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October 9, 2017

VIA ELECTRONIC FILING

M. Lynn Jarvis
Chief Clerk
North Carolina Utilities Commission
4325 Mail Service Center
Raleigh, North Carolina 27699-4300

RE: Duke Energy Progress, LLC's Verified Response to September 25, 2017 Order Requiring Additional Information
Docket No. E-2, Sub 1150

Dear Ms. Jarvis:

I enclose Duke Energy Progress, LLC's Verified Responses to the Commission's September 25, 2017 *Order Requiring Duke Energy Progress LLC to Provide Additional Information,* for filing in connection with the referenced matter.

Thank you for your attention to this matter. If you have any questions, please let me know.

Sincerely,

Lawrence B. Somers

Enclosures

cc: Parties of Record

CERTIFICATE OF SERVICE

I certify that a copy of Duke Energy Carolinas, LLC's Verified Response to September 25, 2017 Order Requiring Duke Energy Progress, LLC to Provide Additional Information, in Docket No. E-2, Sub 1150, has been served by electronic mail, hand delivery or by depositing a copy in the United States mail, postage prepaid to the following parties:

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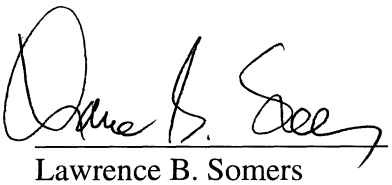
This the 9th day of October, 2017.



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Duke Energy Progress, LLC's Verified Responses to Commission Order Requiring Duke Energy Progress, LLC, To Provide Additional Information
Docket No. E-2, Sub 1150
October 9, 2017

1. Several members of the public commented that they were unaware of the public meetings that DEP hosted in November of 2016, suggesting that they did not learn of the proposed project until they received certified letters from the Company informing them that the route would go through their property. Please explain how DEP notified persons in the potential path(s) of the transmission of the public meetings hosted by DEP, and comment on whether DEP's mailing missed some people in the study area.

Response:

DEP made several reasonable efforts to notify members of the public in the siting study area of the public workshops for the transmission line siting project. The mailing list for the public workshops was developed by DEP contractor Burns & McDonnell within the scope set by the Duke Energy Public Engagement Specialist, Drew Gilmore. The primary data sources to obtain parcel owner information and mailing addresses were the Johnston County and Wake County tax assessor databases. For all candidate routes, the mailing list included owners of parcels within 500 feet either side of a proposed candidate route centerline (1,000-ft corridor). If any portion of a parcel was within the 1,000-ft corridor for any of the candidate routes, a letter was mailed to the owner of record with the respective county tax assessor's office.

Letters were sent to 1,036 owners of 1,313 parcels. In addition, announcement letters were sent to both Johnston and Wake County administrators and each municipal government within the study area. Two newspaper advertisements also ran in the News & Observer in the weeks prior to the events. The letters were sent via USPS priority mail on November 4, 2016 and invited owners to one or both of the open house events on November 16, 2016 and November 17, 2016 respectively.

A small number of letters were returned due to a bad address, or the owner no longer lived at the address on file with the tax assessor, and no forwarding address information was on file with the USPS. In those cases, the letter was mailed again to the address of the subject property, and the envelope was addressed to the owner "OR CURRENT RESIDENT." No letters were returned from the second mailing.

2. Public commenters stated that trees had been inappropriately cut down during the survey process. Explain in detail what occurred and whether it was necessary to compensate any landowners for damage.

Response:

N.C. Gen. Stat. §40A-11 grants DEP the right to enter property to make surveys, borings, examinations, and appraisals as may be necessary or expedient in carrying out and performing its statutory eminent domain rights after providing 30 days' written notice. Each property owner received a certified return receipt letter informing them of DEP's plans and rights pursuant to the statute. Some trees were cut or trimmed in order to site the center line. Pursuant to the statute, DEP will compensate each landowner for the damages. If the CPCN is granted, then the entire 125' path will be cleared of trees and what was damaged during the survey will be included in the settlement.

In DEP's communications with property owners in advance of the centerline survey field work, DEP told property owners that no trees six-inches or larger in diameter would be cut as part of the centerline survey work. Late in the evening of June 15, 2017, Dr. Casey Johnson sent several text messages and included photos of trees that were cut on a neighbor's property, some of which appeared to be larger than six-inches in diameter. DEP asked for the property owner's name, Tracy Adams, and her contact information, and then attempted to call Mrs. Adams to get more information. Mrs. Adams did not answer the phone that evening, but DEP employee Drew Gilmore left a voicemail.

Immediately after attempting to reach the property owner, Mr. Gilmore contacted the project manager, siting lead, community relations manager, real estate personnel and the lead surveyor that same evening to inform them of the information he had received. The lead surveyor stopped all field work until DEP could assess the situation.

Both Miranda Gregory (DEP Real Estate) and Mr. Gilmore tried to reach Mr. and Mrs. Adams the following day, and each left voicemail messages. Miranda Gregory was the first to reach Mrs. Adams when they spoke by phone on June 19, 2017. Ms. Gregory set up a meeting at their home the following week on 6/21/2017.

On June 21, 2017, the following Duke Energy personnel: Phil Williams-Project Manager; Drew Gilmore-Public Engagement Specialist; Buz Moore-Real Estate Lead; Miranda Gregory-Real Estate Land Agent; and Gene Herring-Real Estate & Surveying/Property Owner liaison contractor met with Greg Adams, Tracy Adams, Dana Adams Reaves & Johnston County Commissioner, Larry Wood at the Adams's home. Buz Moore explained the surveying process in detail and answered all of the owners' questions. Mr. Moore told them that Duke Energy would reimburse the property owners for any damages. Mr. Moore introduced Gene Herring as DEP's onsite land agent to serve as an additional resource for them to contact with any questions. Mr. Herring was retained to remain in the field with the surveying crews, provide advance notice of scheduled survey work to property owners by phone or in person when possible and to address

any future issues that may arise in the field as quickly as possible. All DEP personnel engaged with the owners individually, listened to their concerns and answered all their questions.

3. Public commenters questioned why DEP did not propose a shorter route, one using the existing ROW for the Cumberland-Wake 500-kV line. Please respond to that question. In addition, is it possible to serve the area directly from that 500-kV line? Explain.

Response:

DEP's application and testimony explains in detail the basis for the selected transmission line route. As with every DEP siting project, DEP Transmission Planning is consulted prior to initiating the siting study to determine which transmission line(s) could be tapped to serve the new load. For the case of the Cleveland-Matthews Road project, DEP Transmission Planning studied the request and determined that any of the three existing 230kV lines in the area (Lee-Milburnie 230kV, Erwin-Milburnie 230kV, Erwin-Selma 230kV) could serve the new load. As such, the DEP Siting, Permitting and Engagement team decided to use these same three existing lines to define the project study area. As shown in the "Routing Study and Environmental Report," several alternative routes shorter than the preferred route were studied.

At its closest point, the Cumberland-Wake 500kV line is approximately 3 miles to the west of the proposed substation site. A route "using the existing ROW for the Cumberland-Wake 500kV line" would actually have been longer than the preferred route considering the length (either north or south) the line would have to travel before reaching either the Lee-Milburnie 230kV line to the north (approximately 14 miles) or the Erwin-Selma 230kV line to the south (approximately 19 miles). In addition, DEP would not use the existing 500kV ROW for the new 230kV line. There is likely some opportunity to share a portion of the existing ROW, but additional adjacent ROW (on one side or the other of the existing) would be required.

As for serving the area "directly from that 500kV line," DEP has never allowed a load connection to its 500 kV bulk transmission system. DEP's 500-kV transmission network is reserved for the bulk transport of large amounts of electricity. DEP's bulk transmission system includes all 500kV lines and stations. These DEP 500kV facilities help form the backbone of the SERC bulk transmission system and provide the primary means of serving large geographical areas. A comprehensive study would be required to consider the connection of any load to the Bulk System, and the expectation is that this

would be rare. Only generators of 500 MW or greater will be considered for connection to the 500kV system. These guidelines are documented in the DEP Facilities Connection Requirements document (https://www.oasis.oati.com/CPL/CPLdocs/DEP_FCR.pdf).

4. Several public commenters expressed concern about electric-magnetic fields from the proposed power line. How much EMF from the line will be experienced by someone at the edge of the right of way? Directly under the line? In the nearest home?

Response:

Duke Energy's in-house Electric & Magnetic Fields (EMF) expert, Kim L. Craven, Principal Engineer, attended the public workshops and provided information regarding EMF. Please see the three files attached: Question 4, Attachment 1 "EPRI – EMF and Your Health," Question 4, Attachment 2 "EMF Brochure" and Question 4, Attachment 3 "Duke Energy Electric and Magnetic Fields," all of which were available at the public workshops and on DEP's project website.

The following information, taken directly from page 3 of Question 4, Attachment 2 addresses the specific questions asked for a 230kV line:

"*TYPICAL MAGNETIC FIELD READINGS*
Typical 60 hertz magnetic fields measured at various distances.
Magnetic fields are measured in milligauss (mG).

Transmission line:	230kV
Under line:	4.5 – 29
Edge of right of way:	1.9 - 6.4
50 ft. from edge:	1.0 - 3.5"

5. Several public commenters questioned the need for the project. Witness Umbdenstock states that "This new substation site was purchased in 2015 based on the projected load center in the vicinity of Cleveland Road and Mathews Road." Describe the load projections for this area and explain the basis for those projections.

Response:

There are 3 distribution circuits which terminate near the intersection of Cleveland Road and Matthews Road and serve this general area of Johnston County:

Mount Pleasant 24 kV – Edmondson 230 kV Bank #1
Barber Mill 24 kV – Clayton 115 kV Bank #1
Johnson Crossroads 24 kV - Edmondson 230 kV Bank #2

The January 2015 Winter Peak for the three feeders above were:

Mount Pleasant 24 kV – 17.8 MVA
Barber Mill 24 kV – 18.7 MVA
Johnson Crossroads 24 kV – 17.6 MVA

The Winter Planning Limit for 24 kV feeders is 17.6 MVA, so the three main feeders were loaded to or past their planning limit.

The feeder growth rates are based upon the past 5-year historical peak trend or the connected kVA growth over the same period. The connected kVA is the sum of the new service transformers being added to the feeder, which is an indicator of new customers being served.

The actual winter peak growth since 2013 has been 7.3% per year for the Mount Pleasant feeder and 2.1% for the Johnson Crossroads feeder while the connected kVA growth for the same is 2.5% and 3.4% respectively. The Barber Mill feeder winter peak has grown by 3.7% per year, and its connected kVA growth has been 3.1%.

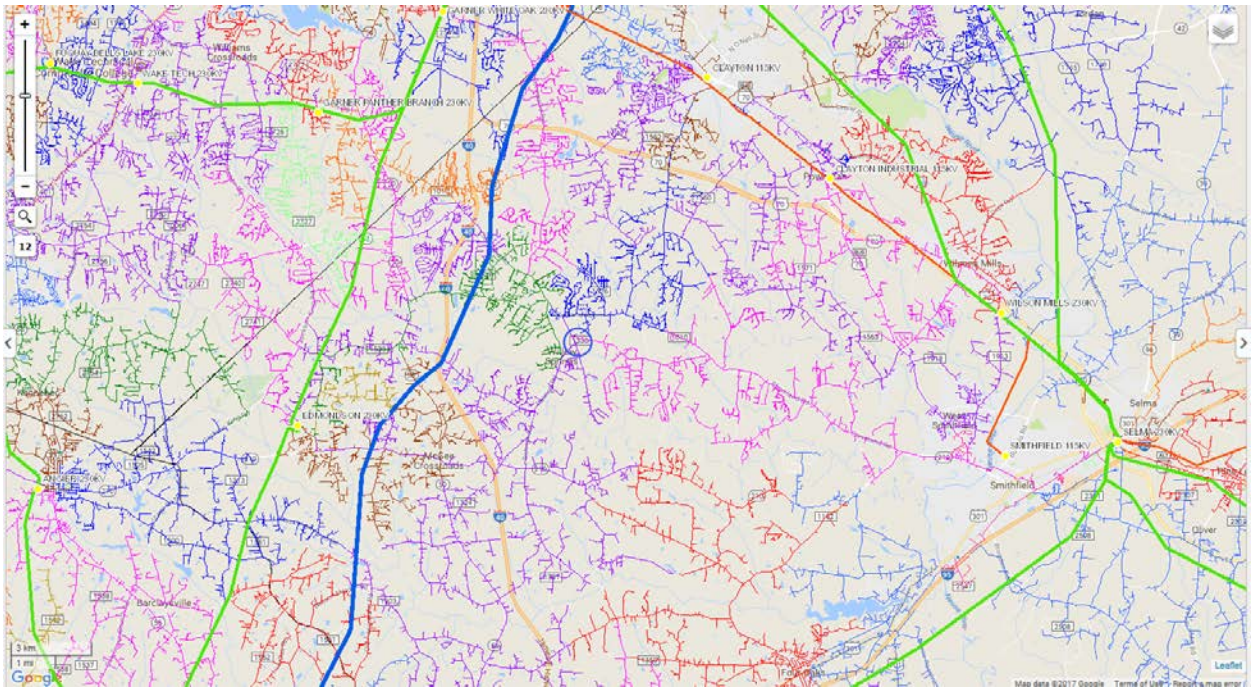
The growth rates used for the future load projections on the Mount Pleasant feeder is 3.0%, Johnson Crossroads is 2.5%, and Barber Mill is 1.0%.

Using the growth rates in the previous paragraph, the projected peaks in Winter 2020 (January 2020) for these same three feeders are:

Mount Pleasant 24 kV – 18.3 MVA
Barber Mill 24 kV – 18.7 MVA
Johnson Crossroads 24 kV – 12.8 MVA

The small blue circle in the middle of the attached map below is the location of the Cleveland Matthews Road substation site. Each different color of line is a different distribution circuit. The "green" feeder immediately northwest of the proposed sub site is the Mount Pleasant 24 kV feeder out of Edmondson 230 kV Sub well to the southwest of this area. Also please note that there are not many customers served by this feeder until it gets to the split of Cornwallis Road and Old Drug Store Road just west of I–40. In other words, DEP is attempting to provide an express circuit to this area to have as much capacity as possible available and still is loaded past the planning limits.

The proposed Cleveland Matthews Road 230 kV substation is critical for Duke Energy Progress to continue providing reliable electric service to our existing and future customers.



6. The letter dated July 31, 2017, to Christopher Ayers from Randy Johnson (submitted into the Commission's docket system on August 15, 2017) includes an attachment purporting to be a map of part of DEP's selected route. Is the map accurate? If this map is accurate, the route appears to cross some 12-15 parcels rather than following property lines. Please discuss the implications of moving the route to the west or east to follow property lines or road(s), so as to reduce the number of parcels being bisected by the route.

Response:

Yes, the referenced map from the letter dated July 31, 2017, to Christopher Ayers from Randy Johnson is somewhat illegible, but it appears to be accurate. Generally speaking, when routing through developed areas, preference is given to maximizing the distance away from structures versus following property lines. DEP's position is, at this point, the route could potentially be moved east or west as long as additional property owners are not impacted. DEP Real Estate representatives are currently working with property owners to evaluate requests to do just this. In addition, the DEP project team (Real Estate, Siting,

Permitting, Engagement, Surveying, Project Management, and Line Engineering) recently met to begin evaluating some of these requests.

On Thursday October 5, 2017, DEP staff met with several Public Staff employees to provide a project update and review several of these requests from property owners to shift the proposed centerline of the preferred route.

7. The same letter (from Mr. Johnson) states that the landowner would need to install multiple access fences in order to accommodate the route. Please respond to this concern.

