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Medway, MA Battery Energy Storage System

Report on Electric and Magnetic Fields

Exponent®

Medway, MA Battery Energy Storage System

Report on Electric and Magnetic Fields

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Limitations

At the request of Medway Grid, LLC, Exponent prepared this summary report on electric and magnetic fields in the context of the proposed 250-Megawatt Medway Battery Energy Storage System Project in the town of Medway, Massachusetts. 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 this project 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

Medway Grid, LLC (Medway Grid) proposes to develop the 250-Megawatt (MW) Medway Battery Energy Storage System (BESS) Project (the Project) in the town of Medway, Massachusetts. Of the 10.6-acre Project Site, approximately 4.5 acres will be developed for the BESS. There is an existing Eversource electric transmission right-of-way to the west along with Eversource Energy's existing West Medway Substation and Exelon Power's West Medway Generating Station to the south. There are residences to the east (off Little Tree Road and Summer Street) and to the north across Milford Street (Route 109).

The Project consists of battery cabinets containing racks of lithium-ion battery modules connected in parallel to form a battery bank. The direct current (DC) electricity stored in the battery banks will be converted to alternating current (AC) and stepped up to 34.5-kilovolts (kV) at the transformers and associated inverters located immediately adjacent to each bank of battery cabinets. From the transformers, the AC power from the Project will be carried a short distance on-site to the Project Substation and stepped up to 345-kV before being routed to the existing Eversource Energy's West Medway Substation over an underground Tie Line.

During operation, electric and magnetic fields (EMF) from the Project will derive from: 1) the DC battery banks; 2) the DC cables connecting the battery banks to the power inverters; 3) the AC power inverters that convert the DC power to AC power; 4) the Project Substation, buswork, and other associated equipment; and 5) the 345-kV AC underground Tie Line connecting the Project Substation and the West Medway Substation. The battery banks and DC cables on site will produce static fields (i.e., at 0 Hertz [Hz]). These sources will not be expected to produce any significant disturbance to the existing levels of static magnetic field produced by natural sources within the earth (i.e., the earth's geomagnetic field) away from the Project Site. The existing level of the earth's static geomagnetic field is about 8,000 times lower than the standard for exposure of the general public to static magnetic fields recommended by the International Commission on Non-ionizing Radiation Protection (ICNIRP, 2009).

The power inverters will produce AC fields at frequencies greater than 60 Hz onsite; these higher-frequency fields from the inverters, like the DC fields from the battery banks, generally decrease rapidly to low levels within a few tens of feet or less and thus will not be an important contributor to AC fields offsite. The Project Substation and associated buswork etc. will be a source of 60 Hz EMF; in general, however, the equipment within substations does not contribute significantly to EMF levels outside the substation perimeter, as the strength of the fields from the equipment inside the perimeter decreases rapidly with distance (IEEE, 2013). Thus, the operation of the Project Substation would not appreciably change the EMF levels outside the Project Site.

The highest levels of EMF outside the site boundary are expected to occur directly above the underground 345-kV Tie Line connecting the Project Substation to the West Medway Substation. However, there are no residences or other public facilities in close vicinity of the Tie Line. The nearest residences to the Project Site are located on Milford Street to the north, more than 600 feet from the Project Substation and connecting 345-kV Tie Line, and on Little Tree Road to the east, more than 450 feet from these elements. Given these distances, the residences are sufficiently far such that the AC EMF levels from this equipment would be in the range of background field EMF levels in the community and far below the reference levels for the general public recommended by international scientific agencies that assure compliance with basic restriction limits on internal fields.

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

Medway Grid, LLC (Medway Grid) proposes to develop the 250-Megawatt (MW) Medway Battery Energy Storage System (BESS) Project (the Project) in the town of Medway, Massachusetts. Of the 10.6-acre Project Site, approximately 4.5 acres will be developed for the BESS. There is an existing Eversource electric transmission right-of-way to the west along with Eversource Energy's existing West Medway Substation and Exelon Power's West Medway Generating Station to the south. The nearest residences are located to the north (across Milford Street) and east (on Little Tree Road and Summer Street) of the Project Site.

