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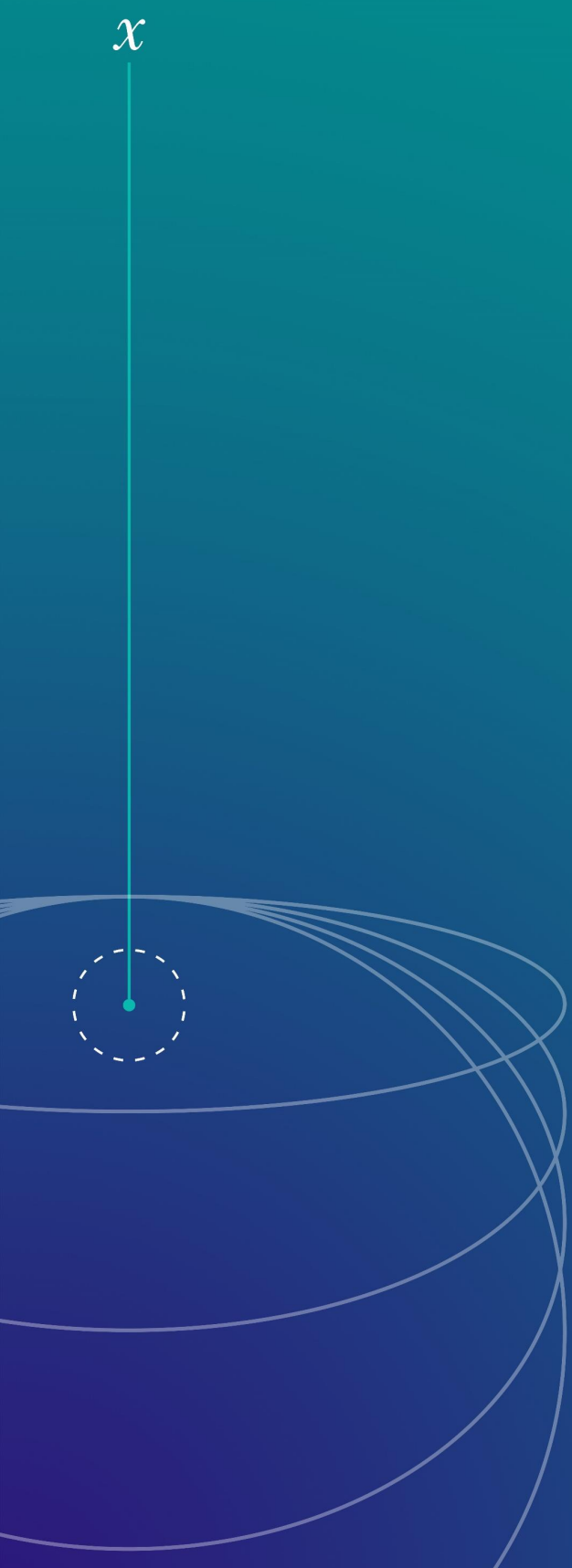

Hillman Energy Center Battery Energy Storage System

Report on Electric and Magnetic Fields

Exponent®

Hillman Energy Center
Battery Energy Storage System

Report on Electric and Magnetic Fields

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Contents

Limitations

Hillman Energy Center LLC (Hillman Energy Center) requested that Exponent prepare this summary report on electromagnetic fields in the context of Hillman Energy Center's proposed 125-megawatt, Battery Energy Storage System Project in the city of Tewksbury, Massachusetts (Project). This report summarizes work performed to date and presents the findings resulting from that work. In the analysis, we have relied on geometry, material data, usage conditions, specifications, and various other types of information provided by East Point Energy. We cannot verify the correctness of these input data and rely on the client for the data's accuracy. Hillman Energy Center has confirmed to Exponent that the data provided herein are not subject to Critical Energy Infrastructure Information restrictions. Although Exponent has exercised usual and customary care in the conduct of this analysis, the responsibility for the design and operation of the Project remains fully with the client. The findings presented herein are made to a reasonable degree of engineering and scientific certainty. Exponent reserves the right to supplement this report and to expand or modify opinions based on review of additional material as it becomes available, through any additional work, or review of additional work performed by others.

The scope of services performed during this investigation may not adequately address the needs of other users of this report outside of the permitting process, and any re-use of this report or its findings, conclusions, or recommendations presented herein other than for permitting of the Project for which it was prepared are at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the time of the investigation. No guarantee or warranty as to future life or performance of any reviewed condition is expressed or implied.

