DNV·GL

Draft Guidelines for Utility Scale Wind in Barbados

Inter American Development Bank

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List of abbreviations

Abbreviation	Meaning
BL&P	Barbados Light & Power Company Limited
BWA	Barbados Water Authority
CBC	Caribbean Broadcasting Corporation
CIA	Connection Impact Assessment
CITES	Convention on International Trade in Endangered Species
dBA	A-weighted decibels
DEM	Digital Elevation Model
DOET	Division of Energy and Telecommunications
DNV GL	GL Garrad Hassan Ibérica S.L.
EHS	Environmental, Health and Safety
ELPA	Electrical Light & Power Act 2013. A law of Barbados
EMI	Electromagnetic Interference
EPD	Environmental Protection Department
ESIA	Environmental and Social Impact Assessment
FAA	United States Federal Aviation Administration
FIT	Feed-in-tariff
FTC	Fair Trade Commission
GCO	Grid Connection Offer
GEED	Government Electrical Engineering Department
IBA	Important Bird Area
IDB	Inter American Development Bank
IFC	International Finance Corporation
IUCN	International Union for Conservation of Nature
LDG	Large (Greater than 150 kW) Distributed Generator.
MOE	Ministry of Environment and Natural Beautification
NCC	National Conservation Commission
NGO	Non-Governmental Organization
NHCA	Barbados Natural Heritage Conservation Area
NHD	Natural Heritage Department
PCC	Point of Common Coupling

Abbreviation	Meaning
PPA	Power Purchase Agreement
Ramsar	Convention on Wetlands of International Importance
RER	Renewable Energy Rider
SEF	Sustainable Energy Framework
UN	United Nations
ZVI	Zone of Visual Influence

EXECUTIVE SUMMARY

To be developed upon the validation of the content

1 INTRODUCTION

Inter American Development Bank ("IDB" or the "Customer") retained GL Garrad Hassan Ibérica S.L. (''DNV GL'') to support the development of guidelines and procedures to expand the utility scale wind sector for generation of electricity in Barbados.

This report presents the results of DNV GL's analysis.

Table 1-1 Barbados basic facts

Topic	Content
Location	North Atlantic Ocean (13 10 N, 59 32 W), 160 km southeast of Saint Lucia and 295 km northeast of Trinidad and Tobago
Area	430 km2
Elevation	Highest point at Mount Hillaby, 336 m a.s.l.
Population	294,560 (July 2020)
Installed capacity (2019)	239 MW
Gross domestic product	US$4,713 million (2019)

Sources: https://www.cia.gov/library/publications/the-world-factbook/geos/bb.html
http://data.un.org/en/iso/bb.html

1.1 Objective and scope of review

The objective of this report is to analyze the regulatory environment in Barbados regarding wind project development. In this area, besides the analysis of the existing legislation with regards to environmental policy, social policy and grid integration, there will be a gap analysis and a recommendation list based in the best industry practices in order to ensure a regulated and streamlined development process, that will include not just the compliance with the existing regulations, but an improvement towards the integration of the wind projects in the Barbados society.

2 DRAFT POLICY GUIDELINES

In completing this review and developing the draft policy guidelines, DNV GL focused on the following three areas:

- Administrative management;
- Environmental and Social Impact Assessment (ESIA); and
- Grid integration.

2.1 Barbados electricity market

The Barbados National Energy Policy 2019-2030 [1] (BNEP) recognizes that over 90% of the energy used for electricity production in Barbados is derived from fossil fuels exposing the economy to risks which are difficult to mitigate. One of the policy's main goals is to transition the energy sector to a 100% renewable energy and carbon neutral island state by 2030.

According to an IDB 2016 report on sustainable energy in Barbados [2], the energy sector institutional organizations are as shown in Figure 2-1.

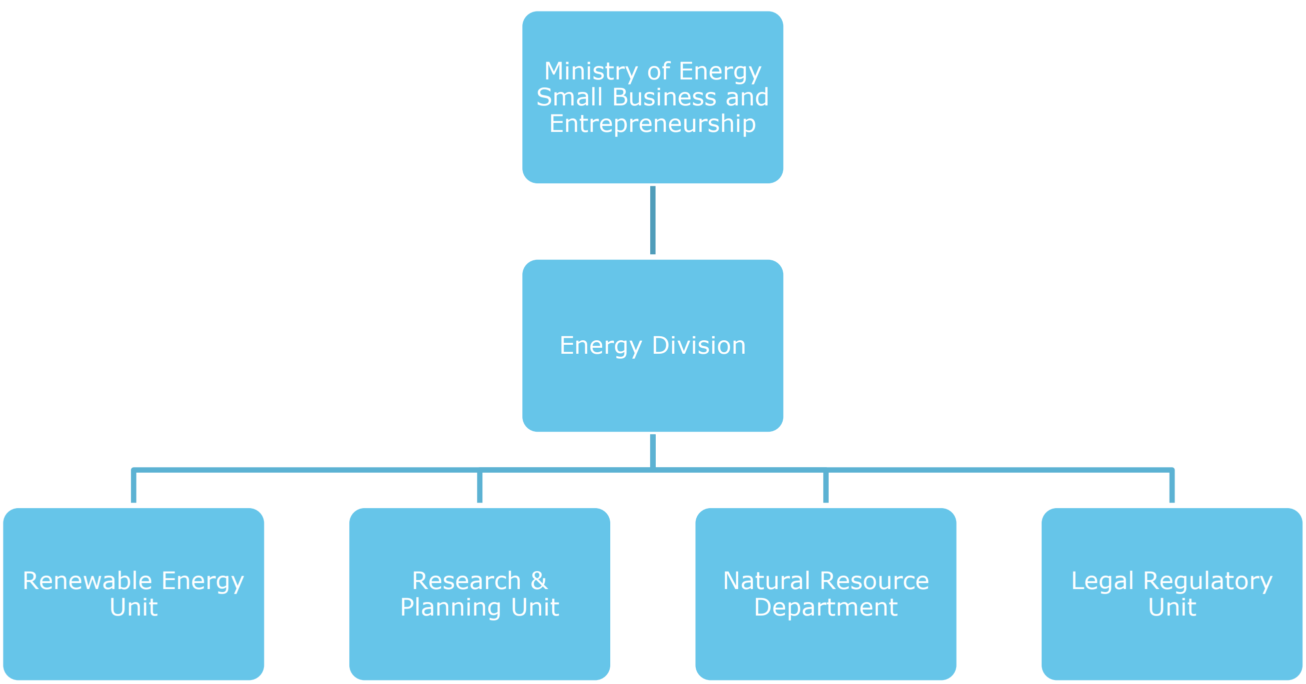

Figure 2-1 Energy sector organization in Barbados

A brief description of each institution’s role is presented in Table 2-1 Institution roles.

Table 2-1 Institution roles

Institution	Role
Energy Division	The Division is part of the Ministry of Energy. It is responsible for the development and monitoring of policies, plans, and providing strategic direction for the energy sector.
Conservation and Renewable Energy Unit	Responsible for the advancement of legislation, policy and programs to give life government’s stated policy which is to transition Barbados to be the first 100% green energy and carbon neutral island state in the world by 2030
Research & Planning Unit	Provides recommendations with regard to sector strategies, infrastructure investments, pricing, and fiscal issues based on collected data.
Natural Resource Department	Promotes the responsible use and exploitation of Barbados’ natural resources including the design of programs that allow for sustainable development.
Legal & Regulatory Unit	Provides legal advice to other units within the division.

Although not part of the Ministry of Energy, the Fair Trading Commission is a government agency that regulates the electricity sector by determining principles, rates, and standards of service for service providers as well as educating and informing consumers about their rights.

Barbados Light & Power Company Limited (BL&P) is responsible for the generation, transmission, and distribution of electricity in all the territory. BL&P is a vertically integrated utility company 100% owned by Emera Inc. [1], a Canadian private company.

Since early 2014 utility scale independent power producers (IPP) are allowed to enter the generation, transmission, and distribution markets [2]; however, in practice this has not occurred, as the development of the regulations for such is not fully developed.

2.2 Administrative management policy guidelines

Typically, a wind project is required to obtain a series of permits and authorizations before being constructed. These permits and authorizations aim to protect the environment, wildlife, and local communities while fostering the development of new infrastructure. Figure 2-2 provides and overview of permits that are commonly required during the development phases of a wind project in most countries with an existing wind energy market.

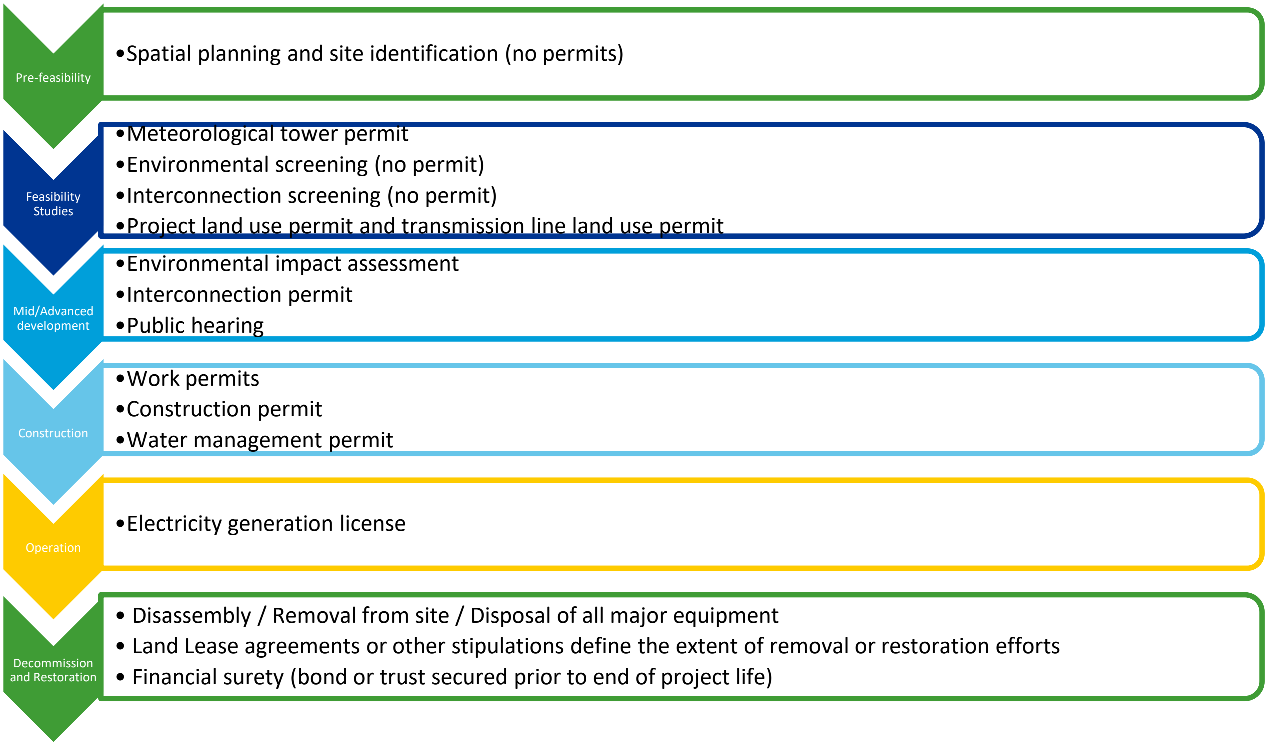

Figure 2-2 Permit process overview

Beyond the permits, it is also required to get to agreements with communities and landowners in order to streamline the project, as the main goal of the developer is to be able to get to the Commercial Operation Date (COD) in the most smooth and direct way.

Pre-feasibility: No permits are required during this phase where a developer can make use of topographic and land cover data, infrastructure geospatial data, wind resource data, natural and physical zones information, and development restrictions to identify areas that can be considered suitable for the development of a wind project.

Feasibility:

- Meteorological tower permit: The purpose of installing a meteorological tower is to collect site-specific wind data. Key wind data variables include average wind speed, wind direction, turbulence intensity, standard deviation, and others, that are essential for accurately estimating the wind project energy production as well as to select a suitable wind turbine model. Meteorological towers typically require an installation permit issued by a local construction authority based on the country's construction code.
- Land use permit and transmission line land use permit: Acquiring the land or entering into long-term land lease agreements of 25 years or more are necessary for the viability of a wind project. Land-use and transmission line land-use permits ensure that the areas selected for the installation of the wind facility assets and the transmission line are registered and approved for such use. A land development and management authority is typically responsible for registering landholdings, issuing land titles and land-use permits, and conducting cadastral surveys.
- Environmental screening: Refers to a high-level evaluation process where the chosen location is analyzed from an environmental perspective. This screening is typically a desktop exercise where key aspects such as flora, fauna, water resources, and archeological features are identified and their sensitivities to the development of a wind project are evaluated.
- Interconnection screening: A developer should have the possibility to know how much capacity can be injected at the substation of interest, which is typically the closest one to the selected site location. An understanding of the system planned upgrades and the capacity in the transmission lines connecting the substation of interest is also of relevance. A screening study is often performed by the transmission operator, at a cost determined by a trade authority and to be paid by the developer, in a time period of approximately three to four months. This is described in the BL&P Grid Code as the connection impact assessment. Typical requirements from the transmission operator to accept an interconnection screening request include identification of the connection point, location of the proposed wind project, a single line diagram of the proposed project, the amount of capacity and energy to be dispatched by the wind project, technical specifications of the wind turbines and supervisory control and data acquisition (SCADA) system, and scheduled commercial operation date.
- Public hearing: Engagement of the community is a key aspect for the successful development of wind projects. A public hearing is meant to inform locals living and working near the proposed project of its impact, project characteristics, listen to the community concerns, answer their questions "in their own language", and collect data to be fed back to the project. Further details on community engagement can be found in Section 2.3.4.

Construction:

- Work permits: While one of the goals of a wind project is to generate local jobs, some of the work to be executed during the project construction almost always requires specialized labor not immediately available where the project is located. For this reason, it is common that some foreign labor is required for some months at the project site. These people should be required to have work permits in accordance with the host country's regulations.

- Construction permit: The construction of a wind project is a complex process that requires detailed planning and management. The project should have maps of the area and details of the construction plan completed in advanced. It is generally recommended to provide a presentation of the construction plan to local residents and planners. A chartered engineer should control the construction process and the compliance with the design documents. Per the BL&P Grid Code, the project should have an approved connection impact assessment, power purchase agreement, and grid connection offer in place before construction starts. More details on these pre-construction steps are described in section 1.1.
- Water management permit: The project needs to follow the general environmental laws that oversee water use and discharge set forth by the Barbados Water Authority. The project should not involve a significant extract, diversion or containment of surface or ground water. More details of the water regulations and policies are contained in section 2.3.2.
- International best practice: AWEA publication Quality during Wind Project Construction (2017) provides a guide for construction phase quality assurance and quality control for utility wind projects [2]. The AWEA QA/QC template includes methods and procedures for the testing, examination and inspection of wind turbine generator foundations [3]. The following international building codes contain provisions and recommendations that are typically applied to wind projects: *IBC 2018 – International Building Code*, and *ACI 318-19 – Building Code Requirements for Structural Concrete and Commentary*. The Barbados government should enforce the application of a building code that incorporates requirements representative of the conditions affecting Barbados and the Caribbean in the last 5 years (i.e. tropical storms, hurricanes, earthquakes). As an example, Puerto Rico updated its building code incorporating significant revisions. According to the Dewberry firm, the 2018 version of the Puerto Rico Building Code provides new wind speed and seismic design category maps, more restrictive design requirements for storm shelters and critical facilities, introduces requirements for the installation of residential photovoltaic panels, and requires the use of more resilient and energy-efficient materials. DNV GL recommends the Barbados government to ensure its building code is up to date and enforced.

Operation:

- Electricity generation license: The wind project must have a registered engineer certify that the project has been designed, tested, and constructed in accordance with prudent utility practices, as well as BL&P's requirements, and applicable standards and codes described within the Grid Code. More details of the Planning Code, Connection Code, and Operation Code are contained section 1.1.

