase**	• Provisional soil compaction • Sealing of soil following concreting and land excavation at the bases of the wind generators. • Limited risk of pollution of the soil and groundwater caused by accidental penetration of liquid pollutants (construction equipment or storage: hydrocarbon, hydraulic oils, lubricants and paint).	• Performance of geotechnical tests in situ. • Agricultural reuse of stripped earth from roads and top soil from the foundations. • Storage of dangerous liquid products (oils, fuel, etc.) during construction in a containment unit able to contain the tank's entire volume. • Provision of anti-pollution response kits on the site.
	Operating phase	• Low risk of pollution of the soil and sub-soil: presence of oil in the wind turbines (around 1,500L/wind turbine), oil in the transformers. Suitable means of containment in the installations concerned should reduce this risk. • Risks of pollution during maintenance and oil changing.	• Introduction of equipment containing oils (gearbox, transformers, etc.) in a containment tank of a sufficient size. • Give preference to dry-type transformers over oil-type transformers. • Performance of maintenance according to a well-prepared schedule and taking all necessary precautions to prevent any leakage of oil or of any other liquid substance that is dangerous for the environment.
Biotopes, flora and fauna	**Construction phase**	**Impact on biotopes:** • Decrease in arable areas and potentially in the initial agricultural production • dust deposit during work; • footprint, land consumption; • land clearance, cutting isolated trees; • alteration to habitats; • trampling of surrounding habitats (works, walkers) and too many people in the environments; • increased risks of fire; • introduction of invasive exogenous species; • destruction of protected species,	• Compensate land owners according to an agreed scale • Protection of notable species in the fields and along the access roads. • Avoidance of sensitive habits and species starting from the project design phase. • Caution when transporting material during construction work; highest level of protection possible for flora present on the site. • application for an exemption for the destruction of protected species must be prepared • labelling of sensitive species before work begins and ecological monitoring of the construction site;

		• damage to heritage and/or decisive species stands. • Temporary changes in soil quality (see effects on soil and sub-soil). • Pruning or potential removal of certain notable plants and/or shrubs along the access roads.	
	Operating phase	**Impact on birdlife** • direct mortality resulting from collisions with wind-turbine blades; • interferences and disturbances, which are reflected by a "barrier effect", a distancing and sometimes even a loss of habitats in critical situations. •	• choice of site: this is the main factor that helps to reduce or eliminate most of the impacts on natural environments and, therefore, on birds; • positioning of wind turbines in order to prevent barrier or funnel effects. Alignment of the wind farms in parallel to migration routes effectively reduces the negative effects on migratory birdlife. • choice of the period of work and scheduling of construction in line with the species' calendar, in particular outside the periods when the most sensitive local species reproduce i.e. between April and September inclusive. • Development of ornithological monitoring to assess the impacts of wind turbines on birdlife and, particularly, on migratory birds. • creation of a replacement habitat including, for example, the reformation of a network of hedges, the creation of a land reserve away from the wind farm to conserve wildlife fallows • marking of wind turbines is needed to limit the impact on birdlife.
Landscape	**Construction phase:**	• direct and indirect effects on the landscape on account of • destruction of existing vegetation and opening up of views; creation or enlargement of access roads, earthworks, uprooting of trees, soil compaction • change to the colour and appearance of the site's plantlife; growth of weeds due to the introduction of exogenous earth • partial or complete artificialisation of the site	• introduction of materials, clearing and modification of the track at the end of construction should be kept to the strict minimum necessary • maintain a load-bearing capacity on the tracks to enable the intervention of motor vehicles for • maintenance, •

		(roads, slopes, areas with no plants, etc.).	
	Operating phase	• creation or modification of existing roads and the creation of routes intended for operation and maintenance or, if applicable, the introduction of wind turbines can have different consequences on the site: o potential of there being too many users as a result of the opening of new access routes or changes made to existing roads; o conflict between activities brought close together for the first time due to the easier access for motor vehicles; o abandonment of the site by some of its users, following the installation of wind turbines. • Strobe effect and **reflection of sunlight**	• The developer has already taken steps to ensure that the wind farm has the lowest possible impact on the landscape (limit to the number of wind turbines, layout of wind turbines according to houses, installation in lines, etc.). • keep the wind turbine raising areas for maintenance, although it had previously been recommended that they be removed after smoothly integrating the master box. • paint the wind turbine mast with a non-reflective coating in order to prevent it from reflecting sunlight. Plants (rows of trees, etc.) or developments with similar features will make it easier to integrate the landscape into the site.

Acoustic environment	**Construction phase:**	• Disturbance caused by construction vehicle traffic (trucks, cranes), increase in the number of peak levels per hour. • The noise generated by the site will be audible not far from the houses closest to the site, but the sound level should be below the limits.	• Choice of installation and machines: seek the lowest noise impact possible. This measure consists of choosing the installation (number, location of wind turbines) and machines in line with local constraints. • Performance of work on working days (work at the weekend, at dawn and in the evening should be avoided as much as possible). • Limitation of sound power levels (must not exceed the values taken into account in the framework of this study).
	Operating phase:	• Increased background noise at immission points (current background noise very low). • The wind farm's specific noise should not exceed the limits in the housing areas nearest the site; the specific noise is very quiet. • Beyond 8 m/s, the noise of the wind should conceal the noise generated by the wind turbines: it can be expected that with these wind speeds, the noise will hardly be audible.	• Periodic maintenance of wind turbines to limit mechanical noise. • Performance of a noise assessment after the farm has been installed. • Adaptation of production mode: set a "slow-motion" mode on the wind turbines (thereby limiting sound emissions) depending on the time of day, week or year.
Capacity of equipment and public infrastructures		• Construction vehicle traffic and heavy loads on the unsuitable secondary network (possible damage to roads and red earth tracks, noise disturbance, etc.). • No impact on air traffic	• Establishment of a route for heavy loads in collaboration with the wind turbine construction company, the police and local authorities. • Day and night markings will be placed on the wind turbines to ensure the safety of the airspace.
Health and safety		• The risk of accidents (breakage of blades, falling masts, fire in the rotor, environmental pollution, wind turbine parts transported by road, lightning). • Electromagnetic interference and radiation • risk of disruption to radars;	• Put up signs warning of the dangers present on the site (falling objects, electric risk, construction traffic, etc.) and prohibiting access. These signs must be put up at the site entrance and on each storage and lifting platform. • Introduction of very strict safety regulations: install barriers on the access roads to the site: fence off the wind turbines and/or the wind farm in order to prevent the public from going near them/it; close off access to mast access ladders;

- risks for air safety;
- risks of disturbance to radio waves
- risk of fire, etc.

install information panels on the risks and on the services to contact in case of emergency.

- (Red) Lighting to warn of the wind farm's existence with a light that does not affect visual quality on the site or for local residents
- Establishment of a structure for dialogue between the authorities, the surrounding community and the applicants.
- Access prohibited to the various potential users (community, sportspeople, etc.) when wind turbines are being raised and dismantled.
- establish a safety zone and design/install wind turbines so that no buildings or residential areas are located in the path on which blades could fall.

The work itself is going to produce waste (household waste linked to the presence of workers, ordinary industrial waste (wood, paper, cloths, metal waste, etc.] and hazardous waste (oils, electrical wires, etc.).

Furthermore, faulty equipment that will be removed may contain residual materials (waste oil, electrical waste, heavy metals, etc.).

In order to prevent visual pollution, environmental pollution and/or improper recovery/recycling, all companies working on the site must follow the waste management table below:

Table 85: Waste management plan

Source	Type of waste	Management measure	Final destination	Measure to be taken at the final destination
Construction work	Domestic	Place waste bins on site	Waste disposal chain or landfill on a suitable site	None
	Ordinary waste	Encourage recycling and recovery by local communities	Population	
	Dangerous waste	Set up a storage area that meets standards	Approved buyers	Compliance with storage and management standards
Faulty equipment	Dangerous waste	Prevent the loss of residual materials and reuse by the local people	PETN	Compliance with storage and management standards.

11.1.3 Dismantling and reinstating the site

PETN is responsible for dismantling and reinstating the land taken by the wind generator farm once operation ceases. Superstructures and machines, including foundations and the power sub-station, will need to be disassembled and removed during the dismantling phase.

This phase causes the same type of impact as the construction phase due to the presence of construction vehicles. The reinstatement involves returning the wind farm site to Taiba Ndiaye so that it is capable of being returned to its former use.

These dismantling and reinstatement operations will cover all of the equipment that was necessary to install and operate the wind turbines, including:

- the wind turbines' foundations;
- powerlines and buried or overhead cables and
- in general, all equipment or fixtures related to the operation of the wind turbine, such as technical installations and the reception.

Reinstatement involves carrying out work aimed at erasing the traces of the operation and promoting the reintroduction of soil into their place, and more generally, into the agricultural environment of Taiba Ndiaye. To the extent possible, returning the agricultural land to its original use will be given priority.

The reinstatement of the access roads and locations of the foundations must be analyzed in detail, with regard to revegetation.

In order to define the final state of the site, the data gathered for the site's initial state and its environment should be relied upon, taking into account the foreseeable evolution of the environments and of land use. This will also involve taking into account the expected impact of the dismantling work, and weighing up the advantages/disadvantages of removing all the foundations or not (which could mean a second phase of disturbance to the natural environment):

When retuning the land to its original use is not desired, the owner must justify this choice:

- the reinstatement will propose a new use for the land which meets real needs, preferably addressing current local concerns;
- PETN shall clearly indicate the new user of the land;
- the project's technical credibility and its financial balance will be demonstrated, in terms of initial investment and maintenance of the site, whenever necessary.

The site reinstatement project will specify, at each stage, the technical content of each substation and calculate the cost of each operation.

The results of the monitoring and regular reports on the environmental impact of the construction and implementation of the project will be taken into account in order to define how the site will be reinstated.

11.2 INSTITUTIONAL MEASURES AND ENVIRONMENTAL MANAGEMENT CAPACITY-BUILDING PLAN

11.2.1 Capacity-building for PETN employees

Given the sheer novelty of wind turbine technology, all members of PETN staff and its subcontractors' employees should receive general training on safety, security and environmental issues, placing great emphasis on each employee's adherence to the charter for health and safety, quality and the environment (HSQE). The capacity-building modules would also benefit from addressing: emergency response procedures, health risks of certain activities, legal and regulatory obligations applicable to the project.

A detailed program of these training modules should be defined in a Provisional Plan on employment management, training and awareness-building to be implemented by PETN's human resources management.

The contractors and subcontractors chosen during the Taiba Ndiaye wind farm life cycle must also follow all the policies and procedures on safety and the environment incorporated into the tender documents (DAO) and the technical specifications for the work, for the duration of their involvement in the project.

11.2.2 Information for local community

Consultation, particularly during the upstream development phases of a wind project, is one of the keys of success to integrating a wind farm both into its natural and human environment.