Executive Summary

Hillman Energy Center LLC (Hillman Energy Center) proposes to develop the Hillman Energy Center Battery Energy Storage System (BESS) project (Project) with an interconnection voltage of 115 kilovolts (kV) near 73 and 75 Hillman Street in Tewksbury, Massachusetts (the Project). The Project will comprise an approximately 125-megawatt (MW) BESS. During peak operation, the Project will provide electricity to power nearly 125,000 homes.

During operation, electromagnetic (EM) fields of varying frequencies from the Project will surround: 1) the direct current (DC) battery banks; 2) the DC lines connecting the battery banks to the power inverters; 3) the alternating current (AC) power inverters that convert between DC and AC power; 4) the Project Substation, buswork, and other associated equipment; and 5) the 115-kV transmission connections (Gen-Tie lines) connecting the Project Substation to the existing Utility Substation.

All Project elements are hundreds of feet from the nearest residential neighborhood. EM field levels from Project-related elements at these distances are expected to be low and within the range of background EM fields. At these distances, Project-related EM field levels also are expected to be significantly lower than health-based exposure guidelines for the general public established by the International Commission on Non-ionizing Radiation Protection and the International Committee on Electromagnetic Safety (ICNIRP, 2009, 2010; ICES, 2019). At one residence, approximately 83 feet from the nearest Project-related infrastructure, EM field levels would be somewhat higher than in the residential neighborhood but are still expected to be low and far below health-based exposure guidelines.

Scientific and health organizations that have reviewed the research on EM fields and health have been consistent in their overall conclusions that exposure to EM fields at the levels experienced in our everyday environment do not cause or contribute to adverse health effects in adults or children.

Note that this Executive Summary provides only an outline of the material discussed in this report. Exponent's technical evaluations, analyses, conclusions, and recommendations are included in the main body of this report, which at all times is the controlling document.

Introduction

Hillman Energy Center LLC (Hillman Energy Center) proposes to develop the Hillman Energy Center Battery Energy Storage System (BESS) project with an interconnection voltage of 115 kilovolts (kV) near 73 and 75 Hillman Street in Tewksbury, Massachusetts. The Project will comprise an approximately 125-megawatt (MW) BESS. During peak operation, the Project will provide electricity to power nearly 125,000 homes.

The purpose of a utility-scale BESS is to smooth out variations of supply and demand cycles for electricity. A BESS stores electricity when there is lower demand and releases electricity to the grid during greater demand, as needed. Advancements in lithium-ion battery and integrated computerized system technology have made BESS systems a feasible option to precisely control the storage and release of electrical energy to supplement more traditional sources of electricity. The Project will include a new electrical substation (the Project Substation) and BESS Yard. The Project Substation will connect to an existing utility substation located northwest of Power Company Road through a 115-kV Gen-Tie line. The BESS Yard will contain lithium-ion batteries installed in racks within prefabricated containers; inverters; medium-voltage (MV) transformers; control equipment; switchgear; and the Project Substation that will collect and transfer voltage between 34.5 kV and 115 kV and connect to the existing utility substation. The Project Substation will be located entirely on the Project Site and include equipment such as 115-kV/34.5-kV transformers, switchgear, circuit breakers, disconnect switches, and buswork.

Figure 1 shows the boundaries of the Project Site (purple outlines), as well as the location of the BESS Yard (pink area), Project Substation (blue area), and the existing Utility Substation (green area). The property lines around non-residential buildings near the Project Site are depicted with blue outlines. The nearest residences are located to the east of the Project Site. The route of the Gen-Tie line connecting the Project Substation to the existing utility substation is depicted in red.

There are several non-residential properties south of the Project site (along Hillman Street) and east of the Project site (along Clinton Street). The nearest non-residential property line is located 75 feet from the battery containers. The nearest residential property is located 83 feet from the nearest battery container with the nearest residential neighborhood located further away (250 feet from the battery containers) east of the Project site. Existing 115-kV and 345-kV transmission lines pass on the north and northwest sides of the Project site, respectively.

Since BESS facilities are relatively new in the United States, the body of information regarding the electromagnetic (EM) environment around a BESS is still somewhat limited. The term EM fields in this report refer to electromagnetic fields of all frequencies. A subset of EM fields, which occur primarily at a frequency of 60-Hertz (Hz) and are most commonly produced by power infrastructure, are referred to herein as electric and magnetic fields (EMF)This report discusses the sources of EM fields related to the Project in the context of relevant guidelines for

human exposure to EM fields and provides a concise summary of the current status of EM fields health research.