The BESS will consist of 140 Tesla Megapack ("Megapack") enclosed units located on the westernmost portion of the Project Site. The Megapack is a standalone modular system with integrated lithium-ion batteries, a bi-directional inverter, a thermal management system, and a Tesla Site Controller. Each Megapack is approximately 30 feet long (359 in.), 5.5 feet wide (65 ¼ in.) and 9 feet tall (110 ¼ in.). The coupled Megapacks are placed immediately adjacent to a medium voltage transformer. The site will have 70 medium voltage transformers. Each Megapack and the medium voltage transformers will be supported on concrete slabs and pier foundations and surrounded by crushed stone.

The Project Substation will be located entirely on the Project Site to the south of the BESS and includes equipment such as a 345kV/34.5 kV main power transformer, switchgear, circuit breakers, disconnect switches, low and high buses. The substation will allow the BESS (34.5 kV) to interconnect with the existing 345-kV Eversource substation to the south via the proposed underground Transmission Interconnection. During charging, the proposed Transmission Interconnection will carry electricity from the Eversource Substation back to the Proposed Project Substation where it will step-down to 34.5 kV for charging the Megapacks. When power demand is higher (e.g., daily peak loading) the power flow will reverse.

Figure 1 shows the boundary of the Project Site (black box), as well as the placement of the battery banks and adjacent transformers and associated inverters (green boxes) and the Project Substation (blue box). The Tie Line (yellow line) connects the Project Substation to the existing

Eversource West Medway Substation. The northern and eastern side of the Project Site are bordered by residential areas along Milford Street and Little Tree Road, respectively.

In this report, Exponent discusses the sources of EMF related to the Project in the context of relevant guidelines for human exposure to EMF and provides a concise summary of the current status of EMF health research. Since EMF from DC and AC fields at frequencies above 60-Hz are expected to be very low off-site, the discussion below focuses primarily on 60-Hz EMF.

