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Bermuda offshore wind: Location assessment

For Greenrock

September 2023

Document history

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Executive summary

The purpose of this document is to help Bermuda reach net zero by providing a levelized cost of energy (LCOE) and technical spatial assessment of offshore wind. It was commissioned as follow up to our previous reports which suggested that one of the key uncertainties to address in considering whether offshore wind makes sense for Bermuda related to project location.[i]

Location assessment

The assessment established four potential sites, as shown in Figure 0. with differing levelized cost of energy, technical, environmental and social considerations. Our preferred is site 1, but the relative difference between all sites except site 4 is relatively low. Site 1 is located in the north of the Bermuda Platform, outside the airport exclusion zone in an area of relatively low LCOE. The site has lower coral reef density and shorter distance to grid connection point (and lower coral reef density along this route) than other sites shortlisted. It offers similar wind speeds to other sites and low anticipated impact on fishing and diving activities.

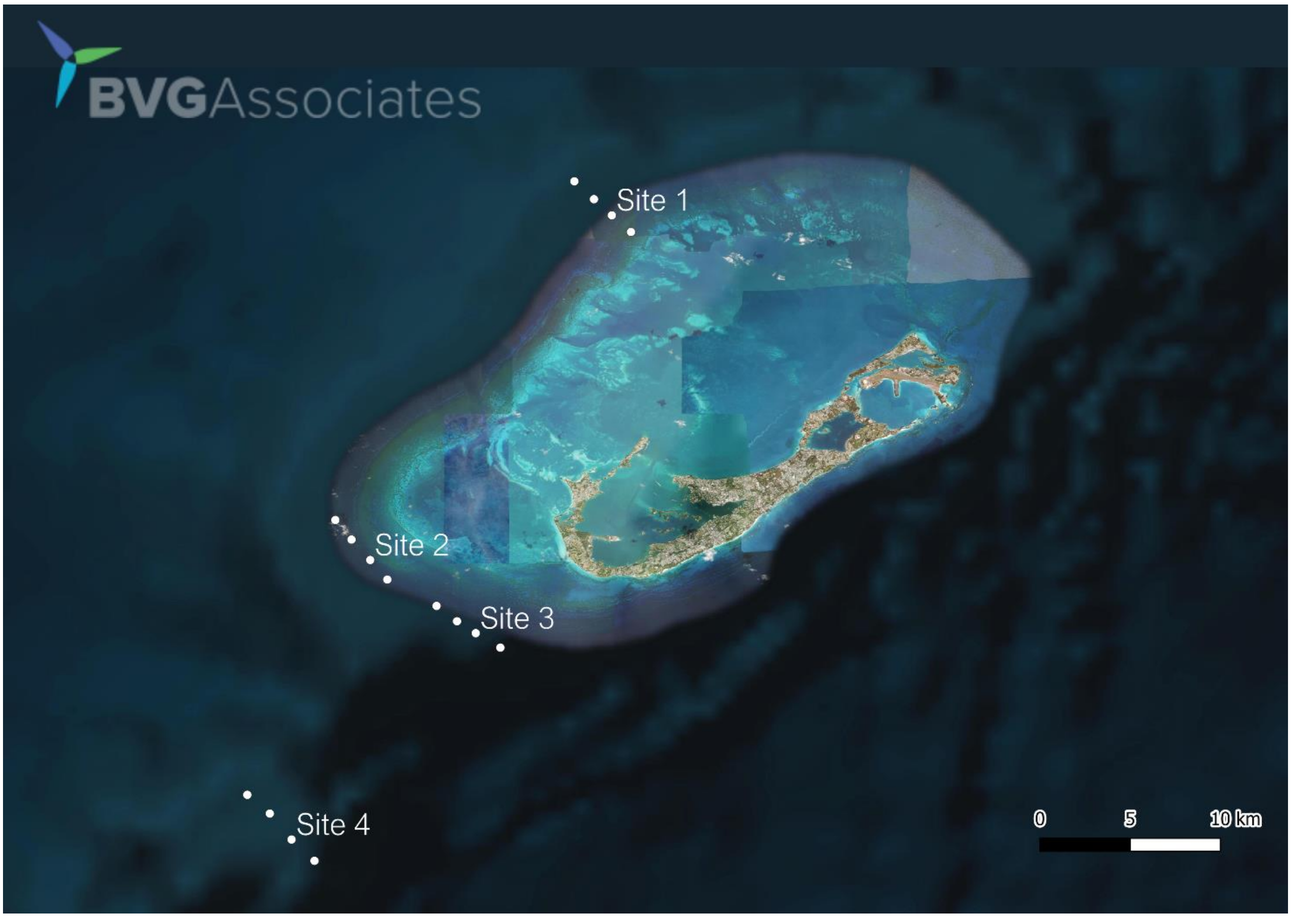

Figure 0.1.1 Potential offshore wind project locations.

[i] For an explanation of LCOE, and information of offshore wind technology and processes more generally, see https://guidetoanoffshorewindfarm.com/, including the *Wind farm costs* tab.

Recommendations

The assessment has used available data to shortlist four potential sites and designate one as preferred Recommended next steps to further reduce uncertainty regarding location include:

1. Development of photomontages showing potential projects, as viewed from key locations. This will help early informal consultation.
2. Early informal consultation regarding potential project locations to gain specific local insights and help inform eventual choice of location.
3. Assessment of operations port and grid connection point. This will enable preliminary cable and operations vessel routing – considerations that could impact project viability.
4. Preliminary visual surveys of potential sites and associated cable and vessel routes, especially to assess water depth and coral cover and diversity. This will enable confirmation of preliminary routing.
5. Preliminary wind resource assessment and design of measurement campaign. This improves confidence in site viability.

At a later date (before site location is confirmed):

6. Geotechnical assessment of seabed at project location and along preliminary cable route. This will enable much better evaluation of technical viability.
7. Comprehensive environmental impact assessment with micro-siting to identify sensitive areas, coral reef hotspots, and benthic habitats. This will inform turbine siting and inform cable route planning and help avoid vulnerable ecosystems.
8. Wind measurement campaign, with associated data processing and correlation with other data sources to predict lifetime resource.
9. Front-end engineering design studies for foundations, cable routing, installation, operation and other aspects, accounting for Bermuda conditions, including storm impacts (wind and wave), foundation scour and cable protection.
10. A geotechnical analysis to provide insights into the substrate types and suitability for monopile and cable installation.

1. Introduction

1.1. Background

Greenrock is seeking to support the decarbonisation of Bermuda's electricity supplies within a timeframe that remains within a 1.5° C carbon budget.

Based on previous renewable energy resource and technology assessments, offshore wind has consistently been identified as the most critical mature renewable energy technology to achieve decarbonisation of the electricity sector.

Greenrock has welcomed the progress made by the Bermuda Government to date considering offshore wind as a key potential element of a sustainable, low carbon energy system for Bermuda. It seeks to help accelerate progress through bringing in global experience of the technology, costs and practicalities of offshore wind, recognising that:

- Offshore wind costs have been falling rapidly and are projected to continue falling, in relative terms compared to traditional forms of electricity generation
- The scale of technology and market continues to grow
- Bermuda has specific characteristics (in terms of size of market, location and available facilities) that need to be addressed, and
- Knowledge about how to progress offshore wind in Bermuda is naturally limited.

Bermuda has a typical power consumption of 30 to 100 MW. Historically, Bermuda has used fossil fuels to generate most its electricity but also uses some small-scale renewables with about 13 MW of solar photovoltaic (PV). It does not have the available landside area to meet its electricity demand with onshore renewables – there is space for approximately 84 MW of solar PV which would meet a quarter of electricity demand. Offshore wind, however, presents an opportunity for Bermuda to vastly increase its share of renewable energy generation, with a relatively small 60 MW installation able to meet about 40% of electricity demand.

1.2. Purpose

The purpose of this document is to provide a location assessment considering technical parameters, levelized cost of energy (LCOE), and environmental considerations. Such an assessment was recommended in our previous report *Bermuda offshore wind: Key publications review and priority actions*, dated April 2022 and building on our report *Bermuda offshore wind: LCOE assessment* dated August 2022, accounting for key factors such as project scale and installation logistics.

2. Methodology

2.1. Overview

In our previous report, *Bermuda offshore wind: LCOE assessment*, we considered LCOE for a project with a single set of generic conditions relevant to Bermuda. Here, we extend this work to provide a spatial LCOE assessment based on relevant geographic Information system mapping (GIS) layers.

We combine this with technical exclusions and environmental and social considerations to produce a map of potential project locations. The environmental and social considerations are based on datasets provided by the Bermuda ocean prosperity programme (BOPP) who have done several pieces of work in this area.[ii]

As an example, coral density directly affects the subsea cable placement and routing as well as installation vessel routing and operation.[iii]

2.2. Site characteristics and assumptions

In line with our previous report, the proposed offshore wind project is assumed to be commissioned in 2028 with a rated power of 60 MW.

Project assumptions are as follows:

- Turbines: Four 15 MW turbines with a rotor diameter of 224 m, certificated to Class IA to IEC 61400-3 standard, representing the average size expected in 2028. Experience to date is that in most offshore wind markets, using the largest available turbine offers the lowest levelized cost of energy (LCOE) solution.
- Turbine spacing: Six rotor diameters across-wind.
- Operational life: Certificated for 32 years.
- Funding: Development and construction costs fully borne by the project developer.
- Contracting approach: A multi-contract model is used for construction.
- Meteorological regime: Wind shear exponent of 0.12, Rayleigh wind speed distribution, annual average temperature of 23°C, air density of 1.225 kg/m3, tidal range of 0.76 m.
- Turbine: Certified to Class IA to IEC 61400-3 standard with a rotor diameter of 224 m.
- Array cables: Three core 66/132 kV AC to grid connection point at Tynes Bay waste to energy facility in the centre of the north shore, without offshore substation.
- Installation: Sequential by foundation, array cable, then the pre-assembled tower and turbine. Monopiles and transition pieces installed by a single jack-up.
- Operation, maintenance and service: Nearshore access by crew transfer vessel (CTV), jack-up vessel for major component replacement.

In order to provide the spatial LCOE assessment, we adjusted project costs and energy production with these significant spatial variables:

1. Water depth
2. Average wind speed at 150 m height
3. Distance to operations port, and
4. Distance to grid connection.

BVGA's in-house LCOE model is continually updated as insights are gained either through consultancy work or when there are major industry announcements such as auction results. Data sources and the validation process for updating the model can be found in Appendix A of our previous report *Bermuda offshore wind: LCOE assessment*. LCOEs stated are average across the site. They are consistent with our previous work which also considered uncertainty.

[ii] https://www.bermudaoceanprosperity.org/_files/ugd/418ca0_2403e13360074d6aad257ef0b705ae29.pdf

[iii] https://global-uploads.webflow.com/62670c93ceef61f2e8acc1ce/649b1ae687f7fe5316bbe7fd_Bermuda%20OSW%20Consultation%20Document.pdf

3. Results

3.1. Potential locations

Figure 3.1 shows four potential project locations based on LCOE, technical exclusions and environmental and social considerations. Purple dots indicate potential locations for individual wind turbines. Final placement would be after more detailed technical work as well as environmental and social impact assessment (ESIA) in line with good international industry practice. All sites are arranged with turbines in a row perpendicular to the prevailing wind direction. This reduces aerodynamic array losses and turbine loading, hence maximising energy production and minimising operational expenditure.

Figure 3.1 also shows various indicative buffer zones from shore and the airport plus Site 1B, as identified by the Regulatory of Bermuda in Offshore wind summary of information package[iv].

The range of LCOE is between $140 /MWh and $165 /MWh, in line with the $152 /MWh for indicative, typical Bermudan conditions considered in our previous report.

The map shows LCOE increasing with water depth and distance to shore due to higher costs associated with greater distance to the operating port and grid connection.

