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September 6, 2006

Daniel F. Caruso, Chairman
Connecticut Siting Council
Ten Franklin Square
New Britain, CT 06051

Dear Mr. Caruso:

Re: Docket No. LIFE-CYCLE 2006 – Connecticut Siting Council Investigation into the Life-Cycle Costs of Electric Transmission Lines

Thank you for the opportunity to review the August 25, 2006 Draft Life-Cycle Cost Report. The draft is an impressive document, which is obviously the product of a diligent and well-informed effort. As is almost always the case, however, there are some respects in which the document can be corrected or improved. We have closely reviewed the draft and offer the following comments for your consideration:

- page 2-2, third bold bullet: As described in section 7.3, there is also a capacity cost associated with losses that is not mentioned in this bullet item on electrical losses.
- page 2-2, bottom paragraph, fifth sentence: We suggest a clarity change as follows: "The four types of lines are *among those* currently is use..." This may also be the right place to note that these are AC lines.
- pages 2-3, 2-4 and 2-5 , note that Figures 2-1, 2-2 and 2-3 each include an indication that energy costs were assumed at 5 cents/kWh. The life-cycle cost tables in Appendix A of the report have all used 55.13 mils/kWh for energy costs with an annual escalator of 5%. In addition to this difference, the energy cost actually paid by CL&P's standard offer customers during the past two years has been significantly higher than 5 cents/kWh. A basis for the assumed value should be stated.
- page 3-1, section 3.2: Because 345-kV lines typically use two conductors per phase (so-called bundled conductors), the text should perhaps be revised to make clear that a line-to-line voltage does not exist between the two current-carrying conductors of a two-conductor phase. Also, in the next paragraph, note that the construction of a new 69-kV line could still be an option for some location in the CL&P system where this voltage is still in use and too costly to change. However, such a line would most likely be pre-designed for 115-kV operating capability.
- page 3-2, Table 3-1: Unlike for the comparable Table 3-5 for underground lines, Table 3-1 (and its three follow-up tables) is missing the all-important conductor

size. Please note that the conductor size assumed for each overhead 115-kV line configuration was 1590-kcmil and that the conductor size assumed for each overhead 345-kV line configuration was bundled 1590-kcmil. Overhead lines that may be built with smaller conductors would cost less.

- page 3-3 at top: the term "Site Work" is defined to include "erecting the structures, stringing the conductors, etc." These words belong instead under the definition of "Construction". Also, the word "cleaning" should be "clearing", and Site Work includes access road construction.
- page 3-5, first large paragraph: In the first sentence, insert the word "usually" after "core". There are existing uses in CT of aluminum core cables in underground 115-kV transmission lines.
- page 3-5, Table 3-5: The header uses the word "Typical" instead of "Characteristics of", as in Table 3-1. The latter words would be accurate for Table 3-5. Note additionally that the 115-kV cable size listed in this table is a UI-provided example. CL&P's recent 115-kV XLPE cable installation on the Bethel-Norwalk project employed a base cable size of 3000 kcmil, and we think of this size as a typical size for future applications, especially for life-cycle cost comparisons to overhead 115-kV lines using 1590-kcmil conductors. The underground 115-kV lines approved in the Council's Docket 292 will employ 3500-kcmil cables. In the text preceding this table, the statement that the four underground transmission line designs in Table 3-5, including conductor size, "represent the majority of the underground transmission lines that are likely to be built in the future" should be modified since future uses of such a relatively small XLPE cable size will not be typical.
- page 3-6, Tables 3-6 and 3-7: An interesting observation from the bottom lines of these two tables is that a double-circuit 345-kV HPFF installation with six 2500-kcmil cables costs about the same to install as a single-circuit 115-kV HPFF installation with three 1750-kcmil cables. On its face, this does not seem realistic. UI provided the 115-kV cost estimates, and CL&P provided the 345-kV cost estimates. The Council's consultant should review the line item detail and assumptions further, and the trench dimensions (see Sketches in Appendix A) to understand, and then explain, the reasons for this improbable result.
- page 4-1, the acronym EMF is used for the first time without definition. Consideration should be given also to eliminating the EMF bullet item here because EMF mitigation need not in many cases be a "key factor" in first costs. Also, in the sentence immediately below the bullets, there is an extra "are" which should be deleted.
- page 4-1, 1st paragraph of section 4.2: We suggest that the word "sliver" in the second sentence be changed to "corridor". Also, the last sentence is unclear. If this sentence is referring to ways of gaining lateral access to a ROW, it is OK, but such access is also common in non-urban areas as a means of avoiding travel through wetlands, for example. If the sentence is referring to wires passing over a property, there is no distinction between a standard CL&P easement for this land use and one which allows a transmission line structure placement. Most of CL&P's existing ROWs are predominantly made up of easement rights over privately owned property.

