Setting the path for

**Wind Energy Generation in Trinidad & Tobago**

May 2023 Report

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European Investment Bank
IDB Inter-American Development Bank
IFC International Finance Corporation
Setting the path for
Wind Energy Generation in Trinidad & Tobago
Study performed September 2022 to April 2023

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Foreword

The days of fossil energy supremacy are evidently numbered. Natural gas will be essential for two or three more decades but, if we want to leave a safe and sustainable planet to the next generation, the choice must be renewable energy.

Trinidad & Tobago pledged as commitments under the Paris Agreement to increase the percentage of renewables onto its energy mix; decarbonize its industry; and endorse clean and efficient transportation. Wind energy is a direct answer to these first two pillars, ultimately contributing to the third.

However, the path to wind energy generation is long and challenging. A judicious approach recommends starting at small-scale immediately, aiming ambitious targets and moving fast. There is no time to waste.

This report results from work of an independent multidisciplinary team over a period of 8 months. Its aim is to set an achievable way forward towards wind power generation, pinpointing the stages from the moment wind is contemplated as a potential solution, to the decommissioning of turbines 25 years later.

The study includes a scientific desktop survey identifying the best locations for wind power generation in Trinidad & Tobago, both onshore and offshore. The economics of wind exploitation and legal framework required for renewable energy production are also depicted.

Finally, this report intends to reveal findings and suggest recommendations. It belongs to the decision makers and stakeholders to consider its usefulness. No solution is unique though the solutions hereby proposed should be taken into consideration.

Having a strategy for wind power generation, the next major step will be to undertake a Wind Resources Assessment Programme. Only measurements collected over a period of at least 12 to 18 months can produce reliable bankable data and ensure fair winds on the road ahead.

Peter Cavendish
EU ambassador to Trinidad & Tobago
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Executive Summary
This report presents a draft strategy for developing a wind industry in Trinidad and Tobago covering the period until 2035 describing the steps that should be taken for its successful deployment. The aim is to create a sustainable energy future for the country while promoting growth and reducing greenhouse gas emissions. Success will depend on the active collaboration of stakeholders, namely the Ministry of Energy & Energy Industries (MEEI), Ministry of Public Utilities (MPU), Ministry of Planning & Development (MPD), Attorney-General & Ministry of Legal Affairs, state agencies and technocrats, funding agencies and developers, financial institutions and, crucially, the private sector.

The Government of the Republic of Trinidad and Tobago (GORTT) will play a critical role in facilitating the development of the wind industry by promulgating a vision for Wind; amending and enacting laws and regulations supporting a policy framework that promotes growth; initially providing financial and economic incentives; and establishing a transparent process for developing wind energy projects according to the best international practices.

Wind Energy Project Cycle

This report builds on the work of a Baseline Report where a robust analysis of suitable locations in Trinidad and Tobago was conducted identifying potential utility sized windfarm sites, both onshore and offshore. These sites were identified and ranked for suitability together with an estimate of their levelized cost of electricity (LCOE). Assessment of the legal and regulatory framework as it pertains to wind energy was conducted to identify gaps within said frameworks for creating a sustainable wind energy industry.

In total, approximately 2.75 GW of onshore wind power is expected to be available and 32 GW offshore.

For the country to benefit from its untapped wind energy potential, a clear and transparent legal and regulatory framework should be adopted to effectively enable wind energy development. This report speaks of a vision to create a wind industry, and gives recommendations on how to develop it through steering the efforts of all key stakeholders.

*For fixed offshore structures.
To achieve the target of 2 GW installed wind capacity by 2035 the actions proposed are time bound in sequential horizons / milestones. To build local capacities and capabilities the wind journey should start from exploiting the onshore wind energy potential and gradually move towards exploiting its offshore vast potential.

While discrete projects can be developed on an ad hoc basis, the creation of an industry that can “green” the country’s energy mix and add further value to the local petrochemical industry, must be carefully thought out, nurtured, and enabled.

The recommendations outlined in this report, aim to contribute to the dialogue on how the country can achieve its vision of a secure, sustainable and carbon-free energy future while promoting economic growth.
Introduction
Aim of this Study
Trinidad and Tobago is actively pursuing the development of its renewable energy sector with a renewed commitment to the Paris Accord target of 30% renewables by 2030. The country has made significant progress having sanctioned in December 2022 its first large scale solar photovoltaic facility (112 MW solar PV), the largest in the English-speaking Caribbean. As the country seeks to advance its renewable energy goals, wind energy has emerged as the leading contender for utility scale sized developments.

The country’s energy sector is currently dominated by the oil industry which has enabled T&T to hold a place among the industrialised nations around the globe and in parallel be among the top global players in Hydrogen and its derivatives (ammonia, methanol). The recent roadmap for a Green Hydrogen economy recognised that wind generated electricity can become a prime enabler of the country’s shift to decarbonisation while at the same time ensuring sustainable economic growth and maintaining the country’s leadership in the petrochemicals sector.

The aim of this study is to propose a strategy to develop wind power generation in Trinidad and Tobago. The study encompasses, through an implementation plan, an assessment of the steps in the exploitation of wind energy covering all phases; from the analysis of wind potential to the decommissioning of assets at the end of their useful life. More specifically the study proposes plans for the execution and performance of a wind resource assessment program (WRAP) at potential areas across the country identified through a multicriteria selection process, for determining the possibility of wind generation on a utility-scale, both on-shore and off-shore. In addition, the study provides recommendations for improvements and additions to the existing legal and regulatory frameworks to enable the development of the wind industry in the country.

Implementation Plan
This document aims to provide a basis and a reference point in support of the development of the wind energy industry in Trinidad and Tobago in terms of actions including policies, programs, and projects. The implementation plan serves as a strategic planning document and a proposal that outlines the steps required to achieve the country’s wind energy vision.

Technical, economic, and regulatory enablers are identified and analysed and a series of action steps that should be undertaken to create an enabling environment stimulating investment and innovation in the renewable energy sector are outlined.

It also seeks to establish a transparent and consistent vision for the development of wind energy in the country and serves as a guide for decision-makers and stakeholders, including government agencies, private sector entities, and civil society groups, on the policies, regulations, and possible incentives needed to promote wind energy deployment.

As part of the implementation plan, a monitoring and evaluation mechanism is outlined that can be used to track progress towards achieving national renewable energy targets in wind. Performance indicators are suggested that enable stakeholders to measure progress and identify areas where improvements might be needed. The monitoring and evaluation framework will also ensure that the proposed wind energy roadmap remains relevant and effective over time as the country’s needs evolve, while contributing to its sustainable development.
**Key Stakeholders**

There is a clear understanding from key stakeholders that the abundant wind energy resources need to be introduced into the country’s energy matrix. Broad support has been expressed for the realization of a wind energy development programme, which requires alignment within the key stakeholders on what is needed to be done to create a thriving wind industry.

Achieving an initial target of 2GW by 2035 will require the cooperation and alignment of several stakeholders, local or international, including the government, the regulator, developers, investors, financiers, local communities, and environmental groups. Each of these stakeholders’ contribution would be needed for Trinidad and Tobago to implement a successful wind energy strategy.

Effective stakeholder engagement and communication will be crucial to gain support, ensure transparency, and overcome any concerns or conflicts that may arise during the development process. A collaborative approach that promotes stakeholder participation and considers their diverse perspectives will lead to better outcomes, improved social acceptance, and a more sustainable and inclusive energy transition.

