

HOPE BEACH WIND FARM PILOT PROJECT

PROJECT SUMMARY

Submitted to Mrs Tashana Redmond, Senior Environmental Officer
Guyana Environmental Protection Agency

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INTRODUCTION

The Hope Beach Wind Farm Project: The planned Wind Farm represents the first substantial utility scale renewable energy project to be implemented in Guyana. The 16.8MW wind farm will generate over 50GWh per year, to be delivered to GPL's grid according to terms of a Power Purchase Agreement and Grid Interconnection Agreement. This wind energy represents some 6% of GPL's projected gross total electricity generation. The Hope Beach wind farm is a pilot project, that will inform all stakeholders on what is required to build and operate a wind farm in Guyana and how to integrate this energy into GPL's grid. The project will confirm the promising performance of wind energy, reduce the reliance on fossil fuels and its associated emissions of CO₂, pollutants, and foreign exchange loss. The wind farm will generate local jobs in construction operation and maintenance of a renewable energy facility.

Project Ownership: The lease, all project rights, assets, and liabilities are owned by Hope Wind Energy Ltd (HWE), which is a wholly owned subsidiary of Hope Energy Development Inc (HED), a project development company owned by a partnership comprising Guyanese, Danish and Trinidadian interests. The Environmental Permit application will be held in the name of Hope Wind Energy Inc (HWE).

Regulatory Compliance: All relevant regulatory, legal, and commercial requirements by the Government of Guyana and its agencies and the Hope Beach wind project are coordinated by an Inter Agency Task Team (IATT) set up by the Ministry of Public Infrastructure, and led by Mrs. Morsha Johnson-Francis, Electricity Regulatory Advisor & Project Coordinator in the Ministry of Public Infrastructure. Regulatory permits and approvals required for the project include:

- EPA: Environmental Permit
- GPL: Grid Interconnection Agreement
- Sea-defence Board Permit (construction near and seaward of the sea-defence)
- National Drainage and Irrigation Approval (construction near NDIA infrastructure)
- Aviation Permit (construction of structures greater than 200ft tall)
- Transport permit for oversize and overweight loads – Chief Roads and Bridge Officer
- Construction permit - NDC and Central Housing & Planning

The project must comply with the Guyana Environmental Protection Act (1998), which states as its purpose: *“To provide for the management, conservation, protection and improvement of the environment, the prevention or control of pollution, the assessment of the impact of economic development on the environment, the sustainable use of natural resources and for matters incidental thereto or connected therewith”*

Environmental compliance outlook (based on studies completed to date or underway): The project has completed or initiated studies by consultants in specific environmental categories identified early in the project as having potential for negative impact, which are: Noise emissions, Shadow-flicker, and Safety off-sets from the nearby Residential areas and the Hope Secondary School. A Bird and Bat biodiversity baseline study has also been initiated in the project area in order to ensure that stakeholder concerns for the potential impact to biodiversity that may be caused by a wind farm are properly addressed. The Bird and Bat biodiversity study will be completed in November, 2018. The project developers and supporting consultants do not foresee any issues with the project meeting both Guyana's environmental requirements, and also the more stringent International Finance Corporation (IFC – a division of the World Bank) environmental guidelines for wind farms.

PROJECT BENEFITS

Green State Development Strategy (GSDS): The development of renewable energy (RE) sources is now clearly endorsed by the Government of the Cooperative Republic of Guyana’s (GOG), driven by the combined imperatives to combat climate change, provide energy security, and to meet rising energy demands together with the development of sustainable growth and competitiveness in the economy. The Government of Guyana (GoG) has ratified the Paris Agreement and adopted the UN Agenda 2030 for Sustainable Development and the Sustainable Development Goals (SDG’s). Guyana’s target contribution is ambitious, stated as 100% renewable energy by 2025. To achieve these goals the Government of Guyana, with aid from the UN, has prepared a “Framework for a Green State Development Strategy and Financial Mechanism” (GSDS Framework), which states:

“The energy transition scenarios over the next 10 years that moves from the current reliance on fossil fuels to one that is based on almost 100% on renewable energy, with an initial focus on facilitating immediate expansion with lower risk projects”

Table 1: Project Fact Sheet: Hope Beach Wind Farm

Likely wind turbine choice	Vestas V150 4MW
Number of wind turbines	4
Tower height (to be finalised)	105 m
Total Wind Farm Capacity (MW)	16.8 MW
Estimated Annual Energy Produced	> 50,000 MWh
% of GPL’s Gross Electricity Generation	6%
Equivalent number of households electricity supply ¹	13000 houses
Tonnes CO2 saved per year ²	33,500 tonnes
Offset GPL fossil fuel consumption	14,500,000 L/yr
Avoided import of HFO fuel ³	6,450,000 USD/yr
Start of Construction	2Q2020
Plant Commissioning	4Q2020
Construction Jobs (9 months period)	30-40 jobs
Permanent Jobs Plant Operation	4 to 6 jobs

Wind Energy Potential, Guyana

Number wind turbines required to supply 60-70% Guyana’s MWh	35-45 4MW wind turbines
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1) Assumes 1,100kWh/yr avg per capita and 3.5 persons/avg household

2) 670 g/kWh Avg OECD Fuel Oil emissions factor per kWh (EIA, 2012)

3) USD 500/tonne CIF price 180 HFO (USD 70/bbl)

Contributing to Guyana’s Green State Development Strategy The project is estimated to replace over 50,000 MWh of GPL’s gross electricity generation from existing fossil-fuel power plants and meet 6% of Guyana’s stated goal in renewable energy (RE) penetration. The project will add substantial momentum to Guyana’s journey towards true energy security based on renewable energy.

Positive Economic Impact: Investment of over USD35million, avoided imports of fuel oil and foreign exchange loss worth over USD 6m per year, reduced exposure to volatile fossil fuel pricing, 30 to 40



construction related jobs, 5 to 10 permanent/part-time technician, security and administrative jobs. RE projects present an ideal opportunity for substantial local ownership of both equity and debt side of the investment for long term investors such as insurance companies and pension funds.

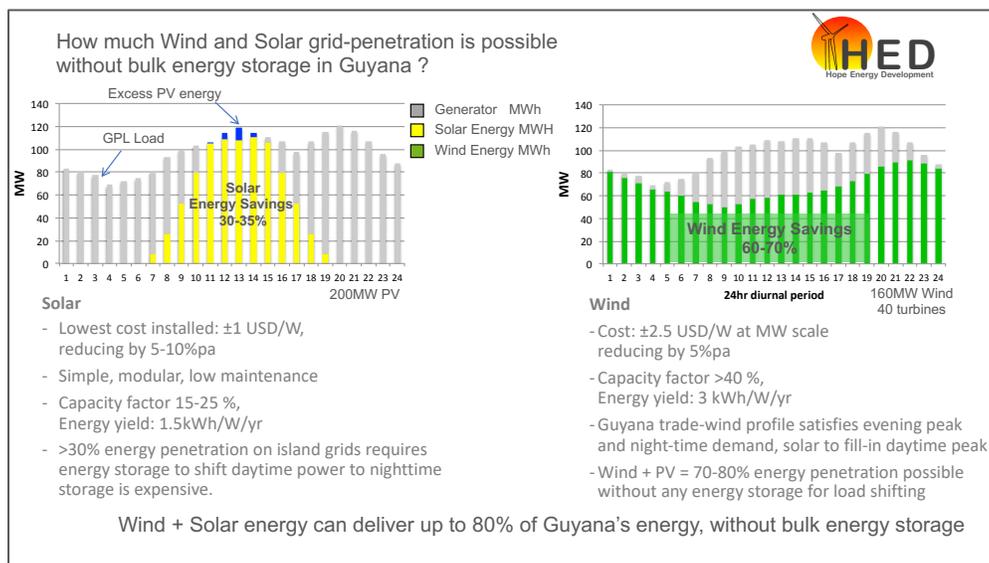
Enhanced Security of the Electrical Grid: Initial grid interconnection study concludes that the Hope Beach Wind Farm will provide reactive-power and voltage support to a weak portion of Guyana’s grid, and have a better chance for the Berbice branch of the grid to operate in islanded mode if the Georgetown portion of the grid is shut-in. As long as the wind is blowing the wind farm will provide much needed additional capacity to the grid. The average wind-speed diurnal profile peaks during the evening hours, which corresponds to the maximum demand on GPL’s grid.

Climate Change and Clean Air: With most of the population in Guyana living 1m below mean high-tide Guyana is highly exposed to the effects of climate change. The project will reduce 6% of GPL’s CO2 footprint from power generation, offsetting some 33,500 tonnes of CO2 per year, and reducing harmful pollutants associated with burning of HFO fuels at GPL’s plants in and near Georgetown.

Pilot Project for Greater Things to Come: The Hope Beach Wind Farm serves as a pilot project and learning opportunity for all the stakeholders involved, which will benefit all future RE projects in Guyana. The project will remove much of the country start-up related uncertainties with regards to developing any wind or larger RE project in Guyana. Based on the project wind data HED estimates that only 40 wind turbines are required in order to provide some 60-70% of Guyana’s energy needs at present. The combination of solar-PV and wind is ideal, with wind peaking during the evening peak demand period, and solar during the midday peak demand period, which could allow some 80% RE penetration levels onto Guyana’s grid without requiring substantial energy storage.

By deploying a few larger RE projects HED believes Guyana’s vision for high levels of RE energy supply can become a reality, and at an affordable cost well below 10c/kWh. This project will be a key stepping stone towards that not too distant future.

With the prospect of electric transportation for both cars and trucks becoming an affordable reality within a similar time-frame, this future vision becomes even more enticing, as it will then also be possible to transition much of Guyana’s transportation needs onto renewable power, with substantial savings to all consumers.



THE PROJECT SITE

The project is located at Hope Beach, on lease A21823, covering an area of 27 acres, some 28km SE of Georgetown centre. The lease is on the seaward side of the existing seawall, North of the plantations: Hope, Douchfour, Two Friends, Anns Grove, Clonbrook and Beehive. The project falls under the jurisdiction of the Grove-Haslington Neighbourhood Democratic Council (NDC). The 50 year lease was awarded on the 9th March 2007 by the President of the Cooperative Republic of Guyana, Mr Bharrat Jagdeo, specifically for industrial purposes: the establishment of a windfarm for electricity generation.



Figure 1. Location of the Hope Beach Wind Farm project site and extent of lease boundaries

The lease is separated from residential areas by a stretch of fallow state-owned agricultural land north of the Demerara-Berbice public road leading up to the seawall. Seaward of the seawall leading up to the lease boundary is a swampy area of Mangrove forest. The Hope Secondary School is situated on the Northern side of the road.

The lease is now dissected by the Hope Canal, and its associated flood control facility. Site access will be via a right of way to the main road on the Western edge of the lease, and an existing access road to the Hope Canal flood control facility.

The site of the wind turbine generators (WTG's) will be on lease block X, a land parcel some 1,280m by 60m along the shoreline, which is the relict Hope Beach ridge, an active sandy beach up till 2008, now covered in grass.

Alternative Configuration includes 2nd site at Chapman's Grove: In considering project configurations and technology choices that could potentially further reduce the environmental impact of the Hope Wind Farm project, private landowners at nearby Chapman's Grove, 2km to the SE of the Hope lease, have indicated an interest to lease land for two wind turbine locations. This second site would then make it possible to reduce the number of wind turbines at the Hope Beach site to just three sites, whilst retaining the commercial viability of project. This "3+2" configuration option is likely to result in the lowest environmental impact to nearby communities. Three turbines at Hope with two at Chapman's Grove allows for longer offsets from nearby residential houses, and an overall lower noise level. The other alternative configuration is for 4 smaller 2.5MW wind turbines at the Hope Beach lease.

Project Sites and Nearby Physical Environments: The entire coastal plain of Guyana landward of the sea-defence wall is highly modified by flood control drainage and agriculture. These fertile lands are

elevated below mean high tide. Drainage and modification of the coastal plain have been in place for over 200 years, and planted with sugar cane and rice. The lands closest to the sea are used mainly for rice farming by private land owners, and in some cases have been converted to coconut plantations and vegetable farming. In the Hope Beach area, landward of the existing Seawall, these modified habitats today comprise: i) Abandoned agricultural lands situated between the seawall and the public road are that were previously farmed for rice, now altered to partially drained fresh water marshlands, ii) Residential developments South and West, of the public road built on drained lands that were previously part of agricultural plantations, and iii) Extensive active farmlands landward of the residential areas (Figure 2).