- page 4-2, section 4.2.1: Add an "s" to "crossing" in the fourth bullet, and consider an additional bullet for the incremental costs of access road building. Might this also be place to note that steeper terrain is not generally suitable for underground cables in pipes or conduit systems, which is why such cables are not commonly sited in off-road right-of-ways in Connecticut?
- page 4-3, paragraph just above Section 4.2.2: Cited words are attributed to Robert Carberry. The cited words come from a CL&P panel response to an interrogatory question which was submitted along with other responses by Mr. Carberry, but the words in this case should be attributed to CL&P's witness Graham McTavish, Manager of Transmission Project Planning for CL&P. Also, at the end of the sentence immediately following these cited words, the words "for water crossing, respectively" should be deleted.
- page 4-3, first bullet item under section 4.2.2: The words "due to avoiding obstacles" could be replaced by "to avoid obstacles".
- page 4-4, second line from the top: Insert "structures," before "insulators and associated hardware". Also, change the words at the end of the next sentence to "...loss of all the wires on one side." Finally, delete the last sentence of this paragraph as this is not a normal line-design practice for CL&P.
- page 4-5, section 4.3: In the last sentence of the first paragraph, "separately" would be a better word than "specifically". Also, in the second sentence of the second paragraph, please add "siting," before "design and associated costs." Please note in addition that an approval of the method and manner of construction of a transmission line, i.e., a design approval, is required by the CT Department of Public Utility Control, whose interest is basically to insure compliance with the National Electrical Safety Code, including for crossings of other utility facilities. For completeness, you should consider listing this permit here. It is also listed in Table 9-2 on page 9-4, but inappropriately because it is not an environmental permit.
- page 4-5, second sentence under 4.3.1: The phrase "utility transmission system planners" would be more accurate than "utilities," because today, the conceptual planning described here is not performed entirely within utility companies, but takes place on a regional basis under the auspices of the Independent System Operator - New England. Also, in the bottom line under section 4.3.1 on this page, the words "was established" appear to be unintentionally left from a previous edit and should be eliminated.
- page 4-6, section 4.3.1: In the clause that introduces the bullet points, the term "new 345-kV" should be substituted for "the" before "overhead and/or underground transmission line designs" because the provisions of the public act discussed here (and therefore all of the bullet points) apply only to lines at 345 kV and above. The term "345 kV" can then be eliminated from those individual bullet points in which it appears.
- page 4-6: The last bullet item in section 4.3.1 should be changed to "Potential increased project costs for magnetic field management measures", since some measures are not costly, and since there is no basis for classifying magnetic field reductions of any size as "significant" or "insignificant." Also, the last paragraph of section 4.3.1 would more accurately read: "Since PA 04-246 requires the use

of underground 345-kV line designs in certain defined areas where technologically feasible, utility companies seeking to build new facilities will, in fulfilling their obligation to manage costs, invest substantial effort to develop alternative designs and to evaluate the technical and financial viability of such underground construction and its alternatives.