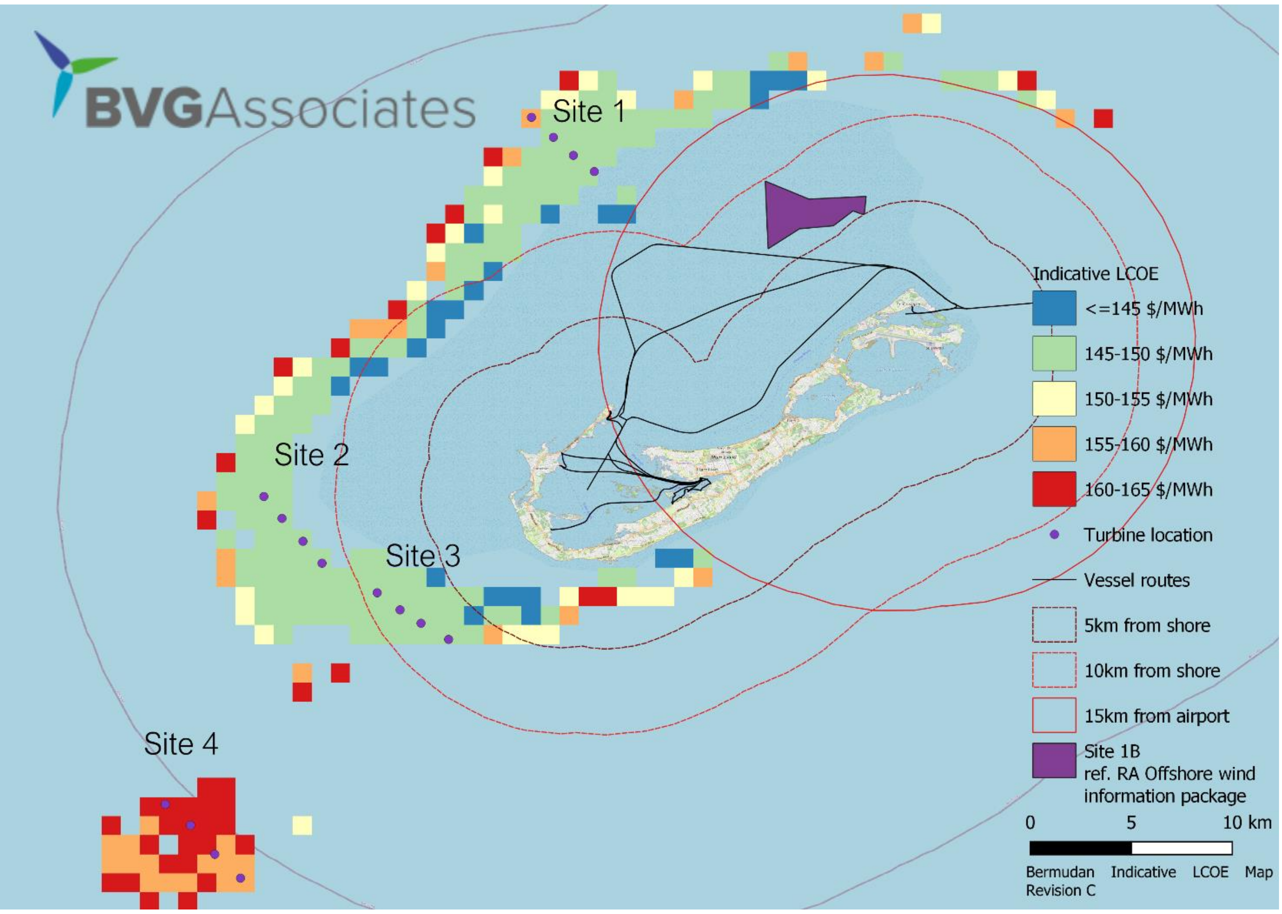

Figure 3.1 Potential project locations combined with indicative LCOE.

Each site is discussed below. Based on this, our preferred is Site 1, but the relative difference between sites is relatively low.

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iv https://global-uploads.webflow.com/61de07132712e04ca912e348/648a0bc5e538f8da805a76e7_Bermuda%20OSW%20Summary%20Information%20Package.pdf

Site 1

Site 1 is located on the north side of the Bermuda Platform, comfortably outside the 15 km airport exclusion zone. LCOE is $149 /MWh.

From a technical perspective, the site has a lower coral reef density where the turbines would be situated as well as within the potential cable route to the potential grid connection point at the centre of Bermuda, making it easier to define an efficient cable route. It is also a shorter distance to a potential grid connection. It has similar wind speed resource to the other sites.

Passage options for crew transfer vessels include the eastern blue cut passage or the north rock cardinal buoy passage.

From an environmental and social perspective, site 1 has minimal effects on areas with high fishing or diving activities, as well as areas with rich coral cover and biodiversity.

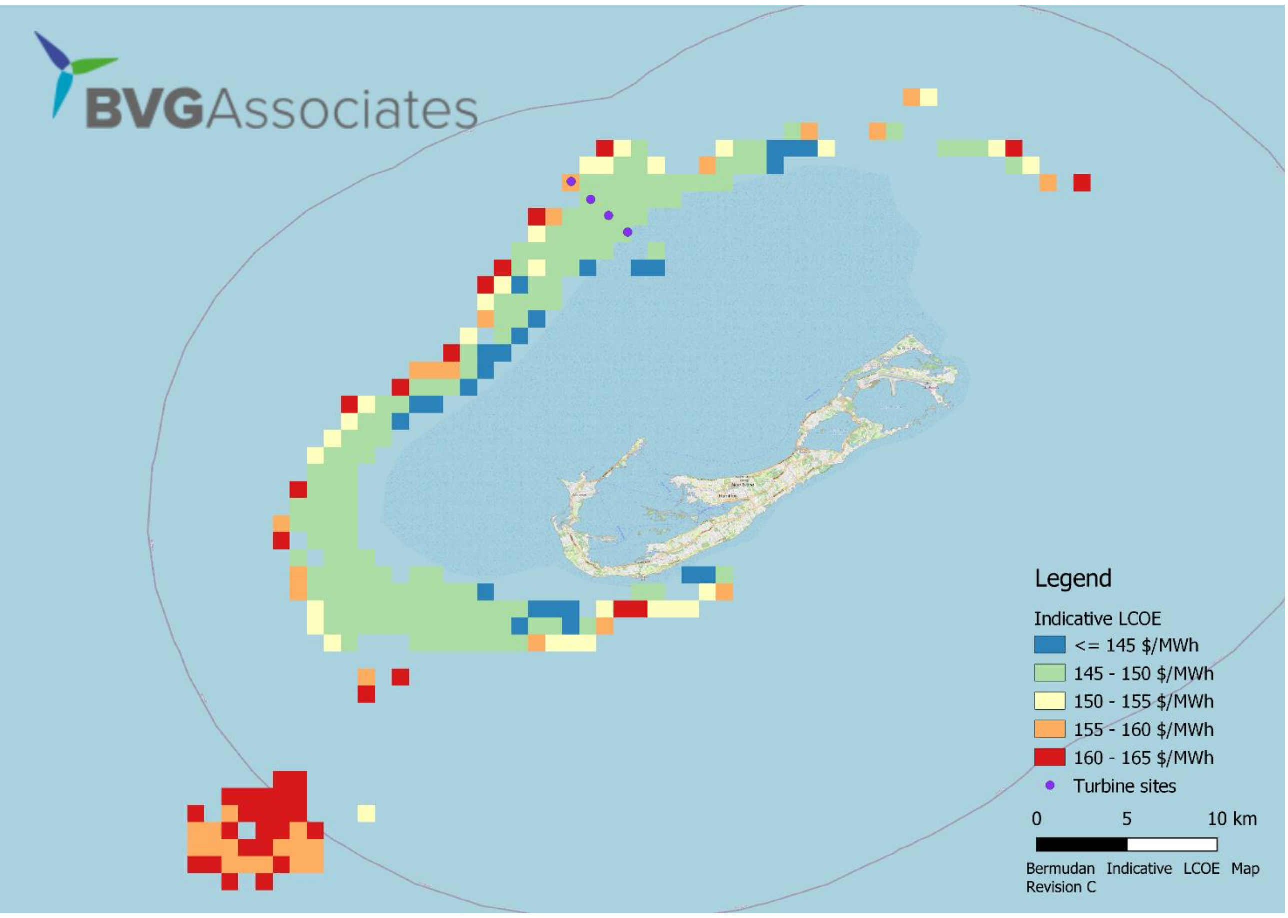

Figure 3.2 Potential site location 1 combined with indicative LCOE.

Site 2

Site 2 is located outside the 10 km shore buffer zone, with an LCOE of $147 /MWh.

The site is adjacent to a seasonally protected fishing area with relatively low coral coverage but relatively high coral diversity.

The seabed rugosity (roughness) is lower compared to other sites which simplifies design and site operations.

There is no safe passage for vessels through the Bermuda Platform due to reef density. As a result, all operation and maintenance vessels will need to navigate around the southern part of the Bermuda Platform entering and exiting the Platform through the Narrows passage or through Town Cut to St. George's harbour. This also means that any required cable routing may have to pass through large areas of coral reef (for the shortest route) distance or take a longer route to avoid the reef, leading to associated cable and installation cost increases, along with higher cable losses.

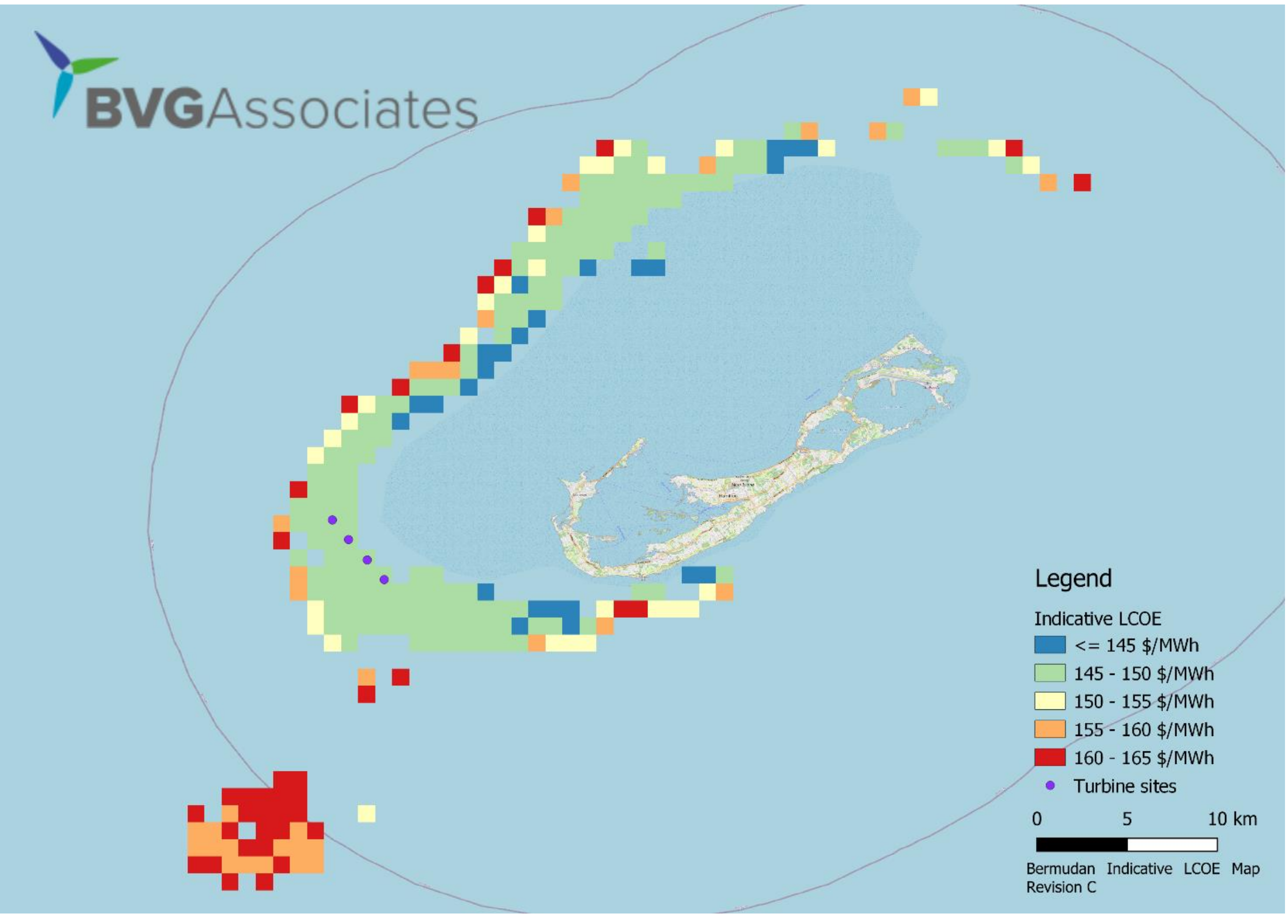

Figure 3.3 Potential site location 2 combined with indicative LCOE.