Response:

As part of DEP's standard right-of-way ("ROW") agreement, any fences crossing transmission line ROWs are required to have gates so that DEP can have access through the fence for Construction/Maintenance/Vegetation Management equipment and activities. DEP would pay for any necessary existing fence modifications and gate installations as part of the ROW agreement. No new fences, however, are required to be installed simply as a result of the new transmission line itself.

8. Explain how the site for the proposed Cleveland-Matthews Road 230kV/23/kV transmission-to-distribution substation was selected, and what other options exist for locating that substation.

Response:

DEP conducted a siting study, which ranked available parcels. DEP attempted to purchase property for the substation from several property owners in the order of priority ranking. The selected site (Site 6 in the attachments) was the highest ranked site with a willing seller. Please see the attached map (Question 8, Attachment 1) and Siting Matrix (Question 8, Attachment 2).

9. Appendix B of the application includes several emails from Duke Environmental Specialist Gail Tyner that raise an issue relative to avoiding a route that crosses Middle Creek due to the possibility that the stream provides habitat for an endangered species. Page 17 of Timothy Swane's testimony seems to conflict with the Tyner emails by stating that Little Creek, Swift Creek and/or their tributaries were designated as "highly sensitive," with Middle Creek and its tributaries designated as "medium sensitivity." (a) Please explain in detail whether and how concerns about endangered species ultimately impacted the route scoring process. (b) Did these concerns cause portions of the study area to be rejected? If so, describe the area(s) and proposed route segments that

were impacted by this issue. (c) Is it known whether the dwarf wedge mussel (or another endangered species) referred to in Ms. Tyner's November 18, 2016 email actually exists in Middle Creek (or any other streams in the study area), or is that an assumption that subsequently impacted DEP's route scoring? Please explain in detail. (d) Assuming an endangered species does exist in streams in the study area, please describe in detail the risks that power line construction and operation would pose to that/those species, whether techniques exist for mitigating those risks, and whether DEP has successfully used those techniques in the past. (e) Is there a statutory, regulatory or other prohibition against crossing a stream that provides habitat for an endangered species with a power line? Please explain in detail the implications of selecting such a route.

Response:

Prior to the Agency Scoping Team meeting, DEP identified potential issues with Middle Creek and documented occurrences of aquatic mussels based on publicly available data from the NC Natural Heritage Program ("NHP") database. In the email requesting the agency scoping meeting, Ms. Tyner only specifically mentioned Middle Creek and mussels in order to differentiate to the agencies that this project did not cover the same exact project study area as a prior agency meeting held to discuss another project in Johnston County (Powhatan Industrial), and that another scoping meeting was warranted for the new project.

Middle Creek, Swift Creek and some of their tributaries are NHP Designated Natural Areas – Aquatic Habitats which have documented occurrences and contain potential habitat for federally protected aquatic species, including freshwater mussels.

Response to (a) and (b):

During the Agency Scoping Team meeting on December 8, 2016, Wildlife Resource Commission ("WRC") and NHP discussed their concerns with the Swift Creek, Middle Creek, and Black Creek Watersheds. NHP and WRC expressed concerns with impacts to the Swift Creek watershed. It is DEP's understanding, confirmed with the agencies during the meeting, that the Swift Creek watershed is less developed, and agencies consider the streams in this watershed more sensitive to impacts. They expressed that the Middle Creek Watershed was already highly developed upstream of the proposed crossing; therefore, the Middle Creek Watershed was not as sensitive (i.e., a lower quality habitat). The Black Creek Watershed did not have documented occurrences of federally protected mussel species adjacent to the proposed study area, so they

were less concerned with impacts to the streams from a mussel habitat standpoint.

DEP discussed how to capture the agencies' concerns for watershed quality and impacts to potential federally protected aquatic species and their habitats as part of the line siting study. DEP decided to apply a "stream sensitivity" score to capture the agencies' concerns for watersheds and potential mussel habitat.

DEP did not reject portions of the project study area that had the potential to contain protected species, but incorporated them into the stream sensitivity as one of the evaluation criteria. In the email to Tim Barton dated December 9, 2016, Ms. Tyner discusses potential weights to be applied for stream sensitivity. Ultimately, the siting team decided that the stream sensitivity scores should not carry the same weight as the "proximity to homes," and a lower weight was applied.

Response to (c):

There have been no physical surveys of Middle Creek and/or Swift Creek within the project study area by DEP. However, there are documented occurrences of the federally protected and federal species of concern in both Middle Creek and Swift Creek. Both creeks are NHP Designated Natural Areas - Aquatic Habitats in part due to occurrences of protected aquatic species and their potential habitat.

In the absence of aquatic surveys, the agencies stated that DEP should assume that mussels and potential habitat may be present since they have been documented both upstream and downstream of the project study area.

As stated above, DEP did not reject portions of the project study area that contained federally protected (endangered) species, but incorporated the stream sensitivity as one of the evaluation criteria.

10. Page 4-24 of Revised Exhibit A (The Routing Study and Environmental Report) states: "… it was discovered that the potential condemnation of open space/green space areas owned by a subdivision homeowner association could require the condemnation of all property owners within that subdivision, based on precedent from a previous legal case. This knowledge, along with proximity to residences and subdivisions, potential environmental impacts to sensitive streams and floodplains, and construction and maintenance concerns associated with the western routes, resulted in the elimination of these two routes (Route 4 and Route 1)…" (a) Please provide specific information about the legal

precedent referenced in the quoted testimony. (b) Which route(s) implicated open space owned by a homeowner association? Provide a map detailing this information. (c) Explain what is meant by "maintenance concerns associated with the western routes."

Response:

(a) *See*, NCDOT v. Stagecoach Village, 174 N.C.App. 825, 622 S.E.2d 142 (2005).

(b) Routes 1 and 4 both had portions crossing these open space areas. Maps are included with this response showing the areas identified as open space. Please see the attached Question 10, Attachment 1 and Question 10, Attachment 2.

(c) Upon completion of the initial scoring/ranking of the alternative routes (quantitative analysis), the DEP Siting, Permitting and Engagement team ("SPE") always performs an additional qualitative analysis. This qualitative analysis is an attempt to look at the results of the route ranking and consider other items that perhaps are not captured in the actual numerical data.

Following the qualitative analysis, SPE then takes several of the top scoring routes and asks other members of the project team (Transmission Line Engineering, Real Estate, Transmission Line Construction Work Management/Work Planning, and Project Management) to perform high level cost estimates and asks these same team members to provide any additional input that they see fit. For this project, routes 1, 4, 31 and 32 (2 western and 2 southern routes) were the routes that SPE recommended for this further evaluation.

The Transmission Line Construction Work Management/Work Planning process resulted in a strong preference for the southern routes over the western routes. The construction and maintenance concerns consisted of general access, overall constructability and the majority of the alignments paralleling environmentally sensitive areas with substantial slopes toward the creeks and streams. The majority of the "upland" areas adjacent to routes 1 and 4 have been developed predominantly with single family residential lots on cul-de-sac style streets. In some areas, the only likely access to the proposed route would be through these cul-de-sac streets and through a single family residential lot. Also, due to the nature of the existing slopes in the areas adjacent to routes 1 and 4, work pads would likely need to be created at each structure which would provide a flat area to work from. These work pads would require additional land disturbance adjacent to the same environmentally sensitive areas.

The majority of the southern routes (31 and 32) are through much flatter, larger parcels, the majority of which have existing access areas due to agricultural activity. There are several perpendicular crossings of creeks/streams with the southern routes, but construction and maintenance of perpendicular crossings are much preferred over continuous construction and maintenance along and parallel to creeks/streams.

11. It appears from page 4-12 of the Routing Study and Environmental Report, that avoiding open spaces was given the same weighting as avoiding residences. Explain.

Response:

Yes, both residences and these open space areas were given the most severe weighting of 5 primarily due to the legal and other issues discussed in the response to Question 10. The DEP Siting team first discovered the potential severity and legal challenges of crossing these open spaces in April of 2017. At this point in the project, the DEP team had already established the 1-5 weighting system. Considering the importance of this criteria and the potential hurdles and time delays that could result from an increased likelihood of condemnation, DEP's position is that a weighting of 5 is appropriate. If a different weighting system had been established with a wider range of scores, perhaps residences and open space would have had a slightly different weight from each other. However, both would have been among the top weighted criteria.

12. Witness Umbdenstock states that six of the existing 13 feeders that currently provide power to the Cleveland area of Johnston County exceeded their planning limit of 17.6 MVA during the January 2015 winter peak. It appears that the proposed new 230-kV line and the Cleveland-Matthews Road substation will not be in service until 2019. How will DEP reliably serve the Cleveland area while the new transmission line and substation are under construction?

Response:

In 2017 two distribution projects are being constructed as a stopgap measure to relieve the circuits feeding the area that will ultimately be served by the new Cleveland Matthews Road Substation.

A fifth feeder circuit breaker ("FCB") is being added at Clayton 115 kV Sub Bank #1 and distribution lines extended from there along Hwy 42 and Barber Mill Road to an area south of the new Hwy 70 Bypass. This new circuit will

relieve the existing Barber Mill 24 kV feeder and thus allow it to have additional capacity until the new sub can be built.

Also, the third FCB out of Edmondson 230 kV Sub Bank #2 is being added. New distribution lines are being constructed from Edmondson Sub along Landmark Road, White Memorial Church Road, Honeycutt Road, Old Fairground Road, Dixon Road, Church Road, BH Parrish Road, Sanders Road, Raleigh Road and Polenta Road all the way to the new Cleveland Matthews Road 230 kV Substation site. This new feeder will relieve the Johnson Crossroads feeder plus provide additional capacity for the area.

These two projects should provide sufficient relief and capacity to the previous configured circuits to ride through the projected peaks until the new Cleveland Matthews Road 230 kV Sub is built and serving load.

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

January 2012

EMF and Your Health

Contents

Electric and magnetic fields (EMF) are present whenever and wherever electricity is generated, transmitted and used. Given electricity's unique and growing role in modern life – to light our homes, refrigerate our food, heal, diagnose, entertain, and communicate – one important question is whether exposure to EMF can have harmful health effects.

To answer this question, hundreds of scientific studies have been carried out around the world over the last 30-plus years. Conducted at universities and research institutions, these studies have used a variety of approaches to explore the potential health effects of EMF. Some have looked at patterns of disease in human populations, some at the effects of EMF exposure on laboratory animals, and still others at biological mechanisms that might plausibly link EMF to various diseases.

The World Health Organization (WHO) has weighed the full body of evidence from all these studies and classified EMF as "possibly carcinogenic," primarily because of observations made in human populations that show an association between magnetic field exposures and childhood leukemia. The association is weak and not supported by laboratory research, but it does show up in studies time and again, so causation cannot be ruled out. Ongoing research is trying to resolve this uncertainty.

This brochure has been developed to help explain the complex issue of EMF to the general public. It covers the physical nature of electric and magnetic fields, the health research and its findings, our everyday exposures to EMF, and the conclusions reached by scientific panels and policy makers, alike.

The brochure was produced by the Electric Power Research Institute (EPRI), a non-profit institution that has been involved in research on the health effects of EMF for more than 30 years. EPRI's EMF program continues to fund independent research at universities and other research institutions, all of which publish their findings in peer-reviewed scientific journals.

EMF Around You

WHAT ARE ELECTRIC AND MAGNETIC FIELDS?

Electric and magnetic fields are part of both the natural and manmade environments, and are often described as invisible lines of force. As shown in Figure 1, these fields are part of the electromagnetic spectrum, which is arrayed by the frequency of the field, or the number of times the field completes a full cycle (oscillates), every second. Near the low end of the spectrum are fields that arise from the use of electricity in the home. They have frequencies of 50 cycles per second in Europe and 60 cycles per second in North America, or 50 and 60 Hertz (Hz). At the high end of the spectrum is ionizing radiation, such as x-rays and gamma rays, with frequencies in the range of a billion-billion cycles per second. In the middle of the electromagnetic spectrum (millions to billions of cycles per second), are the radio-frequency fields we use everyday for TV, radio, and cell and cordless phones, and microwave ovens.

Ionizing radiation, such as x-rays, has enough energy to damage cells, and its use in medicine and nuclear energy is carefully managed. Radio-frequency exposures interact with people by depositing thermal energy in the body, which can result in the heating of tissue. At the frequencies our electric power systems operate, exposures cannot directly damage cells or produce tissue heating. This brochure focuses on the potential health effects of these extremely low frequency (50 or 60 Hz) fields.

Electricity use produces two types of fields–electric fields and magnetic fields. Electric fields arise from a voltage, which is analogous to the water pressure in a hose, whereas magnetic fields arise when the electric current begins to flow, analogous to opening the nozzle of the hose. Electric fields are easily shielded by objects and materials, such as houses, trees, wood, even skin. However, magnetic fields are not easily shielded and pass through most objects. Both can interact with living bodies, inducing electrical forces within those bodies. This is not so foreign as it might sound, since all living things rely upon electricity to run virtually all processes of life. There is a small voltage across the membrane of every cell in the human body that regulates the internal operations of the cell, acts as a traffic cop regulating what passes in and out of the cell, and sends impulses along the nerves to the brain, organs and extremities. The additional

electrical activity "induced" in the body by outside sources, such as power lines, home wiring, appliances, and equipment, are typically a small fraction of those that regulate the body.

Health-related research over the years has shifted away from electric fields to magnetic fields. The reason is that a large body of research supported by the Department of Energy (DOE) and EPRI, among others, did not uncover hazards associated with electric field exposure at the levels encountered in everyday activity. Exposure at very high levels can potentially be harmful, so standards have been established (see page 18). Health concerns are now focused on magnetic fields.

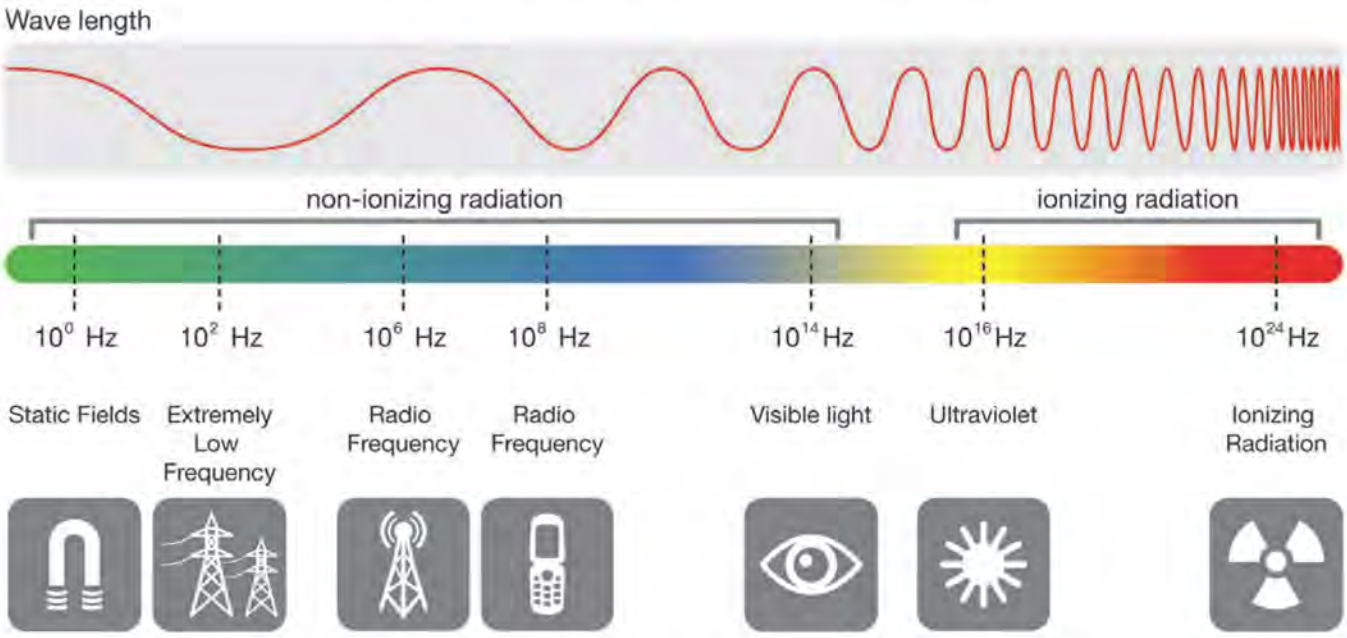


Figure 1 – The electromagnetic spectrum arrays fields by their frequency, ranging from zero (static field) and the very low, with frequencies in the hundreds of cycles per second, to the very high, with frequencies of trillion-billion cycles per second or more. Visible light sits in the middle of the spectrum.