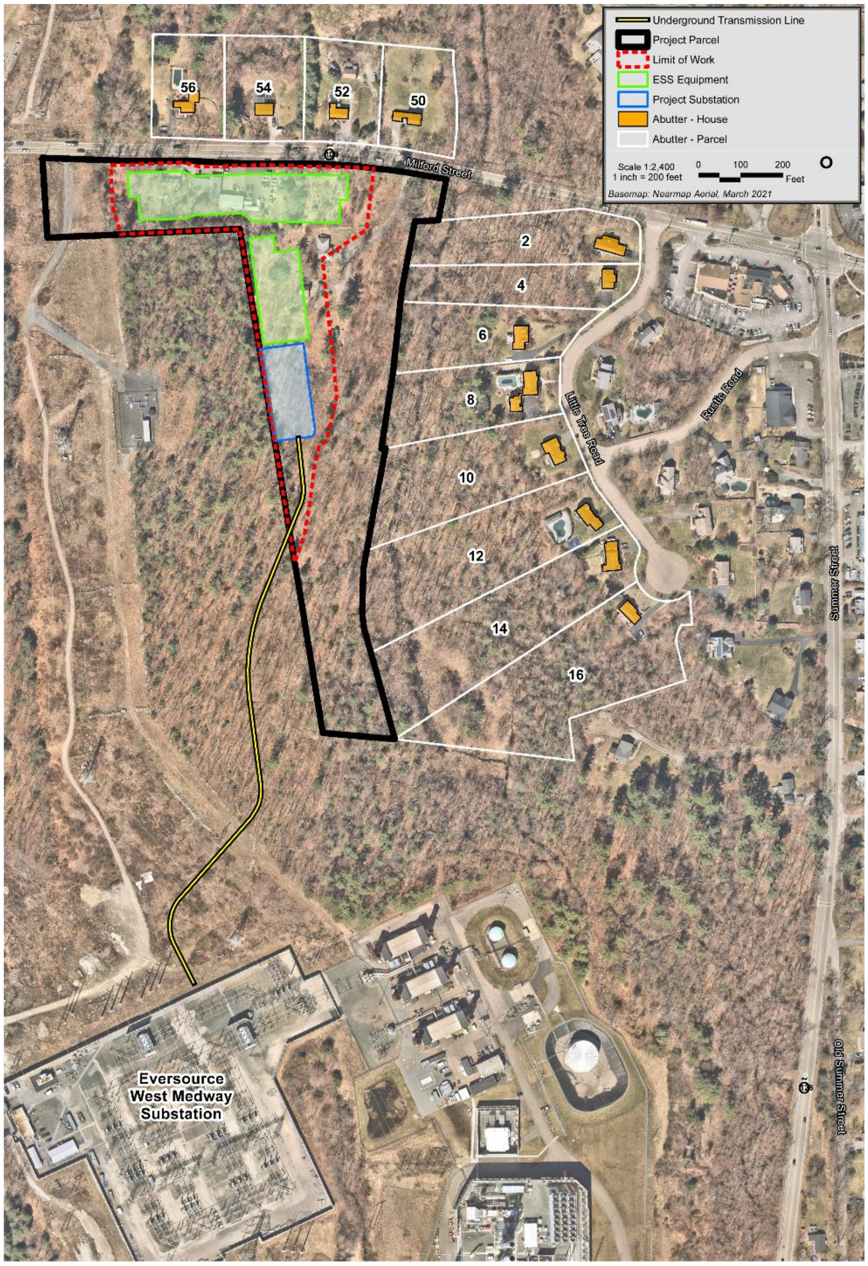

Figure 1. Proposed Site Plan for the 250-MW BESS in Medway, Massachusetts.

The site plan shows the boundary of the Project Site (black box), limits of work (dashed red line),as well as the placement of the battery banks and adjacent transformers and associated inverters (blue green boxes) and the Project Substation (red blue box). The Tie Line (yellow line) connects the Project Substation to the West Medway Substation. The northern and eastern side of the Project Site are bordered by residential areas along Milford Street and Little Tree Road, respectively.

EMF Sources and Characteristics

EMF is produced by all sources that generate, transmit, or use electricity; thus, all things connected to our electrical system—power lines; wiring in our homes, businesses, and schools; and electric appliances and machines—are sources of EMF. In North America, the vast majority of electricity is transmitted as alternating current (AC) at a frequency of 60 Hertz (Hz), that is, the current changes direction 60 times per second. The EMF from these AC sources is commonly referred to as power-frequency or extremely low-frequency EMF.

Electric Fields

Electric fields are the result of voltages applied to electrical conductors and equipment. Electric-field levels are measured in units of volts per meter (V/m) or kilovolts per meter (kV/m), where 1 kV/m is equal to 1,000 V/m. While electric-field levels increase as the voltage increases, since transmission and distribution line voltage is quite stable and does not change very much over time, electric-field levels from this infrastructure are also stable.

Electric fields are easily blocked (i.e., shielded) by most grounded conducting objects, including buildings, walls, trees, and fences. As a result, the primary indoor sources of electric fields are the electrical appliances and equipment used within our homes and workplaces. Transmission lines, distribution lines, and other power-related equipment are the major source of electric fields outdoors.

The intensity of an electric field diminishes with increasing distance from the source. In the case of transmission and distribution lines, electric fields decrease with distance from the conductors in proportion to the square of the distance.

Magnetic Fields

Magnetic fields are produced by the flow of electric currents through wires and electrical devices. The strength of a magnetic field is expressed as magnetic flux density in units called gauss (G) or milligauss (mG), where 1 G = 1,000 mG.[1] The magnetic-field level associated with a particular object (e.g., an appliance or power line) depends largely on various operating characteristics of the source and on the amount of current (i.e., electricity) flowing through the object. Since power demand varies on a given day, throughout a week, or over the course of months and years, the amount of current will also vary, which results in varying magnetic-field levels produced by transmission and distribution lines.

Similar to electric fields, the intensity of a magnetic field diminishes with increasing distance from the source. In the case of transmission and distribution lines, magnetic fields decrease with distance from the conductors in proportion to the square of the distance. Unlike electric fields, however, magnetic fields are not easily blocked by most conductive objects.

EMF in the Environment

Since electricity is such an integral part of our infrastructure and everyday life (e.g., transportation systems, homes, and businesses), people living in modern communities are effectively surrounded by EMF. Figure 2 (below) depicts typical 60-Hz electric- and magnetic-field levels measured in residential and occupational environments, compared to levels measured on or at the edge of transmission line rights-of-way (ROW) and other locations. While EMF levels decrease with distance from the source, any home, school, or office tends to have a background EMF level as a result of the combined effect of the numerous EMF sources.