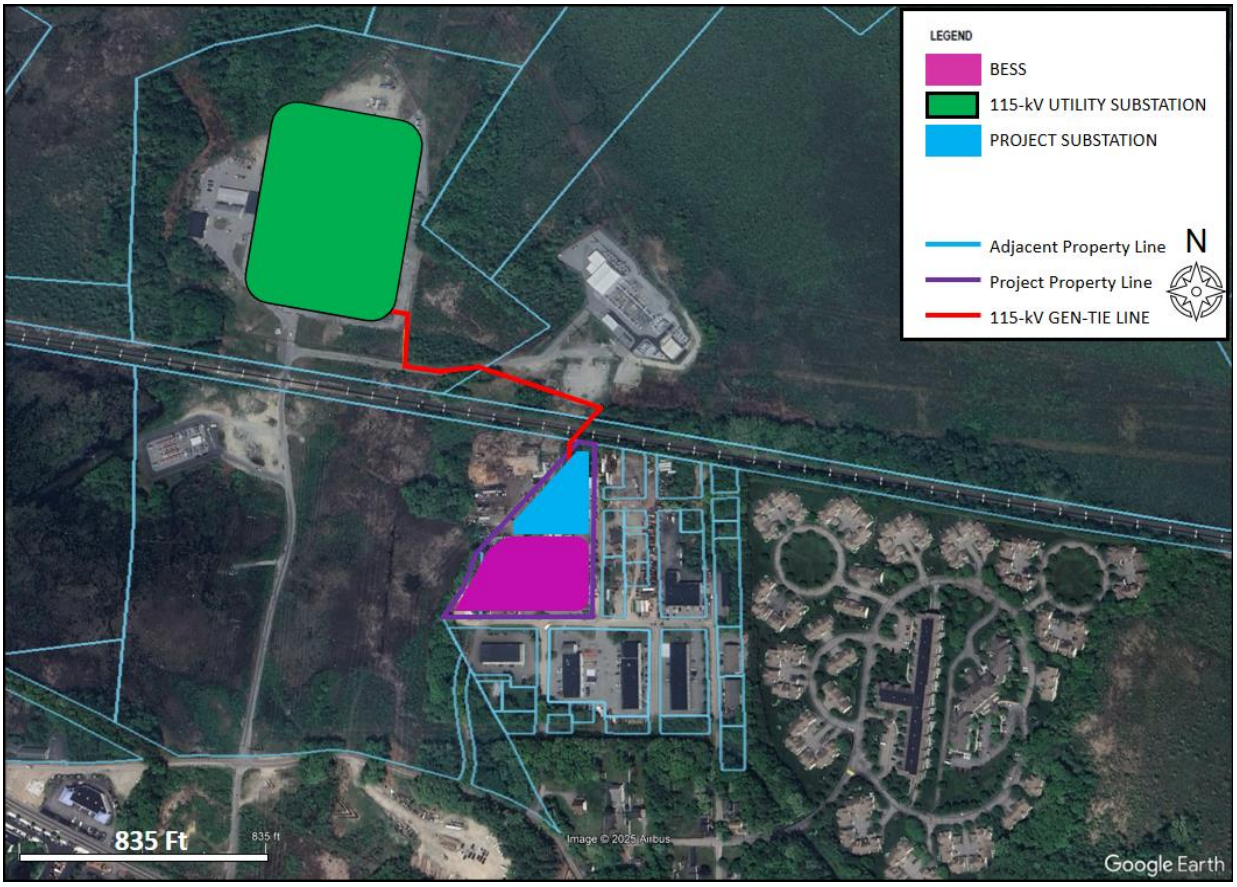

Figure 1. Proposed Site Plan for the 125-MW BESS in Tewksbury, Massachusetts.

Sources and Characteristics of Electric and Magnetic Fields

60-Hertz Electric and Magnetic Fields

In North America most electricity is transmitted as alternating current (AC) at a frequency of 60 Hz (i.e., the current alternates direction 60 times per second), where 60 Hz is located on the extremely-low-frequency (ELF) portion of the electromagnetic spectrum. Since electric power is transmitted at this frequency, the electric and magnetic fields (EMF) produced by the generation of 60-Hz electricity are commonly referred to as power-frequency EMF.