**NON-EXHAUSTIVE LIST OF STAKEHOLDERS**

<table>
<thead>
<tr>
<th>Ministry of Energy and Energy Industries (MEEI)</th>
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<tbody>
<tr>
<td>Ministry of Public Utilities (MPU)</td>
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<tr>
<td>Ministry of Planning and Development (MPD)</td>
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<tr>
<td>Ministry of Works and Transport (MOWT)</td>
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<td>Ministry of Agriculture, Land and Fisheries (MALF)</td>
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<tr>
<td>Commissioner of State Lands</td>
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<tr>
<td>Ministry of Finance (MF)</td>
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<tr>
<td>Attorney General and Ministry of Legal and Regulatory Affairs (AGLA)</td>
</tr>
<tr>
<td>Regulated Industries Commission (RIC)</td>
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<tr>
<td>Town &amp; Country Planning Division (TCPD)</td>
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<tr>
<td>Environmental Management Authority (EMA)</td>
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<tr>
<td>Trinidad and Tobago Electricity Commission (T&amp;TEC)</td>
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<tr>
<td>National Gas Company (NGC)</td>
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<tr>
<td>Institute of Marine Affairs (IMA)</td>
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<tr>
<td>Maritime Services Division</td>
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<tr>
<td>National Energy (NE)</td>
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<tr>
<td>Trinidad and Tobago Meteorological Service</td>
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<tr>
<td>Civil Aviation Authority</td>
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<tr>
<td>Offshore operators (BP, Shell, Woodside, DeNovo, Perenco, EOG Resources)</td>
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<tr>
<td>Tobago House of Assembly (THA) and Regional Corporations</td>
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<tr>
<td>Public advocacy groups (Energy Chamber of Trinidad and Tobago (ECTT, etc.)</td>
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<tr>
<td>European Union (EU)</td>
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<tr>
<td>European Investment Bank (EIB)</td>
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<tr>
<td>Inter-American Development Bank (IDB)</td>
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<tr>
<td>International Financial Corporation (IFC)</td>
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<td>United Nations Development Programme (UNDP)</td>
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</table>
Vision and Targets
A Vision for Wind Energy Development

Trinidad and Tobago, by virtue of its oil and gas reserves, has long been regarded as leader in energy in the Caribbean. This leadership position has allowed the country to develop significant strengths in financial capability, human resource capability and industrial infrastructure. The country is ready to leverage these strengths, all of which are key components to achieving a leadership position in wind energy deployment, while at the same time achieving its climate neutrality.

A carbon neutral Nation and a regional wind energy leader

Trinidad & Tobago’s vast Wind Energy resources can play a key role in the sustainable development of the country providing clean, reliable, and affordable energy. Wind Energy can contribute to lowering the country’s dependence on fossil fuels and accelerate reduction of its GHG emissions beyond the levels committed in the intended nationally determined contribution (INDC) (2).

Both on-shore and off-shore exploitable wind energy potential exceeds 25 GW, far beyond its current and foreseeable power generation capacity, allowing the country to design and explore pathways in the evolving global energy landscape.

Country Goals and Targets

With such a wind energy potential, the country can feasibly have at least 2 GW of wind energy capacity installed by 2035. To achieve this target several precursor steps or actions must be accomplished including political commitment which will, in turn, be translated into policies and an enabling environment through a specific, measurable, assignable, realistic and time bound goal setting exercise.

By 2035, the Government of Trinidad and Tobago will ensure that wind energy will be a significant contributor to the energy mix, with a target of at least 2GW of installed generation coming from wind energy sources.

2 https://unfccc.int/docents/497984
Baseline for the development of the wind sector
Global Wind Atlas® (1) provides a revealing indication of the wind energy potential of the country. For onshore wind energy development, the highest wind speeds in Trinidad are located within the northern mountain ridge which is characterised by very complex terrain, while in Tobago the highest wind speeds appear in the north-western part of it. These, however, may not be the most feasible areas for wind energy development, due to constraints that are not visible at first sight. Similarly, the offshore wind potential appears to promise exploitation of wind energy at large scale supported by favourable wind conditions and shallow waters.

A Wind Resource Assessment Programme (WRAP) builds on two axes, to evaluate the wind energy potential and lay-down all necessary steps to meet the country’s wind energy vision and targets.

**Potential areas for Wind Energy development**

A rigorous site selection methodology using wind resource data from the Global Wind Atlas® and available local georeferenced (GIS) data, revealed several high potential sites for onshore and offshore development that could be utilized to develop the country’s wind energy potential.

**Onshore Trinidad & Tobago**

Twenty (20) layers have been considered to determine onshore site suitability. These layers were separated into Reduction layers and Weighted Overlay layers. Reduction layers have been used to identify those areas that are not suitable for wind development. In addition, for those areas favourable for wind energy development, weighted Overlay layers were also applied representing the importance or relevance of each one, to identify the most relevant areas for wind energy development.

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1 https://globalwindatlas.info/en/
Onshore Suitable areas:
Nine (9) areas, each of a minimum size of 1000 hectares, are identified through a Weighted Overlay Analysis for the development of wind energy projects. All areas showcased were determined to be of high suitability for wind farm placement.

Potential Sites For Construction

<table>
<thead>
<tr>
<th>Site Label</th>
<th>Site Name</th>
<th>Potential Capacity Output (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>North Coast, Blanchisseuse</td>
<td>100</td>
</tr>
<tr>
<td>B</td>
<td>North-East Coast, Toco</td>
<td>155</td>
</tr>
<tr>
<td>C</td>
<td>North-East Coast, Fishing Pond</td>
<td>260</td>
</tr>
<tr>
<td>D</td>
<td>South-East Coast, Galeota</td>
<td>515</td>
</tr>
<tr>
<td>E</td>
<td>South Coast, Los Iros</td>
<td>330</td>
</tr>
<tr>
<td>F</td>
<td>South-West, Palo Seco</td>
<td>865</td>
</tr>
<tr>
<td>G</td>
<td>South, San Fernando</td>
<td>180</td>
</tr>
<tr>
<td>H</td>
<td>Central Range</td>
<td>240</td>
</tr>
<tr>
<td>I</td>
<td>West Coast, Orange Field</td>
<td>120</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td><strong>2,765MW</strong></td>
</tr>
</tbody>
</table>
Setting the path for Wind Energy Generation in Trinidad & Tobago

Offshore Trinidad & Tobago
Another fourteen (14) layers have been considered to determine offshore suitability. Several of these layers fall into the reduction analysis and others have been considered as most suitable for the weighted overlay analysis. As Trinidad and Tobago’s maritime boundary is relatively large, generous setback distances were considered from layer boundaries. While development is possible just on the edge of some of the boundaries (Maritime and Marine Protected Areas), buffer zones have been taken into account to define the potential wind development areas (zones).

Offshore Suitable areas:
Five (5) broad areas have been identified for offshore wind development (labelled Site A to E) representing most feasible areas for the development of offshore wind energy projects due to shallow water depths, transmission proximity and do not fall inside exclusion zones.

<table>
<thead>
<tr>
<th>Site Label</th>
<th>Site Name</th>
<th>Potential Capacity Output (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>South-East Coast Offshore, Galeota</td>
<td>1,255</td>
</tr>
<tr>
<td>B</td>
<td>South Coast Offshore, Los Iros</td>
<td>790</td>
</tr>
<tr>
<td>C</td>
<td>West Coast Offshore, La Brea</td>
<td>225</td>
</tr>
<tr>
<td>D</td>
<td>North Coast Offshore, Diego Martin</td>
<td>175</td>
</tr>
<tr>
<td>E</td>
<td>Tobago South-East Coast, Crown Point</td>
<td>350</td>
</tr>
<tr>
<td></td>
<td><strong>Total capacity for areas of very high potential</strong></td>
<td><strong>2,795</strong></td>
</tr>
<tr>
<td>F</td>
<td>Other High potential Fixed Bottom Areas around T&amp;T</td>
<td>27,830</td>
</tr>
<tr>
<td></td>
<td><strong>Grand Total</strong></td>
<td><strong>30,625</strong></td>
</tr>
</tbody>
</table>
A Huge and competitive Wind Energy potential
The wind energy capacity that can be developed in Trinidad & Tobago exceeds 30 GW, the lion’s share of which is offshore. The onshore potential can reach more than 2.5 GW, whereas the offshore can well reach 30 GW.