The wind project concerns all the actors in the community, particularly the local population and its representatives, the State services and associations. Their involvement and participation in the preparation of the project is essential for to succeed and be socially accepted.

Given its close connection to sustainable development goals, a wind farm project must be carried out within a framework of local consultation and coordination.

The table below presents examples of ways in which the public can be involved.

Table 86: Need for training and information

Project phase	Target audience	Public training and information actions	Body responsible for implementation	Cost of implementation
Project design	- Administrative authorities - Municipal council - Local associations (nature protection, local residents, etc.) - Community of Communes - Local inhabitants, residents - Local economic players (farmers, vegetable farming professionals, ICS, etc.).	- Municipal council decision, - Information on the project's progress in the municipal newsletter, - Public meeting, - Exhibition, - - Distribution of brochures, - Visits from other wind farms, - Information website, etc.	PETN Taiba Ndiaye municipality	Investment cost
Impact assessments - Building permit - public briefings	- Local inhabitants, residents	- Public surveys during the environmental study, - Compensation procedures for people affected by the project (PAPs) - Presentation of the Environmental Impact Study (EIS), - On-site information (display board), - Laying the foundation stone,	PETN Municipal council of Taiba Ndiaye Prefect of Tivaouane Department committee on maintenance expenses assessment	Investment cost
Release of land taken by the wind farm and compensation of PAPs	- People affected by the project	- Compensation procedures - Bodies in charge of handling PAPs - Procedures for filing grievances and complaints - Support for PAPs in managing their compensation - Training on project drafting and management for PAPs	PETN Prefect of Tivaouane Facilitation NGOS	10,000,000
Construction of the wind farm	- Local inhabitants, residents - Local community	- Information on construction progress, - Visits to the site, - Official inauguration	PETN	Investment cost
Operation of the wind farm	- The public, residents - Local community	- Information on the operation of the wind farm, - Presentation by the environmental monitoring manager	PETN	3,000,000

Project phase	Target audience	Public training and information actions	Body responsible for implementation	Cost of implementation
		- Implementation of good practices during the work (waste management, disturbance limitation, etc.) - Organization of technical visits, - Awareness-raising for residents on safety measures - On-site information boards, etc.		
Improvement of environmental authorities' knowledge	- Directorate for the Environment and Classified Establishments (DEEC) - Regional Division of the Environment and Classified Establishments of Thiès (DREEC) - Taiba Ndiaye municipality - SENELEC	- Visits from wind farm already in operation - Training on good practices for monitoring and control of risks related to the operation of wind turbines	PETN	10,000,000
Follow-up after installation of wind turbines	- Research institutes - Local people	- Training on use of monitoring protocols - Dissemination of results	PETN UNIVERSITY RESEARCH INSTITUTES	7,000,000

11.2.3 Capacity-building

The success of an environmental study, the aim of which is to ensure that development projects are ecologically sound and sustainable, depends largely on the environmental management capacity of the actors involved. As part of this process, capacity-building is a good practice that is widely used and often required in terms of reference, this being the case in Sarreole's wind farm project.

Within the scope of this procedure, capacity-building is aimed at improving stakeholders' environmental expertise, particularly by means of upgrading institutional – but also technical – tools, for better control over the whole procedure, and in particular the environmental supervision and monitoring phases.

The institutional aspects generally relate to the organization of the procedure and to the updating of the institutional and legal framework. With regard to technical aspects, they are generally focused on training of personnel and improvements to logistics.

The actions to build institutional and technical capacities proposed in the Sarreole project have addressed, on the one hand, a major environmental issue, namely ornithological monitoring and, on the other hand, public safety, in particularly concerning the risks of disturbance to radars, radio waves and air safety.

In addition, given that this is the first experience of a wind project of this scale in Senegal, it is important to capitalise on the results and lessons learnt from the environmental supervision and monitoring program, in order to develop a methodological reference guide for future environmental assessments of similar projects in Senegal or in the region.

To this end, the following actions have been defined:

- → **Ornithological monitoring:**
  - ✓ Training of national park officials on standardised monitoring protocols for the assessment of the impacts of a wind farm on birdlife developed by the Bird Protection League (LPO), France;
  - ✓ Detailed inventory during a statistically representative period for birdlife;
  - ✓ Definition of a detailed birdlife monitoring plan and national protocols (monitoring of deaths of birds and bats, monitoring of behaviour of birds and bats when flying, monitoring of breeding populations) and implementation of a regulatory framework;
  - ✓ Purchase of monitoring equipment and training of national park management (DPN) staff
  - ✓ Annual assessment of the monitoring plan and regulated protocols.

It should be noted that there are several more or less complex and burdensome approaches to the technical monitoring methods (direct observation, day and night cameras activated by automatic shock detection, Batcorders or Anabats attached to nacelles, thermal and infrared cameras, radars, etc.). In scientific terms, these methods, which will be the subject of protocols, must be validated based on the data relating to the inventory work, but also taking into account national technical capacities for using and maintaining equipment. Furthermore, the baseline situation and monitoring must be based on the same protocols in order for the assessment of the real effects/impacts to be as objective as possible.

Considering the needs of implementing this strategy as a whole, recruiting an international technical assistant who already has extensive experience of ornithological monitoring linked to wind farm projects is recommended.

→ **Public safety**

- ✓ Institutional support in defining public utility easements (protection areas and coordination areas) relating to the protection of radioelectric transmitting and receiving centres against electromagnetic obstacles and disturbances;
- ✓ Institutional support for the implementation of an order on the installation of wind turbines outside restricted areas subject to aviation easements.

The planning of these actions, which are intended to run for a total of five (05) years, is presented in the table below. The funding arrangements will be defined in specific agreements with the national park management (DPN), the Regulatory Authority for Telecommunications and Posts (ARTP) and the National Civil Aviation Agency of Senegal (ANACIM), approved by the Ministry in charge of the environment.

Table 87: Capacity-building plan

Topics	Actions	Due date	Duration	Cost	Beneficiary body
Monitoring of birdlife	Training on standardised birdlife monitoring protocols	Before operation	One week	10,000,000	DPN/Regional Inspectorate of Water and Forests (IREF)
	Technical international assistant		24 months (48 people/day)	Remuneration: $1,500/day Travel and mission fees: 3,500,000 FCFA	
	Detailed inventory of birdlife (baseline situation) and post-installation monitoring	Before operation	12 months (baseline situation) 48 months (environmental follow-up)	PM	
	Development of national protocols and preparation of a draft order	Before operation	1 month	Meetings: 2,500,000 FCFA	
	Purchase of ornithological monitoring materials (in line with regulated protocols)	Before Operation	2 month	PM	
Public safety	Preparation of a draft order on the definition of public utility easements relating to the protection of radioelectric transmitting and receiving centres against electromagnetic obstacles and disturbances	Before Operation	1 month	Meetings: 2,500,000 FCFA	ARTP
	Drafting of an order on the installation of wind turbines outside restricted areas subject to aviation easements.	Before Operation	1 month	Meetings: 1,000,000 FCFA	ANACIM

Topics	Actions	Due date	Duration	Cost	Beneficiary body
Good environmental practices and EIS	Design and editing of a methodological guide to the implementation of wind projects	After 3 years of operation	4 month	Consultants: 15,000,000 FCFA Editing: 3,000,000	Directorate for the Environment and Classified Establishments (DEEC)

11.3 SUPERVISION AND MONITORING PLAN

Despite the in-depth analysis of environmental and social impacts related to the project, a certain degree of uncertainty still remains regarding the clarification of impacts and mitigation measures.

Therefore, there is a need to draw up an environmental supervision and monitoring plan for the entire project that is equally applicable to the preparation, operating and reinstatement phases.

This environmental and social supervision and monitoring plan (ESSMP) was designed to allow the mitigation and environmental and social impact management measures required for the proposed project to be implemented.

In accordance with international best practices, the developer will implement the specific measures proposed by the environmental and social impact study (ESIS) aimed at preventing, mitigating, managing and monitoring the project's environmental and social impacts, from the preparation phase to the post-closure phase.

The ESSMP covers the important aspects of the design necessary to prevent environmental and social impacts and the specific measures required to mitigate the unavoidable impacts.

In addition, it is also concerned with preventative measures that help to manage the potential environmental risks related to the project, as well as with response measures that must be taken in the event of an emergency.

The implementation of the ESSMP will be the responsibility of PETN, while the supervision and control of the application of measures will fall under the responsibility of the DEEC/DREEC of Thiès, specifically the two main divisions: the impact assessment, pollution and disturbances division and the classified establishments division. These two divisions will interact with the other government technical services listed in subsection **10.4.1.** and with third parties throughout the implementation of the ESSMP.

11.3.1 Environmental monitoring

11.3.1.1 PETN's commitments

In order to ensure respect for the environment, the developer must take action in two ways

Firstly, the project estimate must include provisions to ensure that physical, biological and human environments are protected. The developer must ensure that all the standard and specific mitigation measures outlined in this study, as well as all the measures included in the permit applications submitted to the government, are described in the estimate.

These provisions will then be an integral part of the contracts awarded to contractors. A set of environmental and social clauses will be added to the construction company specifications as an annex.

Secondly, while work is in progress the developer must ensure that the work supervision plan is followed. The supervision plan must be prepared before work commences and must specify the tasks and duties of each member of the team assigned to the project.

While work is in progress the developer must take on an environmental manager, who will ensure that each of the mitigation measures and requirements contained in this impact study are respected.

At the end of the work, an environmental monitoring report will be submitted to the competent authority, the Directorate for the environment.

If the environmental control is not separated from the technical control, the consultancy firm must consult an accredited environment expert.

11.3.1.2 Environmental monitoring program

PETN's environmental monitoring program will ensure:

- compliance with mitigation and compensation measures;
- compliance with applicable laws, regulations and requirements, and commitments.

11.3.1.3 Appointment of an environmental officer

PETN will appoint an officer[12]responsible for environmental monitoring for the construction and dismantling phases, whose main duties, under the supervision of the project director, will be:

- assist in planning of work requiring environmental monitoring and inform the various stakeholders (contractors, construction project manager, maintenance officers and wind farm operators) of environmental requirements;
- ensure fulfilment of the monitoring program;
- inspect the work;
- prepare all the required reports, including the monthly and annual projects required by **PETN** management and the government authorities, whenever applicable.
- during the operating phase, the operations manager will be in charge of environmental monitoring.

[12] If the technical control is not separated from the environmental supervision/control, it is essential for there to be an accredited environmental expert in the consultancy firm team

11.3.1.4 Activities that require monitoring

The project's activities will require environmental monitoring depending on the type, intensity and duration of the activity.