2.2.1 Recommendations

According to [4], the total installed capacity in early 2019 was 239 MW with a peak demand of 152 MW. Although the annual electricity consumption declined during the last 10 years [1], factors such as the electrification of transportation defined in the BNEP are expected to increase the electricity demand in the coming years compared to today's levels. In order to achieve the 100% renewable energy goal by 2030, and taking into account:

(i) the 10 MW St. Lucy solar project was commissioned in 2016 [5],

(ii) BL&P is developing a 10 MW wind project, and

(iii) other utility scale solar and battery storage projects may also be developed,

The potential of the island has been considered in several assessments before, and it could top up to 400MW according several studies [4]. In the current scenario of development of different sources of electricity, a thorough planning process and an aggressive operation of the grid could lead to the penetration of high amounts of renewable energy, which should lower the prices of the energy, based on the actual costs of the technology, but will have to have coupled other sources as storage in order to balance the intermittency of RE. In this scenario and based on the development of other generation sources as well as the holistic planning of the system, DNV GL estimates that between 75 and 100 MW of wind power could be integrated. This would mean that one third of the energy consumption will be satisfied by wind energy. Further penetration of wind energy is possible in terms of space availability though the integration in the island system may need additional investments.

The development of a wind energy project takes an average of 5 to 7 years, from the start of feasibility studies until the project is commissioned and exporting electricity to the power grid. This period assumes a relatively smooth permitting process and availability of development capital. Securing financing is typically a smooth process if the developer has followed good market practices during the development process. In order to achieve the 220 MW goal of wind power, Barbados would need to develop an average of 22 MW per year starting in 2021, which could translate into one wind project of 22 MW size or two projects of 11 MW each.

The Sustainable Energy Framework (SEF) provided the following regulatory regime related recommendations:

1. The Fair Trade Commission (FTC) should require BL&P to demonstrate that its generation expansion plan (i) use internationally recognized least-cost expansion planning software, (ii) includes renewable energy projects, and (iii) take into account oil price forecasts. The expansion plan should be subjected to the FTC's approval.

2. BL&P should be able recover any capital expenditure (CapEx) and operating expense (OpEx) costs invested in a renewable energy project, as approved by the FTC. Since the renewable energy project CapEx plus OpEx costs will be lower than maintaining the *status quo* (i.e., fossil fuel OpEx), this must be reflected by BL&P in a reduced customer tariff.

3. The government should introduce a new law into the parliament to give the FTC (i) the power to issue licenses to IPPs to generate and sell electricity commercially; (ii) the power to require BL&P to purchase electricity from licensed IPPs when their offer price is below BL&P's total cost of electricity to the customers. The previous assumes that the IPPs can supply safe and reliable electricity in compliance with applicable technical standards. In addition, clear operation rules for the system, in terms of dispatching of the IPPs should be established in order to foster investments in the power sector. It is understood that the Barbados Ministry of Energy is responsible for issuing Licenses under the Electric Light and Power Act.

4. The FTC should set principles for power purchase agreements (PPA) between BL&P and IPPs that are fair to both parties. Details of PPA measures proposed by IDB are contained in [7].

Pages 146 to 151 of [7] volume 1 include very specific policy recommendations that should be implemented if the BNEP goal of 100% renewable power is to be achieved by 2030.

Assuming the above mentioned four SEF recommendations are already in the process of being implemented, DNV GL recommends the following additional steps:

1. The FTC should continue to work with BL&P and key stakeholders to periodically update and revise the grid code applicable to renewable energy projects. The grid code will need to adapt to an increasing share of generation from renewable energy sources. The BL&P's ability to model, monitor, and schedule its power network will likely need improvements as more renewable energy sources are added.
2. Grant power to the Renewable Energy Unit within the Government's Energy Division to:
    a. Assist BL&P in matters of revising, reviewing, and finalizing updated grid codes.
    b. Prepare a guideline for local authorities regarding the meteorological tower permit approval.
    c. Draft an interconnection screening workflow inclusive of steps and responsible parties such as BL&P, Government Electrical Engineering Department (GEED), and The Ministry of Energy, Small Business and Entrepreneurship (MSBEC). The Renewable Energy Unit should be available to assist developers through the application process. This workflow should consider infrastructure investments and allow for review of the BL&Ps findings. Both the Renewable Energy Unit and the FTC should have the ability to review and mediate applications to the BL&P power system. Key items for review include PPAs, the terms of grid connection offers, and findings from connection impact assessments.
    d. Identify and collect relevant information for developers related to topics such as exemption from customs duties, income tax exemption, and other financial and non-financial incentives applicable to wind projects.

2.3 Environmental and social policy guidelines

It is widely known and acknowledged that wind energy projects have a lower impact on the environment and human health than conventional power generation projects such as natural gas or coal facilities that depend on fossil fuels to operate. Air emissions such as greenhouse gases or other toxic substances are usually limited to vehicle emissions during the construction phase of wind energy projects; therefore, the production of wind energy does not significantly compromise the ambient air quality and does not contribute to increasing climate change. However, like any source of energy at an industrial level, the construction, operation, and decommissioning of a wind energy project does result in environmental and social impacts that necessitate a clear Environmental and Social Impact Assessment (ESIA) policy framework to be developed and followed.

Designing a successful ESIA framework for wind energy projects involves balancing the desire to provide a clear and simplified process for developers, gaining trust with members of the community through a transparent public engagement process, and ensuring that all potential environmental and social impacts are properly addressed and adequately managed. Given the many factors involved and the large amount of facilitation required, a one-window agency approach, whereby a proposed wind farm developer interacts with a single agency that coordinates with other authorities on their behalf with the purpose of streamlining the overall regulatory process, is often the preferred approach for designing and implementing an ESIA framework.

In Barbados, land development is governed by the Planning and Development Act (2019), which serves to facilitate "*land development in Barbados, taking account of all relevant social, economic and environmental factors, so as to ensure that sustainable use is made of public and private land in the interests of present and future generations of the people of Barbados*''. The Planning and Development Department is headed by the Chief Town Planner, who based on DNV GL's understanding of the existing regulatory framework, would likely be the most well-suited to serve as the lead agency for designing and implementing an ESIA policy specific to wind energy projects in Barbados. The Planning and Development Act also provides a strong existing foundation for the implementation an ESIA as this document specifies requirements and triggers for conducting an environmental impact assessment.

The following sections provide a brief summary and overview of the existing Barbadian environmental and social policy guidelines applicable to the wind energy sector and identify existing policy gaps associated with the development, construction, and operation of wind energy projects. Based on the gaps identified, DNV GL will provide recommendations for the development of new and/or refinement of existing policies for the following topics:

- Flora and fauna studies;
- Waterbody and coastal habitat assessments;
- Archaeological and cultural resources studies;
- Community engagement activities;
- Sound impact assessments;
- Electromagnetic interference studies;
- Aeronautical safety;
- Visual impact studies;
- Shadow flicker assessments;
- Setback development.

DNV GL notes that in developing recommendations for each of these sections, DNV GL has made the overarching assumption that wind energy projects will be added to the "Third Schedule" of the Planning and Development Act and thus, will be considered developments that will be required to undergo an environmental assessment.

2.3.1 Flora and fauna

2.3.1.1 Existing framework

The Environmental Protection Department (EPD) and the Natural Heritage Department (NHD) under the Ministry of Environment and Natural Beautification (MOE) are the primary regulatory agencies responsible for the protection and management of wild flora and fauna and their habitats in Barbados. Barbados is also a signatory to several international environmental agreements, including the Convention on International

Trade in Endangered Species (CITES) of Wild Fauna and Flora, the Convention on Wetlands of International Importance (Ramsar), and the United Nations (UN) Convention on Biological Diversity.

Rules governing the protection and management of flora and fauna in Barbados are included in the following pieces of legislation:

- Wild Birds Protection Act (1978);
- Coastal Zone Management Act (1998);
- Trees (Preservation) Act (1981);
- Fisheries Act (1993);
- Protection of New Plant Varieties Act (2001);
- Planning and Development Act (2019); and
- Soil Conservation (Scotland District) Act (1998).

Of the pieces of legislation listed above, the Wild Birds Protection Act, Coastal Zone Management Act, Trees (Preservation) Act, and Planning and Development Act have applicable rules and regulations for the protection of flora and fauna and their habitats that should be considered for wind energy developments in Barbados.

The Wild Birds Protection Act makes it unlawful to knowingly kill or wound or attempt to kill or wound any of 46 protected bird species native to Barbados. The Act also restricts the possession or exportation of these species or the skins, feathers, or other parts of these species. Like other Caribbean islands, Barbados also provides stopover habitat for neotropical migrants, particularly shorebirds. Some sites in Barbados are listed as key biodiversity areas for migrating birds [8], including Graeme Hall Swamp Important Bird Area (IBA) and Chancery Lane Swamp IBA, both of which are located on the southern coast of the island.

The Trees (Preservation) Act protects native trees that are one meter or more in circumference and makes it unlawful to remove or damage trees unless a permit is obtained from the Chief Town Planner. Therefore, permit approval should be sought if any native tree removal is required for the development of a wind energy project.

Part VI of the Planning and Development Act specifies requirements for the protection of natural heritage sites and conservation areas for flora and fauna and the penalties associated with contravention with these protections. However, there are no specific requirements listed for flora and fauna studies or assessments required for new development activities within proximity to heritage sites.

In addition to the regulations described above, the Government of Barbados has developed several guiding policies and plans for the implementation of regulations to manage and conserve biodiversity in Barbados as well as objectives to expand rules and regulations for the protection of flora and fauna and their habitats, including the following:

- National Biodiversity Strategy and Action Plan (2002);
- Coastal Zone Management Plan (1998); and
- Barbados Sustainable Development Policy (2004).

2.3.1.2 Gap analysis

Based on DNV GL's review of the existing legislation for the protection of flora and fauna and assessment of applicability to wind energy projects, the following regulatory gaps were identified:

- **Absence of current legislation for the protection of wild, indigenous flora and fauna.** Barbados is a signatory under CITES; however, with the exception of the wild birds protected under the Wild Birds Act, there are no general protections for wild flora and fauna that are indigenous to Barbados, including species that may be vulnerable to extinction (e.g., species on the International Union for Conservation of Nature [IUCN] Red List of Threatened Species). Barbados' National Biodiversity Strategy and Action Plan [9] was completed in 2002 and outlines objectives to protect critical habitats for rare and endangered species in terrestrial, coastal, marine, and freshwater environments. Therefore, it is prudent that the Biodiversity Strategy and Action Plan be considered within the context of wind energy projects in Barbados.
- **Absence of requirements for pre-construction studies to assess potential impacts to flora and fauna.** During development of a proposed wind project, it is typical to conduct desktop-level and field assessments to identify the habitat characteristics and potential for species of concern to be present. A desktop-level assessment may include a field visit to determine the need and extent of targeted species surveys.
- **Absence of requirements for post-construction studies to determine impact of operational wind energy projects.** Typically, once a wind energy project is operational, standardized post-construction fatality monitoring studies are conducted to identify whether there are unanticipated impacts to birds and bats as a result of the project. An Adaptive Management Plan (AMP) is usually developed to account for unanticipated impacts and typically includes specific mitigation measures, such as coordination with governmental agencies and implementation of operational minimization measures (e.g., turbine curtailment or shut down for certain risk periods during migration) in instances where defined fatality thresholds are exceeded.

2.3.1.3 Recommendations

Given the lack of specific guidance for wind energy project developments, DNV GL recommends that a guidance document be created that provides specific instructions for the assessment of potential impacts of proposed wind energy projects to flora and fauna, and the implementation of operational studies and measures to minimize and mitigate impacts. Based on DNV GL's previous experience working in other countries and jurisdictions and in consideration of international standards and guidelines for wind energy projects, the following recommendations are provided:

- Conduct wildlife habitat characterization studies to assess terrestrial communities that occur in and adjacent to (e.g., within one kilometer) a proposed wind project area (i.e., the study area). The primary goal of such studies is to identify key habitat for any species of concern (i.e., IUCN Red List species) that may occur in the study area. Wildlife habitat characterization studies are expected to have a desktop-level component and a reconnaissance-level, ground-based field review of the study area by a qualified biologist. These studies would provide key habitat information to ensure that subsequent wildlife studies are targeted to appropriate species and seasons to collect usable data. It is recommended that the field review duration, including a site visit and in-person meetings with local authorities (e.g., EPD, NHD, and/or other non-governmental organizations [NGOs]) to identify habitat for species of concern, would be two to four days in length.

- Conduct terrestrial wildlife surveys for targeted species following wildlife habitat characterization studies to further assess potential species presence in the study area. Species surveys should primarily focus on bird and bat species that may occur in the study area and vicinity during breeding and migratory periods. The rationale for this is that Barbados provides habitat for indigenous and migrating birds, little is known about indigenous bat species on the island [10], and bird and bat species are at risk of colliding with wind turbines. Survey duration should cover a period of six to twelve months to identify and assess potential periods of higher risk, which will also help identify appropriate avoidance, minimization, and mitigation measures to reduce potential impacts. Collision Risk Modeling (CRM) [11][12] may also be considered, particularly if a wind energy facility is located in close proximity to areas of high biodiversity value (e.g., IBA) or occurs in areas expected to concentrate large numbers of sensitive species (e.g., migratory bottlenecks, migratory stopover sites, waterbird overwintering areas).
- Coordinate with governmental agencies and other stakeholders (e.g., non-government organizations (NGO) invested in the conservation of biodiversity in Barbados) to identify appropriate project construction and operational avoidance, minimization, and mitigation measures to reduce risk to flora and fauna identified during wildlife surveys.
- Implement industry best practices [11][12][13] to avoid and minimize potential risks to wildlife, which may include scheduling construction activities to occur outside of sensitive periods for target species (e.g., breeding and nesting periods), conducting environmental staff training, minimizing night-time lighting at substations and operations & maintenance buildings, burying transmission lines, and/or using raptor safe designs on power line poles such as those described by the U.S. Avian Power Line Interaction Committee [14][15].
- For operational wind energy projects, DNV GL recommends the following to be consistent with international standards:
    - Develop a post-construction fatality monitoring plan following the International Finance Corporation (IFC) Environmental, Health and Safety (EHS) Guidelines for Wind Energy [11] for operational wind energy projects and IDB protocols [12]. This plan may include standardized monitoring and estimation of fatality rates through bias trials (e.g., searcher efficiency, carcass persistence) for at least one year.
    - Implementation of other mitigations, including implementing operational curtailment strategies (e.g., adjustment of cut-in speeds) or using ultrasonic acoustic deterrents, may be considered contingent on the presence of species of concern and/or the results of post-construction fatality monitoring [12]. DNV GL notes that preliminary studies of ultrasonic acoustic deterrents indicate they may be effective for reducing bat fatalities for some species at wind energy facilities in the U.S. [16][17]. DNV GL is unaware, however, of any current studies of ultrasonic acoustic deterrents at wind energy facilities in the Caribbean or Latin America and notes that little is known about indigenous bat species in Barbados. The effectiveness of acoustic deterrents for reducing bat fatalities in Barbados is therefore unclear and requires further study.
    - Develop an AMP that follows the requirements of IFC Guidance Note 6: Biodiversity Conservation and Sustainable Management of Living Resources [18] to account and provide

mitigation for any unanticipated impacts to bird and bat species as a result of the operation of a wind energy facility..

2.3.2 Waterbodies and coastal habitats

2.3.2.1 Existing framework

Barbados' regulations for water resources is primarily limited to the management of water quality and control of the release of pollution into waters of the island. Water resources, including marine and coastal habitats, are protected by several regulations and policies in Barbados, including the following:

- Barbados Water Authority (Amendment) Act (2010);
- Barbados Territorial Waters Act (1977);
- Coastal Zone Management Act;
- Health Services Act (1997);
- Marine Areas (Preservation and Enhancement) Act (1985);
- Marine Pollution Control Act (1998);
- Planning and Development Act; and
- Underground Water Control Act (1973).