Based on the analysis performed, all the sites identified have potential for development. It is necessary, though, that wind measurement campaigns need to take place to confirm the actual wind speeds allowing proper siting, and the expected energy yield of each potential project determined.

The high-level analysis done, does however give a good indication of which areas have a better potential. It is recommended that wind potential confirmation could start from the South-East Coast, the South Coast and the North Coast areas both for onshore and offshore. Proper planning including the development of the necessary infrastructures will allow Trinidad and Tobago to tap its wind resource.

Map of the Most Feasible areas for Offshore Wind Energy Development

*The onshore estimated energy output is more than 11,000 GWh annually.
*2.82GW first priority areas and another 27.8 GW in areas where offshore wind (fixed type) can be developed.
**Levelized Cost of Electricity (LCOE)**

An estimation of the LCOE has been performed for the areas identified and holding exploitable wind energy potential. The analysis was done considering a 50 MW wind energy project for each location on shore and a 200 MW project offshore. The resulting LCOE for the onshore locations is in the range of 45-85 $USD/MWh whereas for the offshore LCOE in the range of 120-175 $USD/MWh.

On the basis of the LCOE the West Coast, Orange Field area and the South East Coast, Galeota is recommended for starting the onshore wind measurement campaign programme. Similarly, the South East Coast, Galeota area and the Tobago South East Coast, Crown Point are recommended for starting the offshore measurements.

![Graph of LCOE](image)

**Building on capacity and infrastructure**

Large scale wind energy projects require availability of infrastructures to support their development and operation. Such infrastructures make development easier and reduce the overall project risk. Ports, cranes for heavy and very high lifts would be needed together with both heavy haul equipment capable of overland movement of turbine parts, in addition to specialized ocean vessels needed to install offshore fixed wind turbine structures and lift wind turbines in place.

Trinidad and Tobago is an industrialized country owing to the development of the oil and gas sector having several sea ports capable of receiving large vessels with heavy cargo. In addition, the requirements of the oil industry have built an inland transportation logistics expertise, being of utmost importance to the wind industry. Local contractors have proven their capacities and capabilities to support wind energy development in the region including the recently built wind energy project in Jamaica. Trinidad & Tobago’s human capacities developed to support the country’s oil based energy sector can be easily adapted to support the wind industry covering the full span of requirements from development to the implementation and operations & maintenance of wind energy generating assets.
Policy, Legal and Regulatory Instruments

In 2011, the Cabinet-appointed Renewable Energy Committee published “A Framework for Renewable Energy Development in Trinidad and Tobago” or “The Renewable Energy Framework” aiming at improving energy efficiency in the residential, commercial, and industrial sectors.

The Renewable Energy Framework incorporated key components of sustainability including energy security and diversified electricity generation, bolstering the case for renewable energy to boost the country’s socioeconomic well-being by creating employment, creating new service industries, and fostering manufacturing competence in new domestic sectors. The Renewable Energy Framework emphasised that renewable energy policy efforts must be incorporated into legislation to encourage energy efficiency and conservation, improve acceptance of renewable energy technology, and provide incentives to improve the affordability of renewable energy technologies.

Trinidad and Tobago is committed to follow a low-carbon development path. The National Climate Change Policy (NCCP) particularly mentions that the government must boost the use of renewable energy by adopting a renewable energy policy and standards, as well as by establishing fiscal incentives for domestic use and sale to the national grid.

The NCCP published in 2011 signalled a need to develop laws, regulations, financial, and reporting structures to minimise GHG emissions. Such initiatives were integrated into the country’s nationally determined contributions (NDCs) modified in 2021.

The National Environmental Policy (NEP) published in 2018 specifies actions aligning with the United Nation’s SDG 7, including reviewing, and strengthening legislative, policy, and financial frameworks for integrating renewable energy, creating an enabling environment for renewable energy research, and developing public awareness and education programmes on renewable energy.

The Government’s Vision 2030 National Development Strategy emphasises the need to evaluate and revise policies, legislation, and regulations to ensure an enabling environment for the uptake of renewable and alternative energy technologies at the national level. It also highlights policy and legal shortcomings relating to the United Nation’s SDGs.

Institutional Set-up of the Power Generation Sector in Trinidad and Tobago*

The line Ministry tasked with the remit for power generation and line management of the Independent Power Producers (IPPs) is the Ministry of Energy and Energy Industries (MEEI) managing the state-owned companies; the National Gas Company of Trinidad and Tobago (NGC) and the National Petroleum Marketing Company of Trinidad and Tobago (NPMC).

NGC and NPMC supply natural gas and liquid fuels to the IPPs. The Power Purchase Agreements (PPAs) are crafted at the MEEI further to finalisation with the Ministry of Public Utilities (MPU) via the T&TEC.

The MPU is the line ministry for T&TEC, which is responsible for the transmission and distribution of electricity from the IPPs. T&TEC pays the NGC and NPMC for all fuel supplied to the IPPs and pays the IPPs for the supply of electricity under long term, “take or pay” PPAs. All fuel is supplied free of charge to the IPPs (The Energy Chamber, 2017).

The RIC is the independent regulator (The RIC Act) of both the IPPs and T&TEC. The RIC has the duty of care to T&TEC customers and for the regular electricity tariff reviews.

Legislative Instruments for Power Generation in Trinidad and Tobago

The T&TEC Act, the Regulated Industries Commission (RIC) Act, the Environmental Management Authority (EMA) Act and the Town and Country Planning (TCP) Act govern and regulate distinct areas of power generation, infrastructure issues, environmental issues transmission, distribution, and pricing of electricity in Trinidad and Tobago. The main tenets of these Acts of Parliament are outlined below.

Trinidad and Tobago Electricity Commission (T&TEC) Act
Chapter 54:70 of the T&TEC Act:
- Defines the line Ministry's reporting and monitoring responsibilities;
- Provides that T&TEC is vested with the right to create, transmit, distribute, and sell energy in any area of Trinidad and Tobago to the general public or any member thereof;
- Provides that T&TEC may enter into a licence agreement with an approved electricity generator granting the approved electricity generator the nonexclusive right to generate power;
- Provides that T&TEC may, with the agreement of the Minister, declare a corporation or business to be an authorised power generator by order; and
- Does not differentiate between types of permitted generators (fossil fuel vs renewable energy).

Regulated Industries Commission (RIC) Act
Chapter 54:73 in the RIC Act:
- Provides that the RIC may provide advice to the Minister on matters relating to the administration of this Act, including the issuance of licences.
- Specifies that the Minister is responsible for issuing transmission, distribution, and generation licences;
- Defines electricity service providers as "any entity, including a statutory authority or a company formed under the Companies Act."

Environmental Management Authority (EMA) Act
Ch 35.05, Schedule 3, Certificates of Environmental Clearance (Designated Activities Order)
- “Generation of electricity - The establishment, modification, expansion, decommissioning or abandonment (inclusive of associated works) of an electricity generating plant with a capacity of 50 megawatts or greater”.