Since electricity is ubiquitous in modern society, EMF from the generation, transmission, and use of electricity is the most common source of these fields in a person's daily environment—there is a background EMF level in most locations where people spend time. The background EMF level results from the electrical appliances, equipment, and wiring in our homes and workplaces, as well as the transmission lines bringing electricity to our area, and the distribution lines bringing electricity to homes and businesses. The top panel of Figure 2 illustrates typical magnetic-field levels in a number of scenarios: 1) ambient background; 2) away from and near appliances in homes; 3) at the edge and within a distribution or sub-transmission line ROW; 4) at the edge and within a high-voltage transmission line ROW; and 5) in two different occupational environments. The bottom panel of Figure 2 illustrates typical electric-field levels for these same scenarios.

As noted above, all electrical devices are sources of EMF. Magnetic fields, specifically, are generated when *current* flows through conductors, electrical wiring, and electrical devices. Since magnetic fields rely on the flow of current, magnetic-field levels will vary depending on the amount of electricity flowing through an object. In the case of transmission and distribution lines, magnetic-field levels therefore vary based on electricity demand, which can change from day to day, week to week, and season to season. Magnetic fields are measured in units of milligauss (mG).

A property of magnetic fields is that they are not blocked by conducting objects and pass through most materials. Magnetic-field levels, however, diminish with increasing distance from the source and the magnetic-field levels from transmission and distribution lines, generally decrease in proportion to the square of the distance from the source.

Most Project-related sources of 60-Hz electric fields are entirely contained inside metallic or insulated coverings inside the boundaries of the Project fence. Therefore, the Project will not be a significant source of 60-Hz electric fields outside the Project boundaries, so are not discussed in detail. The 115-kV Gen-Tie line, existing 115-kV and 345-kV transmission lines, existing utility substation, and existing distribution lines, however, will be sources of 60-Hz magnetic fields outside the Project boundaries.