- page 4-6, section 4.3.2: The second bullet suggests that attachment of transmission cables on bridges is allowed in CT, contrary to the accurate text on this topic on page 4-7. The points made by the bullets could be more accurately expressed as:
    - Incremental costs for easements over private property because construction within the highway right-of-way for utility facilities such as splice vaults is not permitted
    - Incremental costs for horizontal directional drilling or self-supporting structures to cross water bodies and other features, because attachment of cables to bridges is not allowed
    - Work schedule restrictions.
- page 4-7: In the second sentence of the top paragraph, note that the three-week time frame includes the time for cable splicing operations; in fact most of this time is for cable splicing and not vault burial. Also, we suggest deleting the word "prudently" in this sentence because it is not clear that this is a typical requirement of each state's Department of Transportation. In the text regarding cable installation along bridges, we suggest that this text be changed to say that the attachment of *transmission* cables to these kinds of structures is not supported by CDOT. Historically, things were different, and may still be different for other linear utility facilities. At the end of this paragraph, you might also note that cable capacity decreases with cable depth, another limiting consideration for underground cable system designs.
- page 4-8: In the top paragraph, we suggest deleting the word "prudent". It's not clear that these measures are applied to other types of underground utility projects or if other states enforce similar practices. Also, the last sentence should refer to the example of the Docket 217 Bethel-Norwalk project, which is the only project that has actually incurred these specific costs to date. The increased costs for the Middletown-Norwalk construction are still anticipated costs at this point.
- page 4-8, section 4.3.4: You might also note in the 4th sentence that the Corps does not allow project segmentation in this permitting process. And in the next sentence, we suggest changing the words "in parallel with" to "in connection with". Sometimes these permitting efforts must proceed in series.
- page 4-9, last sentence: This sentence is inappropriately using a specific overhead line ROW cost per mile as an example figure for an underground line.
- page 5-1, first paragraph of section 5.1: In the last sentence, the word "charging" should be "changing", or better yet, "alternating". A "charging" current is associated with capacitance, not inductance.
- on page 5-1, next to last paragraph: The first sentence should refer to the 345-kV Middletown to Norwalk "project". There is not a 345-kV Middletown to Norwalk "line".

- page 5-2, section 5.2: The definition of "hybrid line" leads to an error in Table 5-1 on page 5-4. The word "line" is often defined as a series of overhead transmission structures which support one or more circuits. Option 1 in Table 5-1, for example, is a transmission line supporting two independent circuits, i.e., a double-circuit line. However, the hybrid line concept applies to a single circuit of one voltage; so for example, a 345-kV circuit with an overhead line section joined to an underground cable section at a transition station would constitute a hybrid (or "porpoised") circuit.
- pages 5-3 and 5-4: First, it is Table 5-1, not 5.1, and the word "Archers" in the Figure caption has no apostrophe. More importantly, the text here pointing to Option 2 in Table 5-1 as a "hybrid" line is incorrect, as explained in the previous comment. The Option 2 example in section 5.2 involves different circuits at different voltages: a proposed all-underground 115-kV line between the Plumtree, Peaceable and Norwalk Substations, and a proposed all-overhead 345-kV line between the Plumtree and Norwalk Substations. Neither the 115- nor the 345-kV circuit was a hybrid circuit. However, the 345-kV circuit that was ultimately approved between Bethel and Norwalk is a hybrid circuit, as is the modified 115-kV circuit, and the costs of these additions are estimated in the materials CL&P filed with ISO-NE with its Transmission Cost Allocation application for the Bethel-Norwalk Transmission Project. A copy of a "Breakdown of Costs" table filed in this matter is enclosed; refer to the column headed "Proposed Project Costs."
- page 5-5, Table 5-2: A "Phase Shifting Transformer" is incorrectly included as a type of FACTS equipment.
- page 5-6, section 5.3.2: We do not understand the fourth bullet item. Is the point that the DC line costs less than a comparable AC line because it has only two, not three, conductor sets?
- page 5-7 at the top: The concept of "long distances" where HVDC is the only reasonable application for a point-to-point power transfer could use some further explanation. The distance that qualifies as long for the underground HVAC to underground HVDC comparison is a function of voltage and may be ten to twenty times shorter than the distance that qualifies as long for the overhead HVAC to HVDC comparison.
- page 5-7, just below Table 5-4: The word "Bethel" should be replaced by "Middletown".
- page 5-8, section 5.3.3: In the second sentence of the first paragraph, we suggest inserting the words "potential reconductor" before "solution". The existing sentence is an overstatement without such qualification. Also, the three bullet items need some qualifications. None of the three bullet items makes clear what the comparison is being made to; e.g., reducing line losses in comparison to what other conductor type and size? Because a conductor's resistance increases as its temperature rises, the lower resistance claim may not be true if the comparison conductor type and size would be operating at lower temperatures. The claim in the second bullet of increased reliability during heavy ice loading conditions may not be true. Composite conductors do not stretch and sag as much, so the heavy ice loading will lead to a higher tension on such