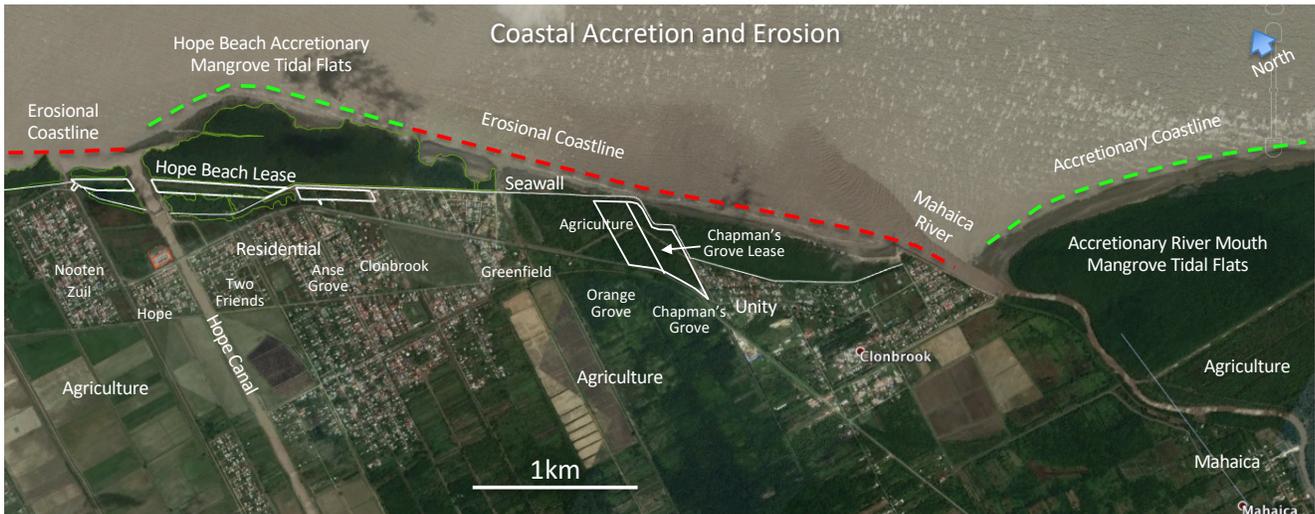


Figure 2. Photomosaic of the nearby coastal region highlighting stretches of coastal erosion and accretion

On the Seaward side of the Seawall at Hope Beach are partially modified natural habitats: iv) Permanently flooded mangrove swamp of limited areal extent, now dissected by the Hope Canal; v) a Relict beach ridge elevated some 30-50cm above the high-tide mark which is now a 50 to 70m wide grass and shrub covered strip running parallel to the shoreline, that comprises most of the lease area, and which was Hope Beach up till 2008; and vi) a wide expanse of tidal flats covered by closely spaced mangrove saplings up to 15-20m tall, which have rapidly accreted on the seaward side of the lease since 2008, which ended the erosional beach forming processes at Hope Beach (Figure 3 and 4).



Figure 3. View of Lease Block – X, towards NW, illustrating location of wind turbines and habitats. Wind meter mast in foreground.

The Chapman’s Grove (ChG) site is agricultural land now under coconut palm plantation, right up to the existing seawall. Immediately outboard of the seawall is an area of active coastal erosion. Southeast of the site, and outboard of the seawall, is an intertidal mangrove strip some 250m wide and 1,300m long, outboard of the Unity community, leading to the mouth of the Mahaica River. Inland and downwind of the Chapman’s Grove site are extensive agricultural lands

Cycles of rapid accretion and erosion of transient mangrove mud-flats are a common feature of the entire coastline from the mouth of the Amazon River to the Orinoco River. Such 10-to-30 year accretion-erosion cycles are related to the migration of large marine mud-banks along the inner Guyana’s shelf, and are well documented off the coast of French Guyana and Suriname in scientific literature, as summarised in a recent review paper by Anthony et. Al. (2010)¹.

Coastal erosion has now commenced immediately West of the recently constructed Hope Canal, affecting the part of the lease where the planned substation and WTG-1 will be located. A broad stretch 400m East of Block Y to the mouth of the Mahaica River, which includes the Chapman’s Grove lease, has also recently entered an erosional phase (Figure 2, pers. comm. Mr K.Ahamad, Sea Defence Chief Officer).

The Sea Defence agency is now considering straightening the alignment of the old sea-defence wall, by extending the recently constructed armoured midden off Block Y towards the West to join up with the newly constructed mouth of the Hope Canal. This would place the new sea-defence outboard of the planned wind turbines at Hope Beach.

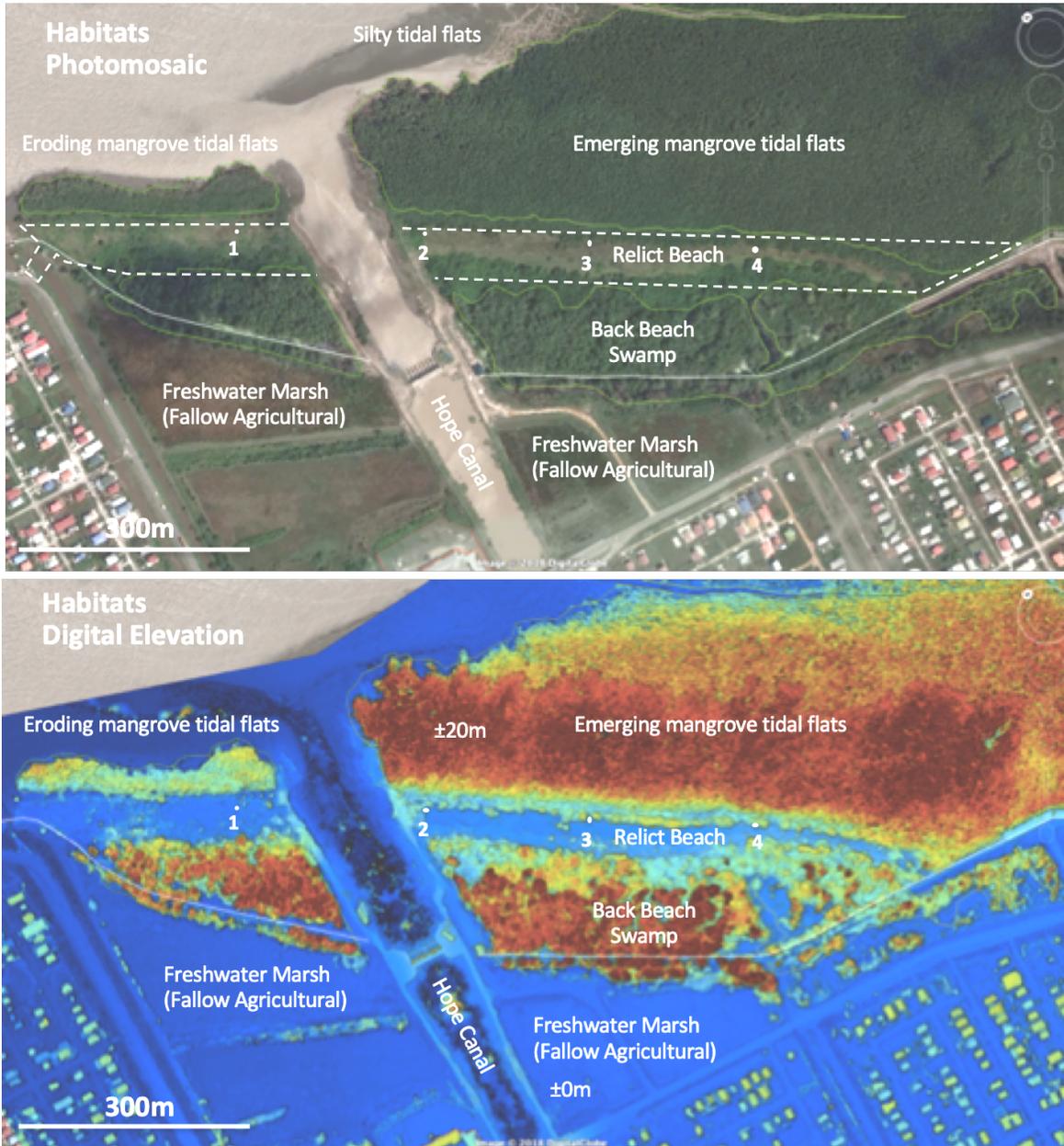


Figure 4a (top) a photomosaic, and 4b (bottom) a digital elevation image, of the Hope Beach lease area illustrating the various habitats in the nearby vicinity

Land Use: As described previously, the coastal area in the vicinity of the lease has traditionally been used for agriculture. Residential areas are now expanding along the Demerara-Berbice public road. In the immediate vicinity of the lease is an active fishing community which use of the dredge channels on the seaward side of flood facilities for mooring their boats, taking on supplies and offloading fish.

Recent Mangrove Flats Accretion



Figure 5. Photomosaic images illustrating historical changes in coastal morphology near the Hope Beach lease area. Before 2008 this was an erosional sandy-beach coastline, with rapid accretion of mangrove tidal-flats since 2008.

The mangrove swamp at Hope Beach and more recent mangrove tidal flats are difficult to access due to the soft muddy and flooded terrain and is used by local residents for harvesting wood and some local hunting. The Lease area itself was up till recently an erosional beach frequented by residents, but is now a relict feature as a result of recent mangrove accretion. No historical cultural resources are known in the recently formed landscape in the immediate vicinity of the lease.

The Chapman’s Grove site comprises agricultural land under coconut plantation owned by the land owners. An unofficial cremation site is used on occasion on the seaward side of the seawall along the Eastern edge of the site.

The sites are not within or near any designated wildlife reserve or national park. 2km to the SE of the Chapman’s Grove site is the mouth of the Mahaica River, which has an expansive and long-lived mangrove swamp along its Eastern bank at the river mouth (Woodlands). The river itself has a narrow green corridor with natural vegetation some 100 to 130m wide which stretches almost 20km inland within the agricultural landscape of the flat coastal plain. The river is host to eco-tourism via boat tour operators.

4. PROJECT DESIGN, PARAMETERS & SIZE

4.1. Wind Farm Configuration

Base-case Option A: The wind farm will consist of four (4) Vestas V150 4.2MW wind turbine generators (WTG's), for a total capacity of 16.8MW. Buried 34KV electrical lines connect the WTG's to a small substation at the Western end of the lease, and an overhead 950m long 69KV electrical feeder line will interconnect the wind farm to GPL's 69KV transmission line.

Alternative Configurations: In line with considering alternative configurations and technology options, the project is also considering:

Option B: Smaller wind turbine option: Four Goldwind G109 2.5MW machines at Hope Beach

Option C: 3+2 – Three Vestas V150 at Hope Beach plus 2 Vestas V150 at Chapman's Grove. The substation will still be at Hope Beach, as before, with a 33KV collector overhead line run along the base of the sea-defence wall from Chapman's Grove to Hope Beach.

Wind Turbine Selection - Base-case Option A: The Vestas wind turbines incorporate state-of-the-art technology from one of the most experienced and the largest of the leading wind turbine equipment manufacturer's in the world, based in Denmark. The V150 4MW models are the second largest units Vestas produce for onshore generation, scheduled for 1Q2020 release, and are based on the tried and



Figure 6. Wind turbine and electrical infrastructure configuration, and resulting maximum noise emission contours.

tested 4MW platform which has over 7,000 units installed worldwide. The IEC Class III WTG's are specifically designed for high efficiency operation in low wind conditions, which is a requirement in Guyana's trade wind belt. The V150 4MW WTG is designed for integration with grids having poor electrical quality, typical of small grids, and grids in the developing world. The grid integration feasibility study performed by GPL concluded that the project will help improve stability of the electrical grid. The V150 also has the latest in aerofoil design technology for efficient energy harvest with very low noise emissions. Low noise is achieved by operating the large diameter rotors at low rotational speeds (5-12rpm), and improved aerodynamic design that includes serrated trailing edge technology which mimics the low noise wing design of quiet-flying birds such as owls. The result is higher energy production, yet noise emissions that are as low, or lower in many



instances, than older 2 MW WTG models. It is also possible to operate the rotors in low-noise mode to reduce noise emissions by an additional 1.5 to 5 dBA using pitch control technology. Noise emissions modelling by the wind engineering consultants indicated that low-noise mode operation will not be required at this site.

Economies of scale is important for wind farm economics, larger machines and larger projects result in lower costs per unit capacity. Smaller units were also modelled, but given the limited size of the site, the V150 was the only model capable of meeting all of the EPA’s and IFC’s environmental and safety criteria whilst also meeting minimum investment hurdles at a PPA pricing below GPL’s stated price ceiling.

Option B: 4 x Goldwind G109 2.5MW: Goldwind is the third largest wind turbine manufacturer worldwide, and the only manufacturer from China providing machines certified for international use, with over 20 years experience and over 10,000 wind turbines installed. Goldwind produces technologically advanced machines using “direct drive” technology, meaning there is no gearbox, and a full conversion power converter ensures the variable speed rotor produces power with the correct frequency and voltage to tie in to the GPL grid. The 2.5MW machine is a smaller class of wind turbine, with 109 diameter rotor and 90m hub height. The reference noise limit with serrated blades is 106dBA, similar though slightly louder, than the Vestas V150. The Goldwind G109 also has noise reduction and serrated blade options.

Such full-conversion technology is common to both wind turbine options, and is ideal technology for integrating with the electric grid, with capability to provide grid support and stabilisation even in weak grids with unstable frequency and voltage issues, which is highly relevant for Guyana. Although these are smaller wind turbines, their reference noise emission is very similar, even slightly higher than the louder V150 units.

2 Wind Turbine Options:

Manufacturer	Vestas	Goldwind
Model	V150 4.2MW	G109 2.5MW
Tower/hub height	105 m	90 m
Rotor diameter	150 m	109 m
Reference noise	104.9 dBA	106 dBA
Wind farm capacity	16 MW	10 MW
% of GPL’s generation	7.5%	4.2%
# Homes supplied*	13,500	7,600

* 1.1 kwh/p/day, 3.5 persons/avg household



- # 1 wind turbine supplier in the world for past 40yrs
- 57,000 units, 100GW capacity installed, 1/5th of all wind turbines are Vestas machines
- Supply, Transport, Install, Maintain
- Based in Denmark
- # 3 wind turbine supplier in the world, 20 yr record
- 10,000 units installed, only Chinese supplier with internationally certified machines
- Supply + Maintain
- Based in China

Option C: 3+2 x Vestas V150 4.2MW: The only other way to further mitigate the environmental and community impact at Hope Beach is to reduce the number of wind turbines at this site to three units, and in order to maintain the commercial viability of the project, to locate two wind turbines at an alternative location. The private landowners Chapman’s Grove, 2km to the SE , have indicated they are

interested in hosting a portion of the Hope Wind farm and related access roads, infrastructure and lay-down areas.