11.3.1.4.1 Preparation and construction phases

- compliance of work, materials used and operations with standards and regulations in force, as well as with other applicable requirements;
- particular attention to limit changes to biophysical components of the environment (soil, water and vegetation), in particular changes caused by clearing trees and construction (paths, hoisting platforms, fibre optic cables, wind turbine foundations and sub-station).
- careful coordination to limit periods of work, thereby reducing the impacts on the environment and local residents' quality of life;
- verification of compliance with environmental requirements by all contractors and those working on the site;
- transport of wind turbine components in accordance with safety and environment protection standards in force;
- monitoring of compliance with occupational health and safety standards;
- minimisation of risks of accidents by specifically identifying working areas, including signs when deemed appropriate;
- proper management of solid and dangerous waste.

11.3.1.4.2 Operating phase

During this phase, PETN will ensure the following elements:

- Observance of environmental monitoring activities for the components of the environment potentially affected by the project.
- Clear identification of areas reserved for the wind farm, in particular the locations of the wind turbines and the sub-station, by means of signs intended to reduce the risks of accidents. In the event of a major breakdown posing a risk to the local inhabitants, the emergency plan will be applied;
- compliance with occupational health and safety standards (for example, maintenance work on wind turbines performed in teams of two or more, mobile communication system, sufficient training of workers for work on elevated structures);
- compliance of wind farm maintenance activities with standards and regulations in force;
- during its operation, the wind farm will undergo the necessary maintenance operations, planned at regular intervals, and at a rate of twice per year per wind farm, without exception. These operations will generate solid and liquid waste that must be managed according to its type.

11.3.1.4.3 Dismantling phase

Once the operating phase comes to a definitive end, the developer must dismantle the installations in accordance with regulations in force. The following equipment will be removed from the area: wind turbines (nacelles and towers), transformers, overhead and buried power lines, top layer of the concrete base and the connection sub-station.

The environmental monitoring program for this phase includes the elements listed for the preparation and construction phases, when deemed appropriate. In addition, certain pieces of project equipment will be dismantled and sent to appropriate recovery and landfill sites, if the type of material permits.

PETN will produce an environmental monitoring report related to the dismantling activities for consultation by the directorate for the environment and classified establishments (DEEC).

11.3.1.5 Agreement with competent environmental authority for supervision, inspection and application of measures

A protocol agreement between the DEEC, Regional Committee of Environmental Monitoring (CRSE) and PETN will define the support that the developer will give to the effective supervision of environmental and social measures.

The protocol could also propose recruiting an independent consultant, who would be responsible for producing supervision reports at all stages of the project.

11.3.2 Environmental monitoring

The aim of the impact study is to conduct an assessment that is as accurate as possible. However, it is not always possible to accurately assess all the consequences of the implementation of the project for the environment. It is therefore useful to propose a monitoring system for support measures or measures to reduce impacts (if the results lead to the implementation of corrective measures).

Monitoring consists of all the means of analysis and measures needed to oversee the running of the works and the installations and monitoring of their impacts on the environment.

Monitoring makes it possible to check that the commitments made regarding the environment are met, by comparing a progress report with the original undertakings. It therefore involves an initial quality review.

Within the scope of the Taiba Ndiaye wind farm, attention is drawn to ecological monitoring and the monitoring of socio-health measures.

11.3.2.1 Ecological monitoring

Ecological monitoring after the wind turbines have been installed must be reserved for situations in which the impacts are known or difficult to foresee. Current monitoring focuses essentially on birds and bats.

The aim is to monitor the following:

- deaths of certain sensitive species, for example diurnal and nocturnal migratory birds, migratory or resident bats, breeding birds of prey, etc.;
- behaviours relating to, for example, migratory birds approaching the wind turbines, seasonal birds staying in the area, travelling breeding birds, etc.;
- reproduction, which will help to assess the influence of the wind farm on breeding populations;
- vegetation.

❖ **Monitoring of deaths of birds and bats**

The method used to monitor mortality involves looking for dead animals (birds and bats) at the bottom of wind turbines. It is then necessary to take into account several important factors, including the effectiveness of the search and the speed with which the remains disappear, in order to estimate a mortality rate for the whole wind farm.

Monitoring will be based on a representative number of visits and on a short interval between each visit, in order to minimize bias linked to the disappearance of remains. The timeframe between each visit must be in proportion to the speed with which remains are disappearing, which is evaluated in advance on each site, as it is specific to it and varies according to the season and type of remains.

❖ **Monitoring of flying behaviour (birds and bats)**

Monitoring the behaviour of birds will cover disturbances such as the "barrier effect" for migratory birds, the fragmentation of territories or the breaking up of transit routes, or even responses involving moving away from stopover and rest areas.

This monitoring will also provide the opportunity to improve scientific knowledge on behavioural responses of certain local species, the sensitivity to the wind turbines of which is still unknown.

For **bats**, monitoring may be carried out by directly observing them or by using devices triggered by automatic shock detection, etc.

❖ **Monitoring of breeding populations**

By monitoring these populations, it is possible to check, for example, that the wind farm is not leading to reproduction areas being moved away or a loss of habitat, to describe the operating wind farm's effect on the spread or density of breeding populations, or even to study gradual habituation, etc.

This monitoring is all the more appropriate given that the impact study is limited in its ability to judge the sensitivity of populations that reproduce on the wind-farm site and in its surroundings and/or use it during this period as an feeding or transit area.

❖ **Monitoring of flora and habitats**

Monitoring flora and habitats within the scope of a wind farm is only justified in specific cases, because of the installation's small footprint and because the measures taken during the project design and implementation phases are generally sufficient to prevent impact. This monitoring may involve:

- monitoring of changes to the size of vegetation groups or stands inhabited by specific species;
- monitoring the development of species intentionally introduced for plants, in order to prevent uncontrolled development;
- monitoring of the development of species or groups benefited by the erection: appearance of pioneer plant communities linked to new open environments, establishment of commonplace species or groups of invasive ruderal plants, etc.;
- monitoring of the effectiveness of ecological management operations, for example clearing undergrowth.

11.3.2.2 Socio-health monitoring

Socio-health monitoring must be carried out for the following components of the environment;

- social implications;
- telecommunication systems;
- sound environment and
- the risks and dangers associated with the operation of the wind turbines (accidents and work, health and safety).

11.3.2.3 Social risk

During the erection phase, managing the social risk must be a priority objective for PETN management. Minimising the impacts arising from the purchase of land was one of the project's main criteria, not only in the social risk management strategy but also in all decisions made involving the choice of location for the project installations.

Setting up a committee to monitor the People affected by the project (PAPs) is essential even if it is known that the wind farm footprint is the subject of an agreement entered into by the Taiba Ndiaye municipality and PETN. Monitoring and processing of complaints and grievances against the wind farm arising from its installation and operation will guarantee social acceptance of the project.

The reintegration and failure rates of activities funded for PAPs will serve as an indicator for measuring the relevance and sustainability of compensation.

The social dimension of the reinstatement and dismantling plan will also outline measures which will be taken as part of the dismantling of the wind farm installations. The main concerns at this stage should be the project's long-term physical and chemical stability and restoring, wherever possible, conditions that will enable the project sites to be used profitably and will protect humans and wildlife species against any potential dangers.

11.3.2.4 Landscapes

This program must make it possible to assess the impact felt by residents after the first year that the wind farm is in operation.

11.3.2.5 Telecommunication systems

This monitoring must measure the quality level of telephone signals from different operators present on the premises when the wind farm is in operation. This evaluation must take place within the two months following the commissioning of the wind farm.

11.3.2.6 Sound environment

The sound environment must be monitored in the year after the wind farm becomes operational and repeated after 5, 10 and 15 years of operation. In the event that monitoring of the sound environment reveals that standards have been exceeded, PETN must implement the corrective measures identified and check their effectiveness. The measures must be taken under operating and sound propagation conditions that are representative of the most significant impacts.

In addition, during the operating phase, the role of the environmental management officer will involve making sure that the developer protects the environment in all its activities and that it carries out the environmental activities that fall within its responsibility.

The sound received from a wind farm will be determined by measuring sound at the most exposed local residences. In order to assess the emissions, measurements when the wind turbines are in motion and when they are switched off will be required.

In order to obtain samples of residual and ambient noise over relatively homogeneous periods in terms of weather conditions, residual and ambient noise will preferably be measured during the wind farm's start-up and shut-down sequences over relatively short durations (depending on the owners' availabilities).

More specifically, the aforementioned officer will be responsible for:

- Checking that environmental legislation has been enforced;
- Coordinating the activities needs to settle environmental complaints or emergency response actions;
- Maintaining, with respect to environmental issues, the developer's relations with the regional offices of governmental bodies;

11.3.2.7 Monitoring accidents at work, health and safety

As regards safety, the following will be necessary:

- Placing appropriate signs in strategic locations, in order to remind humans present on the site for maintenance of the wind farm;
- Keeping a log of personal accidents or incidents attributable to the operation of the wind turbines;
- Drawing up an emergency plan covering potential accidents and the risks of breakage, including appropriate mitigation measures.

This plan will also outline treatment, maintenance and monitoring measures after the closure of the wind farm, which will be implemented after the closing procedures have been completed.

The occupational health and safety section describes the measures that will be taken to protect the health and safety of employees participating in the project's operating phase.

Table 88: Environmental monitoring program and implementing bodies/individuals

Elements to monitor	Monitoring methods and systems	Implementing body/individual	Periods	Costs
Implementation of environmental measures required in the ESMP	Appoint a hygiene, safety and environment office (HSE) and/or demand one from the supervision office Monitoring of effectiveness of measures prescribed (compliance; level of implementation)	PETN HSE officer	For the duration of the project	1,000,000 / month
Social risk management	Setting up of a compensation committee Compensation for owners Preferential employment for local communities Develop and implement an information and awareness program for both operating personnel and local inhabitants Monitoring of PAPs activities	PETN administrative and finance manager Site manager	Before lease is signed During the construction and operation of the wind farm After compensating PAPs	Included in PETN's investment plan Including investment costs
Monitoring of birdlife mortality	Wildlife inventory	HSE officer	Wind farm's first three years of operation	Included in salary
Monitoring of landscapes	Complaints from residents and farmers in the area	HSE officer	During the 1st year of operation	Included in salary
Monitoring of telecommunication systems	Management of complaints from telephone users in the Taiba Ndiaye locality	HSE officer	During the 1st year of operation	Included in salary
Monitoring of sound environment	Noise measurements in the vicinity of homes	HSE officer	Every 5 years	Included in salary
Monitoring accidents at work, health and safety	Open and keep a record of accidents and incidents in workstations	HSE officer	Daily	Included in salary
Traffic-related dangers	Performance on the road safety plan and number of accidents	HSE officer	Monthly	Included in salary

Implementation of emergency response actions.	Monitoring of number of sessions on sharing, testing and effectiveness of methods and emergency-response equipment	HSE officer Thiès civil protection	Biannual	500,000

Table 89: Environmental and social Management Planduring the design and erection phases of the wind farm

Potential negative impacts	**Mitigation measure**	**Period**	**Implementing body**	**Strategy for implementation by the Developer**	**Indicators**	**Cost**	**Monitoring/Regulatory control**
Provisional soil compaction	Performance of tests on the soil to determine the nature of the site.	**Engineering phase**	**PETN**	**Geotechnical studies by an accredited laboratory**	**Results of tests**	**10,000,000**	**PETN** **Taiba Ndiaye rural community** **DREEC/Thiès and Monitoring committee**
Sealing of soil following concreting and land excavation.	Priority reuse of good soil stripped from roads and top soil from the foundations for agriculture.	**Erection phase**	**PETN**	**Recycling and reuse of earth**	**Volume of earth recovered**	**Included in the special technical specifications (CPTP) for the work**	**PETN** **DREEC/Thiès, Monitoring committee Construction manager and Land owners**
Pollution of the soil and groundwater caused by accidental penetration of liquid pollutants (construction or storage machinery: hydrocarbon, hydraulic oils, lubricants and	Storage of dangerous liquid products (oils, fuel, etc.) during construction in a containment unit able to contain the tank's entire volume.	**Erection phase**	**PETN** **Construction Company**	**Provision of anti-pollution response kits on the site.**	**Existence of containment tanks** **Number of emergency responses** **Technical inspection of construction vehicles**	**Included in the estimate for the work**	**DREEC/Thiès, Monitoring Committee and Construction manager**

paint).

