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Via email to: jsablan@gpagwa.com

Subject: Wind Power Site Assessment for Guam

Dear Ms. Sablan:

DNV Global Energy Concepts Inc. (DNV-GEC), under contract with R.W. Beck and the Guam Power Authority (GPA), conducted a preliminary site assessment of Guam to evaluate the potential for utility-scale wind power development on the island. DNV-GEC visited Guam on October 14-16, 2008, for the purpose of evaluating potential areas for wind power development and to identify locations suitable for meteorological (met) tower installation. Prior to the site visit, DNV-GEC reviewed the available wind data, topographic maps and transmission maps provided by GPA and identified areas for evaluating during the sites visit. The specific objectives for the site visit included:

- Evaluate areas of interest for potential wind power development
- Identify potential met tower locations
- Visit existing GPA met tower to inspect sensor placement, understand surrounding land uses, and evaluate the potential as a long-term reference
- Meet with GPA and Winzler-Kelly to discuss development potential on the island, project scale and integration with existing power system, and plan logistics associated with met tower installation

This report summarizes the results of our assessment and provides recommendations based on the site visit and an in-office review of the available information.

Site Evaluation

The site evaluation process is dynamic, factoring a number of site-selection criteria including, but not limited to, exposure to the prevailing wind resource, terrain features and orientation, compatibility with existing or future land uses, proximity to electrical infrastructure, proximity to property boundaries, environmental and community acceptance factors, aviation and telecommunication factors, and appropriate turbine size and setback requirements.



MANAGING RISK

The primary challenges of siting a wind farm on Guam are locating a site with adequate wind resource and sufficient space for wind turbine construction and operation, development of access roads, and connection to the electrical infrastructure.

Guam Wind Resource

The only wind resource map available for Guam is found in the Wind Resource Atlas of the United States developed by NREL in 1986. The report notes that wind data in the Pacific Islands was sparse and that many of the stations had questionable anemometer heights and exposures as a result of inadequate documentation. The wind map, shown in Figure 1, indicates a wind resource of Class 2 on most of the island, although ship wind data indicate Class 5 to Class 6 in surrounding waters. In general, sites with a Class 4 wind resource are typically sought for large-scale utility applications, though it should be noted that the economics of wind projects are heavily influenced by the rising cost of electricity, not just wind resource alone.

Generally speaking, land dissipates wind coming off of the ocean. The ocean has no fixed topographical protrusions, has a very low surface roughness and somewhat laminar wind flows compared to land masses that can have significant topographical protrusions (trees/vegetation, hills/mountains/cliffs, valleys/canyons, buildings/cities, etc.), medium to high surface roughness, and potentially turbulent winds.

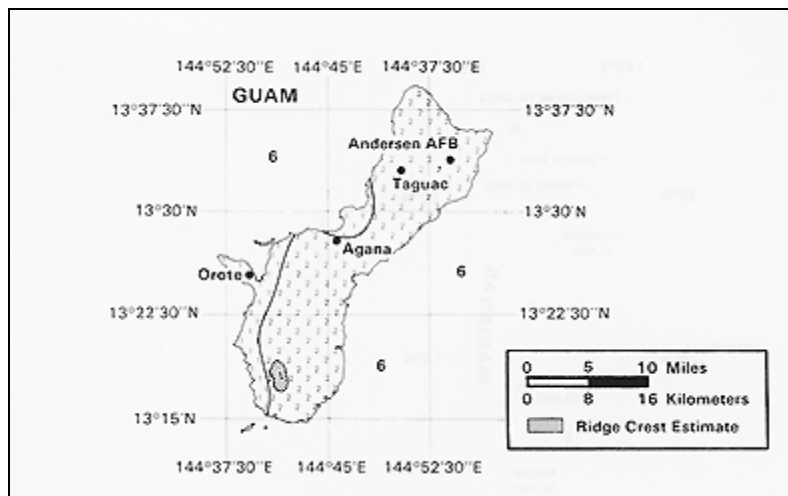


Figure 1. Wind Resource Map of Guam

The best current source of wind data in Guam is from the FAA's Automated Surface Observing System (ASOS) at the A.B. Won Pat International Airport. ASOS is a set of standardized instruments deployed in a consistent manner across the majority of airports in the U.S. DNV-GEC obtained the last eight years of wind data from the Guam airport ASOS station. Data prior to 2000 are not used because the measurement location and equipment were not consistent with the ASOS practices.