TYPICAL SOURCES OF EMF EXPOSURE

From this point on in the brochure, our discussion focuses on the power frequency magnetic fields (50 or 60 Hz) associated with the transmission, distribution, and use of electricity, as shown in Figure 2. The unit of measure in the United States for magnetic field intensity is the "Gauss," and most of the fields experienced in daily life are in the milligauss range

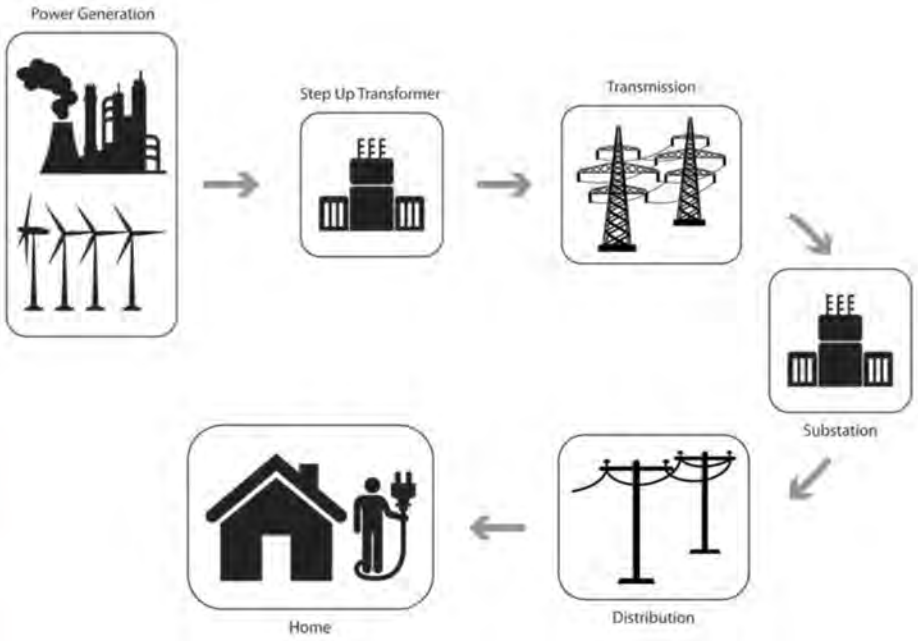


Figure 2 – Keeping the lights on requires an instantaneous flow of electricity from the power station through the transmission and distribution lines directly into the home. Voltage is stepped up or down by transformers to move electricity more efficiently.

OCCUPATIONAL STUDIES

Occupational studies can offer a useful opportunity to examine environmental EMF exposures at higher levels than occur in residential settings. Many occupational studies of electrical workers and others exposed to higher magnetic fields have examined both cancer and other diseases. Overall, the occupational studies do not support the link between magnetic fields exposure and any form of cancer.

(mG = 1/1000 G). The international unit is the "Tesla," which is a multiple of the Gauss, where for example, 10 mG = 1 microtesla.

Most human exposure to EMF from electric power sources (50 or 60 Hz) occurs during daily activities at home, at work and school. This includes exposure to low-level fields from power lines and house wiring, as well as appliances running on electricity. (Note: Exposure to fields from *wireless* communications, such as cell phones, occurs at much higher, megahertz frequencies, and is not covered by this brochure). As shown in Figure 3, magnetic fields from transmission lines fall off rapidly with distance from the lines.

Distribution lines are generally located closer to homes. They also produce magnetic fields but usually at lower levels. Magnetic fields are the result of electrical current, and this flow can fluctuate during the day as demand for power goes up and down. According to the 2002 report of the National Institute of Environmental Health (NIEHS) and the Department of Energy (DOE), "Magnetic fields directly beneath overhead

distribution lines typically range from 10 to 20 mG for main feeders and less than 10 mG for laterals. Peak EMF levels, however, can vary considerably depending on the amount of current carried by the line. Peak magnetic field levels as high as 70 mG have been measured directly below overhead distribution lines, and as high as 40 mG above underground lines."

ANIMALS AND PLANTS

Research on how animals and plants might be affected by exposure to EMF has been conducted since the 1970's. EMF exposure has not been shown to have any consistent detectable, adverse effects on plant growth or animal health. A separate issue is sometimes raised about potential harm to farm animals from "stray voltages." Stray voltage is a general term used to describe the small voltages that may exist at contact locations where they would not be expected nor desired. These voltages may result from the operation of electricity delivery and utilization systems both on and off a farm. Stray voltages may be enhanced by various abnormal and correctible situations, such as poor insulation or wiring errors. Bees in commercial hives with metallic components under or very close to transmission lines may be adversely affected if situated in electric fields high enough to produce conditions prone to shocks within the hives. These effects can be mitigated by shielding and grounding.

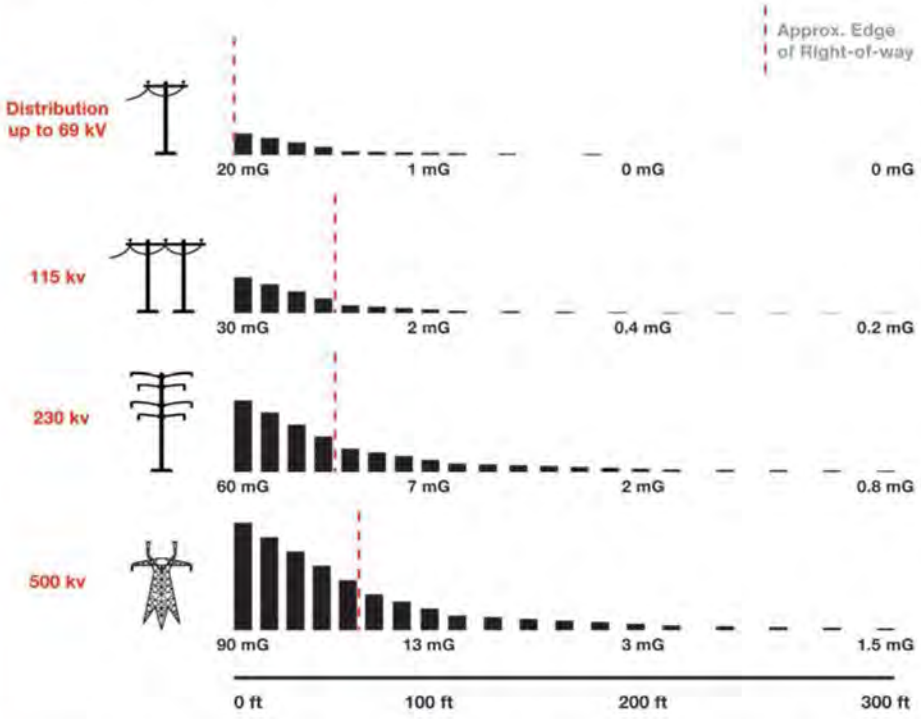


Figure 3 – Magnetic field intensity falls off rapidly with distance for both distribution and transmission lines. The field intensity varies over the day depending upon how much current is flowing through the line, or the design of the line. Source: BPA, 1993 and PG&E, 2008.

HOW EXPOSURE TO FIELDS VARY THROUGHOUT A DAY

A person's exposure changes over time and space, as people move from location to location in everyday life, from home to school or work, as well as when coming closer to appliances or other sources of exposure. Typical exposures throughout the day are shown in Figure 4. An individual may experience momentary peaks while getting dressed (e.g. using a hairdryer), traveling in a vehicle under power lines, and at home during dinner.

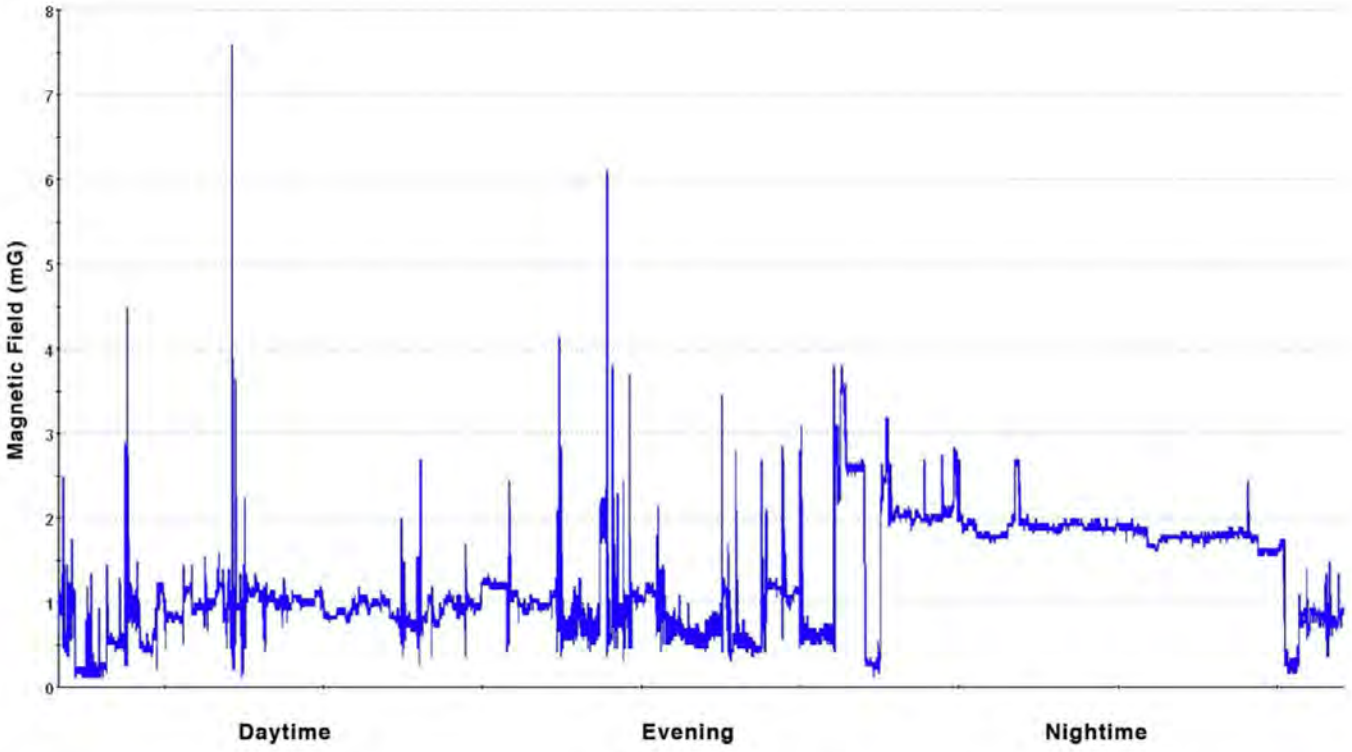


Figure 4 – Fields vary throughout the day. Averages can be quite low but there can be brief spikes as people move around or engage in different activities.

EXPOSURES AND TYPICAL LEVELS

Exposures to EMF in homes vary, depending on the location and type of home, and on how much time a person spends near to sources of EMF, including household appliances and wiring in the walls. In the United States, as shown in Figure 5, about 6% of homes have average exposure levels above 3 mG. One key study found that 3% of California schools are estimated to have average exposure above 3 mG.

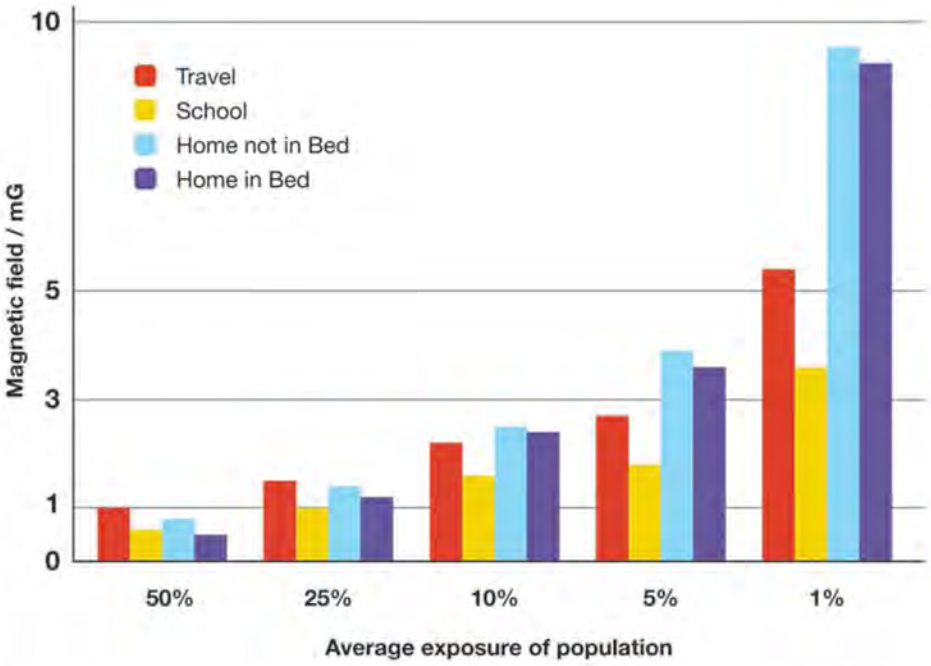


Figure 5 – Average fields found in United States homes, schools and transportation are typically below 3 mG. About 6% of homes show average exposures above 3 mG. Source: EMF Rapid, 1998.

PACEMAKERS AND OTHER MEDICAL DEVICES

Pacemakers and defibrillators are the most commonly implanted medical devices that may be affected by high EMF. Other devices that could possibly be affected by EMF exposure include cochlear implants and neurostimulators. High levels of exposure may cause interference with the operation of these devices through their sensing electrodes. The sensitivity of these devices depends on manufacturer, design, and how they are used by a patient. Metallic case shielding, internal circuits, filters and bipolar sensing have contributed to improved immunity to interference, and in practice, interference is very rare. Concerned individuals should consult their doctor.

Electric fields are produced by household appliances whenever they are plugged in, whether operating or not, while magnetic fields occur only when the appliances are turned on. Both types of fields fall close to background levels within a few feet of the appliance. As shown in Table 1, short-term exposures from some of the appliances that are used close to the body can be quite high. Some hairdryers inches from the head, for example, can produce fields as high as 700 mG. Fields from computer monitors and TVs are quite low overall.