Pollution of the soil and sub-soil: presence of oil in the wind turbines (around 1,500L/wind turbine), oil in the transformers.	Introduction of equipment containing oils (gearbox, transformers, etc.) in a containment tank of a sufficient size.	**Engineering phase**	**PETN**	**Give preference to dry-type transformers over oil-type transformers**	**Idem**	**Included in the estimate for the work**	**DREEC/Thiès, Monitoring Committee and Construction manager**
Decrease in arable areas and production yields Loss of agricultural forestry production	Compensate land owners according to an agreed scale Choice of site Fair and equitable compensation of PAPs	**Engineering phase** **Erection phase**	**PETN**	**Implement in a compensation committee**	**Number of PAPs** **Compensation amount** **Number of complaints and claims**	**To be determined with land owners and the Municipal Council of Taiba Ndiaye**	**DREEC/Thiès, Monitoring committee** **Rural Council** **Compensation committee**
Pruning or potential removal of certain notable plants and/or shrubs along the access roads.	Protection of notable species in the fields and along the access roads.	**Erection phase**	**PETN** **IREF**	**Compensatory planting**	**Number of plants** **Length of plants**	**10,000,000**	**DREEC/Thiès, Monitoring committee** **PETN** **Forestry sector**

Damage to heritage species stands Cutting of trees, clearing Accidental introduction of invasive species	Soil from outside the site not introduced Reinstatement of stripped topsoil after the work Definitive maintenance of the hoisting area Protection of habitats highly sensitive to trampling, public information Management of endangered natural environments,	**Erection phase**	**PETN** **IREF**	Choice of site Verification of absence of heritage species before work begins	**Affected heritage species** **Compensatory planting**	**UNAVAILA BLE**	**DREEC/Thiès, Monitoring committee** **PETN** **Forestry Sector of Tivaouane**
Destruction, loss or damage to habitats (breeding, wintering) Birdlife, bats	Choice of site avoiding migratory routes Choice of wind turbine height Positioning of wind turbines: outside sensitive areas, parallel to birds' paths of travel, opening up of lines to encourage transit Marking of wind turbines to limit the impact on birdlife Maintenance of habitats on the periphery of the wind farm by crop rotation management	**Erection phase**	**PETN**	**Included in the estimate for the work**	**Number of deaths caused by wind turbines**	**Included in the estimate for the work**	**DEEC/Thiès, Monitoring committee** **PETN** **Forestry sector**
destruction, loss or damage of habitats destruction of less	Verification of absence of heritage species before work begins Rehabilitation or creation	**Erection engineering phase**	**PETN**		Choice of site avoiding sensitive areas.	**UNAVAILABLE**	

mobile specimens	of replacement ponds						
Noise generated by the transit of construction vehicles (trucks, cranes), increase in the number of peak levels per hour.	Performance of work on working days (work at the weekend, at dawn and in the evening should be avoided as much as possible). Limitation of sound power levels (must not exceed the values taken into account in the framework of this study).	**Erection phase**	**PETN**	**Construction Company**	**Noise level** **Staff provided with personal protective equipment (PPE)** **Residents' complaints and grievances**	**Include in the CPTP**	**DREEC/Thiès, Monitoring committee** **PETN**
Possible damage to roads and red earth tracks, sound disturbances, etc.	Establishment of a police escort for heavy loads in collaboration with the wind turbine construction company, the police and local authorities. Application for authorization for outsize transport	**Erection phase**	**PETN**	**Combine civil protection**	**% of rotations escorted** **Damage to roads due to overloading of the axle**	**1,500,000**	**DREEC/Thiès, Security forces** **Directorate for land transport** **PETN** **Directorate for Civil Protection (DPC)**

Disturbance of staff and neighbours Release of dust during works on wind turbines' and tracks' footprint Dust released during transit of construction and heavy vehicles along the red earth tracks	Spraying of track running surface Lines of plants along tracks to function as dust suppressants	**Erection phase**	**Construction company**	**PETN**	- **Presence of water tanks** - **Volume of water consumed to irrigate tracks** - **Line of dust suppressants**	**Included in the construction company bid**	**PETN** **DREEC/Thiès** **Health district**
Natural risks of fire following lightning	Carry out a lightning protection study	**Erection phase**	**PETN**	**Include DPC**	**46 lightning rods installed**	**Included in the equipment planned on each wind turbine**	**PETN** **Directorate for Civil Protection (DPC)**
Change in spatial organization, introduction of scaling ratios Interaction with surrounding landscape (rural, urban, industrial) and with landscape features	Landscape project Restrict visibility of site Specific reinstatement operations	**Erection phase**	**PETN**	Choice of site and installation variable	**Proposed landscape integration project**	**UNAVAILABLE**	**PETN** **Taiba Ndiaye municipality** **DREEC**

Table 90: Environmental and social Management Plan during the wind farm operating phase

Potential negative impacts	**Mitigation measure**	**Period**	**Implementing body**	**Strategy for implementation by the Developer**	**Indicators**	**Cost**	**Monitoring/Regulatory control**
Fiscal fallout Tourist fallout	Aid to support operation of local structures (agricultural, associative, tourism, etc.)	**Operating phase**	**Taiba Ndiaye municipality**	**Investment to benefit local communities in the wind-farm area**	**Municipal revenue Subsidies granted to producers' organizations Development projects to benefit the community**	**UNAVAILABLE**	**Municipal council of Taiba Ndiaye Monitoring committee**
Pollution of the soil and groundwater caused by accidental penetration of liquid pollutants (construction or storage machinery: hydrocarbon, hydraulic oils, lubricants and paint).	Storage of dangerous liquid products (oils, fuel, etc.) during construction in a containment unit able to contain the tank's entire volume.	**Operating phase**	**PETN Construction Company**	**Provision of anti-pollution response kits**	**Existence of containment tanks Number of emergency responses Technical inspection of construction vehicles**	**Included in the estimate for the work**	**DREEC/Thiès, Monitoring Committee and Construction manager**

Pollution during maintenance and oil changing.	Performance of maintenance according to a well-prepared schedule and taking all necessary precautions to prevent any leakage of oil or of any other liquid substance that is dangerous for the environment.	**Operating phase**	**PETN**	**Emergency measures**	**Containment tanks and anti-pollution kits**	**- Included in the operating budget**	**DREEC/Thiès, Monitoring Committee and Construction manager**
Decrease in arable areas and production yields	Compensate land owners according to an agreed scale	**Operating phase**	**PETN**	**Implementation in a PAP complaints monitoring committee Provide the committee with an operating budget**	**Number of complaints and claims Disputes solved**	**1,500,000**	**DREEC/Thiès, Monitoring committee Rural Council Compensation committee**
Trampling of nearby habitats by visitors (indirect effect)	Definitive maintenance of the hoisting area Protection of habitats highly sensitive to trampling, public information Management of endangered natural environments,	**Operating phase**	**PETN**	Restoration of damaged environments Stabilisation of access roads	**Restored areas Communication tools developed for visitors**	**Included in cost of work**	**DEEC/Thiès, Monitoring committee Research institutes PETN Forestry Sector of Tivaouane**

Risk of birds colliding with a moving blade (limited risk); birds of prey are however more sensitive to lattice towers.	Marking of wind turbines limit the impact on birdlife.	**Operating phase**	**PETN**	**Introduction of research protocols with universities and research institutes Monitoring of deaths**	**Number of deaths caused by wind turbines**	**7,000,000**	**DEEC/Thiès, Monitoring committee Research institutes PETN Forestry Sector of Tivaouane**
"Scarecrow" effect: risk of disturbance to wild birdlife "Barrier" effect Various types of disruption (e.g. failure of or drop in reduction)	Development of ornithological monitoring to assess the impacts of wind turbines on birdlife Maintenance of habitats on the periphery of the wind farm by crop rotation management Protection of breeding birds Regulation adapted to wind turbine operation	**Operating phase**	**PETN FORESTRY SECTOR**	**Involve research institutes and universities**	**Direct observation of scarcity of local wildlife Existence of monitoring protocols Monitoring results**	**4,000,000**	**DREEC/Thiès, Monitoring committee Research institutes PETN Forestry sector**

Noise generated by transit of operation and maintenance vehicles	Raising the awareness of operating staff of the speed limit and instructions for respecting the highway code and traffic signs Speed limit in accordance with recommendations Limitation of sound power levels (must not exceed the values taken into account in the framework of this study).	**Erection and dismantling phase**	**PETN**	**Construction Company**	**Awareness-raising tools developed Residents' complaints and grievances**	**2,000,000**	**DREEC/Thiès, Monitoring committee Road safety PETN**
Possible damage to roads and red earth tracks, sound disturbances, etc.	Contribute to periodic maintenance of roads Contribution to the Taiba Ndiaye municipality's budget for maintenance and rehabilitation of tracks	**Operating phase**	**PETN**	**Combine civil protection**	**Taxes paid for overloading of axle Budget allocated to maintenance of tracks**	**1,500,000**	**DREEC/Thiès, Security forces Roads Authority Directorate for land transport PETN Directorate for Civil Protection (DPC)**