Due to extensive development for sugar cane plantations on the island, surface water is scarce and only two significant natural wetlands persist, the Graeme Hall Swamp IBA and the seasonal Chancery Lane Swamp IBA [19]. Graeme Hall Swamp is recognized as a Ramsar wetland of international importance and has been designated as a Barbados Natural Heritage Conservation Area (NHCA) because it is the only significant mangrove ecosystem remaining on the island [9]. It is unclear whether the Chancery Lane Swamp is also protected as an NHCA.

In terms of agencies responsible for the protection and regulation of water resources, the Barbados Water Authority (BWA) is responsible for managing, allocating, monitoring, and protecting the water resources of Barbados in the public's interest. The EPD and Environmental Health Department act as regulators of the BWA.

2.3.2.2 Gap analysis

Based on DNV GL's review of the existing legislation for the protection of waterbodies and coastal habitats and assessment of applicability to wind energy projects, the following regulatory gaps were identified:

- **Absence of legislation protecting wetlands.** Wetlands serve as critical ecosystems and provide essential habitat and rest stops for a wide variety of species. As a result, most jurisdictions have adopted stringent regulations to protect wetlands and ensure continued functionality of these water resources. It is typical for wetland legislation to outline requirements specific to the type of development and the extent of disturbance, as well as specify the penalties that will be enforced should the requirements not be adhered to. For wind projects, the primary concern associated with wetlands is impacting wildlife species that use the wetland for habitat or a stopover location. Thus, it is typical for jurisdictions to implement setbacks from wetlands that are based on the turbine tip height.

- **Absence of requirements for development within proximity to coastal habitats.** The absence of requirements for development within proximity to coastal habitats is viewed as a large legislation gap in Barbados, especially with respect to wind energy development due to the risk that wind turbines pose to birds. It is typical for jurisdictions that have coastal habitats to have legislation in place that restricts development, including wind energy projects, within certain proximity to shorelines.
- **Absence of pre-development field study requirements for waterbodies and coastal habitats.** Similar to flora and fauna studies, it is typical for field studies to be required to be conducted prior to construction to evaluate the presence of important water features and habitats that could potentially be impacted by the proposed development. For wind energy projects, these studies generally consist of both observing the species and habitats that utilize these water resources and delineating the water features to ensure adequate setbacks are applied.

2.3.2.3 Recommendations

Recommendations to address the legislative gaps related to waterbodies and coastal habitats are listed below:

- Adopt special land use designations for the Chancery Lane Swamp. Given the fact that only two natural wetlands exist in Barbados, it is critical that special designations be adopted to ensure future protection of these essential wildlife habitats. It is recommended that a minimum 500 m setback from the Graeme Hall and Chancery Lane Swamp, based on turbine tip height, be implemented for wind energy projects.
- Implement a minimum 100 m setback, based on turbine tip height, for wind energy projects from wetlands, watercourses, waterbodies, and coastal waters.
- Require that a desktop and on-site investigation of waterbodies and coastal habitats be completed and documented within a report that is included as part of the ESIA submission.

2.3.3 Archaeological and cultural resources

2.3.3.1 Existing framework

The primary regulatory agency responsible for the protection of archaeological and cultural resources in Barbados is the National Conservation Commission (NCC), which operates under the Ministry of Environment and Natural Beautification. The NCC has the authority to designate historic sites and monuments and protect these resources through permits and licenses. The NCC also has the authority to designate caves.

NCC's administration of archaeological and cultural resource policy is supported by the Barbados National Trust, which is a semi-autonomous NGO, as well as multiple government agencies who have the authority to regulate, manage and protect certain cultural heritage resources. These agencies include the Town and Country Planning Department and the Barbados Museum and Historical Society, which operates under the Ministry of Culture. The Ministry of Planning curates the national register of historic buildings and has the authority to issue development permits that include building preservation orders for historic structures. The Barbados Museum and Historical Society has regulatory authority to declare that something constitutes a relic, acquire antiquities and relics on behalf of Barbados, regulate historic properties and permit the exploration, excavation, and export of archaeological antiquities and relics.

Rules governing heritage resource management and protection in Barbados are contained within the following pieces of legislation:

- National Conservation Commission Act (2002);
- Caves Act (2002);
- Coastal Zone Management Act;
- Tourism Development Act (2002);
- Cultural Industries Development Act (2013);
- Preservation of Antiquities and Relics Act (2006);
- Town and Country Planning Act (1998); and
- Planning and Development Act (2019).

Part VI of the Planning and Development Act specifies requirements for the protection of natural heritage and the penalties associated with contravention of these protections. However, there are no specific requirements listed for the cultural studies and assessments required for new development activities within proximity to heritage sites.

Lastly, the Third Schedule of the Planning and Development Act, lists developments that are located within Heritage Conservation Areas as matters that will require an environmental impact assessment.

2.3.3.2 Gap analysis

Based on DNV GL's review of the existing cultural heritage legislation and assessment of applicability to wind energy projects, the following regulatory gaps were identified:

- **Absence of centralized national register to be used for project screening and assessment.** Barbados currently has the following heritage registers which could complicate the assessment process and increase the timelines associated with project planning and agency reviews:
    - Ministry of Planning: List of Historic Buildings;
    - NCC: List of Shipwrecks;
    - Barbados Museum and Historical Society: List of Archaeological Sites That Have Not Been Formally Adopted; and
    - Management Plan of Historic Bridgetown: List of Heritage Resources.
- **Absence of criteria for cultural heritage resources, procedures for listing a historic resource, etc.** It is typical for cultural heritage legislation or guidance for wind energy projects to include protocol for identification and classification of heritage resources identified during pre-construction field surveys.
- **Absence of requirements for pre-construction cultural heritage desktop and field assessments.** Prior to completing any ground disturbance work within a proposed wind project area, it is typical for a desktop screening for existing archaeological resources be completed. Depending on the results of the desktop screening and whether or not there is a high probability of cultural resources being impacted by project development activities, field investigations including shovel testing to evaluate the presence of cultural resources will be required.

2.3.3.3 Recommendations

Given the large number of acts and legislation related to cultural heritage in Barbados and the lack of specific guidance for wind energy project developments, DNV GL recommends that a guidance document be created that provides specific instructions on the cultural heritage assessment requirements for proposed wind energy projects. Based on DNV GL's previous experience working in other countries and jurisdictions and in consideration of the existing regulatory framework for cultural resources in Barbados, the following approach is suggested:

- Require that a proponent submit the proposed project area to one single agency (i.e., NCC) for review prior to ground disturbance activities taking place. Alternatively, if Barbados was willing to take on the initiative of centralizing the historic resources databases, it is becoming more common for cultural agencies in other countries and jurisdictions to require proponents to conduct an online self-assessment using a screening tool (or equivalent) developed by an agency that contains a centralized database of cultural resources. In this case, the proponent would upload the project area to a form and the screening tool would then determine if additional agency consultation and cultural assessment was required. If the project area submitted does not overlap any listed cultural resources or areas with potential for cultural areas, the screening tool would provide a statement that no further work was required and this could be included as part of any regulatory submission documents to demonstrate that cultural heritage clearance had been obtained for the project.
- As part of the review, the NCC would be required to reach out to other representative cultural agencies for input.
- Once a project has been reviewed, the NCC would issue a record of decision to the proponent that states whether or not the project has obtained clearance to proceed with ground disturbance activities. In the case that there were listed cultural heritage resources and/or potential to impact cultural heritage resources, the NCC would summarize the rationale for their decision and detail the additional steps required by the proponent to obtain clearance. These additional steps could include:
    - Proposing mitigation (e.g. setback and fencing) to avoid or minimize impacts to cultural resources;
    - Conducting a site investigation including shovel tests of the project area to better understand site conditions;
    - Revising the project area to avoid site(s) that are of high cultural significance and should not be impacted.
- The guidance document should also include the requirement for all proponents, regardless of whether or not the project received cultural heritage clearance, to develop an Unanticipated Discoveries Plan (UDP) or equivalent that outlines the steps that a proponent will take in the event that a cultural heritage resource, or evidence of, is encountered during construction.

2.3.4 Community engagement

2.3.4.1 Existing framework

While there are currently no community engagement requirements in place within Barbados that specifically pertain to wind energy developments, Section 30(4)(e) of the Planning and Development Act states that the

Minister shall develop environmental impact assessment regulations that include procedures for public participation in the environmental impact assessment process. Section 30(6) also states that the Chief Town Planner will notify any department or agency of the Government of Barbados having responsibility for the issue of any license, permit, approval, consent, or other document of authorization in relation to an environmental impact assessment application. Lastly, although likely not applicable to wind energy projects under the assumption that these projects will fall under the "Third Schedule", Section 29(1) states that a development order may include a provision that requires a notice of application to be made public.

2.3.4.2 Gap analysis

Based on DNV GL's review of the existing legislation related community engagement and applicability to wind energy projects, the following regulatory gaps were identified:

- **Absence of clear consultation requirements for the public, agencies, and interested groups/stakeholders.** While the Planning and Development Act indicates that the Minister shall develop procedures for public participation in the environmental impact assessment process, there are no existing regulations or guidance in place that outline who should be consulted and how the consultation should take place. The Planning and Development Act also does not specify the specific agencies that will need to be consulted. In order to ensure transparency throughout the public engagement process, it is typical within other countries and jurisdictions for prescriptive guidance related to community and stakeholder engagement.
- **Absence of clear requirements in relation to public meetings and notices.** The Planning and Development Act indicates that public notice of application may be included as part of a development order, but it does not provide clear guidance for what a public notice should include and where it should be published. Required issuance of public notices is considered to be an industry best practice for wind energy projects.
- **Absence of reporting requirements for community engagement activities.** There are no existing reporting requirements associated with the development of community engagement plans and/or the implementation of stakeholder engagement activities in Barbados. Development of a community engagement plan, or equivalent, is considered to be an industry best practice for wind energy projects. Furthermore, tracking stakeholder engagement activities and providing evidence of these engagements is considered to be standard practice for ESIAs.

2.3.4.3 Recommendations

In addition to reducing pollution and delivering a proven reliable source of energy, wind projects provide a significant opportunity for community development. Examples of economic benefits that wind projects can provide to local communities include the revenues associated with local construction and long-term maintenance contracts, an increased and diversified tax base, and long-term employment during operations. In order to ensure a smooth and timely approval process, it is important that these benefits are clearly communicated to stakeholders throughout the entire lifecycle of a wind project. Thus, DNV GL strongly recommends that Barbados develop clear and transparent requirements for community engagement for use within an ESIA framework.

One of the primary objectives for community engagement is to identify, notify, inform, and consult with all potentially interested stakeholders in order to gain a thorough understanding of the issues that are most important to the local community. The recommendations made below aim to enhance community consultation, gain public acceptance, and accelerate the regulatory approval process:

- Given the vague requirements related to consultation and community engagement in the Planning and Development Act and the lack of specific guidance for wind energy, DNV GL recommends that a **community engagement guidance document** be created that provides specific instructions on community engagement and consultation requirements for proposed wind energy projects. Open and proactive consultation should be initiated early on to allow for two-way exchange of information between the wind energy project developers and local stakeholder groups, members of the public, as well as government agencies. In order to ensure consistency and predictability throughout the regulatory review process, DNV GL recommends that the stakeholders, including agencies, that need to be consulted be explicitly identified within the guidance document.
- A **mandatory ESIA kick-off meeting** with Chief Town Planner and other relevant governmental agencies should occur at the beginning of the development phase. During this meeting, a map of the initial location and extent of the wind energy project should be shared with those in attendance in order to obtain feedback from the Chief Town Planner and other invited governmental agencies on the project-specific consultation expectations including identification of stakeholders that will need to be consulted with.
- A minimum of **two public meetings** should be organized to educate and inform local communities about a proposed wind energy project. Information shared during the public meetings should include the location of the project, the project schedule, and the potential environmental impacts associated with the project. DNV GL recommends that the first meeting be held early in the development stage, and the second meeting be held once the draft ESIA report and related studies are ready to be reviewed by the public. This will ensure that concerns are identified and addressed early on the in the development process. DNV GL recommends that questions and comments received during these public meetings, in addition to any other consultative activities associated with the project, be logged for future reporting submissions.
- A **project website** should be created for each proposed wind energy project at the beginning of the ESIA process in order to provide contact information, a description of the project, and the draft and final ESIA application for public review. This is line with best practices from other jurisdictions as well as the Equator Principles (i.e., Principe 10 on Reporting and Transparency) [20]. The project website should be updated regularly throughout the project lifecycle.
- **Notices for proposed wind energy projects** should be published prior to each public meeting. Notices should be published preferably 30 days in advance on the project website, as well as in the local newspapers and online news outlet, when possible. Notices should contain at a minimum the name of the project and developer, the general location and size of the proposed project, contact information, and the date, time, and place of the public meeting. Moreover, DNV GL recommends that notices should also be sent directly to the following stakeholders:
    - Landowners within 1 km of the proposed wind turbines or project area;
    - Primary contacts at applicable government agencies including the Chief Town Planner; and
    - Any other interested stakeholders.

- A **consultation and community engagement report** should be prepared and submitted as part of a complete ESIA application of a wind energy project. DNV GL recommends that this report includes at a minimum:
  - Information on how consultation was conducted;
  - A summary of communication with any members of the public, interested groups and other stakeholders , and primary contacts at regulatory agencies, including the Chief Town Planner;
  - A record of all comments and feedback received by the developer;
  - A summary of how comments were addressed by the developer;
  - Appendices with copies of the notices, evidence of information sharing, written comments received by the developer, and correspondence with the public, government agencies, and any other stakeholders. Sensitive information or personal information from members of the public (e.g., name, address, and telephone number) can be redacted; and
  - A community engagement plan for future phases of proposed wind energy projects is also recommended to describe the ongoing consultation activities that are planned and potential community programs that will be implemented.

2.3.5 Sound

2.3.5.1 Existing framework

While a national sound policy that was intended to address sound pollution in Barbados was passed by the cabinet in 2017, no actions related to legislation development have occurred since then. There are also no sound requirements included within the Planning and Development Act. In recent years, the Barbados MOE, which serves to promote and facilitate the sustainable use of resources, has raised concerns regarding the nuisances and health risks for the public associated with sound pollution. However, based on a review of publicly available information, DNV GL was unable to identify any existing formal sound regulations or requirements within Barbados.

2.3.5.2 Gap analysis

Based on DNV GL's review of the existing legislation related to noise impacts in Barbados, the following regulatory gaps were identified:

- **Absence of formal sound regulations.** Although a national sound policy was approved in 2017, there is no existing legislation or requirements associated with this policy.
- **Absence of formal sound guidelines for wind energy projects.** The sound produced by wind turbines is often a key concern raised by landowners and local communities during the stakeholder engagement process. Various jurisdictions worldwide have developed their own local (general or wind turbine specific) sound guidelines, while others defer to international standards or guidelines from neighboring jurisdictions.

2.3.5.3 Recommendations

DNV GL recommends that a nationwide, comprehensive sound guideline for wind energy projects be developed in Barbados that includes references to other international standards or guidelines, as appropriate. DNV GL also recommends that the guidelines be enforced by the Chief Town Planner, or otherwise designated lead agency for the ESIA framework in Barbados. The following sections provide information, guidance, and recommendations appropriate on the following items and concepts which are typically included a sound policy document for wind energy projects:

- Sound sources;
- Sound receptors;
- Sound propagation modelling;
- Ambient sound;
- Sound limits;
- Layout and turbine technology flexibility; and
- Post construction acoustic audits.

Sound sources

The main sound sources of a wind project are the wind turbines themselves and the main step-up transformer(s) located at the substation. With the exception of existing renewable energy facilities that are located within close proximity to a proposed project and may cause cumulative sound effects, no other sound sources are typically included as part of a sound assessment.

