CONNECTICUT SITING COUNCIL

FINDINGS OF FACT

~FOR~

DOCKET NO. 272 - 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.

April 7, 2005

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GLOSSARY

Alternating Current: (AC) An electric current which reverses its direction of flow periodically. In the United States this occurs 60 times per second (60 cycles, or 60 Hertz.)

ACSR: (Aluminum Conductor, Steel Reinforced) a common type of overhead conductor made up of many strands of aluminum wire wrapped around a small number of steel wires.

Ampere: (Amp) A unit of measure for the flow (current) of electricity.

Arrester: A device that protects lines, transformers and equipment from lightning and other voltage surges by safely carrying the charge to ground.

Autotransformer: A specialized type of transformer with a single winding, commonly used in connecting 345-kV and 115-kV systems.

Avalanche Effect: The downhill creeping movement of cables primarily in areas of grade change as a result of the heating and cooling of cables or substations.

Blackout: A total disruption of the power system usually involving a substantial or total loss of load and generation over a large region.

Blackstart capability: Having the ability to return to service without the need for an outside power source. Usually applies to generators.

Breaker-and-a-half bus: A type of substation design which provides for two main buses, both of which are normally energized. The buses are connected by one or more rows comprised of three circuit breakers separating two circuits.

Bundle (circuit): Two or more parallel three-phase circuits joined together to operate as one single circuit.

Bundle (conductor): Two or more phase conductors joined together to operate as a single phase.

Cable: A fully insulated conductor usually installed underground especially at voltages of 69-kV and above.

Cable Charging Capacitance: The capacitance due to a cable which is the result of having the conductor or a cable at a given voltage and the shield, which is grounded.

Capacitance: The property of an AC system of conductors and dielectrics that permits the storage of electricity separated charges when potential difference exists between the conductors.

Circuit: A system of conductors (three conductors or three bundles of conductors) through which an electrical energy flows between substations and which can be supported above ground by transmission structures or placed underground.

Circuit Breaker: A switch that automatically and rapidly interrupts the flow of electricity in the event of a fault condition. Located in substations.

Conductor: A metallic wire busbar, rod, tube or cable, usually made of copper or aluminum, which serves as a path for electric flow.

Conduit: Pipe, usually made of plastic or steel, for underground power cables. Synonymous with "duct."

Damping: To reduce the amplitude of a wave form; especially the magnitude of undesirable voltages.

Decrement: The ratio of successive amplitudes in a damped harmonic motion.

Delta Configuration: A type of transmission line design in which two of the line conductors are placed on one side of the support structure and one conductor on the other side.

Derating: A reduction in the normal rating of equipment to reflect some impairment in its ability to conduct electricity. Such as caused by hot weather.

Direct Current: (DC) Electricity that flows continuously in one direction.

Duct: Tubular channel for underground power cables. Synonymous with "conduit."

Duct Bank: A group of ducts or conduit usually in a trench encased in concrete.

Dynamic VAR: (D-VAR) A voltage regulation system, which dynamically regulates voltage levels on power transmission grids and industrial facilities. D-VAR systems detect and almost instantaneously compensate for voltage disturbances by injecting leading or lagging reactive power, measured in VARs (volt ampere reactive).

EMF: Electromagnetic fields. A magnetic field caused by the flow of electricity through a conductor.

FACTS: (Flexible AC Transmission System) A type of electronic device used in combination with capacitors and reactors, which optimizes or stabilizes power flow.

Fault: A failure (short-circuit) in an electrical circuit which causes an interruption.

FERC: Federal Energy Regulatory Commission

GIS: (Gas Insulated Substation) A compact type of substation composed of equipment containing sulfur hexafluoride (SF_6) as the insulating medium.

Ground Wire: A conductor, usually located at the very top of transmission structures and parallel to the insulated line conductors, intended to provide the circuit with protection against lightning strikes (hence, sometimes referred to as a shield wire). In general, any conductor used to bond equipment to the earth (ground).

GTIL: Gas Insulated Transmission Lines; occasionally used for short connections with substations or generating plants.

Harmonic: A frequency that is in an integral multiple of the normal power system frequency, which is 60 Hz in the United States. A component of the frequency which is twice the normal frequency is called the 2^{nd} harmonic and would be 120 Hz. The 3^{rd} harmonic is three times the normal frequency, or 180 Hz, etc.

Harmonic Amplification: The increase of magnitudes of harmonic currents or voltages at one point in a system compared to another point.

Harmonic resonance: When the electrical characteristics capacitance and inductance of a system combine to magnify any stimulus at an integer multiple of the normal frequency.

HDD: Horizontal Directional Drilling; An alternative technique to trenching for the installation of underground cable.

H-frame Structure: A wood or steel structure constructed of two upright poles with a horizontal cross-arm arranged, more or less, in the form of the letter "H."

HPFF: High-Pressure Fluid-Filled; a type of underground cable system.

HGFF: High-Pressure Gas-Filled; a type of underground cable system, which is uncommon in the United States.

HVDC: High Voltage Direct Current; as contrasted to HVAC.

Hz: Hertz, a measure of frequency; one cycle/second.

IARC: International Agency for Research on Cancer

Impedance: The electrical characteristic tending to oppose the flow of electricity in an AC system. Specifically, impedance is the vector sum of resistance (R) and the net of capacitance (X_C) and inductances (X_L).

Inductance: An electrical characteristic of AC systems, especially prevalent in motors and transformers.

ISO-NE: Independent System Operator New England, Inc.

kcmil: (thousands of circular mils) a measure of conductor area. A circular mil being the area of a circle 0.001 inches in diameter.

Lattice-type Structure: Transmission or substation structure constructed of lightweight steel components to support conductors or smaller equipment.

Load: Amount of power delivered, as required, at any point or points in the system. Load is created by the aggregate load (demand) of customers' equipment (residential, commercial, and industrial).

LTE: Long-Term Emergency rating; the capacity of conductors and other electrical equipment to carry electric current usually for a duration of several hours. See STE.

Magnetic Field: Produced by the flow of electric current; strength measured as magnetic flux density in units called gauss (G) or milligauss (mG). One gauss = 1,000 milligauss.

Mass Impregnated Paper Insulated Cable: A cable in which the paper insulation is saturated with a waxy type of insulating oil.

mG: milliGauss; the unit of measure for magnetic fields

Monopole Structure: A type of structure frequently used on transmission lines consisting of a single column, usually made of steel, with horizontal arms to support insulators and conductors.

MCOV: (maximum continuous operating voltage) The rating of lighting arresters, measured by phase-to-ground voltage, which can be sustained indefinitely without failure. Transition voltages in excess of this rating for longer than a few cycles will cause a violent failure.

MVA: (Megavolt-Ampere) One million volt-amperes. A measure of electrical flow (or the capacity of some equipment) equal to the product of current times voltage divided by one million. Using vector notation in the form of a right triangle, MVA is the hypotenuse, MW one side, and MVAR the other side.

MVAR: (Megavolt Ampere Reactive) One million volt-amperes reactive. A measure of electrical flow (and sometimes the capacity of electrical equipment) which does no useful work. It is the net difference between effects of capacitance and inductance which electrically are opposites.

MW: (Megawatt) one million watts. A measure of useful work done by electricity. Sometimes referred to as "Active Power."

NEPOOL: New England Power Pool

NERC: North American Reliability Council

NESC: National Electric Safety Code

NIEHS: National Institute of Environmental Health and Sciences

NPCC: Northeast Power Coordinating Council

Phases: AC circuits are comprised of three phases which have a voltage differential between them.

Porpoising: A term to describe a transmission line which includes several segments of both overhead and underground construction.

Prudent Avoidance: A policy of action(s) to be taken at reasonable cost to avoid or minimize effects which may be perceived to be undesirable. Specifically, such steps taken to mitigate EMF.

psi: A measure of pressure expressed in units of pounds per square inch

PVC: Polyvinyl chloride; a type of plastic frequently used in ducts.

Reconductor: To Replace the existing conductors on a circuit with new conductors, typically with little if any replacement or modification of existing structures.

Relay: A device which senses the operating conditions as experienced by an electric line or major equipment and initiates a signal to interrupt if abnormal conditions occur.

Resonance: Frequency at which the impedance is much higher than what would be expected without system capacitance.

RTEP: Regional Transmission Expansion Plan, prepared by ISO.

SCFF: Self-Contained Fluid-Filled cable frequently employing a conductor with a hollow core. A type of underground transmission line used primarily in Europe and for submarine installations.

Short-Circuit: An abnormal, usually very high flow of electricity caused by a failure or the insulator systems. Lightning is frequently the initiating cause

Short-Circuit Duty: The magnitude of current likely to be experienced by circuit breakers under fault conditions.

Shunt Reactor: An electrical device, similar to a transformer, with a high inductance, used to compensate and offset capacitive charging current in high-voltage underground transmission lines.

Splice: A device to connect together the ends of bare conductor or insulated cable.

Splice Vault: A buried concrete enclosure where underground cable ends are spliced.

Split-phase: A design arrangement for a transmission circuit employing six rather than three conductors so arranged as to minimize EMF. This is achieved by placing dissimilar phases near each other. Thus on an overhead line, the phases would be arranged ABC on one side of a structure and CBA on the other.

STATCOM: (STATic Synchronous COMpensator) A solid-state dynamic VAR generator used to provide fast voltage support during critical electrical contingencies.

Static Var Compensators: (SVCs) have been used for a number of years to improve transmission line economics by resolving dynamic voltage problems. Their accuracy, availability and fast response enable SVCs to provide high performance steady-state and transient voltage control, compared with static shunt compensation.

STE: Short-Term Emergency rating; the capacity of conductors and other electrical equipment to carry electric current usually for a duration of minutes rather than hours. See LTE.

Substations: Electric facilities that use equipment to switch, control and change voltages for the transmission and distribution of electrical energy.

Switching Station: A variety of substation where no change in voltage occurs.

Temporary Overvoltage: (TOV) An abnormal oscillatory voltage, usually lasting less than one minute, but capable of causing severe equipment damage. TOVs can be minimized by careful system and equipment design.

Transformer: A device used to change voltage levels to facilitate the efficient transfer of electrical energy from the generating plant to the ultimate customer.

Transient: an abnormal voltage, typically lasting less than one second and often caused by lightning having the potential to damage equipment. A temporary overvoltage (TOV) of short duration.

Transition Station: A specialized facility similar to a substation in which an overhead line is connected to an underground cable. Switching devices and other related electrical equipment (e.g., shunt reactors) may or may not be included.

Transmission Line: Any electric line operating at 69,000 volts or more.

VAR: (Volt Ampere Reactive) The unit of measure for reactive power which can be either capacitive or inductive.

Voltage: A measure of electric force.

VSC: (Voltage source converter) An electrical power device in a DC system to control active and reactive power flows.

XLPE: A type of electrical insulation, cross-linked polyethylene, used widely on low voltage cable but only recently at 345 kV and above.

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Findings of Fact

Introduction

1. Pursuant to Connecticut General Statutes (CGS) §16-50k, on October 9, 2003, the Connecticut Light and Power Company (CL&P) and The United Illuminating Company (UI) [collectively referred to as the "Applicants" hereafter] applied to the Connecticut Siting Council (Council) for a Certificate of Environmental Compatibility and Public Need (Certificate) for the construction, operation and maintenance of a new 345-kV high voltage electric transmission line and associated facilities between the Scovill Rock Switching Station in Middletown and the Norwalk Substation in Norwalk, Connecticut. This includes construction of the Beseck Switching Station in Wallingford, East Devon Substation in Milford, and Singer Substation in Bridgeport and modifications to the Scovill Rock Switching Station and the Norwalk Substation and certain interconnections. (Applicants 1, Volume 1)

2. The Applicants provided service and notice of the application in accordance with CGS §16-50l(b). This included, but was not limited to, notice to municipalities within 2,500 feet of the proposed facility, municipalities affected by the alternate route, published notice in 27 newspapers on three individual dates between September 16, and October 10, 2003, and a distinct notice describing the proposed construction of a high voltage electric transmission line inserted within each electric company or electric distribution company customer's bill in the municipality where the proposed facility would be located. (Applicants 2, 2c, 2d)

3. Pursuant to CGS §16-50l(b), landowners abutting existing or proposed substation /switching station sites were provided notice by the Applicants. Also, community organizations and water companies were provided notice consistent with the Council's Application Guide for Terrestrial Electric Transmission Line Facilities. (Applicants 2, 2e, 2f and 5)

4. Pursuant to CGS § 16-50m, the Council, after giving due notice thereof, held public hearings for citizen comment on December 17, 2003 at Bridgeport City Hall, Bridgeport; January 5, 2004 at Bedford Middle School, Westport; January 15, 2004 at Parson's Government Center Auditorium, Milford; January 21, 2004 at the Weston High School, Weston; (Weston Transcript); February 5, 2004 at the Sheehan High School, Wallingford; February 9, 2004 at the Community Center, Woodbridge; February 23, 2004 at the Mary L. Tracy School, Orange; and February 24, 2004 at the Middletown High School, Middletown. Each hearing commenced at 7:00 p.m. for the convenience of the public. (Record)

5. The Council and its staff conducted public field reviews of the proposed preferred and alternative overhead transmission line routes and underground cable route on the same day of the hearings for citizen input. (Council Hearing Notice)

6. The Council held public evidentiary hearings on March 23, 24, and 25, 2004; April 20, 21, and 22, 2004; May 12, and 13, 2004; June 1, 2, 3, 15, 16, 17, and 23, 2004; July 27, 28, and 29, 2004; August 19, 2004; September 8, 28, and 29, 2004; October 14, 2004; December 14, and 15, 2004; January 5, 11, 13, 18, 19, and 20, 2005; and February 1, and 17, 2005. (Record)

7. Parties and Intervenors to these proceedings include the Applicants, Robert W. Megna State Representative - 97th District; Al Adinolfi State Representative 103rd District; Town of Middlefield; Town of Milford; Town of Wallingford; Town of Durham; City of Norwalk; Town of Westport; Mary G. Fritz State Representative - 90th District; Mary G. Fritz State Representative - 90th District; City of Meriden; Attorney General Richard Blumenthal; Raymond Kalinowski State Representative – 100th District; City of Bridgeport; Communities for Responsible Energy; Office of Consumer Counsel; Woodlands Coalition for Responsible Energy, Inc.; ISO New England Inc.; Department of Transportation; Town of Fairfield; PSEG Power Connecticut LLC; Town of Wilton; Town of Weston; South Central Connecticut Water Authority; Town of Orange; Connecticut Business & Industry Association (CBIA); Town of Cheshire; Town of Hamden; City of Middletown; Town of Bethany; Town of Easton; William A. Aniskovich State Senate – 12th District; Town of North Haven; Ezra Academy, Congregation B'Nai Jacob, the Jewish Community Center of Greater New Haven, the Jewish Federation of Greater New Haven, and the Department of Jewish Education; Senator Joseph J. Crisco, Jr. 17th District; First District Water Department (Norwalk); Leonard A. Fasano State Senator – 34th District; City of New Haven; Branford Conservation and Environment Commission; Town of Branford; Linda Wilson; Kevin M. DelGobbo; Ralph E. Wilson, Allison Wilson, and the South Main Street Irrevocable Trust. (Record)

8. Pursuant to CGS §16-50l(e), CL&P provided draft application documents to the Chief Elected Official for the 24 towns that may be affected by the proposed facility. The preferred route would traverse the towns of Middletown, Haddam, Durham, Middlefield, Meriden, Wallingford, Cheshire, Hamden, Bethany, Woodbridge, Orange West Haven, Orange, Milford, Stratford, Bridgeport, Fairfield, Westport, Norwalk. Alternate A or B route would cross into the Towns of Easton, Weston, Wilton and Trumbull. New Haven and North Haven are towns within the statutory threshold of 2,500 feet for notification of the proposed facility. (CL&P 2)

9. Pursuant to General Statutes §16-50j (h), on November 25, 2003, the following state agencies were requested to submit written comments regarding the proposed facility; Department of Environmental Protection (DEP), Department of Public Health (DPH), Council on Environmental Quality (CEQ), Department of Public Utility Control (DPUC), Office of Policy and Management (OPM), Department of Economic and Community Development (DECD), and the Department of Transportation (DOT). (Record)

Project Area

10. The electric system in "Southwest Connecticut" (SWCT) consists of facilities in the following towns: Bridgeport, Darien, Easton, Fairfield, Greenwich, New Canaan, Norwalk, Redding, Ridgefield, Stamford, Weston, Westport, Wilton, Ansonia, Branford, Beacon Falls, Bethany, Bethel, Bridgewater, Brookfield, Cheshire, Danbury, Derby, East Haven, Hamden, Meriden, Middlebury, Milford, Monroe, Naugatuck, New Fairfield, New Milford, New Haven, Newtown, North Branford, North Haven, Orange, Oxford, Prospect, Roxbury, Seymour, Shelton, Sherman, Southbury, Southington, Stratford, Trumbull, Wallingford, Waterbury, Watertown, West Haven, Wolcott, Woodbridge and Woodbury. (See Appendix B) Because the boundaries of the SWCT electric system are defined by electrical interfaces with other portions of the transmission system (as opposed to municipal boundaries), portions of some of the towns referenced above are outside of the SWCT electric system. (Applicants 1, Vol. 1, p.F-1)

11. The Norwalk-Stamford Sub-Area of SWCT is also defined by electrical interfaces, and includes all or part of the municipalities of Bridgeport, Darien, Easton, Fairfield, Greenwich, New Canaan, Norwalk, Redding, Ridgefield, Stamford, Trumbull, Weston, Westport, and Wilton. The Norwalk-Stamford Sub-Area is the portion of SWCT that is farthest away from the bulk 345-kV transmission grid. (Applicants 1, Vol. 1, p.F-2)

Need for Expansion of the Electric Power Grid

12. Until approximately 1970, peak electric load in the SWCT area was below the generating capacity of the area. However, subsequent to this date, demand has grown and resulted in the need to import power from sources outside the area. (Docket No. 5, Finding of Fact 26)

13. ISO-NE considers the SWCT electric delivery system to be weak and unreliable, and thus in need of reinforcement. (ISO-NE 1, pp. 3 and 13; Tr. 3/23. pp.46 and 120)

14. Connecticut currently has approximately 1,300 circuit miles of 115-kV lines, 398 circuit miles of 345-kV lines, 5.8 circuit miles of 138-kV lines and 104 circuit miles of 69-kV lines; of these, approximately 12.8 miles of 115-kV lines are underground and 2.7 miles of 69-kV are underground. In Docket No. 217, the Council approved a total of approximately 9.0 miles of overhead lines and 17.0 miles of underground line. (Council Review of Ten Year Forecast of Loads and Resources, 2003, p. 10; Docket No. 217, Findings of Fact)

15. The Connecticut Department of Public Utility Control (DPUC) 2002 Summer Shortage Report identified, in part, that: SWCT is generation deficient; transmission of power is constrained, which limits import power into the region without additional generation to increase supply; existing generation in SWCT cannot be dispatched simultaneously; and the congestion costs associated with transmission constraints create significant economic consequences for Connecticut electric customers. The Federal Energy Regulatory Commission (FERC) has designated SWCT as a severe reliability risk. (CL&P Vol. 1, p. F-5; CL&P 31, p.28; Docket No. 217, Findings of Fact No. 28; Applicants 31, pp. 3-4)

16. CL&P's first "Ten and Twenty Forecasts of Loads and Resources" report to the Council, in 1972, listed the proposed Beseck to Norwalk 345-kV transmission line. In 1974, CL&P applied for a Certificate for the first part of the contemplated loop through SWCT – the Long Mountain to Plumtree 345-kV line. At that time, CL&P noted that SWCT was the only major load area in the state not already supplied from the 345-kV system." (Applicants 11, Q. 12, 1972 Load and Resource Forecast)

17. The load growth of the early 1970's indicated a 345-kV loop would be necessary. However, the lower load growth experienced in the late 1970's and early 1980's allowed deferral of the need for a 345-kV supply into SWCT by the use of high capacity 115-kV lines through the late 1990's, after which the existing 345-kV line would need to be implemented. (Docket No. 26, Finding of Fact 27 and 28; Docket No. 57 Finding of Fact 18 and 20; Docket No.26, Opinion, p. 3; Docket No. 141 Findings of Fact No. 15)

18. The existing 345-kV line from Long Mountain switching station in New Milford to Plumtree substation was the first segment of a planned expansion of the 345-kV loop system into southwestern Connecticut. CL&P planned to extend the 345-kV transmission line south from Plumtree substation, to Norwalk substation then northeasterly to Beseck substation in Wallingford, where it would be connected to the 345-kV system. (Docket No. 5 Findings of Fact Nos. 69 and 71)

19. ISO-NE is responsible for managing the New England region's bulk electric power system, operating the wholesale electricity market, administering the region's open access transmission tariff, and conducting centralized electrical power planning (ISO-NE 1, p. 6)

20. In 2001, the FERC delegated to ISO-NE the responsibility to conduct long-term system planning for the New England region, which began the regional transmission expansion planning (RTEP) process. This process is continuous and results in an annual report developed by RTEP participants and reviewed by state regulators, NEPOOL participants and interested parties. (ISO-NE 1, p.8)

21. RTEP is a comprehensive electrical engineering assessment comprised of numerous studies and analyses of the New England bulk electric power system. (ISO-NE 1, p. 8)