The risk of accidents (breakage of blades, falling towers, fire in the rotor, environmental pollution, wind turbine parts transported by road, lightning). Production of infrasound Casting of shadows	Choice of site (away from neighboring houses) Public information Establish an internal operation plan (IOP) and test it regularly	**Operating phase**	**PETN**	**Include DPC**	**Existence and test of IOP** **Information campaign aimed at populations and signalling of safety rules**	**15,000,000**	**DREEC/Thiès, Monitoring committee** **PETN** **Directorate for Civil Protection (DPC)** **Taiba Ndiaye local authority and local inhabitants**
Risk of collision (foundations, towers), catching (bottom of blades, wires)	Installation of wind turbines in the direction of the wind and separation of machines Sound signals	**Operating phase**	**PETN**		**Incident log**	**UNAVAILABLE**	**PETN** **Directorate for Civil Protection (DPC)** **DREEC**
Noise of wind turbines Light emission Disturbance to radio reception Disturbance in the vicinity	Choice of site (away from local residents) Acoustic optimisation of the wind farm Restoration of reception quality Clamping of wind turbines if sound levels are exceeded	**Operating phase**	**PETN**	**Monitoring protocol**	**Complaints from local residents and network operators**	**5,000,000**	**DREEC** **Directorate for Civil Protection (DPC)** **Social security** **University of Thiès** **Municipal council of Taiba Ndiaye**

Natural risks of fire following lightning	Install lightning rods on wind turbines	**Operating phase**	**PETN**	**Include DPC**	**Number of lightning rods** **Fires linked to lightning within the wind farm footprint**	**Planned on each wind turbine**	**DREEC/Thiès,** **Monitoring committee** **PETN** **Directorate for Civil Protection (DPC)**
Frustration of neighboring villages without electricity	Establishment of a structure for dialogue between the authorities, the surrounding community and the applicants.	**Operating phase**	**PETN**	**Involve the Senegalese Agency for Rural Electrification (ASER) in consultation and coordination** **Contribute to costs of connecting remaining villages**	**Number of villages with electricity**	**7,500,000**	**DREEC/Thiès,** **Monitoring committee** **PETN** **ASER** **Taiba Ndiaye local authority and local inhabitants**
Improvement of environmental authorities on the operation of the wind farm	Organization of study trip and benchmarking	**Operating phase**	**PETN**	**Involve Senelec**	- **Number of participants** - **Duration and destination of trip**	**10,000,000**	**DEEC/DREEC** **PETN** **Taiba Ndiaye municipality** **Directorate for Civil Protection (DPC)**

11.4 IMPLEMENTATION OF ENVIRONMENTAL AND SOCIAL MANAGEMENT

11.4.1 Administrative organization

The ESMP applies to the preparation, commissioning and operation of all the installations, including the processing plant, as well as to the site closure and reinstatement phases. It concerns all employees working on the project, including the project's permanent and temporary staff and contractors' employees.

All of them have specific duties, both on the management and operational levels, involving maintenance and implementing procedures linked to the ESMP.

Specific mitigation measures identified for each project component, within the immediate scope of the project and under the responsibility of the aforementioned players, must be implemented and monitored properly. The methods for implementing supervision and monitoring the effectiveness of these measures will be organized around a participatory approach involving several stakeholders, including:

- the developer;
- State technical services (the directorate for the environment and classified establishments, the directorate for energy, the directorate for water and forests, the directorate for livestock, the directorate for agriculture, the directorate for civil protection, the directorate for employment and social security, the roads authority, the directorate for land transport, etc.);
- Thiès regional commission of civil protection;
- research and training institutes in the region: Universities of Thiès, ENSA, CNRA, etc.
- Taiba Ndiaye municipality.

With regard to the need for synergy between these stakeholders, several specific actions are needed to facilitate the implementation of environmental and social measures, and the emergency measures recommended by this Environmental Impact Study.

Table 91: Summary of administrative organization

Stakeholder category	Socioeconomic aspects	Environmental aspects	Information/communication	End-of-life management
Technical services	- Inform local authorities and civil society about the content of the agreement between the Municipality and the project developer; - Build local population's response capacity in order to assist in the implementation of the project; - Inform and raise awareness among local populations about Senegal's environmental policy; - Transfer a share of public revenue generated by the project to local administrations, in accordance with rules governing the decentralization and management of local resources; - Ensure that the environment and natural resources are conserved within the scope of the project implementation	- build institutional project supervision and monitoring capacities; - enforce legislative instruments on the environment; - conduct periodic environmental checks in the project area; - regularly inspect the project activities and management of dangerous products used; - require that sites are rehabilitated after dismantling the wind farm	- ensure wide dissemination of legislative and regulatory texts applicable to the project; - organize a platform for dialogue on environmental issues in the installation area of the two wind farms	- require a report on the dismantling work and reinstatement of the wind farm sites; - create a framework for cooperation and monitoring of the dismantling plan, including all stakeholders involved; - certify the performance of rehabilitation work.

Developer (Sarreole)	- Enforce the laws and agreements signed with the Taiba Ndiaye municipality; - Enforce sectoral regulations (codes and standards) and the law on the Environment Code; - Rehabilitate or strengthen infrastructure, in the fields of health, education and water, so that they meet the local inhabitants' actual needs; - Adopt a preferential hiring policy for indigenous communities; - guarantee the independent control and improvement of environmental and social conditions in the project area; - conserve natural resources and optimal protection for local residents quality of life; - ensure that electrical energy generation activities are monitored and that mechanisms to mitigate the impact of the project on the environment are implemented.	- Follow the recommendations of the environmental and social impact study - involve local communities in the monitoring of wind-farm site dismantling programs; - support the funding of environmental conservation activities in the project area; - ensure the preparation, implementation and follow-up of a site rehabilitation plan once operation has ceased; - build local populations' technical capacities and environmental knowledge in order to better prepare them to assist in the project; - conduct periodic environmental audits to guarantee the effectiveness of existing systems; - actively support environmental protection.	- Implement a voluntary wind-farm related incidents and accidents reporting system with professional organizations - draw up a strategy for communication and sharing experiences with local communities - raise awareness among, inform and train local populations and administration.	- at the start of operation, set up a rehabilitation fund covering all the expenses; - rehabilitate the sites in line with the proposed work schedule; - monitor and control the implementation of the rehabilitation program, by respecting the established timing;
University and research institutes	- Assign corporate social responsibility (CSR) procedures to the scientific and technical research department	- Improved knowledge of the ecological impact of wind turbines - Improve the state of knowledge of the health impacts of wind turbines	- Call for applications from potentially eligible structures - Dissemination of monitoring results for university research	- Adapt the dismantling schedule by capitalising on knowledge acquired

Local authorities and populations	- support the project so that benefits can be gained from it that are of help to community development; - diversify sources of revenue, by reinvesting revenue from mining production in sustainable activities; - play the role of mediator between the project and local populations in the event of conflicts; - support the project for effective environmental monitoring; - raise awareness among and build local inhabitants' capacities with respect to optimal use of the project's benefits.	- share traditional knowledge for better management of natural resources - take part in monitoring the rehabilitation sites; - launch environmental programs at the community level.	- convey information through traditional channels of communication; - raise awareness among opinion leaders of the communication and dissemination of information on the project's activities.	- check that the equipment and installations in place are working; - encourage the project to give local communities and populations the benefit of certain infrastructures;

The environmental protection measures that the developer has recommended and which are linked to the erection activities will form an integral part of contractors' obligations.

The contractor's environmental protection responsibilities will be inserted and specified in all work contracts issued by the developer; these responsibilities include the following:

- the contractor must ensure compliance with national and international laws, regulations and standards on the quality of the work environment and environmental protection;
- the contractor must comply with general environmental guidelines issued by the developer;
- the contractor shall appoint an officer for environmental monitoring. This officer will be responsible for ensuring that the environment is protected during the performance of construction work;
- the contractor must prepare a final report at the end of the work on all its environmental monitoring activities and submit it to the developer.

The dismantling work must take into account social and physical rehabilitation aspects provided for the following purposes:

- not endangering future public health and safety;
- providing affected communities with beneficial and sustainable post-operational land use.

11.4.2 Implementing recommendations

Before and during implementation of the project, the following measures are recommended:

- **Surveys and Public briefing – information and awareness-raising among stakeholders:** Before work commences, a public briefing will be organized with local population officials, to provide information on the project and the planned environmental measures. This meeting will also provide an opportunity for specifying the roles and duties of each individual in order to ensure participation in the implementation of the project.
- **Preparation of a classified establishment dossier:** given that the project falls within the category of a classified establishment, the developer must prepare and submit a classified establishment dossier for review by the DEEC. This dossier includes a project layout and the locations of installations;
- **Communication campaign: information and awareness-raising among all stakeholders:** the Developer must organize a communication campaign (information and awareness-raising) before work starts and during the operating phase.
- **Implementation of environmental measures:** Technical measures will be implemented by the private companies that are going to carry out the project.
- **Monitoring and supervision of the implementation of environmental measures during the work and operating phase:** the HSE expert will perform internal environmental monitoring (preparation and operating phase), while the DEEC and the Directorate for Energy will be responsible for external monitoring.

11.4.3 Cost of environmental and social management plan and monitoring

The environmental and social management plan includes three categories of measures:

- technical and/or environmental measures to be introduced into the tender dossier as contractual measures, which will not be evaluated financially;
- supervision and monitoring measures, including capacity-building measures, the costs of which will be negotiated and agreed upon with stakeholders (actors responsible for monitoring and contractors);
- specific measures which will be charged to the development budget.

Table 92: Cost of environmental and social management plan

SPECIFIC MEASURES	Total (FCFA)
Initial measures	
Geotechnical tests on the wind farm footprint	10,000,000
Setting up and running of a compensation monitoring committee	1,500,000
Developing and performing an IOP test	15,000,000
Contributing to electrification of neighboring villages	7,500,000
Provisions for outsize transport/overloading of axle	5,000,000
Police escort for heavy loads in collaboration with the wind turbine construction company, the police and local authorities.	1,500,000
Support for PAPS by developing a Community Development Plan (CDP)	50,000,000
Compensatory planting along tracks and/or fields	10,000,000
Communication plan for local communities	3,000,000
SUBTOTAL	**103,500,000**
Operational measures	
Recruitment of a HSE officer	7,800,000 FCFA /year
Research agreements for ecological and health monitoring (wildlife, flora, noise)	7,000,000
Training mission for those responsible for monitoring/study trip	10 000 000
Provisions for ESMP monitoring committee	2,500,000
Provision for those responsible for monitoring ESMP activities	2,000,000 FCFA /year

12 CONCLUSION

In the light of the study of the environmental and social impacts of installing a wind farm with 46 wind turbines in the Taiba Ndiaye municipality, it is quite clear the the positive arguments for such an investment make the case for this project to be accepted. The fact is that, as a renewable energy that requires no fuel, does not create greenhouse gases, does not produce toxic or radioactive waste, introducing wind energy is a credible alternative to diversify and strengthen the electricity generation industry in Senegal. Furthermore, by fighting against climate change, wind energy makes a long-term contribution to maintaining the biodiversity of natural environments.

The Taiba Ndiaye wind farm will result in additional power of 150 MW in the Senegalese electricity generation network, which is strongly characterized by recurrent deficits, without affecting the air quality, without polluting water (no discharge into aquatic environment, no thermal pollution) and without polluting the soil (no soot or ash).