The acoustic characteristics of wind turbines are typically provided by the manufacturer in the form of octave band sound power levels, in A-weighted decibels (or dBA). These are often theoretical calculated values, especially for newer models (see Table 2-2).

Table 2-2 Sample octave band sound levels for a wind turbine

Broadband PWL [dBA]	**Octave Band Sound Power Level [dBA] per Frequency [Hz]**								
	31.5	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
105.5	78.7	88.3	93.8	98.4	98.6	99.6	98.7	91.6	74.1

Transformer audible sound levels[1] are typically provided based on NEMA [22] or equivalent, from which sound power levels are calculated per IEEE C57.12.90 [23]. DNV GL notes that certain penalties or adjustments may be applicable at the sound source to account for sound level uncertainty or acoustic profiles that exhibit unwanted characteristics like tonality or low frequency content, both of which cause additional nuisance.

Based on the above considerations, DNV GL proposes the following recommendations for sound sources:

- Sound assessment reports should include all turbines and substation transformer(s), with octave band sound power levels provided for each. It is recommended that the maximum sound power level of the wind turbine be used at all locations, regardless of wind speed. Safety margins may be added at the discretion of the developer.
- A single turbine layout per application is recommended. Turbine layouts may include alternate turbine locations for flexibility, for a total number of permitted turbines that is slightly higher than the amount that will be built.

[1] Audible sound levels (or sound pressure levels) differ from sound power levels. Sound pressure is measured at a given point at a certain distance from a source, whereas sound power is the amount of acoustic energy emitted by the source, which is required as an input into sound propagation models.

- Transformer sound levels should be calculated per the NEMA and IEEE standards mentioned above. It is recommended that the maximum cooling stage (ONAF2) sound level be used as an input to the model.
- Given the potential for cumulative noise effects, including sound sources from neighboring existing or proposed renewable energy facilities (if any) in the sound model is recommended.

Sound receptors

The most widely used definition for a sound receptor is a residential structure used as a permanent dwelling. However, some definitions of sound receptors may include structures such as churches, schools, hotels, hospitals, temporary cabins or campgrounds, mobile homes, and cemeteries. In some cases, the term participant receptor is used to designate receptors that are either located on land that has been leased to the wind energy project or located on land that is owned by a person who has signed up as a participant to the project and is receiving financial compensation. Depending on the regulations in place, participant receptors are sometimes provided the option to waive their right for sound level limits at their residence which provides the wind energy project more layout flexibility.

Receptors are sometimes further classified by the type of acoustic environment in which they are located. For example, a quiet rural area may be given a stricter classification and a correspondingly lower sound limit than a busier suburban or urban area, or an area close to a highway or railway that already experience higher ambient sound.

In North America, receptor heights are typically set to 1.5 m above ground level within the sound propagation model, except for 2-story homes, which are typically set to 4.5 m to represent the height of a bedroom on the 2nd floor. Taller structures usually receive higher sound contributions originating from turbines due to reduced ground attenuation.

The most common point of compliance determination in an acoustic model is the geometric centroid of the receptor's structural footprint. However, in some jurisdictions, compliance is determined at a specified distance from the receptor or the property line.

Based on the above considerations, DNV GL proposes the following recommendations for sound receptors:

- Receptors should include all permanently inhabited structures located within 1.5 km of a wind project turbine. Schools, churches, hospitals, hotels, cabins, campgrounds, seasonal dwellings, mobile homes, cemeteries, or other structures deemed to be sensitive to sound could also be included in the definition of sound receptors.
- One story and two-story houses should ideally be modeled at a height of 1.5 m and 4.5 m above ground level respectively, representing the heights of the bedrooms. A compliance point located at the center of the structure's footprint is recommended.
- A receptor classification system is also recommended. This may depend on rural versus urban settings, existing ambient noise levels, proximity to and frequency of air or road transportation, and dwelling density. Different classes of receptors may be treated with different levels of regulatory strictness such as applicable limits, at the discretion of the Chief Town Planner.
- Lastly, participant residents/owners may also be given the opportunity to waive or increase their noise limits. However, DNV GL recommends that even participants should have a minimum safety setback distance from turbines.

Sound propagation modelling

There are multiple types of mathematical sound propagation models, but the most widely used model for wind energy projects is ISO-9613-2 [24]. This propagation model takes inputs in the form of:

- Octave band sound power levels for sound sources (wind turbines and transformer);
- Heights and locations of sound sources and sound receptors;
- Elevation and ground cover layers; and
- Attenuation parameters related to ground absorption, atmospheric conditions, barriers, and foliage.

The model outputs the sound pressure level at each receptor, which can be broken down by both frequency and sound source. These sound pressure levels are then compared to the applicable sound pressure level limits in order to evaluate compliance. Sound iso-contours are also commonly produced from this model and used on maps to illustrate sound propagations.

Based on the above considerations, DNV GL proposes the following recommendations for sound propagation modelling:

- A sound assessment report based on the sound sources and receptors listed previously, and performed using the ISO9613-2 model, is recommended to be completed and submitted as part of wind energy project ESIA.
- It is recommended to set the attenuation parameters as follows:
    - Global ground factors ranging from 0.5 to 0.7 are common. Ground factors beyond this range can be used with proper justification.
    - Temperature and relative humidity should preferably be set to values that correspond with the annual averages for Barbados.
    - Terrain screening (or barrier attenuation) is recommended, especially in uneven terrain. This requires elevation data to be input into the model.
    - Acoustic barriers for transformers may be included at the discretion of the developer.
    - Foliage screening is only recommended for dense forestry, as defined in ISO-9613-2.

Ambient sound

Ambient sound is defined as the sound levels associated with sound sources that existed prior to a wind energy project being constructed. Some jurisdictions require ambient sound levels (or baseline levels) to be measured prior to project construction. Others present it as optional, but most jurisdictions do not make direct reference to ambient sound levels.

Ambient sound levels are usually used to establish receptor classification or to make further adjustments to applicable sound level limits as a function of existing sound levels at a given receptor. Baseline levels also provide additional information with which to make a more accurate assessment of sound impact risks to the community.

Based on the above considerations, DNV GL proposes the following recommendation for ambient sound:

- Ambient sound measurements can be treated as optional, at the discretion of the developer or the regulating agency, depending on the sensitivity and environment at a given receptor.

Sound limits

There are various ways to set sound limits for wind energy projects. The most common type of sound limit is an absolute limit, which is based on a project's own acoustic contribution at a given receptor, as opposed to limits based on total cumulative sound levels. However, some jurisdictions use relative limits, which specify an allowable increase relative to existing ambient sound levels (e.g., ambient + 5 dB). In such instances, ambient sound measurements prior to project operations are often required to set the allowable sound limits. Relative limits can help developers site turbines more aggressively in high ambient noise environments but can also create challenges for developers in very quiet environments.

Limits are often different for daytime and night-time periods, with daytime usually having a higher allowable limit. A similar distinction is made for receptor classes and participant status (i.e., participating receptor). Limits can also vary as a function of local instantaneous wind speed. Some jurisdictions have a sliding upward scale, increasing the allowable absolute turbine contribution limit as ground level wind speeds increase in the vicinity of a receptor. This is due to stronger winds causing higher ambient noise levels that mask the sound of the turbines.

Quantitatively, regardless of the method chosen, sound limits at dwellings generally vary between 40 dBA and 50 dBA in most regions that have applicable regulations. This limit is subject to adjustments for special cases, as discussed above (e.g., high ambient sound environment).

Based on the above considerations, DNV GL proposes the following recommendations for sound limits:

- DNV GL recommends an absolute night-time project contribution limit of 40 dBA at all non-participant receptors in a quiet environment. However, if it can be demonstrated that ambient sound levels in Barbados reach close to 40 dBA or more at night on a regular basis, it may be appropriate to raise the default limit to 45 dBA.
- Daytime limits set to night-time limit + 10 dB are recommended. The definition of daytime hours can be left to the discretion of the Chief Town Planner.
- Participant receptors limits may automatically be waived. Non-participants may be given the opportunity to waive sound limits as well.
- Limits may also increase based on receptor classification (e.g., rural, urban, etc.), at the discretion of the regulatory agency.

Layout and turbine technology flexibility

A common issue that arises during the permitting of wind energy projects is the flexibility, or lack thereof, to change the layout or the turbine technology. The need for flexibility often occurs at the beginning of the construction phase, after the noise impact analysis has already been approved.

Most permits allow repositioning of individual turbines within a radius ranging from 10 m to 50 m due to small changes that may arise during construction. However, in cases where more drastic changes to turbine locations are required, an update to the sound impact analysis may be necessary to ensure that there is no increase in predicted sound impacts, which may trigger the need for a permit amendment and subsequently delay construction.

Turbine manufacturers routinely update their designs, and regularly create bigger and more powerful wind turbine models. As a result, it is not uncommon for a turbine model to become obsolete within 2 to 4 years of its introduction to the market. Furthermore, wind developers often have not made their final decision on the project turbine model prior to the submission of their permit applications, which often include a sound impact assessment. Thus, it is somewhat typical that the turbine model included in the original sound impact assessment will have changed prior to construction, which can present permitting challenges and impact project development schedules.

In these situations, permitting flexibility by the regulatory agency is an important advantage for developers. One way to address future wind turbine technology changes in the context of a sound impact analysis is to pre-emptively perform the analysis using a more conservative turbine sound power level. This can be done by adding safety margins to each octave band sound power or to the entire spectrum, or by using the loudest, most conservative turbine model contemplated by the proponent. This can be left to the discretion of the proponent at the time of the application, in anticipation of possibly requiring a louder turbine in the future. If the sound power levels associated with the final selected turbine model are lower than those used in the sound propagation model, the conclusion can then be made that no permit amendment is warranted.

Lastly, in highly competitive markets, it is very likely to have multiple projects being developed on adjacent lands and applying for permits simultaneously. In these situations, cumulative sound levels become a concern and in response to this issue, some jurisdictions have developed a system of prioritization, based on application milestones. This prioritization determines which wind energy projects must consider other more advanced projects in their cumulative sound assessment. However, this situation might not occur in Barbados.

Based on the above considerations, DNV GL proposes the following recommendations for layout and turbine technology flexibility:

- Offer some flexibility of 10 m to 50 m for on-site micro-siting during the construction of the project. More significant layout changes should trigger a requirement to update to the sound propagation model.
- Allow for flexibility in turbine technology, such as allowing for safety margins being included in the sound power level inputs. If the final selected turbine model's sound level falls within this safety margin or is quieter than the previously presented turbine, then no additional onerous administrative filings, amendments and evaluations should be required. In such an instance, a short memo or letter demonstrating that the final turbine model meets the required criteria should be requested to ensure compliance.
- While the issue of cumulative noise from multiple proposed projects might be unlikely to occur in Barbados, it is still recommended to establish application milestones in order to prioritize applications for different projects in the same region.

Post-construction acoustic audits

Some jurisdictions require that compliance at receptors be verified shortly after the wind project becomes operational (usually within 1 year). This is done through post-construction immission testing (I-test), using measurement equipment placed near strategically selected receptors, which can be identified by the regulating agency immediately upon issuance of the permit or determined based on complaints received during operations.

There is no internationally accepted I-test methodology. Different jurisdictions have their own interpretations and requirements, which often depend on the type of sound limit that was imposed in the development phase of the project. If sound contribution from the wind project is to be isolated from background sound, it is common practice to shut down some turbines in the vicinity of the measurement location for at least one hour at night in order to compare operational ("ON") sound levels to baseline ("OFF") sound levels. It is recommended to compare ON and OFF during the same night to maintain atmospheric, meteorological, and other variables as constant as possible.

Once the data is collected, it is necessary to perform quality control and data validation. Data validation mainly involves filtering sound events that are caused by atypical sound sources that are not representative of the acoustic environment in the region and do not originate from the turbines. Other filters may include:

- Wind direction (at ground level or at hub height);
- Wind speed (at ground level or at hub height);
- Turbine power production or RPM; and
- Other conditions such as rain, humidity, traffic, animals, etc.

It is important to collect enough valid data at various wind speeds to perform a reliable analysis. Additional analyses may involve 1/3 octave band analysis to verify if tonal components exist and C-weighted measurements to determine if low frequency components exist.

Based on the above considerations, DNV GL proposes the following recommendations for post-construction acoustic audits:

- A complaints-based audit system, rather than a mandatory post-construction I-test, is recommended.
  - I-tests may be completed at receptors that issue formal noise complaints in accordance to the general methodology mentioned above. This I-test could be completed after discussing with the affected plaintiff and concluding that the complaints appears to be valid (e.g., residence relatively close to turbines, modelled value are close to the allowable limit, etc.).
- If the complaint is in relation to a distinct tone, a 1/3 octave band analysis and penalty scheme is also recommended, according to ISO-1996 [25] or other similar standards.

2.3.6 Electromagnetic interference

2.3.6.1 Existing framework

There are no existing regulations in Barbados specific to wind turbine siting as it pertains to the mitigation of electromagnetic interference, Section 83 of Chapter 282B (p. 66) of the Barbados Telecommunications Act (2001) [26] stipulates that:

> *"no person shall use or permit to be used any vehicle, apparatus, motor, machinery, installation or appliance capable of causing harmful interference with the lawful and normal operation or use of a telecommunications network or telecommunications apparatus or a licensed radio station or radiocommunications apparatus"*

and

> *"a person who… neglects to take appropriate measures to reduce interference to the satisfaction of an inspector… commits an offence and is liable on summary conviction to a fine of $50 000 or to imprisonment for one year or to both."*

2.3.6.2 Gap analysis

Based on DNV GL's review of the existing electromagnetic interference regulations and assessment of applicability to wind energy projects, the following regulatory gap was identified:

- **Absence of wind-specific electromagnetic interference guidelines.** The vertical erection of wind turbine towers and blade rotation can adversely impact radiocommunication systems (i.e., over-the-air broadcasting, cellular networks, and point-to-point or point-to-multipoint systems) in a variety of ways including path obstruction, shadowing, mirror-type (specular) reflections, scattering and AM broadcasting re-radiation. Interference by wind turbines can also have a detrimental effect on the performance of any radar system used to detect air and marine traffic, or meteorological events, especially if they are located within the system's line-of-sight. This may cause the radar to detect non-existing features (false positives), fail to detect existing ones, or to be desensitized and thus presenting a potential hazard to aircraft safety. Some of these impacts include blockage, clutter, and Doppler signal degradation. As a result of these potential impacts, electromagnetic interference guidelines including consultation requirements typically specified within policy documents and wind energy siting guidelines in most jurisdictions.

2.3.6.3 Recommendations

DNV GL recommends that the following electromagnetic interference requirements be implemented and incorporated into the ESIA approval process for wind farms in Barbados:

- Conduct an electromagnetic interference (EMI) study that follows the following general procedures contained within the Radio Advisory Board of Canada (RABC) and the Canadian Wind Energy Association (CanWEA) guidelines [27]:

  1) The proponent creates a map or produces the spatial data representing the proposed wind farm project area or turbine layout configuration.

  2) The proponent provides this information along with a notice of consultation to all the relevant agencies.

  3) The proponent uses a publicly available database of all radiocommunication systems and, with the use of GIS or mapping software, applies consultation zones to these systems and determines whether any of these zones are overlapped by the wind farm project area or turbine layout.

  4) If possible, interference risks are identified, the proponent contacts the owner of the system to inquire whether any further assessment is warranted.

  5) If further assessment is deemed necessary, the proponent and/or system owner may opt to perform the necessary technical studies to determine the extent of the possible interference and develop appropriate mitigation measures.

- DNV GL recommends that the following list of consultation zones, largely based on the RABC guidelines, be applied to all radiocommunication and radar systems in Barbados (to help perform step 3 above), in order to determine if consultation with the system owner(s) is warranted:

  1) Point-to-Point/Point-to-Multipoint Systems (Microwave Links)

  At a minimum, it is recommended that any part of the rotating turbine blade avoid the entire 2nd Fresnel zone [28] for a point-to-point/multipoint microwave link with a frequency above 890 MHz.

