



EXECUTIVE SUMMARY

Avangrid Wind Turbine Energy Radar Interference Study

Department of Navy

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INTRODUCTION

Under the provisions of the Department of Defense (DoD) mission compatibility evaluation process¹, the Military Aviation and Installation Assurance Siting Clearinghouse initiated a study of the Navy's Relocatable Over-the-Horizon Radar (ROTHR) to assess the potential impacts from the Avangrid Wind² Turbine Energy project, in Perquimans and Pasquotank Counties, North Carolina, hereinafter referred to as the Avangrid Wind Energy Project. The ROTHR system is located at Naval Support Activity (NSA) Hampton Roads-Northwest Annex, in Chesapeake, VA. Massachusetts Institute of Technology Lincoln Laboratory (MIT LL) was identified as lead independent radar specialist on this study effort due to their significant experience in conducting radar studies in support of DoD missions/operations. Other significant participants of the study include: Forces Surveillance Support Center (FSSC), United States Naval Research Laboratory, Raytheon, WR Systems, United States Air Force Research Laboratory, and Sandia National Laboratories.

OBJECTIVE

The purpose of this document is to provide, as required by the Memorandum of Agreement (MOA) between DoD and Avangrid Renewables and the concurrence for construction of 104 wind energy turbines, a technical summary of the modeling and post-construction field measurements performed in 2017.

¹ The mission compatibility evaluation process is defined in 32 CFR Part 211, see: <http://www.ecfr.gov/cgi-bin/retrieveECFR?gp=1&SID=284108d7dca87a6bea95165fd1c1b0be&ty=HTML&h=L&r=PART&n=32y2.1.1.1.16>

² The project's name changed during the study. Originally identified as the Desert Wind Project, the developer Iberdrola Renewables later identified the project as the Windfall Wind Project, and is currently calling it the Amazon Wind Project. Iberdrola Renewables USA finalized its acquisition of UIL Holdings in December 2015 to create a new company, Avangrid, which is the current operator of the wind energy farm. For purposes of this technical paper, the project is referred to as the Avangrid Wind Energy Project.

SUMMARY OF FINDINGS

The primary conclusion of the study is that the 104 turbines meet the conditions of the MOA, the pre-construction model predictions were accurate, and the installation of additional wind energy turbines at the Avangrid Wind Energy Project site is not compatible with the ROTHr system.

BACKGROUND

The ROTHr system provides tactically significant wide-area air and sea surveillance track information to support U.S. Southern Command's counter-drug mission.

Over-the-horizon radar systems such as ROTHr detect echoes from distant moving targets that are many orders of magnitude smaller than the very strong echoes from the land and sea, or "surface clutter", surrounding those targets. Interference from other sources such as noise and Doppler-spread clutter will ultimately limit the size, or sub-clutter visibility, of the detectable targets. One such source is the scatter from rotating turbine blades in nearby wind energy turbine farms. To determine the maximum compatibility between the Avangrid Wind Energy Project and ROTHr operations in support of successful attainment of counter-drug mission performance goals, a 1 dB reduction in overall Sub Clutter Visibility (SCV) from the Project was considered to be the maximum degradation permitted that would allow the radar system to support the mission. From this 1 dB reduction in SCV, the maximum allowable wind turbine interference threshold is 76 dB below the surface clutter. The -76dB wind farm interference threshold value became the basis for evaluation of pre-construction modeling results for the Avangrid Wind Energy Project.³

In November 2012, DoD informed Avangrid Renewables that Avangrid's proposed wind energy project in eastern North Carolina would adversely affect the ROTHr system, unless action was taken to mitigate the impacts. As a result of the adverse impact determination, DoD and the developer agreed to further study the mission compatibility of the proposed Avangrid Wind Energy Project. DoD funded MIT LL to develop a wind turbine and radar model⁴ for the ROTHr system and conduct field tests to validate the model via post-construction field measurements so as to obtain actual interference measurements and validate the model predictions.

A mitigation agreement between Avangrid and the DoD, acting through the U.S. Navy, was signed on November 5, 2014.⁵ The mitigation agreement required the Navy to determine the need for and conduct measurements and analysis regarding any impact on the operation of the

³ The modeling parameters which were accepted by the DoD in the MOA with Avangrid Renewables of November 2014 are not indicative of future modeling parameters which the DoD may apply to other wind energy projects in determining compatibility with the ROTHr. Future wind energy projects are subject to the established mission compatibility evaluation processes and will be independently and cumulatively assessed for impacts to the ROTHr system.

⁴ Jao, J.K.; Stevens, W.; Eisenman, J.; Coutts, S., "A wind farm interference model for Over-the-Horizon Radar," in Radar Conference (RadarCon), 2015 IEEE, vol., no., pp.0717-0722, 10-15 May 2015

⁵ The mitigation agreement can be downloaded at the following internet site address:
<http://navysustainability.dodlive.mil/files/2015/07/20150717-Iberdrola-Atlantic-Wind-Agreement.pdf>

ROTHR caused by the Test Energy Procedure of various wind turbines, and to share any results with Avangrid Renewables.⁶

The modeling phase of this effort occurred from the Summer of 2013 through October 2014. The post-construction field measurement study was completed in two phases – an initial field study in January 2017 to measure the single-turbine scattering, and a second field study completed in July 2017 to measure multiple turbines and the full-farm effect.