Town and Country Planning (TCP) Act
The National Spatial Development Plan is a strategy establishing the broad framework and guiding principles under which regional and local planning should be conducted. Its goal is the "Harmonized Regional Development", which encourages the diversification of the economy away from reliance on hydrocarbon-based industries in support of the strategic priority sectors outlined in Vision 2030.

The issue of power generation is addressed within the context of the four main acts with specific tenets enshrined in the provision and regulation of power production in Trinidad and Tobago. Therein lies the gap. **Renewables are not mentioned in current legislation.**

What is missing is the inclusion of renewable energy in the country’s power generation strategy and the corresponding legislative, legal, and regulatory frameworks.

Wind and solar PV based technologies are classified as non-dispatchable due to their variable character (Variable Renewable Energy -VRE- sources). Trinidad and Tobago, having a history of using dispatchable technologies for power generation (diesel and natural gas) — has not yet developed the legislative instruments and provisions required for non-dispatchable technologies, including wind energy.
Identified gaps in legislation and regulation
The most significant legislative and regulatory gaps in Trinidad and Tobago to address large scale wind power integration are mentioned in the paragraphs that follow.

Liability
The current legal system does not clearly address “responsibility” for wind turbines, wind farms or wind facilities. In the lack of clear legislation, specific concerns might be included into an EMA-issued Certificate of Environmental Clearance (CEC) as an additional obligation for the applicant to treat with. In principle, a license to build a structure and a license to generate electricity within the context of a PPA can be handled under an EMA-issued CEC obligation. Dedicated law and regulation would be a better way to encourage investor confidence, appease citizens and provide redress were any issues to arise.

Permitting - Overlaps
A permitting review clearly indicates that a power generation facility will require several permits and licenses indicatively from the EMA, the MEEI, the Occupational Health and Safety Authority and Agency (OSHA), the Land Management Division, and the Town and Country Planning Division (Government of the Republic of Trinidad and Tobago, 2021). Permitting requirements differ in many cases both in terms of content and format, whereas not a clear streamlining is in place. Posing the need for alignment among all institutional and organisational stakeholders to allow a project to mature efficiently and not jeopardize the whole undertaking.14

Gap in Policy Alignment and Project Development
Almost all parties acknowledged the need for a more coordinated approach to the approval/licensing process (overlaps and lengthy processes). Revising and updating the procedures contained within the EMA’s Certificate of Environmental Clearance (CEC) might serve as a focal point for increased cooperation. A second recommendation is to establish Intergovernmental Project Committees with representation from all regulatory agencies and a coordinator between the Committee and the project proponent.

Organizational Capacities and Alignment
A key enabler for the development of the wind industry in Trinidad and Tobago is the strengthening and re-purposing of capacities among administrative organizations having the authority to issue permits for wind power projects. Capacity building and consideration of international best practices in areas such as the environmental impact assessment and mitigation measures of wind energy projects, the legal and regulatory treatment of the wind energy penetration in the electricity system, or the support mechanisms in support of wind energy will increase the confidence of the RE investment communities.

Policy and Regulatory Environment
Implementation of the actions required to create an enabling legislative agenda for the introduction of renewables in a country’s power generation matrix is critical to building investor confidence as well as ensuring that legal challenges do not arise to inhibit these projects.

Updating and inclusion of new legislation and associated regulations will ultimately minimise the risks or essentially “de-risk” the envisioned projects if they are conceptualised, constructed, commissioned, and maintained under the Laws of Trinidad and Tobago.

Due to the quantity of permits and licenses necessary, it may be more expedient and cost-effective to adopt either project-specific or wind-specific legislation that addresses administrative concerns and essential wind power issues such as acreage rights. A single authority could manage this.

14 Source: https://sdgs.un.org/statements/trinidad-and-tobago-14799 Last Accessed 10.03.2023
Traditional means of regulation at both the electric distribution and transmission levels historically have been developed to support dispatchable and non-variable centralized fossil fuel energy over renewable generation that is frequently more dispersed and variable\(^{15}\).

It is the right time for a single articulated overarching renewable energy policy for Trinidad and Tobago that will be reflected in the legislative and regulatory framework of the country. Within the realm of the ongoing energy transition, to renewable energy, the laws that govern the inclusion and regulation of electricity must be reviewed and amended to support acceleration of the deployment of renewable energy.

Each nation has its unique set of laws, and Trinidad and Tobago is no exception. Section 39 of the Constitution stipulates that the Parliament consists of the President and the two Houses, the Senate and the House of Representatives. For enacting a law, all three constituent parts of Parliament are engaged.

Create an enabling environment for the deployment of renewable energy technologies in Trinidad and Tobago by enshrining these specific power generation modalities within the Acts of Parliament for Trinidad and Tobago.

\(^{15}\) Source: https://www.unep.org/resources/report/unep-guide-energy-efficiency-and-renewable-energy-law’s
Strengths and Opportunities
Trinidad and Tobago can capitalize on its strengths of having well-developed infrastructure, strong energy demand and existing petrochemical sector to take advantage of the opportunity to produce higher value product with lower carbon intensity and use existing gas reserves to create higher value products.

The country must be mindful however that even with the most compelling of visions and goals, as the threats and weakness identified could potentially derail its efforts.

**SWOT Analysis for Wind Energy Industry in Trinidad and Tobago**

**Strengths**
- Well developed infrastructure.
- Skilled workforce.
- Reasonable wind resources.
- Large energy demand.
- Good theoretical potential offshore.
- Good access to financial markets.
- Strong commitment to honouring contracts.

**Weaknesses**
- No bankable Wind Resource Data.
- Legislation gaps and ambiguities.
- Stakeholder alignment lacking.
- Lack of a clearly articulated policy.
- No relevant planning guidelines.
- Non-aligned, intransparent process.
- Transmission constraints.
- Paucity of technical competence.

**Threats**
- Lack of understanding carving projects.
- Supply chain disruptions.
- Bureaucratic delays setting to cost overruns.
- Wind resource low, projects not feasible.
- Wind data corrupted or invalidated.

**Opportunities**
- Trinidad can capabilize itself into a major player in green hydrogen space.
- Divert gas to higher value uses.
- Develop local industry and workforce in renewable energy.
- Creation of significant levels of employment in a new industry.
- Revitalization of the petrochemical industry.

*Source: [http://www.oas.org/dsd/publications/unit/oea79e/ch08.htm](http://www.oas.org/dsd/publications/unit/oea79e/ch08.htm)
Wind Project Development Cycle
Each wind power plant (WPP) project is unique and is mostly determined by the site's limitations in whichever country the WPP is intended for. The project development stages in both onshore and offshore wind farm development can typically be broken down into several phases.

1. **Identification of suitable sites for wind farms.**
   This involves conducting thorough site assessments, including geophysical surveys, ocean measurements, or ecological assessments.

2. **Planning and development of the Wind project.**
   The project goes through the process of securing all necessary permits and approvals for its construction and installation, including detailed engineering plans for the wind turbines, foundations, and electrical infrastructure.

3. **Construction and installation of the wind farm.**
   This includes all the civil and electromechanical works for building the wind energy project.

4. **Operational phase.**
   It starts when the project is ready and connected to the grid. During this phase, regular maintenance and monitoring is required to ensure the continuous safe and efficient operation.

5. **Decommissioning.**
   At the end of the wind farm's operational life, it is usually decommissioned and removed or re-powered.

**Land Ownership and Suitability:** ownership and availability of the land is a crucial factor that needs to be examined in the project development process for any challenges to be overcome and settled prior to the implementation of the project. The suitability of the land is just as important. Geomorphological and geotechnical characteristics of the land need to be examined to allow proper civil engineering designs.