Whenever possible, DNV GL recommends applying a more conservative buffer corresponding to three times the maximum width of the 1st Fresnel zone for the entire length of the microwave path, in accordance with the CanWEA/RABC guideline recommendations.

2) Broadcast Transmitters

The following consultation zones around broadcasting radio towers are recommended. DNV GL notes that these are not hard setbacks but indicative regions where turbine placement requires consultation and possibly a more in-depth study:

- AM stations (Directional antenna system): A 15 km radius around the multiple towers.
- AM stations (Omnidirectional antenna system): A 5 km radius around the single tower.
- FM stations and TV stations: A 2 km radius around the transmitter.

3) Over-the-air Reception

When a TV station's service contour overlaps the wind farm area, some residences located within the following consultation zones might be at risk of signal degradation:

- Analog TV stations: 15 km consultation zone from wind turbines.
- Digital TV stations: 10 km consultation zone from wind turbines.

In the event that some residences located within these zones are also within the service contours of a given TV station, a detailed analysis of the reception quality or possible mitigation strategies is recommended.

4) Cellular towers, Land Mobile/Fixed systems, and towers belonging to Point-to-Point Systems below 890 MHz:

DNV GL recommends a consultation zone radius of 1 km around the tower.

5) Satellite Systems

Satellite systems communicate with satellites in space by sending signals skyward. A consultation zone of 500 m around the satellite ground station is recommended, along with an inverted conical shaped consultation zone, extending from the station outward up to 10 km, with dimensions defined by the frequency and the turbine rotor diameter.

6) Air Defense, Vessel Traffic, Air Traffic Control and Weather Radars

DNV GL recommends consulting with the relevant radar operators.

- Require that notifications be sent to the following agencies to determine the potential risks to the functionality of radiocommunication or radar systems throughout Barbados:
  - The Royal Barbados Police Force;
  - Barbados Defense Force;
  - Barbados Ministry of Innovation, Science and Smart Technologies – Telecommunications Unit;
  - Barbados Coast Guard;
  - Barbados Air Traffic Services (Civil Aviation Department);

- Barbados Meteorological Services;
- Barbados Department of Emergency Management;
- Barbados Fire Service Department;
- Emergency Ambulance Service; and
- Caribbean Broadcasting Corporation (CBC).

The notifications should be completed early on in the development process and include a description of the wind project, wind turbine locations and dimensions. DNV GL recommends that the contact information for each agency be included within the guideline document and updated on a regular basis. Alternatively, one governmental entity could act as the single point of contact and be responsible for the coordination with the above agencies; however, DNV GL notes that this is not typical within most jurisdictions and could be burdensome for the selected governmental entity.

2.3.7 Aeronautical safety

2.3.7.1 Existing framework

The only airport in Barbados is Grantley Adams International Airport, located on the southern edge of the country, in the Parish of Christ Church. According to the Airport Restriction Zone Policy [29], no development can occur within 300 m of the airport's radar facility. Additionally, any new development within the 300-1000 m radius around the radar facility must be non-metallic, ruling out the possibility of erecting any wind turbine generator in that zone. The policy also states that no development can occur or within the radar's line-of-sight. Further, the Civil Aviation (Air Navigation Services) Regulations state that "The Director shall ensure that the electronic terrain and obstacle data related to the entire area of responsibility of Barbados are made available in accordance with the Air Navigation Services Standards for use by international civil aviation" [30]. Although no policies specific to wind turbine development or radar interference exist within these regulations, there are several issues to consider.

2.3.7.2 Gap analysis

Based on DNV GL's review of the existing electromagnetic interference regulations and assessment of applicability to wind energy projects, the following regulatory gaps were identified:

- **Absence of pre-screening safety assessment requirements.** Most jurisdictions implement nationwide pre-screening assessment requirements for wind turbines to evaluate potential impacts to aeronautical safety. The most significant impact that wind turbines and their rotating blades have on aviation is the potential interference with Primary Surveillance Radars and, to a lesser degree, Secondary Surveillance Radars. Wind projects have the potential to introduce false positives and false negatives, thereby complicating the ability to properly detect moving aircraft and presenting a risk to aeronautical safety. However, completely avoiding the radar line-of-sight may be too restrictive for wind farm siting. The responsible authority may consider mitigation techniques that could reduce the impact of wind turbines on radar operation, such as wind turbine stealth coating or upgrading radar data processing techniques. The Barbados Civil Aviation Department is in the process of installing a new and more sophisticated radar system that will be able to withstand interference from turbines [4].
- **Absence of wind turbine lighting specifications.** The turbine structure itself can pose a risk of collision with low-flying aircraft, for instance, in low-flying military flight paths. Appropriate turbine

lighting reduces this risk of collision at night or in low visibility conditions and as a result, many jurisdictions have implemented wind turbine lighting specification requirements that must be adhered to.

2.3.7.3 Recommendations

DNV GL recommends that the following aeronautical safety requirements be adopted for wind farms in Barbados:

- Implement a pre-screening safety assessment process that is overseen by both the Barbados Civil Aviation Department and Barbados Defence Force. As part of this screening process, the proponent will submit the project layout and elevations above sea level and these agencies will evaluate any potential hazards to civil and military airspace navigation. If no concerns are identified, the agencies will issue clearance for the wind project. If concerns are identified, direction to resolve these concerns will be provided to the proponent by the agencies.
- Require that any significant change in turbine layout configuration throughout the course of the project's development trigger the need for the project to undergo a reassessment. For context, the United States Federal Aviation Administration (FAA) requires a new filing for structures that have been displaced by one arc-second in either latitude or longitude coordinates, or that have increased in the sum of the ground elevation and structure height by one foot or greater.
- Develop standards for marking and lighting systems for wind projects that must be adhered to. DNV GL notes that installation of a radar-based Aircraft Detection Lighting System (ADLS) near the wind farm to reduce light pollution is becoming more common and is explicitly referenced as a requirement within the guidelines of some jurisdictions.

2.3.8 Visual

2.3.8.1 Existing Framework

No regulations specific to visual impact assessments for wind development exist in Barbados.

2.3.8.2 Gap Analysis

Based on DNV GL's review of the existing visual impact requirements for wind energy projects, the following regulatory gap was identified:

- **Absence of visual impact requirements.** Given the nation's renowned reputation as a prime tourist destination, visual impacts are a very important consideration for Barbados. One of the difficult obstacles to any wind energy development is social acceptability. The visual impact of wind turbines tends to be a concern amongst residents located in the vicinity of a wind project, as their shape and color create a marked contrast with the surrounding natural landscape. As such, visual impact is one of the factors to be considered in the planning stages of a wind project. Presenting visual simulations of future projects during public meetings and individual landowner consultations can garner a greater level of trust from stakeholders by demonstrating transparency and is an effective way to proactively alleviate potential concerns regarding visual impacts.

2.3.8.3 Recommendations

DNV GL recommends that visual impact assessment be required and incorporated into the ESIA approval process for wind farms in Barbados.

A visual impact assessment should include the following components:

1) Landscape Sensitivity Analysis

The main purpose of a landscape sensitivity analysis is to estimate the degree to which a wind turbine development will dominate the surrounding landscape due to cumulative impacts on its quality and character. This typically requires an initial characterization of the existing landscape (land cover, relief, man-made and natural features, the degree of remoteness and/or urbanization) and conducting an inventory of all sensitive visual resources. Then, an assessment is made of all potential aesthetic effects that a wind turbine development could have on these features and resources. This exercise can help to distinguish areas that are deemed acceptable for wind development from those that are deemed unacceptable.

2) A Zone of Visual Influence (ZVI) Analysis

A ZVI analysis is a computer-assisted mapping technique that calculates the number of turbines that will be visible from any point within a given domain, typically within a 20 km radius of the proposed wind farm. This distance might be increased to 25 km if an exceptionally sensitive landscape is found to be located within that range. It is recommended that a high-resolution digital elevation model (DEM) and, ideally, any other data representing vertical obstructions, like buildings or forestry, be employed as inputs to the process [31].

3) Photomontages and Visual Simulations

Once a turbine layout has been designed, it is recommended that the project proponent prepare a series of photomontages (DNV GL recommends at least 4 locations) to serve as an aid in visualizing how the turbine structures will appear against the existing landscape:

- **Selection of Viewpoints:** As a first step, local planning documents, existing landscape analyses, and community stakeholders should be consulted in selecting the most sensitive viewpoints that could be affected by the project. These might include scenic areas like beaches, elevated lookout points, specific residences, or places where large numbers of people tend to congregate (town hall, community center, etc.). Ideally, viewpoints will be selected at different locations and at varying distances from the project to cover a wider range of potential visual impacts. The ZVI analysis can aid in determining the worst-case viewing locations and directions, from which the greatest number of turbines are expected to be visible.
- **Photographs:** Photographs should be taken from these selected viewpoints in the direction of the proposed wind farm, preferably with an unobstructed view, using a digital SLR camera. It is recommended that zoom features not be used as this could potentially distort the image and misrepresent the visible extents from a given location. It is also recommended that the camera focal length used is capable of capturing at least a 50-degree horizontal included viewing angle. Narrow viewing angles may misrepresent the horizontal view span of the human eye and may underestimate the visual impact from that point.

Additionally, it is important that the photographs be taken very close to horizontal, with a clean lens and in relatively high resolution, without sun glare, dust, or other irregularities. It may also be helpful to include some physical features or landmarks in the photograph, which may serve as reference points to help determine the photograph's orientation. It is recommended that the photographs not be taken too close to a proposed turbine location, in order to avoid truncating any part of the turbine in the final simulation.

- **Visual Simulations:** Photomontages can be created using a standard wind industry software that is capable of rendering visual simulations. It is recommended that the photomontages include the original image and the final rendered image at a minimum. They may also include a wireframe technical rendering of the simulation (including turbine labels), a reference location map identifying the viewpoint, and additional project details or photograph/viewpoint specifications (i.e., turbine model and dimensions, camera type, viewpoint description, number of visible turbines, etc.).

4) Mitigation Development:

Once all visual impacts of a wind turbine development have been assessed and summarized, the proponent should develop a set of measures that they will employ to mitigate these effects.

Evaluate visual impacts using a complaints-based approach whereby the approving agency (i.e., Chief Town Planner) considers the stakeholder responses to visual impacts and determines whether or not they have been adequately addressed by the wind farm proponent.

2.3.9 Shadow flicker

2.3.9.1 Existing Framework

There are no existing shadow flicker regulations or guidelines in Barbados.

2.3.9.2 Gap Analysis

Based on DNV GL's review of the existing legislation related to noise impacts in Barbados, the following regulatory gap was identified:

- **Absence of shadow flicker requirements or guidelines.** Although many countries and jurisdictions do not have shadow flicker requirements in place, shadow flicker is one of the most common concerns brought forth by wind farm stakeholders throughout the regulatory approval process due to the potential for annoyance and the widespread, but unfounded, belief that there are negative health impacts associated with exposure to shadow flicker. Similar to acoustic impact, shadow flicker is sometimes perceived as a disturbance at residences generally located at distances of approximately 1 km or less from wind turbines. As the name suggests, rotating wind turbine blades cause a repetitive disruption of sunlight which causes their shadows to flicker at various distances and directions throughout the day.

2.3.9.3 Recommendations

While there are no conclusive scientific studies that suggest the need to implement an allowable threshold for shadow flicker in order to protect the health of residents that live within the vicinity of wind farm, evaluating shadow flicker impacts for a wind project is considered to be a best practice to proactively address stakeholder concerns. As a result, DNV GL recommends that the requirement to conduct a shadow flicker study as part of the ESIA approval process be implemented. Recommendations for the shadow flicker study and suggestions for how the results of the shadow flicker study should be evaluated are listed below:

- Require that shadow flicker modelling be completed at dwellings or other sensitive receptors that evaluates both the "theoretical worst case" and "real or expected case" scenarios for the wind project:
  - **Theoretical Worst Case:** The theoretical worst-case shadow flicker duration is simply based on the geometric calculation of the path of the shadow emanating from the turbine rotor throughout the day, based on the position of the sun, receptors and turbines, summed over the course of an entire year. The turbine is assumed to have a spherical rotor that is always rotating, implying that the rotation of blades can be perceived in all directions around the turbine simultaneously. Other assumptions include a constantly clear sky and houses modelled as a "greenhouse", which means that shadows are perceived from all directions. One additional assumption that is included in this case, which is not quite as conservative, is the maximum impact radius. Typically, it is assumed that the intensity of the shadow flicker decreases with distance from the turbine. After a certain distance, it can be assumed that the risk of adverse human impact caused by shadow flicker is negligible. At this distance, the rotor of a wind turbine will not appear to be chopping the light, but the turbine will be regarded as an object with the sun behind it. This distance is a function of rotor size, hub height, and air turbidity (i.e., opacity, as a function of humidity or other air particles). While it is hard to pinpoint an exact distance where this level of attenuation occurs, the typical assumption is a radius of 10 rotor diameters from each turbine. A more conservative assumption of 10 total turbine heights (TTH), which is equivalent to hub height plus rotor radius, can also be used.
  - **Real or Expected Case:** Additional assumptions are factored into the calculation of the "expected case" shadow flicker durations. This calculation often involves calculation of local monthly cloud coverage statistics, wind direction, and wind speed. Each of these factors contributes to a reduction in shadow flicker duration. Clouds obstruct the sunlight, preventing shadow events. Wind direction orients the rotor in a given direction, which narrows the sector in which shadow flicker can be perceived, and low wind speeds (below the cut-in wind speed) cause the turbine to stop rotating altogether. Other factors can also play a part in shadow flicker attenuation, like vegetation or other physical barriers, window orientation, air quality/opacity, and turbine maintenance/downtime periods, but these factors are usually reserved for case specific investigations at individual receptors that might have expressed complaints or are flagged as high risk.
- Require that the shadow flicker study include results corresponding to both scenarios explained above as well as annual shadow flicker isopleth maps, with turbines and receptors clearly labelled. This report can be used to determine which, if any, receptors might have a risk of disturbance. It is recommended that a conservative shadow flicker impact radius of 10 × TTH be used for this study.
- Apply a complaints-based evaluation approach instead of assessing a project based on a specific shadow flicker limit whereby the approval authority (i.e., Chief Town Planner) evaluates whether a wind farm applicant has adequately addressed stakeholder concerns. While 30 hours/year and 30 minutes/day is the most common limit that is applied for shadow flicker in many jurisdictions and is

included within the World Bank/IFC guidelines [32], DNV GL does not recommend imposing this limit because it has no scientific basis and was based off of one single judicial ruling in Germany[2]. DNV GL's experience, as well as related studies[3], have shown that disturbance from shadow flicker is not always well correlated with annual total shadow flicker duration and depends on other factors. Moreover, actual complaints may occur at various levels of exposure, sometimes above or below these limits, or may never occur at all.

- Unlike a sound impact analysis, transformers do not need to be included in a shadow flicker analysis.

Lastly, DNV GL notes that nacelle-based shadow flicker detection modules can automatically mitigate shadow flicker impact by shutting down turbines during conditions favorable to shadow flicker events at select residences. These modules are commonly used in Europe and have become more prevalent in North American wind farms in recent years. DNV GL does not recommend requiring the mandatory use of such modules on wind turbines as part of the national regulations but notes that such modules may be used at the discretion of the wind developer to further mitigate impacts.

2.3.10 Setbacks

2.3.10.1 Existing framework

There are no existing setback regulations for wind energy developments in Barbados.

2.3.10.2 Gap analysis

Based on DNV GL's review of the existing regulations within Barbados, the following regulatory gap was identified:

- **Absence of wind energy setback requirements.** It is typical within most countries and jurisdictions for a standard set of minimum setback requirements and consultation zones be developed for wind energy projects. Setbacks are typically used and implemented as "hard constraints" while consultation zones are used to ensure that further assessment and/or consultation are conducted in a certain area to confirm that impacts are low.