Appliances	Magnetic Field (mG)	
	1.0 foot	User Distance
AC Adapter	0 – 7.5	0 – 0.8
Baby Monitor	0 – 2	0 – 15
Compact Flourescent Bulb	0 – 0.1	0 – 0.6
Digital Clock	0 – 8	0 – 8
Dimmer Switch	0 – 0.8	0 – 0.8
Electric Stove	1 – 5	0 – 20
Gaming Console	0 – 0.5	0 – 0.6
Hairdryer	0 – 70	1 – 700
Laptop Computer	0	0 – 0.1
LCD TV	0 – 2.5	0 – 0.6
Microwave	1 – 200	0 – 300
Plasma TV	1.4 – 2.2	0 – 0.1
Portable Heater	1 – 40	5 – 150

Table 1 – Exposure to 50 or 60 Hz magnetic fields from electric appliances can vary greatly depending upon how close it is to the body. Intensity falls off dramatically with distance. Source: Zaffanella, 1992, NIEHS, 2002, and EPRI, 2010.

Potential Health Effects

There are a couple of guiding principles in health research. First, a single study is almost never definitive. Drawing scientific conclusions requires that the same or similar results be seen by different investigators. The second guiding principle is that different scientific approaches are useful in getting to the answer. When different approaches arrive at the same conclusion, scientists have greater confidence in the results. When judgments are rendered on whether a specific exposure causes a particular disease, expert scientific panels look at the full "weight of evidence" from all of these different studies before they make the call.

There are three basic approaches that can be thought of as forming a three-legged stool of evidence. The three legs are human studies, animal studies, and "mechanistic studies," which involve finding the underlying chain of physical and biological causation. But why use three approaches instead of one? It is very difficult to *directly* measure the impact of a substance on a human population, so *indirect* measures – the three legs – are used. These indirect measures all have strengths and weaknesses, but together, like a jigsaw puzzle, they can provide a more complete picture. When all three legs support the "weight of evidence," the results are considered solid. When one leg supports one conclusion but the other two legs don't, the stool is wobbly. The uncertainty this creates must be factored into the conclusion reached by expert scientific panels.

Studies involving groups of human beings carry more weight in the health research community than studies involving animals or cells in isolation. The most commonly used approach with humans involves comparing a group of people with a given disease (e.g. children with leukemia) with a comparable group *without* the disease, then estimating the historical exposure of both groups to the agent under study. The researchers look for patterns and associations between exposure and disease. This field of science, called *epidemiology*, uses sophisticated statistical techniques to tease out one possible cause of the disease from all the other possibilities. If researchers find a robust association, they then try to establish the nature and level of the risk.

LEUKEMIAS

Leukemias include a variety of cancers that arise in the bone marrow where blood cells are formed. Leukemias represent less than 4% of all cancer cases in adults but are the most common form of cancer in children. For children age 4 and under the incidence is approximately 6 per 100,000 per year, and decreases to 2 per 100,000 per year past the age of 10. Genetic factors may play a role, but the only known causes are ionizing radiation, benzene, and other chemicals and drugs that suppress bone marrow function, and human T-cell leukemia virus.

[Source: NIEHS 2002, page 18]

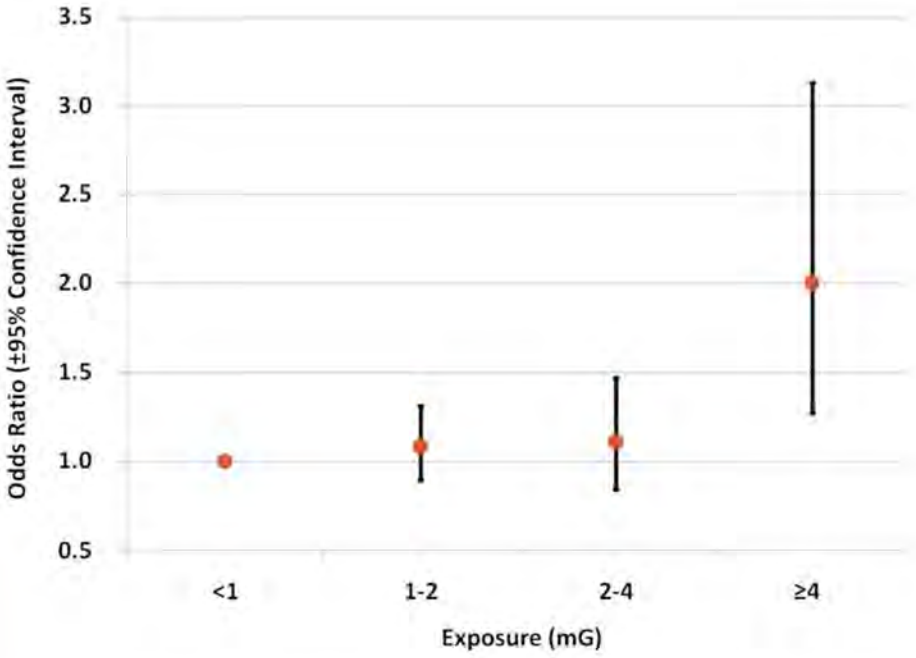


Figure 6 – Results of one pooled analysis of childhood leukemia studies shows the risk of leukemia is increased by a factor of 2 with average exposure levels greater than 4 mG, but found no indication of risk increase below that level. A pooled analysis combines data from different studies into one data set for statistical analyses. Source: Ahlbom, 2000

OTHER THEORIES

Although living near power lines increases exposure to the EMF, there are other factors to consider. According to one theory, interaction between electric fields and airborne pollutants close to high voltage power lines may increase the risk of some health effects. Another theory is that magnetic fields are associated with small voltages in house plumbing systems, which could cause small, imperceptible currents to flow through the bone marrow of children when bathing. These theories are being investigated and thus remain unconfirmed.

If an association is strong, it is more likely that the association does, in fact, denote the cause. For example, the association between smoking and lung cancer is very strong. Epidemiological studies showed more than ten times greater risk for smokers than for non-smokers. If the association is weak, it is possible that the agent is not the *direct cause* of the disease. It could mean that the factor occurs together with some other factor, not measured in the study, that actually causes the disease. In such cases, the association measured may be misleading.

Scores of epidemiological studies, all over the world, have looked at potential health effects in relation to EMF and turned up mixed results. The most consistent finding is an association between magnetic fields and childhood leukemia. Studies that combine or "pool" the data from different studies found the risk of childhood leukemia is increased by a factor of 1.5 to 2 with average exposure levels greater than 3-4 mG, but found no indication of increased risk below the 3-4 mG level. Figure 6 shows the results from one of these pooled analyses (Ahlbom, 2000) where the

risk of leukemia is increased by a factor of 2 with exposure levels greater than 4 mG.

The second scientific approach involves animal studies where laboratory animals, such as mice and rats, are exposed to the agent in question, and often at much higher levels than everyday human exposure. To date, dozens of highly controlled laboratory studies on EMF have been carried out, exposing rodents intermittently and continuously to doses as high as 10 G for as long as two years. These levels are much higher than average residential exposures. The results have been consistently negative, showing no contribution of EMF exposure to the development of cancer. Efforts to extrapolate these results to human beings can be questioned, and future research may use laboratory animals that are genetically engineered to be better models for leukemia research. But one fact stands out: according to the International Agency for Research on Cancer (IARC), *"All known human carcinogens that have been studied adequately for carcinogenicity in experimental animals have produced positive results in one or more animal species."* So, all in all, the second leg of the evidence stool does not support the findings of the first leg.

The third leg of evidence involves more detailed examination of the basic science in an effort to find a plausible biological explanation of how EMF could initiate or promote cancer or some other disease or health outcome. Thus far, a biological mechanism for typical EMF exposures has not been identified despite years of laboratory research. This may be because the energy levels involved are too low to have an effect on DNA. Thus, the third leg of the stool remains shaky, unable to support a coherent picture of how EMF might cause health effects.

The inconsistency in these results has led to classification of magnetic fields as "possibly carcinogenic" by IARC in 2001, and reaffirmed by the World Health Organization (WHO) in 2007. The classification does *not* mean a causal relationship has been established. What it does mean is that an association has been observed that is considered to be scientifically credible, but that chance, methodological bias or some other cause cannot be excluded as an explanation. Table 2 gives examples from the almost 1000 agents evaluated by IARC to date. Extremely low frequency (ELF) magnetic fields are in the same category as lead, chloroform, gasoline engine exhaust, coffee, and pickled vegetables.

IARC Classification	Examples of Agents
Carcinogenic to humans (107) (Usually based on strong evidence of carcinogenicity in humans)	Asbestos Alcoholic beverages Benzene Radon gas Solar radiation Tobacco (smoke and smokeless) X- and gamma-radiation
Probably carcinogenic to humans (59) (Usually based on strong evidence of carcinogenicity in animals)	Biomass smoke indoors Diesel engine exhaust Polychlorinated biphenyls (PCBs) Shift work
Possibly carcinogenic to humans (267) (Usually based on evidence in humans which is considered credible but for which other explanations could not be ruled out)	Chloroform Coffee ELF magnetic fields Gasoline engine exhaust Lead Pickled vegetables Radiofrequency fields
Not classifiable (508)	Tea Hair coloring products (personal use of) Polyvinyl chloride Printing inks Saccharin Static electric and magnetic fields
Probably not carcinogenic to humans (1)	Caprolactam

Table 2 – Examples of IARC classification of different exposures evaluated for their carcinogenicity to humans. To date, 267 out of 942 have been classified as being "possibly carcinogenic to human beings," including extremely low-frequency (ELF) magnetic fields. Source: http://monographs.iarc.fr/ENG/Classification/ClassificationsGroupOrder.pdf, November 2011.

OTHER HEALTH OUTCOMES

In addition to childhood leukemia, many other chronic diseases have been investigated for possible connection to EMF exposure. Results to date have largely ruled out an association of EMF with breast cancer, and heart (cardiovascular) disease. Evidence of an association with childhood brain tumors and adult cancers remains weak. Occupational studies of men and women who have higher exposures at work than at home also do not support the link between magnetic fields and cancer, and research has found no links of EMF with cancer clusters (see sidebars). In addition to childhood leukemia, areas still under investigation include neurodegenerative diseases, such as Alzheimer's, and pregnancy outcomes, such as miscarriage. Each disease or outcome is being evaluated systematically using a rigorous scientific approach that takes into account the overall weight and quality of evidence.

CANCER CLUSTERS

When several cancers occur close in time and space – that is, in a cluster, such as in a given school – people seek a reason, and at times EMF has been thought to be a possible culprit. Most often, upon further investigation, no actual cancer cluster is identified. The perception of a cluster arises partly because people do not always understand how common cancer is. In industrialized countries, one in 2-3 people will develop some type of cancer during their lifetimes. Cancer clusters can and do occur by chance, but distinguishing a chance occurrence from an occurrence with a common cause is difficult. As a result, cancer cluster investigations are rarely productive, and none have linked a cancer cluster to magnetic field exposure.

International EMF Reviews

WHY SCIENTIFIC REVIEW IS IMPORTANT AND HOW IT IS DONE

Organizations that evaluate health research are required to review the entire body of scientific evidence. To do so, they form committees of respected, and well-published experts who evaluate all relevant studies. This requires committee members to look at different lines of scientific inquiry, evaluate the strengths and weaknesses of each, evaluate the scientific relevance of different studies, and the quality of the work. Studies that gather data on long-term human health effects are given more weight by these organizations. Animal studies and mechanistic studies are given less weight, but play an important role as check and balance in the scientific review process.

Not surprisingly, given all the complexities, answers are rarely definitive. No single study ever proves the existence or absence of an effect, which means that science works by the accumulation and evaluation of evidence. That is why the most useful conclusions on the state of EMF knowledge are provided by these scientific panels, usually chosen to provide a range of independent scientific viewpoints and expertise. They work together to develop a balanced consensus. Several such panels have comprehensively evaluated the EMF research literature and their conclusions are cited on the next page. It should be acknowledged that other, less authoritative, organizations have reached conclusions that differ.

National Institute of Environmental Health Sciences (NIEHS) 1999:

"The NIEHS believes that the probability that ELF-EMF exposure is truly a health hazard is currently small. The weak epidemiological associations and lack of any laboratory support for these associations provide only marginal scientific support that exposure to this agent is causing any degree of harm."

"The National Toxicology Program [in the United States] routinely examines environmental exposures to determine the degree to which they constitute a human cancer risk and produces the "Report on Carcinogens" listing agents that are 'known human carcinogens' or 'reasonably anticipated to be human carcinogens.' It is our opinion that based on evidence to date, ELF-EMF exposure would not be listed in the "Report on Carcinogens" as an agent reasonably anticipated to be a human carcinogen."

World Health Organization (WHO) 2007:

"On balance, the evidence [of an association between EMF exposure and childhood leukemia] is not strong enough to be considered causal, but sufficiently strong to remain a concern."

"The scientific evidence supporting a linkage between ELF magnetic fields and any of these [other] diseases is much weaker than for childhood leukemia and in some cases (for example, for cardiovascular disease or breast cancer) the evidence is sufficient to give confidence that magnetic fields do not cause the disease."

European Union's Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) 2009:

"The few, new epidemiological and animal studies that have addressed ELF exposure and cancer do not change the previous assessment that ELF magnetic fields are a possible carcinogen and might contribute to an increase in childhood leukemia. At present, in vitro studies did not provide a mechanistic explanation of this epidemiological finding."

Health Canada 2010:

"There is no conclusive evidence of any harm caused by exposures [to EMF] at levels found in Canadian homes and schools, including those located just outside the boundaries of power line corridors."

Standards and Policies

ESTABLISHING EXPOSURE STANDARDS AND GUIDELINES

There are two main organizations that set EMF exposure guidelines for the general public: the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the IEEE, a professional engineering organization formerly known as Institute of Electrical and Electronic Engineers. ICNIRP and IEEE consider all relevant scientific studies, provide an overall assessment of an adequate level of safe exposure, and then add an additional margin of safety in their standard setting process.

In terms of EMF, they found that there is not enough evidence to support guidelines for long-term exposure to low levels of EMF. The guidelines that do exist are based on limiting the *acute* effects of EMF on the body's nervous system. For magnetic fields, undesirable acute effects, such as nerve stimulation, are created only at field levels much higher than average household exposure. For magnetic fields, the current ICNIRP exposure guideline for the general public at power frequencies (50 or 60 Hz) is 2000 mG.

In addition, electric fields can produce direct effects on the body, such as small electric discharge or causing hairs to vibrate. Everyone is familiar with the phenomenon of touching a doorknob and feeling a small discharge or "microshock." Because it is concentrated on a small area of the skin it can be painful, but it is not usually regarded as harmful. Thresholds for these acute effects of electric fields are typically 5-10 kilovolts per meter (kV/m) for direct perception, and a few kV/m for microshocks. Such electric fields are rarely encountered outside of power line corridors.

NATIONAL POLICIES AND PRECAUTIONARY LIMITS

Health standard setting authorities in the United States and Canada have chosen not to establish national limits on EMF exposure. A few states and a few countries have developed precaution based exposure limits, but many adopt the limits published by ICNIRP or IEEE. Exposures to magnetic fields from power lines, as well as most other ordinary exposures, are well below the prescribed limits.

Some countries, states, and municipalities set limits lower than ICNIRP.

introduce limits based on distance from electric utility facilities, or take precautionary measures that reduce exposure without providing specific guidelines or limits. Regulators in California, for example, initiated a policy for application of low- or no-cost mitigation measures and set cost and performance guidelines.

After its most recent comprehensive evaluation of scientific literature on EMF, the World Health Organization recommended that given the "weakness" of the scientific evidence to date, any expenditures related to reducing EMF exposures should involve "little or no cost." Using a different kind of design during construction of certain types of transmission lines, for example, can reduce fields by about half at a distance of 100 ft, as shown in Figure 7. However, there is no scientific consensus on the application and value of precautionary measures to reduce EMF exposure.