EVALUATION

During the modeling phase in 2013/2014, several scenarios of wind turbine distributions were evaluated based upon Avangrid-proposed turbine type and locations, each one differing in the number or arrangement of turbine locations. The proposed project consisted of approximately 150 turbines with an approximate 100 meter tower height and a 50 meter blade length. The project is located within a section of land that spanned a distance between 22 and 38 km from the ROTHR receive antenna.

This analysis revealed that the impact to radar clutter is not only dependent upon the distance away from the ROTHR receive antenna, but also on the number of turbines in the radar’s “field of view” that are in alignment. Proximity to the ROTHR receive antenna could be mitigated by adjusting the number of turbines and specific locations for the project modeled.

The technical team conducted studies to attempt to optimize a wind turbine project configuration based on a distance from the ROTHR receive antenna that would not exceed the impact threshold.

In 2014, MIT/LL modeling of the Avangrid Wind Energy Project predicted that the “clutter contribution” from construction of 104 of the proposed 150 turbine wind energy turbines would not exceed the threshold allowable, and was the basis of the mitigation agreement. However,

⁶ See section 2(B)(4)(b) of the mitigation agreement which states: "The Navy agrees to determine the need for and conduct measurements and analysis regarding any impact on the operation of the ROTHR caused by the Test Energy Procedure of various wind turbines, and agrees to share with Iberdrola Resources and Atlantic Wind any results." When the mitigation agreement entered into force on November 5, 2014, it envisioned the potential for two tests (test one consisting of a single turbine and test two consisting of multiple turbines or a full farm testing of all turbines to the extent possible). It was also envisioned that one test would occur during construction on a non-interference basis, and a second test to occur after construction completion. These two tests were to take place during a time period characterized in the mitigation agreement as the Test Energy Phase. These factors consisted of a construction schedule that was dynamic due to weather conditions and lack of availability of the construction site to test both during and after construction.

A conceptual test plan was provided to Avangrid Renewables in March 2016 and the Government was notified that the testing could not be accomplished during the construction period. Attempts to reschedule the single wind energy turbine testing at other times in 2016 were complicated by weather conditions which affected the construction period. The testing and field measurements contemplated to take place during the Test Energy Phase were eventually accomplished during the “Confidence Building Measures” phase of the mitigation agreement discussed in section 2(B)(6) which was a one-year time period following the commencement of operation notice by Avangrid Renewables to the Navy. The single wind energy turbine test was accomplished in January 2017 to measure the single-turbine scattering, and a second field study was completed in July 2017 to measure multiple turbines and the full-farm effect.

this required that actual turbine effects and impacts at the ROTHr be measured. To reflect that, the MIT LL model could not be completely validated until a wind energy turbine project was actually constructed somewhere near (or “in field of view of”) the ROTHr system. In cooperation with Avangrid Renewables, provisions were incorporated into the mitigation agreement which required post-construction field testing of impacts to the radar during the construction phase of the project and during the first full year of the wind energy turbine project’s operation. The measurements first required a single-turbine measurement, and then a multi-turbine or full-farm measurement.

In accordance with the terms of the 2014 mitigation agreement, field measurement validation studies were planned to begin upon completion of construction and during the first year of operation of the wind farm. The test objectives were twofold: (1) to test and validate the interference model and, (2) to measure the actual wind farm interference levels at the ROTHr receiver site.

Again, this post-construction field measurement was planned to be completed in two phases – an initial field study completed in January 2017 to measure the single-turbine scattering, and a second field study completed in July 2017 to measure multiple turbines and the full-farm effect.

RESULTS

The first post-construction test of a single operational turbine occurred in January 2017 and was designed to validate the wind turbine scattering model. This post-construction test validated the interference level predicted for a single turbine and validated the radar model that computes the interference level for multiple turbines based on the single-turbine computations.

The second post-construction test focused on the scattering effects from multiple turbines and a full wind energy farm validation. Field work for this test was completed in July 2017.

CONCLUSION

The testing process demonstrated that the average measured wind energy farm interference levels were consistent with model predictions, and validated the construction of 104 wind energy turbines as the maximum allowable wind energy farm without exceeding the pre-determined and agreed upon impact from the Avangrid Wind Energy Project. Based on the results of the post-construction field measurements conducted in January and July 2017, no additional degradation in overall SCV from the Avangrid Wind Energy Project can be accommodated without risking additional degradation of the ROTHr system. Both the modeling and post-construction field measurements confirmed the maximum project size of 104 wind energy turbines; no additional wind energy turbines can be added to this renewable energy site.