[1] Scientists also refer to magnetic flux density at these levels in units of microtesla (μT). Magnetic flux density in mG units can be converted to μT by dividing by 10 (i.e., 1 mG = 0.1 μT).

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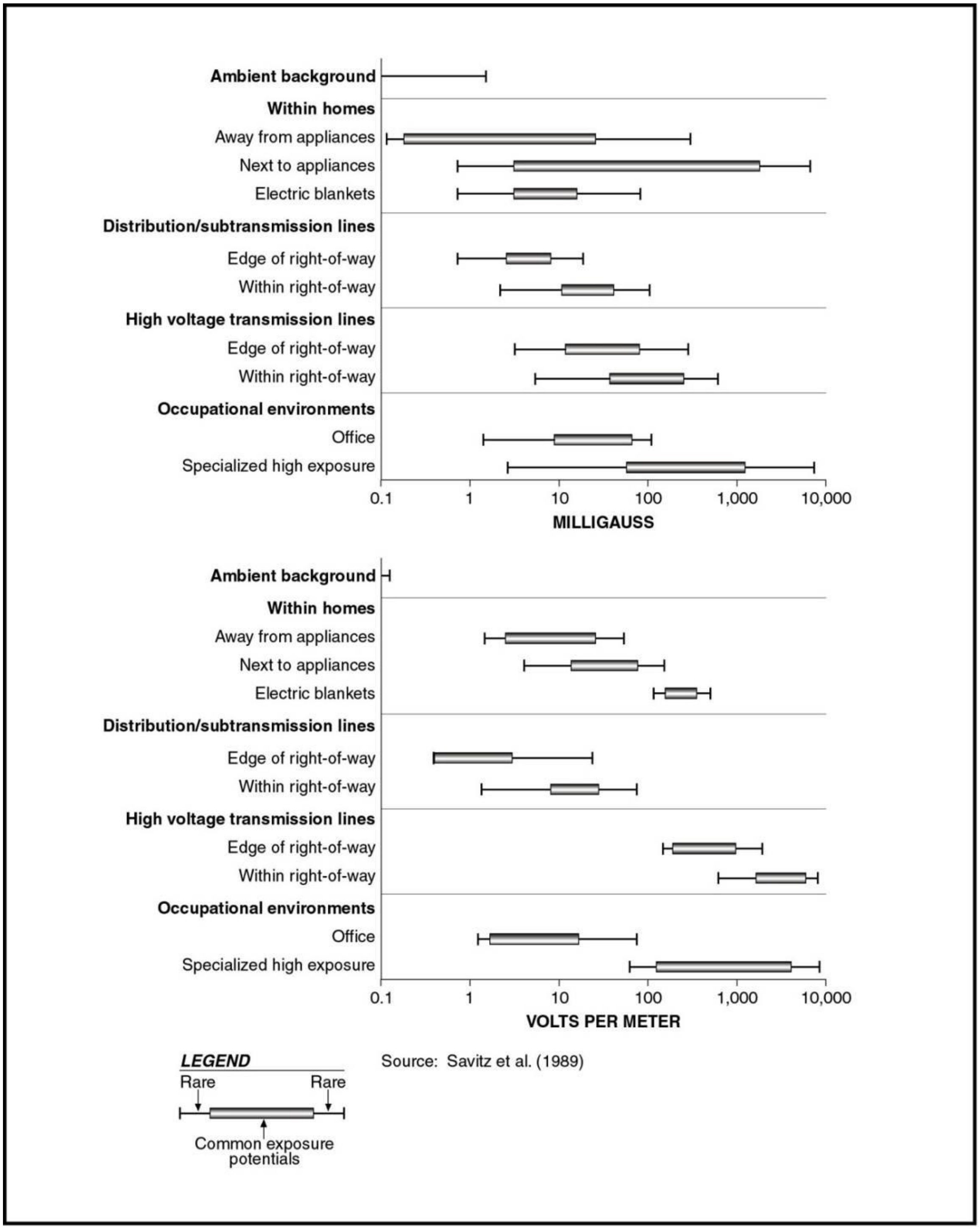

Figure 2. 60-Hz electric- and magnetic-field levels in the environment.