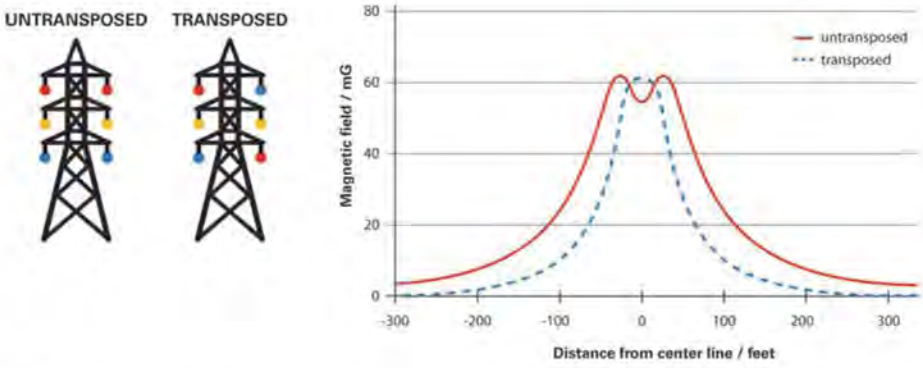


Figure 7– Exposures can be reduced by advanced transmission line design. In this case, exposures are reduced as much as half at a distance of 100 feet. Source: National Grid, 2010.

ELECTROMAGNETIC HYPERSENSITIVITY (EHS)

Some individuals experience a wide range of nonspecific symptoms such as headaches and sleep disturbance that can be quite debilitating, which they ascribe to EMF exposure. Further, some of these individuals believe that they can sense the presence of high fields, which trigger their symptoms. The consensus of the scientific community is that while some of these individuals clearly have health conditions, their symptoms are not related to EMF. This conclusion is based mostly on carefully conducted tests in the laboratory in which individuals self-identified as EHS cannot reliably detect the presence of fields, and their symptoms cannot be attributed to EMF. Several studies have indicated that the observed effects may be caused by an expectation that something harmful is going to happen.

WHAT CAN I DO TO REDUCE MY EXPOSURE?

Concerned individuals can reduce their exposure by learning about sources of EMF in their home and environment and by increasing distance to such sources, or by reducing the time of exposure. Such measures might include moving a bedside clock radio across the room, not using a hair dryer, or moving a child's bed away from EMF exposure sources. The reader can refer to the section of this brochure on Exposures and Typical Levels to learn more about typical exposure levels in many environments.

ONGOING RESEARCH

Much of the research over the years in the United States has been funded by EPRI and various United States government programs. The largest evaluation was undertaken in the early 1990's by the National Institute of Environmental Health (NIEHS) and the Department of Energy (DOE), with input from a wide range of public and private agencies, including EPRI. This evaluation, known as the Electric and Magnetic Fields Research and Public Information Dissemination (EMF RAPID) Program, was a six year project with the goal of providing scientific evidence on whether exposure to power-frequency fields involves a potential risk to human health. In 1999, at the conclusion of EMF RAPID, the NIEHS reported to Congress that the overall scientific evidence for human health risk from EMF exposure is weak.

While much of the government funding has ended since the conclusion of the EMF RAPID Program, EPRI's EMF program continues to fund high quality independent research that is conducted at leading universities and research institutions.

The current EPRI program aims to reduce uncertainty about the observed epidemiologic association between residential magnetic fields and childhood leukemia. Other issues addressed by the EPRI program include pregnancy outcomes and neurodegenerative diseases, such as dementia, Alzheimer's, and ALS (Lou Gehrig disease). EPRI will continue to address this important issue through rigorous research and publish results in the peer-reviewed scientific literature.

FURTHER READING

IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Non-ionizing radiation, Part 1: Static and extremely low-frequency (ELF) electric and magnetic fields. Lyon, IARC, 2002 (Monographs on the Evaluation of Carcinogenic Risks to Humans, 80).

ICNIRP – "Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz - 100 kHz)." Health Phys 99(6):818-836; 2010

IEEE Standards Coordinating Committee 28. IEEE standard for safety levels with respect to human exposure to electromagnetic fields, 0-3 kHz. New York, NY, IEEE - The Institute of Electrical and Electronics Engineers, 2002 (IEEE Std C95.6-2002).

National Institute of Environmental Health Sciences (NIEHS) (1999). NIEHS Report on Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields. NIH Publication No. 99-4493. Research Triangle Park, NC, USA: National Institute of Environmental Health Sciences, National Institutes of Health.

National Institute of Environmental Health Sciences (NIEHS)/DOE EMF Rapid Program (2002). "Electric and Magnetic Fields Associated with the Use of Electric Power: Questions and Answers." Research Triangle Park, NC, USA.

WHO - World Health Organization. Extremely low frequency fields. Environmental Health Criteria, Vol. 238. Geneva, World Health Organization, 2007.

USEFUL WEB LINKS

IEEE Committee on Man and Radiation web page
http://ewh.ieee.org/soc/embs/comar/

International Commission on Non-Ionizing Radiation Protection
http://www.icnirp.de/documents/FactSheetLF.pdf

National Cancer Institute Factsheet Magnetic Field Exposure and Cancer: Questions and Answers
http://www.cancer.gov/cancertopics/factsheet/Risk/magnetic-fields

NIEHS/DOE EMF RAPID Program June 2002, Elecric and Magnetic Fields Associated with the Use of Electric Power, Questions and Answers
http://www.niehs.nih.gov/health/docs/emf-02.pdf

World Health Organization web page on Electromagnetic Fields
http://www.who.int/peh-emf/en/
http://www.who.int/mediacentre/factsheets/fs322/en/index.html

World Health Organization Database of Worldwide EMF Standards
http://www.who.int/docstore/peh-emf/EMFStandards/who-0102/Worldmap5.htm

The Electric Power Research Institute, Inc. (EPRI, www.epri.com) conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public. An independent, nonprofit organization, EPRI brings together its scientists and engineers as well as experts from academia and industry to help address challenges in electricity, including reliability, efficiency, health, safety and the environment. EPRI also provides technology, policy and economic analyses to drive long-range research and development planning, and supports research in emerging technologies. EPRI's members represent more than 90 percent of the electricity generated and delivered in the United States, and international participation extends to 40 countries. EPRI's principal offices and laboratories are located in Palo Alto, Calif.; Charlotte, N.C.; Knoxville, Tenn.; and Lenox, Mass.

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Question 4, Attachment 2
Docket No. E-2, Sub 1150

EMF

Electric & Magnetic Fields

DUKE ENERGY®

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WHAT ARE ELECTRIC AND MAGNETIC FIELDS?

All of us depend on electricity on a daily basis. We rely on electricity to meet basic needs such as heating, cooling and lighting our homes. And we depend on electricity to meet the transportation, communication and industrial requirements of a modern society.

Electric and magnetic fields, often collectively referred to as EMF, are natural occurrences as a result of our use of electricity. Wherever an electric current is present, fields of magnetic force occur.

For example, the earth has a large magnetic field which makes compass needles point north, and the human body generates its own electric current which is necessary for life.

Because electricity is so common in daily life today, most of us are in contact with electric and magnetic fields virtually all of the time. Examples include home wiring, cars, water pipes, kitchen appliances, televisions, computers, hair dryers, electric clocks and utility power lines.

HOW DO THESE FIELDS BEHAVE?

Electric Fields

Electric fields are created by voltage. The higher the voltage, the stronger the electric fields. You will find an electric field near any electrical appliance that is plugged in, even if it is not operating. Electric fields are strongest closest to their source.

Magnetic Fields

Magnetic fields are created by current or electricity flowing through a wire. Magnetic field strength increases with current, so you will find a stronger magnetic field near an appliance when it runs on "high" than when it runs on "low." An appliance must be plugged in and operating to create a magnetic field. Magnetic fields are also strongest close to their source.

WHERE MIGHT I FIND ELECTRIC AND MAGNETIC FIELDS?

Electric and magnetic fields are found everywhere electricity is used, such as personal computer terminals, televisions and other household appliances. The magnetic fields are measured in milligauss. Magnetic fields associated with appliances are typically stronger than those fields found near power lines.

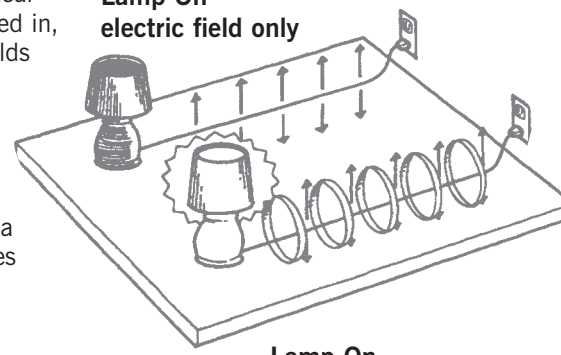
CAN THESE FIELDS BE BLOCKED?

Electric fields can be blocked by most objects such as trees, the ground, buildings and other objects. However, magnetic fields pass through most objects. This is one reason why burying power lines will not necessarily eliminate magnetic fields.

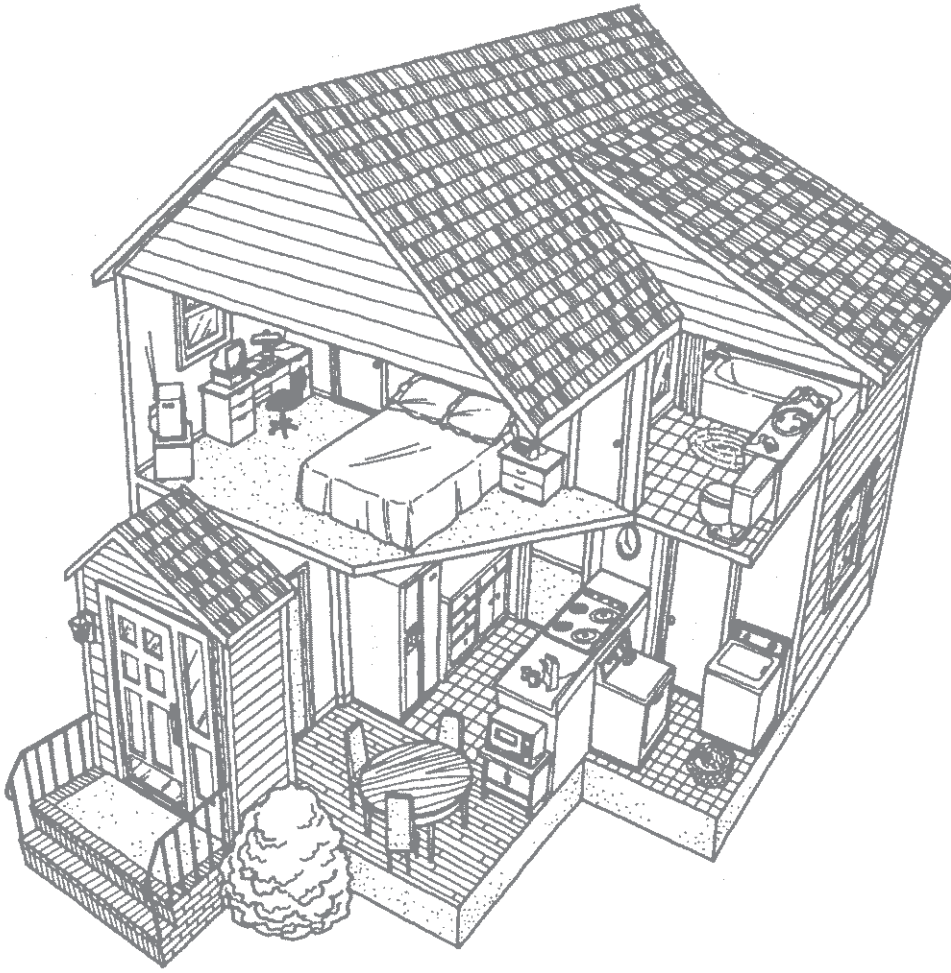
HOW DO YOU MEASURE THESE FIELDS?

The strength of electric and magnetic fields can be measured with special instruments. Electric fields are measured in units of volts per meter (abbreviated V/m) with an electric field strength

Lamp Off — electric field only



Lamp On — electric & magnetic fields



TYPICAL MAGNETIC FIELD READINGS

Typical 60 hertz magnetic fields measured at various distances.
Magnetic fields are measured in milligauss (mG).

Typical items in the home	1 inch	1 foot	3 feet	Maximum
Microwave oven	140.0	65.0	10.0	2,000
Refrigerator	6.0	4.0	1.2	15
Electric range	250.0	25.0	2.0	2,000
Electric razor	500.0	–	–	15,000
Hair dryer	100.0	30.0	–	20,000
Electric can opener	5000.0	470.0	24.0	30,000
Computer terminal/TV	26.0	3.4	1.2	500
Electric clock	130.0	15.5	2.5	900

meter. Magnetic fields are measured in units of milligauss, (abbreviated mG) with a gaussmeter. Most scientific research and public issues have focused on measuring magnetic fields. Therefore, we will be referring more frequently to magnetic fields.

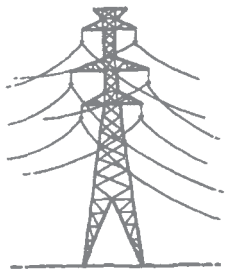
The electric field's strength is determined by the "push" – or voltage – necessary to make the electricity move. The higher the voltage, the greater the field produced. Current does not have to be flowing in an object for an electric field to exist. Thus, a stereo or toaster that is plugged in, but not operating, may still produce an electric field.

The amount of electric current flowing through a wire determines the strength of the magnetic field. Just as a magnet loses the ability to attract as it is moved away from an object, the magnetic field decreases as you move away from the source. Anything that has electricity flowing through it produces a magnetic field.

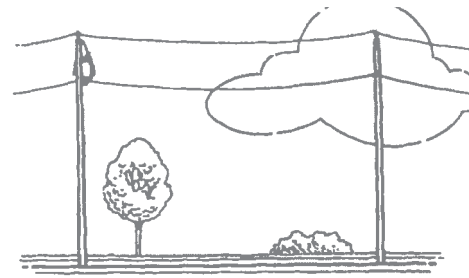
Fields Decrease with Distance

EMF levels are higher close to their source and drop off rapidly with distance. This is one reason why you may measure stronger levels of EMFs from certain home appliances than from nearby power lines.

Typical Transmission Line



Typical Distribution Line



TYPICAL MAGNETIC FIELD READINGS

Typical 60 hertz magnetic fields measured at various distances.
Magnetic fields are measured in milligauss (mG).

Transmission lines*	Under line	Edge of right of way	50 ft. from edge
44kV	1.0 - 25.0	0.2 - 2.5	0.1 - 1.0
100kV	2.1 - 19.3	0.6 - 3.4	0.3 - 1.9
230kV	4.5 - 29	1.9 - 6.4	1.0 - 3.5
525kV	17 - 40	6 - 15	2.4 - 4.0
Distribution lines*	0.1 - 35		

Substation – Magnetic fields from the equipment in a substation, measured at the fence, are generally negligible. However, readings at the fence can reflect the magnetic fields from the power lines entering and exiting the substation and generally do not exceed readings in this table for distribution lines.

*These are typical readings under normal operating conditions at moderate load.

WHAT DO THESE MEASUREMENTS REALLY MEAN?

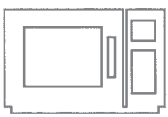
Although new technology has made it easier to measure EMFs, it is still very difficult to relate these measurements to human exposure. Measurements vary from moment to moment, depending on the current flow, the type of appliance and a person's position in relation to the source of the fields.