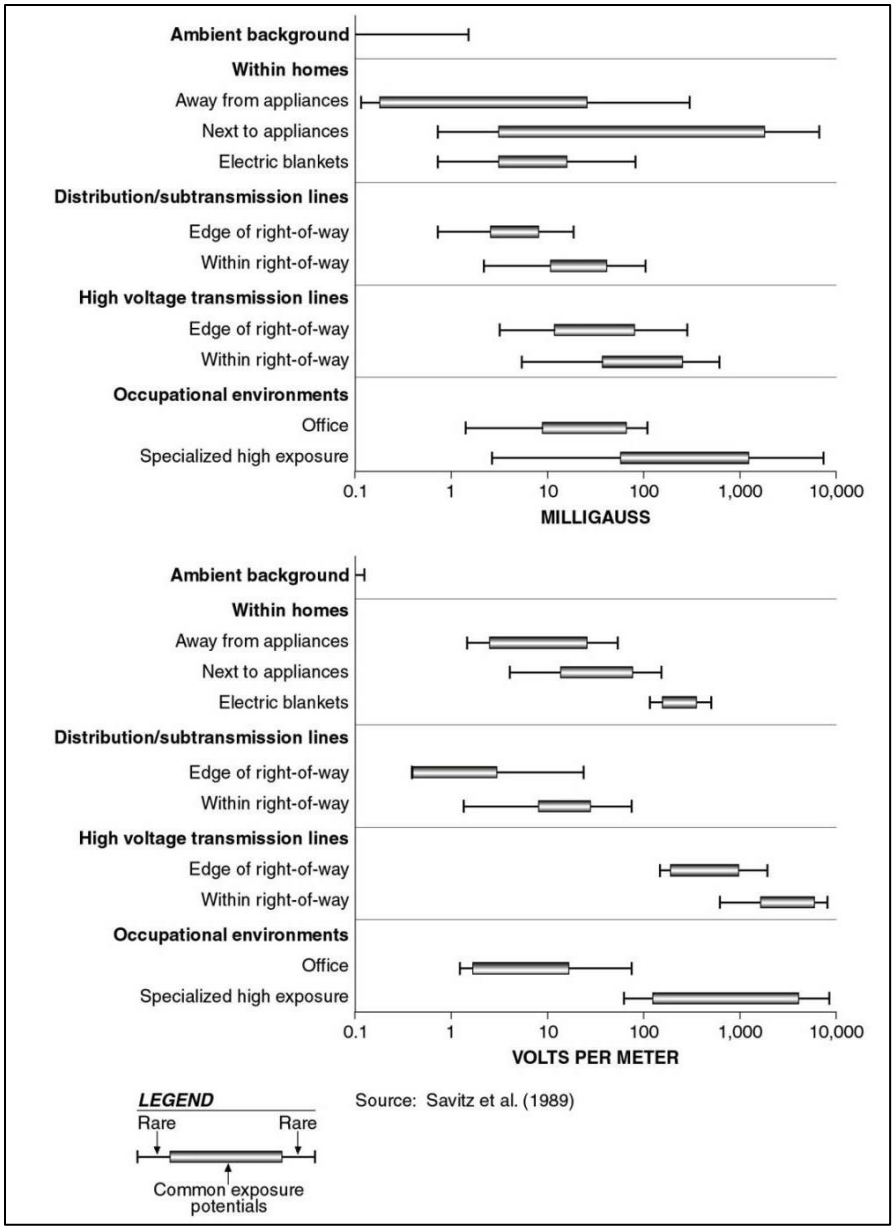

Figure 2. Typical 60-Hz electric- and magnetic-field levels in the environment.

Direct Current Magnetic Fields

While AC power transmission is more common in the United States, some electricity is also transmitted at a frequency of 0 Hz—referred to as direct current (DC) or static electricity, since the strength and direction of the current does not change multiple times per second as does AC current. DC current will produce DC magnetic fields and sources of DC magnetic fields we encounter in everyday life include both natural and man-made sources. The earth's geomagnetic field is the most common natural magnetic-field source. Man-made sources include permanent

magnets in toys, medical devices, and appliances, as well as other sources like batteries, computer power supplies, some transportation systems, solar cells, and DC transmission lines.

Project-related sources of DC electric fields are entirely contained inside metallic or insulated coverings inside the boundaries of the Project fence. Therefore, the Project will not be a significant source of DC electric fields outside the Project boundaries.

Electromagnetic Fields from BESS

The main components of a BESS facility are sources of fields at various frequencies, including 60-Hz EMF and static (i.e., 0-Hz) EM fields, as well as higher-frequency fields (including radiofrequency [RF] fields in the kilohertz [kHz] to megahertz [MHz] range), depending on the type of Project element. The conceptual bi-directional flow of electricity to and within a BESS is illustrated below in Figure 3. The design and layout of a BESS project's infrastructure are particular to each facility. In general, however, the interconnection point of a BESS with the electric grid typically occurs at high-voltage (e.g., 115-kV or 345-kV) utility substations or switching stations. The high-voltage 60-Hz AC electricity flows to the Project Substation where the electricity is stepped down to MV (e.g., 34.5 kV). From the Project Substation, underground feeder lines transfer power to the MV transformer within each BESS container unit. The MV transformer steps down the AC voltage from 34.5 kV to a lower voltage such as 690 V. Next, the inverter and the bi-directional power conversion system converts 690 V AC to DC voltage (Vdc) of 1,500 Vdc, which charges the DC lithium-ion battery units connected in parallel within each container.

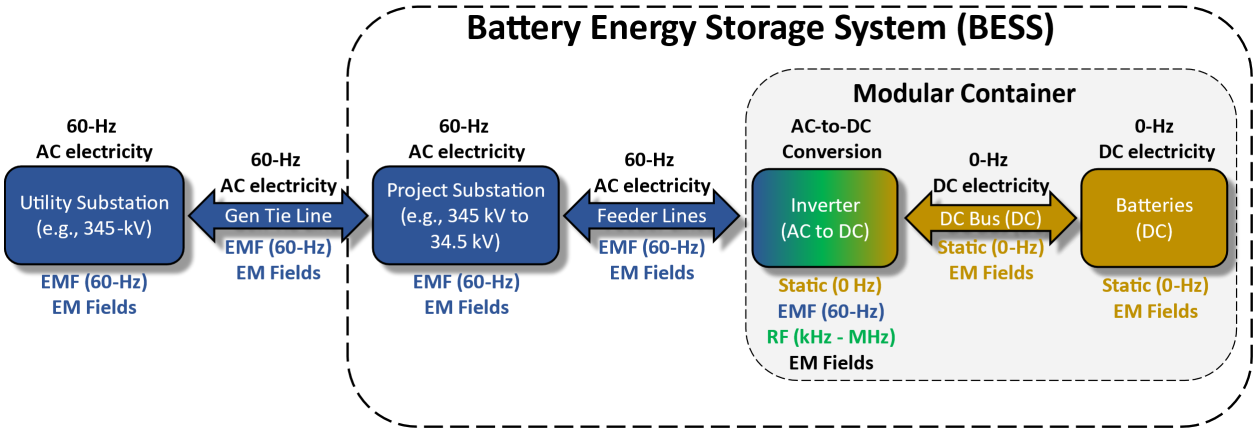

Figure 3. Conceptual flow of electricity in a BESS facility.