22. RTEP is intended to provide information to the wholesale electricity marketplace concerning power system problems and needs that may be addressed through investment in market solutions. Absent market response, ISO-NE is charged with providing a coordinated transmission plan that identifies upgrades for reliability and economic needs. (Applicants Administrative Notice No. 11, CL&P 2004 Forecast of Loads and Resources for 2004-2013, March 1, 2004; ISO-NE 1, p. 8)

23. RTEP01, of October 2001, described the SWCT system as having severe reliability problems whenever the largest single generation source in SWCT is unavailable. RTEP01 recommended feasibility studies to examine alternatives and cost estimates for major transmission upgrades to increase imports to the SWCT and the Norwalk-Stamford sub-areas. RTEP01 also noted the potential for significant congestion costs. (ISO-NE 1, pp. 10-12)

24. RTEP02 and RTE03 continued to recognize SWCT's existing transmission system could not reliably support projected loads, generation expansion, or simultaneous operation of existing generation at full load. (Applicants 31, p. 6; ISO-NE 1, pp. 32-33)

25. Good utility practice considers a range of forecasted peak demands in selecting a load level for planning. ISO-NE considers two forecast scenarios: 1) a 50/50 forecast that assumes average weather conditions and a 50 percent probability that the peak load will be exceeded, and 2) a 90/10 forecast assumes extreme weather conditions and a 10 percent probability that the peak load will be exceeded. (ISO-NE 1, p. 20)

26. The Council's "2003 Forecast of Loads and Resources" predicted total peak load growth will increase by 293 MW from 6851 MW, in 2002 to 7144 MW by the year 2012. (Council 2003 Forecast of Electric Loads & Resources, p. 2)

27. ISO-NE has contracted in recent years for temporary generation resources for SWCT to meet peak loads. ISO-NE continues to seek up to 300 MW of additional generation, demand response, or peak-load reducing resources pending completion of a 345-kV loop. These resources are contracted under a Request for Proposal (RFP) to improve system reliability within SWCT at times of peak load. Neither new generation nor load response programs are able to achieve the same long-term results as a 345-kV loop. (Applicants 31, p. 7; ISO-NE 1, pp. 32-33)

28. Without transmission improvements or added generation, all of the existing generation in SWCT is required for system reliability. (Applicants 1, Vol. 1, p. G-4)

29. Generation in SWCT totals approximately 2,200 megawatts (MW) (summer rating), with peak load in 2002 having reached 3,465 MW. It was, therefore, necessary to import an additional 1,200 MW of additional power to SWCT in 2002. (Applicants 4, May 2003 Technical Application, Vol. 5 Appendix 13, p. 15)

30. Transmission is needed in southwestern Connecticut (SWCT) to resolve line thermal overload and inadequate voltage issues, as well as high short-circuit current ("duty") issues. Transmission must be part of any solution in SWCT. (Tr. 3/23/04, p.31)

31. A STATCOM is in the process of being installed at Glenbrook substation to correct a voltage collapse problem. The 150 MVAR STATCOM will be one of the largest of its kind in the United States. (Tr. 3/23/04. p.33)

32. The system in SWCT experiences overloads of 30 to 60 percent under a variety of contingencies. (Tr. 3/23/04, p.36)

33. The Applicants' studies indicated that a 345-kV east/west line into SWCT is necessary in 2004. (Tr. 06/01/04, p. 233)

34. The proposed project allows increased transmission into southwest Connecticut, which allows a greater portion of the load in that area to be served by generation outside of southwest Connecticut and outside the State of Connecticut. (Tr. 06/15/04, p. 50)

35. The proposed project would enable new generation to connect to the proposed 345-kV system. The existing 115-kV system does not support the connection of new generation in SWCT to the system. (Tr. 06/15/04, p. 51)

36. ISO-NE's highest priority in SWCT is to improve the transmission system infrastructure. ISO-NE states that it possesses adequate electrical generating capacity, but not the transmission system, to move the capacity. (Tr. 3/23/04, p.158)

37. All of the generation located in SWCT is interconnected to the 115-kV transmission system and cannot be operated at the same time because of the inadequacy of the 115-kV transmission system. The proposed 345-kV loop will "unlock" this generation thereby reducing short-circuit duty and power flows on the system and allowing the addition of more generation. (ISO 4, p. 1; Tr. 3/23/04, p.3)

38. The Applicants now have 345/115-kV autotransformers at the Plumtree substation (Bethel), the Frost Bridge Substation (Watertown), the Southington substation, and the East Shore substation in New Haven. The proposed 345-kV loop will include autotransformers at the proposed East Devon substation, and at the proposed Singer substation in Bridgeport. In addition, Docket 217 approved the extension of the 345-kV system from Bethel to Norwalk and the installation of an additional autotransformer at Norwalk. (Tr. 3/23/04, p.41)

39. The autotransformers would supply the 115-kV system from the 345-kV grid, and allow the Applicants to efficiently move bulk power to locations in SWCT. Incremental 115-kV construction would include some reconductoring of certain lines. (Tr. 3/23/04, p.42)

40. The proposed project would allow the Applicants to import power from the eastern part of the state where the largest generating plants at Millstone Power Station are located. Millstone is the strongest source on the NU system. Four 345-kV transmission lines terminate at Millstone, from Montville (Montville Station and AES Thames), Willimantic (Lake Road), Manchester, and Southington. Units two and three at Millstone are capable of producing a total of approximately 2,000MW. (Tr. 4/22/04, p. 78-79) (Tr. 3/23/04, p.44)

41. Modern, efficient combined-cycle generating plants have a capacity of about 550 MW, and the 115-kV system is incapable of allowing the connection of such a large generation source. The 345-kV loop would allow newer and more efficient generation to be added to the transmission system in SWCT. (Tr. 3/23/04, p. 58, p.91)

42. Economic forces have prevented project developers from completing generating plants previously approved by the Council in Meriden and Oxford. (Tr. 3/23/04, p. 58, p.91)

43. Flexibility of operation is important to ISO-NE because of very heavy line loading in SWCT with excessively high dependency upon the availability of the generation in SWCT. ISO-NE dispatches the various resources in SWCT in a manner to avoid overload, often without regard to economic efficiency. (Tr. 3/23/04, pp. 119-120)

44. Building the proposed 345-kV system would allow some generation presently on the 115-kV system to be reconnected to the 345-kV system. This would ultimately serve to reduce short-circuit duties and enable the import of more generation into SWCT from the rest of Connecticut. (Tr. 3/23/04, p.158)

45. Short-circuit duty problems in SWCT are significant because the capabilities of 115-kV circuit breakers to interrupt short-circuit current is at their limit. A 345-kV loop would allow some generation which contribute large amounts of current into a short-circuit, to be reconnected to the 345-kV, reducing short-circuit duty in the area. (Tr. 3/23/04, pp. 118-119)

46. After the project is completed and the system is operating, the Applicants will address remaining problems such as incremental transmission rebuilds by filing those projects with the Council. (Tr. 3/23/04, p.64-65)

47. CL&P forecasts a 2.2 percent annual peak growth rate between 2004 and 2013. (Tr. 3/23/04, p.66)

48. UI's annual peak growth forecast is essentially flat (approximately one-half of one percent). (Tr. 3/23/04, p.67)

49. In seven of the last ten years, peak demand load was a result of extreme weather. Weather can affect a peak forecast by a range of seven to 10 percent. The trend toward larger homes and the addition of more electrical appliances (air conditioning) also increases peak demand. Overall, demand for electricity is exceeding the ability of consumers to conserve. (Tr. 3/23/04, p. 67-69)

50. The NEPOOL 2003 CELT Report forecasts a summer peak load in New England of 27,820 MW in the year 2010. ISO-NE and the Applicants assumed a 27,700 MW system peak load as a design basis for analysis. (Applicants 32, p. 4; Applicants 4, May 2003 Technical Application Vol. 6, p. 7; ISO-NE 1, p. 20)

51. ISO-NE identified the 27,700 MW load level as a reasonable level to use in planning near term transmission additions. The New England peak load has grown by 500 MW in each of the last six years. If the New England load continues to grow at that rate (about 2% annually), peak load would reach 27,700 MW by 2006. (Applicants 4, May 2003 Technical Application Vol. 6, p. 6; Docket No. 217 Findings of Fact 41)

52. SWCT accounts for almost half of the load in the state. This densely populated load pocket is one of the fastest growing and most economically vital regions in Connecticut. SWCT is presently the largest load pocket in New England without 345-kV interregional transmission service capability. (Applicants 4, 2003 Technical Application Vol. 6, SR.3 p. 7)

53. Obsolete and inefficient generating plants are often more harmful to the environment than newer, less polluting plants. (Tr. 3/23/04, p. 58, p. 91)

54. The project has a public need, due to continued load growth, reinforcement to ensure reliability, continued deterioration of the reliability of the electric system in SWCT and a failure to meet regional and national reliability standards. (Applicants 32, p. 4; Tr. 6/3/04, p. 29; PCC 1, p. 4; Applicants 1, Vol. I, p. F-7; Applicants 31, pp. 24-25)

55. SWCT cannot rely on conservation and load management or demand site management programs to resolve the current transmission system problems. (Tr. 3/23/04, pp. 33-35)

56. The project would benefit the area by providing voltage stability, increase transfer limits into the state, allow electricity to move from strong transmission sources in the eastern part of the state, allow newer and more efficient generation to be added, and strengthen the entire New England transmission system via improved interconnections between the rest of New England's 345-kV system and SWCT. (Applicants 31, p. 4, pp. 25-26; Tr. 3/23/04, p. 41-45, pp. 56-59)

Reliability

57. Transmission infrastructure must meet reliability standards set by the North American Electric Reliability Council (NERC), Northeast Power Coordinating Council (NPCC) and the New England Power Pool (NEPOOL). Such standards reflect tests for transmission contingencies, and various dispatch scenarios, such as the unavailability of multiple generation units and/or transmission lines in a local area. (Applicants 4, May 2003 Technical Application Vol. 6, pp. 14-15; Applicants 31, p. 22)

58. The integrated 345-kV system is constructed in a series of "loops" so that if interruption occurs on one of the lines to an area served by a loop system, service can still be provided to the area from the other end of the loop. CL&P's existing 345- kV system includes several interconnected loops within Connecticut, and portions of loops that extend beyond Connecticut into Rhode Island, Massachusetts, and New York. Most of the load centers and generation in the eastern and central parts of Connecticut are connected to loops on the 345-kV transmission grid, which consists of approximately 400 miles of 345-kV transmission lines in Connecticut and 1,769 miles throughout New England. (Applicants 4, Technical Application Vol. 6, pp. 26-29)

59. There is no 345-kV loop in the southwest area of Connecticut. A "full loop" 345-kV transmission line located within southwest Connecticut is necessary to address reliability problems and would satisfy those problems more completely than other alternatives studied by ISO-NE. (Applicants 31, p.11; ISO-NE 1, p. 4, p. 28; ISO-NE 4, p. 22)

60. A 345-kV loop could deliver large blocks of power and reduce power flow on the 115-kV system, thereby relieving overloads and allowing for future local load growth. (Applicants 31, p. 11)

61. One of the elements necessary to maintain the reliability of bulk power systems is to maintain transmission voltage within a prescribed bandwidth. Voltages below 90% of normal damage customer equipment and create a high risk of generator outages and load shedding. (Applicants 4, 2003 Technical Application Vol. 6, pp. 20-21; ISO-NE 1, p. 4; ISO-NE 4, p. 22)

62. Over eighty (80) 115-kV transmission elements exceed emergency ratings under many design criteria contingencies (e.g., transmission line(s) outage, generation outage). Post-contingency overloads on transmission lines range from 100% to over 185% of long-term emergency (LTE) ratings. The most affected transmission corridors are the following:

- Plumtree to Norwalk
- Norwalk to Norwalk Harbor to Glenbrook
- Devon to Norwalk
- Pequonnock to Norwalk
- Frost Bridge to Devon
- East Shore to Pequonnock
- Southington to Devon

All the major transmission corridors in southwestern Connecticut experience transmission line power flows above emergency ratings and voltages that fall outside of acceptable limits. Modeling of contingencies also indicates a potential for voltage collapse. (Applicants 4, 2003 Technical Application Vol. 6, SR.3 p. 19; Applicants 31, p. 25)

63. The most critical and problematic contingencies are those that involve the loss of two transmission lines sharing common structures. More than 70% of the CL&P 115-kV circuits in southwestern Connecticut are supported by multi-circuit structures. Unplanned outages of two of these lines can occur due to a shield wire failure, insulator/hardware failures, tower failure, lightning, severe weather, or a transportation accident. (Applicants 4, 2003 Technical Application Vol. 6, SR.3 p. 20)

64. Modeling indicates that under certain conditions problems in the area could propagate outside of southwest Connecticut to the remainder of Connecticut and potentially affect other northeastern states. (Applicants 31, p. 25)

65. This project is part of a long-range plan for expansion of state electric systems. The Phase I (Bethel to Norwalk) project, approved in Docket 217, would reduce various thermal overloads to approximately 65 incidences; however, with the completion of the proposed Middletown to Norwalk project this estimate

would be reduced to 24. These remaining overloads would be addressed locally through substation or transmission line upgrades. (Applicants 31, pp. 6-7, p. 25)

66. The 345-kV system is considered the "backbone" of the electric utility grid of New England. This system efficiently transmits large amounts of electricity over long distances from major generating plants in New England, New York State, and Canada to 345/115-kV step down substations near load centers. (Docket No. 217 Findings of Fact No. 30)

67. Existing 345-kV transmission line ties with adjacent states include the 347 circuit between the Lake Road Generating station in Killingly, and the Sherman Road substation in Rhode Island connection with the New England Power Company grid; the 395 circuit between the Manchester substation in Manchester, Connecticut and the Ludlow substation in Massachusetts connecting with the Western Massachusetts Electric Company grid (a subsidiary of NU); and the 398 circuit between Long Mountain switching station and Pleasant Valley substation in New York connecting to the ConEdison company grid. (Applicants 4, May 2003 Technical Application Vol. 6, p. 2)

68. Other lower voltage transmission tie line connections are: Cross Sound 330-kV HVDC circuit from New Haven Connecticut to Shoreham New York; the 138-kV 1385 circuit from Norwalk Harbor to Northport New York; the 115-kV 1768 circuit from North Bloomfield Substation Windsor to Southwick Massachusetts; the 115-kV 1781 and 1782 circuits both from Windsor to Agawam, Massachusetts, the 115-kV 1394 and 1515 circuits both from Enfield to Franconia, Massachusetts, the 115-kV 1870 circuit from Mystic to Rhode Island, and the 69-kV 690 circuit from Sharon to Central Hudson Gas and Electric service area. These transmission tie lines to neighboring electric systems provide customers with improved reliability benefits under both non-contingency and contingency conditions. (Applicants 4, May 2003 Technical Application Vol. 6, pp. 2, 3 and 32)

69. CL&P has increased capacity and reliability in SWCT by reinforcing the existing 115-kv system thereby deferring extension of the 345-kV system into SWCT. Such major system upgrades include:

    - Docket No. 26 - the reconstruction of the Plumtree Substation, Bethel to Ridgefield Junction, Redding line completed in 1985;
    - Docket No. 57 - the reconstruction of the Trumbull Junction, Trumbull to Old Town Substation, Bridgeport line completed in 1988;
    - Docket No. 105 - the reconstruction of the Stevenson substation, Monroe to Newtown substation, Newtown to Bethel substation, Bethel line completed in 1992; and
    - Docket No. 141 - a new overhead 115-kv line between United Illuminating's Pequonnock substation, Bridgeport, to CL&P's Ely Avenue Junction, Norwalk completed in 1993.

    (Council Administrative Notice Nos. 11, 12, 13, and 14, Docket Nos. 26, 57, 105, and 141 Findings of Fact, Opinion, and Decision and Order.)

70. Between the mid-1970's and 2002, there were over 30 transmission line projects within the SWCT area which increased the existing transmission system capabilities. This included projects to increase conductor clearances above the ground and installing large conductors. Substation work included upgrading or replacing breakers and capacitors, or adding reactors. (Docket No. 217, Findings of Fact No. 36)

71. The Applicants need to upgrade the SWCT infrastructure to meet North American Reliability Council (NERC) and Northeast Power Coordinating Council (NPCC) criteria. (Tr. 3/23/04, p.36)

72. The interconnected electric system is divided into sub-areas as operating regions to monitor system performance and to protect against wide-area interruptions. Electricity flows within the overall system and sub-areas on a free flowing basis. Inter-area flows are maintained within normal limits by adjusting generation schedules. Reserve capability, both generation and transmission, must be maintained to safely

accommodate equipment outages, whether scheduled or unscheduled. (Applicants 4, 2003 Technical Application Vol. 6, SR.3 pp. 8 and 15 Applicants 31, pp. 19 and 20)

73. The SWCT 115-kV interface connections are as follows:

- Frost Bridge - Carmel Hill 1238 line
- Green Hill - Branford 1508 line
- Frost Bridge - Shaws Hill 1445 line
- East Shore - Branford RR 1460 line
- Frost Bridge - Freight 1721 line
- East Shore - English 8100 line
- Frost Bridge - Baldwin Tap 1990 line
- East Shore - Grand Ave. 8200 line
- Southington - Glen Lake Jct. 1610 line
- Southington - Wallingford Jct. 1208 line
- Southington - Lucchini Jct.1690 line
- Plumtree 345/115-kV T1 autotransformer
- Plumtree 345/115-kV T2 autotransformer

The Norwalk – Stamford 115-kV interface connections are as follows:

- Plumtree - Ridgefield 1565 line
- Pequonnock - RESCO 91001 line
- Trumbull Jct. - Old Town 1710 line
- Pequonnock - Compo 1130 line
- Trumbull Jct. - Weston 1730 line

The power-transfer capability over an electrical interface is not the summation of individual line capabilities. Interface limits are determined by computer simulations calculating maximum allowable power transfer levels of pre-defined transmission facilities within prescribed limits of generator stability, equipment current carrying capabilities or permissible ranges of voltage and frequency within an area. These calculations are performed in accordance with local, regional and national criteria. (Applicants 4, 2003 Technical Application Vol. 6, SR.3 pp. 8, 9; and 15; Applicants 31, p. 9))

74. The transfer limit is an indication of how much power can actually be moved into that area of the state. To allow for load growth most major load pockets have transfer limits greater than the area load. Upon completion of the proposed project, transfer limits into Southwest Connecticut would nearly equal the load in this area. (Tr. 3/23/04, p.57)

75. SWCT peak load is approximately 3500 MW. The present transmission facilities have a range of approximately 2200 to 2400 MW. During peak load conditions of 2400 MW, approximately 1100 MW of additional generation is needed to reliably serve load. The proposed project would increase transfer capability to between 3200 and 3400 MW. Approximately 100 to 300 MW of generation would be needed in SWCT upon project completion. As transfer capability limit increases to 3800 MW, another 400 to 500 MW of generation would be needed. (Applicants 31, p. 20; Tr. 3/23/04, p.59)

76. 300 MW of power would be called upon, by ISO-NE, during NEPOOL OP-4 conditions, an emergency procedure action during a capacity deficiency. (Tr. 3/23/04, p.72)

77. A Flexible AC Transmission Solution (FACTS) device increases transmission capability without operator intervention, by adding capacitance to the system when voltage decreases due to the loss of a generator or transmission line. (Applicants 31, p. 36; Tr. 3/23/04, p. 75 p.79)

78. CL&P has installed FACTS devices (such as Dynamic VAR (D-VAR) voltage regulation systems in the Bethel area and a STATCOM at the Glenbrook Substation in Stamford) for local area voltage support and to increase the transfer limit into these areas. However, FACTS devices are not sufficient to address southwest Connecticut's reliability problems without significant transmission improvements. (Applicants 31, p. 36)

79. The loss of one transmission line causes increased flow of electricity in other parallel transmission lines, which can then lead to increased losses and an additional voltage drop. The FACTS equipment operates in a quarter cycle and will inject capacitive current to maintain voltage or inject reactive current to drop voltage in the event of extremely high voltages. (Tr. 3/23/04, pp.76-78)

80. Relays are devices which sense the operating conditions of a transmission line and cause current breakers to trip open if abnormal conditions exist. (Tr. 3/23/04, p.81)

81. If the proposed 345-kV loop in Southwest Connecticut had been in service during the widespread blackout on August 14, 2003, the loop might have allowed CL&P to restore power faster to affected customers after the outage. (Tr. 3/23/04, pp. 82-83, 170)