Interpreting measurements and setting guidelines for exposure levels are difficult, and there is still no consensus as to any health effects resulting from EMFs, let alone whether such effects are related to stronger or weaker fields. It's also not clear whether brief, high level fields from appliances such as hair dryers have more impact than continuous low-level fields from power lines, wiring or other sources.

ARE EMFs LIKE MICROWAVES AND X-RAYS?

No, they are not the same although they are all forms of electromagnetic energy.

EMFs from 60 Hertz electric utility power do not have the energy of higher frequency EMFs such as microwaves that can heat substances or x-rays that can break apart molecules.



When you use a microwave oven, the energy passes through materials containing water, converting the energy to heat energy. This heat is absorbed by the materials making your food or liquid hot.

X-rays are much stronger. The energy in X-rays is strong enough to break apart the molecules that contain genes. Excessive X-ray exposure can lead to mutations and cancer. While X-ray exposure has its risks, so do the conditions that X-rays are meant to diagnose. This is why you and your doctor should make careful judgments about when you have X-rays taken. EMFs do not have enough energy to break apart molecules like X-rays do. And although EMFs can cause heating in substances, this heat is barely detectable. Normally occurring temperature changes in human cells are greater than the temperature changes EMFs can produce. Some laboratory studies have suggested EMFs may produce small changes in human cells. These changes are yet to be understood.

WHAT KIND OF RESEARCH HAS BEEN DONE?

Two types of studies are being done: laboratory studies and epidemiology studies. Millions of dollars are being spent worldwide on EMF research and more conclusive information is expected in the next few years. To be able to put research results in perspective, it is helpful to understand the strengths and weaknesses of each type of study.

Laboratory studies primarily involve exposing cells, tissues and animals to either electric or magnetic fields under a variety of controlled conditions. These studies allow research to closely control exposure to EMF and provide information about the small-scale changes EMFs may cause. Most emphasis to date focuses on the changes caused by magnetic fields. However, laboratory studies have not shown how or if these changes affect human health. Nor have they been able to precisely duplicate the types of EMF exposures that people experience throughout the day.

In EMF epidemiological studies, researchers try to establish whether there is a statistical association between selected groups of people with certain types of EMF exposure and certain kinds

of disease. However, these types of studies cannot establish a clear cause-and-effect relationship between EMFs and disease. This is because real-life studies cannot rule out other possible explanations for health effects – such as diet and lifestyle – and because it is difficult to discover what past exposures to EMFs and other factors have been.

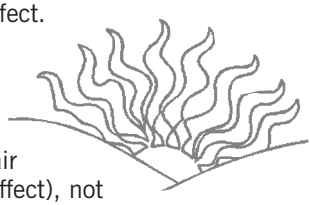
WHAT DO YOU MEAN BY "ASSOCIATION?"

Some studies have suggested an "association" between EMF and some types of cancer. An association is different from a "cause and effect." Association means that two or more events can be joined or linked together. This linking of events does not necessarily mean that the association is valid. Cause and effect means that if one event occurs (cause) another event (effect) will occur a percentage of the time.

The most common analogy of an association is this:

ASSOCIATION: A rooster crowing in the morning will cause the air temperature to rise several hours later.

There is strong statistical association between a rooster crowing and the air temperature rising. We know that this occurs a very high percentage of the time. However, the association, while statistically linked, is incorrect. Therefore, there is NOT a cause and effect.



The sun rising (cause) is the common event that results in the air temperature (effect), not the rooster crowing.

Some studies thus far have tied a slight association to EMF and cancer. No common cause has been directly related to the effect.

Scientists are trained to sort out true causes from observed associations such as that above. This is especially important in the EMF research now under way.

HAVE THERE BEEN RECENT STUDIES ON EMF?

Some laboratory studies have suggested that EMFs may cause small, sometimes reversible changes in cell reproductions, rhythms, communication and growth. Research is being done to confirm these results and to determine how these changes occur and whether they have implications for human health.

WHAT ABOUT STUDIES OF PEOPLE, PARTICULARLY STUDIES INVOLVING CANCER?

Much attention has focused on the incidence of cancer among people living or working near electric and magnetic fields. Researchers in Colorado, Washington, Rhode Island, England, Canada, Denmark and Sweden have completed studies on the statistical incidence of cancer. Some suggest a possible relationship between cancer and the proximity of outdoor power lines; the others found no such relationship. However, none of the researchers found a direct link between actual EMF exposure and cancer incidence. Studies of people who work around electric equipment also have been inconclusive. Some studies suggest that electric and telephone lineworkers, electricians and aluminum workers have a slightly higher risk of cancer while other studies find no evidence of increased risk.

HAVE ANY OF THE LABORATORY, CHILDHOOD OR OCCUPATIONAL STUDIES ESTABLISHED A CAUSE AND EFFECT RELATIONSHIP BETWEEN EMF AND CANCER?

No.

The researchers would like to find a way to separate other factors such as exposure to heavy traffic, air pollution or chemicals that might play a role in increased cancer rates reported in EMF epidemiological studies. For instance, workers exposed to EMFs may also be exposed on the job to chemicals that could cause cancer. Study findings may also be due to the small sizes of the groups studied.

ARE THERE HARMFUL HEALTH EFFECTS?

The use of electricity has increased greatly in the last 40 years, but there has been no corresponding significant increase in childhood leukemia or any of the other cancers suggested by epidemiological studies. The consensus among health professionals and scientists studying the issue is that no firm conclusions can be drawn. Based on this fact, and on the research to date, some researchers believe that if EMFs are shown to cause health effects, the risk of these effects will probably be comparatively small.

Voluntary risks are more accepted.

Individuals will typically accept great risks that they choose for themselves if they think that related benefits are worth it, but still reject even the slightest risks they feel are imposed on them. For example, more than 3 million people are killed or injured in motor vehicle accidents each year – but people continue to drive. Although the risks related to EMFs remain unproven, people may be unwilling to accept those risks because they believe that their exposure is not a matter of choice.

Deciding what is right for you.

We all face risks in life all the time and probably have our own ways of determining what actions are sensible. Do you always spend the extra time it takes to buckle your seatbelt? How much time and money do you invest in fire safety around your home? Like these decisions, the EMF issue requires that we gather information, weigh the risks and do what makes the most sense to us. The aim of Duke Energy is to provide you with the information you need to make that informed decision.

Several states have set guidelines for power line design and location. But because there is no consensus on the issue, most states and regulatory agencies recommend that further study occur before health-based standards are set – or high expenditures are made – to limit EMF levels from power lines and electrical equipment. In the absence of widespread government standards, it becomes a matter of personal responsibility to weigh the potential risks associated with EMFs and to determine your response.

PUBLIC CONCERN

In the early 1970s, public concern began to surface over possible health effects associated with electric and magnetic fields. Since then, hundreds of studies have been completed or are under way. Many of the studies have dealt specifically with magnetic fields that exist around appliances or power lines.

To date, none of these studies have shown a cause and effect relationship between EMF and human health.

The weight of reliable evidence suggests that long-term risk to public health – if it exists at all – appears to be very small. According to a number of science and health experts researching the issue,

including panels convened by the World Health Organization, the National Academy of Sciences and the American Institute of Biological Sciences, there exists no persuasive scientific evidence that electric and magnetic fields can lead to public health problems.

Duke Energy's Commitment to Health and Safety

Our mission is to provide our customers with safe, reliable, cost-effective electric service.

At Duke Energy, one of our top priorities is the health and safety of our customers and employees. We continue to follow ongoing research surrounding electric and magnetic fields (EMFs) and are strongly committed to understanding the scientific facts about EMF and human health.

Hundreds of studies have been generated since the early 1970s. These studies show some inconsistencies in their findings. Scientists continue working diligently and openly to understand the effects of these fields. Our hope is that these studies will resolve the inconsistencies and provide a basis for informed decisions.

Additional research on this complex subject in needed. We also recognize the need to continue developing reliable information on the subject so that responsible, informed decisions can be made. Duke Energy will continue to fund and support a vigorous research effort in conjunction with other electric utilities and research institutions. By participating in and monitoring the results of future studies, Duke Energy will keep abreast of developments and be in a position to provide objective, timely information to you. If this research shows a need to alter our procedures, we will take the steps necessary to continue safe delivery of electricity.

Duke Energy also makes a yearly financial contribution to the Electric Power Research Institute (EPRI), which funds about 40 percent of the world's EMF research. We have joined with other leading energy companies in supporting federal funding with the expectation that those dollars will help speed up the research process.

If you have questions about EMF, call your local Duke Energy office and someone will put you in touch with the EMF contact.

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Electric and Magnetic Fields

Duke Energy is committed to providing electric service safely for our customers and a safe working environment for our employees.

- The company funds, participates in and monitors research aimed at answering questions and addressing property owners' concerns about electric and magnetic fields (EMF).
- Electric fields are created by voltage present when an appliance remains plugged in, even when it is switched off. Magnetic fields, by contrast, only are present when electric current is flowing in wires, so if an appliance is switched off it will normally not create magnetic fields.
- Extremely low-frequency electric and magnetic fields are all around us – not just in power lines, but also in electrical wiring in buildings, electric motors and appliances, TVs, computers, hair dryers, etc.
- Proximity to an electric device is often more a factor in the strength of the magnetic field than the size of the device.
- Numerous studies have been conducted over the past 30 years in an attempt to determine whether an association exists between exposure to magnetic fields and human health.
- There have been studies that pointed to some association between EMF and human health, and others that found no association at all. Association does not mean cause and effect.
- Virtually all laboratory studies on animals and cells have failed to establish a consistent association between EMF and human health.
- International Agency for Research on Cancer (IARC) states: "All known human carcinogens that have been studied adequately for carcinogenicity in experimental animals have produced positive results in one or more animal species." No positive results (causing animal cancers) have been found from magnetic fields exposure.
- An EMF report, completed by the National Institute of Environmental Health Sciences to the U.S. Congress, states, "The lack of connection between the human data and the experimental data (animal and mechanistic) severely complicates the interpretation of these results." Given the limitations of current scientific knowledge, we are not able to determine the potential effect of EMF on human health.

Miscellaneous Related Topics

General Public Exposure Limits for Power Frequency Fields

Organization	Magnetic field (gauss)*	Electric field (kV/m)
ICNIRP	2.0	4.2 (60Hz)/5.0 (50Hz)
IEEE	9.1	5.0 (10.0 on ROW)

*One Gauss = 1000 milli-Gauss (mG)

EHS

Electromagnetic Hypersensitivity (EHS): Some individuals experience a wide range of nonspecific symptoms such as headaches and sleep disturbance that can be quite debilitating, which they ascribe to EMF exposure. Further, some of these individuals believe that they can sense the presence of high fields, which trigger symptoms. The consensus of the scientific community is that while some of these individuals clearly have health conditions and may react to factors in their environment, their symptoms are not related to EMF. This conclusion is based mostly on carefully conducted tests in the laboratory in which individuals self-identified as EHS cannot reliably detect the presence of fields, and their symptoms cannot be attributed to EMF. Several studies have indicated that the observed effects may be caused by an expectation that something harmful is going to happen. In light of the fact that an EMF basis for these individuals' conditions has not been observed, the condition has more recently been labeled "Idiopathic Environmental Intolerance Attributed to Electromagnetic Fields."

Implanted Devices

Pacemakers and Other Medical Devices: Cardiac pacemakers and defibrillators are the most commonly implanted medical devices, and research has indicated that they may be susceptible to interference under certain high field conditions. The sensitivity of these devices depends on the manufacturer, design and how they are used by a patient. Metallic case shielding, internal circuits, filters and bipolar sensing have contributed to improved immunity to interference, and in practice, interference is very rare. Many other medical assist devices are now deployed in patients, such as insulin pumps and brain stimulators, but interference to them from power frequency fields has not been addressed. International product standards generally call for implanted medical devices to maintain immunity to power frequency magnetic fields of 1 gauss (G) and 5 kV/m.

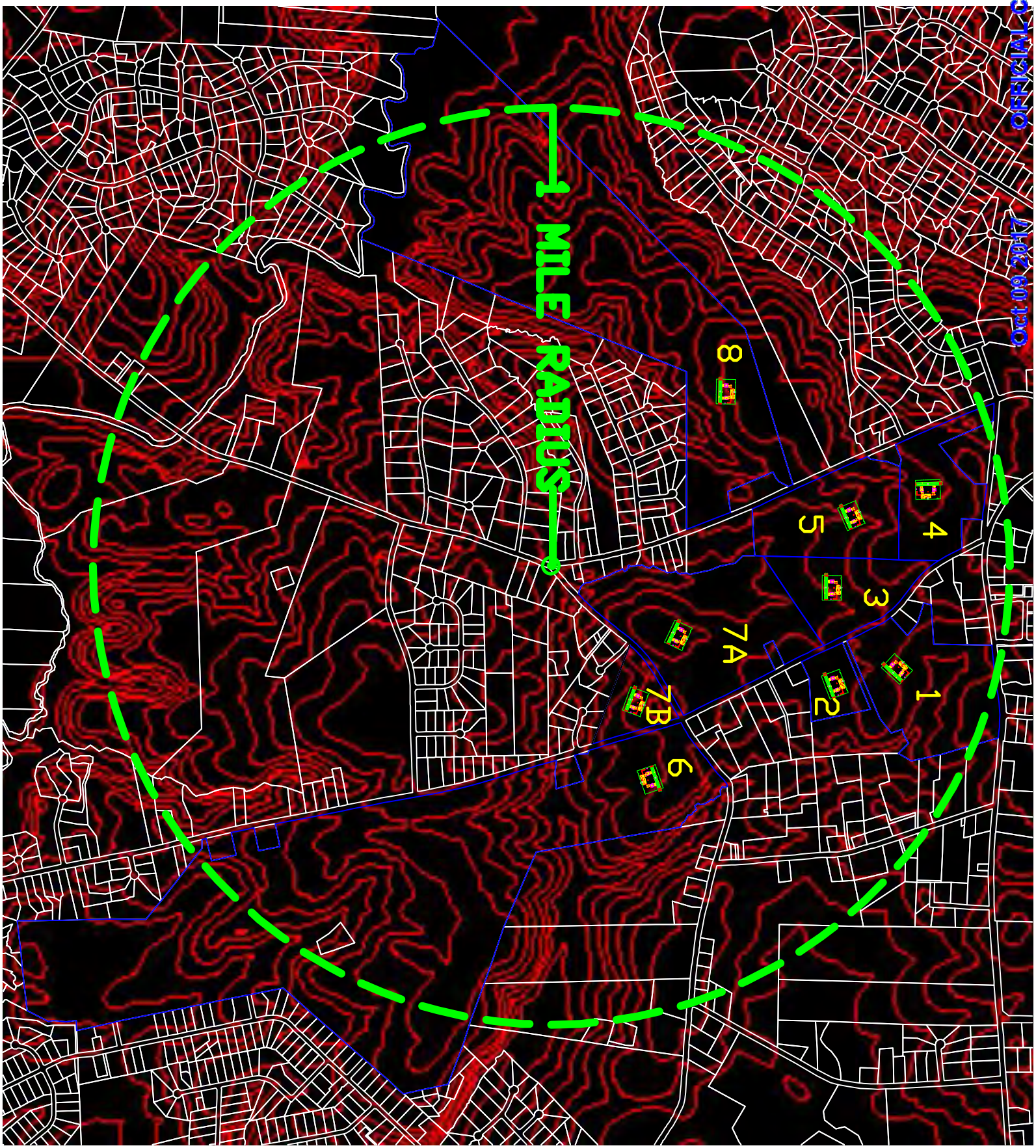
Studies on People Exposed to Higher Than Normal Fields

Occupational Studies: Studies of workers can offer a useful opportunity to examine environmental EMF exposures at higher levels than occur in residential settings. Many occupational studies of electrical workers and others exposed to higher magnetic fields have examined both cancer and other diseases. Overall, the occupational studies do not support a link between magnetic fields exposure and any form of cancer or other adverse effects.