Wind Engineering: The wind farm design was completed by EMD International (EMD), a wind engineering company based in Denmark, considered to be one of the top wind engineering consultancies in the world (www.emd.dk). Vestas and Siemens-Gamesa engineering teams worked the same wind data to come up with their own independent assessment. All three wind engineering teams spent considerable effort to assure themselves and recommend to the investors that four large machines could be located on this site, and still meet all the required criteria for safety, environmental impacts, equipment longevity and performance limitations. The collected wind data and regional long-term wind models indicate a very narrow azimuth range for the incoming trade winds. This allows for close spacing of the WTG’s without creating undue stress on WTG’s due to wind turbulence from upwind machines. Vestas also have the long-term operations and maintenance contract for the wind farm which is tied to a minimum wind farm availability warranty. It is very much in their interest to make sure the wind farm design is within acceptable technical limits for the life of the plant.

4.2. Wind Farm Parameters

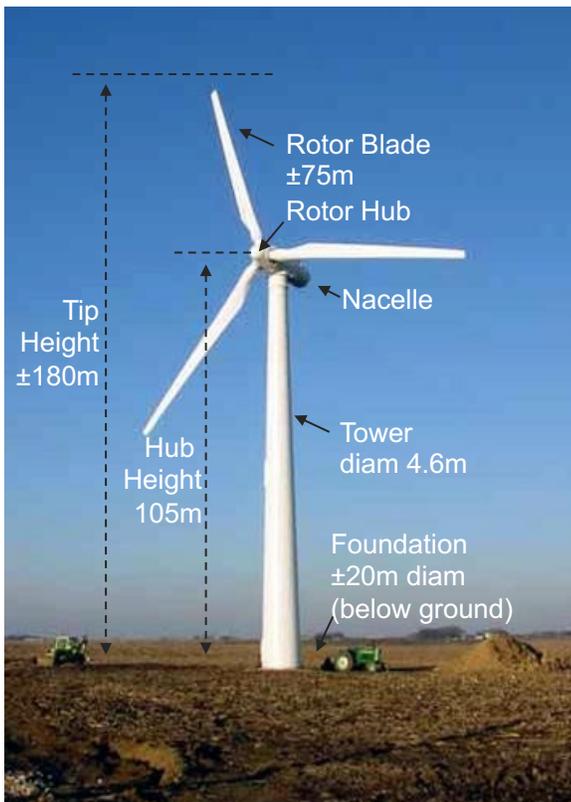


Figure 7. Image of a generic wind turbine used here to illustrate the key components, and the dimensions relevant to the V150 model

Height and Rotor Diameter: Each individual WTG has a rotor hub height of 105 to 120m tall . Three blades are attached to a central hub, each blade is 75m long, and the rotor diameter is 150m. Maximum height of the rotor tip will be 180 to 195m above ground level.

Foundation and ground footprint: The steel tower has a diameter of 4.6m at its base. A reinforced concrete foundation of approximately 20m diameter and 1 to 2m thick is located below ground level, poured on top of 20 to 30m deep pre-stressed concrete piles. This means that the only visible footprint at ground-level is the 4.6m diameter tower base.

Nacelle and Tower: The nacelle located at the top of the tower houses the drive-train, gearbox, generator, power converter and electrical kit. Its dimensions are 4.2m wide, 12.8m long, and 3.5m tall. The entire nacelle swivels (or ‘yaws’) on top of the tower together with the rotor to always face into the wind direction, a movement controlled by a yaw motor. Access to the nacelle is via a ladder of elevator in the hollow steel tower. The low/medium voltage transformer and electrical switchgear is located in the base of the tower. The tower is accessed via a steel door, which is locked.



Wind Turbine Spacing: The distance between HB1 and HB4 is approximately 690 meters. The four wind turbines are spaced some 220 to 240m apart. This spacing is equivalent to 1.5 – 1.6 times the 150m diameter of the rotor, which is considered a tight spacing. Closely spaced wind turbines will experience wake turbulence from the upwind turbines when the wind blows from the SE or NW quadrants. During such wind conditions alternate wind turbines will then need to be shut-in (curtailed) in order to avoid any structural fatigue and long-term equipment damage, a practice known as Wind Sector Management (WSM). Such tight spacing is possible at the Hope Beach site because the wind direction is strongly unidirectional, with most wind energy from a very narrow NE to ESE azimuth range. After extensive review of wind data, the Vestas and EMD wind engineers agree that WSM related curtailment losses will be minimal.

HB2 will be located a safe distance from the Eastern bank of the Hope Canal, its precise location will be determined during the detailed design phase as guided by a qualified structural engineer to ensure that no structural instability is caused to the bank of the canal.

The substation is located at the Western end of the lease, approximately 150m West of HB1, and more than 50m from the nearby drainage canal. The substation will require a footprint of approximately 25m by 30m. The medium voltage collector electrical line that brings power from the WTG's to the substation will be buried, except for the 100m section where it crosses the Hope Canal, which will be via an overhead line suspended off 20 to 27m tall electrical poles.

Offset Distances From Residential and School Buildings: IFC guidelines require a safety offset distance of 1.5 times the maximum height of the wind turbine (tip height) from any residential dwelling. The tip height of the V150 with a 105m tower is $105 + 75 = 180\text{m}$, so minimum offset distance is 270m. For a taller tower option with 120m hub-height, the minimum offset distance is 292m to the nearest residence. The safety distances are greater than the maximum height of the WTG in case a blade breaks off and is thrown by the spinning motion of the rotor. This is a highly unusual type of malfunction.

The wind turbines closest to residential houses are HB1 at the NW end of the lease, and HB4 in the SE. HB1 is located 293m from the nearest residence (Figure 5a). HB4 in the SE is located 270m from informal temporary concessionary-stand structures within the road reserve, and 293m from the nearest residential building (Figure 5b). HB2 is the WTG closest to the Hope Secondary School, at a distance of 430m, which is some 140m more than IFC's minimum guideline.

All Wind turbine locations meet the minimum stand-off distance from residential and school buildings as per the IFC guidelines for the 105m hub height option, and 120m tall hub-heights with the exception of HB4 which would require the informal concessionary structures within the road reserve to be relocated.

The IFC's height related guideline for safety offset is suitable as a first pass safety offset approximation. In order to confirm the validity of the safety offset distance, MMI Thornton Tomasetti, a consultancy specializing in the assessment of manmade and natural risk, will be undertaking a quantitative risk analysis of the safety offset distances from the wind turbines to nearby residencies and the road. This analysis will take into account the particular wind turbines under consideration, their location, and the

wind regime at Hope Beach, and will follow the methodology developed for the UK government’s HSE Executive.

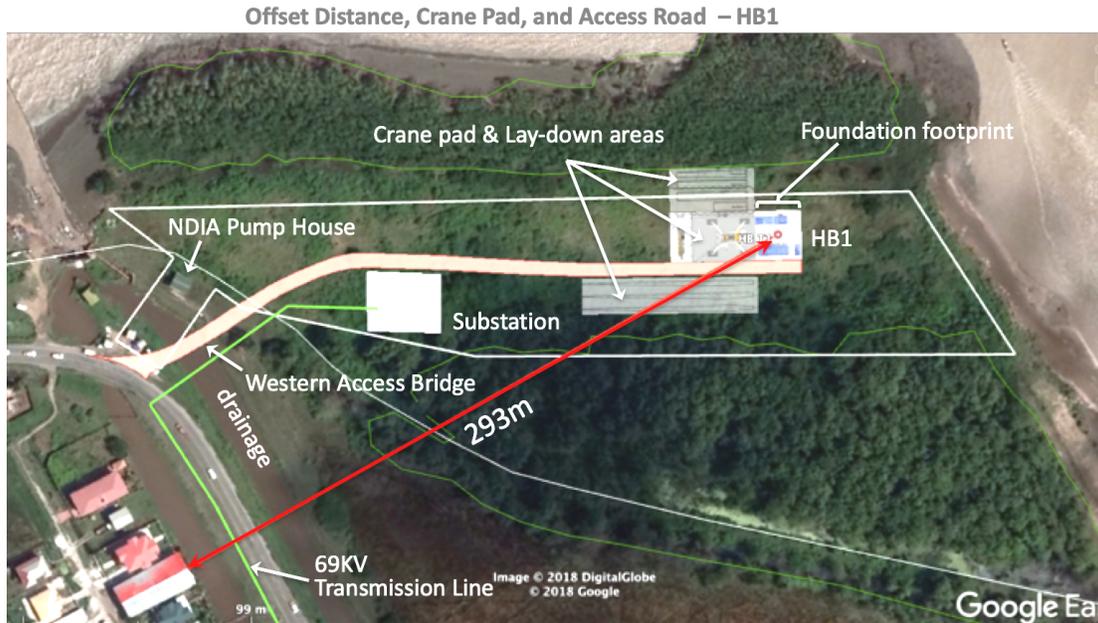


Figure 8a (top) and 8b (bottom) illustrating minimum safety offsets to nearby residential and school buildings, Crane Pad and equipment laydown areas, and road access options.

Option 2: 3+2 V150 configuration: Results in only three wind turbines at Hope Beach, and two at Chapman’s Grove. The Hope Beach machines will have greater than 325m offsets, and 310m offsets at

Lowest Environmental Impact Option



- Fewer wind turbines at hope beach + greater distance from houses =
- lower noise and greater safety offset.

- Even longer offset from houses
- Only agricultural lands downwind of turbines

Figure 9. Layout of wind turbines for the 3+2 configuration option, with three wind turbines at Hope Beach, and another 2 wind turbines at Chapman’s Grove, which results in longer offset distances at Hope. The Chapman’s Grove location is on private land, and favourably located away from the Unity community, with agricultural coconut plantations downwind of the wind turbines.

Chapman’s Grove. The downwind area in Chapman’s grove is open agricultural lands, covered in coconut palms, with the nearest residence building 520m downwind, well outside the impact of any wind turbine for noise or safety considerations.

Crane Pads and Equipment Lay-Down Areas: During the wind farm construction phase the wind turbine components are transported onto the site and will require lay-down areas. Logistically the most efficient means to do this is to have all the equipment required for each wind turbine laid down within reach of the main installation crane at each WTG location. The Crane Pad itself is an area of approximately 40m by 20m comprising a built-up and compacted substrate to provide a stable base for the large installation crane and its loads.

Preliminary Crane Pad and Equipment Lay-Down Configuration

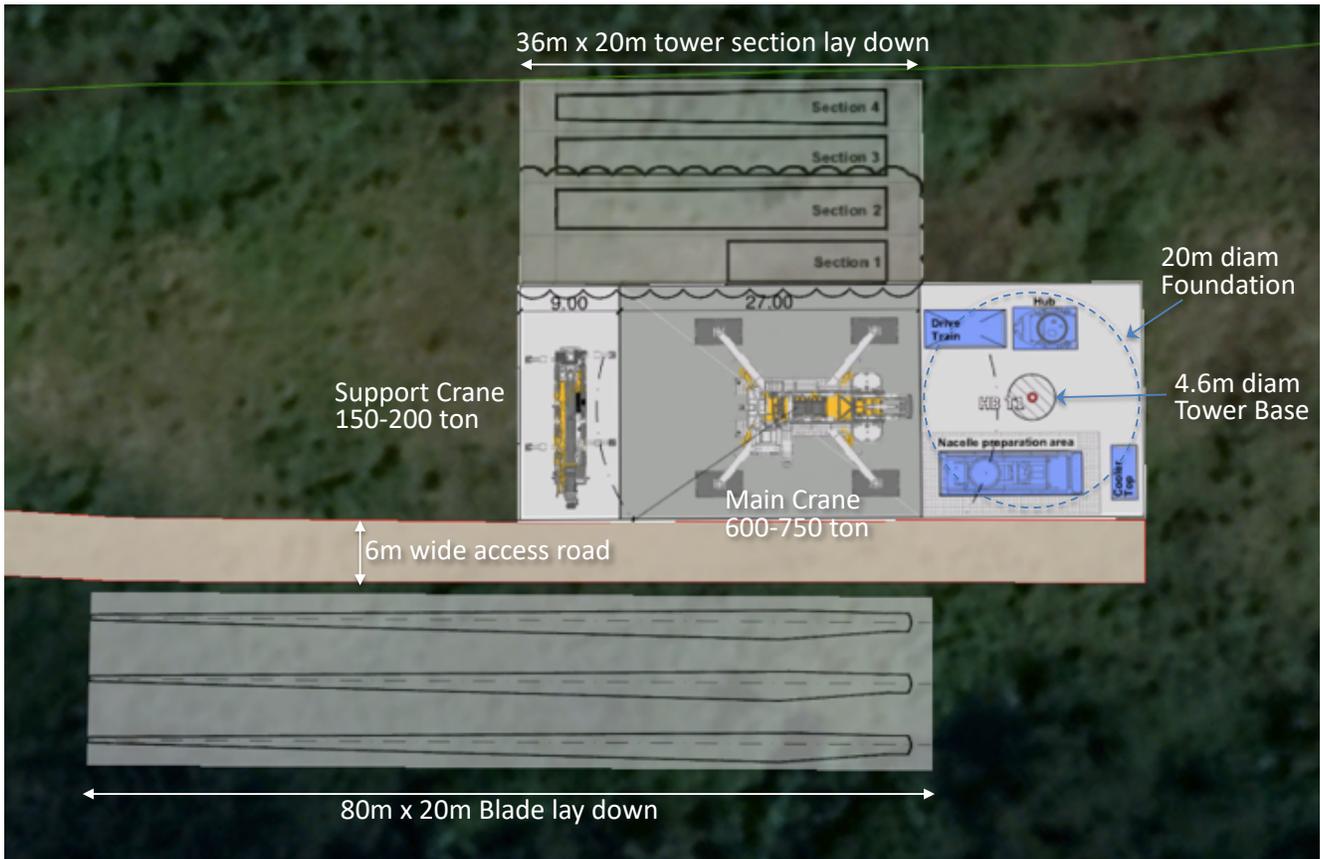


Figure 10. Preliminary crane-pad and equipment lay-down areas at each wind turbine construction site

Site Access Road West of Hope Canal: Access roads must be capable of supporting the heavy loads, and also have wide turn radii to accommodate the extender trailers carrying the long rotor blades. The access road is typically 6m wide. Between the turbine construction sites the access road can be 7m to 11m wide depending on what type of crane is selected.

