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February 16, 2005

Via Email
Ms. Pamela B. Katz, Chairman
Connecticut Siting Council
10 Franklin Square
New Britain, CT 06054

Re: Docket No. 272

Dear Chairman Katz:

Pursuant to the Siting Council's request, attached is a Technical Summary of Steven Boggs and information on GITL Technology presented during the technical presentation on February 14, 2005.

Very truly yours,

REID and RIEGE, P.C.

Thomas M. Armstrong

TMA:lam
Enclosures
cc: Service List

TRANSIENT OVERVOLTAGES, CAPACITANCE, AND TRANSMISSION TECHNOLOGY

Capacitance and Cable Technology

Capacitance can be defined as the degree to which an electrical device can store energy in an electric field. Since power apparatus typically fails near the peak of the AC voltage waveform, the energy stored in the capacitance of the system is near maximum, and this energy is available to cause damage to system components, to cause overvoltages on the system, etc. The Applicants have sponsored numerous studies which tend to indicate that the magnitude of overvoltages on the system when a fault occurs tends to increase with system capacitance, and, in their opinion, becomes unacceptable for cable capacitances greater than about 6.5 μF per phase based on a capacitance for XLPE cable of 0.27 μF/mile-phase. The total capacitance per phase-mile would be about 13 μF, as a double circuit of XLPE cable is required to carry the current of a 345 kV overhead line. A single circuit of GITL in a trench can carry the same current. The issue is clearly not the length of cable but the capacitance of the cable, and for that reason, the Applicants switched from HPFF cable to XLPE cable for much of the cable run. The ratio of capacitance per unit phase length for HPFF, XLPE, and GITL (gas insulated transmission line) is approximately 5.4 to 3.15 to 1 for HPFF, XLPE, and GITL, respectively.

Thus every double circuit mile of XLPE cable which is replaced by a single circuit mile of gas-insulated transmission line (GITL), possibly with an extra phase for redundancy, would decrease the cable system capacitance by about 3.5% or the equivalent of about 0.85 double circuit miles of XLPE cable or about 5.3 single circuit miles of GITL. This could be used either to free up available capacitance so that additional cable could be installed elsewhere or to reduce the total capacitance and thereby improve system security.

Risk and Cable Technology

XLPE Cable

Transmission class XLPE cable is inherently very risky technology, as every mile of such cable contains roughly 24 m^3 (825 ft^3) of solid dielectric (XLPE). Thus 20 miles of two circuits would contain roughly 1000 m^3 of XLPE. To put this in perspective, the insulation would form a cube about 30 ft on a side. A single metallic contaminant greater than 0.1 mm (4 mils) can cause failure of XLPE cable. Worse, such contaminants cannot be detected through any form of factory testing. They will only be detected through failure in the field. Thus if an error is made in manufacturing the cable, the entire installation could be contaminated, and this will not be discovered until failures start to occur in the field sometime after the system is energized. And the failures may never cease. In the worst case, the entire cable system would have to be replaced. The real risk is in the fact that the quality of the cable cannot be assessed or assured through testing after manufacture, as the short factory test applied to the cable, typically 1 minute, is far too short to cause failure from conducting defects which will certainly cause failure in the field, although such failures may take days to years to occur. 345 kV XLPE cable operates at a far greater electric field within the insulation than any other common bulk solid dielectric insulation system. The field is so high that the conductivity of the XLPE dielectric becomes a function of the electric field, which does not occur in any other common bulk solid dielectric insulation system. These characteristics make 345 kV XLPE cable extremely sensitive to a wide range of contaminants in the dielectric, most notably conducting (metallic) contaminants and cotton fibers, both of which are likely to cause failure.

The insulation (XLPE) of a 345 kV cable comes in the form of small pellets which have a very large surface area on which contamination can adhere. The pellets have very low conductivity so that they can charge electrostaticly through handling, and contaminants will be held on the surface by electrostatic charge. The pellets are manufactured at a material supplier, shipped to the cable factory in bulk containers, transferred from the bulk container in which they are transported to the storage facilities of the cable supplier, and then transported within the factory to the cross head extruder where they are melted and formed into cable. Contamination can take place anywhere in this process. The cable manufacturer may or may not attempt to "clean" the pellets in various ways, but these are not likely to remove all particles at the 0.1 mm (4 mil) level. The worst case particle is only about 0.01 mm (0.4 mils) wide, so that it is likely to pass through any filter which the cable manufacturer can use with XLPE.