Cancer Clusters

Cancer Clusters: When several cancers occur close in time and space – that is, in a cluster such as in a given school – people seek a reason. At times, EMF has been thought to be a possible culprit. Most often, upon further investigation, no actual cancer cluster is identified. The perception of a cluster arises partly because people do not always understand how common cancer is. In industrialized countries, one in 2-3 people will develop some type of cancer during their lifetimes. Cancer clusters can and do occur by chance, but distinguishing a chance occurrence from an occurrence with a common cause is difficult. As a result, cancer cluster investigations are rarely productive, and none have linked a cancer cluster to magnetic field exposure.

For Additional information:
Email: CarolinasEast@duke-energy.com
Phone: 866-297-5886



Evaluation Summary

Alternate Substation Site Evaluation System Worksheet

Project: Johnston County Substation Sites **Location:** Johnston County, NC
Field Visit and Inspection Date: 7/27/2015 **Report Completion Date:** 9/1/2015

Evaluation Category & Normalized scores by Site. (Deleate excess Sites Columns to ensure proper ranking)	Weighted Values (.5-1)	110 Matthews Road - Site 1	110 Matthews Road - Site 2	Cleveland Road 8969 - Site 3	Cleveland Road 8969 - Site 4	Wells, David and Elgie - Site 5	Barbour, Larry and Patricia - Site 6	Lawson, Elizabeth Booker - Site 7A	Lawson, Elizabeth Booker - Site7B	Brown, Elizabeth - Site 8
Distribution	0.9	10.00	9.17	9.17	10.00	9.17	9.17	9.17	9.17	9.17
Transmission	1	6.25	5.00	7.50	5.63	6.25	5.00	6.25	6.25	10.00
Land Services	0.8	3.33	3.33	3.33	1.67	3.33	5.83	3.33	7.50	5.83
Siting and Permitting	0.5	9.58	9.58	9.17	9.17	9.17	9.17	8.33	8.33	8.75
Project Management	0.5	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
OVERALL EVALUATION SCORE		7.49	6.95	7.57	6.90	7.23	7.43	7.12	8.02	8.73
OVERALL EVALUATION RANK		4	8	3	9	6	5	7	2	1
Total Cost Comparison ($ in Millions)		$ 1.570	$ 1.340	$ 1.260	$ 1.835	$ 1.065	$ 1.980	$ 1.455	$ 1.710	$ 0.985
Cost Differential Compared to Lowest Cost Option ($ in Millions)		$ 0.585	$ 0.355	$ 0.275	$ 0.850	$ 0.080	$ 0.995	$ 0.470	$ 0.725	$ -
OVERALL COST RANK		6	4	3	8	2	9	5	7	1

Legend

- Best Site
- Middle Ranking Sites
- Least Preferred Sites

** Costs shown herein are NOT reflective of the total project cost, but represent cost difference between options given an undetermined fixed initial cost.

Project Management

Alternate Substation Site Evaluation System Worksheet

Project: Johnston County Substation Sites **Location:** Johnston County, NC
Field Visit and Inspection Date: 7/27/2015 **Report Completion Date:** 9/1/2015

Evaluation Category: Environmental Impacts
(Enter (0,5,7.5, or 10) for each characteristic category for each Site. Read page 2 for descriptions of the rankings)

Site Characteristics/ Quality Ratings	110 Matthews Road - Site 1	110 Matthews Road - Site 2	Cleveland Road 8969 - Site 3	Cleveland Road 8969 - Site 4	Wells, David and Elgie - Site 5	Barbour, Larry and Patricia - Site 6	Lawson, Elizabeth Booker - Site 7A	Lawson, Elizabeth Booker - Site7B	Brown, Elizabeth - Site 8
a.) Schedule Impacts	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
b.) Risk Avoidance (Probability of Successful Execution)	10.00	10.00	10.00	10.00	10.00	10.0	10.0	10.0	10.0
c.) Maintainability	10.00	10.00	10.00	10.00	10.00	10.0	10.0	10.0	10.0

Total Quality Values	110 Matthews Road - Site 1	110 Matthews Road - Site 2	Cleveland Road 8969 - Site 3	Cleveland Road 8969 - Site 4	Wells, David and Elgie - Site 5	Barbour, Larry and Patricia - Site 6	Lawson, Elizabeth Booker - Site 7A	Lawson, Elizabeth Booker - Site7B	Brown, Elizabeth - Site 8
	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

Average Quality Values	110 Matthews Road - Site 1	110 Matthews Road - Site 2	Cleveland Road 8969 - Site 3	Cleveland Road 8969 - Site 4	Wells, David and Elgie - Site 5	Barbour, Larry and Patricia - Site 6	Lawson, Elizabeth Booker - Site 7A	Lawson, Elizabeth Booker - Site7B	Brown, Elizabeth - Site 8
	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Project Management

Superior (10.0)	
a)	**Schedule -** Available to be developed by ISD request
b)	**Risk Avoidance -**There are no identified risks which may delay the project or land acquisition.
c)	**Maintainability -** All spacing within the Substation, around the substation, and between equipment pieces are standard and easily maintainable.
Acceptable (7.5)	
a)	**Schedule -** Available to be developed by ISD request with additional measures
b)	**Risk Avoidance -** There are identified risks, but they are understood to be unlikely and have minimal impact if realized.
c)	**Maintainability -** The design is non-standard, but still allows for maintenance access to all structures and equipment
Inferior (5.0)	
a)	**Schedule -** Available, but ISD at risk
b)	**Risk Avoidance -** There are identified risks, which may delay the project or increase the project cost.
c)	**Maintainability -** The design is non-standard, and may be difficult to maintain.
Fatally Flawed (0)	

Distribution

Alternate Substation Site Evaluation System Worksheet

Project: Johnston County Substation Sites **Location:** Johnston County, NC
Field Visit and Inspection Date: 7/27/2015 **Report Completion Date:** 9/1/2015

Evaluation Category: Distribution Connectivity
(Enter (0,5,7.5, or 10) for each characteristic category for each Site. Read page 2 for descriptions of the rankings)

Site Characteristics/ Quality Ratings	110 Matthews Road - Site 1	110 Matthews Road - Site 2	Cleveland Road 8969 - Site 3	Cleveland Road 8969 - Site 4	Wells, David and Elgie - Site 5	Barbour, Larry and Patricia - Site 6	Lawson, Elizabeth Booker - Site 7A	Lawson, Elizabeth Booker - Site7B	Brown, Elizabeth - Site 8
a.) Corridors	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
b.) Circuit Branching	10.0	7.5	7.5	10.0	7.5	7.5	7.5	7.5	7.5
c.) Number of Circuits	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
d.) Cost	$ 20,000	$ 40,000	$ 40,000	$ 20,000	$ 40,000	$ 80,000	$ 80,000	$ 80,000	$ 50,000

Total Quality Values	110 Matthews Road - Site 1	110 Matthews Road - Site 2	Cleveland Road 8969 - Site 3	Cleveland Road 8969 - Site 4	Wells, David and Elgie - Site 5	Barbour, Larry and Patricia - Site 6	Lawson, Elizabeth Booker - Site 7A	Lawson, Elizabeth Booker - Site7B	Brown, Elizabeth - Site 8
	30.0	27.5	27.5	30.0	27.5	27.5	27.5	27.5	27.5

Average Quality Values	110 Matthews Road - Site 1	110 Matthews Road - Site 2	Cleveland Road 8969 - Site 3	Cleveland Road 8969 - Site 4	Wells, David and Elgie - Site 5	Barbour, Larry and Patricia - Site 6	Lawson, Elizabeth Booker - Site 7A	Lawson, Elizabeth Booker - Site7B	Brown, Elizabeth - Site 8
	10.0	9.2	9.2	10.0	9.2	9.2	9.2	9.2	9.2

Distribution

Superior (10.0)	
a)	**Corridors**- All planned distribution circuits can connect to the existing distribution lines on the alternate substation site and/or by building a line along the transmission corridor.
b)	**Circuit Branching** - Circuit branching (i.e., circuits built along existing distribution lines running in multiple directions, usually along two or more public roads; or along existing distribution corridors that connect the site to existing distribution circuitry; or underbuilding along the planned transmission corridor; or a combination of these options).
c)	**Number of Circuits** - The site provides to maximize the number of distribution circuits through the application of routine and standard engineering and construction practices and thereby serves to delay the need for additional new substations in the region.
Acceptable (7.5)	
a)	**Corridors**- All planned distribution cCorridors - All planned distribution circuits originating at the future substation can connect to the existing distribution lines in close proximity to, but not on, the alternate substation site (typically, directly across public roads from the alternate substation site). ircuits can connect to the existing distribution lines on the alternate substation site and/or by building a line along the transmission corridor.
b)	**Circuit Brancing -** (1) Circuit branching (i.e., point where multiple circuits diverge and run in different directions-----usually along two or more public roads) can occur within close proximity to the alternate substation site (usually 1/8 mile or less); and/or (2) minor new distribution corridors (<400') will be required to reach points where circuit branching can occur.
c)	**Number of Circuits** - The site does not provide the opportunity to maximize the number of distribution circuits and thereby will not serve to delay the need for additional new substations in the region to the maximum extent possible.
Inferior (5.0)	
a)	**Corridors** - All planned distribution circuits cannot sufficiently connect to the existing distribution lines in close proximity to the alternate substation site; therefore, to develop the desired number of distribution circuits from the site, special distribution corridors will be required.
b)	**Circuit Brancing** - Circuit branching (i.e., point where multiple circuits diverge and run in different directions-----usually along two or more public roads) cannot occur within close proximity of the alternate substation site (i.e., cannot occur within 1/8 mile of the alternate site).
c)	**Number of Circuits** - The site does not provide the opportunity to maximize the number of distribution circuits and thereby will not serve to delay the need for additional new substations in the region to the maximum extent possible.
Fatally Flawed (0)	

Transmission

Alternate Substation Site Evaluation System Worksheet

Project: Johnston County Substation Sites **Location:** Johnston County, NC
Field Visit and Inspection Date: 7/27/2015 **Report Completion Date:** 9/1/2015

Evaluation Category: Transmission Connectivity
(Enter (0,5,7.5, or 10) for each characteristic category for each Site. Read page 2 for descriptions of the rankings)

Site Characteristics/ Quality Ratings	110 Matthews Road - Site 1	110 Matthews Road - Site 2	Cleveland Road 8969 - Site 3	Cleveland Road 8969 - Site 4	Wells, David and Elgie - Site 5	Barbour, Larry and Patricia - Site 6	Lawson, Elizabeth Booker - Site 7A	Lawson, Elizabeth Booker - Site7B	Brown, Elizabeth - Site 8
a.) Location	5.0	5.0	7.5	5.0	7.5	5.0	5.0	5.0	10.0
b.) Distance	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	10.0
c.) Roadways	5.0	5.0	7.5	7.5	7.5	5.0	7.5	7.5	10.0
d.) Orientation	10.0	5.0	10.0	5.0	5.0	5.0	7.5	7.5	10.0
e.) Sub. Site Development Costs	$ 250,000	$ 350,000	$ 250,000	$ 275,000	$ 250,000	$ 250,000	$ 275,000	$ 400,000	$ 275,000
f.) Line Construction Cost	$ 1,000,000	$ 700,000	$ 550,000	$ 620,000	$ 380,000	$ 1,200,000	$ 780,000	$ 1,005,000	$ -

Total Quality Values	110 Matthews Road - Site 1	110 Matthews Road - Site 2	Cleveland Road 8969 - Site 3	Cleveland Road 8969 - Site 4	Wells, David and Elgie - Site 5	Barbour, Larry and Patricia - Site 6	Lawson, Elizabeth Booker - Site 7A	Lawson, Elizabeth Booker - Site7B	Brown, Elizabeth - Site 8
	25.0	20.0	30.0	22.5	25.0	20.0	25.0	25.0	40.0

Average Quality Values	110 Matthews Road - Site 1	110 Matthews Road - Site 2	Cleveland Road 8969 - Site 3	Cleveland Road 8969 - Site 4	Wells, David and Elgie - Site 5	Barbour, Larry and Patricia - Site 6	Lawson, Elizabeth Booker - Site 7A	Lawson, Elizabeth Booker - Site7B	Brown, Elizabeth - Site 8
	6.3	5.0	7.5	5.6	6.3	5.0	6.3	6.3	10.0

Transmission

Superior (10.0)	
a)	**Location -** The existing transmission line that will be tapped to connect the substation to the grid crosses the alternate substation site.
b)	**Distance** - The distance from the existing transmission line to the future substation will be less than 500'.
c)	**Roadways** - The future tap line will cross no public roads.
d)	**Orientation -** The transmission line will likely enter the station's high-side bus from a direction that will not conflict with planned distribution circuits.
Acceptable (7.5)	
a)	**Location** - The existing transmission line that will be tapped to connect the substation to the grid does not cross the substation site; however, undeveloped area in the vicinity of the substation site offers opportunity to route a transmission line to it.
b)	**Distance** - The distance from the existing transmission line to the future substation will be greater than 500' but less than 1/8-mile.
c)	**Roadways** - The tap line will cross one public road.
d)	**Orientation -** The direction of the distribution and transmission grid connections is the same and it appears likely that the new transmission line will enter the alternate substation site on the side of the substation's low-side bus. There appears to be ample space to accommodate both.
Inferior (5.0)	
a)	**Location** - The existing transmission line that will be tapped to connect the substation to the grid does not cross the substation site and its future route will likely pass in close proximity to developed areas.
b)	**Distance** - The distance from the existing transmission line to the future substation will be greater than 1/8-mile.
c)	**Roadways** - The future tap line will cross two or more public roads.
d)	**Orientation** - The direction of the distribution and transmission grid connections is the same and it appears likely that the new transmission line will enter the alternate substation site on the side of the substations low-side bus where space to accommodate both is somewhat limited.
Fatally Flawed (0)	

Land Services

Alternate Substation Site Evaluation System Worksheet

Project: Johnston County Substation Sites **Location:** Johnston County, NC
Field Visit and Inspection Date: 7/27/2015 **Report Completion Date:** 9/1/2015

Evaluation Category: Compatibility with Surrounding Land Uses
(Enter (0,5,7.5, or 10) for each characteristic category for each Site. Read page 2 for descriptions of the rankings)

Site Characteristics/ Quality Ratings	110 Matthews Road - Site 1	110 Matthews Road - Site 2	Cleveland Road 8969 - Site 3	Cleveland Road 8969 - Site 4	Wells, David and Elgie - Site 5	Barbour, Larry and Patricia - Site 6	Lawson, Elizabeth Booker - Site 7A	Lawson, Elizabeth Booker - Site7B	Brown, Elizabeth - Site 8
a.) Location	5.0	5.0	5.0	0.0	5.0	7.5	5.0	10.0	7.5
b.) Screening	0.0	0.0	0.0	0.0	0.0	5.0	0.0	7.5	5.0
c.) Ownership	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
d.) Property Acquisition Costs	$ 200,000	$ 150,000	$ 300,000	$ 800,000	$ 275,000	$ 350,000	$ 200,000	$ 125,000	$ 525,000

Total Quality Values	110 Matthews Road - Site 1	110 Matthews Road - Site 2	Cleveland Road 8969 - Site 3	Cleveland Road 8969 - Site 4	Wells, David and Elgie - Site 5	Barbour, Larry and Patricia - Site 6	Lawson, Elizabeth Booker - Site 7A	Lawson, Elizabeth Booker - Site7B	Brown, Elizabeth - Site 8
	10.0	10.0	10.0	5.0	10.0	17.5	10.0	22.5	17.5