The long-term average wind speed from the A.B. Won Pat International Airport is 4.4 m/s (9.8 mph) measured at a height of 10 m above ground surface. This wind speed corresponds to a low Class 2 wind resource which is considered “marginal” for purposes of utility-scale wind projects in North America. However, as previously stated, the high local cost of electricity on Guam could result in the available wind resource being considered better than “marginal.”

DNV-GEC also reviewed three years of data collected from the GPA met tower located at the Cabras-Piti power plant on the west side of the island. The NREL wind resource map has this location classified as having a Class 1 wind resource. The average measured wind speed at 60 m is 4.9 m/s (10.9 mph), which is consistent with a Class 1 wind resource and not surprising due to the tower’s poor exposure to the prevailing east-northeast wind direction.

There are currently no public sources of wind data to verify the wind resource along higher-elevated and better-exposed ridgelines. Although, data collected at the airport may server as a long-term reference station, it provides little value in understanding the local wind conditions in Guam’s complex terrain. The wind resource at the potential development sites, discussed later in this report, may exceed the Class 2 wind resource depicted in Figure 1.

Map Review

DNV-GEC identified the hilltops of the Cotal and Pulantat areas in the center of the island as areas of interest. These areas are currently undeveloped, have potential exposure to the prevailing east-northeast wind resource and are within close proximity of existing roads and electrical infrastructure. Although there are higher ridges with potentially stronger wind resource, the steep topography and distance to existing roads and transmission would likely make them cost prohibitive. DNV-GEC also identified the undeveloped area near the village of Yigo on the north end of the island as a third area of interest. Again, this area is close to existing roads and electrical infrastructure and exposed to the prevailing east-northeast wind resource. Figure 2 shows a map with the areas of interest circled in red.



Figure 2. Guam Areas of Interest

GPA acquired property ownership maps and identified government-controlled parcels in both the Cotal and Northern areas of interest. With the exception of the Pulantat power plant and substation, all parcels in the Pulantat area are privately owned and were not accessible during the site visit.

Cotal Area

GPA arranged for access to the Department of Agriculture land parcel outlined in blue in Figure 3. The Cotal area lies north of the Cross Island Road in the center of the island and is made up of two ridges divided by the Tarzan River. The northern ridge is roughly 150 to 210 m (490 to 690 ft) in elevation and the southern ridge is approximately 120 to 160 m (390 to 530 ft) in elevation.