Exposure Guidelines

Federal & State Standards

There are no U.S. federal standards for either electric fields or magnetic fields from transmission infrastructure or other sources at power frequencies. In a 1985 ruling, the Massachusetts Energy Facilities Siting Board (EFSB) deemed electric field levels of 1.8 kV/m and magnetic field levels of 85 mG at the edge of transmission line ROWs to be acceptable in the licensing of 345-kV transmission line facilities (Massachusetts Electric Company, 12 DOMSC 119, 228-242, 1985). Since then, the EFSB has assessed EMF levels from transmission lines on a case-by-case basis with a focus on practical, no-cost or low-cost options to reduce magnetic fields along transmission line rights-of-way. This practice is also consistent with the recommendations of the World Health Organization (WHO, 2007).

Guidelines from Scientific Organizations

In the absence of any federal or state standards, 60-Hz EMF levels can be assessed using the exposure guidelines recommended by two international scientific organizations: 1) the International Committee on Electromagnetic Safety (ICES), and 2) the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The exposure limits set by these organizations, summarized in Table 1, were developed to protect the health and safety of the general public and workers and are based upon comprehensive reviews and evaluations of relevant health research. These guidelines set limits to protect against the known effects of EMF exposure, which are short-term (acute) effects that can occur at very high field levels and generally cause no long-term damage or health consequences. As discussed further in the section on the *Current Status of EMF Health Research*, the review of the health research by ICNIRP and ICES led to the conclusion that there was insufficient evidence to warrant the development of standards or guidelines on the basis of hypothesized long-term adverse health effects such as cancer.[2]

Table 1. ICNIRP (2010) and ICES (2019) guidelines for EMF exposure at 60-Hz

	Exposure (60 Hz)	
Agency	**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

*Within power line ROWs, the guideline is 10 kV/m.

The World Health Organization (WHO) has recommended that policy makers should adopt international exposure limit guidelines, such as those from ICNIRP or ICES, for exposure to EMF (WHO, 2007).

2 These organizations also have exposure guidelines for DC and higher-frequency fields.

Assessment of Project EMF

Sources of EMF

Existing sources of EMF along the boundaries of the Project Site include the 60-Hz AC fields associated with nearby existing 345-kV overhead transmission lines, to which the electricity from the battery banks will connect as well as existing distribution lines bringing electricity to local residences and businesses.

When the Project is operational, EMF on the Project Site will derive from the following sources:

- the DC battery banks;
- the DC lines connecting the battery banks to the power inverters;
- the power inverters that convert the DC power to AC power;
- the Project Substation, buswork and associated equipment; and
- the 345-kV AC underground Tie Line connecting the Project Substation and the existing Eversource West Medway Substation

The DC battery banks and the lines connecting the battery banks to the power inverters will produce static fields (i.e., at 0 Hz); the power inverters will produce AC fields at a frequency greater than 60 Hz; and the Project Substation, buswork and associated equipment, underground 345-kV Tie Line, and existing 345-kV transmission lines will produce fields at a frequency of 60 Hz.

Assessment

At distances of approximately 140 feet or more from the nearest residences, the DC magnetic-field levels from the lines connecting the battery banks to the inverters are expected to be a small fraction of earth's natural static geomagnetic field in the Project area (517 mG)[3] and

[3] https://www.ngdc.noaa.gov/geomag/calculators/magcalc.shtml?#igrfwmm

significantly lower than the ICNIRP standard for exposure of the general public to static magnetic fields of 4,000,000 mG (ICNIRP, 2009). The higher-frequency (>60 Hz) AC fields from the inverters, like the DC fields from the battery banks, generally decrease rapidly to low levels within a few tens of feet or less (Tell et al., 2015). As the battery banks and inverters are located approximately 80 feet or more away from the nearest parcel and approximately 140 feet or more away from the nearest residences, the operation of these sources would not appreciably change the EMF levels outside the Project Site's boundaries.

