STATE OF CONNECTICUT

SITING COUNCIL

Re: The Connecticut Light and Power Company and The United Illuminating Company Application for a Certificate of Environmental Compatibility and Public Need for the Construction of a New 345-kV Electric Transmission Line and Associated Facilities Between Scovill Rock Switching Station in Middletown and Norwalk Substation in Norwalk, Connecticut Including the Reconstruction of Portions of Existing 115-kV and 345-kV Electric Transmission Lines, the Construction of the Beseck Switching Station in Wallingford, East Devon Substation in Milford, and Singer Substation in Bridgeport, Modifications at Scovill Rock Switching Station and Norwalk Substation and the Reconfiguration of Certain Interconnections	)	Docket 272 July 19, 2004

SUPPLEMENTAL TESTIMONY II OF DR. WILLIAM H. BAILEY CONCERNING OPTIONS TO ESTABLISH 'BUFFER ZONES' BY REDUCING 60-HZ MAGNETIC FIELDS

Q. As a result of the amendments to the Public Utilities Environmental Standards Act by Public Act 04-246 and the July 1, 2004 interrogatory from the Council, have you been requested to describe how the Council may evaluate the adequacy of the existing right-of-way as a magnetic field buffer zone for the new 345-kV overhead transmission line, in light of potential reductions in magnetic fields along the proposed route?

A. Yes. We have considered this issue in light of our understanding that the intent of Public Act 04-246 is to minimize increased exposure of children to magnetic fields. Thus, the buffer provided by a right-of-way is a function not only of distance to facilities that may be occupied by children and the use of those particular facilities by children, but, more importantly, by the strength of the magnetic fields produced by the lines within the right-of-way. Therefore, for instance, designs that reduce magnetic fields below existing levels create a larger buffer zone around the right-of-way than that currently provided by the right-of-way alone. In effect, reducing magnetic fields below levels from existing lines accomplishes the same goal as moving the proposed line farther away from a statutory facility.

Methods for Reducing Magnetic Fields

Q. What methods have been evaluated to reduce magnetic fields along the route of overhead sections of the proposed 345-kV line?

A. We have evaluated a number of methods based on recognized physical principles for reducing magnetic fields:

- **Relocating lines to another location (overhead or underground) or increasing distance from the conductors (in a horizontal and/or vertical plane)**

  The reduction in the strength of the magnetic field with distance from the conductors is self-evident.

- **Adjusting the phasing of proposed and existing lines to maximize field cancellation**

  The voltage and current flow on each of the conductors of 60-hertz, three-phase power lines vary sinusoidally in time and are separated by 120 degrees throughout the cycle. At any location on or near adjacent lines on the same corridor, the field that is measured (or calculated) is the vector sum of the components deriving from all of the phase conductors. The electrical phasing of the conductors on one line can be changed in increments of 120 degrees such that the sum of the components from all of the conductors at any specified location throughout the power cycle is lower than for other phasing choices.

- **Changing the configuration of proposed and existing lines**

  Decreasing the distance between conductors, adding additional conductors, and changing the arrangement of the conductors in space, in conjunction with adjustments in the phasing of the conductors (for multi-line corridors) are all well-known steps that can reduce the magnetic fields of power lines at distribution or transmission voltages.

Q. Have the Applicants applied these methods in various ways to identify options to reduce magnetic fields of both the proposed and the existing overhead lines?

A. Yes. We have modeled the effects of these options on magnetic field levels and ranked the relative effectiveness of several design options to reduce magnetic fields for each cross section of the right-of-way on which the new 345-kV line is proposed to be routed overhead. Exhibit 1, “Potential Magnetic Field Reduction Options for Proposed Overhead Lines,” provides a basis for ranking the relative efficiency of design options to reduce the magnetic fields from the levels that would be associated with the overhead construction originally proposed in the Application. It also provides a basis for comparing the magnetic field levels associated with design options to magnetic field levels that are associated with the existing lines, which would continue to be sources of magnetic field, whether or not the new 345-kV line is constructed along the proposed route.