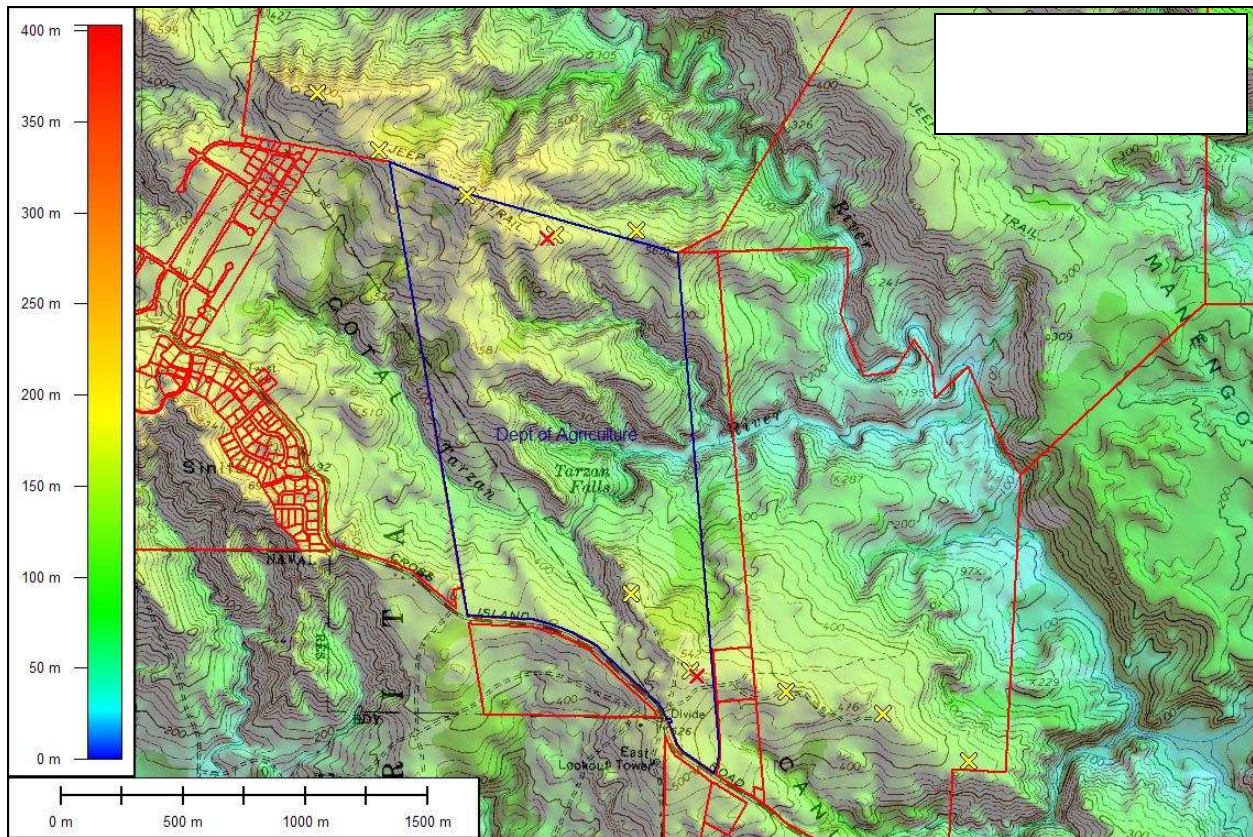


Figure 3. Department of Agriculture Parcel – Cotal Area

Both ridges are generally oriented west-northwest to east-southeast, which is favorable given the prevailing east-northeast wind direction recorded at the airport. This orientation will allow for efficient turbine spacing. During the site visit, DNV-GEC observed scattered trees along the ridge that exhibited signs of wind-induced flagging. These conditions generally indicate that higher wind speeds are likely in areas of higher elevation that offer good exposure to the prevailing wind. The wind resource along these ridgelines may be higher than the Class 2 wind resource shown in Figure 1. Based on DNV-GEC's inspection and topographic map analysis, it is estimated that 8 to 10 multi-megawatt scale turbines (2 MW) could be situated along the two ridges in the Cotal area. A conceptual turbine layout is presented in Figure 3; potential turbine locations are represented by yellow X's.



Figure 4. Example of Flagging in Cotal Area, Photo Facing Southeast

A 34.5 kV overhead power line follows the Cross Island Road. The road grade appears reasonable for delivery of turbine components; however, some turns may require widening. Land adjacent to the Department of Agriculture parcel is privately owned, which would require obtaining long-term access to the land through a lease agreement with the land owners. Most of the land is currently undeveloped, but used for recreation. The Cotal area is sufficiently far from the airport and its associated airspace that aviation concerns do not appear to be significant.

Three areas of potential concern that require further assessment include determination of potential environmental issues, visual impacts and conflict with military defense radar. Potential environmental concerns may be present if sensitive habitat or species are located along the ridges. There may also be concerns associated with the visual/aesthetic impact. A wind project on these ridgelines would be visible from homes along the Sinifa ridge to the west and the Leo Palace Resort directly north. Also, there are several established trails for hiking and mountain biking. The Tarzan Falls are accessed from a trail along the southern ridge.

The Department of Defense (DOD) radar station located on the north end of the island has been identified as being a significant concern for placement of turbines on Guam. The Federal

Aviation Administration's (FAA) online *DOD preliminary screening tool*¹ (utilized by DNV-GEC) indicates that a wind project constructed in the Cotal area would be highly likely to impact Air Defense and Homeland Security radar and would require completion of an aeronautical study by the DOD. The form of mitigation and impact on development potential cannot be known at this stage. Early discussions with the FAA and DOD are recommended to begin this process.