Site 3

Site 3 is closely located to site 2, but it falls within the 10 km shore buffer zone. It has a similar LCOE to site 2 but poses challenges due to its placement in an area with much higher coral density (though with lower diversity) and, consequently, higher rugosity. This makes it less favourable for installing foundations and cabling.

The increased visual impact of having an offshore wind farm within 10 km of the shoreline makes this site slightly less desirable compared to the other sites, It also does not border any seasonally protected fishing areas.

Site 3 has the same challenges regarding vessel access and cable routing as site 2.

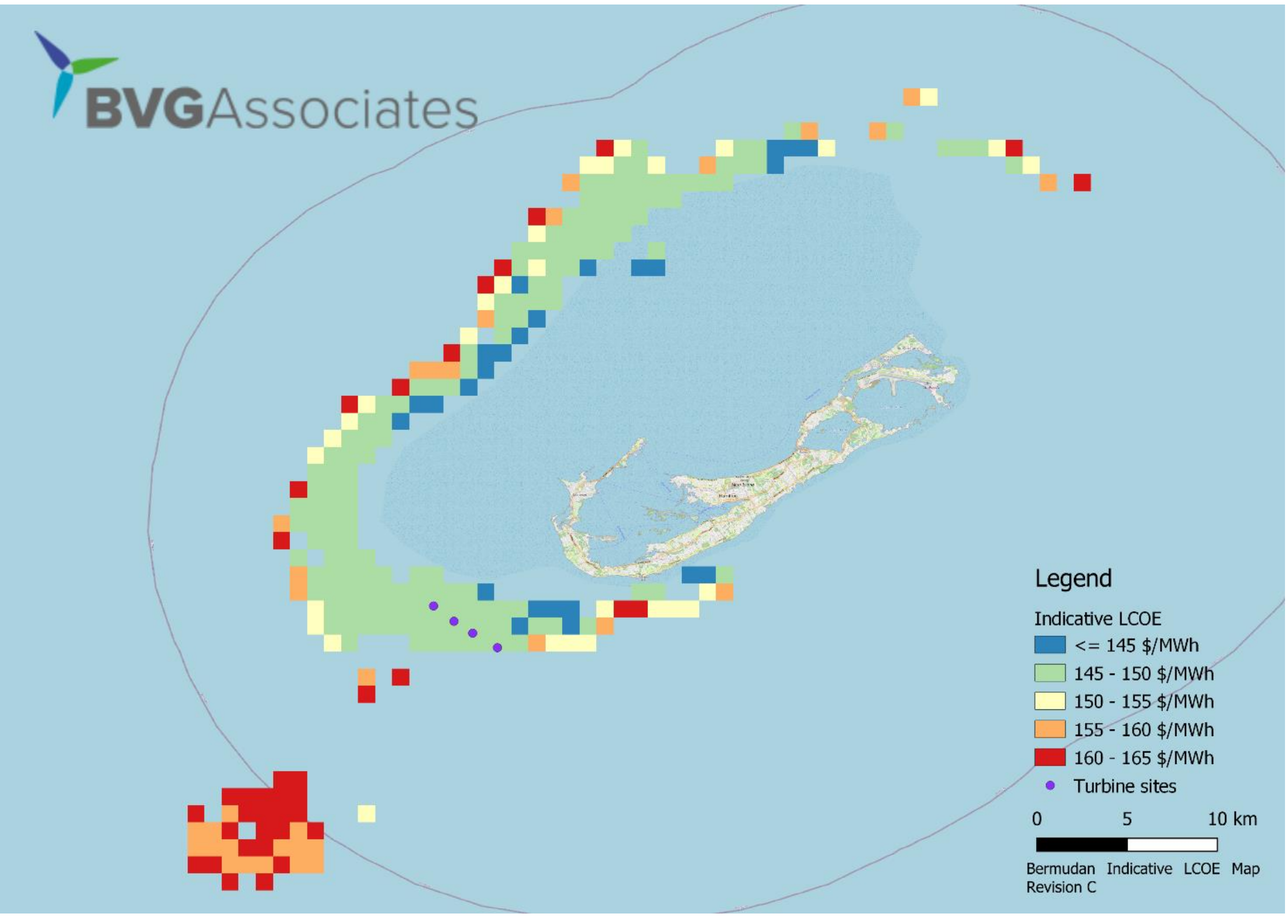

Figure 3.4 Potential site location 3 combined with indicative LCOE.

Site 4

Site 4, situated on the Challenger Bank to the southwest of the Bermuda Platform, has the highest LCOE $160 /MWh. This higher cost is primarily due to its location in deepest water and its distance from grid connection and operations port.

Site 4 has an increased distance to shore and so will have lower visual impact on the surrounding landscape compared to the other sites. It is located far away from major fishing zones and areas of coral reef. Cable routing, potentially down to the bottom of the channel between Challenger Bank and the Bermuda Platform where depths exceed 1100 m introduces challenges and adds extra complexity, though is well within capability of installers.

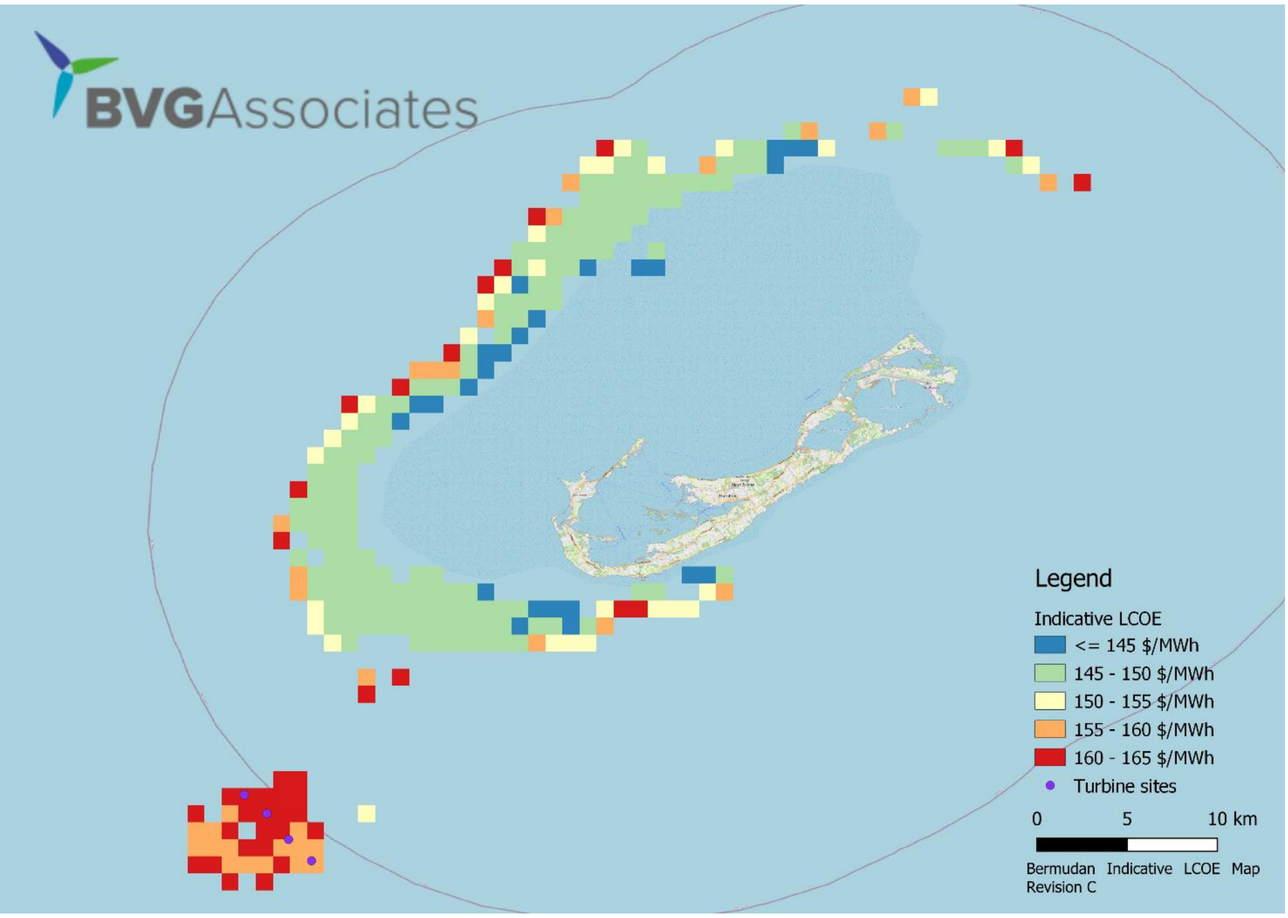

Figure 3.5 Potential site location 4 combined with indicative LCOE.

Regulatory Authority proposed site 1B

The Regulatory Authority of Bermuda identified in its *Offshore wind consultation documen*t *site* 1B, as shown in Figure 3.1.[v] This 61 MW site consists of 17 3.6 MW turbines in an array, rather than the four 15 MW turbines assumed for Sites 1-4 in this study. The use of fewer, larger turbines reduces environmental impact due to less seabed disturbance and less activity during installation and operation and reduces social impact due to a smaller site footprint and simpler view. Larger turbines can, however, be seen from further away. Typically, project economics are improved with larger turbines and it may be more difficult to source 3.6 MW turbines by the end of the decade, as average turbine size being installed offshore is already much larger than 3.6 MW.

We also considered 6 MW turbines in our report *Bermuda offshore wind: LCOE assessment* dated August 2022. Both 3.6 MW and 6 MW turbine are no longer in production for offshore wind use, but turbines for onshore wind use at this scale are available and it may be possible to procure marinized versions for offshore wind use (changes required are limited), but at a cost premium due to the small number required. We note that RA site 1B is within 7 km of the airport and within 400 m of a defined vessel route.