BESS modules are sources of EM fields. BESS elements that are sources of 60-Hz EMF are shown in Figure 3 in blue and include the Gen-Tie line, Project Substation, feeder lines, and MV transformer. Sources of static magnetic fields include the DC bus bars and batteries and are shown in gold in Figure 3. The inverters are sources of static magnetic fields and 60-Hz EMF, as well as very low frequency and radiofrequency (RF) magnetic fields (shown in Figure 3 as a

multi-color element). The BESS modules are expected to generate the largest fields during dynamic conditions (i.e., when the batteries are being charged to capacity or when discharging energy to the grid).

Exposure Guidelines

Federal and State Standards

There are no federal standards in the United States for 60-Hz EMF from transmission of electricity (e.g., from distribution or transmission lines), from transmission utility infrastructure (e.g., substations or the AC components of a BESS facility) or from other sources. Only a few state regulatory authorities have enacted guidelines related to 60-Hz EMF from distribution lines, transmission lines, or related infrastructure. In Massachusetts, the Energy Facilities Siting Board (EFSB) previously applied a 1985 guideline for 60-Hz EMF levels at the edge of 345-kV transmission line rights-of-way (ROW) of 1.8 kilovolts per meter (kV/m) for electric fields and 85 mG for magnetic fields (Massachusetts Electric Company, 12 DOMSC 119, 228-242, 1985). More recently, the EFSB has evaluated EMF related to the siting and permitting of proposed transmission projects on a case-by-case basis and, consistent with recommendations of the World Health Organization (WHO) in 2007, takes into account various no-cost and low-cost practical options to reduce EMF levels along transmission line ROWs.

Health-Based Guidelines from Scientific Organizations

General guidelines have been established by two scientific organizations that regularly review the research on EMF—the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the International Committee on Electromagnetic Safety (ICES)—to protect health and safety. The limits in these guidelines are meant to protect against known effects of EMF exposure that occur at very high field levels; these are short-term, reversible, acute effects, and are not known to cause long-term damage or health outcomes. The WHO recommends adopting these ICNIRP and ICES guidelines (WHO, 2007). Table 1 summarizes the exposure guidelines developed for the general public, as well as for workers in occupational settings.

Table 1. ICNIRP and ICES guidelines for 60-Hz EMF exposure

		Exposure (60 Hz)	
Agency	**Exposure Scenario**	**Electric Field**	**Magnetic Field**
ICNIRP*	Occupational	8.3 kV/m	10,000 mG
	General Public	4.2 kV/m	2,000 mG
ICES†	Occupational	20 kV/m	27,100 mG
	General Public	5 kV/m‡	9,040 mG

* ICNIRP (2010).
† ICES (2019)
‡ Within power line ROWs, the guideline is 10 kV/m.

These agencies have also recommended health-based exposure limits for DC magnetic fields and higher-frequency AC magnetic fields. ICNIRP recommends an exposure limit of 4,000,000 mG

for static (0-Hz) magnetic fields for the general public, while ICES recommends a limit of 1,670,000 mG for exposure to fields with frequencies less than 0.153 Hz (ICNIRP, 2009; ICES, 2019). For comparison, the earth's static geomagnetic field in Massachusetts is about 500 mG, more than 8,000 times lower than the standard for exposure of the general public to static magnetic fields recommended by ICNIRP.

ICNIRP and ICES also have recommended exposure limits for RF fields that vary with frequency. At a frequency of 1 kHz the recommended ICNIRP magnetic-field limit is 270 mG, and the ICES limit is 2,050 mG. For electric fields, the recommended ICNIRP limit is 83 volts per meter (V/m) and the ICES limit is 614 V/m.

Assessment of Project Electromagnetic Fields

The 60-Hz EMF and static magnetic fields and higher frequency EM field sources within the Project Site when the Project is operational are summarized in Table 2. The sources of static magnetic fields include the DC battery banks and DC lines connecting the battery banks to the power inverters. The EMF sources include the power inverters (which will produce EMF at 60 Hz, as well as RF fields at higher frequencies) and the Project Substation, associated equipment, and the 115-kV Gen-Tie Lines, which will also produce 60-Hz EMF.