82. The New England Dispatch Scenarios used in system modeling are as follows; capacities are given in MW.

New England Dispatch Scenarios

Generators	Capacity	Dispatch - 1	Dispatch - 2	Dispatch - 3	Dispatch - 4	Dispatch - 5	Dispatch - 6
Maine							
MIS	549	0	0	0	0	0	0
AEC	173	158	158	15	158	158	0
RPA	273	0	0	0	0	0	0
Westbrook	565	0	563	563	563	563	0
Wyman	875	420	340	400	392	496	26
New Hampshire							
Newington/s	955	0	955	422	422	955	0
Seabrook	1150	1150	1150	1150	1150	1150	1150
Schiller	146	0	146	146	146	146	146
Merrimack	466	320	433	433	113	433	320
Comerford/Moore	356	0	272	272	272	272	272
AES Londonderry	823	0	0	0	0	0	0
NEMA/Boston							
Mystic	2706	558	1517	952	952	1517	565
Salem Harbor	702	0	700	700	700	700	0
New Boston	760	0	380	380	380	380	707
SEMA/RI							
Milford Power	153	0	124	124	124	124	124
ANP Blackstone	580	0	580	290	290	580	0
ANP Bellingham	580	0	0	0	0	0	0
NEA	301	301	249	249	249	249	249
Ocean State Power	524	262	339	339	339	339	0
Brayton Point	1512	605	1084	1084	1084	1084	818
Manchester/FRSQ	495	0	485	485	485	485	425
Hope Energy	545	0	0	0	0	0	0
Sith Fore River	881	0	0	0	0	0	0
Dighton	185	185	185	185	185	185	0
Tiverton	281	281	281	281	281	281	281
Canal	1143	498	1142	1142	1142	1142	1143
Pilgrim	670	670	670	670	670	670	670
W. Mass/VT							
Vermont Yankee	563	496	563	563	563	563	0
Bear Swamp	588	-560	588	294	294	588	0
Northfield	1080	-1000	1080	1080	1080	1080	0
Stony Brook	412	0	0	0	0	0	0
Berkshire Power	305	0	305	305	305	305	280
Millennium	390	390	390	390	390	390	390
Connecticut							
Lake Road	840	0	840	840	840	840	0
Milistone	2008	2008	2000	2000	2000	2000	1137
Middletown	771	0	750	750	750	750	517
Montville	489	0	483	483	483	483	0
Meriden	586	586	586	586	586	586	586
Milford	610	280	280	560	560	0	585
Wallingford	255	0	0	255	255	0	255
Towantic	550	0	0	515	515	0	548
South Meadow	186	0	0	0	0	0	0
New Haven Harbor	447	447	447	447	447	447	447
Bridgeport Harbor	567	375	375	375	375	375	0
Bridgeport Energy	520	0	0	520	520	0	520
Norwalk Harbor	330	0	0	0	329	329	0
Devon	382	0	212	212	212	0	0
Interfaces	**Limit**						
NB-NE	700	700	700	700	700	700	700
Highgate	225	150	225	225	225	225	225
Phase II	2000	0	2000	2000	2000	2000	2000
ME-NH	1400	686	384	444	436	539	-229
NNE-Scobie	2550	1603	1927	1482	1382	2066	692
North-South	2700	2145	1575	1136	807	1714	148
East-West	2000	257	443	-869	-1198	590	574
NY-NE	±700	14	-6	-8	-8	-3	19
PV-20	150	110	110	110	110	110	110
Boston Import	3500	1529	2513	3080	3084	2514	2336
SEMA/RI Export	2200	740	731	441	440	731	1296
Conn. Import	2200	-1018	1484	-120	-857	1237	495
SWCT Import	2000	660	3126	1556	822	2880	669
Norwalk-Stamford	1100	516	1530	1531	799	795	904
1385 Cable Export	±200	0	200	200	-199	-200	0
481 Cable Export	355	352	352	352	352	352	352

(Applicants 4, 2003 Technical Application Vol. 6, SR.3 pp. 12 and 13)

83. The generation dispatches that were modeled at each load level are as follows:

New England Load Level	Dispatches Modeled
30,000 MW	**2,3,4,5**
27,700 MW	**2,3,4,5**
19,000 MW	**4,6**
11,400 MW	**1**

(Applicants 4, 2003 Technical Application Vol. 6, SR.3 pp. 12 and 13)

84. The proposed 345-kV line, by itself, addresses voltage criteria violations in the SWCT system. New 115-kV transmission lines would not adequately resolve these voltage criteria violations. (Applicants 4, 2003 Technical Application Vol. 6, SR.3 pp. 12 and 13)

No Action Alternative

85. A no action alternative means no improvements would be made to the existing transmission infrastructure or generation resources in SWCT. This course of action would continue to place the SWCT region at an ever-growing risk for electric outages while incurring increasing congestion charges. Moreover, a no-action alternative would increase the number of violations of national and regional reliability standards. (Applicants 1, Vol. 1, pp. G-4-G-5)

All 115-kV Alternative

86. A 115-kV transmission system was considered and rejected because reinforcement of the existing SWCT 115-kV system would require extensive upgrades to multiple rights-of-way as well as exacerbating problems of high short-circuit duty and the installation of modern efficient generation. (Applicants 31, p. 38)

87. The rebuild of the existing 115-kV transmission grid in southwest Connecticut would require modification to 111 miles of existing ROWs, creation of 37 miles of new ROWs, 155 miles of new underground 115-kV lines, and 32 substations including some STATCOMs and phase shifting transformers. (Applicants 1, Vol. 1, p. G-15)

An All Underground Alternative

88. An all underground route within the existing transmission line ROW would require construction within steep terrain, rock outcroppings, inland wetlands, and watercourses. (Applicants 1, Vol 1, pp. 21 to 24)

89. An all underground route using public road rights-of way would add an additional 10 miles to the proposed approximately 69 mile route. For each overhead 345-kV circuit, at least two circuits of underground cable would be required to achieve minimal reliability and equivalent capacity. An all underground scenario would require four circuits for the 9.1 mile section between Oxbow Junction and Beseck Switching Station, eight circuits for the 4 miles between Black Pond Junction and Beseck, and three circuits for the 30.4 miles between Beseck and East Devon which totals approximately 159 circuit-miles of cable in addition to the 48 circuit-miles proposed between the proposed East Devon and existing Norwalk substations. (Applicants 44, Q. 28)

90. An all underground route would require two or three substations or switching stations between Beseck and East Devon, where very large amounts of reactive compensation would be installed to offset the high amount of cable capacitive charging current. (Applicants 44, Q. 28)

91. The Applicants did not study an underground route from Millstone to East Devon because the length of cable required would far exceed the capability of what can be achieved with alternating current design. (Tr. 4/22/04, p. 72)

Generation Alternative

92. The Applicants now do not own or control electric generation. Siting and operation of electric generating facilities is driven by market forces, independent of transmission planning. Historically, the generation and transmission of electricity was an integrated process where utility companies would plan for both generation and transmission when and where supply resources, required to meet demand. However, in 1998, Connecticut legislation created a competitive energy marketplace and, accordingly, state utilities were required to divest themselves of their electric generating facilities. (Applicants 1, Vol. 1, pp. G-4-G-5)

93. New electric generating facilities that have been certificated and constructed in SWCT since 1998 include the Bridgeport Energy facility and the Milford Power facility (Applicants 1, Vol. 1, p. G-5)

94. Distributed generation (DG) is small modular electric generation or storage technology typically installed at the customer's point of use. DG can be used for emergency generation, back-up power, peak-load shaving, premium power for critical loads (i.e. computer operated equipment), and combined heat and power. (Applicants 32, p. 12; ISO-NE 1, p. 33)

95. RTEP03 projects DG will grow slowly over the next 10 to 15 years, and as much as 21 to 186 MW of DG will be developed in SWCT by 2013. Obstacles to DG technologies include lack of technology maturation and reliability, cost associated to economy of scale, regulatory barriers (air permitting), and ISO-NE's ability to dispatch during peak load events. While these resources have a limited role in meeting future load growth, DG cannot alleviate the reliability concerns and operating constraints of a large bulk power transmission system. (Applicants 32, pp. 12-13; Applicants Administrative Notice No. 12, p.121; Council Administrative Notice No. 8, p. 9; Tr. 3/23/04, p. 156)

Conservation and Demand Response Alternative

96. Conservation and Load Management (C&LM) programs are implemented by the state's utilities with input from the Connecticut Energy Conservation Management Board. Such programs include Energy Star appliances, high efficiency fluorescent lighting, high efficiency heating/cooling systems and variable speed motors. (Applicants 1, Vol. 1, p. G-9)

97. C&LM funding was established by the State's legislature and is derived from an assessment of 3 mils per kilowatt hour of electricity sold to each customer. However, due to State budget revenue shortfalls, recent legislation transferred some C&LM funds (44 percent of the year 2004 funding) into the State's general fund account effective through 2011, thereby reducing available resources to further conserve electric consumption. (Applicants 1, Vol. 1, p. G-8; Applicants 32, p. 9)

98. For the C&LM plan year of 2003-2004, both CL&P and UI spent about $90 million with an energy savings of approximately 108 MW statewide. About $55 million was expended in SWCT with an approximate energy savings of 70 MW. Projected cumulative summer peak load reduction in 2006 from C&LM programs between CL&P and UI is expected to be about 985 MW, which is roughly equivalent to a very large electric generating facility. (Applicants 1, Vol. 1, p. G-9; Applicants 32, pp. 8-9)

99. C&LM programs have been targeted to SWCT pursuant to the DPUC decision in Docket No. 03-11-01 with special efforts targeting such uses as air conditioning equipment for residential, commercial and

industrial customers. Present expenditures have been directed at the most targets, so it is most likely that future MW peak reduction would require more dollars per MW than the savings have achieved so far. (Applicants 32, p. 10)

100. Conservation programs have been focused in SWCT for several years due to transmission congestion in the area. CL&P has marketed conservation programs to replace existing equipment with more efficient equipment. (Tr. 3/23/04, p.37)

101. Demand response programs are typically used by commercial and industrial end users. Customers receive incentive payments for reducing electricity consumption during peak demand. In Connecticut, the utilities enrolled about 50 MW of demand response for load reduction, of which 32 MW is in SWCT. (Applicants 1, Vol. 1, pp. G-9 and G-10; Applicants 32, p. 11)

102. Both conservation and demand response programs are customer driven. Implementation is at the customer's discretion. Because of the nature of this arrangement, C&LM programs alone cannot provide a complete solution to the capacity and reliability problems that exist in SWCT. (Applicants 1, Vol. 1, p. G-9; Applicants 32, p. 10)

103. The Applicants have relied on conservation and load management to hold the load down to current levels. Approximately 450 MW of peak load reduction has been accounted for via conservation and load managements. (Tr. 3/23/04, p.33)

104. CL&P does not believe the problems in SWCT can be solved by the use of conservation and load management, demand-side management and using both STATCOMs and D-VARS. (Tr. 3/23/04. p.34)

High Voltage Direct Current Technology Alternative

105. ABB was engaged by Northeast Utilities to study a DC based underground option from Beseck to Norwalk as an alternative to the proposed Phase II AC solution. The study considered the HVDC alternative relative to system criteria established by Northeast Utilities and ISO New England. ABB developed three underground HVDC alternatives which it believed were technologically feasible. (Tr. 12/15/04, p. 46, 47)

106. ABB Limited is based in Zurich, Switzerland. ABB, Inc., based in the U.S., and ABB Power Technologies, based in Sweden, are affiliated ABB companies. (Tr. 12/15/04, p. 44, 45)

107. ABB Power Technologies division is a provider of transmission and distribution equipment and systems. ABB supplies equipment to electric utilities including AC and DC systems, electric equipment such as transformers and circuit breakers, power electronics equipment such as STATCOMs, static VAR compensators, and high voltage DC. (Tr. 12/15/04, p. 45)

108. ABB is the only manufacturer of the HVDC cable and the Voltage Source Converter (VSC) converter that was evaluated for use in this project. (Tr. 12/15/04, p. 92)

109. ABB has used HVDC technology since 1954 and the VSC HVDC technology since 1997. (Tr. 12/15/04, p. 258)

110. There are two types of HVDC systems: Classic and DC Light. Classic HVDC does not have the ability for instantaneous load pick-up, and causes harmonics to be introduced into the system. DC Light does have instantaneous pick-up and does not introduce harmonics into the system; however placing multiple circuits in parallel has never been done with this technology. ABB is the sole supplier of HVDC Light technology. (Tr. 06/15/04, p. 110; Tr. 7/29/04, p. 153)

111. HVDC facilitates power flow but does not provide strength in an AC system. (Tr. 06/15/04, p. 111)

112. The cost to construct an HVDC system for the proposed project is estimated at between $1.73 to 2.0 billion. (Applicants, 178, pp. 6-7)

113. In the event of a power outage, an HVDC cable does not have the capability of independently starting up. Strong AC sources are needed to operate a DC system. (Tr. 06/15/04, p. 88, 116)

114. The construction of a substation and converter station associated with DC Light would require approximately four acres of land area. (Tr. 06/15/04, p. 129)

115. The construction of a switching station and a converter station with 2,000 MW capacity located at East Devon would require the acquisition of approximately 24 acres of land. There is approximately 30 acres of land owned by CL&P at the Beseck switching station, which would be adequate space for a converter station at that end. (Tr. 06/15/04, p. 130, 131)

116. An all-overhead DC line would require approximately 75-foot high structures to be added along the right-of-way. (Tr. 06/15/04, p. 157)

117. For VSC HVDC there are energy losses on the converters, the stations, and the cables themselves. (Tr. 12/15/04, p. 100)

118. Aspects of expandability include the interconnection of new generation, the ability to add a substation to strengthen the system, and the ability to incrementally increase the capacity on the system. (Tr. 12/15/04, p. 120, 121)

119. There are no multi-terminal VSC HVDC installations currently in existence. (Tr. 12/15/04, p. 127)

120. Each converter station would cost approximately 51 million dollars at 370MW, which includes the converter box and the breakers needed to connect it to an AC substation. (Tr. 12/15/04, pp. 136-138)

121. To connect a generator to a VSC HVDC line would cost much more than to connect to a 345-kV overhead AC line because of the high cost of the converter. (Tr. 12/15/04, p. 285, 286)

122. Redundancy is used in auxiliary systems, control systems, and cooling systems. Under such redundancy arrangements, failures can occur on main circuit equipment and the system may continue to operate without derating. An outage of a transformer in the main circuit would cause a forced outage of the converter station. (Tr. 12/15/04, p. 139)

123. DC lines would not become overloaded in the event of a contingency on the AC system because their power flow can be controlled. (Tr. 12/15/04, p. 174)

124. ABB recommends control techniques for HVDC projects that are operated in parallel to AC projects. The simplest is a bipolar system, which is similar to an AC system, which directs that if one line goes out the other automatically compensates. At stations where generation use DC as an outlet, there is an automatic scheduling protocol that can allocate a portion of the generator dispatch to the DC system and allow another portion to remain on the AC. system (Tr. 12/15/04, p. 190, 191)

125. The duct bank for the VSC HVDC cable would have an average depth of approximately three and a half feet. The deepest burial of the cables that is expected is approximately 60 inches. (Tr. 12/15/04, p. 248)

126. If the VSC HVDC cable is buried deeper, the conductor would need to be larger to maintain the same rating on the cable because of problems which would occur with heat transfer away from the cable. (Tr. 12/15/04, p. 248, 249)

127. Magnetic fields from DC cables are static fields similar to those of the earth's magnetic field. The magnetic field would increase with greater spacing between the cables. (Tr. 12/15/04, p. 250)

128. An HVDC cable could be buried at the edge of the transmission line right-of-way, as long as there are access roads to the cable or in the streets. (Tr. 12/15/04, p. 256)

129. Integrating additional converter stations along the line is possible but would materially complicate operation. (Tr. 12/15/04, p. 274, 275)

130. A voltage source converter is expected to have approximately three forced outages per year. (Tr. 12/15/04, p. 279)

131. The control and operation of a VSC HVDC system would be more complex than a conventional AC system due to the scheduling of power. (Tr. 12/15/04, p. 285)

132. The amount of space required for two 530 MW converter stations would be approximately 377 feet in length by 476 feet in width. (Tr. 12/15/04, p. 296)

133. AC system line losses are estimated at about 1.2 percent. (Tr. 7/29/04, p. 96)

134. VSC DC technology generally has substantially lower space requirements than conventional DC. A conventional converter station in East Devon would require approximately 10 acres of land with DC light and stacking the 330 MW units would require 8 acres (plus the AC interconnection). (Tr. 7/29/04, p 107-108)

135. CL&P would have to acquire two parcels of land to the west of the proposed project in East Devon, and the land may be available. (Tr. 7/29, p. 108-109)

136. There is an electrical interaction between an AC line and a DC line which can affect conventional DC lines. Blocking filters can be placed on the DC system if needed. (Tr. 7/29/04, p. 123)

137. A blocking filter is a device to prevent alternating current induced in the DC line which could damage equipment. Blocking filters are terminal equipment typically placed in a converter station. (Tr. 7/29/04, p. 123-125)

138. All HVDC source converter transmission lines to date have been placed underground. ABB has never installed a VSC HVDC link above ground. (Tr. 7/29/04, p. 126)

139. If a DC system were to be installed between the Beseck and East Devon substations, the line north of Beseck would probably have to be installed overhead. (Tr. 7/29/04, p. 130)

140. Installation of a DC terminal at Millstone would be the first of its kind and the Applicants have concerns related to harmonics and the interface between the terminal and the generating plant. (Tr. 4/22/04, p. 77)

141. Installing a 115-kV line and also a DC cable with both circuits on a single monopole or lattice tower is not known to have ever been done. (Tr. 7/29/04, p. 132)

142. An all-DC solution may preclude any additional generation from ever being installed between Beseck and Norwalk due to the additional costs of a 100 to 150 million dollar for each generator connection and the difficulty in recovering these high costs. (Tr. 7/29/04, p. 139)

143. Having generators off-line increases the need for the capacitors for voltage support of a system. (Tr. 7/29/04, p. 144)

144. Harmonic impedance in the current system range from 2.9 to 8.8. (Tr. 7/29/04, p. 146)

145. Voltage source converter use would not further weaken the CL&P system. Conventional HVDC use would weaken the system.(Tr. 7/29/04, p. 146-147)

146. A voltage source converter can be used to black start a system, which would be an advantage over conventional DC. (Tr. 7/29/04, p. 150)

147. A "commercial orphan" occurs when a manufacturer with a new technology finds insufficient business to sustain that technology and exits the business. Owners of that equipment would be left without technical support. HVDC Light may be considered an immature technology, which is therefore at risk of becoming a commercial orphan because of small demand. (Tr. 7/29/04, p. 155, p. 162)

148. GE studied the DC alternative from Beseck to East Devon, with two alternatives for the AC cable running from East Devon west to Norwalk (one was HPFF and the other XLPE.) For the HPFF alternative, the Bethel-Norwalk line was modeled as the composite of XLPE for a short-distance overhead line with two HPFF cables in 8.7 mile segments. For the XLPE option for the East Devon-Norwalk transmission system, GE modeled the Bethel-Norwalk 345-kV circuit with one of the two HPFF cables out of service to reduce capacitance. (Tr. 7/29/04, p. 159-160)

149. Any DC option from Beseck to East Devon would have technical limitations. Conventional DC for that segment would be most impractical. A VSC DC would be an engineering challenge because of weakening of the system with the capacitance still there. A fully DC system from Beseck to Norwalk with conventional DC would be infeasible because of weakness of the system. (Tr. 7/29/04, p. 161)

150. One of the detriments of using synchronous condensers to correct power faults is that they contribute to short-circuit problems. (Tr. 7/29/04, p. 171)

151. 14 converter units would be required at four locations, to install VSC in a total DC option. (Tr. 7/29/04, p. 173)

152. To install DC from East Devon to Beseck would require 2 locations with eight 330 MW converter units. The flow of DC is highly controllable and can therefore be set to maintain certain amperage. (Tr. 7/29/04, p. 173-175)

153. DC can behave like a generator. HVDC has been used to integrate generation from remote locations into locations of need. (Tr. 7/29/04, p. 174)

154. The Applicants have no plans to develop new substations between East Devon and Beseck. (Tr. 7/29/04, p. 184)

155. Voltage source DC is more amenable to a multi-terminal structure than conventional DC. (Tr. 7/29/04, p. 195)

156. HVDC does not provide instantaneous backup upon component loss as would an AC alternate. (Applicants 15, Q. D-W-14; Applicants 54, p. 20)

157. Direct costs of an HVDC underground facility are approximately 5.5 times that for an equivalent AC facility. The primary reason for higher cost is the need for converter stations at the terminals to convert AC to DC and vice versa. (Applicants 15, Q. D-W-14)

158. HVDC is a viable technology for submarine installations, because no reactive compensation is needed, unlike AC technology, which requires reactive compensation stations to offset changing current. (Applicants 15, Q. D-W-14)

159. AC/DC converters require installation of capacitive reactance. For a 1,200 MW HVDC line, synchronous or static capacitance would range from 480 to 660 MVAR, or about 50 percent of the line rating. (Applicants 15, Q. D-W-14)

160. AC/DC converters generate harmonics, and filters (for AC) and reactors (for DC) would be required to mitigate this harmonic interference. This equipment requires a large amount of space and is typically noisy. (Applicants 15, Q. D-W-14)

161. One of ISO's concerns about an embedded HVDC system is that it is not a typical application and did not meet operability and reliability criteria of the Reliability and Operating Committee (ROC). HVDC has been used more to link systems of different frequencies and for scheduled point-to-point deliveries from one system to another. (Tr. 1/13/05, p. 143)

162. ISO did not collaborate with ABB to develop and test a model in scheduling of DC links into ISO's Security Constrained Unit Commitment and Security Constrained Economic Dispatch System. (Tr. 1/13/05, p. 147)

163. ISO and the Applicants believe that their experience and knowledge of VSC HVDC systems and their feasibility and reliability are more credible than that of ABB. (Tr. 1/13/05, p. 155)

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164. The route was determined by first establishing the best strong source, which is the Beseck area in Wallingford. Then the strong source has to be connected to intermediate terminals, which are East Devon Substation, and Singer Substation, and finally terminating in Norwalk. (Tr. 06/01/04, p. 11)

165. The route evaluation criteria used to identify and investigate potential overhead and underground routes are: system benefit [operability and reliability], technical feasibility [can it be engineered and can it be built?], property impact [impact to home and property and visual impact], environmental impact [impact to wildlife, vernal pools, aquifers], and cost. (CL&P 1, Vol. 1, p. ES-5; Applicants 44, Q. 28)

166. The following assumptions were used by the Applicants to evaluate the selection of an overhead transmission route for the 345-kV Middletown to Norwalk Project:

- maximize the use of existing linear corridors (existing gas and electric rights-of-way, highway, railroad);
- minimize conflicts with developed areas (local, state, and federal land use plans, public health and safety, condemnation or voluntary sale of property);
- consideration of visual impacts (residents, historic, scenic resources);
- avoid or minimize impacts to environmental resources;
- construction feasibility constraints; and
- accessibility.