Clearly transmission class EHV (420 and 345 kV) XLPE cable can be reliable and has been in many installations. However other installations have been disastrously unreliable, and, as noted above, the risk is in the fact that unreliability will not become evident until after the cable has been installed and energized for some time, i.e., after the major investment of installing the cable and the cost of correcting the problem is enormous.

GITL

GITL is a mature technology with some designs essentially unchanged and highly reliable for over 30 years. Installation of GITL carries lower risk and, based on historical data, should provide greater reliability than 345 kV XLPE cable. GITL has the major advantages of (i) much lower capacitance, (ii) far less solid dielectric in the system which cannot be tested effectively in the factory, (iii) the solid dielectric in the system is operated at far lower electric field than is the XLPE of a 345 kV cable, (iv) the primary insulation is gas which can be tested effectively after installation. The risk associated with a GITL is far less than with an XLPE system because the likelihood of a common mode defect which causes the entire system to be unreliable, and which might require replacement of the entire installation, is much less than for XLPE.

Cable Technology and Legislative Mandate

Studies carried out for the Applicants indicate increasing transient overvoltages with increased cable capacitance. The Applicants have taken the position that 24 miles of cable is technically feasible, but no more. However such studies are at best semi-quantitative. They provide trends rather than definitive numerical data. Clearly no "brick wall" limit to the amount of cable exists. KEMA has suggested that the data presented by the Applicants could be interpreted to support as much as an additional 5 miles of cable. Further KEMA, as the Applicants, agree that the issue is not the length of cable but rather the capacitance of the cable which, as noted above, can be reduced substantially by replacing portions of the XLPE cable with GITL.

Replacing as much of the XLPE as possible with GITL would have the advantages of reducing substantially the cable system capacitance which is of such concern to the Applicants and could make available capacitance which could be used to install cable or GITL in other areas of concern for which cable has not been proposed by the applicants, thereby meeting the intent of the Connecticut legislature. Historically, GITL has been as reliable or more reliable than EHV (345 and 420 kV) XLPE cable, and GITL is far better established in terms of a history of successful installations than is EHV XLPE cable technology. Thus additional underground transmission beyond the present 24 miles is certainly technically feasible. Further, one or two additional sections of single circuit GITL transmission with a total length in the range of a two miles would add about 1.3% to the cable capacitance proposed by the Applicants, and this is well below the margin of error in the capacitance of the cable system, i.e., the additional capacitance would be immaterial in the context of the overall capacitance of the cable system.

Areas of Agreement

In our view the following represent areas of agreement among the technical experts:

- With regard to transient overvoltages, the relevant issue is total cable system capacitance, not the length of the cable.
- GITL (16 pF/phase-ft) has far lower capacitance than XLPE cable (51 pF/phase-ft or 102 pF/double circuit phase-ft, which is the relevant basis of comparison, as one circuit of GITL can carry the current of two circuits of XLPE cable).
- One double circuit mile of XLPE cable replaced with a single circuit mile of GITL cable would lower the cable system capacitance by about 3.5%, equivalent to about 5.3 single circuit miles of GITL or 0.85 double circuit miles of XLPE cable. Thus replacement, where technically feasible, of limited lengths of XLPE cable with GITL would open the possibility of installing additional underground transmission elsewhere along the route without increasing overall system capacitance.
- The repair time of GITL, around 1 week, is much less than the repair time of XLPE cable which is closer to one month.
- EHV (345 and 420 kV) XLPE cable technology is inherently risky at the present state of the art, to the point that this option was originally rejected by the Applicants in favor of HPFF cable. Only when the capacitance of HPFF cable made this option untenable did the applicants adopt XLPE cable technology.
- The reliability of GITL is at least as good as EHV XLPE cable technology and probably better. GITL has been established at EHV voltages for a much longer time than has XLPE cable technology and is far more mature.

Summary

By any standard, the Applicants have a difficult job to install a new 345 kV transmission line in a heavily settled state such as Connecticut. However the position taken by the Applicants, that the 24 miles of cable, which is more or less dictated by inadequate right of way width for a 345 kV line, is technically feasible, but no more than that is feasible, can only seem self-serving. The reality is that the Applicants can engineer wide range of constraints, although such constraints may increase the risk of unforeseen problems. On the other hand, obvious options exist which can improve the reliability of the approach suggested by the Applicants as well as facilitate additional underground transmission at other locations along the transmission line route. While acknowledging that capacitance and not the length of cable is the relevant issue, the Applicants appear to dismiss out of hand all suggestions which would increase the amount of underground transmission while retaining or very likely improving the reliability of the transmission line route. As a result, the Applicants do not appear to take seriously their legislative mandate to maximize the amount of underground transmission within the constraints of technical feasibility.