Table 2. Sources of EM fields from the Project

Source (frequency)	Project Infrastructure
DC (0 Hz)	Battery banks Lines connecting the battery banks to the power inverters
AC (≥ 60 Hz)	Power inverters that convert between DC power and AC power
60-Hz AC Sources	Project Substation, buswork, and associated equipment; feeder lines; 115-kV Gen-Tie lines

In addition, existing sources of 60-Hz EMF outside the boundaries of the Project Site include: 1) the existing 115-kV and 345-kV overhead transmission lines; 2) the existing utility substations; 3) existing distribution lines bringing electricity to nearby residences and businesses.

Assessment of 60-Hertz EMF

As noted in Table 2, the 60-Hz EMF from the BESS will be due to the Project Substation, buswork, feeder lines, and Gen-Tie lines. The Project Substation, as well as other facilities such as feeder lines, are more than 135 feet away from the nearest non-residential buildings to the east and the south of the Project and all residences are more than 250 feet away from the Project Site except one house that is located 83 feet from the nearest battery container. Moreover, at these residences, the magnetic fields from the Project elements are expected to be low. Other existing sources of magnetic fields such as nearby distribution lines bringing power to the residences and existing 115-kV transmission lines to the north and 345-kV transmission lines to the west of the Project site are expected to be sources of comparable 60-Hz magnetic fields. There are no other buildings or public facilities in the immediate vicinity of the Project Site, including the western boundary of the Project. The western boundary of the Project Site and the Gen-Tie line are immediately adjacent to the existing 345-kV transmission line ROW and are unlikely to significantly change EMF levels from the existing transmission lines. In general, 60-Hz equipment within a BESS (such as transformers, buswork, and other associated equipment) do not contribute significantly to 60-Hz EMF levels outside the site perimeter, since the strength of the magnetic fields from the equipment inside decreases rapidly with distance, reaching very low levels at relatively short distances beyond the substation boundary. Electric fields from elements inside the facility can be effectively blocked by metal fences around the equipment. This is

consistent with Institute of Electrical and Electronics Engineers (IEEE) Standard 1127 (IEEE, 2023), which notes that at the boundary of a substation (or a facility like a BESS that contains equipment similar to that found in a substation), the dominant sources of 60-Hz EMF are the transmission or distribution lines entering and exiting the substation.

Assessment of Static and Radiofrequency Fields

Direct Current Magnetic Fields

The strength of the DC magnetic fields from the lines connecting the battery banks to the inverters will decrease rapidly with distance to low levels within a few tens of feet or less (Tell et al., 2015). This equipment is located 135 feet or more away from the nearest building and more than 250 feet from the nearest residential neighborhood, with one existing residential property 83 feet from the nearest battery container. At these distances, the DC magnetic-field levels from these sources are expected to be a small fraction of the earth's natural static geomagnetic field in the Project area (~515 mG).[1] The DC magnetic fields will be significantly lower than the health-based standards for exposure of the general public recommended by ICNIRP and ICES.

Radiofrequency Electromagnetic Fields

In a BESS container, the inverter operates using power electronics that switch at a high frequency to convert AC electricity to DC electricity (and vice versa). As a result, the inverter is a source of 60-Hz EMF and 0-Hz static magnetic fields, as well as higher-frequency fields (i.e., RF fields in the kHz to MHz range).

The higher-frequency (> 60 Hz) AC fields from the inverters, like the DC fields from the battery banks, also decrease quickly with distance (Tell et al., 2015). Since the inverters are located a similar distance from the nearest residences as the battery banks (), the level of RF field levels at these buildings or residences from the Project is expected to be low and far below health-based standards for exposure recommended by ICNIRP and ICES.

[1] https://www.ngdc.noaa.gov/geomag/calculators/magcalc.shtml?#igrfwmm (42°3714"N 71°14'36"W).

Discussion

All Project elements that produce EM fields are hundreds of feet from the nearest residential neighborhood, and at that distance, are expected to result in low field levels within the same range as typical background levels. The battery banks and DC cables on site will produce static magnetic fields (i.e., at 0 Hz). These sources are not anticipated to appreciably change the existing levels of the earth's static geomagnetic field outside the boundaries of the Project site and are expected to be significantly lower than health-based ICNIRP and ICES exposure guidelines for the general public (ICNIRP, 2009; ICES, 2019). Similarly, the higher-frequency (> 60 Hz) AC fields produced from operation of the power inverters are not anticipated to contribute significantly to EM field levels at the residential neighborhood.