This means that the wind farm's ecological and economic viability can be guaranteed if the measures to mitigate the related social and environmental impacts are implemented in a timely manner. The main requirements are:

Fair and equitable compensation for those entitled to it and social support for people affected by the wind farm;

- Implementation of actions to restore biotopes and mitigate disruption caused to wildlife
- Compliance with the formal agreement with the Taiba Ndiaye local authorities;
- Compliance with forestry regulations and the provisions of the ESMP outlined in this report.

The research has found an enabling environment for removing uncertainties related to the impact of wind turbines on wildlife (mortality) and man (noise, vibrations, etc.). This presents Sarreole with the chance to build up the resources of the universities and training institutes that it will involve in the company's CSR procedures.

In short, these are arguments in favor of the social and environmental acceptance of Sarreole's project to construct a wind farm with 46 wind turbines in the Taiba Ndiaye Municipality, in the Tivaouane department.

ANNEXES

Annex A: Terms of reference and response from the DEEC
Annex B: Decision of the Municipality
Annex C: Extracts of some regulatory texts
Annex D: List of people met and/or contacted
Annex E: List of experts that conducted the study

Annex A: Terms of reference and response from the DEEC

DRAFT
TERMS OF REFERENCES FOR THE ENVIRONMENTAL IMPACT ASSESSMENT OF THE PROJECT TO BUILD WIND FARMS IN TAIBA NDIAYE, SENEGAL

Chapter 1- INTRODUCTION AND CONTEXT

Population growth, especially in urban areas, is leading to increased needs for energy and, in particular renewable energy. The local traditional operator, the Senelec company, has announced an increase in consumption and in the number of customers at a rate of around 10% per year. The majority of electricity is, more significantly, generated from thermal (along with the drawbacks associated with the petroleum products market in terms of cost, energy dependence and pollution) or hydraulic sources. In these circumstances, it appears appropriate to concentrate on local renewable resources, such as solar and wind energy.

The development of wind energy now forms part of policies to combat the greenhouse effect. The Kyoto (1997) and Buenos Aires conferences concluded that greenhouse gas emissions need to be reduced. It is the burning of fossil fuels (fuel oil and coal, in particular) which is responsible for the majority of air pollution and the warming of our planet.

Wind power is expected to undergo significant development in the current context of the dramatic increase in the use of fossil fuels. Although this so-called "renewable" energy offers many advantages to the environment, it may also lead to certain changes or disturbances.

It is therefore important to develop high-quality wind farms that are integrated into their natural and human environment, in the spirit of the Environment code (Law No. 2001 - 01 of 15 January 2001), which specifies the following in its Title I, Chapter III (Instruments of environmental protection) Article L 8: The national strategy for the implementation of the United Nations Framework Convention on Climate Change is one of the instruments of environmental protection. Wind power is a form of energy which produces no greenhouse gas.

A clear sign of modern dynamism, the installation of wind farms will be perceived as even an unprecedented demonstration of innovation, a strong commitment to a sustainable energy policy concerned with respecting future generations.

This project with a total power of at least 151.8 MW involves installing at least 46 wind turbines each with a unit capacity of 3.3 MW, or any variant equipment whose total power will be compatible with the scope of the project, which will be carried out in 3 phases:

- The development phase: impact feasibility study: timeframe 18 months from June 2007; budget: around €82,000.

- Administrative and contractual phase: obtaining permits (building permit, operating permits) and contracts for the purchase of electricity generated over 15 to 20 years; the models of electricity purchase contracts produced by thermal power plants could be adapted.

- Implementation phase: the installation of wind turbines could be carried out in three (around) 50-MW phases. This 50-MW power per phase may be seen as a critical power level for the construction of a project. The successful completion of this phase involves implementing a project that is substantial enough to motivate investors and wind turbine suppliers in particular and makes it possible to use the scale factor to pool costs (studies, creation of accesses and electrical connection, transport of resources and construction equipment and raising of wind turbines).

The main purpose of this impact study is to:

- ensure that all stages of operations to be started within the scope of this project are compatible with the environmental sensitivities of the sites accommodating the wind turbines, as well as with the regulatory requirements that the national authorities have defined for their protection;

- to identify and recommend concrete actions to reduce the disturbances that are likely to be caused, as well as an environmental management project for the entire duration of the project.

The study will be conducted based on terms of reference, the subject of this document, and will be prepared by taking into account the obligations and recommendations of the Senegalese Environment Code.

Given that the wind farm would be composed of a series of wind turbines and also an access road and an outgoing electricity grid, the impact study must take into account the various components of the wind farm.

A. Duties of the Consultant

In consultation with the Developer, the Consultant will have to carry out the following duties:

Chapter 2- DESCRIPTION AND JUSTIFICATION OF THE PROJECT

The consultant will present the various components of the production, installation, operating and wind-farm installation dismantling program, and it will include:

- ✓ **General presentation of the study area (base map 1:100,000);**
  - General presentation of the wind farm location (1:25,000 map);
  - Proposed location and footprint required;
  - Electrical power and expected generation;
  - Number, type, dimensions and location of wind turbines;
  - Project stakeholders: project owner, construction manager;
  - Background to the project development;

- Provisional project schedule.

✓ **Construction;**
- Description of construction and wind-turbine installation methods; foundations, access during construction and operation, raising procedure;
- Description of connection to the grid and interconnection of wind turbines: transformers, power sub-station, electrical cable routing;
- Other equipment: measurement mast, car park, public information area, etc.
- Human resources required during construction and reception;
- Type and movement of construction vehicles, transport of materials and traffic;
- Duration of construction phases and provisional schedule.

✓ **Operation;**
- Description of plant operation;
- Conditions of access to the wind farm;
- Estimated project lifetime.

✓ **Dismantling and reinstating the site;**
- Description of structure dismantling plan;
- Description of the site reinstatement.

Chapter 3 - ANALYSIS OF THE POLITICAL, LEGISLATIVE, REGULATORY AND INSTITUTIONAL CONTEXT

The consultant will conduct research on relevant regulations and standards concerning environmental quality, including the requirements of international conventions that the country has ratified on environmental protection. This analysis must take into account the legal status of the sites expected to accommodate the wind farms.

The mandates and capacities of institutions concerned with the management of wind farms should also be studied.

Chapter 4 - DESCRIPTION OF THE INITIAL STATE AND RELEVANT COMPONENTS OF THE ENVIRONMENT

This will involve collecting and analyzing basic data on the relevant elements that are a feature of the physical, biological and sociocultural environment in the study area.

Firstly, the Consultant must geographically identify the sites (on a map of an appropriate scale) and indicate the location of the administrative authorities which they fall under (region, department, neighborhood, municipality or community, etc.).

Secondly, the Consultant must define the project's area of influence, that is, all geographical areas that are likely to be affected by the impacts of the project. The boundaries of the study area are defined by the potential impact with the wider study areas having the most noticeable repercussions. The visual impact is the factor most often taken into account when determining the wide study area. However, this does not mean that each of these aspects should be studied with the same degree of precision for the whole study.

These study areas vary depending on the subjects to be studied (very large view corridor, presence of an element with UNESCO world heritage status, migratory bird routes, presence of settlements that are sensitive to noise pollution, etc.).

Different types of information need to be collected to define the initial state and to assess the sensitivity of sites (indicative list):

- regulatory easements: they concern both the airspace that the wind turbines will occupy (microwave radio signals, movement of aircraft, etc.) and the ground area occupied by other activities (transmission pipes, infrastructures, etc.); in particular, air space easements (clearance and radio) and the constraints relating to the operation of aerodromes under visible flight rules and under instrument flight rules, environmental protection areas;

- territorial management guidelines mentioned in planning documents (local development plan [PLD], Regional Land-Use Planning Strategy [SRAT] for the Grande Côte),

- territories subject to specific regulations (urban planning restrictions, constraints linked to natural heritage, constraints linked to cultural heritage).

During the analysis of the initial state of the sites and their environment, the consultant must provide sufficient data to identify, evaluate and rank the potential effects of the wind farms. The initial state must describe the context specifically and in detail (place, geographical size), as well as the specific (notable aspect, originality, rarity) and significant features (quality of environments, protection level) of the components of the environment.

In addition, thematic maps may be prepared, for example:

- **location** (project location map, study area map);
- **physical environment** (topographic map, hydrographic chart, wind rose);
- **biological environment** (map of inventoried natural environments, map of protected natural environments, map of breeding and migratory birdlife);
- **human environment** (occupied areas map, land use plan (POS) zoning map, technical easements map

- **heritage and landscape** (notable or protected heritage map, landscape units map, landscape frequentation map).

Chapter 5 - ANALYSIS OF VARIABLES

As part of the process of identifying wind sites, several alternative sites will be described and compared on the basis of technical, economic and environmental criteria. The consultant will consider these different alternative sites as well as each of the potential layout schemes.

Subsequently, the assessment process must encourage variables that have the least impact on the selected site to be defined and analyzed:
- wind turbine location variations on a single site;
- variations of infrastructure related to the project: location, type of connection and electricity network routing, other accesses for the transport of wind turbines, etc.;
- technical variables: type of wind turbine, foundation, network connection, etc.

This phase of the study provides an opportunity to take a critical look at the project, by presenting the various paths explored during the design phase. It facilitates understanding of the choices that the project leader made and justification of the selected option. It also makes it possible to choose the best alternative, by comparing the different layout schemes, by drawing on a small amount of environmental data. In this way, this phase makes it possible to dedicate most of the resources to a more limited area.

Chapter 6 - ANALYSIS OF EFFECTS AND EXPECTED IMPACTS ON THE ENVIRONMENT

The study of the effects on the environment must be based on methods and tools that make it possible to foresee and determine the significance of the different effects (positive or negative) by making a distinction between direct or indirect, temporary or permanent, or cumulative effects, during construction, operation and dismantling.

The analysis and assessment of the impacts must cover the following phases in particular:

- Site preparation, installation, erection of wind farm;
- Operation of wind farm;
- Dismantling of wind farm and reinstatement of site

In addition, the study will focus on the following aspects during this analysis phase:

6.1 AIR QUALITY

- Identify the project components that will affect air quality.
- Identify sources of emission.

6.2 WASTE AND POLLUTED WATER TREATMENT

- Quantity and sources.
- Waste water treatment system (consider the best technology to measure loads and harmful concentrations).
- Produce and discuss:
  - the limits for contaminants to be taken into account;
  - the effects in discharge areas;
  - the possibility of reducing the harmful effects, in relation to treatment technology.

6.2.1 Noise and vibrations

Wind turbines generate noise when in operation. Although the sound levels emitted are relatively low, compared to those emitted by a heavily used road, for example, the sound requirement is one of the main constraints on setting up a wind farm and therefore features prominently in the impact study. It must demonstrate compliance with regulations in force, on the one hand, and address the issue of noise in terms of public health, on the other.