The lease area to the West of the Hope Canal, which contains the substation and the HB1 wind turbine, will be accessed from the originally intended access point on the Western end of the lease, via a planned bridge across the 15m wide drainage canal, leading straight off the main road (Figure 7a). HED is coordinating efforts with NDIA in order to make sure the location of bridge and road will be designed to also accommodate with their planned location of a new pump house. The present temporary pump house is located in the middle of the lease right-of-way.

Site Access Road East of Hope Canal: Access to HB2, HB3 and HB4 is complicated by the recently constructed Hope Canal cutting through the middle of the lease. Figure 7b illustrates the two options under consideration. Both options make use of NDIA’s existing access road where it starts at the main road. Option 1 follows this existing access road to the flood-gate facility, then extends north to the site along the base of the canal dam midden. Most of the existing access road will require upgrading in

order to accommodate the heavy loads. Option 2 is a more direct route, passing through the back-beach swamp habitat. Option-2 is NDIA’s preferred option.

Site Access Chapman’s Grove Site Option:

Site access at Chapman’s Grove would be directly from the Main road onto private land covered by coconut plantations. Two options are being considered: Option 1, onto Lot 3 of Chapman’s Grove, with bridges to cross two drainage canals, and subsequently following the access road along the sea-defence wall. Option 2 follows the boundary between Orange Grove and Chapman’s grove, and then along the seawall access road to the sites further East. The private land owners are considering which option they would consider to be the most suitable. Initial discussions with the head of the sea-defence board indicates this would be possible, and that the resulting upgraded road would be of benefit to the Sea Defence efforts to access this stretch of seawall.



Figure 11. Site access options, equipment laydown areas, foundations and crane pad areas at Chapman's Grove.

5. NON-TECHNICAL PROJECT OVERVIEW

5.1 Wind Energy Introduction

The four key components of a wind farm:

- 1) A spinning generator is driven by wind acting on a large rotor, and in this way converts wind energy into electrical energy. The larger the diameter of the rotor, and the stronger the wind, the more power that is generated by the wind turbine generator (WTG).
- 2) A transformer at each WTG increases the voltage for transmission to the wind farm electrical substation. This medium voltage power is collected from each WTG via a collector network of medium voltage cables, usually buried.
- 3) The wind farm substation collects the power from all WTG's in the wind farm, converts the power to high voltage electricity suitable for feeding onto the national power grid, and meters how much electricity is generated.
- 4) The utility company purchases the electricity at a wholesale price, distributes and sells the power in turn to its customers at a retail price determined by cost of generation, grid maintenance, overhead costs and profit margin of the utility company.

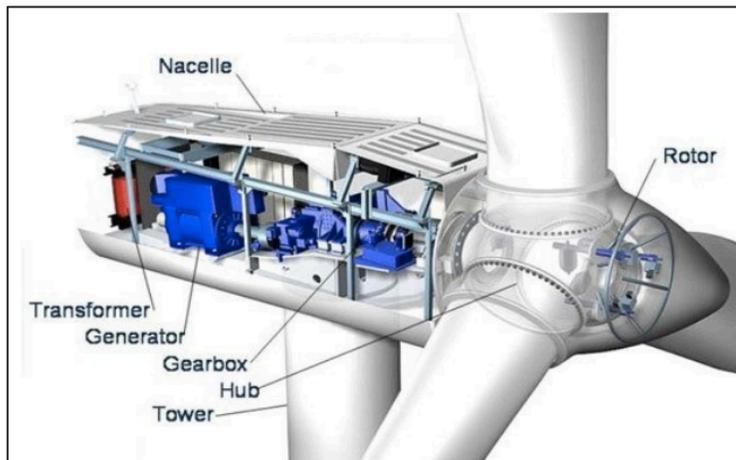
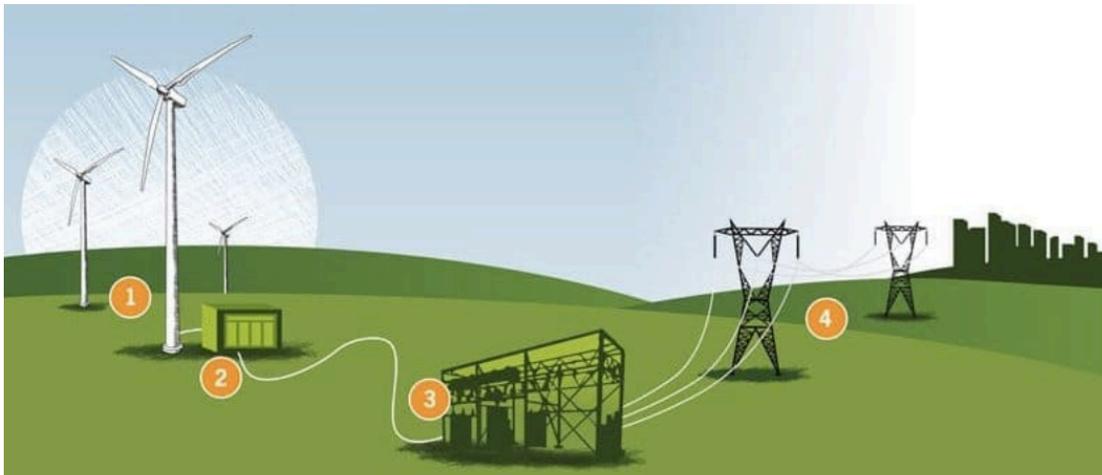


Figure 12a (top) and 12b (lower right) illustrating the major components of a wind farm, and main drivetrain and electrical components contained in the WTG nacelle located on top of the tower..



Wind Power is Intermittent: Similar to solar energy, wind energy is intermittent, generating power according to how strong the wind blows. There are times when the wind is not blowing at all, and no power is generated. Such low power periods must be compensated for by the utility using alternative generation sources. In effect, renewable energy can thus be viewed as an opportunity to replace the fuel burden of traditional fossil fuel generation plants.

Trade Winds are Consistent: Although the average wind speed on the coast of Guyana is considered to be low to moderate, it is very consistent. As all Guyanese know, the trade winds blow night and day, all year round, dominantly from the same direction. This is an ideal characteristic for integrating large amounts of wind power into the grid and managing the intermittency. In particular, the wind peaks during the early night, coinciding with the peak demand on GPL's grid. The amount of time that the wind is too weak to generate power is less than 5%. The lowest wind supply is late morning to midday, when the sun is strongest. The combination of wind and solar energy in Guyana is highly complementary, and holds the promise of very high penetration of renewable energy onto Guyana's grid in the not too distant future.

Economies of Scale are Key for Low Cost Wind Energy:

Wind turbine scale: Wind turbine models are increasing in size with successive models. The driver for this is that winds are stronger stronger and less turbulent at higher elevations. The relationship between how much power is generated and wind speed is exponential, related to the cube of the wind speed (V^3). Also, the amount of energy harvested is related to the area swept by the rotor blades. A small increase in the diameter of the rotor has an exponential increase in swept area, and therefore the amount of energy harvested. Taller wind turbines with larger rotors therefore harvest substantially more energy per unit steel, concrete, and effort used to install each unit. This trend in larger wind turbines has reduced the cost of wind energy to levels where it is now economically viable to install wind turbines even in areas with low wind speeds, such as Guyana.

Wind farm scale: Wind farm projects are impacted by a considerable amount of fixed costs, especially when constructing a wind farm in a new remote location which does not have the specialised transport and crane equipment easily available. Whether this imported equipment installs just one turbine or 10 turbines, the cost of importing it is the same. Other fixed costs includes the costs incurred during the project development phase, financing, shipping, access roads, amongst others. A wind farm can consist of anything from a single wind turbine, to hundreds of wind turbines covering many square kilometres of terrain. Such large wind farms located in good wind regions are today competing on cost without subsidies against low cost coal and nuclear power plants in large power markets around the world (Irena, 2018). A typical small wind farm usually consists of 3 to 10 WTG's, with total output capacity in the 15 to 30MW range.

The small scale of this pilot wind farm, and the low to moderate wind energy setting in Guyana, necessitates using the large low wind-turbines developed by leading wind turbine equipment manufacturers over the past few years. Deployment of such large machines is the key to unlocking a future with substantial amounts of low-cost renewable energy feeding into Guyana's grid.



5.2. Wind Project Development Phases

Typical of project development phases in many industries, a wind farm project can be divided into five (5) distinct phases of development:

1) Feasibility Stage – Collecting wind data and information to determine whether project is technically feasible, commercially viable, likely to pass regulatory hurdles, securing the power purchase agreement and land rights. Typical studies at this stage include: wind resource assessment, wind engineering, selection from design options, initial environmental assessments, grid interconnection, logistics study, geotechnical sense check, regulatory compliance screening. Typical timeline is 18 to 24 months. The Hope Beach Wind Farm project is in the advanced feasibility phase. This stage culminates with a Feasibility Stage Gate, with a decision on whether the project has sufficient merit to proceed to the next stage.

2) Detailed Design Phase – Preliminary plans from the feasibility stage are converted to detailed designs by contracted engineering consultancies, procurement of equipment and services for the construction phase, detailed logistics planning, completion of regulatory permitting, environmental studies if required, and raising required financing and investor capital. Typical timeline is 4 to 12 months, but may be longer in some jurisdictions where regulatory and legal hurdles are considerable. This stage culminates with a Final Investment Decision Stage Gate, with a decision by investors on whether the project has sufficient merit to proceed to the Construction Phase.

3) Construction Phase – Long lead orders are placed for the wind turbine equipment and select electrical equipment, such as the substation transformer. Wind turbine equipment lead times are typically 6 to 12 months till delivery. Whilst waiting on wind turbine equipment the project completes the electrical and civil works. Civil works entails the construction of the site access roads, the wind turbine foundations. Electrical works entails laying of buried medium voltage collector cables, construction of the substation, and high-voltage transmission line to interconnect with the grid. When the wind turbine equipment ships the crane and specialised transport equipment is also mobilized. It usually takes 3 to 4 days to install a single wind turbine once the crane and equipment are on site. Typical construction timeframe for a small wind project is 6 to 12 months, depending on equipment lead times. During the Construction Phase all activities are in accordance with relevant Regulatory Permit requirements, including adherence to the Environmental and Social Management Plan. The Construction Phase ends when the installed equipment has passed all commissioning tests and relevant inspections, and the project is commissioned.

4) Operate Phase – The wind farm is set into operation, generating and selling renewable energy onto the grid in accordance with contractual agreements. The operator maintains the site, and contracts relevant services to monitor and maintain the equipment of the wind farm. Operation of a wind farm is considerably simpler than that of a fossil fuel power plant, as there are almost no consumables, and maintenance requirements are much lower. The Environmental and Social Management Plan will guide monitoring and reporting activities for the life of the plant, which is typically in excess of 20 years for a wind farm.

5) Wind Farm Repowering and Decommissioning Phases – The Hope Beach Wind Farm lease is a 50 year lease with option to renew. Wind turbines have a minimum design life of 20 years, and typically



will keep functioning for 25 to 30 years without requiring any major upgrades. The draft PPA is for 20 years with an allowance to extend or renew the contract for an additional term. Electrical substations typically have a technical life of more than 30 years. Once the initial WTG’s reach the end of their functional life, the typical route is to then renew/extend the PPA offtake agreement, and then to either upgrade specific equipment in the existing wind turbines in order to provide another 20 year operational phase, or to completely upgrade all the equipment by replacing the entire wind turbine structure to more modern designs. It is our expectation that this site will remain a wind farm generation facility in the foreseeable future. Should it be decided to cease using the site as a wind farm, then the crane and transport equipment would return to the site, disassemble all the wind turbines down to foundation level, and remove all the equipment to be scrapped or to be refurbished. At that point it can be decided whether the site should be returned to its original state, in which case the roads and crane pads would be removed. The foundations are already below grade and would most likely be abandoned in place. The commercial plan for the wind farm includes funds in year 25 to decommission the wind farm, if required.

5.3. Project Schedule

Wind Farm commissioning is scheduled for early 2020. Submission of this Project Summary occurs in in project week 32, and project delivery is approaching the end of the Feasibility Phase, with the PPA Stage Gate planned for early 1Q2019.

The subsequent Detailed Design Phase requires some 4 to 5 months to complete. Regulatory approval processes commence during the Feasibility Stage and must all be completed during the Detailed Design Phase and the Financial Close Stage Gate in order for the project to proceed.