The Project Substation, associated buswork, and Gen-Tie lines will be sources of 60-Hz EMF. However, equipment within substations does not contribute significantly to 60-Hz EMF levels outside a substation's perimeter, because the strength of the fields from the equipment inside a substation (or BESS) decreases rapidly with distance. As noted above, the main sources of 60-Hz EMF at the boundary of a substation are generally the power lines entering or exiting the substation (IEEE, 2023). The project facilities including Project Substation, feeder lines, batteries, inverters, etc., all are more than 250 feet away from the nearest residential neighborhood. These distances are great enough that the 60-Hz EMF levels from the Project at the closest residences will be within the range of background values encountered in most communities. They are also well below the 60-Hz EMF exposure limits for the general public recommended by ICNIRP and ICES (ICNIRP, 2010; ICES, 2019).

At one residence, approximately 83 feet from the nearest Project-related infrastructure, EM fields from inverters, static magnetic fields from DC sources, and EMF levels from 60-Hz sources would all be somewhat higher than at the residential neighborhood but are still expected to be low and far below the ICNIRP and ICES health-based exposure guidelines.

Current Status of 60-Hz EMF Health Research

Reviews by Scientific and Health Organizations

Research on 60-Hz EMF and health has been on-going since the late 1970s. Over the past nearly 50 years, thousands of research studies have been conducted to examine whether there are long-term health effects from exposure to 60-Hz EMF. This research has been reviewed and evaluated by multiple scientific and health organizations, which convene multidisciplinary expert panels to perform *weight-of-evidence reviews* of research literature. Weight-of-evidence reviews consider *all* relevant studies in a systematic and thorough process, giving more weight to higher quality studies, to evaluate if the overall data present a logically coherent and consistent picture about possible causal relationships between exposures and health outcomes.

Organizations that have performed comprehensive reviews of the research on 60-Hz EMF include the International Agency for Research on Cancer, the National Radiological Protection Board of the United Kingdom, WHO, the Health Council of the Netherlands, the European Commission's Scientific Committee on Health, Environmental and Emerging Risks (SCHEER),[2] and the Swedish Radiation Safety Authority (IARC, 2002; NRPB, 2004; WHO, 2007; HCN, 2009; SCENIHR, 2015; SSM, 2016, 2018, 2019, 2020, 2021, 2022, 2024a, 2024b; SCHEER, 2024). The overall conclusions of these reviews have been consistent over the decades—none of these agencies have concluded that long-term exposure to 60-Hz EMF, at the levels experienced in our everyday environment, causes or contributes to adverse health effects in adults or children.

As discussed above, the only confirmed effects from 60-Hz EMF exposure are short-term, acute effects that do not cause long-term damage or health consequences and that occur at very high exposures—levels that even electrical workers typically will not experience. These effects may occur if current density or an induced electric field that results from an extremely strong magnetic field exceeds a specific threshold. The ICNIRP and ICES guidelines, however, are set at levels that protect against these effects, so they are unlikely to occur in the general population.

Some of the same organizations that reviewed 60-Hz EMF research also conducted weight-of-evidence review of the health effects of exposure to DC fields or included an assessment of DC fields in their evaluations of EMF noted above (IARC, 2002; WHO, 2006; SSM 2016, 2018, 2019, 2020, 2021, 2022, 2024a, 2024b). Similar to the evaluations of 60-Hz EMF research, these organizations have not concluded that exposure DC fields, even at high levels, has any long-term health effects on the general population or that exposure poses any safety risks.

[2] On July 8, 2015, the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) was renamed SCHEER.

Summary

This report summarizes the anticipated static magnetic-field levels, 60-Hz EMF and RF field levels from the development of the 125-MWBESS in Tewksbury, Massachusetts. Post-development, sources of static magnetic fields within the Project Site will include DC magnetic fields from the battery banks and from the lines connecting the battery banks to the power inverters. Sources of 60-Hz EMF will include the Project Substation, feeder lines, buswork, and 115-kV Gen-Tie line connecting the Project Substation to the existing utility substation. The power inverters will also be sources of 60-Hz EMF and DC magnetic fields, as well as RF EM fields.

Scientific and health organizations that have reviewed the research on 60-Hz EMF and DC EM fields and health have been consistent in their overall conclusions that exposure to these fields at the levels experienced in our everyday environment do not cause or contribute to adverse health effects in adults or children.

All Project elements that produce EM fields are hundreds of feet from the nearest residential neighborhood. At one residence, approximately 83 feet from the nearest Project-related infrastructure, EM field levels would be somewhat higher than at other residences. However, all field levels (DC, 60-Hz, and RF) from the Project at these locations are expected to be low and far below the exposure limits for the general public recommended by ICNIRP and ICES (ICNIRP, 2009, 2010; ICES, 2019).

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