DNV-GEC has identified two locations appropriate for installation of 60-m tall meteorological (met) towers on Department of Agriculture land. Table 1 presents coordinates and elevation for these locations. These tower locations are also identified in Figure 3 as red X's. DNV-GEC would give priority to the Met 1 location on the southern ridge, as data collected from this location would yield more conservative energy production estimates and that location would be easier to access for construction. Both locations would require tree/brush clearing to accommodate anchor installation and tower erection.

Table 1. Proposed Met Towers on Department of Agriculture Parcel

Tower	Easting	Northing	Elevation (m)
Met 1	253471	1481337	165
Met 2	252856	1483125	180

Note: Coordinates in UTM Zone 55 - WGS84

Pulantat Area

A second possible area where a utility-scale wind project may be conceivable is located in the Pulantat area along the ridgeline feature locally known as Sabana Batea. A topographic map with a rough turbine layout is shown in Figure 5. The ridge is approximately 105 to 145 m (340 to 475 ft) above sea level and has a west to east crescent shape, which is not necessarily ideal given the prevailing east to east-northeast wind direction. The ridge orientation is not considered a fatal flaw; however, care is required in determining adequate inter-turbine spacing to minimize inter-turbine wake effects and associated turbulence. It is estimated that four to five multi-megawatt scale turbines (2 MW) could be situated on Sabana Batea.