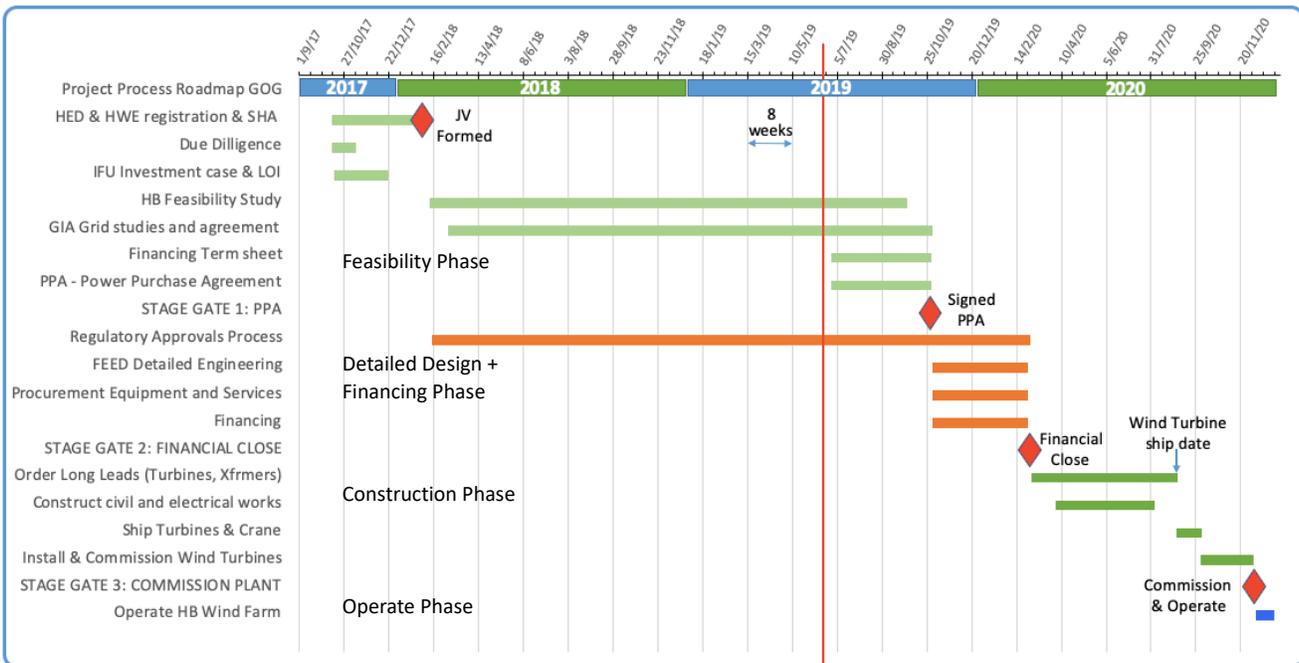


Figure 13. Project Gant Chart 2Q2019



During the present Feasibility Phase the project HED initiated various studies associated with environmental compliance, including:

- Background noise survey at nearby residential houses and the school (completed)
- Noise emissions analysis (completed)
- Shadow flicker analysis (completed)
- Locations of WTG's to comply with minimum safety offsets
- Biodiversity Baseline Study for Birds and Bats (due for completion in November 2018)

5.4. Overview of Wind Farm Construction Phase Activity

5.4.1. Construction of Civil and Electrical Works

Activities during the construction of the civil works are typical of any industrial construction site. Transport of prefabricated concrete piles, steel reinforcement bars, and concrete. The site will have the temporary amenities typical of any construction site, such as a mobile site office, portable bathroom facilities, lay-down areas, a portable field workshop, security, portable generator/s and fuel depot, etc. Preliminary estimate of the time required to complete this set of activities is three (3) to six (6) months. The civil and electrical works occur during the long-lead waiting period required for delivery of the wind turbines.

- **Access roads:** The first activities during the construction phase is the construction of 6m wide access roads from the National Road to each WTG site. This will entail grubbing (removal of organic rich top-soils) of the top 0.3 to 0.6m of substrate, build-up of some 0.6 to 1.0m of compacted construction sand, followed by 0.3 to 0.5m of compacted silty sand, and finally a layer of graded and compacted aggregate of some 0.15 to 0.3m thick. Any excavated material will be trucked off site and deposited at an approved location. All sands and aggregates will be trucked to the site using the national road network. A total of some 1.3km of 6m wide access roadway is planned (Figure 7b).

1 km of this access road runs parallel to the shoreline along the relict beach ridge. A preliminary geotechnical survey (2009) describes the substrate as a 1 to 5m thick layer of firm to stiff silty clays. It may be possible to reduce the amount of imported sand for this relict beach ridge section by making use of compacted in-situ substrate – to be confirmed by further geotechnical sampling. The existing NDIA access road is built up on top of unconsolidated, flood-land clays underlain by the thick unconsolidated Demerara Clay formation. This section of road will likely require build-up of additional compacted sand and aggregate in order to meet the load requirements for the wind farm.

- **Access Bridge:** The Western portion of the lease will be accessed via a bridge connecting the lease to the main road which crosses a 15m wide local drainage canal (Figure 7a). The project will be advised by NDIA and local civil engineers as to the requirements for minimum spans in order to ensure proper functioning of the drainage canal. The bridge design will likely entail the installation of deep pre-stressed concrete piles as the vertical supports between spans. Prefabricated concrete beams will then span the canal.

- **Wind Turbine Foundations:** The 2009 preliminary geotechnical borings confirmed some 20 to 30m thickness of the unconsolidated and weak Demerara Clays at the site. Typical of the Guyana coastal plain, this is underlain by a transition zone to the firmer, mottled silty clays of the Coropina Formation. The wind turbine foundation will require piles to this firmer level in order to support the weight and dynamic loads expected. The top of the piles will be linked by a reinforced concrete raft foundation some 20m in diameter, varying from some 1m at the outer edge, to over 2m thick at the centre. The concrete raft will contain the steel anchor tube at the centre, which is what the base of the steel tower will be connected to. Electrical ducting and the electrical grounding system will be installed in coordination with construction of the foundation. Civil works are expected to be undertaken by local contractors supervised by civil engineering consultants experienced in wind turbine foundation design and construction, and in compliance with codes relevant to International standards and Guyana.
- **Crane Pads and Lay-down areas:** Similar to the access roads, the crane pad will require grubbing, infill and build-up of a compacted sand and aggregate substrate. The Crane pad is an area of some 120m² which requires a thicker base, and possibly requires a reinforced cast concrete slab at its base. The lay-down areas for each WTG site covers approximately 2,000m² (0.5ac) and also require compacted sand and aggregate substrate, but not as thick as the crane pads.
- **Substation foundations and wind farm site office / switchgear building:** Most of the substation components will likely require simple raft foundations, except for the large 34/69KV transformer, which will likely require piles. The entire surface of the substation will be covered by a layer of compacted aggregate, which acts as a form of insulating safety barrier from electrical shock for persons inside the substation area.



Figure 14. Typical project activities during construction of wind turbine foundation., lhs: installation of pre-stressed concrete piles; rhs: construction of the reinforced-concrete foundation.

- **Electrical Works:** encompasses 3 main activity sets – installation of medium voltage collector lines, substation electrical equipment, and the 69KV feeder transmission line. Each wind turbine will be connected to the substation via a medium voltage (34KV) electrical collector line. These

lines will be routed into the base foundation of the turbines via electrical ducting, linked to the substation via a trench and a short section via overhead cables crossing the Hope Canal. Trenching, installation of overhead poles at the canal, laying of the lines, and backfilling the trenches, installation of substation equipment and the 69KV overhead lines are typical of electrical works activities common to Guyana and previously commissioned by GPL for its transmission line and substation network. The electrical works will be undertaken by existing local contractors and supervised by electrical engineering consultants familiar with design and construction of similar works, and in compliance with codes relevant to International standards and Guyana.

5.4.2. Installation of the Wind Turbines

Activities during installation of the wind turbines involve the logistics of shipping, hauling, lifting and assembly of oversize and heavy equipment. The turbine equipment supplier is responsible for this set of activities and is one of the most experienced installer of wind turbines and transport logistics in the world.

- **Transport route preparation:** The preliminary logistics study has identified a transport route which will allow transport of the longest and heaviest WTG components with very minor route modifications. The blades, each 74m (240 ft), and the heaviest components; the tower sections and nacelle, weighing 70 to 80 tonnes each, require oversize and overweight hauling equipment, which will also be brought in to Guyana. The equipment will be shipped to Guyana from the equipment manufacturing plants, offloaded and laid down at a wharf in Northern Georgetown. A local civil engineering consultant familiar with recent upgrades of the Georgetown to Berbice coastal highway has determined that all bridges and culverts along the 28km route will be able to support the loads, in rare instances with the assistance of temporary reinforcement.

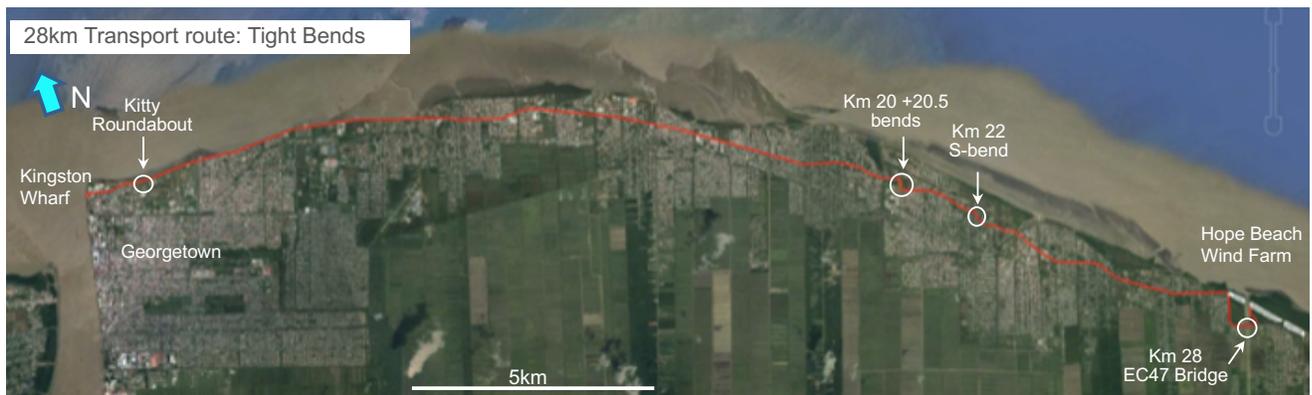


Figure 15. 28km transport route from Georgetown to the project site

The blades can be transported from the Kingston Wharf to the project site with only minor modification of 2 to 3 of the tighter corners. The modifications encompass using the verges of the road on these corners, which will require temporary removal of lamp-posts, deposition and grading of an aggregate substrate.

Two to three of the bridges have yet to be upgraded by the Ministry of Public Infrastructure and are scheduled for an upgrade during 2019/2020. Should it be required, these bridges can be

temporarily reinforced. All required oversize transport permits, permits for minor road modifications, and procedures to apply for police escort will be coordinated via the Chief Roads and Bridge Officer



Figure 16. Oversize and overweight wind turbine components, upper image shows a tower section, lower image a rotor blade

- **Shipping and Transport of Wind Turbine Equipment:** Oversize transport is likely to be done at night, as certain sections of the road may require temporary closure as each load passes through. The total time required for transporting all equipment, assuming night-time transport only, is less than 2 weeks.
- **Lifting and Assembly of Wind Turbine Generators:** Once all the wind turbine components have been delivered to the construction site, the assembly of each wind turbine can commence. The main crane for lifting and assembly will be a 600 to 750 metric tonne unit with extended boom to 120-140m height. The main crane is assisted by a smaller 150-200 tonne unit. The 4 to 5 tower sections are assembled, followed by the nacelle and drivetrain, hub, and finally the three blades. The entire assembly of a single WTG usually takes 3 to 4 days. Including assembly and breakdown of the crane, moving the crane to each site, the entire wind farm assembly will likely take less than 1 month. Each wind turbine is then connected to the medium voltage collector line, and the wind farm completes all inspections and tests in order to commission the wind farm.



Figure 17. Main crane lifting the nacelle onto the top of the assembled tower.

5.5. Operation and Maintenance of the Wind Farm

Operation and maintenance of a wind farm is considerably less complicated than a standard generation plant running diesel/HFO generator units. The Equipment Manufacturer will be responsible for the operation and maintenance of the wind turbine generators for the life of the plant. HED will be responsible for operation and maintenance of the substation, medium voltage electrical lines, and the wind farm grounds.

No fuel is required, and almost no consumables aside from minor amounts of lubricants, hydraulic and coolant fluids. Compared to an internal combustion engine there are very few moving parts, and rates of rotation and movement are much slower than combustion engines. The machines are designed for automated operation with remote monitoring and control capability with very long lifespans of over 20 years.

No permanent personnel are required at the wind turbine sites. There will be 24hr security personnel and a plant operator at the substation. Operations technicians are typically required at most for quarterly to

annual inspection and maintenance routines, unless there are requirements for site visits associated with unplanned maintenance. The maintenance disciplines can be divided into: 1) electrical components 2) mechanical components, 3) hydraulic and cooling system components, and 4) telecommunication and controls equipment.



6. POTENTIAL ENVIRONMENTAL IMPACTS

Relevant environmental legislation and guidelines for the project include:

- The Environmental Protection Act (1998, Chapter 20:05), Laws of Guyana
- Guyana Guideline for Noise Emissions Standard GYS263-2010
- Guyana Guideline for Industrial Effluent Discharge Standard GYS207-2002

In addition, the Hope Beach Wind Energy project is seeking financing via the Danish State investment fund for developing countries, IFU. IFU requires all investment projects to comply with both country specific regulations and IFC regulations, whichever are the most stringent. HED is also in discussions for financing via the International Finance Corporation (IFC). The International Finance Corporation (IFC), a member of the World Bank Group, is an international finance institution providing financing services to encourage private-sector development in developing countries. IFC funding requires projects to abide by a set of published international standards for environmental, health and safety (EHS) compliance. The IFC EHS guidelines are published online at www.ifc.org. IFC publish industry specific EHS guidelines, www.ifc.org/ehsguidelines, that include guidelines specific to wind energy projects. The Hope Wind Energy project aims to comply with all relevant environmental regulations in Guyana, and must also meet IFC guidelines, whichever are the more restrictive. Relevant IFC guidelines are as follows:

- IFC General EHS Guidelines
- IFC EHS Guidelines for Wind Energy (2015)
- IFC EHS Guidelines for Toll Roads (2002) (construction of roads and civil works)
- IFC Performance Std. 1, Environmental and Social Impact Assessment and Management (2012)
- IFC Performance Std 6, Biodiversity conservation and sustainable management of living natural resources.