**Social Factors:** community participation and social acceptance are of paramount importance for the development of wind energy projects. Consultative processes involving neighbouring communities as part of the environmental and social impact assessment of the projects aims to increase awareness, ease concerns, and minimise any negative impacts.

**Environmental and Ecological Factors:** development of any WPP needs to respect environmental constraints be it conserved areas, forestry or wildlife (especially birds and bats). Environmental and ecological impacts are assessed, and avoidance or mitigation actions are determined. Competent authorities safeguard compliance of the projects with applicable laws, rules and regulations.

**Planning and Permitting:** in Trinidad and Tobago, the permitting process and project implementation involve several stakeholders at various government levels, including the Town and Country Planning Division, the Regulated Industries Commission, the Environmental Management Authority, the Civil Aviation Authority, the Water and Sewerage Authority of Trinidad and Tobago, Trinidad and Tobago Electricity Commission, the Ministry of Energy and Energy Affairs, the Ministry of Public Utilities, the Constituency Representative and the Community Spokesperson, among others.

It is crucial that all stakeholders from any prospective WRAP and WPP be included in the development process and all stakeholders are consulted throughout the phases of implementing the WRA and WPP to inform, streamline efforts, ensure compliance with all technical, social, and environmental requirements, and develop efficiently and timely the projects.
Typical Life Cycle of a Wind Energy Project Implementation

1. **Start**
2. **Pre-feasibility** (Site Selection Factors)
   - **State Entities**
   - **Developer and State Entities**
   - **Developer and Financing Parties**
3. **Legislative Changes**
4. **Financial Changes**
5. **Wind Resource Assessment Programme (WARP)**
6. **Auction Process**
7. **Project Awarded**
8. **Engineering, Procurement, and Construction Agreements**
9. **Power Purchase Agreements**
10. **Permits**
11. **Financing**
12. **Notice to Proceed**
13. **Construction and Commissioning**
14. **Commercial Operations**
15. **Operations and Maintenance**
16. **Decommissioning or Repowering**
17. **Transmission Upgrades**

**END**
**Wind Resource Assessment Programme (WRAP)**

A wind project’s development cycle involves addressing different layers of information to confirm suitability and ensure smooth implementation and operation.

**Wind Resource Validation:** assessment of the feasibility of any Wind Energy project can only be based on valid resource data, being also a prerequisite for its financing. The information available from open sources, such as the “global wind atlas”, or “3Tier Wind Maps”, can give an indication of the expected wind energy potential but provided data are not adequate to drive and justify an investment decision. **A wind potential measurement campaign has to be performed to give information on windspeed and direction, temperature, relative humidity, atmospheric pressure, or air density of a particular site.** Specialised software can be used to optimally assess the energy yield based on the actual wind characteristics, the site’s morphology, and the layout of a wind park for different types of Wind Turbines.

**Pre-feasibility and Prospecting**

WRAPs consider the prospective availability of wind energy at a given location through established wind resource maps, such as the World Wind Atlas Map, 3Tier Wind Maps, or AWS Truepower. Should wind energy potential is observed, a site survey is necessary to assess site conditions. A site survey includes not only physical characteristics of a site (e.g. land, impediments or vegetation) but also any impediments or high vegetation that may disturb wind flow and decrease the potential for energy generation.

**Wind Measurements**

Wind measurements are performed to verify the wind energy potential of a prospective site, while different measurement systems can be used depending on the site characteristics, either with equipment installed on meteorological masts or with remote-sensing systems (RSDs).

**Data Collection and Analysis**

Data analysis is an essential component of a WRAP. This includes assessing wind resource data gathered by meteorological masts or LiDARs deployed on-site. Windographer, WindFarmer, or WindPRO software, for example, can be used to process wind data and provide information such as the wind profile or the wind rose, which is a graphical representation of the wind direction and speed distribution over time. These are used to support the selection of the appropriate for the site wind turbine.
Other necessary analyses
To assess the electricity yield of a wind energy project, potential losses or uncertainty factors need to be assessed and quantified. Potential losses can be attributed to the transmission of electricity, the wind plant availability, turbine performance or other environmental factors such as weather phenomena. Quantification of such losses can improve the accuracy of the energy yield estimations and thus reduce financial uncertainty.

WRAP in Trinidad and Tobago
Starting a WRAP requires the use of existing data sources, such as satellite data and models (Wind Atlas). Use of such data allowed for the selection of several potential sites in Trinidad and Tobago. The fact that two (2) LiDAR systems have already become available in Trinidad & Tobago allows wind resource measurements to start immediately to confirm wind energy potential. It is recommended that measurements should start from the sites/areas which have been assessed as having the highest wind speeds and continue to the rest of the identified sites.

Technology to be used at Highest Ranked Sites from the Reduction Method

<table>
<thead>
<tr>
<th>Site Ranking</th>
<th>Site Name</th>
<th>Site Label</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>West Coast, Orange Field</td>
<td>I</td>
<td>LiDAR</td>
</tr>
<tr>
<td>2</td>
<td>South-East Coast, Galeota</td>
<td>D</td>
<td>LiDAR / MET Tower</td>
</tr>
<tr>
<td>3</td>
<td>South Coast, Los Iros</td>
<td>E</td>
<td>LiDAR</td>
</tr>
<tr>
<td>4</td>
<td>North-East Coast, Fishing Pond</td>
<td>C</td>
<td>Telecom</td>
</tr>
<tr>
<td>5</td>
<td>North-East Coast, Toco</td>
<td>B</td>
<td>Can be combined</td>
</tr>
<tr>
<td>6</td>
<td>Central Range</td>
<td>H</td>
<td>Telecom</td>
</tr>
<tr>
<td>7</td>
<td>South, San Fernando</td>
<td>G</td>
<td>Defer</td>
</tr>
<tr>
<td>8</td>
<td>South-West, Palo Seco</td>
<td>F</td>
<td>Defer</td>
</tr>
<tr>
<td>9</td>
<td>North Coast, Blanchisseuse</td>
<td>A</td>
<td>Defer</td>
</tr>
</tbody>
</table>
**Meteorological Masts**
Where a project is to be implemented, wind measurements for a period of one to two years are necessary using special equipment mounted in met masts. The most common height of masts currently used is 80 meters. Wind speeds are often monitored using calibrated class I anemometers at the highest level, and conventional calibrated cup anemometers can be used at different levels. Wind direction is measured with wind vanes. Trinidad and Tobago’s predominant wind direction is from the East, therefore, the arms on the meteorological tower must be installed in the North or South direction to avoid interference from the tower structures. Data collection is done every 10 minutes, data are stored and transmitted via GSM on a regular basis for processing.

Masts can be installed temporarily or permanently and have a lattice or tubular structure. Temporary masts are secured using guywires whilst permanent masts are secured to concrete foundations. Wind speeds are monitored using calibrated class I anemometers at the highest level and conventional calibrated cup anemometers at different levels to allow calculation of the wind speed profile using the logarithmic law approach. Two (2) levels of wind direction are measured using calibrated wind vanes. It should be noted that the arms that host the anemometers and the wind vanes, must be installed perpendicular to the predominant wind direction. Trinidad and Tobago’s predominant wind direction is from the East, therefore, the arms on the meteorological tower/s must be installed in the North to South direction, so that interferences from the tower structures are minimized. Data collection is done every 10 minutes and stored data are transmitted via the mobile network at regular intervals.

**LiDAR Sensors**
LiDAR equipment measures wind speed and direction by shining a pulsed laser beam and calculating the duration it takes for the reflected beam to return. It allows wind data to be acquired at several user-defined heights. LiDAR offers the flexibility of being able to be installed offshore either on already-built offshore platforms or onshore along the coastline.

Floating LiDAR system (FLS) are increasingly used for offshore wind-measurement operations.