The 60-Hz AC field levels outside the boundary of the Project Site also are expected to be low. The Project Substation will be located on the southern end of the Project Area, 150 feet or more away from the Project Site's northern, southern, and eastern borders. At the western border of the Project Site, the Project Substation will be approximately 20 feet away from the site boundary, but there are no residences or other public facilities in the vicinity. In general, the equipment within substations (such as transformers, buswork and other associated equipment) do not contribute significantly to EMF levels outside the substation perimeter, as the strength of the fields from the equipment inside the perimeter decreases rapidly with distance, reaching very low levels at relatively short distances beyond the substation boundary. Rather, the dominant sources of magnetic fields in the vicinity of a substation are the transmission or distribution lines entering and exiting the substation, as summarized by IEEE Standard 1127 (IEEE, 2013). The 60-Hz elements of the proposed Project are similar to those found in a substation and therefore the operation of the Project Substation and related equipment are not expected to appreciably change the EMF levels outside the Project Site.

The highest levels of 60-Hz EMF outside the project perimeter are expected to occur above the proposed underground 345-kV Tie Line connecting the Project Substation to the West Medway Substation. The magnetic field from this underground line will diminish quickly with distance and there are no residences or other public facilities in close vicinity of this Tie Line. The edges of the properties nearest to the Tie Line are located more than 170 feet to the east, while the buildings on these properties are situated more than 500 feet from the Tie Line.

Adjacent Properties on Milford Street

The northern end of the Project Site is bordered by Milford Street. Several residences are present on the northern side of Milford Street and are located approximately 100 feet or more from the Project Site's northern boundary; approximately 140 feet or more from the battery banks and inverters; and approximately 600 feet or more from the Project Substation. Based on the considerable distance of the battery banks, inverters, and Project Substation from the Milford Street residences, the operation of this equipment is not anticipated to appreciably affect the EMF levels at these locations (Tell et al., 2015). To confirm this expectation, Exponent calculated the maximum EMF levels from buried 34.5 kV feeder lines closest to the adjacent properties (i.e., those proposed to be routed near the northern border of the BESS). These 34.5 kV feeder lines were modeled using the full 250 MW load (and 50 MW on an individual feeder cable). The model included three 750 kcmil conductors, all contained within a single 5-inch duct. The results of this calculation indicate that 60-Hz magnetic fields from the feeder lines will be less than 0.5 mG at the nearest property boundary, and less than 0.1 mG at the residences themselves.

The nearest residences on the northern side of Milford Street also are located approximately 600 feet or more from the underground 345-kV Tie Line. Given the considerable distance of these residences from the Tie Line, the EMF levels associated with the Tie Line at these residence are expected to be in the range of background field EMF levels in the community and far below the exposure limits reference levels for the general public recommended by international scientific agencies that assure compliance with basic restriction limits on internal fields.

Current Status of EMF Health Research

Reviews of EMF by Scientific and Health Organizations

Since the late 1970s, researchers have examined whether EMF from man-made sources can cause short- or long-term health effects in humans using a variety of study designs and techniques. This large amount of research has subsequently been reviewed by multidisciplinary scientific expert panels, assembled by national and international scientific and health organizations, to draw conclusions about EMF exposure in the general public. Organizations that convened expert panels to conduct reviews of EMF research include the International Agency for Research on Cancer (IARC, 2002), the National Radiological Protection Board (NRPB, 2004), the WHO (WHO, 2007), the Health Council of the Netherlands (HCN, 2009), the European Commission's Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR, 2015), and the Swedish Radiation Safety Authority (SSM, 2016, 2018, 2019, 2020, 2021). As discussed above, ICNIRP and ICES also reviewed the relevant health research when developing recommended exposure guidelines.

When conducting reviews of scientific research, expert panels consider all the evidence on a particular issue in a systematic and thorough manner to evaluate whether the overall data present a logically coherent and consistent picture. This is often referred to as a *weight-of-evidence review*, in which all research studies are considered together, giving more weight to studies of higher quality and using an established analytic framework to arrive at a conclusion about possible causality between an exposure and disease. The weight-of-evidence review process helps to ensure that studies with a given result are not selectively chosen from the overall body of research to advocate for or suppress a preconceived idea of an adverse effect.

The reviews published by scientific and health organizations, including those listed above, have been consistent in their overall conclusions. None of the reviewing organizations have concluded that long-term exposure to EMF at the levels experienced in our everyday environment causes or contributes to adverse health effects in adults or children.