The impact of sound emissions by the wind turbines will be studied from the most exposed residences, namely:

- dwellings closes to the site: pinpointing them is essential in order to identify sensitive areas (type of occupation, layout, etc.);
- dwellings located under prevailing winds (in particular where the direction of prevailing winds is marked);
- dwellings located in specific topographical arrangements that could lead to low residual noise levels locally, despite high wind speeds on the wind farm site;
- the activities that are going to affect the actual noise level, during the construction and operating phases;
- The expected sound level of the installations;
- The impact of noise on the property boundaries during the construction and operating phases.

6.2.2 Waste management

- Production of waste in the different phases: construction, energy generation, maintenance and dismantling of installations
- For each type of waste: identification, quantity, volume, method of elimination or recovery, internal or external, processing method,

- Measures taking for treatment.

6.3 FLORA AND FAUNA

A description of the plants and wildlife in the natural environment (terrestrial wildlife) will be produced. It will cover both the species that frequent the wind farm site and their use of the site. The research must be more in-depth for rare or heritage species. Migratory, breeding and wintering birds will be studied according to appropriate methods.

6.3.1 Hygiene, Health and safety

Like any industrial equipment, wind turbines involve a technical risk linked to their operation. Although this risk is classified as very low overall, complying with the design and operation rules is an essential factor for the safe and reliable operation of equipment. The consultant must also:

- Determine whether the implementation of the project will have an impact on the health of local inhabitants and workers.
- Identify the exposed populations and the risks in relation to the polluting components released into the environment.

6.3.2 Human environment

The study of the environmental effects on the human environment will address the identified consequences of the project for the various components of the environment concerning usage by local inhabitants, in particular:

- Compliance with Regional Land-Use Planning Strategies for the Grande Côte area and the Taiba Ndiaye Rural Council's local development plan (PLD),
- Land tenure and owners located in the vicinity,
- Usage of soil:
  - Agriculture: *affected properties, agricultural potential, land under cultivation, forestry data*
  - Tourist recreation activities,
  - Infrastructure and services: *road transport, maritime transport, electricity network, water supply and management of waste water, management of solid and liquid waste, services, chemical factory (i.e. ICS),*
  - Culture and heritage: *archaeological potential, built heritage*, quality of life.
  - Human health: *toxic organic compounds, "classic" contaminants, inhalable and ozone particles, assessment of effects on health, expected sound impact.*

6.3.3 Local and regional economy

The study of impacts in the economic sector will address the following aspects:

- Impact on local employment and creation of wealth,
- Improvement of living conditions of disadvantaged local communities: access to electricity,
- Impact on taxation and local finances of the Rural Council of Taiba Ndiaye, and
- Impact on reduction of electricity deficit and on GDP.

6.3.4 Landscape

The landscape will be analyzed on different scales:

- A wide study area: It has a territorial scale (from 10 to 15km) making it possible to include the project in the landscapes affected and to identify "co-visibilities";
- A narrower study area: it is used to make a choice among the variables and the layout scheme selected (between 1 and 10 km);
- A study area comprising the immediate surroundings, which concerns the accesses to the wind farm, the related equipment (transformers, fences, power sub-stations) and land taken (access routes to site, raising platform, etc.)

It is necessary to determine the importance of each of the effects analyzed above; different methodologies can be used to achieve this result. They are based on comparing the effects (positive or negative) associated with the installation of wind turbines and the environment's sensitivity. The study will determine the most significant impacts.

At this stage, using a matrix to identify the impacts and a list of checks is recommended.

Once the study has established that an impact is likely to arise, it must be categorised. The study will define the criteria for categorising the impacts.

6.4 HAZARD STUDY

The main purpose of this study is to identify and evaluate the risks linked to the construction and operation of a wind farm and its related installations (track, underground cable network, technical room, etc.) and to propose effective risk control measures tailored to the wind farm's life cycle.

The consultant will refer to the hazard study guide edited by the ministry responsible for the environment in Senegal.

6.5 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (ESMP)

6.5.1 Mitigation measures

The study will specify the actions and work, corrections and additions planned for the various phases of the construction work, operation and end of the project's duration, in order to eliminate or reduce the negative impacts of the project. Where applicable, the study will describe the measures envisioned to promote or enhance the positive impacts.

A distinction will be made between reduction measures – or even impact elimination – and compensatory measures. For the sake of readability, all these measures are grouped together in the rest of the text under the term "reductive measures".

The environmental and social management plan (ESMP) will be presented in the form of a table. The viability of the proposed measures must be expressed by means of presenting the expected outcome, and as far as possible the cost, the time frame for implementation and the body responsible for implementation.

Considering the degree of involvement and participation of partnering groups and populations in the management of the installations, special emphasis must be placed on the awareness-raising and information components with a view to prompting acceptance of this major innovation in the territory of the local community of Taiba Ndiaye.

6.5.2 **Monitoring and supervision plan**

It is not always possible to accurately assess all the consequences of the implementation of the project for the environment. In certain cases, proposals from the project owner may only be approved once the wind turbines have been installed, or even after they have been in operation for several years (evolution of sound levels, behaviour and evolution of bird populations, etc.).

This consideration of the environment can be incorporated into various phases:

1) during the consultation with companies phase;
2) during construction with the participation of environmental professionals;
3) during the operating phase, to verify and refine knowledge of impacts and the effectiveness of reductive measures.

In these cases, a monitoring system may be proposed for measures to reduce impacts. This system must define:

- the monitoring protocol to implement;
- the bodies or experts appointed to carry out complementary studies;
- the way in which the project owner implements reductive measures that it has proposed and how it funds them;
- the re-assessment of these commitments.

It must indicate the links between the identified impacts and the indicators to be measured, the methods to use, the frequency of measures, the level of thresholds that trigger correctional measures. The plan must determine the monitoring parameters, as well as the relative monitoring costs. It will be presented in the form of a table.

6.5.3 **Monitoring program**

This monitoring program is aimed at ensuring that mitigation measures are implemented and that they yield the expected results and that they are either amended or cancelled if they do not give conclusive results.

6.5.4 **Institutional responsibilities**

The implementation of mitigation measures and the completion of the monitoring program requires the clear establishment of responsibilities for the various organizations involved in implementing and commissioning the project, which must be established by the Consultant.

6.6 PUBLIC PARTICIPATION

The participation of the main institutions affected by the project (the Directorate for the Environment, Directorate for energy, Ministry of biofuels and renewable energy, Regional Council of Thiès, the Rural Community of Taiba Ndiaye, local projects, NGOs and professional organizations, Sporting and Cultural Association [ASC], the general public) is a key element of the study.

The regional (Thiès) and departmental (Tivaouane) Water and Forest departments must be closely involved in the project due to the potential impacts of the project on the protected strip of casuarinas on the coast.

The Consultant will reveal the extent of consultations that it will have held with a view to obtaining the opinion from a given organization on the execution of the project and on the measures to take.

Team of Experts

The study will be conducted by a consultancy firm accredited by the Ministry of the Environment and Nature Protection with a multidisciplinary team, which must include:

- An environmental project leader experienced in EIS;
- An expert on pollution, disturbance and sound;
- A naturalist, birdlife specialist;
- A socio-economist;
- An energy and electromechanical expert.

Reports to be prepared by the consultant

The consultant must write a report and make it available in paper and digital formats:
- fifteen copies of the provisional EIS report will be submitted to the Directorate for the Environment and Classified Establishments;

- the observations of the technical committee shall be taken into account in the final report. The consultant will present the EIS report during a public briefing, the fees of which must be covered by the developer in accordance with the law;
- three copies of the final report, which will be prepared by taking into account the results of public consultations and remarks from the Project owner, are submitted to the Directorate for the Environment and Classified Establishments along with a non-technical summary and useful annexes (plans, diagrams of installations, etc.).

It must be structured in accordance with regulations (**MINISTERIAL ORDER No. 9472 MJEHP-DEEC** ***of 28 November 2001 on the content of the Environmental impact study report).***

Annex B: Decision of the Municipality

REPUBLIC OF SENEGAL

REGION OF THIÈS

DEPARTMENT OF TIVAOUANE

DISTRICT OF MEOUANE

RURAL COUNCIL OF TAIBA NDIAYE

ANALYSIS: EXTRACT OF DECISION ON LAND USE

THE RURAL COUNCIL

- Having regard to the constitution

- Having regard to Law 64-46 of 17 June 1964 on national property;

- Having regard to Law 96-06 of 22 March 1996 on local authorities;

- Having regard to Law 96-07 of 22 March on the transfer of competences to the regions; to municipalities

And to rural communities;

- Having regard to decree 72-1288 of 10/10/1972 on land use and decommissioning of land that is part of national property;

- Having regard to decree 1130 of 27 December 1996 on the application of the law on the transfer of competences to the regions, to municipalities and rural committees for management and use of private property of the state, of public property and of national property;

- Having regard to decision No 04/CRTND of 29/05/2008 approved on 25/06/2008;

- Having regard to the interested party's application

Hereby decides that

Article 1: land of an area of Seven Hectares located at the entrance to Taiba Ndiaye is allocated to Sarreol for the generation of wind power

Article 2: the recognition of the land will be carried out in the presence of the local committee and of the interested party

Article 3: after making itself aware of the provisions of the referenced texts, the allottee of land commits to comply with them.

Article 4: this decision will be recorded in the land register of the rural community and published wherever required.

- Read and approved

In Taiba Ndiaye, 01/11/08

Sub-Prefect

President of the Rural Council

Annex C: Summary of some international standards

IEC standard 61 400 – 1

Wind turbines
Design requirements

The version is referenced as 88/184/CDV published on 12 December 2003.

1. **Scope of application.**

The purpose of the standard is to establish design requirements to be followed to provide "an appropriate level of protection against damage from all hazards during the planned lifetime of the wind turbine".

2. **General principles.**

The requirements cover the design, manufacture, installation, operation and maintenance manuals and the related quality assurance procedures, with the aim of making the wind turbine's structure, mechanical and electrical equipment and control system safe.

3. **Environmental conditions.**

The wind turbine must be designed to withstand the weather conditions in the site in which it is intended to be installed.

The standard defines "wind turbine classes" according to wind speed and turbulence. The first classification parameter is the maximum average speed over 10 minutes (the "reference speed):

- ✓ Class I: 50 m/s, i.e. 180 km/h;
- ✓ Class II: 42.5 m/s, i.e. 162 km/h;
- ✓ Class III: 37.5 m/s, i.e. 135 km/h;

A second classification parameter (A, B or C) identifies a wind turbine's ability to withstand the intensity of the wind turbulence while in use.

In addition, the standard requires that extreme wind turbulence is taken into account when designing the machine.

With regard to other environmental parameters, the standard specifies that wind turbines must be designed to operate between -20 and +50°C. It stipulates that the influence of frost, ice or snow and, if applicable, earthquakes, must be taken into consideration in the design. It does not, however, set any thresholds.

4. **Design of the structure**

The standard lays down an obligation to demonstrate the resistance of the structure under various loads using calculations or tests. The loads to take into account are defined by their type (gravity, inertia, influence of wind, etc.) and the machine's situation (transport, assembly, raising, production, maintenance, etc.).