(Applicants 1, Vol. 1, p. H-4; Applicants 54, p. 7-9)

167. The National Electric Safety Code (NESC) establishes the minimum design levels and clearances that must be maintained for public safety such as: structure height, distance between structures (span lengths), conductor and shield wire tensions, structure configurations, and ROW widths. (Applicants 1, Vol. 1, p. I-57 and I-58)

168. A basic structure configuration, such as a vertical configuration, requires the narrowest ROW, but has the tallest structure. H-frame configuration uses the shortest structure, but has the widest ROW and delta configuration blends the features of both the vertical and H-frame configurations. Available ROW is a factor in determining options for the structure configuration. If additional ROW is made available, some variations in the design may be possible and structure heights may be reduced. (Applicants 1, Vol. 1, p. I-57 and I-58)

169. Taller structures with higher tensions could be used to span greater distances and thus reduce the number of structures. However, this places structures in new locations and increases the visual impact due to increased heights. Tension on the line has been increased from company standards in areas that were not prone to wind vibration, low level, steady state wind-induced vibration, which can cause fatigue on the conductor and is more likely to occur at higher tensions. Although the tensions have not exceeded the NESC limits, they have been increased from company standard values. These higher tensions would require the use of dampers on the lines to absorb this vibration. (Applicants 1, Vol. 1, p. I-57 and I-58)

170. The proposed 345-kV transmission line will be located overhead for approximately 45 miles from CL&P's existing Scovill Rock Switching Station to the proposed East Devon Substation (Segments 1 and 2). The proposed line will be installed underground for approximately 24 miles from the proposed East Devon Substation to UI's proposed Singer Substation to the existing Norwalk Substation (Segments 3 and 4). See Appendix C. (Applicants 1, Vol. I, p ES-2)

171. The following table describes characteristics of the existing and proposed overhead ROW:

Proposed Route: Summary Characteristics of Overhead Portion (as in 10/9/03 Application)

Transmission Line Section (Municipality)	Approx. Mileage	Existing Structure Configurations and Typical ROW Width		Proposed 345-kV/Reconstructed 115-kV Configurations and Typical ROW Width[1]	
		Structure Type and Height[2]	**ROW Width (feet)**	**Structure Type and Height[2]**	**ROW Width (feet)**
Segment 1 See Figure I-1					
Scovill Rock Switching Station - (Middletown)	2.5	Two 345-kV circuits supported on wood H-frame structures, with a typical height of 80 feet and heights ranging between 61 and 102 feet.	250	Install one steel or laminated 345-kV H-frame, with a typical height of 80 feet and heights ranging between 65 and 120 feet. Two existing 345-kV H-frames would remain.	335 (85 feet of additional ROW required, for non-CL&P owned property)
Oxbow Junction Beseck Switching Station (Middletown, Haddam, Durham Middlefield, Wallingford)	7.0	Two existing 115-kV circuits supported on wood H-frame structures, with a typical height of 57 feet and heights ranging between 43 and 61 feet.	125	Install one steel composite (115-kV/345-kV) monopole, with a typical height of 105 feet and heights ranging between 92 and 157. Existing 157-kV wood H-frame structures would be removed.	125 (no additional ROW required)
Black Pond Junction to East Meriden Substation (Meriden)	1.4	One 345-kV circuit supported on steel monopoles with a typical height of 130 feet and heights ranging between 115 and 160 feet.	275	Install two steel 345-kV single circuit monopoles, each with a typical height of 130 feet and heights ranging between 120 and 165 feet. Existing steel 345-kV monopoles would remain, but would be modified.	275 (no additional ROW required)
East Meriden Substation to Beseck Switching Station (Meriden, Wallingford)	1.4	Two circuits, one 115-kV supported on wood H-frames with a typical height of 57 feet and heights ranging between 48 and 57 feet and one 345-kV circuit supported on steel 345-kV single circuit monopoles with a typical height of 130 feet and heights ranging between 120 and 145;	320	Install two steel composite (115-kV/345-kV) monopoles, each with a typical height of 130 feet, and heights ranging between 105 and 160 feet in height. Existing steel 345-kV monopoles would remain, but would be modified. Existing wood 115-kV H Frame would be removed.	320 (no additional ROW required)

[1]Figure Nos. refer to Typical Cross-Sections Drawing No. CS-001 Figures 1-22 in Volume 10.

[2]The typical height refers to the height of the structures under certain prescribed conditions in topography and the line layout. Individual Structure heights may vary from this value.

The range in height refers to the variation in height between the shortest structure and the tallest structure, based on the layout of the line. The range in height is caused by topography conditions and engineering design criteria.

Proposed Route: Summary Characteristics of Overhead Portion (Continued)

Transmission Line Section (Municipality)	Approx. Mileage	Existing Structure Configurations and Typical ROW Width		Proposed 345-kV/Reconstructed 115-kV Configurations and Typical ROW Width[1]	
		Structure Type and Height[2]	ROW Width (feet)	Structure Type and Height[2]	ROW Width (feet)
Segment 2 See Figure I-2					
Beseck Switching Station to East Wallingford Junction (Wallingford)	5.9	One 345-kV circuit supported one wood H-frame structures with a typical height of 90 feet and heights ranging between 70 and 110 feet.	275	Install one steel 345-kV H-frame structure, with a typical height of 90 feet, and heights ranging between 75 and 140 feet. Existing 345-kV H-frame structures would remain.	275 (no additional ROW required)
East Wallingford Beseck Switching Station (Wallingford)	2.1	One 115-kV circuit supported on wood H-frame structures with a typical height of 57 feet and heights ranging between 57 and 79 feet.	200	Install one steel composite (115-kV/345-kV) monopole with a typical height of 105 feet and heights ranging between 102 and 158 feet. Existing 115-kV H-frame structures would be removed.	200 (no additional ROW required)
Wallingford Junction to Cook Hill Junction[3] (Wallingford and Cheshire)	2.9	Two 115-kV circuits supported on steel double-circuit lattice towers, with a typical height of 90 feet and heights ranging between 89 and 109 feet.	200	Install one steel 345-kV delta monopole structure, with a typical height of 108 feet and heights ranging between 98 and 128 feet. Existing 115-kV lattice steel structures would remain.	200 (no additional ROW required)

[1]Figure Nos. refer to Typical Cross-Sections Drawing No. XS-001 Figures 1-22 in Volume 10.

[2]The typical height refers to the height of the structures under certain prescribed conditions in topography and the line layout. Individual Structure heights may vary from this value.

The range in height refers to the variation in height between the shortest structure and the tallest structure, based on the layout of the line. The range in height is caused by topography conditions and engineering design criteria.

[3]The supported change in Cheshire, beginning near the Cheshire town line and extending to Cook Hill Junction, would place one of the 115-kV circuits underground along Old Farms Road to allow installation of one steel composite (115/345-kV) monopole with a typical height of 130 feet, and heights ranging between 125 and 140 feet, to carry both the new 345-kV and the existing 115-kV lines in the ROW. (Figure 7B)

Proposed Route: Summary Characteristics of Overhead Portion (Continued)

Transmission Line Section (Municipality)	Approx. Mileage	Existing Structure Configurations and Typical ROW Width		Proposed 345-kV/Reconstructed 115-kV Configurations and Typical ROW Width[1]
		Structure Type and Height[2]	ROW Width (feet)	Structure Type and Height[2]
Cook Hill Junction to East Devon Substation (Cheshire, Hamden Bethany, Woodbridge Orange, West Haven, Milford)	22.5	Two 115-kV circuits each supported on wood H-frame structures, with a typical height of 57 feet, and heights ranging between 43 and 79 feet and one 115-kV circuit* supported on a steel lattice tower, with a typical height of 80 feet and heights ranging between 80 and 101 feet. *This was originally two separate circuits now tied Together to operate as one.	165	Install one steel 345-kV delta monopole, with a typical height of 85 feet, and heights ranging between 70 and 123 feet. Install one steel 115-kV double circuit monopole for the reconstructed 115-kV lines with a typical height of 80 feet, and heights ranging between 60 and 120 feet. Existing 115-kV wood H-frames and 115-kV lattice steel towers would be removed. One of the 115=kV lines is to be de-energized and removed from service.

172. The following table describes characteristics of the proposed underground route:

Proposed Route: Summary Characteristics of Underground Portion

Transmission Line Section (Municipality)	**Approx. Mileage**	**Description of Proposed Route**	**Description of Proposed Facilities**
Segment 3 See Figure I-3			
East Devon Substation (Milford, Stratford, Bridgeport)	8.1	Primarily along municipal streets and along U.S. Route 1. Would involve crossings of Housatonic River, Bruce Brook, Yellow Mill Creek, and Pequonnock River.	The design of the duct bank for the proposed 345-kV circuit design consists of two 8" pipes, spaced 24" on center, each containing three phases of the new underground HPFF 345-kV line, backfilled with a thermal material and placed in a trench 4' wide and 5' deep. The duck bank will also include 2-5" steel pipes, to permit future installation of an insulating fluid circulation system, and 2-3" PVC conduits associated with the installation of fiber optic cable for relaying purposes. Splicing vaults, 8'H x 8'W x up to 28'L, would be buried approximately 2000' apart along the route. Additional underground ROW would be required in instances when the crossing of watercourses requires an alignment of the underground cables to avoid the bridges and thereby located outside of the roadway ROW.
Segment 4 See Figure I-4			
Singer Substation to Norwalk Substation (Bridgeport, Fairfield, Westport, Norwalk)	15.5	Primarily along municipal streets and along U.S. Route 1. Would involve crossings of Ash Creek, Southport Harbor, Sasco Creek Deadman's Brook, Willow Brook, Saugatuck River, Stony Brook and Norwalk River.	Same facilities as above.

(Applicants 1, Vol. 1 pp. I-8 to I-10; Applicants 1, Vol 1 p. I-11)

173. The towns and cities and distance of the proposed overhead and underground transmission lines.
(Overhead = OH Underground = UG)

	Proposed Route w/ supported changes	Alternate A Route	Alternate B Route
Bethany	2.6 OH	2.6 OH	2.6 OH
Bridgeport	6.3 UG	5.5 UG	5.9 (2.0 UG) (3.9 OH)
Cheshire	0.9 OH	0.9 OH	0.9 OH
Durham	5.0 OH	5.0 OH	5.0 OH
Easton	N/A	1.0 OH	1.0 OH
Fairfield	3.6 UG	(2.9 OH) (3.0 UG)	5.2 OH
Haddam	0.2 OH	0.2 OH	0.2 OH
Hamden	3.7 OH	3.7 OH	3.7 OH
Meriden	2.3 OH	2.3 OH	2.3 OH
Middlefield	0.7 OH	0.7 OH	0.7 OH
Middletown	3.1 OH	3.1 OH	3.1 OH
Milford	5.5 (3.4 OH) (2.1 UG)	5.5 (3.4 OH) (2.1 UG)	4.7 OH
Norwalk	3.1 UG	2.5 OH	2.5 OH
Orange	5.9 OH	5.9 OH	5.9 OH
Stratford	2.8 UG	2.8 UG	3.8 OH
Trumbull	N/A	N/A	3.1 OH
Wallingford	11.5 OH	11.5 OH	11.5 OH
West Haven	0.1 OH	0.1 OH	0.1 OH
Weston	N/A	2.7 OH	2.7 OH
Westport	5.0 UG	N/A	N/A
Wilton	N/A	3.4 OH	3.4 OH
Woodbridge	6.2 OH	6.2 OH	6.2 OH
Total	**68.5 miles**	**73.1 miles**	**74.5 miles**

(Applicants 1, Vol. 1, pp. I-20, I-38, I-53)

174. The components of the proposed project are as follows:

- Bundled 1590-kcmil ACSR conductor (2040 MVA summer normal capacity) would be used for the new overhead 345-kV segments from the Scovill Rock Switching Station to Beseck Switching Station to East Devon Substation.
- Two sets of 3000-kcmil XLPE cable (1650 MVA summer normal capacity) would be used for the new underground 345-kV segments from East Devon Substation to Singer Substation to Norwalk Substation.
- One 1590-kcmil ACSR conductor (340 MVA summer normal capacity) would be used for the rebuilt overhead 115-kV segments from Scovill Rock Switching Station to Beseck Switching Station to East Devon Substation.
(Applicants 1, Vol. 1, p. I-21, Vol. 6, Cable Tutorial p. 10, Vol. 9, Segment Nos. 61, 61A, and 62)

175. The existing Scovill Rock Switching Station is located off Freeman Road in Middletown. (An existing 420-foot by 535-foot fenced compound would not be expanded.) The Applicants would:

- Install one new 345-kV line position with associated equipment which would connect to the Southington Substation. This equipment includes two 345-kV circuit breakers, four 345-kV disconnect switches, other associated equipment, and bus supports. The new 345-kV line termination structure would be approximately 90 feet high, similar to the existing line termination structures.
(Applicants 1, Vol. 1, p. I-23, H-4421)

176. To construct an overhead transmission line between Scovill Rock Switching Station to Beseck Switching Station (Segment 1) the Applicants would:

- Build an OH 345-kV line (2-1590 kcmil ACSR) from Scovill Rock Switching Station to Chestnut Jct and connect it to the existing 348 Line (western section)
- Build an OH 345-kV line (2-1590 kcmil ACSR) from Beseck Switching Station to Oxbow Jct and connect it to the 348 Line (eastern section)
- De-energize the 348 Line between Chestnut Jct and Oxbow Jct
- Split the existing 362 Line at Black Pond Jct and loop it through the Beseck Switching Station
- Rebuild the 1975 Line (1-1590 kcmil ACSR) between Oxbow Jct and East Meriden Substation
- Rebuild the 1466 Line (1-1590 kcmil ACSR) between East Meriden Substation and Beseck Switching Station
  (Applicants 1, Vol. 1, p. I-12)

177. The proposed Beseck Switching Station would be a new facility to be located north and west of the intersection of Carpenter Lane and High Hill Road in the Town of Wallingford. This new switching station would occupy approximately 5.4 acres of a 52 acre parcel currently owned by CL&P. This property is located within an area zoned "Industrial Expansion District – IX".
To construct the switching station, the Applicants would:

- Install four new 345-kV line positions with associated equipment to allow termination of lines from Southington, Haddam Neck, East Devon and Millstone. The switching station yard would be graded and fenced to allow the future installation of four additional 345-kV line positions and associated equipment without expansion of the yard.
- A 345-kV air-insulated outdoor breaker-and-one-half bus arrangement consisting of steel structures, porcelain insulators, aluminum tubular bus conductor, seven circuit breakers, twenty disconnect switches and other associated equipment;
- A new 32-foot by 56-foot by 10-foot high equipment enclosure for protective relay, control, and communications equipment; and
- An emergency generator is expected to be installed. The emergency generator would burn either diesel or propane fuel. If the emergency generator is a diesel generator, a diesel fuel tank with spill prevention measures or leak detection measures would be installed.
  (Applicants 1, Vol. 1, pp. I-23 and I-24)

178. To construct an overhead transmission line between the Beseck Switching Station and the East Devon Substation (Segment 2) the Applicants would:

- Build an OH 345-kV line (2-1590 kcmil ACSR) from Beseck Switching Station to East Devon Substation;
- Rebuild the 1655 Line (1-1590 kcmil ACSR) between East Wallingford Jct and New Haven Jct;
- Rebuild the 1630 Line (1-1590 kcmil ACSR) between New Haven Jct and Pent Road Jct (does not include the taps to WALREC and to Wallingford);
- Rebuild the 1640 Line (UG 3000 kcmil XLPE) for approximately 2100' easterly and approximately 2800' southerly from Cook Hill Jct;
- Reconductor the 1208 Line for approximately 2,100' easterly from Cook Hill Junction;
- Rebuild the 1640, 1610 and 1685 Lines (1-1590 kcmil ACSR) between Cook Hill Jct and Devon 7R Substation (does not include the tap to June Street Substation and Mix Avenue Substation); and
- De-energize and remove from service the 1690 Line from Cook Hill Jct to Devon 7R
  (Applicants 1, Vol. 1, p. I-12; Vol. 9 segment 45)

179. The proposed East Devon Substation would be a new facility located south of the intersection of Shelland Street and Plains Road, adjacent to the Milford Power generating facility, in the Town of Milford. The Applicants would have to acquire this 15 acre site from a private landowner. This property is located within an area zoned "Housatonic Design District – HDD." To construct the substation the Applicants would:

- Install 345-kV breakers, one 345/115-kV auto transformer, and other equipment, three new 345-kV line positions with associated equipment to allow termination of lines to Beseck and Singer, and four new 115-kV line positions and associated equipment to allow termination of lines to the Milford Power generating facility and to Devon Power Plant Substation;
- A 345-kV air-insulated outdoor breaker-and-a-half bus arrangement consisting of steel structures, porcelain insulators, aluminum tubular bus conductor, seven circuit breakers, two circuit switchers, twenty-one disconnect switches, and other associated equipment.
- A 115-kV air-insulated outdoor breaker-and-a-half bus arrangement consisting of steel structures, porcelain insulators, aluminum tubular bus conductor, eight circuit breakers, twenty-six disconnect switches, two circuit switchers, two current limiting reactors and other associated equipment;
- One 600 MVA 345/115-kV autotransformer consisting of one bank of three 200 MVA single-phase units and the required insulating fluid spill containment measures;
- New 32-foot by 110-foot by 10-foot high enclosure to house protective relay, control, and communications equipment;
- An emergency generator which would burn either diesel or propane fuel. If the emergency generator is a diesel generator, a diesel fuel tank with spill prevention measures or leak detection measures as required would be installed; and
- A 115-kV overhead line would serve as the generation interconnection between the East Devon Substation and the Milford Power Plant.
(Applicants 1, Vol. 1, p. I-12; Applicants 201, p. 2)

180. To construct an underground transmission line between East Devon Substation to Singer Substation (Segment 3) the Applicants would:

- Build an UG 345-kV line (2-3000 kcmil XLPE) from East Devon Substation to Singer Substation;
- Re-terminate the Milford Power generator lead to the new 115-kV substation near Devon 7R (East Devon Junction) by re-using the existing generator lead from Devon 7R;
- Build an OH 115-kV line (4-954 kcmil ACSR) from Devon 7R to the new 115-kV substation near Devon 7R (East Devon Junction);
- Reconductor existing 1780 and 1790 115-kV lines (1-1590 kcmil ACSR between Devon Substation and Devon Switching Station);
- Install 1percent series reactors on each of the 115-kV lines between Devon 7R and the new 115-kV substation near Devon 7R (East Devon Junction);
- Open the bus tie (1480) at Devon 7R; and
- Disconnect Milford Power from Devon 7R and re-connect to the new 115-kV substation near Devon 7R (East Devon Junction)
(Applicants 1, Vol. 1, p. I-12; Applicants 201, p. 2)

181. The proposed Singer Substation would be a new facility bounded by Main Street, Russell Street, Atlantic Street, and Henry Street, near the Bridgeport Energy generating facility in the City of Bridgeport. This site is approximately 2.8 acres, essentially vacant, and owned by PSEG. PSEG has agreed to sell a 1.5 acre parcel to UI and retain the remaining 1.325 acres as a lay down area for Bridgeport Harbor Station. The City of Bridgeport does not object to this site. This property is located within an area zoned "multi-use." An architectural-treated sound barrier/screen wall, approximately 35-40 feet in height, would be installed, on the north, west, and south sides of the substation. To construct the substation the Applicants would install:

- 500-kV class breakers, two 345/115-kV auto transformers, four variable 345-kV shunt reactors, and other equipment. New facilities would include four 345-kV underground line terminations with associated equipment to allow termination of lines from the East Devon Substation and from the Norwalk Substation. Two 115-kV underground line termination positions with associated equipment to allow termination of 115-kV lines from Pequonnock Substation and Bridgeport Energy would also be installed. One 115-kV underground line would serve as the generation interconnection between the proposed Singer Substation and the Bridgeport Energy Generating Plant. The second 115-kV underground line would serve as the facility interconnection between the proposed 345-kV Singer Substation and a new 115-kV position at the existing Pequonnock Substation, and associated work. The existing 115-kV overhead generation interconnection between the Bridgeport Energy Generating Plant and Pequonnock Substation would remain as a contingency backup;
- One 345-kV gas-insulated indoor breaker and a half bus arrangement consisting of sixteen circuit breakers, thirty-eight gas insulated disconnect switches and other associated equipment with gas insulated switchgear (GIS) housed in a rectangular building (312' long x 75' wide x 40' high);
- Two 600 MVA 345/115-kV autotransformers consisting of one three single-phase unit each and the required insulating fluid spill containment measures;
- Four 345-kV 50-100 MVAR variable shunt reactors with fluid containment.
- One Relay and control enclosure integrated into the GIS facility.
  (Applicants 1, Vol. 1, pp. I26-I27; Applicants 52, pp. 32-34; Applicants 201, p. 3; Applicants 188, p. 3-4)