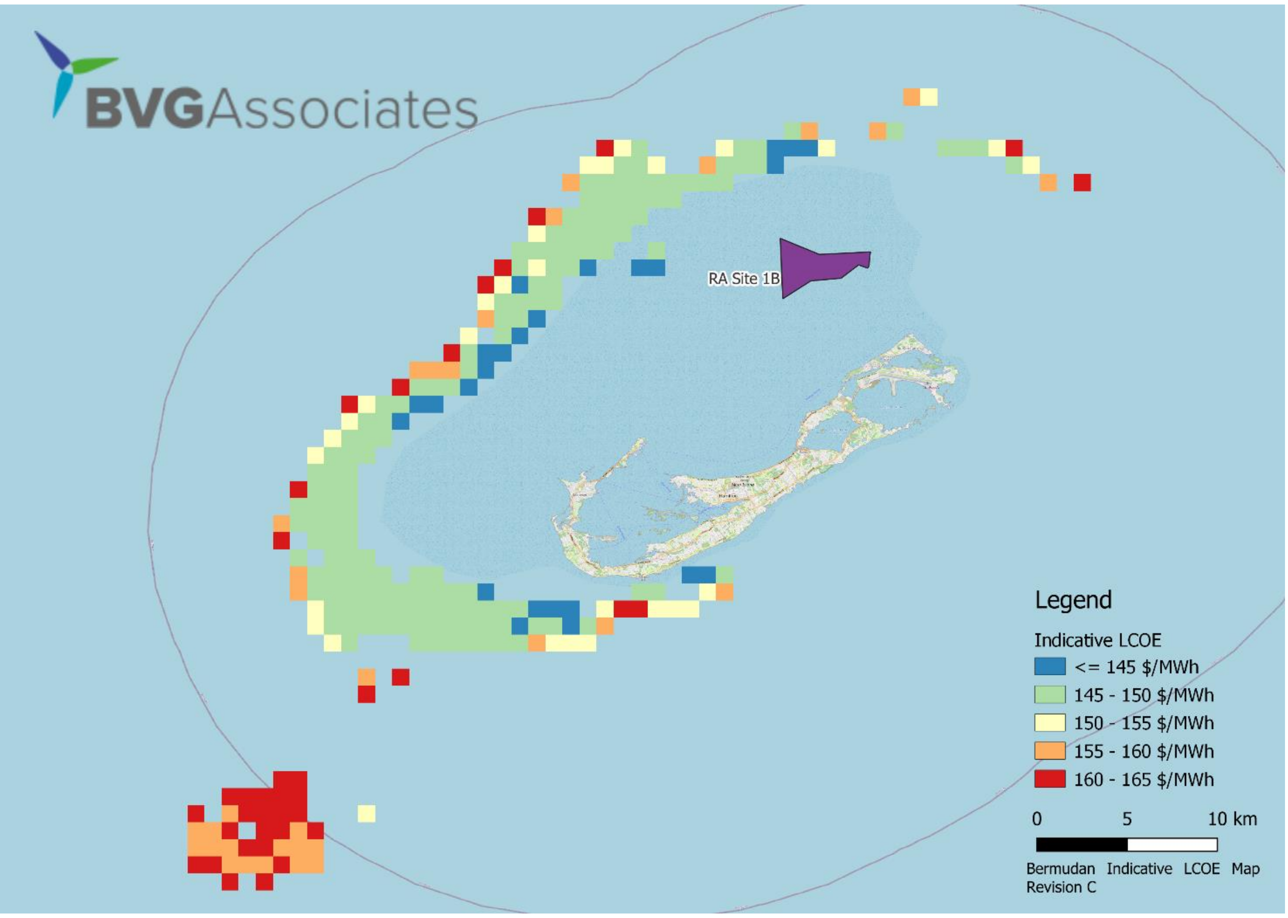

Figure 3.6 RA Site 1B.

[v] https://global-uploads.webflow.com/62670c93ceef61f2e8acc1ce/649b1ae687f7fe5316bbe7fd_Bermuda%20OSW%20Consultation%20Document.pdf

University of California Santa Barbara and Ricardo proposed sites

The previous studies by University of California Santa Barbara (UCSB) and Ricardo proposed sites A to C and D to F, respectively, in Figure 3.7. Sites A, C and D, fall within the 15 km radius of Bermuda's airport. Sites B and F align closely with this report's Sites 1 and 4. Site E is positioned further south than Site 2 to avoid a seasonally protected area.

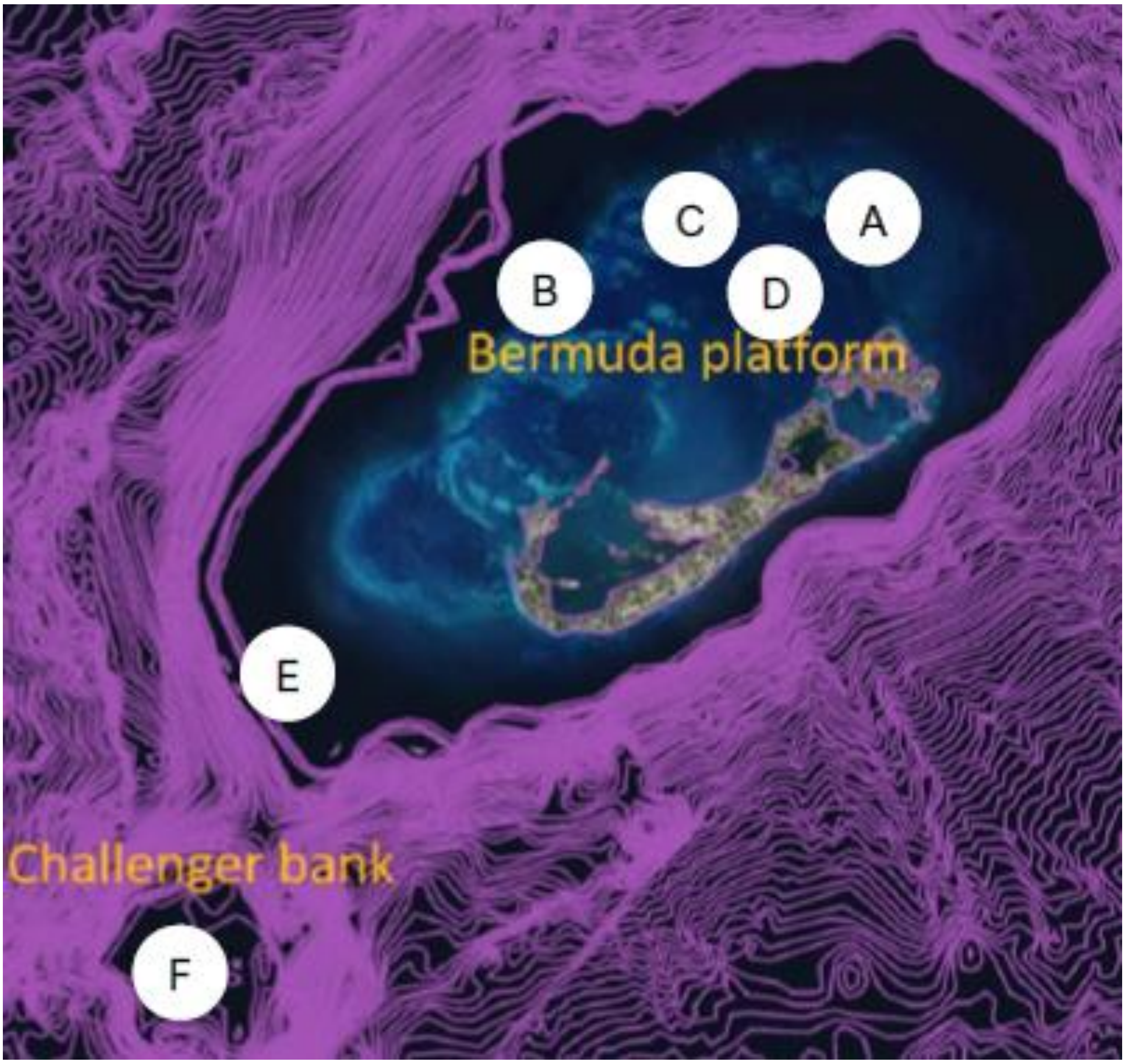

Figure 3.7 Approximate location of wind farm sites proposed by UCSB and Ricardo, based on map from Ricardo.

Technical, environmental and social considerations

This section contains the technical exclusions applied, as well as the key environmental and social considerations that materially impacted location assessment. Other environmental and social considerations that we included in our assessment are provided in Appendix A.

Water depth

Offshore wind foundation and turbine installation vessels require a minimum depth of water to operate effectively.

We have excluded transit through (and operation in) water depths of less than 10 m at lowest astronomical tide (LAT) established to accommodate the large size of these vessels

As well as depths of greater than 60 m This is due to:

- Manoeuvrability at slow speeds, making safe navigation between areas of constrained depth operationally unsound,
- The interaction between ship wash (vessel's disturbance) and the seabed,
- Monopile foundations not widely installed at depths greater than 60 m and,
- Cable installation in depths greater than 800 m with steep contours can be technically challenging.

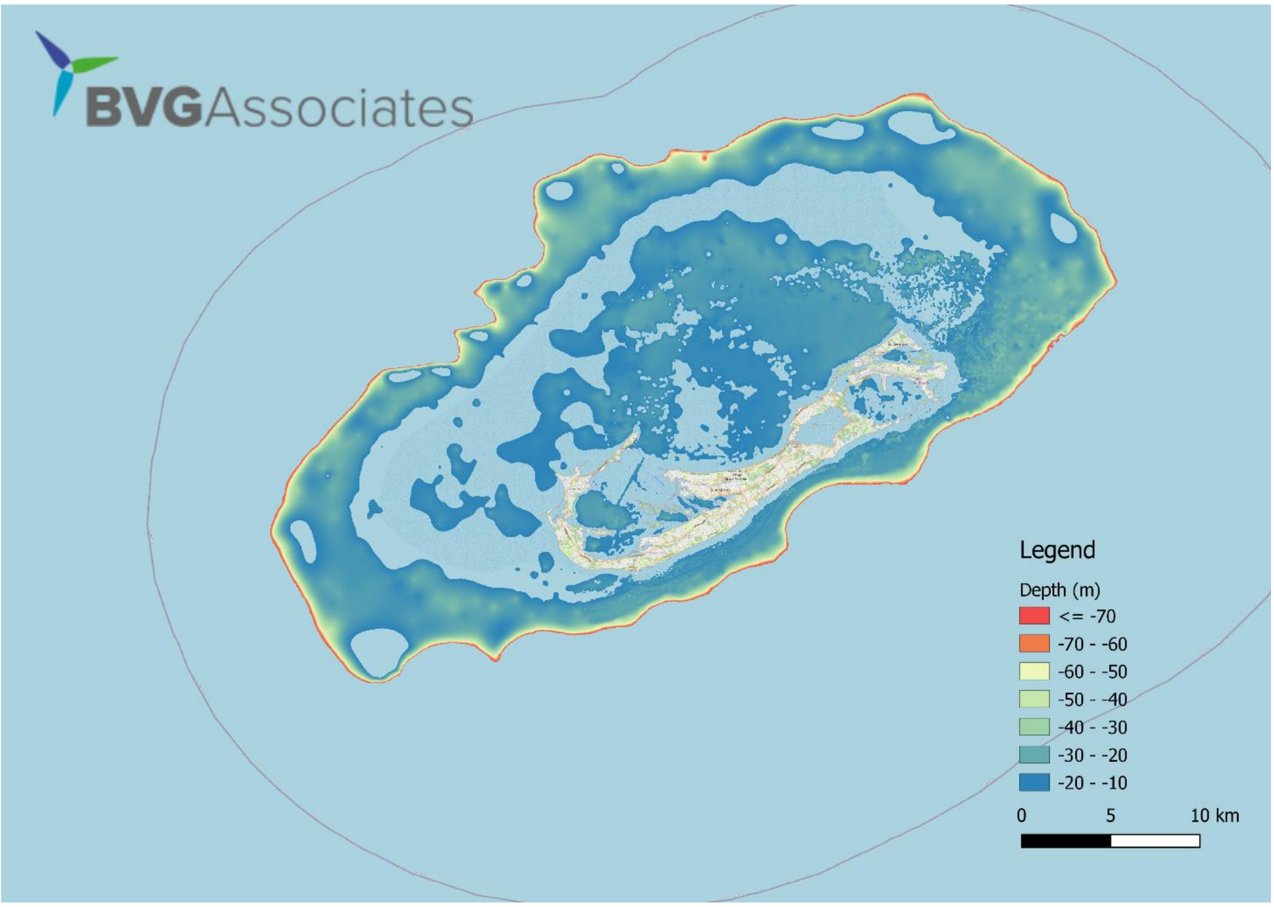

Figure 3.8 Lidar digital elevation model of water depth.

Protected dive sites

Protected dive sites are excluded with a buffer of 250 m radius from the maximum extent of the wreck. This is because:

- Equipment used in offshore wind operations at risk of damage (or causing damage) if it encounters submerged structures or artifacts often present in dive sites
- Storm events or strong currents can potentially displace wrecks or artifacts, posing a danger to the infrastructure and operations of the wind farm, and
- Installation and day-to-day activities of the wind farm can be affected by dive site activities, leading to disruptions and potential safety hazards.