The Ministry of Public Utilities, through T&TEC, has recently acquired 2 Lidars and 2 more are foreseen for the near future. Together with the required software and manpower, that could be brought with donors’ grants, there will be conditions to start immediately a WRAP in 2 onshore locations identified by this study.
To accommodate the envisaged wind energy capacity the transmission system of Trinidad & Tobago needs to be upgraded. Already, T&TEC has indicated that the Galeota and Mayaro substations and circuits will be upgraded to 66kV until 2028 (shown as the brown dashed lines in the diagram), allowing wind power generation, up to 50 MW, in the Southeast coast, but further upgrades of the grid system will be necessary. Indicatively, a) the Brechin Castle to San Raphael lines should be upgraded to at least 220kV (red dashed line), or b) the north-eastern substations should be upgraded to at least 132kV to unlock wind energy development along the northeast and east coast. Until wind energy potential is validated along the West Coast, wind project development can be served by the existing westernmost part of the transmission system.

The exploitation of the offshore wind energy potential will require further studies to identify any necessary upgrades of the electricity transmission systems or proper dimensioning of new transmission lines off the coasts of both Trinidad and Tobago.

T&TEC Transmission System
Proposed Legislative Amendments

To develop wind energy in the country, the policy, legal and regulatory environment will need to include provisions enabling the uptake of the wind industry. To this end the following suggestions are made for the improvement and implementation of a sturdy regulation policy within the pertaining legislative framework. Such suggestions aim to ensure that the transition to wind power in the native power generation matrix is just, inclusive and equitable.

EMA Act

No amendments are proposed for the EMA Act however it is suggested that the EMA integrate into its licencing and permitting process, a new regulation to the effect: “For any projects which involve the use of solar energy or wind energy for the production of electricity, the board of the EMA shall treat with these projects as priority and ensure that measured against best global practice, a timely and just decision be made for which the board will provide a comprehensive explanation to the Minister within 1 (year) of the initial application for such projects”.

TCPD Act

The TCPD Act should be updated, for the purposes of large-scale wind power integration, to include a clause entitled “Wind Power Structures” or “Wind Energy Facilities”. A separate set of Guidelines and Regulations under this clause should be developed by the TCPD in collaboration with any other relevant Government Ministries, Agencies and stakeholders. The Regulations should include but not be limited to siting setbacks, site design standards, visual appeal, environmental impact, disturbance and discomfort, operations and upkeep, safety and security, development, and decommissioning and dismantlement. As well as a mapped and clear approval process and application guidelines.

T&TEC Act

The T&TEC Act should contain a new clause or section of the existing TTEC act entitled “Wind Power”. Accordingly, the supply contract of energy from wind developers would be considered “Wind PPAs” to distinguish them from traditional dispatchable power PPAs. A standard interconnection agreement and grid code should be developed to ensure that developers are aware of the standards and regulations that govern interconnection with the national grid. The clauses would introduce the guarantee of interconnection, costs of interconnection, grid upgrades costs, and commitment offtake generated electricity. In addition, a form of the governance structure of wind power purchase, monitoring and evaluation of renewable PPAs, critical excess energy production, smart energy systems, and referral to the TTEC Act.

Legislative Review Process

If the Minister determines that legislative action is necessary, the Minister submits the proposal to the Cabinet for approval along with a request that the Attorney General and Minister of Legal Affairs be tasked with drafting the law. When the Cabinet accepts a proposal, the Attorney General is tasked with drafting the law. Public Bills are drafted by two ministries, both of which operate under the auspices of the Office of the Attorney General and the Ministry of Legal Affairs. Ordinarily, a Bill must be passed by the House of Representatives and the Senate and gain the assent of the President of Trinidad and Tobago for it to become law. 17
RIC Act
The RIC Act should be amended to support the deployment of utility scale wind power by consideration of a number of issues which will also be addressed in the amendments to the TTEC Act. These would include the imposing and collection of license fees; and ensuring that service providers make a sufficient return to fund essential investment. The act should also clearly outline a transparent and accountable process on providing recommendations on license awards and monitoring and enforcing compliance with license conditions. These should be aligned with proposed changes to the TTEC Act such that the RIC lead in developing the fundamentals upon which tariffs will be based, monitoring billing rates to guarantee compliance. With the advent of utility scale wind power, the RIC Acts will need to speak specifically to the issues on which TTEC’s envisaged amendments are based as a regulator to both TTEC and IPPs.

Other Supporting Policies and Actions
Local Content Policy and Participation: to create a sustainable wind industry in Trinidad and Tobago, special emphasis must be given to developing the local talent in all areas of the wind value chain. Developers, Engineers and Operators, Construction workers and supply chain specialists will all be locally developed so that the sector is able to grow independently and organically. While importation of equipment and know-how might be essential at the early stages of development, projects with higher local content in higher value activities must be encouraged. Trinidad and Tobago does not have a legislated Local Content Act, however in an overarching policy, the Permanent Local Policy Committee has proposed the following policies and targets for the Energy sector:

Overarching local content policy for Trinidad and Tobago

Societal and Political De-risking
Opposition to large scale energy projects in Trinidad and Tobago have occurred in the past and must be considered. The EIA (Environmental Impact Assessment) studies and CEC (Certificate of Environmental Clearance) mandated by the EMA specify that public consultations must be held and that the ensuing reports accompany the applications for projects. Ensuring that this happens in a clear, informed and transparent manner is key enabler for the success of a project.

In addition, recent amended legislation through the Parliament presents opportunities for onboarding all political players.

Accordingly, the project would be at low risk from societal and political pressure as long as the requisite processes of consultation are met with a special focus on transparency, accountability and education, and awareness progress in line with the Sustainable Development Goals.

Passage of the intended amendments through the Parliament would also be following the public consultations and would be informed by these outcomes. During the ensuing debates in Parliament, it is imperative that the merits of the project are presented with empirical data and strong arguments for these measures which not only are economically attractive but also in line with the multilateral agreements Trinidad and Tobago is signatory to including the Paris Agreement 2015.

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Source: https://www.ema.co.tt/our-environment/cec/
Source: https://sustainabledevelopment.un.org/memberstates/trinidadtobago
Capacity Building and Skills Development

The development of wind industry in Trinidad & Tobago presents a new opportunity to build native capacity and create gender equal thousands of jobs along the wind energy lifecycle, i.e. in the Design & fabrication, Construction & installation, operations & maintenance phase and Decommissioning or repowering phase.

Design and Fabrication: The design and fabrication of wind turbines, blades, and towers is a well-established industry. Nevertheless, employment opportunities may arise in the design and fabrication of peripheral systems necessary for the implementation of wind energy projects. In addition, soft skills are needed for the development of the sector spanning all phases of project implementation.

Construction and Installation: The capacities needed to support the development of wind energy projects span the entire value chain. From engineering, legal and financial skills to support the development of projects up to engineering and technical skills necessary for the implementation of them including inter alia transportation, earthworks, building foundations, equipment lifting, building/upgrading electricity infrastructures to mention a few. Trinidad & Tobago is in a unique position to benefit from the expertise built over the years to support the oil industry. Shifting local skills to support the wind industry of the country is a logical and efficient transition. Offshore wind farms need distinct skill sets from both the conventional power industry and offshore wind installation expertise. There is a strong association between putting offshore oil and gas drilling equipment and anchoring a wind farm to the ocean floor or rigging a floating farm.

Operations and Maintenance: Wind farm maintenance requires a large number of maintenance staff. Significant number of sustainable employment opportunities will be created for local engineers, technicians, craftsmen and operators.