182. To construct an underground transmission line between Singer Substation to Norwalk Substation (Segment 4) the Applicants would:

- Build an UG 345-kV line (2-3000 kcmil XLPE) from Singer Substation to Norwalk Substation;
- Modify existing Bridgeport Energy connection to Pequonnock 8J by adding a disconnect, a series reactor and a bypass switch;
- Re-connect Bridgeport Energy to the new 345-kV Singer Substation; and
- Build 115-kV connection from Pequonnock (modified) to Singer Substation.
  (Applicants 1, Vol. 1, pp. I-27 and I-28; Applicants 201, p. 3; Applicants 71, Q. 55)

183. The existing Norwalk 9S 115/345-kV Substation is located north and east of the intersection of the Norwalk River and New Canaan Avenue (Route 123) in the City of Norwalk. New equipment would be installed within the expanded fenced compound approved in Docket 217. To modify this substation, the Applicants would:

- Install two new 500-kV class circuit breakers with associated equipment for the lines from Singer includes four gas insulated 345-kV circuit breakers and switches, and two 345-kV, 50-100 MVAR variable shunt reactors isolated by circuit switchers;
- Install three single phase 115-kV/345-kV 200 MVA autotransformers
  (Applicants 1, Vol 1, pp. I-27 and I-28; Applicants 54, pp. 4, 36; Applicants 201, p. 3)

184. A secondary containment system would be installed at Singer to protect against the possible loss of insulating fluid from transformers and shunt reactors. This system would consist of a containment pit surrounding the equipment with concrete walls, an impervious plastic liner, and filled with 2" trap rock. The containment pit with the trap rock would be sized to accommodate 110 percent of the volume of fluid contained in the device. Periodic monitoring and removal of rainwater would be accomplished through oil/water separators located on-site. Monitoring devices would be provided to indicate rainwater levels that need to be pumped out in order to accommodate the fluid volume of the transformer or reactor. (Applicants 1, Vol. 1, pp. I-27 and I-28; Applicants 54, pp. 4, 36)

185. The Applicants support a change of the proposed transmission line infrastructure within the Town of Cheshire. Specifically, the existing transmission line corridor traverses 4,900 feet through the Old Farms Road/Old Lane Road subdivision (between existing structure Nos. 4663 and 4020). Initially, the structures were designed with one new and one existing structure between the Cheshire-Wallingford town line and Cook Hill Junction, and with two new structures between Cook Hill Junction and the Hamden-Cheshire town line. (Applicants 1, Vol. 1, pp. I-2 and I-3; Vol. 9, segment 23 and 24, Vol. 10 Drawing XS-001 Figure 7B)

186. A change supported by the Applicants would consist of removing one of the existing 115-kV overhead circuits (Circuit 1640) from the ROW and placing it underground (using 115-kV XLPE cable) along Old Farms Road and Old Lane Road for approximately 5,000 feet. Thus the proposed 345-kV transmission line and the remaining 115-kV line (Circuit 1208) would be installed on a single double-circuit monopole structure. This change would eliminate the need to clear 60 feet of additional tree buffer within the existing ROW from the Cheshire-Wallingford town line to Cook Hill Junction (3 acres). (Applicants 1, Vol. 1, pp. I-2 and I-3; Vol. 9, segment 23 and 24, Vol. 10 Drawing XS-001 Figure 7B)

187. The Applicants support a change of the proposed transmission line infrastructure within the City of Bridgeport. The proposed route follows Noble Street, turns west on Washington Avenue to cross the Pequonnock River, and turns south on Housatonic Avenue. The supported change would have the route continue along Noble Street under the Metro North Railroad and then cross the river onto waterfront property owned by the city. The variation would then cross back under the railroad and turn south on Housatonic Avenue/Water Street. This variation would reduce the length of the route by approximately 1,850 feet and would provide for a crossing of the Pequonnock River that minimizes the use of private property. (Applicants 1, Vol. 1, pp. I-3 and I-4, L-15, Vol. 9 segment 52)

188. The Applicants support a change of the proposed transmission line infrastructure within the Town of Westport. The proposed route would turn north off of Post Road onto Myrtle Avenue, then turn west on Kings Highway North, cross the Saugatuck River and continue until the route merges back with the Post Road. The supported change would turn south from the proposed route on the Post Road and follow Imperial Avenue for approximately a quarter of a mile, and turn west into Westport Commuter Metro North parking lot before crossing the Saugatuck River. On the west side of the river, the route would cross over Riverside Avenue and continue west along Lincoln Avenue before merging with Post Road. The variation would reduce the length of the proposed route by approximately 2,750 feet and avoid the Westport historic district and downtown businesses. (Applicants 1, Vol. 1, pp. I-3 and I-4, L-15, Vol. 9 segment 5)

189. In place of the proposed Norwalk River crossing, the Applicants support a change with an alternate crossing that would begin approximately 1,000 feet south of the original location which would require property of the Riverside Cemetery Association and cause conflicts associated with construction of the New Canaan Avenue Bridge. This would avoid disruption of the cemetery location and mitigate concerns about conflicting construction activities. This route would be 650 feet shorter and improve bending radii of the pipe and cable. (Applicants 54, Supplemental testimony dated April 19, 2004; Applicants 15, Q. D-W-14)

Alternative A (Singer-Hawthorne)

190. Alternative A, 73 miles in total, would consist of 60 miles overhead and 13 miles of underground lines. Alternative A is identical to the proposed route from Scovill Rock to Singer Substation. From Singer Substation, this alternative would place lines underground from Singer Substation to Hawthorne Substation to Norwalk Substation. Alternative A would be along an existing CL&P transmission corridor. (Applicants 1, Vol. I, pp. H-28-H-29, H-34)

191. The existing overhead line from Hawthorne Transition Station to Norwalk Junction has two 115-kV circuits on one lattice structure. The lattice structure would be replaced with one compact composite steel monopole holding one 345-kV line and one 115-kV line. The second 115-kV line would be removed from service. (Tr. 2/1/05, p. 281-282)

192. Alternative A would require 62 additional acres of easement to be acquired. The route would have to traverse underground through a residential street in Bridgeport. (Tr. 4/20/04, p. 201-202)

193. Alternative A would not require the taking of homes because it involves a narrow right-of-way. (Tr. 4/20/04, p. 207-208)

194. If either alternatives A or B are used, wrap around or temporary lines would have to be constructed to leave an energized line in place. The additional work involved with these lines would extend the construction schedule, increase costs, and cause greater potential environmental impacts. (Tr. 4/20/04, p. 198-199)

Alternative B

195. Alternative B is the all overhead route except for two circuit miles in Bridgeport, between Seaview and Singer Streets, which would be underground. In Stratford, Trumbull, Bridgeport and Fairfield, 29 homes would have to be acquired to install the 345-kV line. (Tr. 4/20/04, p. 207-208)

196. There would be 49 wetlands crossings for Alternative A and 85 wetlands crossing on Alternative B. Alternative A would result in four miles more of construction than the proposed route. (Tr. 4/20/04, p. 210-211)

197. Compared to the proposed route, Alternative A would result in:

- Overhead crossings of 49 more wetlands and watercourses, including four wetlands with high potential and five wetlands with moderate potential for productive amphibian habitat. (Along the underground portion of the proposed route between Singer Substation and Norwalk Substation, the cable would be installed beneath 11 watercourses and associated wetlands using subsurface installation techniques such as horizontal directional drilling or boring);
- Acquisition of overhead easements of 62 acres of privately-owned land for the expanded ROW, underground easements of over 2.4 acres, and approximately 2-4 acres of privately-owned land for the Hawthorne Transition Station;
- Clearing of approximately 59 acres of forested areas (it is assumed that the existing vegetation on virtually all of the expanded ROW would have to be cleared);
- Substantially longer alignment through residential areas; and
- 15 more miles of overhead transmission line.
  (Applicants 1 Vol. 1, p. H-33; Applicants 54, p. 6; Applicants 59. revised p. 20; Applicants 49, p. H33)

198. Compared to the proposed route, Alternative B would result in:

- Construction and operation of approximately 5 more miles of transmission line;
- Potential acquisition of a total of 29 homes and one commercial structure in order to expand the ROW;
- Acquisition of easements of over 111 acres of privately-owned land for the expanded overhead ROW. (it is assumed that the existing vegetation on virtually all of the expanded ROW would have to be cleared), underground easement over one-acre, and approximately 2-4 acres of privately-owned land for the Seaview Transition Station;
- Substantially longer alignment through residential areas;
- Overhead crossings of 85 more wetlands and watercourses, including four wetlands with high potential and seven wetlands with moderate potential for productive amphibian habitat compared to the underground portion of the proposed route where the cable would be installed beneath 14 watercourses and associated wetlands using subsurface installation techniques such as horizontal directional drilling or boring;
- Additional impacts to water birds and other coastal/estuarine-dependent wildlife species resulting from the overhead crossing of the Housatonic River; and
- Minor benefits to shrubland, birds and other wildlife species dependent on shrub lands, but significantly greater adverse impacts to wildlife in general.

(Applicants 1 Vol. 1, p. H-33; Applicants 59, p. revised pp. 21 and 22)

Segments 1 and 2

199. The highest poles proposed along the right-of-way are 140 feet agl. The height of the poles can be increased to approximately 199 feet agl and still be operational. With poles that are 199 feet agl and 600 foot spans between poles, the height of the lowest conductor would be approximately 100 feet agl. (Tr. 09/28/04, p. 221-225)

200. The monopoles used to support the transmission lines are typically designed for approximately 120 percent of the stresses that they would experience. (Tr. 10/14/04, p. 236)

201. If a transmission structure were to fail, the conductors would tend to keep the structure from falling sideways. The structure would fall in line with the conductors because of the tension and the large size of the conductors that are proposed. (Tr. 10/14/04, p. 239)

202. In the proposed project the 348 line which currently runs between Millstone and Southington would become the Scovill to Southington line. A new section of the 348 line at Oxbow Junction would go through the Durham area into Beseck. There would be three 345-kV lines going from east to west through Black Pond, including the proposed route. The proposed route creates additional lines west and south of Black Pond. (Tr. 06/01/04, p. 229)

203. The proposed 345-kV system is predicted to last for 20 to 30 years before major investments are required. (Tr. 3/23/04, p.40)

Route Alternatives

204. The general types of route alternatives identified and reviewed include:

- Use and/or expansion of existing transmission line ROW;
- New ROW alternatives;
- Railroad alternatives;
- Highway alternatives;
- Combination overhead/underground/marine alignment;
- Combinations of use or expansion of existing overhead transmission line ROW and use of underground cable along streets.
  (Applicants 1 Vol. 1, H-10)

205. Criteria used by the Applicants on the project in evaluating routes include system benefit, operability, reliability, property impacts, home impacts, environmental impacts including effects on wildlife, vernal pools and aquifers, and cost. (Tr. 4/22/04, p. 68)

206. The Applicants considered alternative corridors including highway corridors such as Interstate 91, Interstate 95, and Route 15; railroad corridors such as Amtrak and the Air Line, and the transmission line rights-of-way. (Tr. 06/01/04, p. 15)

Northerly Route

207. The northerly route would traverse portions of Middletown, Middlefield, Meriden and Wallingford. The proposed 345-kV transmission line would follow an existing transmission line right-of-way starting at Chestnut Junction and traversing west through Hans Brook Junction and then to Black Pond Junction. The route would follow a ROW presently occupied by three 345-kV transmission lines (the 387, 362, and 348 lines). From Hans Brook Junction to Chestnut Junction, a 115-kV line is also located on the ROW. This configuration would place four 345-kV lines on a common ROW. (Applicants 90, pp. 12-13)

208. This alternative transmission line would extend south from Black Pond Junction to the proposed Beseck Switching Station, along the same ROW as the proposed route. This ROW is presently occupied by one 345-kV transmission line (the 387 line). Three additional 345-kV lines would be added to the ROW which would place four 345-kV lines on a common ROW. (Applicants 90 p. 12)

209. The northerly route would have approximately 11 miles (50 percent longer than proposed route) of four 345-kV lines on a common ROW. The following table compares the proposed route with variations of the northerly route:

	Northerly Route - Configuration			Proposed Route
	A (H-frame)	B (Monopole)	C (Monopole)	Composite Monopole
Circuit length (miles)	10.5	10.5	25.9*	7.0
ROW width increase (feet) Chestnut to Black Pond	80	40	0	0
ROW Width Increase (feet) Black Pond to E. Meriden Jct.	20	20	20	0
Structure Height (feet)	90	130	130	105
ROW Increase(acres) Chestnut to Black Pond	75	38	0	0
ROW Increase (acres) Black Pond to E. Meriden Jct.	3	3	3	0
Home acquisition	8	4	0	0
Cost (not including uplift)	$24.5M	24.9M	70.3M	$22.9M
Reliability	Less Reliable			More Reliable

(Applicants 90a)

210. The new corridor alternative is an entirely new ROW (sometimes referred to as a "greenfields" corridor), not adjacent to any existing corridors. An entirely new overhead corridor for a 345-kV transmission line would require a minimum 120-foot-wide ROW, whereas a corridor for a new cross-country (non-street) underground transmission cable would require a minimum 40-foot-wide ROW. This alternative was rejected due to population density and development in SWCT. Other factors considered include steep slopes, wetlands, designated natural areas, and the high costs of acquiring a new easement. (Applicants 1 Vol. 1, H-11)

Railroad Route

211. Many railroad corridors traverse Connecticut; however, most of these railroad corridors do not provide a direct route from Middletown to Norwalk nor sufficient space for transmission line construction. The primary railroad routes considered are the Amtrak lines from Hartford to New Haven, and the portion of the Metro-North/Amtrak rail corridor between New Haven and Norwalk. (Applicants 1 Vol. 1, H-12)

212. The CL&P agreements that were signed on the Pequonnock-Ely Avenue line do not allow for any transmission lines on the railroad greater than 115,000 volts. A separate UI agreement in effect until the year 2030 limits voltage on the existing railroad catenaries at 115-kV. (Applicants 67, pp. 5-6; Tr. 4/21/04, pp. 140-141)

213. Any construction on the railroad line from Milford to New Haven by UI would require the total rerouting of existing 115-kV underground lines in that area, with separate pole line structures to support the 345-kV lines. The height of the structures would be a minimum of 120 feet, and 200 feet at highway crossings. Some condemnation of property would be necessary. (Tr. 4/22/04, p. 127)

214. The Applicants considered use of the existing Airline Railroad, but encountered major problems with lack of space in industrial areas. The lines traverse into central New Haven, leading to a dead end. (Tr. 4/22/04, p. 133-134)

215. Possible railroad derailments are a consideration of placing overhead transmission facilities along a railroad. A derailment approximately 15 years ago took down catenaries, and both 115-kV UI circuits were out of service for a considerable time. (Tr. 4/22/04, p. 142-143)

216. The railroad corridor would require an additional 125 feet of right-of-way for the construction of a transmission line. The location of many businesses and some residences along the railroad corridor would cause a conflict with the expansion of the right-of-way. (Tr. 06/01/04, p. 27)

217. Installation of a railroad underground route between East Devon and Singer Substations would necessitate the removal of one existing 115-kV line and its placement underground, for a distance of two miles, using two cables. (Tr. 4/22/04, p. 30)

218. The top of the existing railroad catenaries is about 65 feet off the railroad bed; other structures are 90 feet. To consider building a 345-kV line would require structures of 120 feet, which is 30 feet higher than present. Feeder wires for the railroad are now on the outside of existing poles. To put the wires inboard for safety clearances would require taking the 12V wires and placing them outside. Any clearances must not only consider the 345-kV lines, but the 12V lines also. (Tr. 4/22/04, p. 32-33)

219. The line would have to terminate at Bridgeport Energy because there would be no room for the 345-kV line at Pequonnock Substation. (Tr. 4/22/04, p. 34-35)

220. Existing 120 foot towers in Stratford would have to be raised by 20-30 feet and some streets would have to be relocated. (Tr. 4/22/04, p. 38)

221. To use the railroad corridor, the Applicants would have to perform a full study of the impacts of EMF on the railroad signaling system. To use the railroad the Applicants would have to build new structures to hold the new 345-kV line, as the existing catenaries are not sufficient to handle the weight and stresses that would be placed on them by a 345-kV line. (Tr. 4/22/04, p. 49-50)

222. The Applicants has considered the railroad option and rejected it due to its environmental, economic, and social and construction challenges. (Tr. 4/22/04, p. 41)

223. Shielding technology could be used to shield the railroad signaling system; however, the entire signaling infrastructure would need to be replaced. (Tr. 4/22/04, p. 52-53)

224. On the railroad route, a minimum of 25 feet of space would be needed away from the railroad track to meet clearance requirements. (Tr. 4/22/04, p. 55)

225. Structures on the railroad line would typically be approximately 300 to 400 feet apart at maximum, compared to 700 to 800 feet on an overland right-of-way. This would minimize the amount of conductor movement and blow-out by use of short span lengths. (Tr. 4/22/04, p. 55)

Highway Corridor Option

226. Connecticut has a well-developed network of interstate, state, and local highways. This alternative would involve the alignment of the proposed 345-kV facilities (either overhead or underground) within or adjacent to existing highway corridors. The principal highways that are aligned in the general direction for the proposed Middletown – Norwalk transmission line are:

- State Route 15 (Wilbur Cross and Merritt Parkways) from Meriden to Norwalk;
- I-91 from Meriden to New Haven;
- I-95 from New Haven to Norwalk;
- U.S. Route 7 in Norwalk; and
- U.S. Route 1 between Stratford and Norwalk.

(Applicants 1, Vol. I, p. 4-14)

227. Route I-91 is elevated in some areas. In some areas the highway is cut through rock, making going around the highway infeasible. (Tr. 4/22/04, p. 22)

228. It might be possible to attach an underground cable to an overhead road structure, but such an option would be subject to DOT permitting requirements. (Tr. 6/16/04, p. 232)

229. The Applicants would need to acquire an additional 65 feet outside the DOT right-of-way, to use the highway corridor. An aerial easement would also be needed with DOT. (Tr. 4/22/04, p. 56-57)

Route 15 Option

230. If Route 15 were used as an alternative route, approximately 24 homes or businesses would be taken, and on Routes 91/95 approximately 100. (Tr. 4/22/04, p. 54)

231. The portion of Route 15 referred to as the Merritt Parkway is designated as a scenic byway. Factors considered in rejecting the highway corridor are the historical significance of the Merritt Parkway, width and availability of a ROW; (120-foot required for an overhead and 15 feet for underground), steep side slopes; shallow depth to bedrock, elevated portions of roadway, and the potential to displace homes or businesses located adjacent to the highway corridors. Moreover, no significant length of highway corridor was found that would provide a complete linear connection between the various transmission substations and switching stations. (Applicants 1 Vol. 1, H- 14 to 15)

232. The median of Route 15 was considered but eliminated as being impractical. The median is very narrow and all of its vegetation would have to be cleared. (Tr. 4/22/04, p. 59)

233. The portion of U.S. Route 1 west of Milford was identified as a feasible route for an underground cable because it would avoid the need to expand existing overhead transmission line ROW through lower Fairfield County where the existing ROW is not wide enough to accommodate a new transmission line. (Applicants 1 Vol. 1, H-15)

234. To use the median a four-foot wide trench would be needed plus 15 feet of construction access. (Tr. 4/22/04, p. 61)

235. During construction the entire width of the median would be needed for construction easement. The Merritt Parkway right-of-way is 300 feet wide, shoulder to shoulder, as is the Wilbur Cross Parkway. (Tr. 4/22/04, p. 63-64)

236. The Applicants would not place an overhead cable inside the tunnel of West Rock because more protection of the cable is needed. Burying or tunneling through would be required and although feasible, it would be difficult. Putting a line over West Rock Ridge would require cutting a swath across the ridge, a task complicated by existing hiking trails and archaeological resources. (Tr. 4/22/04, p. 65-66; p. 90)

237. An overhead route along Route 15 would require construction along a limited access highway and the clearing of numerous trees. (Tr. 4/22/04, p. 67)

238. The portion of Route 15 referred to as the Merritt Parkway is designated as a scenic byway by the United States Department of Transportation. (Applicants 4, p. 6)

239. An overhead transmission line could be built along a portion of Route 15. Underground transmission lines would be more difficult to construct along a portion of Route 15 than an overhead transmission line. (Tr. 06/01/04, p. 26)

240. According to design standards, installation of cable must be at least 30 feet from the road. The median is less than 20 feet wide on the Wilbur Cross section and thus the median is not considered a viable alternative. In some places, Jersey barriers stand back-to-back, leaving no room for equipment. (Tr. 4/22/04, p. 83-84)

241. For overhead lines at least 75 feet of right-of-way (ROW) beyond the edge of the pavement is required. If a compact delta structure is used, the ROW would be 95 feet. For underground lines, only 40 feet of ROW would be needed, consisting of 15 feet for actual construction and 25 feet for access for vehicles. (Tr. 4/22/04, 84-85)

242. Route 15 is paralleled by the Quinnipiac River, wetlands, and a flood plain, with a large portion of the highway on a raised road bed. The toe of the slope would put the line in the river and the other side is often the site of commercial and residential buildings. (Tr. 4/22/04, p. 86-87)