¹ <https://oeaaa.faa.gov/oeaaa/external/gisTools/gisAction.jsp>

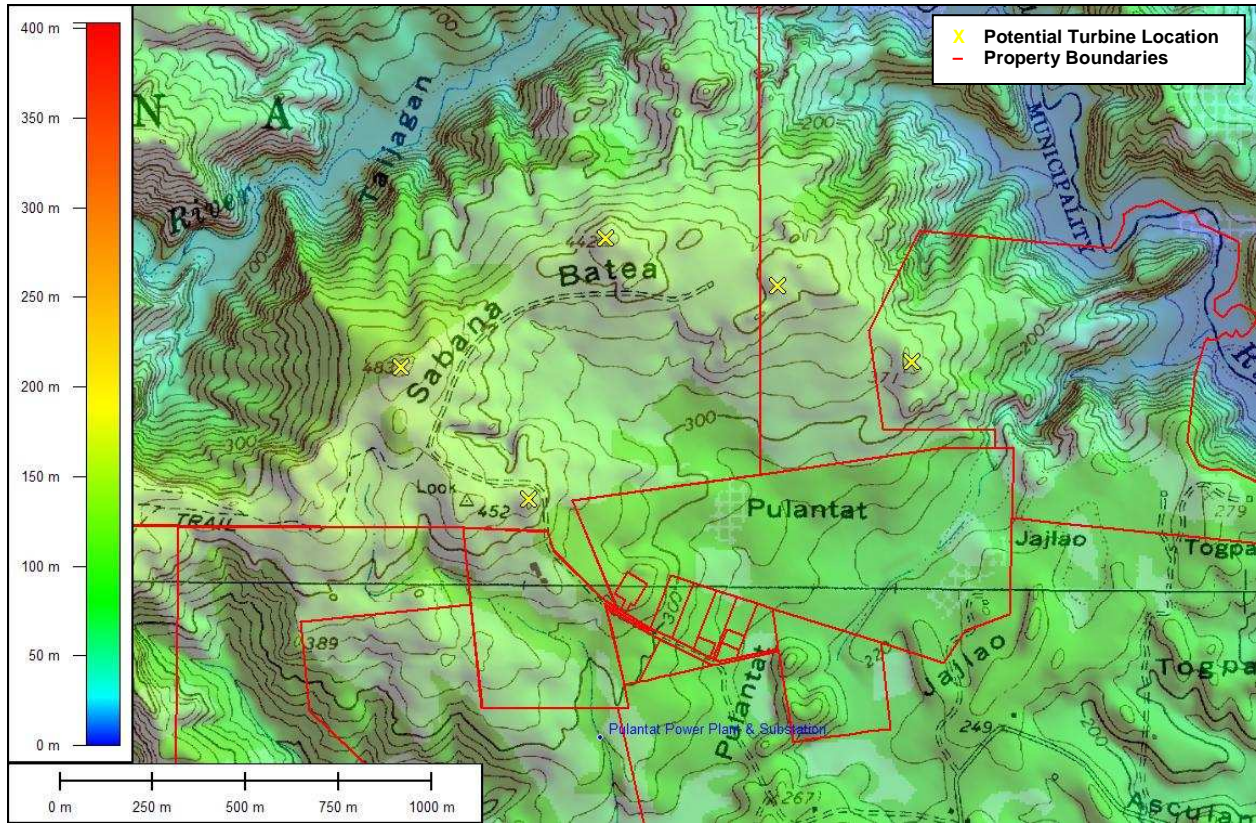


Figure 5. Pulantat Area – Topographical Map

There has been additional development not shown on the topographical map in Figure 5. A paved road now crosses over the Sabana Batea ridgeline southwest to the Leo Palace resort. Both Leo Palace and the access road are visible in the aerial image presented in Figure 6. The access road grade appears reasonable for delivery of turbine components; however, maneuvering oversized turbine components through the village of Orot (directly north of image) will require planning. A 34.5 kV power line connects to the Pulantat power plant and substation from the east and primarily feeds the Leo Palace resort.

GPA has determined that all land along the ridge is privately owned and would require obtaining long-term access to the land through a lease agreement with the land owners. The land is currently undeveloped and the largest parcel is owned by the Texas A&M Foundation.

DNV-GEC did not observe any homes along the ridge. The nearest homes are adjacent to the Pulantat power plant to the southeast. The Pulantat area is approximately 6.5 km (4 mi) from the airport and its associated airspace. At this distance, the FAA may impose height restrictions. Early discussions with the FAA are recommended to confirm this observation.