conductors in comparison with ACSR conductors, for example. That could be a factor which reduces reliability. And a caveat for the third bullet is that the ability of the structures to support the wind load and the conductor tension can be limiting.

- page 5-10, first paragraph: We suggest changing the last sentence to "The cost of line losses in a particular application might also be reduced through use of this technology." In an application where a smaller diameter composite conductor is used instead of a somewhat larger diameter ACSR conductor, and the composite conductor also operates in higher temperature range, the cost of line losses might be increased.
- page 5-10, second paragraph: The first sentence is not correct. It may be a claim made by a manufacturer using a comparison to a utility which conservatively limits maximum ACSR conductor temperatures to very low levels in comparison with line rating practices in Connecticut. CL&P views the potential increased current-carrying capability of composite conductors as 30 to 60%, not two to three times.
- page 6-1, next to last paragraph: In the next to last sentence, we suggest changing the words "on rerouting power" to "how", because operator actions would more typically be generation adjustments.
- page 6-3, first paragraph of section 6.3.1: We suggest inserting the words "and access ways" after "vegetation" in the second sentence. Also, the two bullet lists should be combined into one which is introduced as "routine maintenance activities", and the last three bullets should be brought to the top as the most routine of these activities. On the first wood-pole item, add "inspection" as an activity. On the second wood-pole item, change "higher outages and older poles" to "higher outages or older poles". Finally, change the first sentence below the bullets to "Vegetation management, or maintenance of the line right-of-way, is a *cyclical* process that provides for *periodic* clearing of..."
- page 6-4, bullets at top: add a bullet for clearing of vegetation to maintain access ways, and replace "removal of trees within the right-of-way" with "removal of vegetation within the right-of-way which could grow too close to the line". In the sentence just below these bullets, change to "....to inhibit the growth of *tall*-growing species of *brush* and trees.
- page 6-4, first paragraph of section 6.3.2: A more commonly used term for "electrolysis preventive devices" is "cathodic protection devices."
- page 7-1, section 7.1: In the second sentence of the second bullet, note that variation also is associated with the temperature of the conductor in addition to the square of the current. Also, the first sentence below this bullet is not correct. We think that this sentence means to say that because currents on line conductors will be higher because of the reactive power demands of lines and loads, then the resistive I^2R losses over the line conductors will be higher. There may also be insulation losses, more so for underground cables than overhead lines, but these are insignificant by comparison and seldom considered.
- page 7-2, middle of page: A sentence states that energy costs will be highest during high load conditions. It might be prudent to insert the qualifier "usually", since that might not always be the case in today's evolving market system.