Decommissioning or Repowering: The average lifespan of wind farms is 20 years. Beyond that period projects are either decommissioned or repowered, yielding further manpower requirements including those related to the recycling business.

Jobs in Wind Development Phases
Financial dimensions for the wind industry development of the country

Trinidad and Tobago will leverage its position and strength in the petrochemical industry to transition to a sustainable future. Wind Energy can be an enabler to this transition through merging international best practices and instruments with local capacities. There are several challenges to overcome in order to develop the wind energy sector in the country. Achieving 2 GW of wind capacity until 2035 would require investments of more than 7 to 8 billion USD with the involvement of investors and the commercial banking sector or Development Finance Institutions.

Decisions to invest or finance projects in a country consider monetisation of perceived risks that would potentially hinder the financial performance of the assets, as they may cause delays in the development of projects, yield higher cost of capital, require expensive imported labour and equipment, need for additional infrastructure, need for guarantees, leading to increased project costs and ultimately high energy prices. These include among others:

- **Policy Risk**, which is dependent on the availability and clarity of relevant legislation and regulation, as for instance, project permitting process, grid code, rules for the offtake of generated renewable electricity, etc.

- **Currency Risk**, which is the kind of risk that relates to weak economies which are also experiencing high currency volatility.

- **Project Implementation Risk**, which can be reduced through development of skills and capacities, improved availability of project implementation equipment or improvement of necessary infrastructures.

- **Business Risk**, which is gradually reduced with the development of the sector and built of confidence.

- **Counterparty Risk**, referring to the ability of the electricity offtaker (be it a utility or a private company in case of a corporate PPA) to meet contractual obligations, can be treated through offtake risk mitigation instruments.

Financing options for wind energy projects

Trinidad and Tobago is classified as a high to middle income country and hence most of the times does not qualify for DFI financing as this facility is left for lower income countries. The EU has recognized this issue and has created innovative approaches to this problem. The combination of political and policy dialogue, regional and country actions addressing shared challenges, triangular cooperation and the use of credits and blending are important tools to address the varied needs. The EU sustains close cooperation with regional organisations and groups such as the Caribbean Community (CARICOM) and multilateral partners such as the EIB, the IDB and the International Finance Corporation (IFC) to make headway on regional and global challenges.

**Wind projects are capital-intensive.** Main financing options to be investigated for the development of the wind energy sector in the country would involve for instance, (i) blended financing (ii) a combination of equity and non-recourse debt (project finance) or (iii) balance sheet finance.

**Blended Finance:** based on the varying definitions for blended finance “it can be assumed that blended finance would typically involve an element of debt concessionality (i.e., involves transactions where a loan is granted bearing an interest payable below normal market rates), and that its purpose is to mobilise additional funding for private projects. It is also plausible to include technical assistance grants aimed at supporting project development and bankability in this concept of blended finance” (One Planet Lab, 2021). Certain risks must be mitigated for blended finance as well as for project finance to ensure that projects can be financed.
Project Finance: most commercial renewable energy projects, including wind energy projects, have been funded through project finance. Project finance is essentially a project loan, backed by the cashflow of the specific project. Project finance is highly suited investment mechanism to this type of projects due to the “predictable” nature of cash flows. Therefore, financing of a project requires careful consideration of all technical (e.g. wind electricity yield, backed by “bankable measurements”) and non-technical aspects, as well as the associated legal and commercial arrangements, so as repayment of the loan to be guaranteed over the loan term.

Balance Sheet Finance: as an increasing number of large companies have become involved in the sector, there has been a move towards balance sheet funding, mainly for construction. This means that the owner of the project provides all the necessary financing for the project, and the project’s assets and liabilities are all directly accounted for at a company level.

Trinidad and Tobago has the potential to develop a significant wind energy sector, improve knowledge on its wind resource and develop a conducive legal and regulatory framework.

Blended financing comprising a mix of concessionary funds from institutions like the European Investment Bank (EIB), the Inter-American Development Bank (IDB), the International Finance Corporation (IFC) and grant funds from agencies like the European Union (EU) and Global Environment Facility (GEF), early equity investors and debt lenders, could be a preferred option for the early stages of the sector’s development.

As Trinidad and Tobago progresses with first projects, the regulatory and permitting processes improves and data accuracy is improved, a shift towards project financing is expected. Once the country becomes a mature wind province the option of balance sheet financing can become an opportunity for investors pooling money together.

Auctions for renewable energy

Auctions for wind energy have become “a norm” in the renewable energy sector due to their flexibility in design, the degree of commitment and transparency they create and their potential for determining the market price.

Auctions award long-term contracts that guarantee a sustainable revenue to project developers, and at the same time due to their design fundamentals they tend to lower risk perception and increase confidence in banks and other financial institutions in the presence of a conducive environment. Where risks are mitigated, investment (including financing) costs tend to decrease, resulting in lower electricity prices. The credibility of the off-taker as identified above, the design of the auction including the regularity of auctions and the remuneration profile, and the presence of a stable and enabling environment that is conducive to market growth are important for instilling investor confidence. An important way to reduce investors’ risk perception is to ensure that demand-side responsibilities will be met — usually through a reliable off-taker contract backed by, e.g., Guarantees.

Major design elements for an auction system.
Implementation Plan and Monitoring
Sections 5 to 7 deal with the different facets of developing the wind energy sector in Trinidad and Tobago. The implementation plan describes the roles and responsibilities of the parties, a suggested timeframe for the execution of specific tasks and the financial and human resources needed to achieve the 2 GW by 2035 goal. In addition, a vital part of this process is a monitoring and evaluation plan which tracks progress to achievement so that all stakeholders are aware of the status and interventions can be made in a timely fashion should the need arise.

**Stakeholders Engagement**

**Roles and Responsibilities for Key Stakeholders:** the implementation plan requires the involvement of various stakeholders, each one with specific roles and responsibilities.

**Hierarchy of Roles and Responsibilities of Key Stakeholders**

- **Government**
  - Sets vision and goals, amend and create laws, and demonstrate commitment

- **Steering Committee on Wind Energy**
  - Develop policies, procedures and legislation, and tracks progress

- **Technocrats and State Entities**
  - Implement laws and procedures and manage the auction process

- **Wind Energy Developers**
  - Develops projects, manages risk and ensures economic viability

The implementation plan outlines the steps required to achieve the vision of 2GW of offshore wind by 2035. The plan provides a comprehensive guide for stakeholders to follow, outlining their respective roles and responsibilities, as well as the resources required to achieve the objective. The plan outlines key milestones, budgetary requirements, and specific actions that need to be taken.
### Implementation Timeline.
**Target:** 2GW of wind power installed in the country by 2035.

Seven development horizons are proposed with key activities detailed within each period allowing for each succeeding step to be accomplished. The proposed implementation plan can be executed over a period of 12 years, starting from the second half of 2023.

### Planning Horizons

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Key Activities</th>
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</table>
| Horizon 1 | Set Vision.  
- Form Steering Committee  
- Implement legislative actions  
- Develop the auction process and economic incentives.  
- Start WRAP - Install LIDARs at selected high potential sites.  
- Conduct transmission system analysis and upgrades.  
- Develop a Grid Code. |
| Horizon 2 | Conduct onshore auction process or PPP projects.  
- Award Onshore projects.  
- Finance and place order for turbines. |
| Horizon 3 | Construct and commission onshore projects.  
- Apply learnings from onshore wind development projects.  
- Develop Human Resource skills for wind power industry. |
| Horizon 4 | Determine offshore lease blocks for wind development.  
- Start Transmission upgrades for power transfer.  
- Develop and Conduct offshore auction process. |
| Horizon 5 | Award to successful bidders.  
- PPA, EPC and Permitting finalized.  
- Finalising financing of projects.  
- Place order for turbines. |
| Horizon 6 | Issue Notice To Proceed (NTP).  
- Transmission Interconnection Ready.  
- (July 2033) Turbines on site and available for installation. |
| Horizon 7 | 2GW Installed. |
Short-Term Actions — Horizon 1

Adopt a Vision

Vision
To be the regional leader and knowledge hub for Renewable Energy within the Caribbean.