Q. How did the Companies select the mitigation options shown in Exhibit 1?

A. On May 28, 2004, the Companies filed illustrative data describing the various designs that could be employed to further reduce the magnetic fields of transmission lines in addition to those already incorporated into the overhead construction design originally proposed. Illustrations of calculated magnetic field levels and the characteristics of the support structures that would be required for each line design were displayed. Separate data were provided for each different section of the right-of-way (called a "cross section") where the configuration of the existing facilities and those to be constructed is different. The Companies then asked each town to designate for further study two of the mitigation options (where at least two were available) for each cross section in that town. The Towns of Woodbridge, Orange, and Milford responded to this request, and the mitigation options they identified for their town are evaluated in Exhibit 1. For cross sections in other towns, the Companies selected the options that they concluded struck the optimal balance between maximum field reduction and structure height.

Q. Please describe how the data presented in Exhibit 1 were prepared.

A. Dr. Gary Johnson of Exponent developed models of the arrangement of the electric conductors (that is, the wires) that would be associated with each of the proposed and the "mitigated" line designs for each cross section and operating characteristics, including current flow at 15 GW and 27.7 GW system loadings. Among the factors that affect the calculated values is the height of the conductors above the ground. This height, of course, varies because of varying heights of the support structures and the sag in each segment of line between the support structures. In the model, the height of the conductors above the ground is assumed to be at the point of maximum sag of the conductors where the conductors are closest to the ground. The terrain beneath the lines is also assumed to be flat. The electrical phasing of conductors of the existing lines is determined at the terminal substations at either end of the lines. For the proposed and design options the phasing of the conductors has been specified to obtain maximum magnetic field cancellation at the edge of the right-of-way. Based on these models, magnetic fields, out 150 feet beyond each edge of the right-of-way, were then calculated for a 15 GW system loading. In addition, in order to bound the upper limit of the fields that could be associated with the lines in normal operation, the magnetic field from the modeled lines was calculated for the peak hour when a 27.7 GW New England load will be achieved.

Q. How representative are these calculations of actual future magnetic fields?

A. The main purpose of Exhibit 1 is to compare the relative efficiency of the various line design options in reducing magnetic fields. For the typical conditions identified, they are accurate. As a presentation of field levels that may now occur along the right-of-way, or that will be present if a particular line design is chosen, they provide a representation of typical conditions that is useful for ranking the relative efficiency of the options to reduce magnetic field levels. Moreover, the Companies have testified that the generation dispatch assumptions that are used to determine the current loading on these lines at the 15 GW New England wide load level are fairly representative of the actual generation mix for such a load level. On the other hand, the generation dispatch used for the 27.7 GW peak load illustration uses the same "extreme" assumption concerning the unavailability of generation within southwestern Connecticut that is used to "stress" these lines in the planning load flow studies that were used in determining the need for the line. So the 27.7 GW case assumes not only peak system load, but also very high currents on these lines that would not exist even on peak days, unless an unusual amount of generation within SWCT was also not available to maintain service in this part of Connecticut.

Reductions in Magnetic Fields and Corresponding Increases in Buffer Zones along the Proposed Route

Q. Do the design options reduce the magnetic fields at the edges of the rights-of-way?

A. Yes. As Exhibit 1 shows, use of the new line designs, particularly split-phasing, results in large reductions in magnetic field strengths along the right-of-way, as compared to the fields that would be associated with the overhead construction originally proposed. Moreover, on most cross sections, one or more designs lead to reductions in the magnetic field at one or both edges of the rights-of-way and beyond, as compared to existing fields.

No design option was evaluated for Cross Section 6W because this portion of the line is located in an industrial area that includes the Wallingford landfill on the west side of Route 5 in Wallingford. The only statutory facility in Cross Section 6W is a ball field that has been abandoned because of chemical contamination. On Cross Sections 6E, 7 (7A), and 7B, which total 4.8 miles, none of the options evaluated reduced the calculated magnetic field below that produced by the existing lines on the right-of-way. To a degree, this is expected because the magnetic fields produced by the existing lines are low in magnitude, e.g. in the range of 0.2 to 4.4 mG at the edges of the right-of-way at a 15 GW system load.

The right-of-way on which the new overhead construction is proposed is approximately 46 miles long in total. Exhibit 1 shows that magnetic fields on both sides of the existing right-of-way could be lowered, or at least not increased, using one or more of the identified line designs as compared to the fields that are associated with the existing lines, for a distance of approximately 16.8 miles (36% of the proposed route).

