Electric and Magnetic

Fields Analysis

Fawn Meadow Lane

Woodbury, CT

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Summary

This analysis has been put together as part of a Connecticut Siting Council certificate for a proposed solar array at Fawn Meadow Lane in Woodbury, CT by Greenskies Clean Energy LLC. The proposed system will be a 4.625-Megawatt AC ground mounted 19-acre solar array on the 36.87-acre property. The array lies on a secluded access road connecting to Fawn Meadow Lane, nestled against a hill and surrounded by woods. To the immediate East and North of the Project is an open space owned by the Fawn Meadow Estates Homeowners Association and houses line Fawn Meadow Lane, and Orchard Avenue up to the Watertown Fire District Pumping on Nonnewaug River. To the North is Pondview Farm and Little Farm. These farms are nearby the Transfer Station, Bethleham Mini Storage, an Auto Repair Shop and other light industrial services. To the South and West, more homes line Church Hill and Cowles Road up to the Flanders Nature Center and Land Trust. EMF have been evaluated for this site exploring the impacts from the direct current produced by the modules that is then converted to alternating current and stepped up to 13.8-kV by a transformer where the current then travels to the point of interconnection to connect to the Eversource Utility line at Fawn Meadow Lane. A background on Electric Fields, Magnetic Fields, and EMF has been provided as a part of this report. The sources of EMF produced by the solar modules and the DC wires will not create any effects that would disturb the fields around the area. The effects from the specified equipment will have an effect a fraction of the Earth's geomagnetic field which is thousands of times lower than the recommended exposure limits set by the ICNIRP. (ICNIRP). The inverters create AC fields that decrease to negligible levels within a few feet. Given that all inverters are at least 112 feet from adjacent properties no harmful impacts are expected. The EMF effects due to the 13.8-kV interconnection equipment with the Eversource distribution line are not expected to have any impacts outside of the typical distribution line effects which have not been found to create

harmful impacts. The design of the proposed EMF producing equipment from Greenskies Clean Energy LLC's proposed solar array has been evaluated and will minimize the field levels at the property lines and is in accordance with the Connecticut Siting Council's EMF Best Management Practices (CSC).

Introduction

Greenskies Clean Energy LLC, proposes to develop a 4.625-Megawatt(AC), ground-mounted solar facility in Stonington, Connecticut. The Solar Array system lies within a 19 acre project area on the 36.87-acre site. on a secluded access road connecting to Fawn Meadow Lane, nestled against a hill and surrounded by woods. To the immediate East and North of the Project is an open space owned by the Fawn Meadow Estates Homeowners Association and houses line Fawn Meadow Lane, and Orchard Avenue up to the Watertown Fire District Pumping on Nonnewaug River. To the North is Pondview Farm and Little Farm. These farms are nearby the Transfer Station, Bethlehem Mini Storage, an Auto Repair Shop and other light industrial services. To the South and West, more homes line Church Hill and Cowles Road up to the Flanders Nature Center and Land Trust.

The solar modules generate DC current which then is converted to AC current. This then goes through a transformer and stepped up to 13.8-kV to interconnect at the existing Eversource distribution lines. This report evaluates the EMF impacts of the proposed system.

This report, details Electric and Magnetic Fields, the sources on the site, and analyzes Connecticut Siting Council's (CSC) EMF Best Management Practices in accordance with the project design.

EMF Background

Electromagnetic fields (EMF) are a fundamental aspect of electromagnetism and physics in general. They arise from the interactions between electric charges and currents. Electromagnetic fields consist of two interrelated components: electric fields and magnetic fields. Electric fields are created by electric charges. A charged particle generates an electric field that influences the behavior of other charged particles in its vicinity. Electric fields exert forces on charges, either attracting or repelling them based on their polarities. Electric fields can also induce charges in nearby conductive materials, leading to the redistribution of charges. Magnetic fields, on the other hand, are generated by moving charges, such as electric currents. A current flowing through a wire creates a magnetic field around it. Magnetic fields exert forces on moving charges and are responsible for phenomena like the deflection of charged particles in a magnetic field and the operation of devices like electric motors and transformers. Electromagnetic fields play a central role in a wide range of natural and technological processes. They are responsible for the transmission of radio waves, microwaves, and light, allowing for communication and the propagation of energy. EMFs are also essential in the operation of electric generators, transformers, and a multitude of electronic devices.

Electric Fields

Electric fields are vector fields that exert forces on charged particles. These forces are governed by Coulomb's law, where the force between two charges is proportional to the product of the charges and inversely proportional to the square of the distance between them. Electric fields can be visualized using field lines, which depict the direction and strength of the field at different points in space. The analysis of electric fields involves calculating field strengths, mapping field distributions, and predicting the effects of these fields on nearby objects and charges. Components such as capacitors, transistors, and insulators require precise control of electric fields to ensure optimal performance and prevent breakdown. In power transmission and distribution systems, managing electric fields is essential to minimize energy losses, control corona discharge, and maintain the integrity of equipment and infrastructure. As technology advances, a thorough understanding of electric fields remains paramount for the continued progress of the engineering field.