The Vision and clear goals that are specific, measurable, assignable, realistic and time-bound will ensure that the country will take the steps required to achieve its vision.

The following items are recommendations that are been proposed to allow for the vision and target to be achieved.

Establish a Steering Committee
The steering committee will provide all necessary guidance and resources to ensure that processes and all stakeholders are aligned. State entities and Ministry technocrats will develop and implement policies and procedures so that investments are encouraged. The Steering Committee must have a Ministerial component to ensure that decisions made are adopted quickly by the Government. EU's Technical Assistance Facility can support with resources to navigate the new renewable energy space. This will allow for accelerated capacity building of the State Entities which will be crucial for the development of the Wind Industry and by extension the renewable energy industry in Trinidad and Tobago.

Implement Legislative Actions
Creating an enabling legislative agenda for the introduction of renewables in the country’s power generation matrix is critical to building investor confidence. Updating and inclusion of new legislation and associated regulations will “de-risk” the envisioned projects.

At this time, there is no single articulated overarching renewable energy policy for Trinidad and Tobago with Renewable energy not being addressed in the legislative or regulatory framework for the country. Within the realm of the ongoing energy transition, to renewable energy, the laws that govern the inclusion and regulation of electricity must be reviewed and amended to support acceleration of the deployment of renewable energy. Therein lies the challenge, to create an enabling environment for the deployment of renewable energy technologies in Trinidad and Tobago by enshrining these specific power generation modalities within the Acts of Parliament for Trinidad and Tobago. The Steering Committee would lead to ensure that the right framework and laws are implemented to best serve Trinidad and Tobago's renewable energy ambitions.

Develop a Framework for Wind Energy Auctions
Auctions for wind energy have become increasingly popular due to their flexibility of design, the increased certainty they lend to electricity prices and quantities, the degree of commitment and transparency they create and their potential for determining the market price. The auction process should be guided by the Steering Committee, benefitting from the experiences gained and the expertise developed around the world.

Start a Wind Resource Assessment Program
Several areas have been identified as having a promising wind energy resource technically and economically. The resource potential has to be verified through wind resource measurement campaigns. It is recommended that wind resource validation could start from the West Coast — Orange Field and the Southeast Coast — Galeota under the auspices of the Ministry of Public Utilities and should be guided and monitored by the Steering Committee.

Conduct transmission system analysis and plan upgrades
In order to attain the target of 2GW of wind power by 2035, the transmission system will have to be analyzed and upgrades planned. A network development plan needs to be performed to allow understanding the network upgrade needs to accommodate planned wind capacity. Analyses such as those of load flow, inductive reactance, short-circuit, and dynamic stability need to be performed to ensure that the power can be injected into the grid.
Develop a Grid Code
The Grid Code, being a set of regulations defining technical requirements and duties, responsibilities and rights of all stakeholders involved (e.g., the Utility, IPPs, customers) in the power system is an essential instrument for the safe integration of renewable generation into the grid as well as an enabler for the development of the renewable energy sector. A consensus-building process including possible stakeholders will need to be in place to determine the right balance in favour of developing the sector. The Steering Committee should be tasked to ensure the development of a T&T specific Grid Code so that the wind and by extension the renewable energy industry can be developed and accelerated to the scale necessary to decarbonize the downstream energy sector.

Projected Budget and Resource Requirements:
The implementation of the plan requires significant resources and budgetary allocation. The estimated investments can reach $7 to 8 billion USD over the 15-year period along the full value chain, from the activities related to the development of the projects (e.g., site and wind resource assessment, environmental impact), building of all necessary infrastructures (e.g., electrical grid) and the implementation of the projects, up to the operation and maintenance of the onshore and offshore wind farms.

The resource requirements for the implementation of the plan include skilled workforce, technology, and equipment, whereas the involvement of various stakeholders, including the government, investors, developers, and contractors is a prerequisite for its success.

Monitoring and evaluation
To ensure effective progress of the country in realizing its wind energy development, and as an integral part of the country’s Wind Energy roadmap, a Monitoring and Evaluation (M&E) plan should be developed outlining the approach needed to track progress. The M&E plan comprises key components that include purpose, key performance indicators (KPIs), targets, data sources, data collection and analysis, reporting, and evaluation.

The purpose of the M&E plan is to evaluate the effectiveness of the roadmap in achieving its objectives, identify areas for improvement, and provide feedback for decision-making. The M&E plan identifies KPIs, such as legal and regulatory instruments developed, installed wind capacity, investment attracted, number of projects completed, jobs created, and CO2 emissions avoided, to measure the progress of the roadmap. Additionally, the plan sets targets for each KPI and outlines the data sources, collection, and analysis procedures.

Reports generated at regular intervals will provide a comprehensive overview of progress towards the targets, and the plan outlines the process for evaluating the effectiveness of the roadmap and making recommendations for improvement. The M&E plan should be reviewed periodically to ensure that it remains relevant and effective in monitoring and evaluating the progress of the wind energy development roadmap.
The roadmap proposes a clear path to reaching the 2GW wind energy target by 2035. It entails cooperation among all actors, including the government, international partners, international development organisations, developmental banks, the private sector, and other stakeholders from civil society. It is in the common interest of all to collaborate in the successful implementation of the roadmap, adapted or not as the decision-makers consider appropriate.

The national decision-makers may choose to use this report to construct and articulate a compelling vision and in adapting, growing, and evolving the necessary support paradigm, including future policies and regulations that will facilitate private sector participation in wind energy development. A steering committee is a useful key component in this energy transition process, as it should provide the necessary technical guidance and resources to ensure that the process remains on schedule and all stakeholders are aligned and realigned as circumstances change.

National decision-makers and senior technical officials may choose to use the roadmap when developing and implementing the policies and procedures that will underpin the success of this development and to further reduce risk to manageable levels. This is so that investors and developers, international and national, are encouraged to capitalize on the opportunities presented by the roadmap and invest in renewable energy.

It is crucial to emphasize the urgency of taking action to achieve the vision of 2GW by 2035. The transition to renewable energy is vital not just for the environment but also for economic growth and energy security especially as we look to the future of petrochemical industries that rely on grey hydrogen as a feedstock.

The next 3 to 5 years are crucial as competitors elsewhere are also moving to determine their paths. Combining the comparative advantages of Trinidad and Tobago with a revised decision-making paradigm and the establishment as a showcase of the first large-scale wind installation could give Trinidad and Tobago a front-row position for future investments.

A first showcase project could be fully promoted by national decision-makers and either retained or taken to the private sector for auction, wholly or in part, once ready to start producing energy. There are several international developmental banks which are keen to invest in green energy: with favourable interest rates; often a long period of grace (5 to 6 years); and technical assistance as well. Such loan(s) could be repaid by the cash flow of the project, should a concession be auctioned to the private sector for management of operations and maintenance over 20/25 years. When the time comes to start paying off the debt the project would be already generating cash flow.

There is an increasing international competitive challenge for national decision-makers to adopt the necessary legal framework to succeed, based on best practices and adapted to the local reality. Trinidad and Tobago have a highly educated and experienced population, which gives it a solid advantage currently.

As a key step forward, it is necessary to proceed to launch in the near term a Wind Resource Assessment Program.
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