Because of the design of existing transmission lines and the placement of the new proposed line on one side of these lines, the magnetic fields on each side of the right-of-way will not be equal. For another 24 miles (52% of the proposed route), the fields on one side of the right-of-way would be reduced by the design options as compared to existing field levels, as per the calculation model. On the opposite side of these sections of right-of-way, the same degree of field reduction would not be achieved, i.e. the magnetic field level would be higher than that modeled for the existing lines alone. For approximately 5.4 miles (12% of the proposed route), fields would go up on both sides of the right-of-way, even using the low magnetic field line designs. However, as noted, in most of these areas, the fields are already quite low and fall within the range of magnetic fields associated with distribution lines.

Q. It has been asserted in Exhibits and testimony in this case (*see*, for instance, prefiled testimony of Dr. Ginsberg, DOH Ex. 5, at 2 and attached Fact Sheet; and Ginsberg Tr., 5/12/04 at 172) that typically, the magnetic field associated with a 345-kV transmission line decays to "background levels" of around "a milligauss" within about 300 feet from the edge of the right-of-way. Would that statement accurately characterize the fields that would be associated with the overhead lines constructed using the low magnetic field designs to which Exhibit 1 relates?

Q. No. As Exhibit 1 shows, except for a few sections of the line, the low magnetic field designs cause the magnetic field from the proposed 345-kV line and existing 345 and 115-kV lines at a typical loading of 15 GW to fall below 2 mG, and often below 1 mG, within 150 feet of the edge of the right-of-way.

Re-routing as a Means of Reducing Magnetic Fields

Q. Do the illustrations in Exhibit 1 reflect any other field reduction strategies besides the low magnetic field line design options?

A. Yes. In Cross Sections 2 (design options 2 & 3) and 7B (design option 1) the existing 115-kV lines would be removed from the right-of-way and placed underground beneath town streets as part of the strategy to reduce magnetic fields.

Q. Do the design options shown in Exhibit 1 include any options to reroute sections of the overhead lines away from the existing right-of-way?

A. No. The design options shown are not site-specific. They do not, for instance, take into account the effects of route adjustments that have been discussed, such as the bypass around the Royal Oak Subdivision in Durham or potential relocations of the right-of-way on the B'nai Jacob property and the JCC complex in Woodbridge.

Q. Are there other possible options to reduce magnetic fields at specific locations along the proposed route, in addition to such route adjustments?

A. Yes, these can be evaluated on a case-by-case basis.

Validation of the Split-Phase Design Option

Q. Questions have been raised about the capability of one method to reduce magnetic fields from the new 345-kV line by adding three additional phase conductors on the opposite side of the poles and splitting the current flow among all six phase conductors, thus optimizing the phasing of the conductors to reduce magnetic fields. In particular, it has been asserted that this ‘split-phase’ method has not been proven in actual practice.

What has Exponent done to address these questions?

Q. We are completing two studies to address these questions. First, we identified a 115-kV transmission line in western New York State that was designed to operate in the split-phase configuration. We made a site visit during which we measured the electric and magnetic fields under sections of line configured in the split-phase design and under other sections of the same line configured in a delta design. Second, we are constructing a small laboratory model of a split-phase transmission line to illustrate how adding three additional conductors and splitting the power flow among six conductors affects the magnetic field as the phasing of the conductors is varied. These studies will confirm that a split-phase design can be incorporated into the transmission system and that the reductions in the magnetic field occur in the ‘real world’, not just in theory. We hope to present the results of these studies at the upcoming hearing.

Factors to Consider Besides Field Reduction at the Edge of Right-of-Way

Q. Do you understand the concept of a “buffer zone” to take into account more than just the magnitude of the magnetic field at the edge of the right-of-way?

A. Yes. As the Companies have explained in their response to the Council’s interrogatory concerning buffer zones, the statute does not specify the delineation of a uniform zone along the entire length of a line, either by specifying a certain distance, or a certain magnetic field strength. Rather, it requires that where the line is adjacent to each statutory facility, there will be a determination as to whether an adequate buffer will exist between the lines (which produce magnetic fields) and the adjacent facility (where existing and proposed transmission lines may contribute to magnetic field levels from other sources). In each case, the Council will determine first if the existing right-of-way provides an adequate buffer, presumably by considering such things as the likely number of children with potential exposure, as well as the magnitude and frequency of their exposure in the particular facility; and the likely contribution of the transmission line field levels to the magnetic field environment of those children.