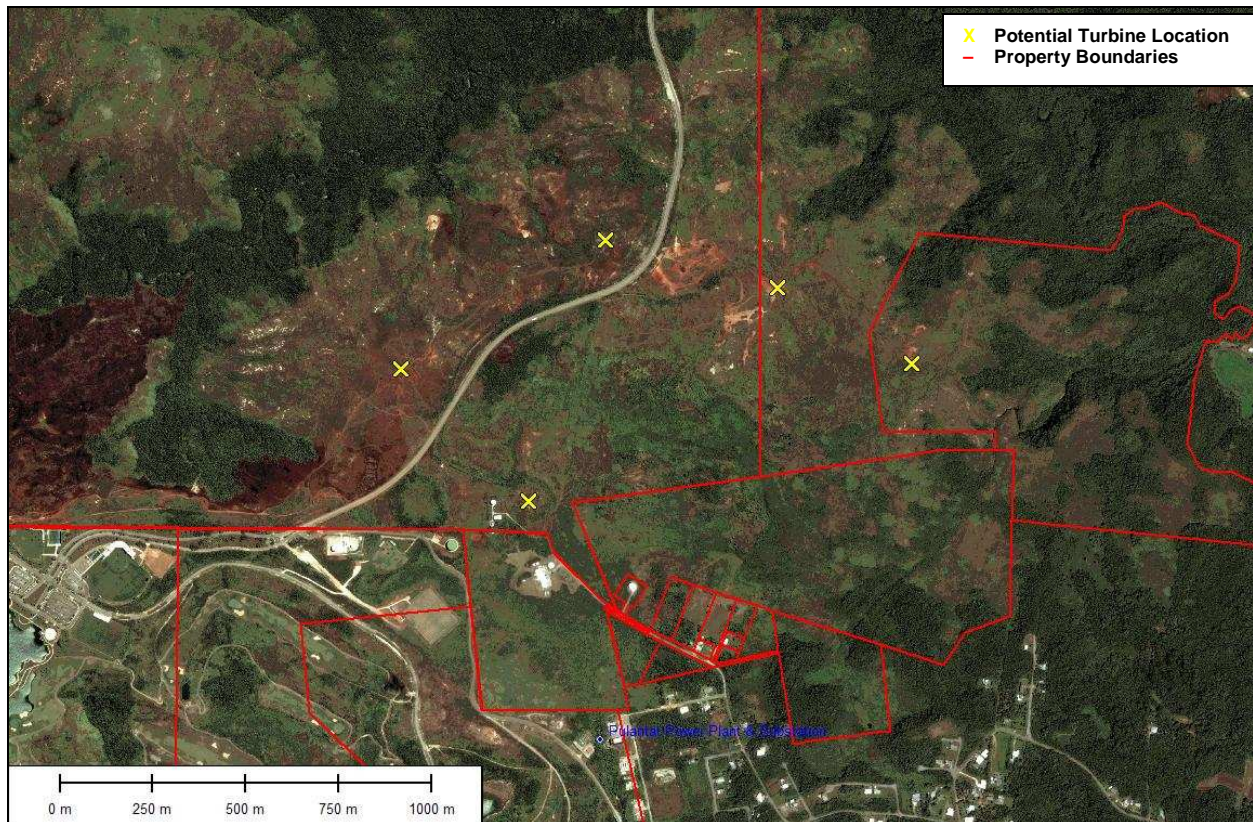


Figure 6. Pulantat Area – Aerial Image

The Pulantat area would have the same potential concerns as the Cotal area that would require further assessment. These concerns include potential environmental issues, visual impacts (particular with the Leo Palace resort) and conflict with military defense radar. In addition, DNV-GEC observed a down-range radar station operated by the Japan Aerospace Exploration Agency. This station receives telemetry signals from rockets launched from the Tanegashima Space Center in Japan. The impacts wind turbines would have on these communications is not known at this time and would require further assessment.

Since only government-controlled land is being considered for initial met tower installations and wind resource assessment, DNV-GEC did not identify specific met tower locations in the Pulantat area. However, DNV-GEC observed several viable locations on the Texas A&M Foundation land from the Leo Palace Resort access road.

Northern Area – Chamorro Land Trust

GPA arranged for access to three parcels of land controlled by the Chamorro Land Trust on the north end of the island near the village of Yigo. As shown in Figure 7, these land parcels are situated on the east coast of Guam's northern plateau approximately 160 to 180 m (525 to 590 ft) above sea level. Although this area appears unobstructed and well exposed to the prevailing east winds, the near-vertical cliff face is believed to divert wind flow around the island to the

southwest, rather than over. During the site visit, DNV-GEC observed no evidence of flagging on exposed vegetation. Given the expected low wind resource, DNV-GEC has not prepared a preliminary layout or provided proposed met tower locations for this area.