2.3.10.3 Recommendations

In order to ensure consistency and provide predictability to developers and reviewing agencies, DNV GL recommends that a standard set of minimum setback requirements for wind energy projects be developed. Table 2-3 includes a list of recommended setbacks for implementation in Barbados.

[2] Currently contained in a guideline issued by LAI, which translates to National Working Group for Immission Protection
[3] "Estimating annoyance due to calculated wind turbine shadow flicker is improved when variables associated with wind turbine noise exposure are considered". https://asa.scitation.org/doi/10.1121/1.4942403

Table 2-3 Setback Table

Features	Best Practice Setback	Rationale
Hard Constraints		
Dwelling, cemetery, school, hospital	2 x Total turbine height or 350 m (whichever is the greatest)	Best practice for safety, noise, and visual considerations. The setback could be revised after completion of a noise impact assessment and consultation with stakeholders. Refer to Section 3.5.3.3.
Other Building	1x1 Total turbine height	Best practice for safety considerations.
Participating Property Line	1.1 x Blade length	Best practice to avoid blade overhang on adjoining property. A waiver may be obtained to remove this setback between two adjacent participating properties.
Non-Participating Property Line	1x1 Total turbine height	Best practice to minimize impact on adjacent property.
Public Road (Highway 2A, Primary Road, Secondary Road)	1.1 x Total turbine height from right-of-way	Best practice for safety considerations
Public Road (Local)		Best practices for safety considerations. This setback could eventually be reduced for road segment with low traffic.
Other Road/Pathway	1.1 x Blade length from right-of-way	Best practices for safety considerations. This setback could eventually be reduced for road segment with low traffic.
Overhead Power Line (Transmission, Primary and Secondary)	1.1 x Total turbine height from right-of-way	Best practices for safety considerations.
Underground Power Line (Primary and Secondary)	1.1 x Blade length from right-of-way	Best practices for safety considerations.
Substation	1.1 x Total turbine height from substation boundary	Best practices for safety considerations.
Oil and Gas Well	1.1 x Total turbine height	Best practices for safety considerations.
Oil and Gas Pipeline	1.1 x Blade length from right-of-way	Best practices for safety considerations.
Slope Exceeding 15%	Avoid	Best practices for Balance of Plant construction and upflow angle on wind turbines.
Hydrography (Stream, Waterbody, Wetland)	20 m from stream bank or wetland boundary	Best practices to minimize impact on biodiversity. These setbacks can be revised once stream and wetland delineation and/or characterization are completed.
Flood Hazard Zone	Avoid	Best practices to minimize risk.
Existing Solar Farm	1.1 x Total turbine height from solar farm boundary	Best practices for safety and shading considerations This setback could be revised once shading modelling has been performed.
Open Spaces and Land Use Designations		

Features	Best Practice Setback	Rationale
OS1 - The Barbados National Park	Avoid	Cultural, touristic, recreational, social and environmental sensitivity.
OS2 - Natural Heritage Conservation Areas		
OS3 - Coastal Landscape Protection Zone		
OS4 - Public Parks and Open Spaces (Historic Urban Parks, Coastal/Beach Parks, Recreational Parks and Community Mini Parks)		
OS5 - National Attractions[4]		
OS6 - Barbados National Forest Candidate Sites		
OS7 - Shore Access Points		
Land Use (Community Plan Area - Bridgetown, Community Plan Area - Regional Center, Shopping Center, Mixed Use, Predominantly Residential, Employment, Major Institutional, Resource Extraction, Golf Course, Major Recreational, Tourism, Rural Settlement, Landfill)	Avoid	Conflicting land use.
Land Use (Special Industry, Food & Agriculture)	No setback	
Consultation		
Point-to-Point/Point-to-Multipoint System (Microwave Link > 0.89 GHz)	2nd Fresnel zone or 3 times the first Fresnel zone	Refer to sections 2.3.6 and 2.3.7
Broadcast Transmitter	AM station (directional): 15 km AM station (Omnidirectional): 5 km FM and TV station: 2 km	
Cellular Tower, Land Mobile/Fixed Radiocommunication System, Microwave Towers (Telecommunications Unit Sites)	1 km consultation zone	
Air Defense, Vessel Traffic, Air Traffic Control and Weather Radars	Radar line-of-sight	
Airport/Runways	Variable depending on obstacle limitation surfaces.	
Potential Airport Site	Variable depending on obstacle limitation surfaces.	

[4] Like the St. Nicholas Abbey Heritage Railway

Features	Best Practice Setback	Rationale
Neighboring Wind Turbine (Permitted or pending)	Variable depending on wake impact assessment.	
Resource Extraction (Potential Natural Gas or Oil Exploitation Site, Sand and/or Clay Reserve, Closed Quarry)	Variable depending on consultation with proponent/owner	
Proposed NPC Pipeline	1.1 x Blade length from right-of-way	
Forested Area	Avoid	Tree clearing is subject to a permit from Chief Town Planner, as per the Tree Preservation Act.

The following list of assumptions were made when creating setbacks to be included in the GIS data package:

- Dwellings and other buildings
    - Rogers et al. [4] cites communication with the Barbados Town and Country Development Office's Chief Town Planner, stipulating that the required setback distance from any building is 1.5 x Total turbine height. Given the dimensions of a typical wind turbine used in more recent projects, DNV GL does not consider this setback distance to be sufficient for dwellings.
    - For the purpose of this work, the recommended setback for dwellings is also applied to other buildings as no distinction is made between dwellings and other buildings in the spatial data provided.
    - Setbacks are applied to building footprint centroids as topological errors in the spatial file for building footprint polygons prohibit the geoprocessing of setbacks.
- Property Lines
    - Rogers et al. [4] cites communication with the Barbados Town and Country Development Office's Chief Town Planner, stipulating that the required setback distance from any landowner property is a minimum of 350 m. DNV GL considers this setback distance to be too high.
    - For the purpose of this work, property line setbacks are not applied as no property line data were made available.
- Public Roads
    - Rogers et al. [4] cites communication with the Barbados Town and Country Development Office's Chief Town Planner, stipulating that the required setback distance from any road is 1.5 x Total turbine height. DNV GL considers this setback distance to be too high.
    - Road rights-of-way are estimated using aerial imagery.
- Power Lines and Pipelines
    - Overhead power line rights-of-way are estimated using aerial imagery.
    - Underground power line rights-of-way are estimated to be approximately 5 m.
    - Pipeline rights-of-way are estimated to be approximately 5 m.
- Streams
    - The streams dataset provided appears to be incomplete. As such, setbacks on streams are also likely to be incomplete.

2.3.11 Decommissioning and Restoration

2.3.11.1 Existing framework

There are no existing decommissioning regulations for wind energy developments in Barbados.

2.3.11.2 Gap analysis

Based on DNV GL's review of the existing regulations within Barbados, the following regulatory gap was identified:

- **Absence of wind farm decommissioning requirements.** Decommissioning requirements appear occasionally in state/provincial or local requirements in North America. They also may appear within land lease agreements with individual landowners involved with the wind energy project. There is no standard format for decommissioning requirements, but they cover common points such as equipment removal extent and depth, extent and level of restoration, and cost assurances.

2.3.11.3 Recommendations

Wind farms are composed of very large and complex equipment with a variety of possible long term and short term environmental impacts, as described in previous sections. It is therefore important to restore a project site to its original condition by disassembling and removing major equipment and restoring lost vegetation if applicable.

From a regulatory perspective, DNV GL recommends the following elements to be incorporated in the permitting process and applied in the pre-construction, operational, or end of life phases.

Decommissioning plan report (pre-construction)

In some jurisdictions, a decommissioning plan report is included as part of ESIA and as a pre-condition to obtaining the ESIA approval. Since this report is created early in the project life-cycle, residents and government authorities can be reassured early on that a proper assessment and commitments related to decommissioning have been made. Decommissioning plan reports typically include the following sections:

- Procedures for dismantling the facility;
- Activities related to the restoration of any land and water affected by the facility; and
- Management of recyclable and non-recyclable materials and waste.

While the initial decommissioning plan report is proposed to be completed as part of the ESIA process, it is recommended that an updated report be produced and submitted to the Chief Town Planner for review between 6 and 12 months prior to the actual decommissioning.

Regulatory requirements pertaining to decommissioning activities

Regulatory language typically requires project owners to disassemble and remove all turbine components, as well as Balance of Plant elements such as collector cables, access roads, crane pads, substation/switching station equipment, foundation, operational buildings and transmission line if applicable. Here are some requirements that are proposed to be included as part of a formal regulation or wind project decommissioning guideline:

- For foundations (turbine and transformer) or buried collector cables, it is recommended to require removal down to 4 feet below grade.
- Existing road improvements can be left intact, but turbine access roads are typically removed, especially if they were built on leased farmland.
- Decommissioning exemptions can be made for installations (e.g. operational buildings or other equipment) located on private lands owned by the developer. Moreover, operational buildings or access roads located on leased land can also be sold or donated to the property owner if they desire to repurpose them for farming or other activities.
- Reseeding with non-invasive and native species and restoration of previously removed vegetation or agricultural fields is also typically performed after all equipment components have been safely removed from the site. Monitoring of the restored land should be implemented to ensure successful revegetation.
- The expected start and duration of all decommissioning activities must be communicated to local residents and agencies in a prompt and transparent manner.
- The estimated cost of decommissioning should be communicated to the relevant government authorities.
- In a broader context, disposal or recycling requirements may also be put in place within a national waste management regulatory framework. This may include requirements for proper disposal of lubricant oils, batteries, or other hazardous waste at appropriately equipped waste management facilities on the island, or shipped to adapted facilities off the island.

Financial assurance

It is also recommended to require a more detailed decommissioning cost evaluation study during the operational phase of the wind energy project. This is typically updated every 5 years until the end of the project operating life. The purpose of these studies is to provide the government and the project owner visibility on the expected upcoming costs to decommission the project. In some jurisdictions, project owners are required to provide a financial assurance instrument (e.g. performance bond, letter of credit, etc.) that helps mitigate the risk that owners lack the necessary financial resources to comply with their decommissioning responsibilities.

2.4 Grid integration policy guidelines

2.4.1 Overview

As mentioned in Section 2.1, BL&P currently operates 100% of the transmission infrastructure. BL&P customers that wish to generate electricity and sell to BL&P can do so through the feed-in-tariffs (FIT), and the Renewable Energy Rider (RER) program [33]. The FIT program is revisited annually to meet the goals of the BNEP. As of 2019, the program has allocated up to 32.7 MW of renewable energy capacity to be eligible for a favorable feed-in rate. Of the 32.7 MW, 3 MW have been allocated for land-based wind, with the maximum installation size of 1 MW. For land-based wind installations, the rate is $0.315/kWh. The FIT program seeks to maximize local participation in renewable energy, and provides a 10% increase on the base rate for locally owned programs. Although the integration of larger scale wind power projects is in line with the BNEP, DNV GL considers that the current 3 MW threshold and 1 MW installation limit for onshore wind is too low and therefore the FIT should be updated to reflect the BNEP goals. The adoption of utility scale projects could be incentivized from additional measures within the FIT framework to accommodate modern turbines and industry best practices. Modern wind turbines have a capacity greater than 1 MW limit in the FIT, and utility scale projects require longer development times than 12-month schedule included within the FIT.

A key milestone during the pre-feasibility stage of a project, is a Grid Impact Study. This preliminary study is generally undertaken by the project developer. This study should confirm how the electrical system can safely and reliably integrate the utility scale wind project [26]. In particular, the study needs to establish the capacity of the point of connection, and whether it can handle the power being generated. A Grid Impact Study also considers a holistic view of the entire system. During the Grid Impact Study, a project should not only include consideration for integration with the existing generation and transmission capacity, but include some foresight into the energy planning BNEP. As the policy directives are targeting a 100% renewable generation level, this study provides an opportunity to identify voltage levels, interconnection services, distribution load, new operational practices and additional flexibility that may be needed in order to move closer to the 100% renewable generation target. At the same time, the BL&P must provide a level generation adequacy and ensure that reliable load will be provided. The challenge of renewables is driven by the variability and uncertainty of wind energy. The BL&P must ensure that the transmission system (cables, lines, transformers, etc.) is physically able to handle the new load. Finally, the BL&P must ensure that the existing safety systems will continue to work as more renewable energy sources are added.

In order to maintain a safe, high quality, achievable and reliable operation of the transmission grid, BL&P released the Grid Code in 2017 for interconnection requirements at voltages 24.9 kV and below [35]. The transmission system runs at voltages of 24.9 kV and 69 kV before being transformed down to 11 kV for distribution feeders. Modern utility scale wind turbines output at voltages below 24.9 and typically use a transformer to set-up to that voltage. The Grid Code specifies technical requirements and identify critical planning steps to integrate a new (or modify an existing) project into the power distribution system. It is worth re-emphasizing that the Grid Code does not constitute a design handbook and is not a substitute for any safety code. The Grid Code was produced, after the RER and TIFs programs were established, and includes some consideration for Renewable Energy Supply Integration initiatives. Among other changes, the code was updated to include some protection for operational frequency and faults, which had been identified as an area of concern for renewable energy systems. This current grid code may be suitable for the grid network with low renewable adoption, but will likely need future review to ensure stability with an increase of variable renewable energy sources. The grid code contains three classes of power generation based on the amount of generation, as shown in Table 2-4.

Table 2-4 BLPC large distributed generator classification

Class	Generation capacity
1	Between 150 kW and 1500 kW
2	Between 1.5 MW and 10 MW
3	Greater than 10 MW

The BL&P Grid Code outlines the technical, planning, and operational requirements for the installation or modification of distributed generators connecting to the transmission and distribution system feeders. The BL&P contains series of studies and technical requirements that a project must take to comply with distribution grid. These are divided into three sections within the Grid Code: the planning code, connection code, and operating code. The Grid Code contains separate provisions for projects below 150 kW and above 150 kW. Projects above 150 kW are referred to as Large Distributed Generators (LDG). As projects increase in power output, there are more requirements. Some requirements are for Class 2 and above projects, and additional clauses are applicable only for Class 3 projects.

The project owner must apply for a license for with the Division of Energy and Telecommunications (DOET) and receive validation document before undertaking the application contained within the grid code.

2.4.2 Planning code for generators

The following considerations are part of Section 3: Planning Code for Generators > 150 kW. These sections describe the application process and workflow that LDG facilities must go through to begin operation with BL&P. DNV GL recommends increasing transparency of the application process by sharing project status, findings and information request documents on a public docket. DNV GL also recommends the FTC and/or Renewable Energy Unit, and allow the FIT to serve as third party mediator in the event of disputes. BL&P may need to update their system planning and modelling to adequately plan for renewable energy in the long-term future (months/years) as well as their operational scheduling (day/week).

2.4.2.1 Existing framework

The key milestones for the Grid Integration are described in Section 3 of the Grid Code.

Table 2-5 Milestones contained in the Grid Code

Milestone	Description
Application for Proposed Connection	Developer submits the application contained within Appendix C of the Grid Code. The application includes consideration of the planning code, operation code and connection code sections of the BL&P Grid Code.
Connection Impact Assessment	BL&P reviews the application and evaluates how the additional generation will be intergraded into the transmission and distribution system.
Grid Connection Offer	BL&P provides the terms required for the project to integrate into the transmission and distribution system.
Power Purchase Agreement	Developer and BL&P negotiate terms of generating new electricity.

Installation[1]	After the PPA is negotiated, the generation facility may be installed.
Further Documents Required for Connection	Insurance, Town Permits, design documents of the interconnection and other documents are shared between the project and BL&P.
Interconnection	Commissioning and verification of the new system by registered engineer, to ensure safety during start of operation
Validation	After the new system is operational, performance metrics should be collected and evaluated by BL&P.
[1] Within the BL&P grid code, installation is contained within the Power Purchase Agreement section	

Details on these milestones and sections of the planning code are provided within the following paragraphs.