Safety coefficients are defined to take these uncertainties into account. The consequences of material fatigue must be estimated by means of calculations.

5. **Control and protection systems.**
The standard requires functions to control the power supplied, the machine's rotor speed, its alignment to the wind, etc., protection functions against excessive speed, excessive vibration, as well as braking and blade-stop systems.

6. **Mechanical and electrical components.**
Various requirements covering the machine's mechanical and electrical components are laid down, most often in reference to existing standards. These requirements specifically address lightning protection and electromagnetic compatibility (covered by a European directive).

Standard EN 50 308
Wind turbines
Protection measures
Design, operation and maintenance requirements

The version is referenced as Pr EN 50308 and dates from August 2003.

1. **Scope of application.**
It lays down "requirements for protection measures relating to the health and safety of staff, applicable to the commissioning, operation and maintenance of horizontal axis wind turbines".

Its requirements consider mechanical hazards (falls, sliding, etc.), thermal hazards (fire, burns, etc.), electrical hazards and those caused by noise or resulting from a failure to observe the principles of ergonomics.

It refers to almost thirty other standards, including the standards in the EN 292 series (safety of machinery: general principles), which are therefore indirectly brought into line with it.

2. **Safety requirements and protection measures.**
The standard lays down general requirements (all elements must be safe during the wind turbine's lifetime, etc.) and a series of specific requirements covering, for example, access points, evacuation conditions, platforms, raising installations, moving parts, locking devices, noise, emergency stops, disconnecting the power and fire protection.

It also includes requirements relating to the existence and content of manuals to be prepared for the user: a manual describing the safety instructions and emergency procedures, operating manual, maintenance manual.

3. Operation and maintenance requirements.
These requirements cover the training and skills of operating and maintenance personnel, personal protective equipment and safety instructions to be laid down (two people must always be present when an operation is being performed, etc.).

4. Annex

Finally, in accordance with current practices in European standardization, the standard includes an "informative annex" referring to the regulatory requirements that exist in certain member states and which complement the standard's requirements. This annex refers to Germany, Denmark, the United Kingdom, Greece, Italy, the Netherlands and Ireland.

Annexe D: List of people met and/or contacted

List of participants in the environmental and social impact study of the project to build a wind farm in Taiba Ndiaye

Villages: Ndomor, Keur Male, Minam, Mbayéne, Keur Birama, Keur Samba Awa, Keur Mbaye Sénoba

First name	Surname	Profession/job	Tel
Mamadou Lamine	Diop	Ndomor Village Chief	776314850
Cheikh	Ndiaye	Keur Male Village Chief	776305890
Elhadji Ibra	Diop	Minam Village Chief	775782359
Gora	Mbaye	Mbayene Village Chief	764924471
Talla Mbaye	Mbaye	Mbayéne	
Bassirou	Mbaye	Keur Birama Village Chief	773132381
Mor Talla	Diop	Keur Samba Awa Farmer	766928034
Mapathé	Mbaye	Keur Mbaye Retailer	764672368
Daouda	Diop	Mbayéne 3 Retailer	773504114
Cheikh	Niang	Mbayéne Painter	765803192
Alassane	Sonko	Keur Mbaye Sénoba Farmer	766999832
Mor Marème	Diop	Minam Farmer	
Ibrahima	Ndiaye	Keur Male Driver	773761071
Babacar	Ndiaye	Keur Male Driver	773774727
Bacar	Mbaye	Mbayéne Farmer	701028016
Ngouda	Ndao	Keur Mbaye Sénoba Driver	776560589
Mor	Ndao	Keur Mbaye Sénoba Councillor	764689405
Mbaye Sy	Diop	Minam Pupil	763982678
Massyla	Ndao	Mbayéne Councillor	766987169
Ousseynou	Diop	Minam Driver	775124034
Moussa	Ndao	Keur Mbaye Sénoba Farmer	767330350
Bassirou	Mbaye	Keur Birama Joiner	763132381
Ndiaye Samba	Thiam	Keur Male Welder	766669807
Mballo	Niang	Mbayéne Retailer	766865658
Magor	Diop	Minam Farmer	
Djibril	Mbaye	Keur Mbaye Kheury Driver	775659403
Djiby	Mbaye	Keur Mame Mbaye Retailer	766930497
Ousseynou	fall	Keur Mambaye Farmer	762864227
Khady Tine	Tine	Mbayéne GPF, Housekeeper	
Adji	Wade	Mbayéne Housekeeper	

List of participants in the environmental and social impact study of the project to build a wind farm in Taiba Ndiaye

Village of Taiba Mbaye

First name	Surname	Job/occupation	Tel
Abdou	Guéye	ICS official	776120726
Yamar	Sarr	Farmer	775761049

Meïssa	Sarr	777270693
Touba	Touré	763355096
Mor	Sarr	776954523
Mansour	Lô	763456506
Nogaye	Mbaye	
Abdou	Souaré	
Cheikh	Souaré	
Madické	Souaré	
Madiagne	Sarr	705000095
Mathioune	Ndoye	
Bassirou	Diop	777005172
Mbaye	Diop	
Ndiaye	Thiam	766669887
Ibrahima	Guéye	
Bara	Diop	767479188
Serigne	Touré	772753307
Modou Khabane	Léye	775709020
Mor	Mboup	774305643
Bara	Ka	
Mankou	Guéye	
Malick	guéye	
Cheikh Mbaye	Souaré	775985636

List of participants in the environmental and social impact study of the project to build a wind farm in Taiba Ndiaye

Village of Same Ndiaye

First name	Surname	Profession/job	Tel
Elhadji Bathie	Ndaiaye	Village Chief	762944955
Cheikh	Diongue	driver	774415850
Ibra	Diop	Farmer	774432249
Madiambon	Sarr	Farmer	
Alassane	Sarr	Joiner	762987149
Thierno	Sonko	Teacher	765817117

List of participants in the environmental and social impact study of the project to build a wind farm in Taiba Ndiaye

LOCAL ELECTED OFFICIALS OF TAIBA NDIAYE

First name	Surname	Position	Tel
Samba	Sarr	Vice-President of the Rural Council	774404500/774500030
Elhadji Modou	Ndiaye	Chair of the land ownership committee	772145321
Mbaye	Guéye	Member of the land ownership	765989013

		committee	
Assane	Ndiaye	Chair of the finance committee	776391096

List of participants in the environmental and social impact study of the project to build a wind farm in Taiba Ndiaye

VILLAGE OF KEUR ASSANE

First name	Surname	Profession/job	Tel
Balla	Ndiaye	Farmer	76478837
Songo	Ndiaye	Farmer	
Abdoulaye	Ndiaye	Retailer	766660444
Ibou	Diongue	apprentice	
Matar	Diongue	apprentice	
Chiekh	Diongue	tailor	
Mansour	Ndiaye	Driver	
Abdou	Diongue	pupil	
Mamour	Ndiaye	Village Chief	
Mamour	Ndiaye 2	Farmer	
Pape	Sarr	Retailer	
Mbaye	Diongue	Tailor	
Moussa	Ndiaye	apprentice	
Songo	Ndiaye	pupil	

List of participants in the environmental and social impact study of the project to build a wind farm in Taiba Ndiaye

VILLAGE OF KEUR MADIAGNE

First name	Surname	Profession/job	Tel
Songo	Ndiaye	Village Chief	775685306
Ali	Wade	Notable	
Iba	Ndiaye	Notable	
Modou	Gaye	Farmer	
Malick	Wade	Retailer	
Maguéye	Wade	Retailer	
Birane	Ndiaye	Farmer	
Ndiaw	Kane		
Sala	Mbaye		
Pape	Ndiaye		
Ali	Pigue		
Birane	Wade	ASC President	
Samba	Ndiaye		
Gora	Mbaye		
Salla	Mbow	GPF	
Khabane	Ndiaye		

List of participants in the environmental and social impact study of the project to build a wind farm in Taiba Ndiaye

Village of Taiba Santhie

First name	Surname	Occupation-job	Tel
Mbaye	Ndiaye	Teacher	772798187
Daouda	Fall	Farmer	
Oumar	Ndiaye	Farmer	
Abdou G	Ndiaye	Fish and seafood wholesaler	
Mor	Ndiaye	driver	768736109
Massamba	Diop	Farmer	
Malal	Sow	Driver	773053573
Matar Sop	Ndiaye	Village Chief	

List of participants in the environmental and social impact study of the project to build a wind farm in Taiba Ndiaye

Village of Baity Guéye

First name	Surname	Profession/job	Tel
Mbaye	Fall	Imam	764738853
Thierno	Guéye	Farmer	766767216
Iba	Guéye	ASC President	765873303
Nalla	Guéye	Village Chief	774285146
Mbaye	Guéye	Notable	765989013
Yoro	Guèeye	Farmer	
Oumy	Mbacké Guéye	GPF	763362531
Khabane	Guéye	Farmer	767443495

List of participants in the environmental and social impact study of the project to build a wind farm in Taiba Ndiaye

Village of Baity Ndiaye

First name	Surname	Profession/job	Tel
Aliou	Ndaiye	Farmer	
Lamine	Mbaye	Driver	761324438
Ndiaye	Thiam	Farmer	
Daouda	Diop	Farmer	
Mbaye	Guéye	**	
Birane	Guéye	**	

Modou	Lô	**	
Aliou	Fall	driver	773020998
Oumar	Diop	Builder	
Diaga	Badiane	Builder	764935740
Omar	Ndiaye	Farmer	772017760
Asse	Ndiaye	Guardian	773581504
mohamadou	Ndiaye	**	773998809
Mar	Guéye	**	
Talla	Guéye	Guardian	
Massamba	Guèye	Farmer	764776353
Sangué	Ndiaye	**	
Massamba	Dione	Builder	763990455
Fatou	Ndiaye	Farmer	765106716
Anta	Ngom	GPF	768400678
Nogoye	Souaré	GPF	768872962
Khoudia	Samb	GPF	766981778
Nogoye	Diop	GPF	
Madiaye	Ndiaye		
Anta	Ndiaye		
Amar	Ndiaye	Village Chief	765968916

List of participants in the environmental and social impact study of the project to build a wind farm in Taiba Ndiaye

TECHNICAL SERVICES

First name	Surname	Position	Tel
Baba	Weyni	IREF	339511012
Mamadou	Sangharé	DREEC	766481400
DR	Ndoye	IRSV	339511091

Annex E: List of experts that conducted the study

No.	Name and Surname	Structure/Position
1	Al Assane Sene	Coordinator, Geographer - environmental expert
2	Mamadou Diedhiou	Sociologist, Environmental expert
3	Insa Fall	Geologist-environmental biologist
4	Oumar Fall	Hygienist, Environmental expert
5	Idrissa Guiro	Geographer, Cartographer
6	Mouhamed THIOYE	Electromechanical engineer - process expert