243. The Route 15 route would involve 24 bridges and overpasses, the majority of which are on the National Register of Historic Sites. (Tr. 4/22/04, p. 94)

244. Installing a line along Route 15 would directly affect the possibility of future expansions to the highway. (Tr. 4/22/04, p. 97)

Marine Route Options

245. Alternative marine routes considered and rejected were the proposed Singer Substation, Bridgeport to the existing Norwalk Substation, and the existing East Shore Substation New Haven to the proposed East Devon Substation. Factors considered were; impacts to at least some sensitive marine resources, distance of route (extended by as much as eight miles), laws governing the protection of water, marine, and coastal resources (i.e., the project is not considered a "water dependent use"); and use of self-contained fluid filled (SCFF) cables, a technology not favored by Connecticut resource agencies. (Applicants 1 Vol. 1, H-14)

246. Other issues raised concerning marine routes included the Federal Clean Water Act, the Federal Coastal Zone Management Act (CZMA) and recent legislation concerning the protection of Long Island Sound. Under the CZMA, projects that are not water-dependent are encouraged to be located inland. (Tr. 4/22/04, pp. 102-103)

East Shore-Devon Route

247. A route from East Shore into New Haven harbor would have impacts to shellfish beds. Any marine route would use self-contained fluid filled cables. The route would have to traverse the Housatonic River, a major source of seed oysters, and pass the Stewart B. McKinney National Wildlife Refuge. (Tr. 4/22/04, p. 104-105)

248. The shellfish beds off of the Devon section of Milford and the Housatonic River are a major source of seed oysters. The Housatonic River is classified as a Federal Navigation Channel. (Tr. 4/22/04, p. 118)

Singer-Norwalk Marine Route

249. The feasibility of a marine route from Singer Substation to Norwalk Substation was considered. Such a route would cross shellfish beds. (Tr. 4/22/04, p. 107)

250. The SCFF cables would need to be 90 feet apart in near-shore areas, and 200 feet apart in offshore areas. There would be two bundles of such cables, embedded into the sea floor at a depth of 6 to 15 feet. Issues include geological obstacles, federal channels, dredge disposal grounds, shipwrecks, sensitive environmental resources, shellfish beds, wetlands, cultural resources, protected species habitats and impacts to communities. (Tr. 4/22/04, p. 108-109, 114)

251. An optimized route was selected out of nine potential route alternatives. This route is 23 miles long, 15.4 miles of which is marine and 7.6 miles of upland. By comparison the proposed alternative from Bridgeport to Norwalk would be 15 miles long. (Tr. 4/22/04, p. 109-110)

252. DC cables are best suited for long distances. SCFF cables cannot be used in lengths greater than 25 to 30 miles. The project would require a bundle of two to six cables. The two circuit configuration would provide 1000MW of capacity. (Tr. 4/22/04, p. 113-114)

253. A marine route between Millstone and Norwalk could not avoid shellfish resources. (Tr. 4/22/04, p. 120)

East Shore Option

254. The East Shore route would run from Beseck through Wallingford Junction to East Shore then to East Devon. (Tr. 06/02/04, p. 8)

255. There are two alternatives to get from Beseck to East Wallingford; an overhead route and an underground route. The overhead route adds an H-Frame to the existing right-of-way for six miles. No widening of the right-of-way is necessary. The underground route would use Williams Road in Wallingford, and a transition station with full switching capabilities would be located south of Pond Hill School. (Tr. 06/02/04, p. 9, 10)

256. There are three routes to get from East Wallingford to East Shore: the existing right-of-way, the Amtrak corridor, and the Conrail corridor. The existing right-of-way can be used through Wallingford, North Haven, North Branford, and into East Haven. There are 226 homes that are within 150 feet of the right-of-way, and 13 statutory facilities within 1,200 feet. The Amtrak and the Conrail corridors are immediately adjacent to business and residential development. There are 237 homes within 150 feet of the Amtrak corridor, and 18 statutory facilities. There are 260 homes within 150 feet of the Conrail corridor, and 18 statutory facilities. (Tr. 06/02/04, p. 14-19)

257. There are two route options to get from East Shore to East Devon; an overhead/underground hybrid, and an all underground route. The overhead/underground route involves six miles of underground to a transition station in the Orange/West Haven area then eight miles overhead to East Devon. The all underground route has various street combinations that could be used, totaling 12.7 miles to 16 miles. (Tr. 06/02/04, p. 21-23; Applicants 91, pp. 24-27)

258. The East Shore route would work only if a second line were installed into East Shore. The second additional line would be needed because in the event the existing 387 line were lost, the 329 line, from Frost Bridge to Southington, would be overloaded. (Tr. 06/02/04, p. 148, 149)

259. The East Shore route is not a viable alternative because when compared to the proposed route, 50 percent more wooded vegetation would have to be cleared, there are operational and reliability issues due to underground installation, and the cost would be twice as great as the proposed route. (Tr. 06/02/04, p. 211, 212)

260. An existing circuit (387) traverses portions of the proposed route from Scovill Rock Substation on to Black Pond Junction to Beseck Junction to Totoket Junction and terminates at the East Short Substation. This circuit was considered with upgrading conductors, rebuilding the line, or constructing a new line adjacent to the 387 line. (Applicants 89, Q. 66-SP01 pp. 10-12)

261. To consider an upgrade with a larger conductor, the total number of replacement structures to support the conductor must not exceed 50 percent of the original line, which would warrant a rebuild of the line. (Applicants 89, Q. 66-SP01 pp. 10-12)

262. Potential conductors considered were the 1158 kcmil and 1455.3 kcmil sized conductors. The load analysis of structures to support a 1158 kcmil conductor would require replacement of as much as 39 percent of existing structures between Scovill Rock and Black Pond, and as many as 18 percent of existing structures from Black Pond to East Shore. The 1455.3 kcmil conductor would require replacement of 69 percent of existing structures between Scovill Rock and Black Pond. Based on the substantial inadequacy of existing structures, a 1455.3 kcmil conductor would require a complete rebuild of the line. (Applicants 89, Q. 66-SP01 pp. 10-12)

263. A probable route would be to place the lines entirely underground from East Shore to East Devon via Route 1, a distance of approximately 13 miles. Another route would be from East Shore, approximately six miles along the streets of New Haven along an existing right of way, through West Haven and Orange (a two to four acre transition station would be needed). The route would then follow the proposed right of way route ten miles to East Devon. (Tr. 4/22/04, p. 135-136)

264. The East Shore alternative does not strengthen the power supply to SWCT by introducing a new source because the 387 line would be excessively loaded. (Tr. 3/23, p. 163)

265. Use of HVDC from East Shore to East Devon would require four DC converter terminals at East Shore. The existing terminal at East Shore has 330MW of capacity. The proposed project would require 1200MW capability. (Tr. 4/22/04, p. 75)

266. Even if the 387 line is reconductored with the largest conductor available, it still has to be protected for loss of the line. (Tr. 09/28/04, p. 65)

267. If Miramichi conductors were used on the 387 line and the 329 line, 50 percent of the structures would have to be replaced. The Miramichi is a larger wire that requires more deadends. (Tr. 09/28/04, p. 66)

268. A second circuit would be necessary on the 387 right-of-way to avoid conflict with the standards of NPCC and ISO-NE. However, a second 345-kV circuit on the same right-of-way is not desirable because it would essentially duplicate the existing 345-kV circuit, and therefore is an alternative that would not work as well as the preferred route. (Tr. 09/28/04, p. 90, 91)

Environment

269. Some critical wetland areas include vernal pools and wetlands with a high or moderate potential for amphibian breeding. (Tr. 06/01/04, p. 59)

270. The Applicants would minimize the removal of vegetation in the habitat surrounding a vernal pool because such vegetation provides shading that is necessary for amphibian breeding. (Tr. 06/01/04, p. 95)

271. There is a physical and biological component to vernal pools. The vernal pool should be protected from sedimentation and filling. The upland areas surrounding the vernal pools also should be protected. Vernal pools are evaluated through the study of their location, and which species are using them. (Tr. 06/03/04, p. 182, 183, 242, 243)

272. To protect amphibians, construction of the proposed project can be scheduled to avoid the breeding season, which is spring. Silt fencing or other erosion controls can be placed around the construction area so that amphibians cannot get into the construction area. In addition, herpetological specialists can be hired to identify and relocate amphibian species that exist in the area. (Tr. 06/01/04, p. 79)

273. If poles are currently located in wetlands, modifications are being evaluated by the Applicants to move the structures out of these areas. (Tr. 06/01/04, p. 61, 62)

274. There are some wetlands that run longitudinally along the right-of-way for a distance, making it difficult to avoid wetland impacts. The Applicants would determine the area of the wetland where the depth of water is the shallowest, and would minimize the impact of construction on that wetland. (Tr. 06/01/04, p. 94)

275. Final placement of the poles would be determined during the preparation of the Development and Management plan. (Tr. 06/01/04, p. 111)

276. Temporary impact of construction impacts to wetlands could be reduced from 100 feet by 100 feet, as stated in the application, to 40 feet by 50 feet, through the use of wooden mats. (Tr. 06/01/04, p. 76, 77)

277. The construction process for the removal of poles that are located within wetlands would include placing matting in the area where the existing poles are located. The poles would then be cut into smaller pieces to minimize the amount of heavy trucks; the pole butts would be pulled up and a new structure would be constructed in the same location, if necessary. The butt of the pole could be left in place if a new structure is not proposed to be constructed in the same location. (Tr. 06/01/04, p. 123, 125)

278. A crane would be used to hold the pole in place while it is being dismantled. The crane boom can be 15 to 20 feet away from the pole, depending on the distance from the wetland. (Tr. 06/01/04, p. 124)

279. The Applicants are willing to not locate pulling stations in wetlands. (Tr. 06/01/04, p. 134)

280. Shrubland provides habitat for certain species, including some birds and amphibians. The right-of-way provides shrub and forested habitat. It is the Applicants intent to make the right-of-way available to smaller shrubs and natural vegetation. Utility ROW's often have a greater number and diversity of birds than forested habitats. (Tr. 06/01/04, p. 224, 225; Applicants 1, Vol. I, p. L-41))

281. The noise that is associated with a conductor pulling station is typically from a crane to lift the cable reels onto the tensioner machines. The conductor pulling process at each pulling location would last approximately one and one half days of daylight hours. A pulling location is where a conductor will be pulled and tensioned from structure to structure. (Tr. 06/01/04, p. 135; Applicants 83, Q. 15)

282. The Applicants consulted with the Connecticut DEP, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, and the Bureau of Aquaculture of the Connecticut Department of Agriculture in preparation of the application. (Applicants 1, Vol. I, pp. L-1 to L-2; Applicants 53, pp. 2-4; Applicants 90, 5/25/04, pp. 20-22)

283. The Applicants performed noise surveys near the proposed locations of substations and switching sites; examined amphibian breeding habitats and breeding birds and their habitats; examined inland and tidal wetlands; and researched cultural resources along the proposed route. (Applicants 1, Vol. I, p. L-2; Applicants 53, pp. 3-10; Applicants 90, pp. 20-26)

284. The project would maximize use of existing linear corridors consistent with FERC guidelines. The overhead portion of the route would be primarily within existing ROW's. The Applicants would purchase approximately 9.5 acres of new easement from private landowners. The underground portion of the route would be located largely within existing public roads. (Applicants 1, Vol. I, p. I-21, p. L-51; Vol. 9, 11, 12)

285. In the underground portion, the cable system would not be visible, except for manholes near splice vaults, and the proposed above ground facilities at Singer, Norwalk and East Devon. (Applicants 1, Vol. I, p. 14-30; Applicants 53)

286. The overhead portion of the new line would be aligned generally along existing transmission line ROW's. Some of the existing structures would be consolidated or removed. New structures would generally be placed at the same locations where existing structures are located. (Applicants 1, Vol. I, pp, M-31 to M-38; Applicants 90, pp. 33-34; Applicants 1, Vol. I, Table M-5)

Cultural Resources

287. Cultural resource studies were conducted along the proposed route, conducted in accordance with the Connecticut Historical Commission standards, and included visual inspection of existing transmission structure sites and an examination of the ROW. Slopes, drainage areas, landfills and ledge sites were examined as potential archeological sites. The studies found no documented archaeological sites within the proposed ROW. (Applicants 1, Vol. I, pp. M-40 to M-41; Vol. III, Abstract)

288. Additional field studies at proposed transmission pole locations might be needed for a final determination of areas where reconnaissance investigations would be needed to find sites of Native American archaeological sensitivity. (Applicants 1, Vol. I, p. M-41)

289. Fourteen significant above-ground historic resources were identified within approximately 0.25 miles of the overhead section of the line, including sites listed on or eligible for listing on the National Register of Historic Places or State Register of Historic Places. Of the 14 historic properties, terrain and vegetation would preclude visibility of the new line. One of the remaining four properties may be subject to adverse visual effects. (Applicants 1, Vol. III, Abstract)

290. Thirty-three significant above-ground historic resources were identified within 500 feet of the proposed underground route. The 500-foot distance is cognizant of potential blasting effects. Identified resources include four cemeteries at least 100 years old. (Applicants 1, Vol. III, Abstract)

Soil Contamination

291. When UI has encountered contaminated soils, the State of Connecticut has taken control of the soils management and disposal, under state mandated projects. In non-state mandated projects, the company seeks to determine the source of contamination, and if not found, takes control of the material. (Tr. 4/21/04, p. 81-82)

292. In state mandated projects, the DOT pays for the cost of handling contaminated material. (Tr. 4/21/04, p. 81, p. 85)

293. Any hazardous material encountered would be collected, properly documented, and disposed of. (Tr. 4/21/04, p. 90)

294. An independent environmental inspector would be involved in monitoring the contamination issues. (Tr. 4/21/04, p. 90-91)

Endangered Species

295. To protect endangered species, the Applicants would consult with the US Army Corps of Engineers and the DEP regarding timing of construction. One such species is the peregrine falcon, nesting under the I-95 Barnum Bridge. Another is the Atlantic sturgeon, which potentially occurs in the Housatonic River. The actual proposed crossing of the river is not near the peregrine falcon nesting area. Construction timing could be adjusted to avoid the life cycles of both species. State-listed species include: blue-winged teal (threatened) and king rail (endangered) are identified as being at Durham Meadows Wildlife Area; wood turtle (special concern) in Middletown, and the box turtle (special concern) in Middlefield, red-shouldered hawk (special concern) in Woodbridge, and two plant species of state special concern, mudwort and bayonet grass in the Saugatuck River basin. (Tr. 4/20/04, p. 268-269; Applicants 1, Vol. 6, Analysis of Bird Species, p. 16, p. M-26)

Department of Environmental Protection Comments

296. Alternatives A and B appear to offer no advantages compared to the proposed route, while involving additional impacts, including the acquisition and clearing of additional ROW width. (DEP letter of 5/4/04, p. 2)

297. The DEP would be unlikely to approve a marine route alternative in light of less-disruptive land-based alternatives. (DEP letter, 5/4/04, p. 2)

298. Permits needed for the project include a Structures, Dredging and Fill and Tidal Wetlands Permit, and a Section 401 Water Quality Certification. The Office of Long Island Sound Programs would review and evaluate each tidal crossing. Horizontal Directional Drilling (HDD) projects require the Applicants to submit a Monitoring and Operations Plan. All HDD projects require the Applicants to obtain a performance bond for each tidal crossing. (DEP letter 5/4/04, p. 3)

299. The DEP has not determined yet which crossing technique, HDD or jack and bore, is the preferred method for each location. DEP must make sure the depth of the proposed crossing does not interfere with future maintenance dredging. (DEP letter 5/24/04, p. 3)

300. Along the overhead portions of the project, no direct construction related impacts to watercourses are expected. Fording of streams can and should be avoided during and after construction. As a routing Best Management Practice, the DEP Inland Fisheries Division suggests in stream work be restricted to the period from June 1 to September 30, inclusive. (DEP letter, 5/24/04, p. 4)

301. The recommended window for construction activities in areas which support wood turtles and box turtles is November 1 to April 1; these species may occur in Middletown, Middlefield and Milford. If any of these wetlands are riverine wetlands, it will be necessary to avoid any in stream work or access in these areas. (DEP letter, 5/24/04, p. 4)

302. The Inland Fisheries Division advocates that 100-foot wide naturally vegetated buffers be maintained along perennial watercourses, and 50 feet along intermittent watercourses. It is recommended as much natural vegetation is preserved for beneficial shading. (DEP letter, 5/24/04, p. 5)

303. Many of the streams to be crossed support resident freshwater fishes, and anadromous fishes, including blue-black herring and alewife. If it is determined by DEP that seasonal restrictions are needed, they would generally apply to the period of upstream migration of anadromous fishes, April 1 through June 30. Unconfined in-water work is often prohibited in selected areas from February 1 to May 15 to protect winter flounder spawning areas. Anadromous migration should be protected from July 1 to September 30. DEP letter, 5/24/04, pp. 5-6)

304. It is imperative the Applicants design each HDD crossing to minimize threat of a drilling fluid release as much as possible. This may require much deeper drilling through underlying materials. Complications can be avoided by the use of qualified, experienced independent contractors, who will use best management practices such as periodic drill bore cleaning and plugging of minor leaks. (DEP letter, 5/24/04, p. 6)

305. If a jack and bore crossing technique creates a substantial amount of noise, DEP may request a time-of-day restriction for work within the standard anadromous period from April 1 to June 30 to ensure a continuous 12 hour period free of noise in each 24 hours, to allow fish to pass the work zone. (DEP letter, 5/24/02, p. 6)

306. DEP is not aware of any critical Atlantic sturgeon habitat in the Housatonic River, but the applicants may be required to submit more information on the sediments and benthic community adjacent to the crossing route. (DEP letter, 5/24/04, p. 7)

307. The DEP property most impacted would be the Housatonic Boat Launch in Milford by I-95. Because of the busy activity here in summer, the crossing should not be scheduled during the active boating season. The line should also be sited so as to not interfere with any future maintenance needs. (DEP letter, 5/24/04, p. 8)

308. The impacts of the project to Quinnipiac River State Park and Sleeping Giant State Park are expected to be negligible. (DEP letter, 05/24/04, p. 8)

309. The proposed route crosses the Middletown-Durham and Wallingford landfills. If any new pole structures fall within the footprint of any previously places waste, an authorization for disruption of a solid waste disposal area must be obtained from the DEP Bureau of Waste Management. (DEP letter, 05/24/04, p. 8)

310. At the East Devon Substation site, DEP notes there has been no detailed testing for presence of trichloroethylene (TCE) on the site. Levels are likely to be low, but testing should be done. If contamination is found, removal and disposal of contaminated soils will be required. (DEP letter, 05/24/04, p. 9)

311. At the Southport Harbor Crossing, it is imperative that the HDD path be deep enough to stay within bedrock and not allow the migration of chromium-contaminated groundwater from the west side of Mill Creek. (DEP letter, 05/24/04, p, 11)

312. A set of existing pole structures could re removed immediately adjacent to the Farmington Canal Recreational Trail in Hamden. Structures on circuits 1610 and 1640 (structure #4010 in latter case) may be eliminated. In Woodbridge, structure #3920 is located in a marshy area with poor access and new poles may be eliminated in the area of wetland #133. A number of structures within wetland #70 adjacent to Tamarac Swamp in Wallingford may be reduced, especially structures #8769 and 8800, which are within a wetland in difficult-to-access areas. (DEP letter, 05/24/04, p. 13)

South Central Connecticut Water Authority Land

313. The South Central Connecticut Regional Water Authority (RWA) owns land in the Segment 1 and Segment 2 portions of the proposed route. Land owned by the water utility within the State of Connecticut within a watershed area is defined as Class I or Class II depending on the distance to the reservoir. Class III land is owned by a water utility but is outside of the watershed. The land in Bethany and northern Woodbridge is primarily Class I and Class II. The land in southern Woodbridge and northern Orange is Class III land. There are also two separate watersheds within the Segment 1 and Segment 2 areas, one of which drains into more than one reservoir. A watershed is the capture area where water is collected and stored in reservoirs throughout the water district. (SCCRWA Ex. 1; Tr. 06/03/04, p. 119, 120, 136 137)

314. As a condition of approval, the RWA recommends the Council require the following information that the DPH requires to issue a Change in Use permit: evidence of a revocable license for construction activities on RWA land; an estimate of how much Class I and II land to be impacted during construction; the exact number of structures removed and installed on RWA land; the location of storage/staging areas and temporary access areas; location of sanitary facilities, number and types of construction equipment; fueling locations; how many sites active each day; identification of blasting areas; details on long-term maintenance; and an Integrated Post Management Plan to limit use of pesticides. (SCCRWA brief, 3/16/05, pp. 3-4)

315. The largest reservoir in the Segment 1 and 2 areas is Lake Watrous in the Town of Woodbridge. (Tr. 06/03/04, p. 120)

316. The largest watershed within the Segment 1 and 2 area is the watershed to Lake Whitney, which is approximately 37.5 square miles. Lake Whitney is located in Hamden. (Tr. 06/03/04, p. 121)

317. If the RWA watershed property were crossed, a DPH change-of-use permit would be required. This permit would be applied for by the RWA based on information supplied by the applicants of the project. (Tr. 06/03/04, p.151)

318. The RWA recommends the condition that the Applicants would submit an annual report regarding its Integrated Pest Management Plan. (Tr. 06/03/04, p. 154)