- **Introduction** (Overall System Planning) – The BL&P needs information so it can plan for the long-term development of the power system. This includes, but is not limited to:
    1. *Connection of new generators or consumers to the network*
    2. *Modifications of existing connections to the grid*
    3. *Longer-term changes to the generation and consumption patterns due to technical, economic, and environmental changes*
    4. *The cumulative effects of the above changes.*
- **Overview of Connection Application Process –** The prospective (or existing) project developer shall submit the application in Appendix C for proposed connection (or modification of existing source) along with a Government Electrical Engineering Department (GEED) approved diagram. BL&P will carry out a connection impact assessment, and shall make a connection offer within 6 months of receiving the application. If the connection offer is accepted, a power purchase agreement (PPA) can be set in place. The PPA should be submitted to the FTC for approval. Once approval of the PPA has been granted, the developer may proceed to install the project. The developer shall submit all remaining additional documents including design and insurance documents to BL&P. Once installation has been completed, all testing and commissioning requirements must be performed. If BL&P has given its written permission, the new system may be connected to BL&P's transmission and distribution system.
- **Application for Proposed Connection –** Extensive studies and technical requirements for the proposed connection must be submitted within the report. The details of these studies are included further below in the section for the Connection Code for Generates > 150 kW.

  DNV GL recommends that a filing notification of the application project be publicly posted. This would allow developers to better plan for the needs of BL&P and neighboring projects, increase transparency, and public engagement with the BL&P. The status of each application should be shared and updated as projects move through the grid code application process.

  DNV GL recommends any information requests from BL&P in response to the application be made public. This ensures transparency during the review process, reduces overhead/delays for developers and BL&P and facilitates future projects from avoiding common requests which may not be included within the Grid Code. During the grid code review process, it allows stakeholders to see common areas which need improvements. The developer should have the option to remove project sensitive information from the documents before they are shared publicly.

- **Connection Impact Assessmen**t **(CIA)** Upon receiving an application for a new facility, BL&P will carry out a connection impact assessment to assess the impact of the operation on the system.

  DNV GL recommends that the finding of the connection impact assessment be posted publicly.

  Should the CIA review process become too resource intensive for the BLPC or not suitable for the adoption of utility scale integration, the Grid Code should be revised by the stakeholders. In the event that an insufficient number of projects are meeting the CIA requirements to meet the renewable energy targets, then the application process should be reviewed. The BLPC, FTC, renewable energy office and project developers should have the opportunity to revise the Grid Code to facilitate the transition to renewable energy targets.

- **Grid Connection Offer (GCO)** – Based on the CIA, BL&P shall make a GCO available to the project. The GCO provides details of the how the connection is made. The GCO can contain additional modifications and charges that the project must undergo.

  The FTC and renewable energy office should have the opportunity to review the grid connection offer. BLPC has the right to request additional charges and modifications to the interconnection application as terms of the grid connection offer. The adoption of renewable energy projects may reduce the lifespan and revenue generated from existing generators. The FTC can serve as a mediator for situations where there is a dispute about the modifications to the project, and which entities are responsible for additional charges.

- **Power Purchase Agreement (PPA) –** If the project accepts the GCO within its validity period, the BL&P and project may negotiate a Power Purchase Agreement. Once the PPA and BL&P have agreed on terms, the PPA is submitted to the FTC for approval. After FTC approval, and all other statutory permissions have been granted, the PPA can be executed. The project can install the generation system.

- **Further Documents Required for Connection** – Insurance documents, interconnection certificates, Electrical Light and Power Act (ELPA) license, safety and design documents for interconnection shall be provided to BL&P.

- **Interconnection –** Commissioning and verification shall be performed by qualified agents using prudent utility practices, applicable standards and codes. BL&P will advise the applicant in writing whether or not the proposed project qualifies for interconnection.

- **Data for Systems Planning –** BL&P may request additional data from the project for system planning purposes. The project shall submit the information without delay.

- **Validation and Verification of Data –** BL&P may request additional information to validate any data submitted to BL&P. In the case of double, the project shall provide access to the BL&P for visual inspection.

2.4.2.2 Gap analysis

The following regulatory gaps were identified.

- **Absence of public notification processes and/or mechanisms in place to distribute information on projects going through the application process.** There is no method of the public, government or project developers to keep track of which projects have been submitted and/or under review.
- **No dispute resolution procedure for the terms of the CIA, GCO and PPA.** If the findings and terms of these milestones are deemed unreasonable by the project developer, there is no recourse to mediate a new solution.
- **No apparent network modelling information within the CIA process**. As renewable energy adoption becomes more widespread, network modelling will be more critical to the entire system. Developers and BL&P should have tools to understand the variable generation capacity of renewables on the grid.
- **Absence of feedback mechanisms between BL&P and the FTC during the CIA and GCO process.** The CIA and GCO may identify infrastructure investments which may require collaborative efforts between BL&P, FTC and project develops to create.
- **No consideration for facility decommissioning and expiration of PPA** – There is no consideration for the expecting life of the machinery (beyond the PPA), and whether the generation facility may extend the PPA or be reconfigured/repowered for additional use.
- **No clarify on GEED Approval**. It is not clear what is required for a submitting a GEED approved single line diagram, and how GEED approval is given.

2.4.2.3 Recommendations

DNV GL recommends that status notifications for projects be made publicly available. This would allow developers to better plan for the needs of BL&P and neighboring projects, increase transparency, and public engagement with BL&P. The status of each application should be shared and updated as projects move through the grid code application process through a publicly available website. Stages include application received, CIA under review, CIA completed, GCO under review, GCO completed, PPA under review, PPA completed, Installation, Operational / Under Testing and Operational / Fully Verified.

DNV GL recommends that any information requests from BL&P in response to the application be made public. This ensures transparency during the review process, reduces overhead/delays for developers and BL&P and facilitates future projects from avoiding common requests, which may not be included within the Grid Code. The developer should have the option to remove project sensitive information from the documents before they are shared publicly.

DNV GL recommends that dynamic and static computer models of the power system stimulations are performed. These studies should assess how the new system will integrate into the grid and inform investment work that may be needed to update the power system. The models must ensure that the load and generation balance is adequate, define the size of reserves and update the scheduling priority. These studies should be designed with future additions in mind, so that any modifications and updates, can be considered a minor change rather than a separate study.

These modelling studies will become more critical as the penetration of variable renewable energy increases. The studies will inform both long-term planning of the grid system to allow for effective development. At the same time, these studies allow for informed forecasting windows for the upcoming day/week ahead that will be part of the operational planning [26]. More details on the system modelling are outlined in Section 2.4.5.

The FTC and Renewable Energy Unit should have the opportunity to review the CIA, GCO and PPA. This review could be triggered automatically or at the request of developers. The PPA format used for conventional generation may be too rigid for renewable generation [26]. BL&P may need external input to draft a format suitable for renewable energy facilities. BL&P has the right to request additional project changes and modifications for interconnection under terms of the grid connection offer. These changes can include infrastructure upgrades, such as increasing the strength and structure of the transmission and distribution networks. In some instances, energy storage systems or more flexible generating units may be needed to solve issues identified with the CIA. The adoption of renewable energy projects may reduce the lifespan and revenue generated from existing generators, and trade-offs may be needed. The FTC can serve as a mediator for situations when there is a dispute over project modifications or infrastructure updates, and how to balance the responsibility of required upgrades between the parties. The BL&P should be able recover costs invested in renewable infrastructure. Incentive programs may offset costs associated with upgrading the grid infrastructure. If additional incentives are needed for renewable energy transition, the FIT could be modified to include provisions specifically for utility scale wind projects. This would include considerations for price, duration, and generation capacity.

Should the CIA review process become too resource intensive for the BL&P or not suitable for the adoption of utility scale integration, the Grid Code should be revised by the stakeholders.

The Grid connection offer is valid for 12 months after the date of submission from BL&P to the project developer. The Grid Code should contain provisions to extend the application.

In the event that an insufficient number of projects are meeting the CIA, GCO and PPA requirements to meet the renewable energy targets, then the application process and renewable energy policy should be reviewed. The BL&P, FTC, renewable energy office and project developers should have the opportunity to revise the Grid Code to facilitate the transition to renewable energy targets.

2.4.3 Connection code

2.4.3.1 Existing framework

The following considerations are part of the Section 5: Connection Code for Generators > 150 kW. These sections describe the technical specifications and studies that a project should undertake when submitting an application for proposed connection. The technical specifications are detailed and robust. The grid code may need additional information on frequency regulation and start-up, as the adoption of variable renewable energy grows. However, these terms should be managed by the BL&P.

- **General Requirements –** The General Requirements of the code form the foundation for a Grid Impact study. This section contains specifications for the safety, reliability, and operability of the new generation unit. It requires modelling of the new unit, as well as designated a point of interconnection.

  Safety is of primary concern and shall be the main consideration when designing the wind project. All electrical equipment and installation shall be in accordance with GEED requirements, BL&P's

Safety procures and BL&P's Information & Requirements Booklet. The project shall restrict their active power to the capacity which was applied and approved. The project shall be maintained throughout the life of the asset to ensure it operates as designed.

The point of common coupling (PCC) shall be identified on a signal line diagram. The project owner is responsible for the design, construction, maintenance, and operation of all facilities on the LDG side of the PCC. All specifications and parameters for voltage, frequency and power quality must be met at the PCC, unless otherwise stated.

Among other requirements, additional details shall be provided on the isolation device, interconnection transformer, high voltage interrupting device, fault levels, and monitoring devices.

The LDG must submit to BL&P a time-domain computer power system simulation with the simulation software ETAP.

The Grid contains provisions for future changes, should additional studies or requirements be needed by BL&P.

- **Performance Requirements –** The interconnection of the LDG facility must not compromise the reliability, operability, or power quality of the grid system. The new facility shall have performance records that demonstrate compliance with the Grid Code. A failure to meet the performance of BL&P's transmission and distribution system, shall result in disconnection until appropriate measures are taken to mitigate the negative impacts.

  DNV GL recommends resonance studies be required for wind utility systems. The increased connection of rotating machines to an electrical power system can lead to greater oscillations. These oscillations can post a threat to system stability and lead to equipment damage. Damping measures may be needed for some utility scale wind systems.

  Wind turbines have some measures to regulate harmonics, flicker, and reactive power capability. The existing grid code provides targets for the LDG facility to meet. Flicker mitigation and frequency regulation can be achieved through control systems. A converter can address low-voltage ride through and provide a wide range of reactive power if sufficiently dimensioned

- **Protection Requirements –** Class 2 systems and above must have dedicated failsafe devices for interconnection protection. Three phase LDG facilities must have trips for over/under voltage, over/under frequency, and other protection elements. All protective device settings and protection schemes must be submitted to BL&P for review. BL&P reserves the right to request additional protection requirements.

- **Operating Requirements –** LDG should operate with the terms of the PPA. Automatic reconnection of class 2 or above unless is not allowed unless special conditions are met. The facility shall not energize when the distribution system is de-energized. The facility shall not energize when the transmission and distribution system is de-energized.

- **Control and Monitoring Requirements –** Control and monitoring facilities shall be required at LDG facilities connected to BL&P's transmission and distribution system for provision of real-time operating data.

- **Telecommunications Requirements –** A secure and robust telecommunication infrastructure must be in place to transmit critical information about power system conditions. The LDG shall provide real-time operating information to BL&P.
- **Metering Requirements** LDG facilities should follow guidelines in BL&P's information and requirements booklet for configuration of the metering facilities.
- **Commissioning and Verification Requirements** LDG facilities shall use a "Confirmation of Verification Evidence Report" to track LDG facility's commission and verification plans and execution. Commissioning of the protection control systems shall be complete and thorough.

2.4.3.2 Gap analysis

- No resonance studies required for wind systems.
- No data backup requirements for telecommunications.

2.4.3.3 Recommendations

DNV GL recommends resonance studies be required for wind utility systems. The increased connection of rotating machines to an electrical power system can lead to greater oscillations. These oscillations can post a threat to system stability and lead to equipment damage. Damping measures may be needed for some utility scale wind systems. Wind turbines have some measures to regulate harmonics, flicker, and reactive power capability. The existing grid code provides targets for frequency and voltage control that the LDG facility must achieve. Flicker mitigation and frequency regulation can be achieved through control systems. A converter can address low-voltage ride through and provide a wide range of reactive power if sufficiently dimensioned.

Telecommunication systems should be designed with robustness and scalability in mind. The LDG generator should be required to archive its own data as a back-up data source. The amount of data being transferred and being analyzed is increasing rapidly. Infrastructure monitoring systems are improving rapidly and more data will inform better scheduling and system modelling for the entire system.

2.4.4 Operation code

2.4.4.1 Existing framework

The following considerations are part of Section 7: Operating Code for Generators > 150 kW. This section of the code contains scheduling and reporting requirements for the operation of the facility. These parts of the code should be maintained by BL&P, and any changes that affect operation should be addressed application process within the planning code. In particular, the PPA can set terms of operation for the wind generator, and its place within the priority queue.

- **Scheduled Outages** – Generation facilities larger than 1.5 MW (Class 2) facilities must submit their plans for scheduled outages to BL&P on a regular basis. Scheduled outage plans shall contain the start and end time for each outage, as well as an alternative outage window. BL&P may request changes to the timing and duration of outages.

  BL&P must be informed with all reasonable speed should outages become necessary at short notice.

- **Operation Scheduling and Dispatch –** The PPA shall govern the dispatch scheduling and/or the position of the LDF Facility in the merit order of the Barbados power system.

  See PPA section for recommendations.

- **Submission of Hourly and Monthly Availability Data –** Facilities of Class 2 or above whose active power is not dispatched, shall submit monthly and hourly availability data.

  DNV GL recommends that this data be shared with the Renewable Energy Office for all renewable power generation sources.

- **Fault & Other Event Reporting Requirements -** LDG owner shall keep an electronic log of all incidents according to international standards. The logs shall document power quality, disturbances, and recording of the sequence of events. The logs shall monitor frequency and other critical metrics of the power system.

- **Operating Reserves** – Operating reserves are defined by the ability of the LDG facility to increase its active power output automatically in response to deviations of the frequency below the nominal value. The PPA may include provisions for Operating Reserves.

- **Power System Restoration –** In order to recover the power system after a total shutdown, it is necessary for BL&P to define a procedure for restoring the system without an external electrical power supply. Renewable systems along cannot easily start on their own during a shutdown.

- **Operational Testing –** BL&P may request the monitoring logs of systems for analysis of system performance. If the data presented in fault records shows the LDG is out of compliance with performance requirements, BL&P may revoke the right to connect.

- **Safety Coordination –** LDG Facilities should abide by local GEED requirements, BL&P's Information and Requirements Booklet, the Grid Code, BL&P's safety procures, the National Fire Protection Association (NFPA) 70, the National Electric Safe Code (NESC) and the National Electric Code (NEC Standards).

2.4.4.2 Gap analysis

No Gaps identified.

2.4.4.3 Recommendations

Safety guidelines should continually be reviewed to integrate new standards and best practices.

2.4.5 System modelling and technical studies

Increasing the quality of models for power generation and network studies, will result in a more effective planning by BL&P of new sources and utilization of existing sources. These studies should be considered living models where additions and modifications can be performed quickly. The grid code supports the exchange of operating data, and the BL&P is responsible for becoming the centralized source of monitoring and performance reporting.

The operator must know the minimum load level, peak level, and load level profile of the entire network. The profiles are typically different on weekdays and weekends, as well as days and nights. The peak level is based on the "loss of load expectation metric", which is the metric when the load will exceed available generation of a given period. Forced outages, and maintenance planning should also be considered in load scenarios. In Barbados this was 24 hours per year based on 2014 Integrated Resource Plan [37]. That plan is currently under review. New targets will be set for increased resiliency and improved response to natural disasters.

The interaction between load levels and renewable energy generation is essential for effectively generation scheduling and future planning of the grid resources. The power output of renewable energy systems is inherently variable. Flexible generators that can rapidly ramp up and down their power generation over time and operate at partial loads will increase the flexibility of the system. Conventional diesel generators may initially fill these roles, although contractual aspects may restrict how they are used. In the event of a sudden decrease in demand, load shedding schemes will be needed to maintain system stability [26].