In terms of this project, the relevance of the Act is for the application for an Environment Permit. Although not expressly listed in the Fourth Schedule, there is the potential for this project to impact the environment and hence HED should apply for an environmental permit. Section 11 of the Environmental Protection Act, 1998 and the Environmental Protection (Authorizations) Regulations, 2000 require a developer of any project listed in the Fourth Schedule of the Act, or any other project which may significantly affect the environment to apply to the Environmental Protection Agency (EPA) for an environmental permit. No public authority may give development consent unless such authorization has been issued. Within six weeks of the receipt of the application, further information, an Environmental Management Plan (EMP) or an Environmental Impact Assessment (EIA) may be requested from the developer.

Section 21 of the Act also describes the requirement by developers for construction permits. Where there is the potential for negative impacts on the environment, no construction permit or operation permit shall be granted unless an environmental permit is issued under Part IV of the Act.



6.1. Project Stakeholders Impacted by the Project

6.1.1 Government Stakeholders

- **MoPI – Ministry of Public Infrastructure**, the key ministry overseeing governance of independent power producers (IPP) selling power to the state utility, and the development of renewable energy. MoPI has initiated an Inter-Agency-Task-Team (IATT) comprising representatives from all Government agencies that are relevant for coordinating all and any legal, regulatory, or commercial aspects relevant to development of IPP power projects, such as the Hope Beach Wind Project. The IATT is led by MoPI’s Electricity Regulatory Advisor, Mrs Morsha Johnson. Once the Minister of Public Infrastructure can be satisfied that the project is in compliance with all regulatory, commercial and legal requirements, the Minister awards the Independent Power Producer Licence to HWE, which will allow the Hope Beach Wind Farm to commence commercial operations. The following Government enterprises report through MoPI.
 - a. **GPL – Guyana Power and Light Inc**, the state utility company, administer generation, transmission and distribution of electricity. GPL are the offtake party which will purchase the power from the wind farm according to terms set out in the Power Purchase Agreement and Grid Interconnection Agreement. GPL and IPP’s must abide by the National Grid Code.
 - b. **SDB – The Sea Defence Board**, regarding any construction near or seaward of the sea-defence structures.
 - c. **Civil Aviation Authority** – regarding any tall structures above FAA regulation guidelines which require risk assessment for aviation
 - d. **Chief Officer Roads and Bridges** – regarding transport of oversize and overweight loads on national roads
- **EPA – Environmental Protection Agency**, ensuring compliance with regulatory guidelines ensuring protection of the environment, public health and safety
- **NAREI, National Agricultural Research Institute, Mangrove Restoration and Management Department**, regarding potential impact to the Mangrove habitats near the wind farm
- **GEA – The Guyana Energy Agency**, ensuring consistency in energy project development with respect to Guyana’s energy policies.
- **NDIA – National Drainage and Irrigation Authority**, regarding any structures or roads built near or within the reserve areas of drainage and irrigation canals
- **Central Housing and Planning**, regarding construction permits
- **Go-Invest Guyana**, regarding any financial incentives that may be required in order to realise the project and its benefits



6.1.2. Local Community Stakeholders

- **NDC – Neighbourhood Democratic Council Grove-Haslington**, comprising locally elected councillors, responsible for ensuring efficient services to the local communities (sanitation, garbage disposal, maintenance of roads and drainage dams, market facilities, burial grounds etc), to maintain and protect public property, administer any local approvals, represent the local communities.
- **Nearby Residents** – the project developers will need to engage with local residents to communicate project plans, impacts on the community during the construction phase, impacts and benefits of the project to Guyana and the local community. Local residents will require opportunities to interrogate various aspects of the project in order to appreciate the potential impacts to the local communities.

6.2. Physical Environmental Impacts During Construction and Decommissioning

Environmental impacts during the construction and decommissioning activities - typically include impacts such as: habitat loss from clearing land for infrastructure, access roads and foundations; dust, noise, exhaust fumes and fuel spills during construction works; interference with regular traffic along transport routes due to the challenge of hauling oversize and overweight loads.

Habitat loss: Wind projects do not require modification of large surface areas, and the footprint of habitat loss is relatively low per unit capacity installed when compared to Hydro or Solar-PV projects.

Clearing land for the construction of project related infrastructure will mainly impact the grass covered relict beach ridge habitat, with minimal impact on the ecologically sensitive mangrove tidal flats and mangrove swamp habitats.

Total access roads of some 1,300m length are required, covering some 10,500 m², or 1.05 Ha (2.6ac). Some 20% of this will be upgraded existing access roads, and 80% is new build. Of the new build road 70% is situated in the grassy beach ridge habitat.

Each WTG site requires 2,500m² (0.25ha, 0.6ac) for foundation, crane pad, and lay-down areas, another 1,500m² is required for the substation, totalling 1.2 ha (3ac) for the four sites, all of it on the grass covered relict beach ridge. Of this, the temporary laydown areas total 70%.

Habitat areas impacted by construction of Hope Beach infrastructure				
Infrastructure	Ha	Ac	%	Habitat
Access roads	1.05	2.6	47%	Permanent, 70% on grassy beach ridge, 20% use existing road, 10% excavated swamp
Foundation + Crane pads	0.25	0.6	11%	Permanent, all on grassy beach ridge
Substation	0.15	0.4	7%	Permanent, on grassy beach ridge
Lay-down areas	0.80	2.0	36%	Temporary, grassy beach ridge, <0.1ha in transitional mangrove tidal flat
Total Area	2.25	5.6	100%	

Table 3. Habitat and Land Area Impact



- **Habitat loss from access roads West of Hope Canal:** extends from the planned 15m bridge across a drainage canal some 300m and 6m (20ft) wide roadway along the grass covered beach ridge. There is no impact to either mangrove swamp or mangrove mud-flat habitats (Figure 8a)
- **Habitat loss from access roads East of Hope Canal:** has two options (Figure 8b).
 - o **Option-1** has almost no impact to the mangrove swamp, maximizing use of the existing 10m wide access road reserve and areas already impacted by construction of the flood gate facility. This involves infilling a 170m long excavated section of the swamp which is devoid of any trees in order to extend the existing access road to the lease area. Both options involve construction of almost 500m of access roadway along the grassy beach habitat impacting an area of 0.5 ha (1.25 ac).
 - o **Option-2** is a more direct route to the lease area, extending and straightening the existing excess road via a 150m long section straight through the marsh and mangrove swamp. Option-2 impacts the more ecologically sensitive mangrove swamp habitat, with loss of some 0.25ac (0.1ha) of habitat and dividing the 6ha (15ac) area of this swamp into two sections. Option-2 is preferred by the NDIA as this would completely avoid any of NDIA's drainage facility reserve. The mangrove swamp has already been severely impacted by the construction of the Hope Canal.
- **Habitat loss from Foundations, Crane-Pads and Substation:** These permanent features are all located on the grassy relict beach ridge, and cover a total area of less than 3,500m² (<0.4 ha, 1ac). The Crane pads will be retained throughout the life of the plant to allow cranes to return should any major part replacements be required.
- **Electrical Lines:** Medium voltage (MV) collector lines will be buried in trenches running along the side of the share-parallel access roads on the grass covered beach ridge. Burial is required to allow for lifting operations by the cranes. The MV line will transition to overhead lines for 100m in order to cross the Hope Canal, suspended on tall electrical poles supported by Guy-wires. Impact is minimal. The 69KV connector to GPL's transmission line will run as overhead lines parallel along the road /drainage-canal reserve for 950m, with poles spaced about 100m apart. The distances are short and Impact is minimal. The electrical works will be completed by qualified personnel, and in accordance with Guyana's electrical code (local adaptation of USA's NEC code) to ensure safety of personnel and the public.
- **Transport congestion and safety:** Transport of oversize and overweight loads on public road bridges and culverts introduces the risk of structural damages to the national roads, collision with vehicles, pedestrians being struck by or crushed by moving vehicles and loads during transport. Transport of aggregate materials and supplies for the civil and electrical works requires the movement of a substantial number of dump-truck and transport loads to the site along the busy Demerara-Berbice Public Road. Such transport may cause congestion, in particular during peak traffic hours. Oversize and overweight loads may require temporary closure of sections of roads related to tight corners, bridges and culvert crossings which can be a nuisance to public and commercial traffic.



- **Construction noise, dust and fuel spills:** Typical of any construction site, earth moving equipment, transport trucks, piling machines, and cranes will all be operational at the site. Earth moving equipment and cranes will require the installation of a temporary fuel depot, lubricant and hydraulic fluid supplies. The moving machinery and trucks and pile driving will generate noise at the site. During dry spells dust may be kicked up during operations. Fuels and lubricants may be spilled during maintenance activities.
- **Waste and Spoil Disposal** – The worksite will generate waste spoil from grubbing and excavation which needs to be disposed of. Human sanitary waste and wash facilities, spent fuel and lubricants, are other waste streams which require proper disposal.
- **Water Quality** – the close juxtaposition of sea and flooded swampland necessitates careful management of any potential waste-streams or spills to these sensitive aquatic environments. Water quality can also be impacted by surface runoff tainted by excavated material and imported sand and aggregate during civil works, or any water that may be required as part of concrete works during construction of the foundations. The sea is generally turbid, laden with suspended sediments from nearby rivers and from as far as the Amazon River mouth.
- **Worksite Safety** – construction projects have inherent dangers. Transport of oversize and overweight loads on site access roads introduces the risk of structural damages to the roads and vehicles overturning. Site workers could be struck by or crushed by moving vehicles and loads during transport. Dangers are associated with excavation and lifting, working at heights, lifting of heavy loads, respiratory risks due to dust and exhaust emissions, and electrical burns and shocks during the interconnection of the electrical infrastructure.
- **Community Health and Safety:** The dangers facing site workers are also relevant to the public, and worksite access control is necessary. Construction noise, dust, and exhaust fumes emissions can spread beyond the worksite. Communities most affected would be the fishermen at the Hope Canal mouth. Residential areas are at least 290m from the wind turbine sites, however, may be impacted by construction work on the access roads and access road bridge.

6.3 Physical Environmental Impacts During Wind Farm Operation

IFC Guidelines on EHS impacts associated with Wind Energy facilities during the >20-year operating phase includes noise emissions and shadow flicker at nearby residential houses caused by the rotating wind turbines, Impact on bird and bat biodiversity due to fatalities caused by strikes with the moving rotor blades, safety aspects to workers and the nearby community, and possible visual impact of the tall, rotating wind turbine generators in areas sensitive to visual aesthetics, such as tourism areas, nature reserves, or viewscapes associated with areas of cultural importance.

- **Noise Emissions:** Wind turbines generate noise from movement of mechanical parts in the drivetrain within the nacelle, and from aerodynamic effects associated with the spinning rotor blades. The major mechanical noise contributors include the gearbox, generator and yaw motors. The rotor blades generate noise as the blades move through the air, in particular



from the tips of the blades which have the highest velocity through the air, and the trailing edges of the blades. The noise radiated by the wind turbine components will travel towards the residential areas as air-pressure waves, which is attenuated by various well-known physical processes and results in decrease the volume of the noise with increasing distance from its source. Wind Turbine manufacturers provide the noise characteristics for each wind turbine model under different wind speeds. Wind engineers can then calculate the noise emissions at any given location.

Receptor	One Hour L _{Aeq} (dBA)	
	Daytime 07:00 - 22:00	Nighttime 22:00 - 07:00
Residential; institutional; educational ⁵⁵	55	45
Industrial; commercial	70	70

Table 4. IFC guidelines for maximum noise emissions at nearest receptors. If background noise is above these levels, then maximum noise emissions can be no more than 3dBA above the background noise levels.

- Guyana’s noise standards require maximum noise emissions at residential areas of 75dBA daytime, and 60dBA night-time. IFC guidelines require maximum noise emissions at residential dwellings of 55dBA daytime (7am to 10pm) and 45dBA night-time (10pm to 7am), or if the background noise is higher than these values then maximum noise emissions can be no more than 3dBA above background noise levels of the nearest residential or school receptors. Background noise monitoring should be carried out by qualified personnel for a minimum 48 hour continuous period, taking into account variations in wind speed measured at 10m height. Guyana’s EPA have proposed a maximum night-time noise limit at nearby residencies of 45 dBA. A noise emissions impact study has been completed by EMD International, a qualified and industry recognised wind engineering consultancy based in Denmark. Background noise levels were continuously measured night and day over a 5 day period in April 2018 by Kaizen Environmental Services. The results of the studies are discussed in the following section on environmental impact mitigation, and engineering reports are attached to this Summary (Attachments 1a, 1b & 1c).
- **Shadow Effects (Shadow Flicker):** The rotating blades of the wind turbine will cast long shadows when the sun is at a low elevation, which at the site is relevant in the early morning hours when the wind turbines will cast a shadow onto residential areas located West of the turbines. As the rotors are spinning the blades cut in and out of the light causing a flickering of the shadow. The flickering effect can be irritating for any residential dwelling with windows facing into the early morning sun, and only on sunny mornings. The flicker effect can impact residences as up to 1,500m from the wind turbines. The frequency of the flicker is related to the rotor revolution frequency. The V150 rotates at 5 to 12 rpm, resulting in a maximum flicker frequency of 0.6Hz per rotor. The Epilepsy Foundation states that frequencies below 3Hz do not cause seizures in people with photosensitive epilepsy. IFC



guidelines stipulate that flicker effects should be limited to less than 30 hours per year and 30 minutes per day at any sensitive location (residence or school). EMD International have completed a Shadow Flicker analysis for the selected wind turbine configuration, which is discussed in the section on Environmental Mitigation, and the report attached to this Summary (Attachment 2).