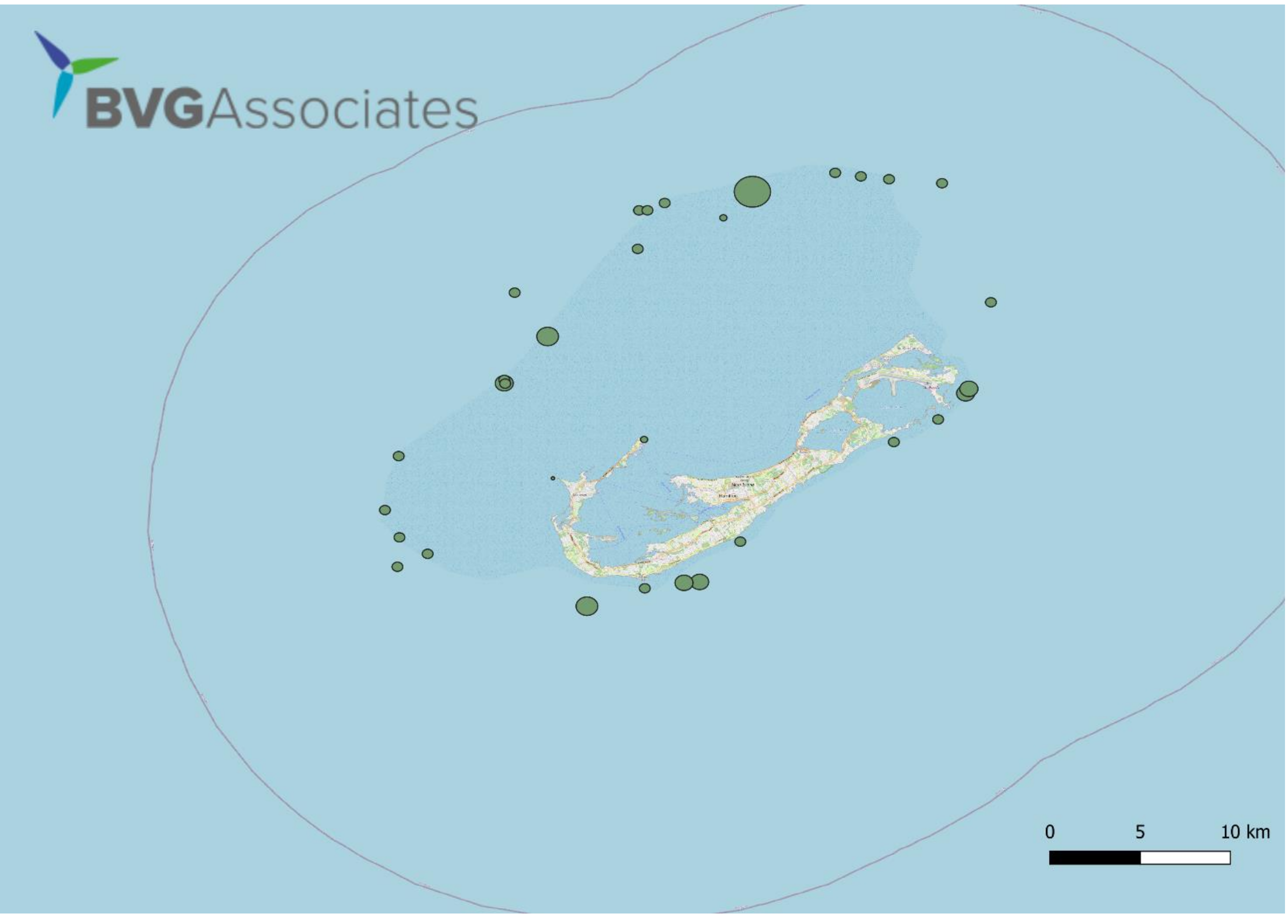

Figure 3.9 Protected dive sites.

Submarine cables

Existing submarine cable routes are excluded to avoid interference with cables with buffer of 100 m either side of the cable. This is because:

- Installation and large component exchange activities to avoid risk of damage submarine cabling.

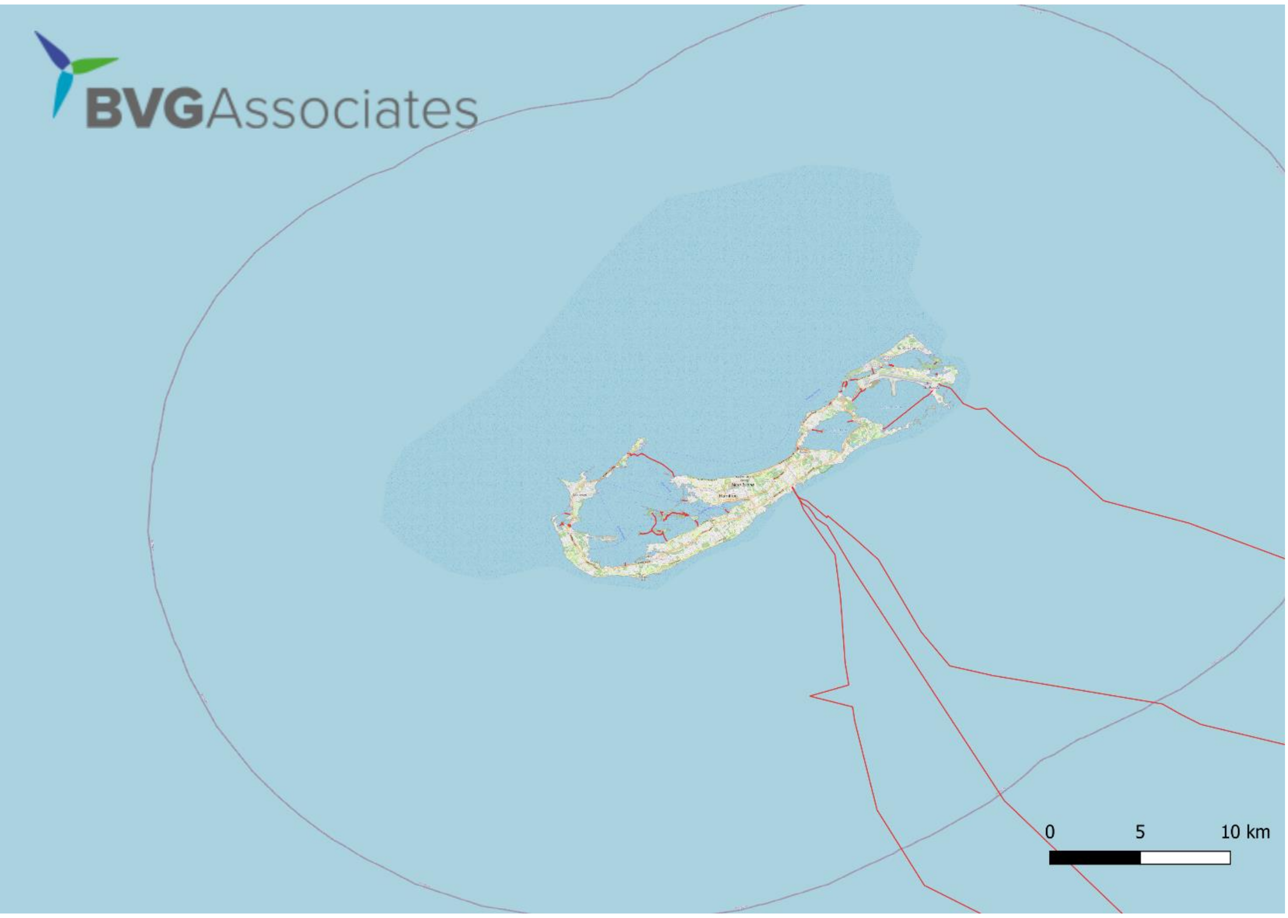

Figure 3.10 Submarine cables.

Vessel traffic routes

Vessel traffic routes are excluded to maintain the safety and efficiency of vessel traffic systems and routes with buffer of 500 m either side of the route. This is because:

- Vessel traffic systems are designed to ensure smooth navigation and minimize the risk of collisions in busy maritime areas
- Maintaining clear and unobstructed vessel traffic systems allows for the safe passage of commercial ships, fishing vessels, and other maritime activities, and
- The exclusion zone also minimizes the potential for conflicts between offshore wind farm operations and existing shipping routes.

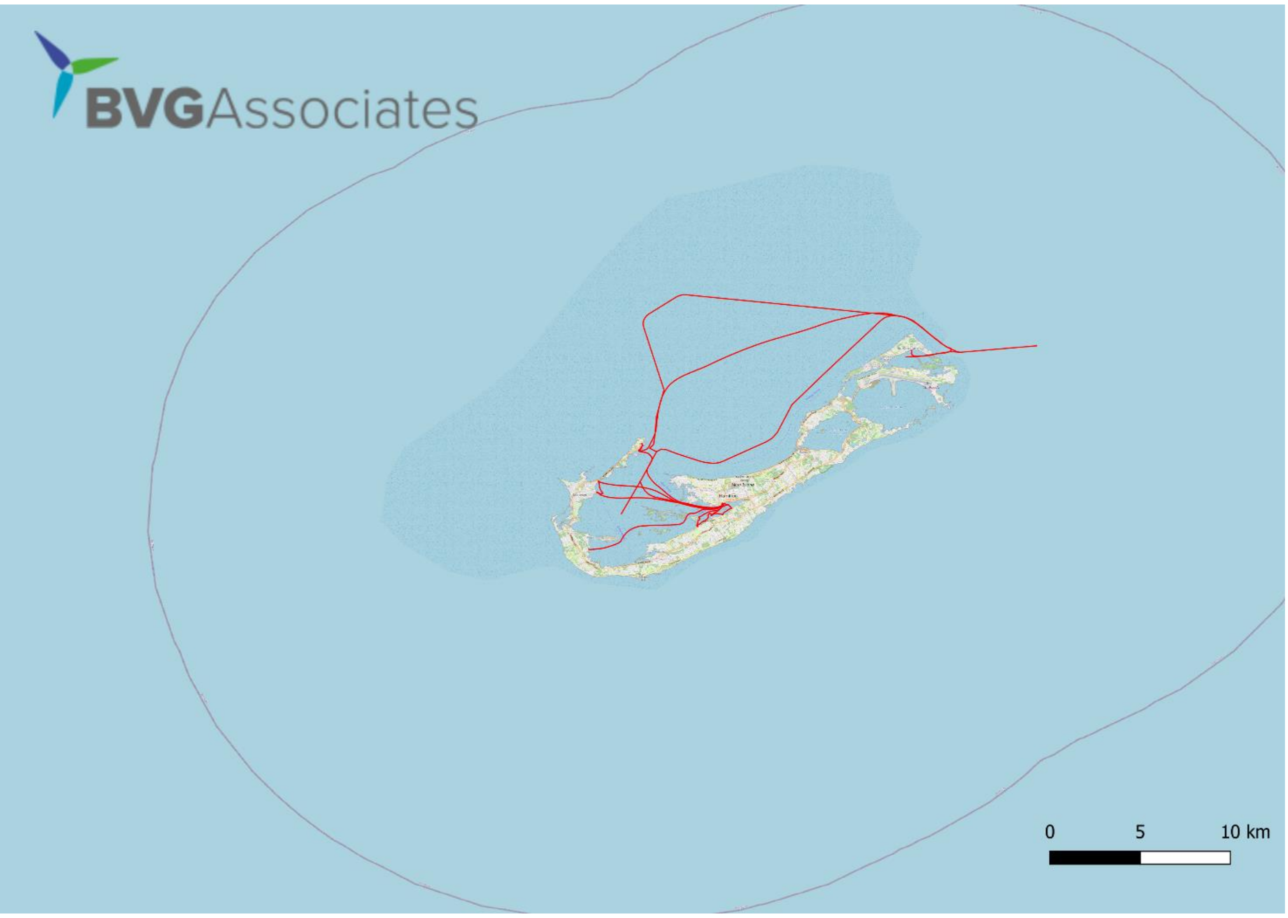

Figure 3.11 Vessel traffic routes.