Cables

Gas Insulated Transmission Lines (GITL)

319. Gas-insulated transmission lines (GITL) have only been used in sections of several hundred meters in length. One meter is equal to 3.28 feet. (Tr. 1/19/05, p. 45)

320. Gas-insulated lines are installed either at ground level or in a covered trench. (Tr. 1/19/05, p. 46-47)

321. The recommended minimum phase-to-phase separation for a 345-kV (GITL) line is 22 inches. The trench would have to be two to three feet in depth. (Tr. 1/19/05, p. 49)

322. An open grate would be installed to cover the trench. This would provide air circulation to improve the current-carrying capacity of the buses. (Tr. 1/19/05, p. 50)

323. In the Royal Oaks ROW, several options are available. One option is to install GITL to the side of the existing towers, close to the edge of the ROW. Another option is to re-conductor one of the tower systems with an aluminum-clad steel re-enforced (ACSR) conductor, after which one of the two lines would carry the entire current, and then put the GITL close to the dead line. (Tr. 1/19/05, p. 53)

324. Changing the conductor from copper to ACSR, using the same structure, would allow the ACSR conductor to carry the entire load that is presently carried on the two existing lines using copper. (Tr. 1/19/05, p. 54)

325. Examples of GITL include the Seabrook Nuclear Station, and at Con-Ed. (Tr. 1/19/05, p. 56-57)

326. The GITL has about one half the capacitance of XLPE cable and much less than HPFF cable. (Tr. 1/19/05, p. 93)

327. GITL installation in New England have all been a part of a substation or a generation station. (Tr. 1/19/05, p. 78-79)

328. EMF in a GITL is relatively low because the current in the enclosure is similar to the current in the conductor, so it tends to cancel. (Tr. 1/19/05, p. 94)

329. If the GITL were kept away from the edge of the ROW, no EMF shielding would be needed. (Tr. 1/19/05, p. 108)

330. The three phases are contained inside aluminum pipes. For the 15-inch enclosure of a 345-kV line, the conductor would be five to six inches in diameter, and supported on epoxy spacers. Sulfur hexafluoride (at a pressure of about 45 psig) insulates the system. (Tr. 1/19/05, p. 81)

331. Two circuits are recommended to provide for 100 percent redundancy. (Tr. 1/19/05, p. 90)

332. Although the gas-insulated system has about a 30-year history, there is not significant utility experience in the use of GITL. (Tr. 1/19/05, p. 92)

333. ISO-NE has concerns regarding the use of gas-insulated lines, because it has not been applied in a transmission power application. ISO-NE states that they would not support any amount of gas-insulated line. The magnetic fields at a level of 1 meter above the ground over the center of the trench would be approximately 30 mG. (Tr. 2/17/05, p. 259-260)

Cross-linked polyethylene cable (XLPE)

334. Cross-linked polyethylene cable (XLPE) is now widely used in 115-kV systems worldwide. The operating experience of the XLPE cable is not as substantial as that of 115-kV XLPE cable or 345-kV HPFF cable. (Applicants 1, Vol. 6, pp4, 10-11, 26; Applicants 176, App. A. p. 6)

335. Significant progress has been made in the design of the XLPE cable and its splices, which has served to make it more reliable. The electric industry is therefore more willing to embrace it for high-voltage cables and is now moving toward the use of XLPE technology. (Tr. 2/17/05, p. 82)

336. The life expectancy of an XLPE cable joint would be the same as the cable itself. (Tr. 2/17/05, p. 226)

337. Among the advantages of XLPE cable over 345-kV HPFF cables are: lower capacitance; higher load carrying capability; allowance of splicing in discontinuous shifts, enabling cable installation to take place during lower traffic periods; a lack of insulating fluid, thereby eliminating risk of leaks; and lower losses and lower maintenance costs. (Applicants 176, App. A, p. 2)

338. Among the disadvantages of XLPE compared to HPFF cable are: greater cable cost; higher levels of magnetic fields and less operating experience at 300kV and above. (Applicants 176, p.5, pp. 18-19, App. A, p. 2)

339. The applicants evaluated use of both XLPE and HPFF cable, including such factors as reliability, fault rates, and experience of cable operation worldwide. The applicants propose to use XLPE cable because it has lower capacitance than HPFF cable. (App. Ex. 179; Tr. 1/13/05, pp. 77-78, 85)

340. ISO supports the use of both HPFF and XLPE technology, if best practices are used. (Tr. 1/13/05, p. 191)

341. The use of XLPE, instead of HPFF, would mean more vaults in the state highway system (96 versus 32). The trenches would be similar. (Tr. 1/13/05, p. 216)

342. There is some uncertainty as to the exact amount of cable capacitance in the XLPE cables. There is also uncertainty as to whether deviations may be required in the final cable routing. Together, these uncertainties could contribute additional capacitance equivalent to another 2.5 miles of underground installation to the proposed Case 5 alternative. (2/14/05 Tr. at 108)

Avalanche Effect

343. The "avalanche effect" is a longitudinal creeping of cables which are installed in pipes, ducts and extruded aluminum sheaths and has been recognized since the 1920's, especially in areas of grade change. There is a tendency for cables to move downhill, as a result of heating and cooling of cables. Vibrations from vehicle movements can also cause a similar effect. (Tr. 2/17/05, pp. 215-217)

344. The Applicants expect splices to be designed with appreciable margins such that any movement of the cable would not be within the splices. (Tr. 2/17/05, p. 232)

Cable Failure Rates

345. The failure rate for 48 circuit miles of XLPE, using optimistic assumptions would be once every 39 months. A realistic failure rate would be once every 12 months. A more pessimistic failure estimate would be once every two and a half months. (Tr. 1/19/05, p. 128-129)

346. The Singapore 345-kV XLPE cable has, after five years in service, experienced three cable failures, nine splice failures, and two termination failures, due to cable quality issues. (Applicant ex. 113; Tr. 1/19/05, p. 139)

347. The amount of time to repair and service HPFF versus XLPE cable would be very similar. (Tr. 1/19/05, p. 143)

348. In the 1960's and 1970's there were several failures of Con Ed's 345-kV HPFF cables caused by thermal mechanical bending, a movement of the cables within the joint casing that flexed the cables and caused eventual failure. (Tr. 4/21/04, p. 107)

349. Restraints are now installed on cables to prevent mechanical bending. (Tr. 4/21/04, p. 108)

Reliability and Operability Committee

350. The Applicants and ISO-NE established a Reliability and Operability Committee (ROC) in June 2004 to study and determine the maximum amount of underground cable that would be technologically feasible to use in this project, while meeting reliability and operability requirements. (Tr. 1/11/05, p. 44; Applicants 147, p. 1)

351. The ROC issued a report on August 16, 2004, an interim report on October 8, 2004, and a final report on December 20, 2004. The ROC tasked its consultants, including General Electric (GE) and EnerNex, with modeling transient network analysis studies to predict temporary overvoltage conditions in underground cable installations. (App. Ex. 147; Applicants 164; Applicants 176)

352. To determine technological feasibility the ROC looked at acceptable ratings for voltages, primarily in the transient network analyses, under various load conditions, combinations of generation, and combinations of substation capacitor switching. (Tr. 01/11/05, p. 45)

353. The ROC held technical sessions at which CL&P, ISO-NE, and UI were represented. All three participants had to agree on the contents of the ROC Report. (Tr. 01/11/05, p. 38, 39)

354. The ROC found that more risks are assumed as more underground cable is added to the weak system in Southwest Connecticut. (Tr. 01/11/05, p. 30)

355. The ROC identified three supported solutions; the four-mile underground solution, the 13-mile underground solution and the 24-mile underground solution, if mitigating measures are used. (Tr. 01/11/05, p. 31)

356. The mitigating factors that would be required for the 24 mile underground case include using pre-insertion resistors, using two XLPE cables instead of HPFF cable, in most cases, operating only one of the two HPFF cables approved in Phase I, replacing more than 1,200 arresters, and the installation of 500-kV circuit breakers, rather than 345-kV circuit breakers. (Tr. 01/11/05, p. 32)

357. The ROC ran studies on the use of C-type filters to mitigate harmonics and increase the amount of underground installation. The results of the studies were volatile; in some cases the C-type filters worked, in other cases the C-type filters hurt the system. (Tr. 01/11/05, p. 33)

358. The ROC studied the use of HVDC Light in Southwest Connecticut. The use of HVDC Light integrated within an AC system has not previously been done and would be complex. (Tr. 01/11/05, p. 34)

359. The ROC found that 24 miles of underground cable was the maximum feasible amount of underground installation. From a strictly engineering viewpoint, the preference of the ROC would be to have four miles or 13 miles of underground cable because it would entail less risk of failure. (Tr. 01/11/05, p. 39)

360. Synchronous condensers located at the optimal part of the system could be used to absorb the reflected waves and control temporary overvoltages. (Tr. 01/11/05, p. 52)

361. In terms of voltage mitigation, a synchronous condenser is the same as a generator. The difference is that a synchronous condenser is not steam driven. It is a 500 MW machine that is brought to synchronous speed with a pony motor and when there is a change in system conditions it has the ability to deliver energy to the system in megaVARs. (Tr. 01/11/05, p. 69-71)

362. If 24 miles of underground cable were installed, all future additions of generation to the system would have to be studied to ensure that the reliability of the system is not compromised as a result of those modifications. (Tr. 01/11/05, p. 52, 53)

363. Generation connecting to an underground cable may result in an adverse situation because of the additional capacitance on the cables and further study would be necessary prior to the interconnection. (Tr. 01/11/05, p. 56, 57)

364. As more cable is added the resonance points move lower between the second and the third harmonic, which is where the majority of the harmonic current injection is, due to the transformer in-rush currents. (Tr. 01/11/05, p. 166)

365. The line outage conditions that were modeled were intended to represent cases for which a line was out of service for maintenance and a fault then occurred on another line. (Tr. 1/13/05, p. 13)

ISO-NE

366. ISO dispatches generation to maintain system reliability to protect for voltage thermal stability constraints on its system. ISO could also perform load shedding on rotating feeder blackouts. (Tr. 1/13/05, p. 15-16)

367. ISO-NE supports the 24 mile underground installation case, although it carries some risk. (Tr. 1/13/05, p. 41)

368. ISO-NE has stated it could not accept an underground cable length of greater than 24 miles due to its capacitance and unreliability. (Tr. 1/13/05, p. 60-61; pp. 79-81)

GE Portion of ROC Report

369. General Electric (GE), a consulting firm engaged by the applicants, ran 650 cases based upon the Base 5 Case. Of the 650 cases, GE found one case, excluding the Rocky River Substation, which exceeded maximum temporary overvoltages. (Tr. 1/13/05, p. 16-17)

370. The GE model above assumed all capacitor banks were in service. (Tr. 7/29/04, p. 160)

371. GE modeling assumed the DC source was a current source with very high source impedance. (Tr. 7/29/04, p. 191)

372. In Table 8 of the GE Report, there are no results of extended underground installation. (Tr. 1/13/05, p. 17)

373. In its sensitivity cases, GE considered weakening an already weak system. GE added more capacitor banks beyond those on the existing system. (Tr. 1/13/05, p. 18)

374. The sensitivity cases considered minimal local generation in service. The cases that looked at the additional cable were with 70 percent load. A sensitivity analysis was performed with 30 percent load, but not with the cable additions. (Tr. 1/13/05, p. 18-19)

375. The GE Report narrative did not discuss any of the assumptions used in GE's modeling for additional underground installation. (Tr. 1/13/05, p. 22/23)

376. GE considered some mitigation, including synchronous condensers, to evaluate some additional strength in the system and in some cases it made conditions worse. (Tr. 1/13/05, p. 34-35)

377. A feasibility study by GE examined the use of DC with an AC cable in place between East Devon and Norwalk. Such a system had problem caused by a substantial amount of cable capacitance, while the primary source of short-circuit strength from Beseck was cut off, and thereby weakening the system. The study results further indicate low resonant frequency if the East Devon to Norwalk section of AC cable is stranded from its source of strength. (Tr. 7/29/04, p. 138-139)

EnerNex Portion of ROC Report

378. EnerNex, a consulting firm engaged by the applicants, ran 740 cases based upon Case 5 (24 miles of 345-kV underground cable from East Devon substation to Singer substation to Norwalk substation) with no additional underground installation, and 740 cases based upon Case 5 for ten miles of additional underground installation. (Tr. 1/13/05, p. 23)

379. The Applicants assumed certain mitigating measures when studying 24 miles of underground installation, including operating one of the cables instead of two on Phase One; using XLPE on Phase Two with two circuits; changing out the lightning arresters with higher rated arresters which puts more risk on the transformers. (Tr. 1/13/05, p. 32)

380. The Applicants could not find any additional mitigation measures to extend beyond a total of 24 miles of underground installation. (Tr. 1/13/05, p. 34)

381. EnerNex ran hundreds of simulations of the C-type filter impact on the frequency response of the system in one mile increments from the zero base 24 miles up to and including 40 miles to understand the underlying phenomena. See Appendix A. (Tr. 1/13/05, p. 34)

382. EnerNex evaluated synchronous condensers for five, ten and twenty mile additional underground installation cases. (Tr. 1/13/05, p. 35)

383. EnerNex studies show multiple temporary overvoltages at multiple 345-kV buses simultaneously. Many 345-kV and 115-kV locations in the system experience temporary overvoltages, because it is a low frequency phenomenon. (Tr. 2/17/05, p. 118)

384. For every three miles of underground installation between Devon and Singer, the system can only accommodate two miles north and east of Devon. (Tr. 1/13/05, p. 51)

385. If the system had 13 miles of underground installation between Norwalk and East Devon, the system could only support between seven and eight miles in the northern portion of the route. (Tr. 1/13/05, p. 51-52)

386. Use of underground cable may delay electric service restoration after a blackout. All black-start equipment must be in operation prior to restoration to re-establish oil pressure in HPFF cables. Energizing cables with no load on them can lead to extremely high voltages, so the restoration is meticulous and slow. (Tr. 1/13/05, p. 92-93)

387. If HPFF cable were installed, the length limit would be approximately 13 miles due to high TOVs. (Tr. 1/13/05, p. 94)

388. The purpose of having only one of the Bethel to Norwalk cables in operation in a study is to reduce capacitance from the system. (Tr. 1/13/05, p. 117)

389. The system could operate with only one cable between Plumtree and Norwalk, particularly during periods of lighter load. (Tr. 1/13/05, p. 117)

390. If only two cables were assumed to be in operation during periods of lighter load, there would be less capacitance in the system. Two cables in operation would yield better temporary overvoltage results. (Tr. 1/13/05, p. 119)

391. The Applicants did not perform any studies assuming the installation of C-Type filters and one additional STATCOM facility. (Tr. 1/13/05, p. 120)

392. In future gas-insulated substations, the Applicants will use 500kV-rated circuit breakers with pre-insertion resistors. (Tr. 1/13/05, p. 129)

393. If the Applicants had to construct additional underground installation it would prefer to do so from East Devon, especially with XLPE cable. This is because East Devon Substation has an extremely good ground system which helps to stabilize voltages. (Tr. 1/13/05, p. 134-135)

394. After further study of the ABB proposal, the ROC group's conclusions remain the same as those contained in the interim ROC report. (Tr. 1/13/05, p. 142)

395. The ROC report did not provide an analysis of ABB's claims that the principles developed for conventional HVDC multi-terminal technology are directly applicable to VSC HVDC. (Tr. 1/13/05, p. 148)

396. The Applicants only made extensive studies of underground installation for the proposed route, Alternative A, and Alternative B. (Tr. 1/13/05, p. 158)

397. The addition of generation to a 345-kV loop through SWCT would strengthen the system. Strengthening the system with the addition of new generation would counteract the additional capacitance that any new underground line would require, if the generation were strong enough. (Tr. 1/13/05, p. 163-164)

398. The 13-mile case (Case 2) would be the preferred alternative, over the 24-mile case, from an engineering viewpoint. By comparison to the four mile underground case, the 13 mile case would not involve the need to acquire 24 homes and businesses, and would involve less acquisition of ROW between East Devon, Singer, and Hawthorne. (Tr. 1/13/05, p. 172-173)

399. Because of less capacitance the 13 mile underground system would be considered a stronger system than the 24 mile route. (Tr. 1/13/05, p. 173)

400. The Applicants has concluded that change-out of substation equipment required for the 24 mile underground case is acceptable. (Tr. 1/13/05, p. 179)

401. With the exception of the HPFF 345-kV cable, most all 345-kV and higher equipment is manufactured outside of the US. (Tr. 1/13/05, p. 181)

402. As more cable is added to a system, a resonance is created which aggravates the TOV problem. (Tr. 1/13/05, p. 186)

403. The replacement of surge arresters with ones better able to survive temporary overvoltages, would be done on a case-by-case basis at each substation to optimize parameters. A higher rated surge arrester would be more likely to survive the TOV, but would provide less protection for the associated equipment. The Applicants will put the lowest-rated surge arresters possible in each location to have the maximum protection for the existing equipment but still be able to tolerate the TOVs. (Tr. 1/13/05, p. 187)

404. From a purely engineering and reliability standpoint, the four mile underground system would be better than the 13 mile case. (Tr. 1/13/05, p. 190)

405. Going beyond 13 miles of underground installation to 24 miles of underground installation increases risk of transients and voltage abnormalities which reduce reliability due to increased capacitance on the system. (Tr. 1/13/05, p. 194)

406. The four mile underground installation case offers a better margin of safety for TOVs than 13 miles of underground installation. (Tr. 1/13/05, p. 195)

407. If there were more 345-kV connections into the grid from Southwest Connecticut so that when a contingency arises, major sources in the area are not lost, and the impedance stays strong, this would constitute a more robust system, which is capable of accepting more than 24 miles of underground installation. (Tr. 1/13/05, p. 206)

408. The Applicants recommend having 24 miles of double circuit cable west of East Devon, which is a total of 48 circuit miles. (Tr. 1/13/05, p. 214)

409. The Applicants recommend a minimum of three cables per circuit between Beseck and East Devon for all conditions so that two cables are available in the event one fails. (Tr. 1/13/05, p. 215)

KEMA

410. KEMA, NV is based in the Netherlands and owns KEMA Incorporated (KEMA) in the United States. The headquarters of Transmission and Distribution Consulting is in Raleigh, North Carolina. KEMA is not affiliated with any party or intervenor in this case, or the Applicants. (Tr. 12/14/04, p. 20)

411. KEMA provides services related to the design, testing, and analysis of power supply systems and equipment. (Tr. 12/14/04, p. 20)

412. KEMA responded to a request for proposals issued by the Council in early 2004 and was retained by the Council on May 21, 2004. The original scope of the work that KEMA was contracted for included support of the Council in reviewing studies made by the Applicants, and parties in this proceeding, and to assist in discovery and interpretation of the results of those studies. Subsequently the contract was altered to include the additional study of harmonic resonances and impedances on the Southwest Connecticut system. (Tr. 12/14/04, p. 20, 21)

413. KEMA was asked by the Council to develop a harmonic resonance model, and perform harmonic analysis with that model as a first step in assessing the feasibility of the proposed 345-kV improvements and various alternatives. (Tr. 12/14/04, p. 21)

414. KEMA studied the new base system, Case 5, using 24 miles of underground XLPE cables and to compare the harmonic resonance performance with the approved Phase I system. KEMA also investigated extending the underground installation, using XLPE cable, along the Devon to Beseck corridor and looked at 10, 15, 20, and 40 additional miles of underground installation. The studies also looked at STATCOMs and C-type filters as methods of mitigating the harmonic resonance performance and the resonance peaks. (Tr. 12/14/04, p. 22)

415. The initial results of the KEMA studies found that C-type filtering, a passive filtering, were encouraging. Based upon its initial studies of harmonics, KEMA concluded that an additional up to 20 miles of underground installation appeared to be technologically feasible, but after further examination, later determined that this was not reasonable. (Tr. 12/14/04, p. 22, 23; 2/17/05, pp. 44-45)

416. The harmonic studies done by KEMA are indicative of additional underground installation rather than definitive. To determine if additional underground installation is feasible a more extensive harmonic impedance evaluation and transient network analysis would be needed. (Tr. 12/14/04, p. 76)

417. KEMA did not perform any transient network analysis (TNA) studies of their own. (Tr. 12/14/04, p. 23)

418. KEMA determined TNA studies would be valid for some time into the future unless additions significantly change the nature of the transmission system. Most changes in the system tend to be gradual. (Tr. 12/14/04, p. 68)

419. Steady state voltages would reside on the system under steady state normal operating conditions. Transient voltages result from transient phenomena on the system, usually lasting only a few cycles. Temporary voltages result from temporary changes on the system, not necessarily in response to a transient phenomenon, and would typically last for less than a minute. (Tr. 12/14/04, p. 28-30)

420. After a significant blackout, the restoration of underground cable systems is slower than for overhead portions of the transmission system, because of the high amount of capacitance. (Tr. 12/14/04, p. 43)

421. Increased damping results from the additional capacitive charging on that corridor and having more damping resonances and impedances at the lower frequencies is a positive result. (Tr. 12/14/04, p. 128, 129)

422. In designing a transmission system it is important to allow a sufficient margin of safety with regard to resonance to take into account uncertainties and variation in operating conditions. (Tr. 12/14/04, p. 163)

423. At higher frequencies the shunt reactor is damping the higher frequencies, which may be associated with the voltage at that bus bar. Damping means reducing the impedance. (Tr. 12/14/04, p. 184)