- **Biodiversity:** Biodiversity impacts due to habitat loss has been covered in the construction impacts section above. The impact on birds and bats due to impact with the rotor blades, and displacement of bird or bat populations are the main biodiversity impact factors to consider. The site area has not been designated as a legally protected area, however, the site is on the coast adjacent to mangrove and tidal flat areas and as such may be of importance to local bird populations. Initial discussions with the Mangrove Research unit at NAREI (pers. Comm., Moseley, 2008) identified previous bird studies from the nearby coastal areas undertaken by University of Guyana and NAREI staff (Dookram et al, 2017; King, 2015; Roopsind, 2012) at mangrove habitats near Hope Beach, Golden Grove and Belfield. These previous semi-quantitative studies provided useful input on species of birds, and formed the basis for designing the baseline bird and bat biodiversity study commissioned by HED.
- **HED-Commissioned Baseline Bird and Bat Biodiversity Study (In Progress):** A team of 6 Guyanese bird biologists and field rangers, and 2 bat survey specialists, supported by Ecoengineering Ltd of Trinidad, have completed a review and evaluation of the habitat, a 10-day bird survey (June, 2018) and a 5 day bat survey (August, 2018). A second 10-day bird survey will be completed in October. The two bird surveys are designed to sample both migration seasons. Dr Kerlinger (USA), an industry expert bird/bat biologist with some 30 years of experience undertaking wind-farm and communication tower bird/bat impact assessments, is on standby to support Ecoengineering and the Guyana team with the biodiversity risk assessment, and to ensure it meets IFC requirements. Dr Kerlinger has access to over 150 bird and bat impact studies on wind farm installations in the USA and Canada, and has experience working in the Caribbean area.

This is work in progress. Based on Ecoengineering's preliminary assessment of the baseline survey there is no cause for concern that this small wind farm will have any noticeable impact on bird and bat biodiversity: no IUCN Red listed endangered or critically endangered species, no night-migrating birds, no migrating bats. Two "vulnerable" species and one "near endangered" species on the IUCN Red list of threatened birds were identified, all other species are in the "least concern" category, and 7% are on the IUCN list but do not have sufficient data to classify. Of the 102 species observed, 28 species have flight patterns at heights which can potentially bring them into harms-way from wind turbine rotors. Of these 28 mid- to high-elevation fliers only the Rufus Crab Hawk is listed as a "near-endangered" species on the IUCN list.

The Bat survey identified only 5 species of bats, and only 36 individuals were caught in total in all the mist nets during the 5-night survey. All of these species reside and hunt below the forest canopy. No high-flying bats could be seen during the dusk period. Of the species identified all are common to the region, none are endemic to the Guyanas coast, and all are listed as "Least Concern" on the IUCN Red List.



The next steps are to complete the second 10-day bird survey in October/November, followed by a bird/bat biodiversity impact assessment by Mr Kerlinger working closely with Eco-Engineering and the Guyanese biologists. Finally, of a monitoring program will be designed to assess post construction impacts on the bird and bat populations, which will help inform any additional future wind farm projects in the region. The interim baseline study report is attached to this summary as Appendix 3.

- **Worksite Safety:** During operation of the wind farm the only safety risk is the highly improbable potential of structural collapse of the wind turbine, or potential blade throw if a rotor blade was to catastrophically fail. Also, during the maintenance and operation of the wind farm, safety risks typically associated with working with high voltage electrical equipment, being struck or crushed by rotating heavy mechanical equipment, and safety issues typical for working at heights and lifting operations.
- **Community Safety - Offset Distance:** During operation of the wind farm the only safety risk is the highly improbable potential of structural failure of a rotor blade and the potential throwing of the blade. For this reason IFC guidelines stipulate a minimum offset distance from any nearby residential or school building of 1.5 x the maximum tip height of the wind turbines. This distance corresponds to 280m for the V150 with 105m hub-height, or 292m for the V150 with a 120m hub-height. The IFC guideline is used here as a preliminary indication of safety. A planned quantitative risk analysis of safety offset distance will be undertaken, in line with the methodology developed for the UK's HSE Executive.
- **Community Safety - Other:** Dangers to the public during the operational of the Wind Farm is mainly in regards to the potential for electrocution via high-voltage transmission lines, the sub-station, or inside the wind turbines. All such facilities shall be secure and off-limits to the general public, as specified by the electrical code.
- **Air and Water Emissions:** As there is no combustion of fuel, there are no air emissions or effluents. The only relevant waste streams are minor volumes of sewage from the security and site office to be located at the substation, and disposal of lubricant, coolant or hydraulic fluids associated with scheduled maintenance.
- **Visual Aesthetics:** The nearby region is designated as a mix of industrial, residential and agricultural zones. There are no designated significant viewscales or seascapes in the region, this is not a common practice in Guyana. There are no significant historical or cultural sites which rely on a certain viewscape in the immediate vicinity of the lease. There are no nearby ecotourism or any tourism sites that may rely on certain viewscales for attraction. Eco-tourism boat tours on the Mahaica River are some 5 to 20 km from the site, and wind farm will not be visible through the forest-lined river banks by persons in a boat.

6.4. Socio-Economic Impacts

- **Impact to Existing Activities:** Community engagement and surveys will be an important component in generating the Environmental and Social Management Plan in order to better understand the concerns and potential impacts to residents of the nearby communities.



- Based on initial observations, the main commercial and livelihood activities in the nearby area appears to be related to fishing and street side vendor stalls located along the public road. The wind farm will not impact either of these activities. On the contrary, there will be opportunities for employment at the wind farm via security and grounds maintenance jobs, environmental monitoring tasks, and if suitably qualified, via technical maintenance of the electrical and wind turbine equipment.
- In addition, the wind farm, as the first substantial renewable energy facility in Guyana, is likely to be an attraction, which may open up the possibility of educational-tours. This could benefit any local aspiring tour-guides and vendors. HED would be very supportive of tours highlighting wind and renewable energy technology, mangrove forest ecology, the technology of coastal plain drainage, and importance/threat of climate change to the population of Guyana, for example.



7. ENVIRONMENTAL IMPACT MITIGATION

During the present Feasibility Phase the project developers initiated various studies to assess and mitigate against the key environmental impacts typically associated with wind farms, and to ensure environmental, health, and safety compliance, including:

- Background noise survey at nearby residential houses and the school (completed)
- Noise emissions analysis (completed)
- Shadow flicker analysis (completed)
- Locations of WTG's to comply with minimum safety offsets and noise emissions limits
- Biodiversity Baseline Study for Birds and Bats (due for completion in November 2018)

The work completed to date indicates that there are no concerns with the selection of wind turbine generators and their location regarding environmental impact. The Hope Beach Wind Farm will satisfy all the Guyana EPA and also IFC's Environment, Health and Safety Guidelines.

In particular, there has been concern regarding the wind farms ability to meet maximum noise emissions when utilizing large IEC Class-III wind turbine generators at this site. The assessment of the noise impact was undertaken by EMD International (EMD), a highly experienced and respected wind engineering consultancy based in Denmark. EMD worked closely with the engineering teams of the two largest wind turbine equipment manufacturers in the world, Vestas and Siemens-Gamesa, over a 4-month period assessing their various wind turbine models, analysing the wind data, and analysing the parameters relevant to noise and shadow-flicker impact assessment, including local site conditions.

EMD are satisfied that the maximum noise emitted by the wind farm will easily meet Guyana's existing limits, and also the more stringent IFC and proposed new Guyana guidelines of 45 dBA at nearby residences and the school. In addition, the background noise levels were measured at the nearby resident houses and the Hope Secondary School. Background noise levels are substantially higher than the standard maximum IFC and proposed Guyana noise limits. **The conclusion is that the wind farm will meet the IFC Guidelines for noise emissions with a margin of over 10dBA versus the IFC limit set by background noise. As the wind farm noise emissions are well below the existing background noise at the residencies and the school, the wind farm sound emissions will in effect be drowned out by the existing background noise, and will have no perceptible impact for residents, school children in the playground, or school children in the classrooms.**

7.1. Mitigation Measures: Construction Phase

Potential EHS impacts typical of wind farm construction was described in the previous section. Most of the activities, and also the mitigation of impacts, are typical of any industrial construction site, and are familiar in Guyana. The only exception is the transport of oversize equipment, in particular the long rotor blades, each 75m long, yet the mitigation of safety and traffic congestion issues this may cause are standard, and familiar practices in Guyana.

The mitigation actions for construction are summarised in Table 5, on the following page.

Table 5

Mitigation Measures: Wind Farm Construction Phase		
Impact	Mitigation Measure	Responsible Party
Land and Habitat Loss	<ul style="list-style-type: none"> - Minimize impact to the most sensitive habitat - Mangrove swamp and mangrove mud flats - Select options with least land and habitat loss 	Developer
Transport Congestion and Public Safety	<ul style="list-style-type: none"> - Complete detailed route survey, confirm initial structural analysis of bridge/culvert structural integrity - Avoid transportation during high traffic congestion periods - Develop a detailed logistics plan for transport of oversize and overweight equipment, with police escort, consider night-time transport. - Inform the public regarding oversize/overweight transport and related temporary road closures. 	Developer, Transport Contractor Traffic Police
Construction Noise	<ul style="list-style-type: none"> - Ensure vehicles have adequate mufflers - Operate near resident houses only during daytime hours 	Contractors
Construction Dust and Air Pollution	<ul style="list-style-type: none"> - wet transport and dust prone area during dry conditions. - Maintain motorized equipment to minimize exhaust pollution. 	Contractor
Liquid Spills	<ul style="list-style-type: none"> - Ensure onsite fuel/fluid depot is maintained an leak free - Locate fuel, lubricants, and fluid stockpiles away from waterways 	Contractor
Waste and Spoil Disposal	<ul style="list-style-type: none"> - Collect all waste streams in approved containment vessels - identify suitable site for excavated soil material - Identify suitable site for used fuel and lubricants disposal - Contract portable ablution facilities, contract waste disposal 	Developer and Contractors
Water Quality	<ul style="list-style-type: none"> - Ensure excavated materials and aggregate stockpiles are contained, covered, and located a minimum distance from local waterways in order to avoid sedimentation - Ensure proper containment and disposal of waste-streams 	Developer and Contractors
Worksite Safety	<ul style="list-style-type: none"> - Wear Personal Protection Equipment - Ensure basic HSE training - Ensure adherence to basic worksite HSE practices - Coordinate parallel worksite activities - Monitor and record safety behaviour and indicators - control worksite access 	Developer, Contractors
Community Safety	<ul style="list-style-type: none"> - Control worksite access - Clearly post notices of restricted areas and potential dangers - Communicate operational plans to community, with avenue for community feedback - Follow above mitigation procedures 	Developer, Contractors



7.2. Mitigation Measures During the Wind Farm Operation Phase

Potential EHS impacts typical of wind farm operations were described in the preceding section. Table 6, below, summarises the mitigation measures relevant for each identified EHS category.

Table 6

Mitigation Measures: Wind Farm Operation		
Impact	Mitigation Measure	Responsible Party
Noise Emissions	<ul style="list-style-type: none"> - Noise emissions analysis performed by qualified contractor - Select wind turbine equipment with suitably low noise emissions - Establish background noise baseline at nearby residences and school - Locate equipment to ensure noise emissions guidelines are satisfied at nearby residential and school receptors - Employ additional noise reduction technology or noise reduction operational modes, if required 	Developer Environmental and Wind Engineering Consultants
Shadow Effects (Flicker)	<ul style="list-style-type: none"> - Flicker analysis performed by qualified contractor - Locate wind turbines as far from West end of lease as possible - Install technology to automatically curtail (shut in) wind turbines during sunny mornings to reduce shadow flicker to less than 30 hrs/year, 30min per day 	Developer Wind Engineering Consultants
Biodiversity Impact	<ul style="list-style-type: none"> - Perform Baseline Bird and Bat bioiversity sudy - Experienced biologist to assess the bird and bat biodiversity impact risk - Employ approved facility lighting practices to reduce night-time impact - Monitor the bird and bat fatality - Monitor biodiversity impact (repeat surveys) 	Developer Plant Operator Environmental Consultant
Waste and Spoil Disposal	<ul style="list-style-type: none"> - Identify suitable site for used lubricants, coolant, hydraulic fluids disposal - Install field site bathroom facilities with approved sewage disposal infrastructure 	Developer and Plant Operator
Worksite Safety	<ul style="list-style-type: none"> - Wear Personal Protection Equipment - Ensure basic HSE training - Ensure adherence to basic worksite HSE practices (electrical, working at heights, lifting) - Coordinate any parallel worksite activities - Monitor and record safety behaviour and indicators - control site access, restrict access to critical safety areas. 	Developer and Plant Operator
Community Safety	<ul style="list-style-type: none"> - Locate wind turbines with minimal offsets for safety, inspect blades - Obtain Aviation Permit, ensure proper anti-collision lighting - Control and coordinate site access by the public, ensure off-limit areas and wind turbine towers are locked and secure - Communicate any operational plans to community, such as oversize transport. - Clearly post notices highlighting restricted areas and dangers - Provide means for community noices and feedback 	Developer and Plant Operator



The Noise emissions and shadow-flicker mitigation measures are discussed at length as these were identified as primary concerns. EMD’s engineering reports on the assessment of noise and Flicker mitigation, and Kaizen Environmental Services’ report on background noise survey, are included as attachments to this Project Summary (Attachments 1a, 1b, 1c and 2). The potential impact on Bird and Bat biodiversity was covered in the previous section. Eco-Engineering’s Preliminary Report on the Bird and Bat Biodiversity Baseline Survey is included in Attachment 3.