Areas close to the airport

In accordance with the Bermuda Plan, an obstacle limitation surface, pertinent to a Code number 3 or 4 runway, extends for a 15 km radius around the centre of the airport. This outer horizontal surface is situated 150m above the aerodrome elevation, as stipulated to ensure the safety of aircraft operations. This measure follows both local guidelines from the Bermudan Civil Air Authority and international regulations as per the International Civil Aviation Organization's Annex 14, aimed at mitigating risks of interference with navigation systems or damage to aircraft.

Furthermore, the Airport Authority has expressed the need for applicants to conduct surveys, ensuring that any potential wind farm developments would not adversely affect the performance of existing aircraft surveillance and weather radars located in Bermuda. While not a direct exclusion criterion, this is a significant spatial consideration.

Figure 3.12 15 km distance from airport perimeter.

Areas close to shore

The map includes two dotted lines (5 and 10 km to shore) to provide spatial context.

Although we have not excluded any sites based on distance to shore, we recognise that visual impact increases with proximity to viewers, as well as being affected by direction to shore and onshore land use.

Photomontages showing views from shore will be a useful next step in reducing uncertainty regarding visual considerations.

Wind turbine blades passing in front of the sun can cause a visual disturbance called flicker at particular times of the day, depending on distance from the viewer.

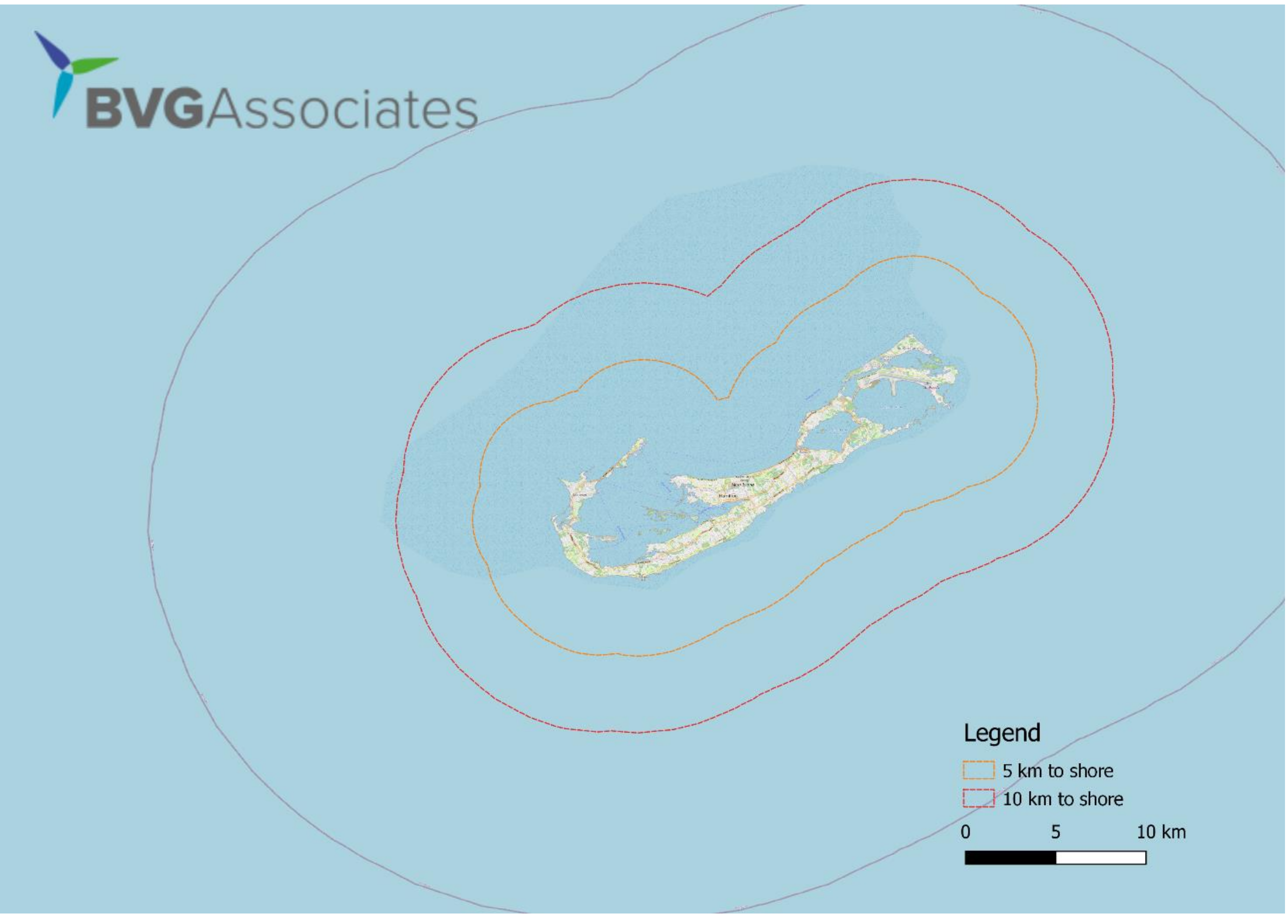

Figure 3.13 Distance to shore.

Coral reef cover and diversity

Offshore wind turbine foundations and cables require suitable substrate for installation. We have sited the four potential wind farm locations in areas where there are lower levels of coral cover and diversity compared to much of the Bermuda Platform. This is because:

- Installing monopile foundations can lead to local habitat loss
- The interaction between ship wash (vessel's disturbance) and the seabed can lead to habitat loss
- Installing cables to shore is complex and can lead to local habitat loss in areas of high coral cover, and
- Extreme weather events can lead to natural coral loss which could pose danger to the infrastructure and operations of the wind farm.

In Figure 3.14the higher the diversity number, the higher the diversity of coral types present.

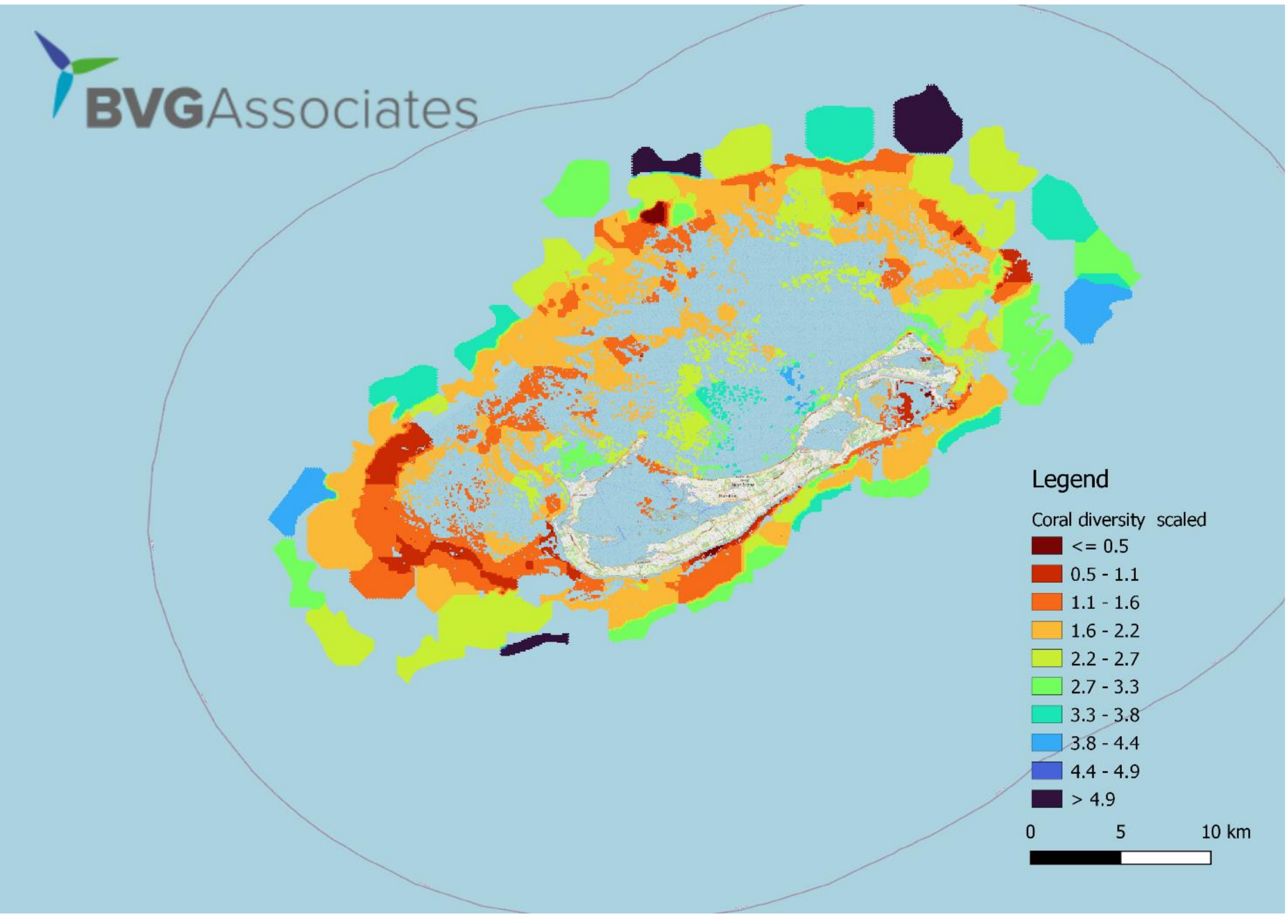

Figure 3.14 Coral reef diversity.

Fishing activity

Fishing activities have been considered in our planning for the potential wind farm locations. This is because:

- Fishing vessel traffic can pose a risk to the operation of the wind farm
- Fishing equipment such as nets and trawling can impact the wind farm infrastructure such as cabling, and
- Areas of lower fishing activity have been selected so as to have a minimised impact on fishing activity.