New concerns may arise as renewable adoption passes higher thresholds. Synthetic inertia, frequency control, and voltage control require more grid level planning. The existing Grid Code contains provisions for "future changes," and new data input will be likely required from the existing generation systems.

Both dynamic and static computer simulation models should be used to understand the impact of adding additional renewable capacity to the grid including generation adequacy, intraday flexibility, and power quality. Load flow studies can assess the reactive power capabilities of generators. A ramping study on reserve requirements and gradient limitations, should also include a frequency stability study. Voltage stability and transient stability analysis will also be required.

With an increased understanding of the new generation sources, a cost benefit analysis should be performed to understand the increased adoption of renewable energy sources. The economic analysis should balance policy goals, with costs to the consumers and BL&P.

2.4.6 Grid code review process

A periodic review of the Grid Code should be conducted to accommodate changing needs of the power system. Revisions of the Grid Code occurred in 2014, 2016 and 2017 which incorporated feedback from public consultation, government departments, energy consultants respectively. Progressive improvements will be needed as new technologies come to the market and more variable energy sources are integrated into the grid. Opportunities and shortcomings of the Grid Code may be identified during application process. In particular, the review of connection impact assessment will determine how the grid can integrate new sources. The stakeholders identified in Table 2-7 should have the opportunity to provide feedback on the Grid Code [35]. If the period between grid code revisions is too slow, the requirements needed for new power generation may fall behind what is needed for a safe and stable grid. As noted in section 2.4.1, if an insufficient number of renewable sources are able to comply with the grid code application process, then the policy and code should be reviewed.

Table 2-6 Grid code stakeholders[5]

Stakeholder	Role in grid code development
Policy makers	Sets the energy policy for the country and legal mandates.
Regulator	Responsible for ensuring a revised grid code is written. Approves grid code and may lead future revisions.
Network operator	Responsible for preliminary studies, grid code draft revisions, consulting other stakeholders, finalizing grid code. Responsible for implementing and enforcing grid code.
Manufacturers, generator owners, installers, Consumers	Consulted during develop of the grid code.

[5] Source: Scaling up variable renewable power: the role of grid codes, IRENA 2016.

3 CASE STUDIES

Communities usually benefit from wind projects in many ways. From the most basic, which is contracting local workforce for the construction and operation of the wind farms, to the renting of the lands. In this environment, each country has developed an almost unique approach. Moreover, there are countries in which different practices are seen in different regions.

Project development practices need to be analyzed carefully as signature of the land rental or purchase, does not always imply that the communities in the project locations will agree with those. Therefore, community information, and implication in the projects, is something that is a must in any project. In most of the cases, it is just a matter of making plain the benefits of the project for the townhall, or municipality, as we were highlighting before, and in the tax payment of the different projects. This constitutes a recurrent revenue stream for at least 20 years. In other cases, different approaches to community issues, such as employment or integration in the environment, must be developed in order to close the loop with the local practices. All in all, is a matter of showing the benefits of the project to the community, financially or socially.

There are a number of community profit sharing mechanisms for renewable energy projects currently used worldwide. Apart from straight taxation of project generated revenue, other methods with more direct links to the community have been implemented, such as:

- Royalties paid directly to landowners or social projects as a percentage of project revenues.
- Community funds put aside by the wind energy project owner and paid annually directly to local community projects or local non-profit organizations. These may be fixed amounts not directly linked to the project's revenue stream, or a percentage of their annual earnings.
- Equity partnership
    - Equity ownership (e.g. a local community group or organisation owns a percentage of project equity and its profits, by means of financial investment or providing land).
    - Subscription model (i.e. individuals in the community may choose to invest in the project's development phase, for an affordable sum. They may receive a portion of the profits but generally do not participate in the executive decision making).

Each of these options has its upsides and downsides, but in all the cases, the maximum transparency of the project owner is required in order to educate the communities and get along positively with them.

The following three case studies provide examples of projects or jurisdictions that have implemented one or more of these community profit sharing mechanisms.

3.1 Case 1: Canada

Location/jurisdiction	Canada
Project name(s)	Several projects. Examples include: Cypress Wind Power Project (Alberta) Parc éolien Pierre-de-Saurel (Quebec) Romney Wind Energy Centre (Ontario)
Type of program and profit sharing mechanism	Equity partnership with local communities, promoted by the utility/system operator (All projects named above) Dedicated funds for community social projects (Romney project)
Description of program and profit sharing scheme	The three largest wind markets in Canada (Ontario, Alberta, and Quebec) have often promoted equity ownership schemes with local communities. These partnerships can be with a cooperative of local residents, First Nations (Canadian indigenous people), or local governments. In 2017, the province of Alberta launched the first of three rounds of Renewable Electricity Programs (REP). These were intended to solicit competitive bids for procurement of renewable energy projects in Alberta. REP Round 2 (total of 300 MW target) was "designed to include an Indigenous equity ownership component to encourage participation by Indigenous communities". A minimum of 25% indigenous equity ownership was required in order to qualify. The five winners were announced in December 2018[6]. The largest of the five winning projects was Cypress Wind Power Project (200 MW), developed by EDF Renewables in partnership with the Kainai First Nation, who invested $CAD 75 million in the project's development, with an expected return on investment of 4% as well as construction and maintenance employment for members of the First Nation[7]. The province of Quebec has also issued four wind energy procurement through requests for proposals (RFP) in 2003, 2005, 2009, and 2013[8]. The 2009 RFP (500 MW target) was solely for projects with community equity partnerships. The first 250 MW was reserved for partnerships with local municipalities/communities and the other 250 MW was reserved for partnerships with First Nation communities. One of the projects awarded is Pierre de Saurel wind farm (24.6 MW), of which 30% is owned by the local government (MRC de Pierre-De-Saurel). The project regularly posts press releases on its website announcing the dividends (totalling approximately $CAD 1.8 million annually), paid to the municipality who has sole decision-making authority on how to reinvest their returns into their community[9]. The 4th RFP in 2013 awarded 450 MW of wind power contracts with a minimum requirement of 50% community ownership[10]. Three projects were awarded contracts. Similarly, the Mesgi'g Ugju's'n wind farm (150 MW) was awarded a contract in parallel to the 4th RFP[11]. This project is an equity

[6] https://www.aeso.ca/market/renewable-electricity-program/rep-results/
[7] https://globalnews.ca/news/4775753/kainai-first-nation-hopes-to-see-financial-benefit-from-wind-project/
[8] https://mern.gouv.qc.ca/energie/energie-eolienne/projets-eoliens-au-quebec/
[9] http://eoliennespierredesaurel.com/documents/
[10] https://www.radiogaspesie.ca/nouvelles/appel-doffre-eolien-lance/
[11] http://www.muwindfarm.com/

	partnership between Innergex and the Mi'gmawei Mawiomi, who owns and controls 50% of the project. Lastly, in the province of Ontario's first Large Renewable Procurement (LRP I) program was launched in 2014, for up to 300 MW of onshore wind (among others). While aboriginal or community equity partnerships were not mandatory, additional consideration, using a point system, was given to projects with such partnerships. EDF Renewables and their Aamjiwnaang First Nation were awarded a LRP I contract for the 60 MW Romney Wind Energy Centre[12]. The Municipality of Chatham Kent was also given the option to participate[13]. This project received the maximum number of points in the "Community Support" category partly because of their equity partnership, which helped them win a contract ahead of their competitors. In addition to equity partnerships, in 2019, Romney Wind Energy Centre launched the Wheatley Area Community Fund[14]. The fund objective is to award a total of $CAD 25,000 annually to locally driven initiatives in and around the village of Wheatley that is within the project area. Beneficiaries to date include the school, food banks, and youth sports organisations.
Concluding remarks	Some of the wind energy procurements and wind projects in Alberta, Quebec and Ontario have successfully employed the community equity ownership model for over a decade and continue to do so. Contrary to government taxation of revenue or confidential landowner lease agreements, this method ensures that more direct, transparent and tangible benefits are felt by local residents and in some cases, may reduce opposition. These partnerships can be a mandatory RFP qualification criterion for wind developers, with a fixed minimum equity percentage to be given to a local community. They may also be optional, but with priority given to developers/projects who choose to implement such a partnership (i.e. Ontario LRP I).

[12] https://www.businesswire.com/news/home/20160414006631/en/EDF-EN-Canada-Announces-Signature-Power-Purchase
[13] https://www.edf-re.com/press-release/edf-renewables-announces-the-signature-of-a-ppa-with-the-ieso-for-its-romney-wind-energy-centre/
[14] https://www.edf-re.com/project/romney-wind-energy-centre/community-benefits/

3.2 Case 2: Mexico

Location/jurisdiction	Mexico
Project name(s)	Confidential (Northern states. Approximately 800 MW of wind projects) Confidential (Oaxaca region)
Type of program and profit sharing mechanism	Royalties paid to communal landowners (per kW installed and per kWh produced) with fixed minimum guaranteed amount. Dedicated funds (Oaxaca) invested in community social projects through a fixed amount unrelated to energy production.
Description of program and profit sharing scheme	In the case of the projects in the northern states of Mexico, a royalty payment system was implemented, both during the development and operational phases of the wind projects. In the development phase, an amount per leased hectare was paid annually to landowners located in *ejidos* (communal land). In the operational phase, these landowners were compensated on a per kW and kWh basis. These operational payments add up to approximately 3% of the net project revenue, or an average of $1,000 per installed MW that is paid to landowners annually for all active projects. A minimum payment amount is also guaranteed, in case of years with very low energy production. It is important to note that these lands are not privately owned by a few individuals but are communal lands (called *ejidos*) that belong to a community as a whole. It was challenging in the beginning as the legal entity of the ejidos was unclear, and caused some hesitation on the part of the lenders, but as projects developed, certainty over this figure was confirmed. Thus, the agreement benefits many people, without raising issues about lack of transparency, preferential treatment, or inequitable distribution of profits. In some cases, payments linked to wind farm production, which does not remain stable over the years, has triggered concerns from the community regarding an unfair management. One lesson learned from these concerns is that educational campaigns and transparency regarding production related payments should be planned and implemented at early stages of development for the community to understand the mechanism and avoid future mismanagement concerns. In the case of the project in Oaxaca, a dedicated community funds approach was taken. Oaxaca is a region with proud Indigenous populations, with a reputation for having high standard of land conservation and new development. As such, the developer implemented several measures to promote community profit sharing with the local community: • More lands than necessary were leased during development of the wind project, in order to increase payments to the community and maximize the number of people participating in the project. • In order to implement the best approach for compensation during the operational phase, a public consultation process was held with the community members and a Social Responsibility Plan was created. It was determined that a Community Project Fund was the favoured approach for the project. A committee of community members, with the supervision of a representative

	from the Energy Secretary (SENER), evaluates community project proposals and decides where to spend the allocated funds. The chosen projects must have a least one of these components: education, health, sustainability and employment. It should be noted that a royalty system ($ per kWh) was proposed as well, but was refused during the consultation process, over concerns of transparency with production results. A fixed fee approach to finance the Community Project Fund was preferred instead. Both cases were implemented through the initiative of the developer. No regulatory or contractual conditions required a profit-sharing scheme, which is common in Mexico.
Concluding remarks	Different schemes are used in different regions of the country, as can be seen in the examples above. The Mexican case studies highlight the importance of community and stakeholder consultation even for profit sharing scheme and community benefits. Contrary the to Canadian examples, where profit-sharing mechanism was stipulated in contractual conditions, the two Mexican projects had more flexibility between the involved parties. A common element in all cases is the desire for transparency and fairness. While the opposition to projects may not always be strong, transparent profit sharing mechanism provides assurances and trust that increase social support of a project. Such initiatives also have the effect of unifying communities by providing a sense of communal identity and purpose.

3.3 Case 3: Denmark

Location/jurisdiction	Denmark
Project name(s)	Several nationwide (under the Buy-Legal System) Middelgrunden (offshore 40 MW)
Type of program and profit sharing mechanism	Equity partnership with local communities - Subscription model.
Description of program and profit sharing scheme	Since 2011, Denmark has implemented the "Buy Legal System". Under this system, developers of onshore wind farms must offer shares worth at least 20% of the project to residents. This was implemented with the intention of turning public opinion in favor of wind farms by encouraging local communities to benefit financially from the projects. A private company is usually hired to distribute the shares that are advertised in local newspapers. Priority is given to residents who are 18 years of age or older and who live within 4.5 km of the wind farm, while the remaining shares are then offered to residents living beyond this zone. The price of the shares is also regulated and cannot exceed the purchase cost of the turbines for the 20% share. In other words, the developer is not allowed to sell these shares for a profit. A single share is sold for approximately 4,000 Danish Kroner (US$700), which corresponds to approximately 1,000 kWh of generation; the share then entitles the owner to the revenue associated with that generation[15]. The case that inspired this subscription-based profit sharing program was Middelgrunden offshore wind farm, which became operational in 2000 and consists of twenty 2-MW turbines located in shallow water in Copenhagen harbor. This was the world's largest offshore wind project at the time. Ten of the twenty turbines were purchased by a cooperative of 10,000 local investors while the other ten turbines are owned by Copenhagen Energy (now called HOFOR), the local utility. This wind farm produces 3% of Copenhagen's energy needs[13]. Shares were purchased in 1,000 kWh increments and were reported to deliver a solid 12.5% annual rate of return in the first few years. This corresponds to a payback period of just 8 years. After 10 years, everyone had received their investment back and were making at least 7% return annually, which is higher than the interest most banks would offer. It should be noted that the newer Buy Legal System does not apply to turbines smaller than 25 m, experimental turbines, or offshore turbines. Lastly, Denmark also has separate provisions to compensate landowners for property value depreciation[16], applicable to land within 6 tip heights of a turbine[17]. A claim can be filed at no cost by the landowner.
Concluding remarks	This Denmark "Buy Legal System" government lead initiative was built into the country's regulations. Therefore, it does not allow much flexibility for negotiations between the involved parties and developers were reluctant at first. However, this community profit sharing mechanism proved to be effective at reducing opposition and increasing social

[15] https://www.forbes.com/sites/justingerdes/2012/10/22/community-wind-projects-poised-to-take-off-in-denmark/#3f9ef6807e4f
[16] https://www.deutschland.de/en/topic/environment/wind-power-is-a-model-for-success-in-denmark
[17] http://energytransitionkorea.org/sites/default/files/2019-01/Denmark%20Business%20Authorites%2C%20Onshore%20Wind%20Turbines%20in%20Denmark%202.pdf

	acceptability of wind projects, in a climate where opposition was beginning to grow due to the large number of wind turbines in the country. Some of the key advantages of this system are potential profit sharing directly to local residents and the opportunity to help finance projects with a larger pool of investors, thereby relying less on banks or other large corporate investors. While this model provides some project equity to public investors, it typically does not allow smaller shareholders to participate in the executive decision-making process related to the project's management. A possible drawback of this model might arise in areas with pronounced income inequality, where richer residents have access to more capital for investing in the wind projects over the less fortunate. Nonetheless, this drawback can be countered by relatively affordable shares with a cap on the number of shares a resident can purchase.

Several community profit sharing mechanisms were presented in the case studies above. A common advantage of these mechanisms is that they increase social acceptability of wind projects and benefits to communities. While profit-sharing programs bring many benefits, they should nonetheless carefully balance the needs of all parties (e.g. local residents, developers, investors, regulators, etc.) and be tailored to the development opportunities specific Barbados.

Other examples include:

El Salvador: In the 2014 competitive auction for 100 MW of solar and wind, 3% of the revenue was required to be reinvested in social projects in adjacent communities. These communities typically present proposals for projects that are voted on by assembly elected representatives.

Ecuador: Similarly, in Ecuador's Feed-in Tarif program, projects were required to invest an amount per kWh to local community development projects.

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