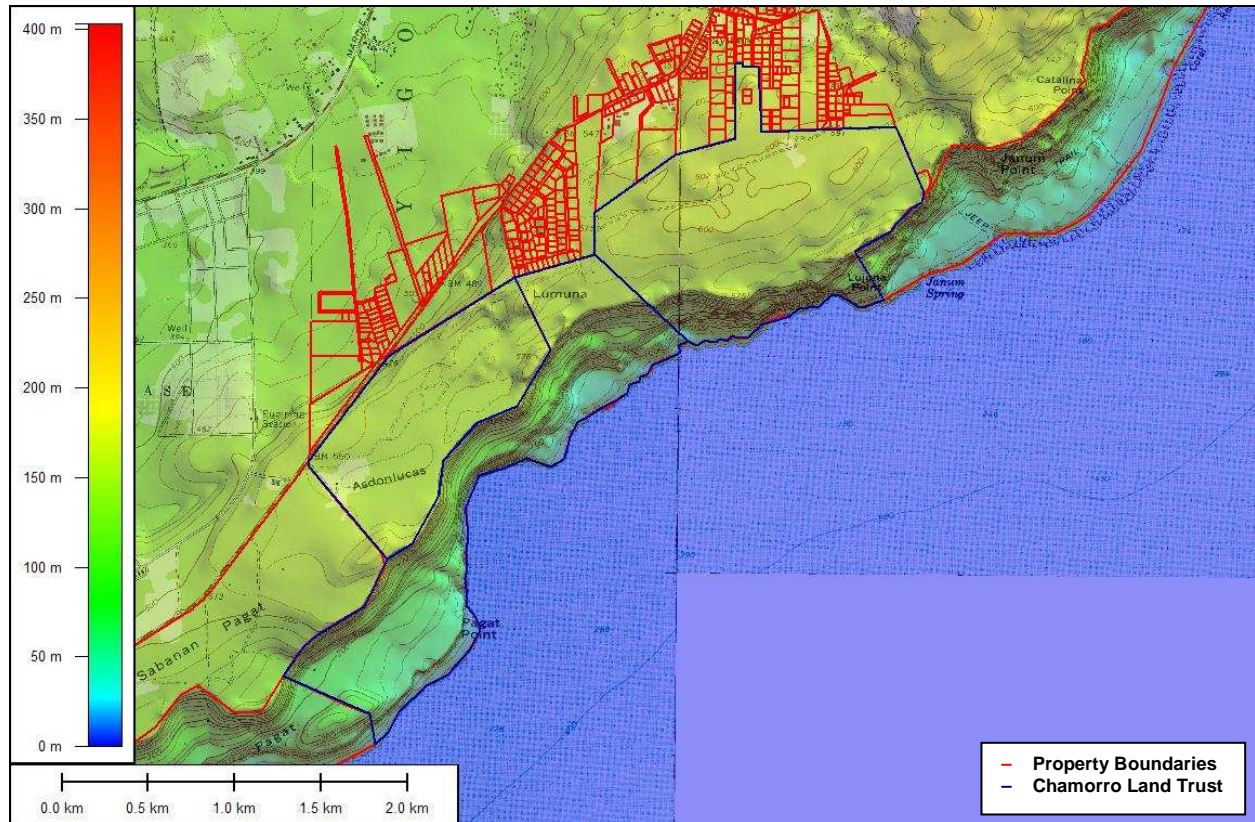


Figure 7. Chamorro Land Trust Parcels

Met Tower Evaluation

While on Guam, DNV-GEC visited the GPA met tower located at the Cabras-Piti power plant. A photo of the tower is presented in Figure 8. Wind speed and direction data are collected at approximately 8 and 58.5 m (27 and 192 ft). Additional meteorological measurements (temperature, pressure, solar radiation and precipitation) are collected at ground level. The tower width is 2 ft and the sensor mounting booms appear to be roughly 8 to 10 ft long, which is less than recommended for wind resource assessment data collection. Wind speed data will be impacted by wind flow around the tower. The close proximity of large obstructions; buildings, smoke stacks, fuel tanks, and transmission towers will further impact the data and increase measurement uncertainty. Given the topographical differences and measurement uncertainty, it is unlikely that there will be a strong correlation between data collected at the GPA met tower and data collected at the Cotal area.



Figure 8. GPA 60-m met tower at Cabras-Piti Power Plant

Conclusions and Recommended Next Steps

The preliminary assessment has determined that 20 to 30 MW of wind energy generation is conceivable for well-exposed ridgelines in the Cotal and Pulantat areas. Although the wind resource is expected to be lower than typically sought for projects in the continental U.S., the high cost of power generated with diesel fuel provides a leveling effect. DNV-GEC recommends installing at least one 60-m monitoring tower and proceeding with one year of data collection. The estimated cost for this endeavor ranges from \$60,000 to \$80,000 per tower, depending on the availability of local tower installation contractors. Measurement of the wind resource is required to make more informed business decisions at this stage.

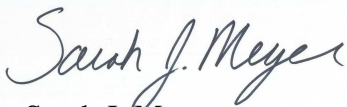
Summary of recommended next steps:

1. DNV-GEC recommends installing a 60-m wind resource monitoring tower at the Met 1 location identified in Figure 3 and Table 1. This will require permission from the Department of Agriculture. As an attachment to this letter report, DNV-GEC has prepared a map of the proposed met tower locations showing the maximum clearing required to accommodate a 60-m guyed tubular tower. A 60-m guyed lattice tower will likely require less clearing; however, anchor placement will need to be determined by the tower manufacturer and installation contractor.

2. DNV-GEC recommends that GPA investigate local zoning regulations and building codes for 60-m temporary tower structure (tower to remain in place for 1-2 years) and obtain the required permits.
3. DNV-GEC recommends that GPA file a Notice of Proposed Construction (Form 7460-1) with the FAA. Although structures under 200 ft and greater than 20,000 ft from an airport runway are not required to file, early discussions with the FAA will be helpful for future wind turbine permitting.
4. DNV-GEC also recommends that GPA begin discussions with the DOD regarding the likely radar communication conflict and possible mitigation strategies.

Please contact me with any questions regarding the information contained in this report or if additional information is needed to support met tower permitting.

Sincerely,



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