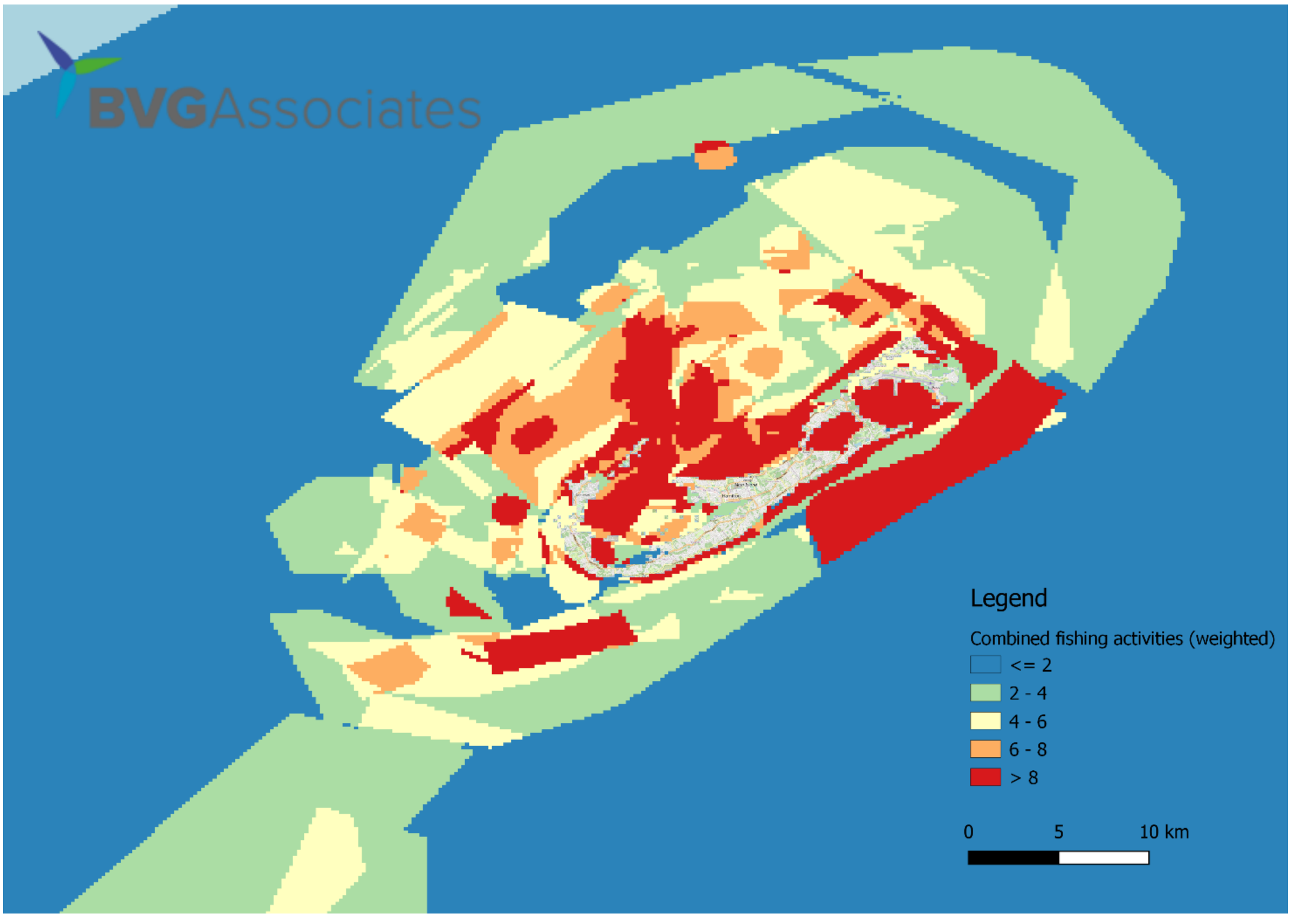

Figure 3.15 Combined fishing activities (weighted).

Undisclosed wrecks

Offshore wind foundation and cable installation require careful consideration of the seabed, particularly when undisclosed wrecks are present as they represent the approximate location of wrecks that have not been properly surveyed. We have sited the four potential wind farm locations in areas where there are no undisclosed wrecks. This is because:

- Installation of monopile foundations near undisclosed wrecks can compromise both the historical value and the structural integrity of the wrecks, as well as adding complexity to the installation process
- The proximity of vessel activity to undisclosed wrecks can increase the risk of further damage to these sites and pose navigational hazards to installation ships
- Routing cables near undisclosed wrecks must be handled with great care to avoid damage, and
- It is important to recognize the historical and ecological importance of undisclosed wrecks.

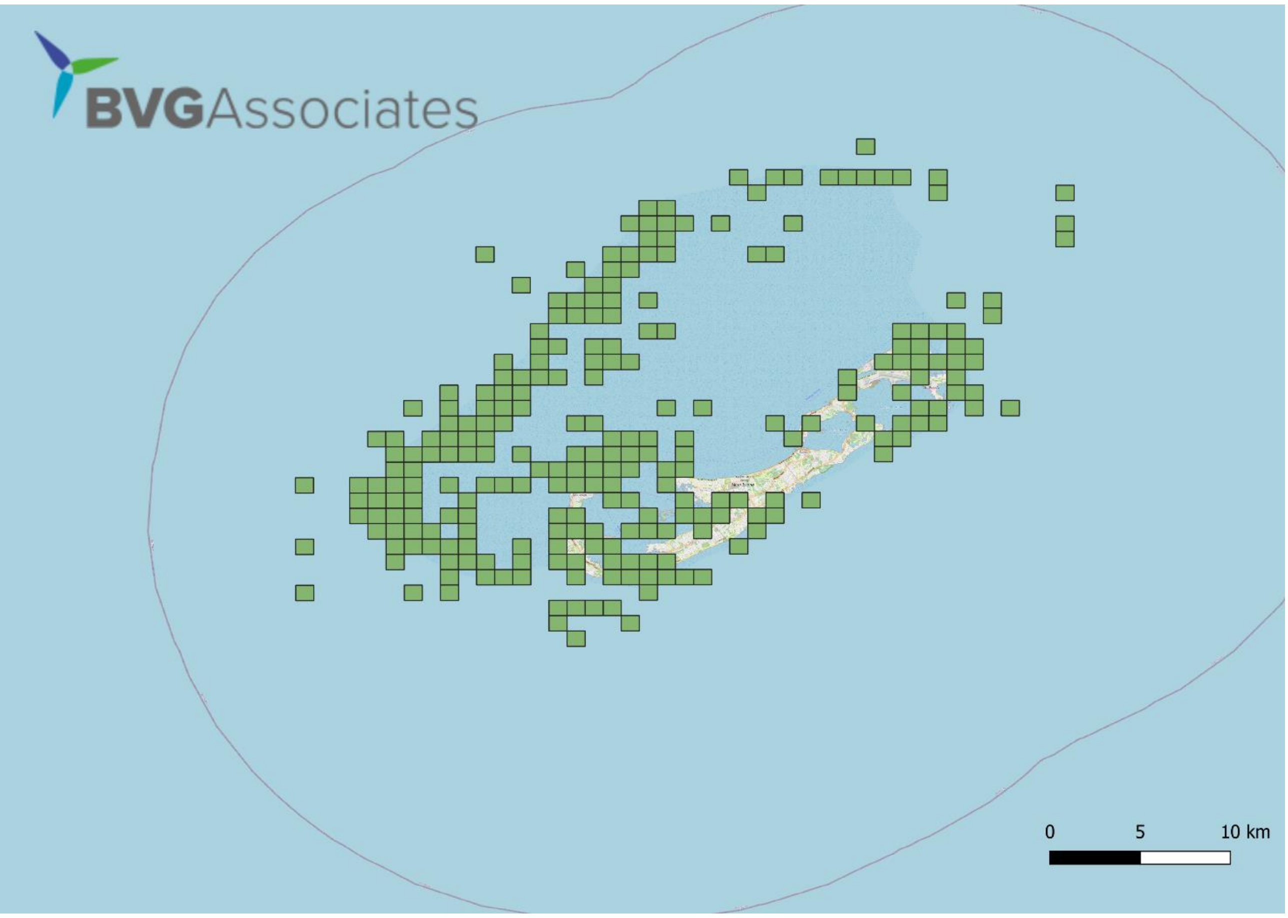

Figure 3.16 Undisclosed wrecks.

Avian zones

The four potential wind farm locations are all situated well away from avian zones. This is because:

- Operating turbines can influence bird behaviour in the vicinity, and
- Birds can be injured or killed by impacting turbine blades while in operation.

Specific efforts are underway to support local species, such as Cahows, which will need to be taken into consideration prior to final site selection.

The locations are all close to shore and so do not drive exclusions in this assessment.

Figure 3.17 Avian areas.

Seagrass

We have chosen the four potential wind farm locations to minimize interaction with sea grass meadows, recognizing their ecological importance. This is because:

- Foundation installation and cable routing have a negative impact on seagrass meadows, and
- Regular vessel traffic during operation could negatively impact the meadows.

The scale in Figure 3.18 is of coverage (0.2 = 20% coverage).

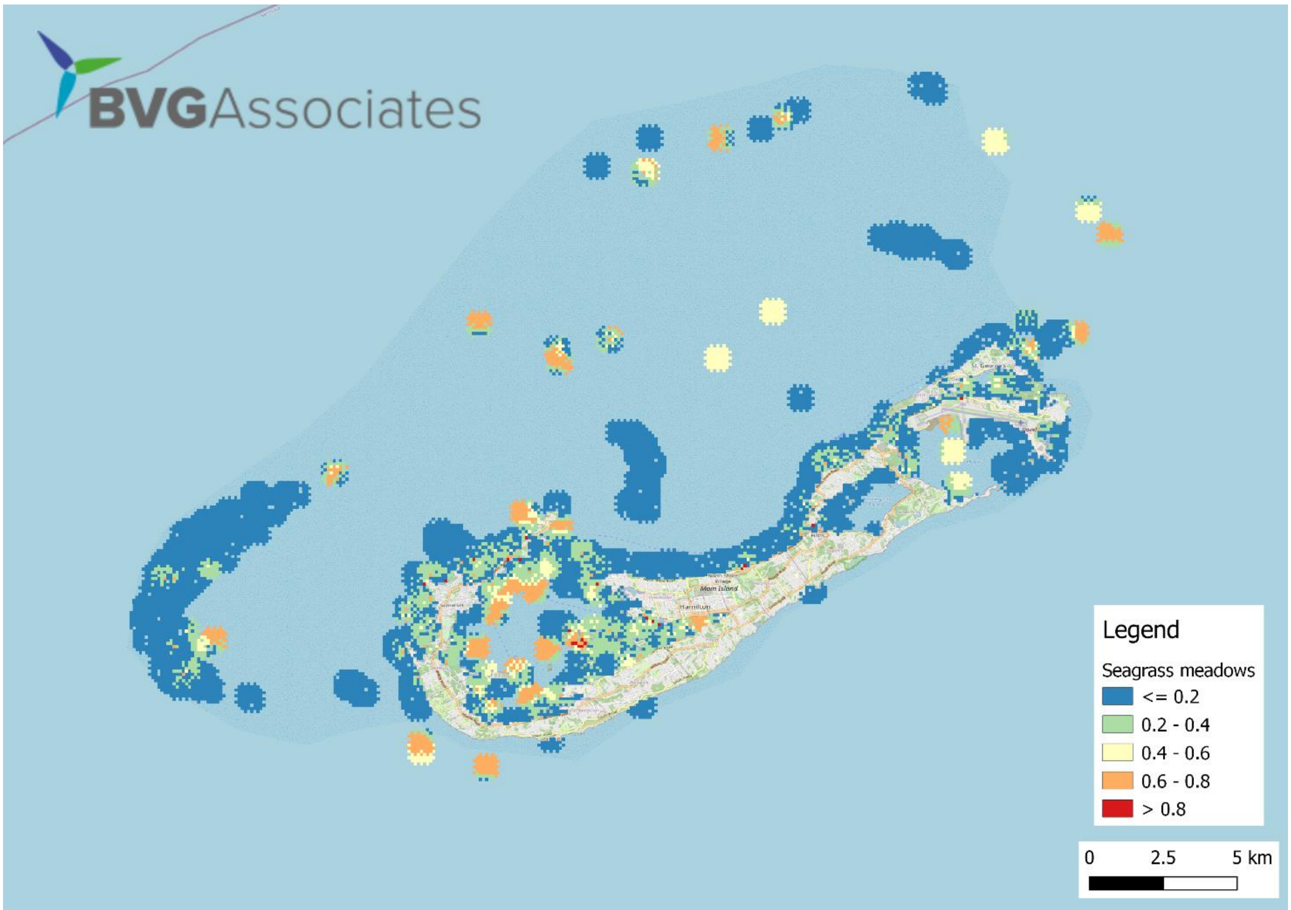

Figure 3.18 Seagrass meadows.

3.1.1 Location of operations port

A thorough assessment of the port infrastructure available is necessary to determine its suitability for accommodating the required operations and maintenance activities. Limited upgrades to port infrastructure may be required to support the logistics and functionality of the operations.

Upgraded port facilities and offshore and onshore activities relating to wind farm operation bring benefits to the local economy, creating jobs and stimulating economic growth in the area, including in related industries.

Offshore wind offers an opportunity to revitalize and refurbish old sites within the port area. Repurposing and upgrading existing infrastructure, such as the dock in St. George's Harbor, as shown in Figure 3.19, can enhance its functionality, preserve historical assets, and contribute to the overall revitalization of the port and surrounding areas.

Figure 3.19 Potential operations port locations, Saint Georges Harbour.