7.2.1. Noise Emissions Impact Assessment and Mitigation

Attachments 1a and 1b contain EMD’s reports on the noise emission analysis for the 4 x V150 wind turbine configuration. A 5-day background noise survey by Kaizen Environmental Services Ltd is included in Attachment 1c. EMD has completed such analysis for a variety of scenarios that HED considered, including for 4 x Siemens-Gamesa G132, and 4 x Vestas V-136 wind turbines.

Wind Turbine Technology has come a long way, in particular on noise emissions for the very large turbines, which in many instances are now less noisy than the smaller 2MW machines from a decade ago. The new machines from top tier manufacturers achieve this by having much slower rotations per minute, at 5 to 12 rpm for the Vestas V150, better aerodynamic design, and introduction of new technology in the form of serrated trailing edges which mimic the wings of silent-flight birds. In addition, these turbines can reduce their noise emissions a further 1-5 dBA by varying the pitch of the rotors using pre-programmed noise-reduction settings.

The rule-of-thumb that relates the minimum offset distance for acceptable noise emissions to multiples of the rotor diameter for wind turbines from a decade ago are not valid for these modern machines. The V150 reference noise levels are within 1dBA of much smaller 1.5 to 2.5 MW machines with 80 to 120m diameter rotors. The human ear is not able to distinguish such a small dBA difference.

Table 7

How Much Noise Makes a Difference ?
The human response to sounds measured in decibels has the following characteristics: 1dB change in sound level cannot be perceived except under laboratory conditions 3dBA corresponds to a doubling of the sound source energy 3dB change in sound level is considered barely discernible outside the laboratory 5dB change in sound level will typically result in a noticeable community response 6dBA increase is equivalent to moving half the distance towards the source 10dBA increase is subjectively heard as a doubling in loudness, and will cause a community response
Typical noise levels:
140dBA: threshold of pain 94dBA: 4hr OSHA safety limit 80dBA: average street traffic 60dBA: average conversation, outdoor airconditioning unit at 20ft 40dBA: quiet library
Source: Rogers and Manwell, 2004, NREL White Paper, Wind Turbine Noise Issues

Methodology for Emissions Calculation: The noise emissions calculations follow the methodology described in International rule DIN ISO 9613-2 “Attenuation of sound during propagation outdoors, Part 2”. The analysis considers wind turbine noise emissions specifications in octave bands provided by the wind turbine manufacturer, wind farm configuration, and location of residential receptors, and calculates the noise attenuation from source to receptor. Calculations include attenuation due to geometric expansion from source to receptor, effect of wind, air attenuation, and ground attenuation due to the nature of the land surface (grassy marshes and forested swamp). EMD, a 3rd party wind non-profit engineering firm based in Denmark, and a respected engineering consultants in the wind industry (they designed the original WindPro wind engineering software which most other consultants now use), undertook the wind data assessment, the wind farm design, and the assessment of noise emissions, shadow flicker and safety stand-off distances to meet IFC (World Bank) Environmental, Health and Safety guidelines.



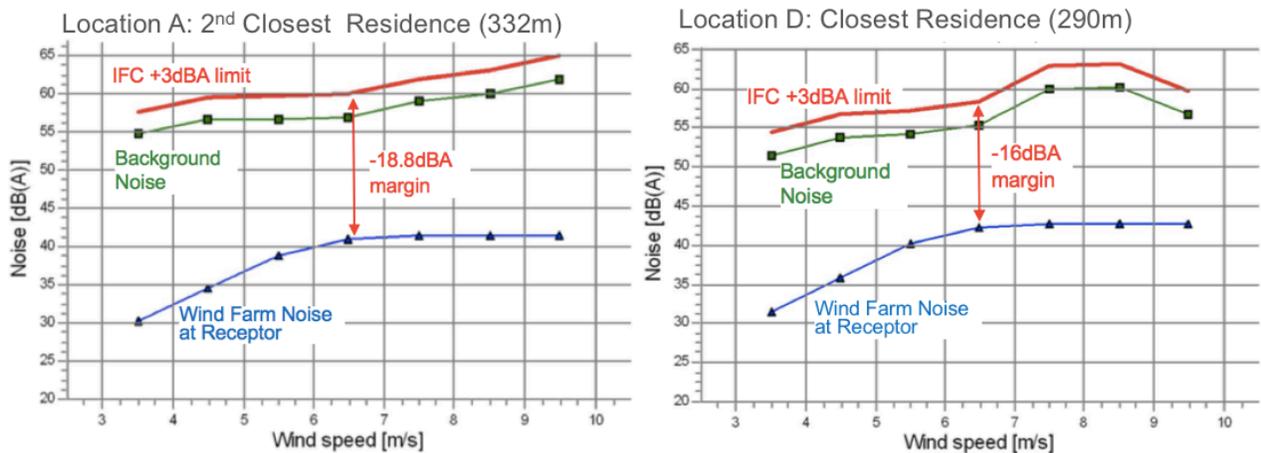
Figure 18. Maximum noise emissions map showing noise contours corresponding to the loudest noise emissions by the wind farm. Background noise levels were surveyed at the 6 receptors labelled A to F. Hope Secondary School is located at Site B.

Maximum noise emissions limit: The wind farm noise emissions are first tested against the standard IFC maximum noise limits of 55dBA daytime, 45dBA night-time. EPA have indicated a proposed



maximum noise level at nearby residencies night of 45dBA for the wind farm. The maximum noise contours in Figure 18 clearly show that the 45dBA contour line does not encroach onto any residential buildings or the school. EMD has concluded that the maximum noise emissions from the proposed 4 x V150 wind farm at nearby residential buildings, including the secondary school at the Hope Canal Bridge, is 41dBA at the back of the school, and 41 to 43 dBA at the nearest residences. This is substantially less than IFC’s guidelines which is for 55dBA daytime, and 45dBA night-time. **On this basis alone the proposed wind farm meets IFC and EPA’s proposed night-time 45dBA noise emissions regulations.**

Maximum Noise Emissions vs Background Noise: EMD then compared noise emissions vs background noise levels at various wind speeds at the same 6 receptor sites (Appendix 1b). Kaizen Environmental Services completed a 5-day/24hr background noise emissions survey at 6 (six) nearby receptors: 5 residential locations and at the Hope Secondary School (Sites A to F in figure 16, the school is site B)



Sound level

Noise sensitive area
No. Name

Most critical demand Predicted sound level Demands fulfilled ?
Wind speed Demand WTG noise Max exceedence Noise
[m/s] [dB(A)] [dB(A)] [dB(A)]

No.	Name	Wind speed [m/s]	Demand [dB(A)]	WTG noise [dB(A)]	Max exceedence [dB(A)]	Demands fulfilled ? Noise
A	Resident - Night	6.5	59.8	41.0	-18.8	Yes
B	Primary school - Night	9.5	46.0	41.0	-5.0	Yes
C	Resident-next to construction site - Night	9.5	52.5	42.1	-10.4	Yes
D	Resident-dose to church - Night	6.5	58.3	42.3	-16.0	Yes
E	Resident-dose to canal - Night	8.5	53.9	37.0	-16.9	Yes
F	Resident-dose to sawmill - Night	6.5	53.2	31.9	-21.3	Yes

Figure 19. Summary of results for maximum wind farm noise emissions at the 6 receptor sites versus measured night-time background noise levels. The wind farm noise emissions must be below the “Demand Level” (background noise level plus 3dBA) in order to meet IFC guidelines. Background noise tends to increase with increasing wind speed, whereas the wind turbine noise peaks at 7 m/s 10m wind speed. The school is closed at night, daytime background noise at the school is 51dBA at 6 to 7 m/s, which results in a daytime Demand Limit of 54dBA, and max noise from the wind farm that is 13dBA less than the IFC requirement. **The wind farm is therefore always below the IFC requirement for maximum wind noise by a margin of at least 10 dBA.**



IFC guidelines state that should the background noise at nearby residential receptors be above the 55dBA daytime/45 dBA night-time limits, then the emissions of the WTG's can be higher, but no more than 3dBA above the measured background noise. In other words, if background noise is similar or higher than wind turbine sound, then the wind turbine sound will be drowned-out by the background noise and thus will not be perceived as a nuisance.

The Kaizen survey methodology followed IFC guidelines, with noise measurements correlated with 10m height wind speed from the Hope Beach wind mast. guidelines **Background noise levels at all locations were above the IFC guidelines of 55dBA daytime and 45 dBA night-time.** In line with IFC guidelines of maximum noise vs background noise + 3dBA, **the wind turbine sound will be drowned-out by the background noise and thus will not be perceived as a nuisance.**

EMD assessed the background noise emissions vs wind speed and compared this against the wind farm noise emissions vs wind speed for night-time periods (when background noise is lower). The wind farm is below IFC's maximum limit of permissible noise at night (called "Demand" = night background noise + 3dBA) by 10.4dBA to 18.8dBA at the nearest residences (Figure 16 Locations A, C & D). During the day background noise levels were even higher, so day-time noise emissions margins have an even greater level of safety.

The secondary school is open only during the day, and for wind speeds above 6 m/s has daytime background noise levels above 51 dBA (Appendix 1c, Table 3, Site 2). The wind farm noise maximum emissions of 41dBA at the school during the day for these wind speeds is therefore at least 13 dBA below the required daytime IFC limit of 54dBA (51dBA + 3dBA).

In conclusion, noise emissions with the Vestas V150 wind turbines is not an issue. The wind farm meets the new proposed Guyana 45dBA limit, and also IFC's requirements for maximum noise vs background noise by a margin of more than 10dBA night and day at the nearby receptors. There is no need to further mitigate wind farm noise emissions by enabling available additional noise reduction modes of operation.

7.2.2. Shadow Flicker Impact Assessment and Mitigation

Attachment 2 contains EMD's reports on shadow flicker after curtailment to reduce shadow flicker has been applied. The location of the wind farm, with the residential area to the West and SW less than 1,500m from the wind turbines, and the Atlantic Ocean to the E and NE, results in wind turbine rotor shadows to be cast onto the residential area during first 30 min to 2 hrs after sunrise on sunny mornings.

IFC Guidelines specify that residential receptors should not experience more than 30 minutes of shadow effect per day, and less than 30 hrs cumulative per year. IFC specifies that this calculation should assume sunny mornings every day of the year.

The shadow calculation is a simple geometrical solution between sun azimuth and inclination throughout the year, the position and geometry of the wind turbine rotor, and the location of nearby identified sensitive receptors. The residential buildings facing the wind farm along the public road and

the secondary school were identified as the most critical receptors which would receive the most shadow flicker hours per year. EMD entered 26 receptor sites, labelled A to Z, into their WindPRO software used for shadow flicker assessment (Figure 18).

Initial calculations without curtailment indicated all sites would experience substantial shadow-flicker throughout the year, with most experiencing more than 30 minutes every day, and almost all selected sites exceeding the maximum 30 hours cumulative shadow flicker per year.

Figure 20. Site map with receptor locations A to Z selected by EMD for Flicker Shadow impact analysis, and the locations of wind turbine generators 1 to 4. Site A corresponds to Hope Secondary School.



Shadow Flicker Curtailment: The only recourse for avoiding shadow flicker is to curtail (shut in) the wind turbines during the hours that they cast shadows onto residences until the IFC guidelines are met. EMD applied curtailment of the wind turbines in order to meet the IFC maximum shadow-flicker requirements.

As Table 8 below, indicates, **after curtailment of the wind turbines all sites are well within acceptable shadow flicker limits as set by the IFC.**



Calculation Results Shadow Flicker After Curtailment

Shadow receptor

Shadow, worst case

No.	Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Avoided hours per year [h/year]	Avoided days per year [days/year]
A*	0:00	0	0:00	194:55	200
B*	0:00	0	0:00	266:08	165
C*	2:26	42	0:06	296:16	193
D*	4:27	54	0:08	308:11	211
E*	3:58	54	0:07	298:29	221
F*	2:56	54	0:07	304:01	235
G*	2:22	30	0:07	318:55	251
H*	5:59	84	0:10	337:00	301
I*	4:49	56	0:09	345:39	325
J*	4:00	56	0:07	382:22	363
K*	2:25	56	0:05	390:37	358
L*	0:00	0	0:00	399:14	352
M*	1:02	28	0:04	378:34	349
N*	2:02	32	0:06	343:28	343
O*	2:21	48	0:06	323:01	339
P*	0:00	0	0:00	215:49	285
Q*	0:00	0	0:00	143:10	210
R*	1:47	26	0:07	167:28	253
S*	1:49	21	0:10	152:14	225
T*	3:15	102	0:05	112:45	168
U*	1:20	53	0:02	108:22	155
V*	0:41	27	0:02	104:21	148
W*	0:00	0	0:00	131:36	124
X*	6:39	68	0:09	98:16	96
Y*	6:41	61	0:09	84:43	86
Z*	0:00	0	0:00	16:15	32

* Receptors where shadow flicker is reduced by curtailment

Table 8: Calculated results of total Shadow Flicker at the selected nearby residential receptors A to Z after curtailment of the four wind turbines has been applied. Total shadow hours per year was reduced to less than 10 hours at all locations. Maximum shadow hours per day is below 10 minutes per day for all sites and all days of the year. Avoided cumulative shadow hours and days are also shown.

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Appendix 1a: Maximum Noise Emissions 4xV150 EMD Report





Appendix 1b: Maximum Noise vs Background Noise 4xV150 EMD Report

Appendix 1c: Hope Residential Background Noise Survey Kaizen Report





Appendix 2: Shadow Flicker 4xV150 with Curtailment EMD Report





Appendix 3: Hope Beach Bird Bat Biodiversity Baseline Interim Report Ecoengineering





Appendix 4a: EMD Statement of Capabilities

Appendix 4b: EMD senior wind engineer Maurizio Motta Resume





Appendix 5a: Ecoengineering Statement of Capabilities

Appendix 5b: Expert Bird/Bat Biologist Dr Kerlinger Resume