As noted previously, the only confirmed relationship between EMF exposure and adverse biological or health effects occurs at very high exposure levels to which neither electrical workers nor the general public could be exposed. If the current density or electric field induced by an extremely strong magnetic field exceeds a certain threshold, excitation of muscles and nerves is possible. Similarly, strong electric fields can induce charges on the surface of the body that can lead to small shocks (i.e., micro shocks). These short-term, acute effects cause no long-term damage or health consequences. ICES and ICNIRP have developed recommended exposure guidelines (see *Exposure Guidelines* section above) for workers and the general public to protect against the occurrence of these effects.

Childhood Leukemia

The 2007 WHO report, and much of the subsequent research on EMF, has paid particular attention to childhood leukemia because of epidemiologic associations found in some studies between this disease and high estimates of time-weighted average magnetic-field exposure (e.g., Ahlbom et al., 2000; Greenland et al., 2000).[4] The WHO report noted that *"[c]onsistent epidemiological evidence [i.e., differences in the estimated exposures of case and control children] suggests that chronic low-intensity ELF magnetic field exposure is [statistically] associated with an increased risk of childhood leukaemia. However, the evidence for a causal relationship is limited, therefore exposure limits based upon epidemiological evidence are not recommended, but some precautionary measures are warranted"* (WHO, 2007, p. 355). The WHO concluded that reconciling the epidemiologic data on childhood leukemia and the absence of findings (i.e., no hazard or risk observed) in experimental studies through innovative research is currently the highest priority in the field of EMF research.

The suggested weak statistical association between ELF magnetic field exposure and childhood leukemia reported in some of the earlier studies has not been strengthened or substantially diminished by subsequent research, although the more recent and larger studies tend to show no overall associations with distance from power lines or measured or calculated magnetic fields

4 Time-weighted average is the average exposure over a given specified time period (e.g., an 8-hour workday or a 24-hour day) of a person's exposure to a chemical or physical agent.

(Sermage-Faure et al., 2013; Bunch et al., 2014, 2015, 2016; Amoon et al., 2018). The recent literature does not alter the previous conclusions of the WHO and other reviews that the epidemiologic evidence on magnetic fields and childhood leukemia is weak, inconsistent, and includes outstanding questions about study design or other methodological issues (WHO, 2007; HCN 2009; SCENIHR 2015; SSM 2020). The recent weight-of-evidence review released in 2015 by SCENIHR concluded that the epidemiological data on childhood leukemia and EMF exposure continued to *"prevent a causal interpretation"* and that *"no mechanisms have been identified and no support is existing from experimental studies that could explain these findings"* (SCENIHR, 2015, p. 7).

Summary

This report summarizes the anticipated effect on EMF levels from the development of a 250-MW BESS located on approximately 10.6 acres in Medway, MA. Post-development, sources of EMF within the Project Site will include DC magnetic fields from the battery banks and from the cables connecting the battery banks to the power inverters, as well as AC fields from the power inverters, Project Substation, buswork, 345-kV AC underground Tie Line connecting the BESS to the West Medway Substation, and the existing 345-kV transmission lines.

The DC magnetic-field levels produced from the Project's BESS and related equipment are expected to be a small fraction of earth's natural static geomagnetic field and significantly lower than the ICNIRP standard. Therefore, the operation of these sources would not appreciably change the EMF levels outside the Project Site. The highest levels of AC EMF outside the Project Site are expected to occur directly above the underground 345-kV Tie Line connecting the Project Substation to the West Medway Substation. However, there are no residences or other public facilities in close vicinity of this Tie Line. At the northern boundary of the Project Site the nearest residences on Milford Street are located approximately 600 feet or more from the Project Substation, 345-kV Tie Line and existing transmission lines and approximately 140 feet or more from the battery banks and inverters. Similarly, residences to the east of the Project Site along Little Tree Road are more than 450 feet from these elements. These distances are sufficiently great such that the AC EMF levels from this equipment at residences would fall within the range of background values encountered in most communities and would be far below the exposure limits for the general public recommended by ICNIRP and ICES. Scientific and health organizations that have reviewed the research on EMF and health have been consistent in their overall conclusions that exposure to EMF at the levels experienced in our everyday environment do not cause or contribute to adverse health effects in adults or children.

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