- page 7-3, last bullet above section 7.5: We suggest inserting the words "in cables" before "will vary".
- page 7-3, section 7.5: The second sentence should be changed to "The loss calculations are based on an example peak load current for a line." It would also be a nice addition to characterize your choice of an example peak load current as generally on the conservative side, but to do so you should change the assumed peak load current for 345-kV lines to 1,500 amperes per phase (750 amperes per conductor/cable). A related comment pertaining to the tables in section 11 is that data above each table includes "Load 1000 amps". This should instead say "Peak Line Current".
- page 8-1: Delete the word "and" from the section 8 header.
- page 8-2, section 8.1.1: Change the last sentence to "The changes are primarily due to differences in conductor configuration and spacing." Conductor spacing is not a "minor" factor for field levels.
- page 8-3, Table 8-1: Change the word "Strengths" in the header to "Levels", similar to the headers for Tables 8-2 and 8-3. Also, please indicate for the Split-Phase Configuration C whether or not a reverse conductor phasing was used. Only split phasing which includes reverse phasing of each set of three line conductors will achieve substantial EMF mitigation.
- page 8-5, section 8.1.3: The third sentence reads as follows: "Even though the power flow is doubled under these loading assumptions, EMF levels for the double-circuit line increase by less than a factor of two." This statement suggests to us that the double-circuit line that was modeled to produce the data in Table 8-3 has a like phasing of the two sets of vertical line conductors, and like current directions. If reverse phasing was employed instead, the result would be substantial reductions in EMF levels in comparison with the single-circuit vertical line. Circuit phasing is an important detail to report whenever multiple lines are modeled together.
- page 8-6, section 8.2.1: In the third sentence, change "a loading level" to "a peak current level". Also, the fourth sentence and associated Figure 8-2 have a major problem. These speak to a 115-kV XLPE cable line in a delta configuration, but Table 3-5 of the report, and associated Figures in Appendix B, do not show any such XLPE cable configuration. Therefore, it is unclear what cable spacing is used for these calculations. If the model assumed the in-contact delta arrangement of three cables that applies to HPFF cables, note that such a delta arrangement of three XLPE cables is not a realistic application. Unlike for HPFF cables, XLPE cables are pulled individually through separate conduits and should be spaced some distance apart for heat-transfer considerations.
- page 8-6, section 8.2.2: In the third sentence, change "an assumed loading level" to "a peak current level". Also, please check the results reported in Figure 8-3 for this 115-kV HPFF cable system. It seems likely that the results have not fully accounted for the magnetic field attenuation afforded by the steel pipe.
- page 8-7, section 8.2.3: The first sentence addresses the "two most common methods for mitigating the magnetic fields of solid dielectric cables". We do not believe that shielding, especially by plates, qualifies as a "common" mitigation method. None have been used in CT to our knowledge. Where plates have

been used elsewhere, the applications are localized and not continuous over a cable route. Also, the number and relative location of ground continuity conductors can be a mitigating method.

- page 8-8, section 8.2.3: The second sentence and associated Figure 8-4 demonstrate the same problem identified above for section 8.2.1. There is no such delta configuration of XLPE cables. Consequently the text on page 8-8 and Figure 8-4 should be replaced. The Council could consider use of information and/or findings on this topic within the Docket 272 or Docket 292 records. The facts stated in Docket 272 were that steel plates installed over the top of the 345-kV cable trench could reduce magnetic fields directly over the trench by a factor of two to five. However, such steel plates also cause a "wing effect" to either side of the trench where the magnetic fields would increase somewhat. Any figure that is used with such text should be one that shows this wing effect because plates are not an effective tool for mitigation of field levels when the location of interest is a short distance away from the cable trench.
- page 9-1, section 9.1: In the third sentence of the last paragraph, change the word "siting" to "permitting". Also, make this same change in the first line of the first complete paragraph on page 9-2.
- page 9-4, Table 9-2: You might consider including under DEP their Stream Channel Encroachment Line permit, which has been needed on some recent projects and can take a considerable time to obtain. Also, under the U.S. Army Corps item in regards to the asterisk, note that the nationwide permits have been replaced with Programmatic General Permits.
- page 9-5, section 9.2: In the third bullet, change the word "toxic" to "contaminated".
- page 9-7, section 9.2.3: Change the word "toxic" to "contaminated" in the section header and within the text of this section. You might consider mentioning as well that soil testing for contaminants has to become part of the street excavation protocol because contaminated soil may not always be obvious.
- page 9-8, section 9.2.5: You could add, if you wish, that DEP and U.S. Army Corps permitting have taken 18 months in some recent instances. You could also mention that court appeals of siting decisions are another source of delays in project completion.
- section 10: Figures 10-3 through 10-6 have header words saying "Cumulative PV of Life Cycle Cost Components". Figures 10-1 and 10-2 appear to be showing "cumulative" PV, but the word "cumulative appears not to be right on the subsequent figures.

Sincerely,

Enclosure

cc. Service List