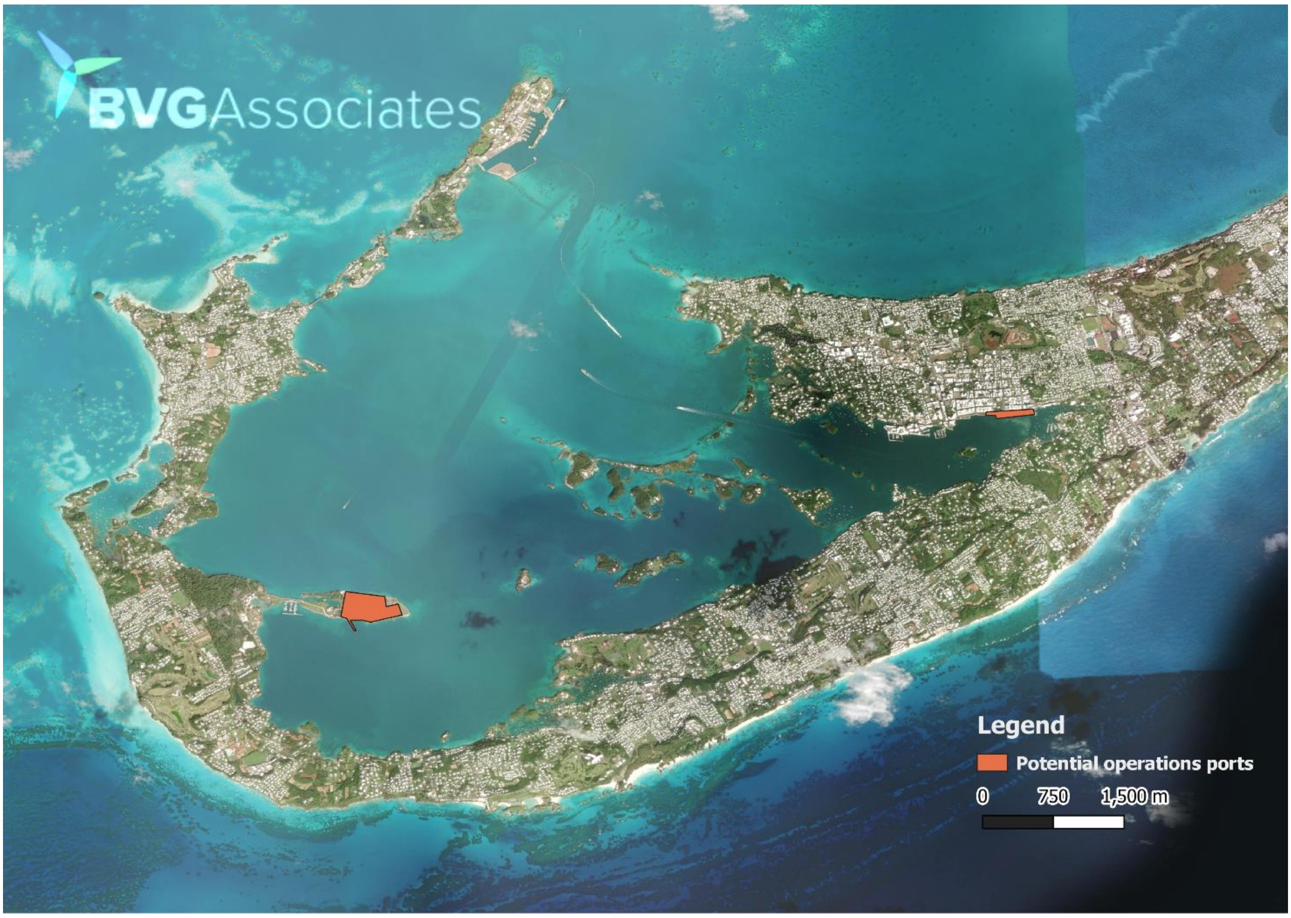

Figure 3.20 Potential operations port locations, Hamilton Harbour and Morgan's Point.

3.2. Uncertainties

In this section, we consider key uncertainties in this assessment. Beyond the specific points discussed, there may be errors or inaccuracies in any data used. While local knowledge and input are valuable for understanding coral reef locations, there is often increased risk of human error or discrepancies in the reported data.

3.2.1 Seabed conditions

Information regarding seabed, composition, bearing pressure, and the potential presence of caverns is limited. These actors introduce risks in foundation design, turbine and cable installation, all impacting capital cost.

3.2.2 Coral reef locations

The resolution of existing coral reef records, such as those derived from aerial surveys and satellite imagery and local stakeholders, often lacks the necessary level of detail for precise mapping of coral reef locations. These traditional methods tend to provide a coarse resolution, making it challenging to accurately identify the boundaries and characteristics of coral reef habitats such as with the large coral reef exclusion on the Bermuda Platform.

3.2.3 Cable routing

Due to the uncertainty concerning the exact locations of coral reefs, further investigation is necessary to facilitate accurate and resilient cable routing with micro-siting along possible pathways. While there is some data from previous coral reef survey work, the data required for a cable route survey will need finer resolution. Additionally, more geotechnical data on seabed composition and stability is required to ensure safe installation of cabling.

3.2.4 Location of grid connection point

The location of the onshore substation requires careful consideration to balance social impacts, cost, technical requirements, and grid capacity. Social impact assessments and community engagement help minimize disruptions and gain community acceptance. Optimizing the location involves assessing load distribution, grid stability, and future expansion potential. Collaboration among stakeholders aids in identifying suitable sites that meet criteria for sustainability and grid optimization. In this assessment the assumed location of the grid connection point is next to Tynes Bay waste to energy facility in the centre of the north shore the cost of which is included in the LCOE model.

3.2.5 Operations vessel routing

The nature of the Bermuda Platform being a habitat with large areas of reef and shallow water means that operation and maintenance vessel routing will need to be examined to find the best route to the project site.

3.3. Recommendations

Based on this assessment, to further reduce uncertainty we recommend the following early (relatively low-cost) actions:

1. Early informal consultation regarding potential project locations to gain specific local insights and help inform eventual choice of location.
2. Assessment of operations port and grid connection point. This will enable preliminary cable and operations vessel routing – considerations that could impact project viability.
3. Preliminary visual surveys of potential sites and associated cable and vessel routes, especially to assess water depth and coral cover and diversity. This will enable confirmation of preliminary routing.
4. Development of photomontages showing potential projects, as viewed from key locations. This will help early informal consultation. This is already being taken by Greenrock.
5. Preliminary wind resource assessment and design of measurement campaign. This improves confidence in site viability. This is already being taken by Greenrock.

At a later date (before site location is confirmed):

6. Geotechnical assessment of seabed at project location and along preliminary cable route. This will enable much better evaluation of technical viability.
7. Comprehensive environmental impact assessment with micro-siting to identify sensitive areas, coral reef hotspots, and benthic habitats. This will inform turbine siting and inform cable route planning and help avoid vulnerable ecosystems.
8. Wind measurement campaign, with associated data processing and correlation with other data sources to predict lifetime resource.
9. Front-end engineering design studies for foundations, cable routing, installation, operation and other aspects, accounting for Bermuda conditions, including storm impacts (wind and wave), foundation scour and cable protection.
10. A geotechnical analysis to provide insights into the substrate types and suitability for monopile and cable installation.

The timing and owner of activities 6 to 10 depend on the route to market for a project, especially when (and how) a project developer secures exclusive rights to develop the site.

Appendix A GIS layers used

Dataset	Description	Source
Wind resource	Global wind data at a height of 150 m	Global Wind Atlas v3.3, Technical University of Denmark (DTU) (https://globalwindatlas.info)
Bathymetry	Gridded data representing ocean floor depth of water	GEBCO Compilation Group (2023) GEBCO 2023 Grid (https://download.gebco.net/)
ICESat-2 lidar data	Lidar data obtained from ICESat-2 satellite providing higher resolution depth of water measurements and cross checked with GEBCO bathymetry data	ICESat-2 (https://nsidc.org/data/search#keywords=lidar/sortKeys=score,,desc/facetFilters=%257B%2522facet_sensor%2522%253A%255B%2522%2520%257C%2520ALTIMETERS%2522%255D%257D/pageNumber=1/itemsPerPage=25)
Marine Protected Areas	Database of protected areas worldwide including marine protected areas	UNEP-WCMC and IUCN (2020) Protected Planet: The World Database on Protected Areas (WDPA), [August 2020], Cambridge, UK: UNEP-WCMC and IUCN (www.protectedplanet.net)
RAMSAR sites	Wetland areas of international importance, Dataset consulted however no data relevant to Bermuda	UNESCO (http://ihp-wins.unesco.org/geoserver/ows?service=WFS&version=1.0.0&request=GetFeature&typename=geonode%3Asites&outputFormat=SHAPE-ZIP&srs=EPSG%3A4326&format_options=charset%3AUTF-8)
World heritage sites	UNESCO world heritage sites, St. George's town listed as site but no relevance to project	UNSECO (https://whc.unesco.org/en/syndication)
Submarine cables	Data on the locations of submarine communication cables	Telegeography (https://www2.telegeography.com/submarine-cable-faqs-frequently-asked-questions?__hstc=196094579.1852b6f62ae5461a699aa7e80e055c6a.1620827506168.1626126220956.1626139254572.81&__hssc=196094579.1.1626139254572&__hsfp=3839890209)

Dataset	Description	Source
Global shipping density	Density of global shipping activity	EMODnet - Human Activities, and CLS (https://ows.emodnet-humanactivities.eu/geonetwork/srv/api/records/0f2f3ff1-30ef-49e1-96e7-8ca78d58a07c)
Cyclones	Data related to cyclones occurring at a global scale with a 100-year return period	GeoServer (https://www.geonode-gfdrrlab.org/geoserver/wcs?crs=EPSG%3A4326&service=WCS&format=ArcGrid&request=GetCoverage&height=424&width=1327&version=1.0.0&BBo)
Mangrove habitat extent	Mangrove sites around Bermuda	Global Mangrove Watch (http://www.globalmangrovewatch.org/)
Pelagic fishing	Data related to bait fishing for pelagic fish species.	BOPP
Bottom feeding species	Data on species that feed near the ocean floor such as Snapper and Grouper and their catch data	BOPP
Catch and release	Data on fish caught and subsequently released	BOPP
Trapping	Data related to marine species caught using traps and pots	BOPP
Shark	Data on shark fishing and activities	BOPP
Spiny lobster	Data on spiny lobster fishing activities populations and habitats	BOPP
Trolling	Data on fishing activities using trolling methods	BOPP
Vertical line fishing	Data on fishing activities using vertical line methods	BOPP
Coral cover	Data on the extent of coral cover in specific areas	BOPP
Coral density	Data on the density of coral populations	BOPP
Fish density	Data on the density of various fish species	BOPP
Rugosity	Data on the rugosity (roughness) of the seabed	BOPP
Seagrass	Data on seagrass distribution and health	BOPP

Dataset	Description	Source
Open wrecks	Data on wrecks in open waters	BOPP
Prohibited Marine Board Notice areas	Data on areas where marine activities are prohibited	BOPP
Protected dive sites	Data on dive sites that are protected for conservation	BOPP
All undisclosed wrecks heatmap	Data and heatmap visualization of undisclosed wrecks	BOPP

Appendix B About BVG Associates

BVG Associates is an independent renewable energy consultancy focussing on wind, wave and tidal, and energy systems. Our clients choose us when they want to do new things, think in new ways and solve tough problems. Our expertise covers the business, economics and technology of renewable energy generation systems. We're dedicated to helping our clients establish renewable energy generation as a major, responsible and cost-effective part of a sustainable global energy mix. Our knowledge, hands-on experience and industry understanding enables us to deliver you excellence in guiding your business and technologies to meet market needs.

- BVG Associates was formed in 2006 at the start of the offshore wind industry.
- We have a global client base, including customers of all sizes in Europe, North America, South America, Asia and Australia.
- Our highly experienced team has an average of over 10 years' experience in renewable energy.
- Most of our work is advising private clients investing in manufacturing, technology and renewable energy projects.
- We've also published many landmark reports on the future of the industry, cost of energy and supply chain.