Application of Magnetic Field Reduction Analyses to Evaluate Buffer Zones

Q. How can the Council and others use the data provided in Exhibit 1 to assist them in evaluating the “buffer” provided by the existing right-of-way?

A. Exhibit 1 provides calculations of magnetic field levels out to 150 feet from the right-of-way for both the existing lines and the proposed new lines, using low magnetic field designs. So long as a facility of interest is within 150 feet of the right-of-way, the Council – or any other interested person - need only determine the relevant "cross section" in which the facility is located, and approximate the distance from that facility to the right-of-way from the table. The values in Exhibit 1 will then provide a basis for estimating the magnetic field from the transmission line at that point, under both average and peak loading assumptions.

Q. Are Exponent and the Companies also using the data generated to prepare Exhibit 1 together with other data in order to prepare an table showing calculated magnetic fields from the both the existing and the proposed transmission lines, at both average and peak loads, at the various statutory facilities along the overhead portions of the proposed route?

A. Yes. The Companies and we are in the process of completing a response to the outstanding interrogatory of the Attorney General (AG-03) that asked for measurements and calculations of magnetic fields at numerous locations along the proposed right-of-way (as well as along alternate overhead rights of way). These locations include the statutory facilities for which the buffer zone determination is required. We are using information generated by the Companies and Burns & McDonald to respond to this interrogatory, along with its own calculations, to prepare a table that will show each statutory facility along the proposed right-of-way, its location in relation to the right-of-way, as well as the calculated magnetic fields from the existing transmission lines at the nearest portion of the facility, at both average and peak loads; and for the lines as originally proposed and as they would be constructed using the low magnetic field designs referenced in Exhibit 1 for the relevant cross section.

Q. Will the values provided in this Exhibit 1 be fairly representative of existing and probable future conditions?

A. Yes. However, it should be understood that the analyses were developed for the purposes of a comparative analysis and so are generic in nature. As previously noted, the models do not incorporate assumptions about other input conditions, including site-specific inputs to the models that reflect local tower design, line heights, terrain, or other loading conditions.

Q. Does the existing right-of-way provide a buffer between the transmission lines and all adjacent statutory facilities today?

A. Not in every case. For instance, I understand that some playgrounds have been constructed partially within the right-of-way. There may also be structures – even parts of houses that have been constructed within the right-of-way. As the Companies' buffer zone brief points out, in such cases the new statute would appear to require the Companies to enforce their easements to prevent such uses on the right-of-way.

Availability of More Drastic Methods to Enlarge Buffer Zones

Q. Suppose that the Council concludes in a given instance that the buffer provided by the existing right-of-way is not adequate to meet the requirements of Public Act 04-246 for a facility adjacent to the right-of-way, even using one of the low magnetic field line designs assumed in Exhibit 1. How could the Council then provide for expansion of the buffer beyond that provided by the existing right-of-way?

A. That would very much depend on the specific circumstances. For instance, if there was available land on the side of the right-of-way away from the statutory facility, the most efficient solution could be to just expand the right-of-way in that direction. Whether or not that was the case, the Council might want to first consider whether there is another means of reducing the fields, rather than expanding the width of the right-of-way. Thus, the Council might consider a site-specific mitigation option not shown in Exhibit 1 that might work at that specific location – such as taller support structures. If the land were available, a relocation of a portion of the new line to another route may be possible – such as the Durham bypass that has been discussed.[1] At some locations, placing existing 115-kV lines underground and placing the new 345-kV line at the center of the existing right-of-way may provide enough additional distance to the facility such that a satisfactory buffer is achieved without expanding the width of right-of-way. Finally, the right-of-way could be expanded even if that meant taking structures as well as land. This would likely require the taking of the adjacent statutory facility and, in effect, meet the requirements of the Act by relocation of the statutory facility rather than the relocation of a transmission line or a right-of-way. Such a drastic action would go far beyond anything contemplated by the policies of "prudent avoidance" and the "precautionary principle" that I have discussed in previous testimony.

Q. Does this conclude this testimony?

A. Yes.

[1] Since under the current scheme overhead lines will be considered only if undergrounding of the 345-kV line is not feasible, we have assumed that reconstruction of the 345-kV line underground is not an option.