Average Quality Values	110 Matthews Road - Site 1	110 Matthews Road - Site 2	Cleveland Road 8969 - Site 3	Cleveland Road 8969 - Site 4	Wells, David and Elgie - Site 5	Barbour, Larry and Patricia - Site 6	Lawson, Elizabeth Booker - Site 7A	Lawson, Elizabeth Booker - Site7B	Brown, Elizabeth - Site 8
	3.3	3.3	3.3	1.7	3.3	5.8	3.3	7.5	5.8

Land Services

Superior (10.0)	
a)	**Location -** Site is located in an industrial use area or, in lieu of this condition; (1) Existing trees can be retained on the alternate substation site in perimeter buffer zones that will provide significant visual screening of the substation; or (2) A combination of grading technique and topographical conditions will provide significant visual screening.
b)	**Screening -** Homes and institutional land uses (schools, churches, libraries, etc.) will not have views of the future substation.
c)	**Ownerhips -** Together, the property needed for the substation lot, and any necessary transmission line right-of-way , special distribution corridors, and and substation access road easements, will likely affect only one property ownership.
Acceptable (7.5)	
a)	**Location -** (1) Through the application of earth berms, and/or landscaping, and/or tree retention, the substation will be moderately screened; or, (2) visual compatiblity with surrounding land uses can be achieved by constructing a screen wall at selected locations (less than 75% of the substation perimeter) around the substation that will be 15' or lower in height.
b)	**Screening** - Though not remote and totally screened from surrounding residential and/or institutional land uses, the substation will not be visually apparent from these uses due to the use of berms and landscaping.
c)	**Ownership** - Together, the property needed for the substation lot, and any necessary transmission line right-of-way , special distribution corridors, and and substation access road easements, will likely affect only two property ownerships.
Inferior (5.0)	
a)	**Location** - Limited screening of the substation can be accomplished on the alternate substation site through retention of existing trees or by careful grading design. Visual compatibility with surrounding land uses can only be achieved by constructing a screen wall around the majority of the substation perimeter (greater than 75% that will be over 15' in height.
b)	**Screening** - The substation site is closely surrounded by residential and/or institutional land uses that will have views of the future substation or development of the site will necessitate the relocation of residents to provide room for the planned substation.
c)	**Ownership** - Together, the property needed for the substation lot, and any necessary transmission line right-of-way , special distribution corridors, and and substation access road easements, will likely affect three or more property ownerships.
Fatally Flawed (0)	

Siting and Permitting

Alternate Substation Site Evaluation System Worksheet

Project: Johnston County Substation Sites **Location:** Johnston County, NC
Field Visit and Inspection Date: 7/27/2015 **Report Completion Date:** 9/1/2015

Evaluation Category: Environmental Impacts
(Enter (0,5,7.5, or 10) for each characteristic category for each Site. Read page 2 for descriptions of the rankings)

Site Characteristics/ Quality Ratings	110 Matthews Road - Site 1	110 Matthews Road - Site 2	Cleveland Road 8969 - Site 3	Cleveland Road 8969 - Site 4	Wells, David and Elgie - Site 5	Barbour, Larry and Patricia - Site 6	Lawson, Elizabeth Booker - Site 7A	Lawson, Elizabeth Booker - Site7B	Brown, Elizabeth - Site 8
a.) T&E Issues	10.0	10.0	10.0	10.0	10.0	10.0	10.0	7.5	7.5
b.) Wetlands	10.0	10.0	7.5	7.5	7.5	10.0	7.5	10.0	7.5
c.) Cultural Resources	10.0	10.0	10.0	10.0	7.5	7.5	5.0	5.0	7.5
d.) Grading	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
e.) EC Measures	7.5	7.5	7.5	7.5	10.0	7.5	7.5	7.5	10.0
f.) Lack of Remediation Potential	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
g.) Permitting Costs	$ 100,000	$ 100,000	$ 120,000	$ 120,000	$ 120,000	$ 100,000	$ 120,000	$ 100,000	$ 135,000

Total Quality Values	110 Matthews Road - Site 1	110 Matthews Road - Site 2	Cleveland Road 8969 - Site 3	Cleveland Road 8969 - Site 4	Wells, David and Elgie - Site 5	Barbour, Larry and Patricia - Site 6	Lawson, Elizabeth Booker - Site 7A	Lawson, Elizabeth Booker - Site7B	Lawson, Elizabeth Booker - Site7B
	57.5	57.5	55.0	55.0	55.0	55.0	50.0	50.0	52.5

Average Quality Values	110 Matthews Road - Site 1	110 Matthews Road - Site 2	Cleveland Road 8969 - Site 3	Cleveland Road 8969 - Site 4	Wells, David and Elgie - Site 5	Barbour, Larry and Patricia - Site 6	Lawson, Elizabeth Booker - Site 7A	Lawson, Elizabeth Booker - Site7B	Lawson, Elizabeth Booker - Site7B
	9.6	9.6	9.2	9.2	9.2	9.2	8.3	8.3	8.8

Siting and Permitting

Superior (10.0)	
a)	**T&Es -** No rare, threatened or endangered plant or animal species arer on the alternate substation site.
b)	**Wetlands -** Development of the site will not affect jurisdictional wetlands.
c)	**Cultural Resources -** No recorded archaeological sites are present on the site.
d)	**Grading -** The site's topography will allow minimal grading to prepare the substation pad (estimated to be less than 5,000 cubic yards of cut that will be pushed into fill).
e)	**Erosion Control Measures -** The site's topography and proximity to streams will allow the retention of sediment on the site by employing standard and routine sediment control measures.
Acceptable (7.5)	
a)	**ETRs -** Rare, threatened or endangered plant or animal species are documented to occur on the site but will not be affected.
b)	**Wetlands -** Development of the site will affect wetlands but can proceed under the Nation-Wide Permitting System (no individual permit will be required).
c)	**Cultural resources -** Are documented to exist on the site but will not be affected.
d)	**Gradnig -** Due to site's topography, moderate grading will be required to prepare the substation pad (estimated to be 5,000 to 10,000 cubic yards of cut that will be pushed into fill).
e)	**Erosion Control Measures -** The site's topography and proximity to streams will allow the retention of sediment on the substation site by employing extensive sediment control measures.
Inferior (5.0)	
a)	**ETRs -** Site development activity at the substation site may affect rare, threatened or endangered plant or animal species that are documented on local, state or federal records or verified to be present on the substation site.
b)	**Wetlands -** Anticipated impacts to wetlands will not likely be allowed under the Nation-Wide Permitting System.
c)	**Cultural Rsources** Development of the site will affect recorded cultural resources (eligible for the NRHP, potentially eligible, and/or eligibility undetermined.
d)	**Grading -** Due to site's topography, extensive grading will be required to prepare the substation pad (estimated to be greater than 10,000 cubic yards of cut that will be pushed into fill).
e)	**Erosion Control Measures -** Exceptional measures will be required to ensure that sediment movement during substation site grading activities will not move into streams, wetlands, or beyond the boundary of the substation site.
Fatally Flawed (0)	

Cost Summary

Alternate Substation Site Evaluation System Worksheet

Project: Johnston County Substation Sites **Location:** Johnston County, NC
Field Visit and Inspection Date: 7/27/2015 **Report Completion Date:** 9/1/2015

	110 Matthews Road - Site 1	110 Matthews Road - Site 2	Cleveland Road 8969 - Site 3	Cleveland Road 8969 - Site 4	Wells, David and Elgie - Site 5	Barbour, Larry and Patricia - Site 6	Lawson, Elizabeth Booker - Site 7A	Lawson, Elizabeth Booker - Site7B	Brown, Elizabeth - Site 8
Distribution Feeders Costs	$ 20,000.00	$ 40,000.00	$ 40,000.00	$ 20,000.00	$ 40,000.00	$ 80,000.00	$ 80,000.00	$ 80,000.00	$ 50,000.00
Transmission Line Costs	$ 1,000,000.00	$ 700,000.00	$ 550,000.00	$ 620,000.00	$ 380,000.00	$ 1,200,000.00	$ 780,000.00	$ 1,005,000.00	$ -
Transmission Sub Site Costs	$ 250,000.00	$ 350,000.00	$ 250,000.00	$ 275,000.00	$ 250,000.00	$ 250,000.00	$ 275,000.00	$ 400,000.00	$ 275,000.00
Land Purchase Costs	$ 200,000.00	$ 150,000.00	$ 300,000.00	$ 800,000.00	$ 275,000.00	$ 350,000.00	$ 200,000.00	$ 125,000.00	$ 525,000.00
Environmental Permitting Costs	$ 100,000.00	$ 100,000.00	$ 120,000.00	$ 120,000.00	$ 120,000.00	$ 100,000.00	$ 120,000.00	$ 100,000.00	$ 135,000.00
Total (in millions)	**$ 1.57**	**$ 1.34**	**$ 1.26**	**$ 1.84**	**$ 1.07**	**$ 1.98**	**$ 1.46**	**$ 1.71**	**$ 0.99**
Cost Differential	**$ 0.59**	**$ 0.36**	**$ 0.28**	**$ 0.85**	**$ 0.08**	**$ 1.00**	**$ 0.47**	**$ 0.73**	**$ -**

Lee-Milburnie 230kV
Clayton Industrial-Milburnie 115kV
Erwin-Milburnie 230kV
Cumberland-Wake 500kV
Erwin-Selma 230kV
Matthews Road Substation (Proposed)
Swift Creek
Little Creek
Middle Creek
Black Creek
Neuse River
JOHNSTON COUNTY
70
70W
70B
42
50
210
40
301
95
96
701
27
76

Key Map
North Carolina
Wake County
Johnston County
Project Location

Study Area
Proposed Substation (230kV)
Route Alternatives for New Transmission Line (with segment numbers)
County Boundary
Segment Endpoint
Open Space

NORTH
8,000 4,000 0 8,000
Scale in Feet

DUKE ENERGY

Figure 1
Duke Energy
Cleveland - Matthews Road 230kV Transmission Tap Line Project
Route Alternatives with Open Space

Source: USDA NAIP Aerial (2016), USGS, Johnston County, Esri, and Burns & McDonnell Engineering Company, Inc.

Issued: 10/4/2017

Service Layer Credits:
Path: \\bmcd\Dfs\Clients\ENS\DukeEnrgyPro\92394_Cleveland230kV\Studies\Geospatial\DataFiles\ArcDocs\Post_Application\CMR_Figure_2_Route_Alternatives_Open_Space_2017.10.04.mxd tbarton 10/4/2017

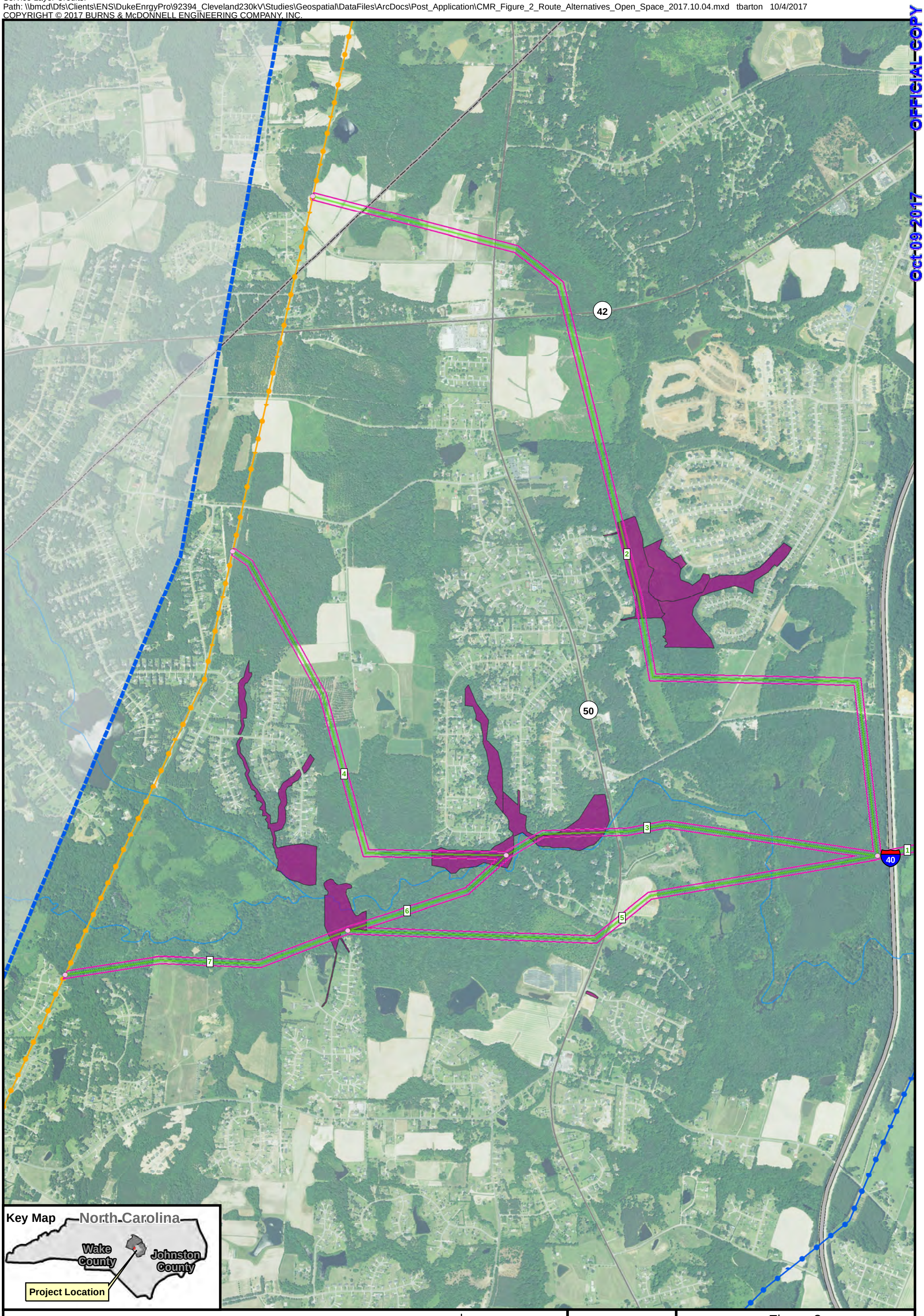


Figure 2
Duke Energy
Cleveland - Matthews Road 230kV
Transmission Tap Line Project
Route Segments 2-7
with Open Space

Source: USDA NAIP Aerial (2016), USGS, Johnston County, Esri, and Burns & McDonnell Engineering Company, Inc.

Issued: 10/4/2017

VERIFICATION

STATE OF NORTH CAROLINA)
)
COUNTY OF MECKLENBERG)

DOCKET NO. E-2, SUB 1150

Timothy J. Same, being first being duly sworn, deposes and says:

That as Manager, Site Design & Permitting, and former Lead Transmission Siting Specialist, Transmission Siting and Permitting for Duke Energy Progress, LLC, he has read the foregoing responses of Duke Energy Progress, LLC to the North Carolina Utilities Commission's questions regarding proposed transmission line project and knows the contents thereof; and that the same is true and correct to the best of his own personal knowledge, except for any matter stated upon information and belief, and as to those matters, he is informed and believes them to be true.

Dated this, the 9 day of October, 2017.

Timothy J. Same

Subscribed and sworn to me
this 9th day of October, 2017.

Notary Public Peggy Holton

PEGGY HOLTON NOTARY PUBLIC WAKE COUNTY, NC

My Commission Expires: 12/22/2021