Electric field intensity, often denoted as E, is a fundamental parameter in electromagnetics that quantifies the strength of an electric field at a given point in space. It represents the force experienced by a unit positive charge placed at that point and is measured in volts per meter (V/m). Electric field intensity is a vector quantity, indicating both the magnitude and direction of the force that a positive charge would experience due to the presence of surrounding charges. The Intensity of the field can be measured using the inverse square law.

Electric fields can be effectively blocked or shielded through the strategic use of conductive or insulating materials. Conductive materials, such as metals, offer a low-resistance pathway for the flow of electric charges. When placed between a source of electric field and a sensitive area, these materials divert the electric field lines, effectively channeling the field around the shielded region. Insulating materials, on the other hand, possess high resistivity, impeding the flow of electric charges. By surrounding an area with insulating materials, electric field lines are unable to penetrate, resulting in reduced electric field intensity within the shielded zone.

Magnetic Fields

Magnetic fields arise due to the motion of electric charges, generating a force that exerts itself on other charged particles and currents. The behavior of magnetic fields is described by Maxwell's equations, a set of fundamental equations that govern electromagnetic phenomena. Engineers extensively analyze magnetic fields to design and optimize devices like transformers, motors, and generators. One key aspect of engineering analysis related to magnetic fields is the concept of magnetic flux density, often denoted as B. This quantity represents the strength of the magnetic field at a particular point in space and is measured in teslas (T). The analysis of B involves understanding its magnitude, direction, and spatial distribution. Finite element analysis (FEA) techniques are commonly employed to simulate and visualize the behavior of magnetic fields in complex geometries. Another critical consideration in magnetic field analysis is the interaction between magnetic fields and electric currents. Ampère's law states that a closed loop of current generates a magnetic field around it. This principle is harnessed in the design of electromagnetic coils, which find application in solenoids, inductors, and transformers.

Magnetic field intensity, symbolized as H, is a fundamental parameter in the study of electromagnetic fields. It represents the ability of a magnetic field to induce a magnetic flux in a material medium, typically measured in amperes per meter (A/m). Magnetic field intensity takes into account the influence of both free currents and bound currents within a material, making it a crucial factor in designing and analyzing magnetic circuits, transformers, and other electromagnetic devices.

Magnetic fields can be blocked or attenuated using a variety of methods based on the principles of electromagnetic shielding. One effective approach involves using materials with high magnetic permeability, such as ferromagnetic substances like iron and nickel. These materials divert and channel the magnetic field lines, effectively creating a path of least resistance for the magnetic flux and reducing its strength in the protected area. Another technique employs electrically conductive materials, like copper or aluminum, which create eddy currents when exposed to a changing magnetic field. These eddy currents generate opposing magnetic fields that cancel out the external field within the material, a phenomenon known as electromagnetic shielding. By strategically incorporating these shielding materials into enclosures, cables, and electronic devices, engineers can mitigate unwanted magnetic interference and maintain the integrity of sensitive equipment.

Project Analysis

Electromagnetic Fields have been evaluated at the Property Line as part of Connecticut Siting Council requirement. Electric and Magnetic Fields will be produced by Solar Panels producing DC current, the cables that carry the DC current to inverters that convert the power to AC current. The existing sources of electric and magnetic fields along the Property Line of the project derive from the Eversource 13.8-kV overhead distribution line that the proposed solar array will tie into once the utility performs upgrades per the interconnection agreement requirements.

All equipment producing EMF for the 4.625 MW project will be at a minimum 112 feet from the Property Line abutting neighboring properties. The equipment will be located on pads that have been laid out to give sufficient room for no impacts to be produced at neighboring properties. The effects from the equipment drop to negligible levels per ICNIRP guidelines for EMF exposure within a few feet. The effects can be measured using the inverse square law. The sources of EMF produced by the solar modules and the DC wires will have an effect a fraction of the Earth's geomagnetic field which is thousands of times lower than the recommended exposure limits set by the ICNIRP. (ICNIRP).

Greenskies evaluated the Connecticut Siting Council's Best Management Practices regarding EMF. In document CSC determines there is "lack of credible scientific evidence for a causal relationship between Magnetic Field exposure and adverse health effects" (CSC). At a few feet from the equipment the forces are near negligible.

It can be concluded that the EMF at the neighboring residential property line 112 feet away is sufficiently more than far away enough in order to not produce any adverse effects. The effects of Electric and Magnetic Fields produced by the system will be negligible and well below recommended exposure limits.

References

Connecticut Siting Council (CSC). Petition 754 - Best Management Practices for Electric and Magnetic Fields. February 14, 2014.

International Commission on Non-ionizing Radiation Protection (ICNIRP). ICNIRP Guidelines on Limits of Exposure to Static Magnetic Fields. Health Physics 96(4):504-514; 2009.