424. KEMA attended a Technical Session held on February 14, 2005, which discussed additional undergrounding beyond 24 miles, the use of C-type filters, and the feasibility of alternative underground technologies. At the session, additional investigation by the applicant and its consultants were summarized. (Council ex. 25, p. 1)

425. After reviewing the results discussed at the technical session, KEMA revised its original conclusions and found the additional results provided by EnerNex do support the conclusion that 10 to 20 additional miles of undergrounding would not be technologically feasible. (Council Ex. 25, p. 1)

C-Type Filters

426. A C-Type filter is a standard shunt capacitor along with a reactor, which is tuned to have a total harmonic filtering characteristic at a specific frequency. The size of a C-type filter at 115-kV would be approximately 50 feet by 50 feet. (Tr. 12/14/04, p. 83, 84)

427. C-type filtering could be beneficial to the system regardless of the TNA results because of their ability to reduce harmonic impedances in areas where there are critical problems. They allow the switching in and out of capacitor banks without shifting the harmonic impedance peaks of the system. (Tr. 12/14/04, p. 153, 154)

428. C-type filters operate based on the conditions of the circuit. (Tr. 12/14/04, p. 157)

429. If the C-type filters were off-line there would be less damping on the system but there also would be less capacitance on the system, which would increase the resonance points. (Tr. 12/14/04, p. 158)

430. The most beneficial location to place C-type filters to reduce the magnitude of temporary overvoltages is at locations where harmonic currents are generated, especially at sites with auto transformers stepping up the voltage from 115-kV to 345-kV. (Tr. 2/17/05, p. 91)

431. If a component of a C-type filter is not properly rated for temporary overvoltage mitigation, unexpected operational problems could result. (Tr. 2/17/05, p. 63)

432. C-type filters are not used for mitigation of harmonics in transition stations. (Tr. 2/17/05, p. 64-65)

433. Although the use of C-type filters may be a promising mitigation method for temporary overvoltages, there is still to date no record of any established industry practice in using C-type filters for mitigating temporary overvoltages. The use of C-type filters would then result in significant risk in a way which could affect customer load and power supply equipment. (Tr. 2/17/05, p. 16-17)

434. C-type filters have been employed through the electric power industry for a long period, but these filters have not been used specifically to mitigate temporary overvoltages. The C-type filters may be phased in at selected locations under carefully monitored conditions in situations with minimal possible impacts. (Tr. 2/17/05, p. 17-18)

435. C-type filters have not been previously used to mitigate temporary overvoltages in a system as large and extended as proposed by the Applicants. (Tr. 2/17/05, p. 20)

436. C-type filters may be effectively and safely employed for the proposed 24 miles of underground installation to reduce the overvoltages that may occur. Even an additional five miles of underground installation with C-type filters is not recommended, given the number of installations required to mitigate the temporary overvoltages. See Appendix A. (Tr. 2/17/05, p. 24-26)

437. The Applicants performed further studies on additional types of filtering beyond C-type filters with GE Energy. The studies showed that using C-type filters would result in a reduction of temporary overvoltages after both two cycles and six cycles. However, there is an inherent risk using such filters which is magnified by the number of possible temporary overvoltages and the severity of those temporary overvoltages. (Tr. 2/17/05, p. 49-50)

438. While computer studies indicate that the use of C-Type filters may become a feasible technical option to mitigate TOVs, their use for such applications is unproven in industry practice. Because of this, there is uncertainty regarding their physical size, power rating, and TOV mitigating performance. Therefore, the use of C-type filters to mitigate the extensive number of TOVs that could occur in SWCT is too risky and is not technologically feasible at the present time. The introduction of these filters should be done in a conservative, step-wise process. As more experience is gained with the design and use of C-Type filters they may prove to be an effective mitigating device in the future that may permit additional underground cable to be installed. (Tr. 2/17/05, pp. 16-18)

Surge Arresters

439. Surge arresters are normally used to control transient overvoltages. Surge arresters are subject to failure from longer duration temporary overvoltages. (Tr. 2/17/05, p. 90)

440. Surge arresters need to be replaced to make the 24 miles of 345-kV underground technologically feasible to survive some of the temporary overvoltages associated with that configuration. The Applicants will potentially replace a total of 1,200 surge arresters in substations in Southwestern Connecticut such as Southington, Frost Bridge, Long Mountain, and East Shore. Additional studies will be performed to identify the exact number. (Tr. 01/11/05, p. 135)

Temporary Overvoltages (TOVs)

441. The maximum length of transmission underground installation that is technologically feasible is limited by the magnitude and number of temporary overvoltages (TOVs) that are likely to occur on the SWCT transmission system. (Tr. 2/17/05, pp. 44-46 Wakefield and Enslin)

442. A temporary overvoltage is defined as an oscillatory overvoltage that is at a given location of relatively long duration (seconds, even minutes) and that is undamped or only weakly damped. Temporary overvoltages usually originate from switching or fault clearing operations or from nonlinearities, or both. They are characterized by the amplitude, the oscillation frequencies, the total duration, and the decrement. (Applicants Ex. 176, Appendix B, p. 3)

443. Overvoltage conditions can cause problems on a utility's system such as equipment failures, overheating or mis-operation. Overvoltages increase the magnetic flux in the magnetic cores of equipment such as transformers and shunt reactors, which produces heat in the transformer cores, and can cause the equipment to fail. Overvoltage can cause mis-operation of equipment. For instance, it can cause surge arresters to fail, causing short circuits, or it can cause circuit breakers to fail to interrupt power flow. (Applicants Ex. 176, Appendix B, p. 4)

444. Using underground cable, rather than overhead design, adds capacitance to a power system. This additional capacitance changes the system "resonances" – frequencies at which the impedance is much higher than what would be expected without system capacitance. Because the magnitude of harmonic currents during disturbances tends to be greatest at the second and third order harmonics, resonances at and near those levels are concerns. The point of first resonance will be lower when there is more capacitance on the system or when the system is weaker (less generation and/or less transmission capacity in the area than "normal"). (Applicants Ex. 176)

445. When system elements that increase the capacitance of the system (cable and capacitors) are added, the primary resonance frequency moves lower. Since the main source of disturbing current under fault conditions is due to transformer saturation and the highest currents produced are at low frequencies, in general the highest TOVs are created when the system resonance is lowest. This is the fundamental reason why power engineers try to keep the primary resonance of the power system from getting too low. It is also the reason why the introduction of a large source of capacitance – such as underground cables – into a weak transmission system raises concerns related to harmonic resonance of the system, and warrants investigation by harmonic screening studies to identify impedances that could interact with low order harmonic currents. (Applicants Ex. 176)

446. Certain kinds of electrical disturbances generate voltages and currents at magnitudes and frequencies based on their physical characteristics. The current inrush to multiple transformers following the clearing of a nearby fault is the most significant, because large currents at several frequencies other than the fundamental power frequency are generated. The largest magnitude of these frequencies occurs at low-order multiples of the fundamental power frequency (120, 180, and 240 Hertz for example) For this reason, power engineers try to keep the primary resonance of the power system from getting too low. A common rule is to avoid resonances at or below the third harmonic, or 180 Hz. With 345-kV XLPE cables added to the SWCT power system, the first resonance is below 180 Hz, and will closely approach 120 Hz in some configurations. Because of this, there is a concern that fault clearing transients will produce sustained temporary overvoltages (TOVs) which could damage equipment and lead to outages. (Applicants Ex. 176, Appendix C, pp. 8-9)

447. A safety margin of 0.25 per unit (i.e., 25 percent) for temporary overvoltages is appropriate. The potential for high temporary overvoltages increases with the amount of cable as the linear miles of underground cable increase from 24 miles. (Tr. 2/17/05, p. 56-57)

448. The Applicants have revised their original proposal to include several mitigating measures, including the use of XLPE cable, replacement of surge arresters, and use of 500-kV rated equipment at substations. (Tr. 2/17/05, p. 58-59; Applicants Ex. 199, p. 3)

Acceptable vs. Unacceptable TOVs

449. Lower level TOVs are unavoidable on a large power system. However, it is clear that the existing equipment in SWCT cannot tolerate the TOVs shown in most of the Transient Network Analysis (TNA) results – including those for Case 5. In considering how the rated capability of critical system elements could be upgraded to handle these TOVs, the ROC Group was required to exercise engineering judgment, with the assistance of its consultants. No system should be designed with an expectation that it will be operated for an indefinite time at or near the limit of tolerance of new system equipment, since equipment integrity degrades slowly over time. Moreover, all of the TNA models incorporated assumptions as to load characteristics that are necessarily based in part on engineering judgment rather than definitive data. In any event, these load attributes will change over time. Finally, system conditions will change, including the possible addition of generators and substation capacitor banks. Perhaps most important, it is impossible to be sure that the TNA studies and screens have definitively identified the worst TOV cases that the system will be required to withstand. Some margin of safety is prudent to account for system variability. (Applicants Ex. 176)

450. The Applicants determined the limiting factors for TOVs to be as follows:

Table 1
Typical 84 kV MCOV *and 235 kV MCOV* Surge Arrester Temporary Overvoltage Limits

	2 cycles	6 cycles	30 cycles	1 second
115-kV (84 kV MCOV)	2.03	1.98	1.92	1.89
345-kV (235 kV MCOV)	1.85	1.80	1.74	1.71

(Applicants Ex. 176, Appendix, B, p. 21) *Maximum Continuous Operating Voltage"

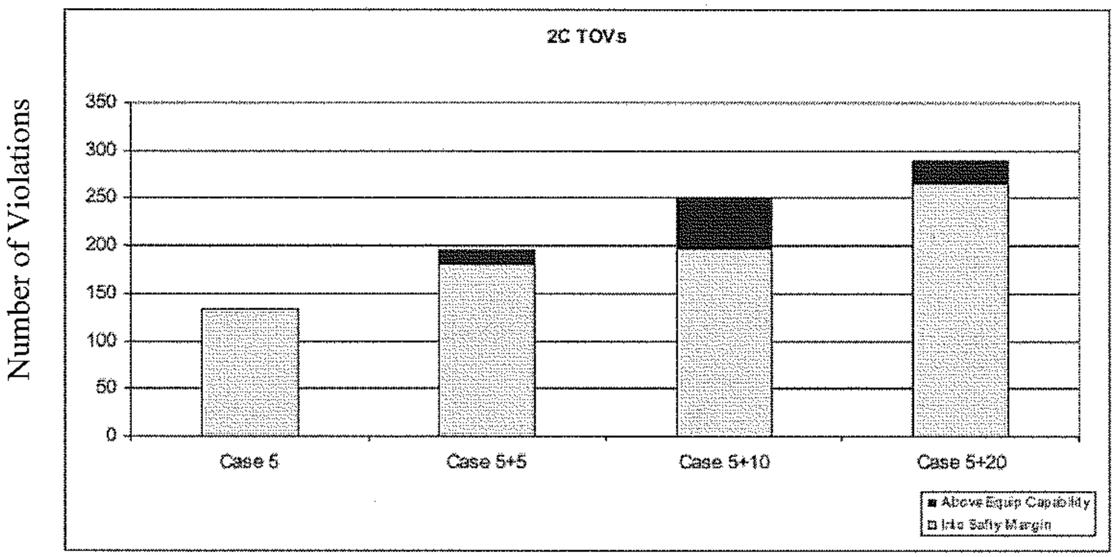
451. Together with their consultants, the ROC Group identified an operating margin to account for the elements of system variability to address sensitivities associated with additional substation capacitor banks, additional generation, and loads. The ROC Group assessed each of the components of the required system variability margin individually and then derived a total margin of 0.25 per unit. This defines a "safety margin" beneath the limiting factors listed in Table 1. TOVs within the safety margin are a cause for concern. TOVs that exceed the safety margin are clearly unacceptable. (Applicants Ex. 176)

Expected TOVs on the SWCT System

452. TNA studies were performed by the Applicants, and these studies confirm that TOVs become higher as the total length of underground transmission increases. This is due to the associated increase in system capacitance and its tendency to lower the frequency levels of the first system resonance peaks. Even for the proposed amount of underground installation (approx. 24 miles) the magnitude of TOVs exceeds recommended safety margins on some occasions. (Council Ex. 25, pp. 2-3))

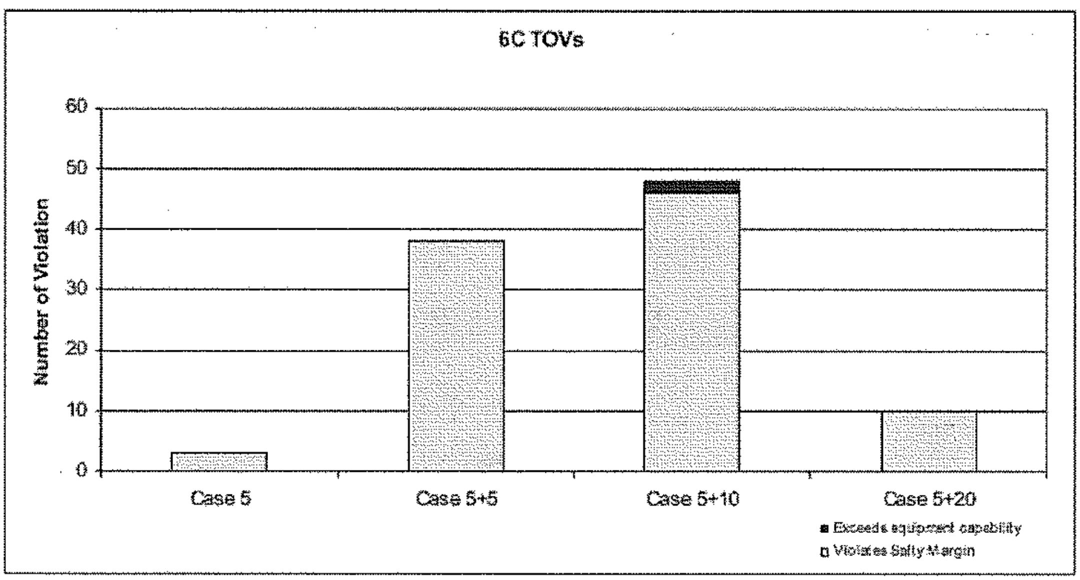
453. Additional underground installation increases TOVs to unacceptable levels, even for an additional 5 miles of U/G. EnerNex studies indicate the potential for exceeding surge arrester ratings on numerous occasions. With an additional 10 and 20 miles of underground installation the number of such TOVs increases further as shown in Figures 1A and 1B. See also Appendix A. (Council Ex. 25, pp. 2-3))

Figure 1A



Note: "2C" = 2 cycle duration

Figure 1B



Note: "6C" = 6 cycle duration

TOV Mitigation Options

454. One mitigation option that was considered and adopted for reducing capacitance was to change the type of underground cable technology to XLPE. In their original application, the Applicants proposed to use HPFF underground cable because of its proven reliability. As the Council noted in Docket 217, XLPE cable is a newer and still maturing technology at the 345-kV voltage level. However, the capacitance of this cable is only about 60% of that of HPFF cable. Since the capacitance of the system is a significant cause of TOVs, XLPE cable can reduce the negative effect of capacitance compared to HPFF cable. The harmonic screens and TNA studies that were performed before the ROC Group was formed indicated that the Applicants original proposal, with HPFF cable, would produce unacceptable harmonic resonances. A change to XLPE cable preserves the underground route as originally proposed. (Applicants Ex. 176)

455. After considerable deliberation, the ROC Group determined that, in light of performance statistics that have become available since the Docket 217 hearings, XLPE cable will be reliable enough for this application, and the greater risk of employing this cable can be accepted in order to comply with the mandate of P.A. 04-246 to maximize 345-kV underground construction. (Applicants Ex. 176)

456. Another measure that was adopted to reduce system capacitance was the removal from service of one of the Phase I cables when it is not needed. Under light and moderate load conditions, the Bethel to Norwalk system will be operated with only on of its two 345-kV HPFF cables in service so as to reduce system capacitance. Both HPFF cables are likely to be in operation under heavy generation conditions, and may be operated then without a problem since more local generation would be in service and far greater load would be connected to the system acting to dampen transients and TOVs. Even when only one cable is operating during light load periods, the other could be switched into service following a system contingency. (Applicants Ex. 176)

457. The substitution of STATCOMs for shunt capacitors to reduce system capacitance was considered but rejected because the control of a large number of STATCOMs in close electrical proximity presents additional design, reliability, and operational challenges. Also, STATCOM technology is not a mature, reliable technology for this application, and its use would not result in a reliable solution to the electric needs of SWCT. (Applicants Ex. 176)

458. The use of various types of passive filtering was considered as a potential means of mitigating the magnitude of TOVs. Such filters reduce (or attenuate) harmonic impedances in specific frequency ranges, causing a directly proportional reduction in the TOVs from the affected harmonic resonance peaks. The most promising filter option was the use of C-Type filters, because it provides damping across all the frequencies. (Council Ex. 25, p. 2-3)

Construction

State of Connecticut Department of Transportation (DOT)

459. The DOT has requested that the Council allow the DOT to negotiate an agreement with the applicant regarding issues with the installation of the proposed cables within State roadways, comparable to Phase I (Docket 217). The DOT proposes that the encroachment agreement made in Phase 1 be used as a template for the proposed project. (Oral Arguments Tr. 03/31/05, p. 200-201)

460. An encroachment permit issued by the DOT allows the permittee to make installations within the highway right-of-way under certain conditions. The encroachment permit issued by the DOT, based on past time limits, typically takes approximately three weeks to review, for this type of utility installation, and an additional one to two weeks or two to issue the permit. Consequently, such a permit may take one to two months to process, and involves a full review of the construction plans, methodologies, timing of the work, and traffic management. (Tr. 4/22/04, p. 168; Tr. 06/15/04, p. 232, 233)

461. The DOT would be willing to allow the applicants to bury the proposed cables at a depth of three feet if the applicants are willing to agree to pay the relocation costs of the cables in the future. The three foot burial depth of the cable is consistent with the encroachment agreement for Phase I (Docket 217). (Tr. 06/15/04, p. 229; Oral Arguments Tr. 03/31/05, p. 201)

462. The encroachment agreement for Phase I (Docket 217) took more than a year to be reached. The DOT feels that using the Phase I agreement as a template would save time in finalizing an encroachment agreement for the proposed Phase II project. (Oral Arguments, Tr. 03/31/05, p. 201)

463. The DOT recommends locating the underground transmission cable in roads other than state highways to minimize the construction impact on traffic and the community. (Tr. 06/15/04, p. 215)

464. The DOT believes secondary or town roads do not have the amount of underground utilities in them that the state highway system has, nor do they have the traffic volume. They are better able, therefore, to withstand alternating, one-way traffic during construction. (Tr. 4/22/04, p. 174)

465. The DOT has asked the Applicants to avoid the use of Route 1. The DOT is concerned about segments 3 and 4. (Tr. 7/28/04, p. 116-117)

466. On August 19, 2004, the Applicants met with representatives of the towns in segment 4 and the DOT to discuss route options and the possibility of using roads off of Route 1. The Applicants then had individual meetings with the City of Bridgeport on September 14, 2004, the Town of Westport on September 16, 2004, and the City of Norwalk on September 22, 2004. (Tr. 09/29/04, p. 9-11)

467. The DOT brought forth two additional routes for consideration. Both of the DOT routes were 2.6 miles longer than the original proposed route. The routes that the DOT proposed are solely in residential areas. The original proposed route along Route 1 is a combination residential and commercial area. (Tr. 09/29/04, p. 11, 12, p. 60)

468. Prior to construction of the proposed underground cable in state roads, traffic safety, traffic operations, and mobility issues have to be resolved to allow the DOT to maintain a safe and efficient transportation system and accommodate the cables in the roadway. (Tr. 06/15/04, p. 215)

469. The DOT would recommend the Applicants consider the land use of each area to determine hours of construction. (Oral Arguments, Tr. 03/31/05, p. 203)

470. Along Route 1, permissible DOT construction schedules are typically limited to the hours of 10:00 p.m. to 6:00 a.m. (Tr. 4/22/04, p. 170)

471. The DOT would require daily progress reports from the applicants. A DOT permit inspector would be on site to oversee the general administrative issues with the permit. (Tr. 06/15/04, p. 283)

472. Restrictions on the construction along railroad lines are governed by the operating railroad, the criteria and requirements, of which, are established by the railroad company and the Federal Railway Administration. (Tr. 4/22/04, p. 151)

473. DOT concerns on utility construction along highways include operations and safety. Route 1 in southwestern Connecticut is one of the most heavily traveled roadways in the state. Along limited access highways, which are high volume, high speed roadways; there cannot be any longitudinal activity near the highway pavement. (Tr. 4/22/04, p. 155-156)

474. To allow access to splice vaults for maintenance, the DOT recommends that the vaults be located outside of the roadway wherever feasible to avoid impact to the transportation system, especially during peak travel periods. The DOT prefers the vaults must be located off the paved surface of the right-of-way because cable splicing is a lengthy procedure. (Tr. 09/29/04, p. 71; Tr. 4/22/04, p. 162)

475. There is a long history of cooperation between UI, CL&P and the DOT. (Tr. 4/22/04, p. 166)

476. In the case of electric transmission, a co-location agreement is for longitudinal installation of lines which are permitted under appropriate DOT conditions. An encroachment permit would still be needed if a co-location permit is issued. Fiscal responsibilities would be included in the co-location agreement, and night time construction limits are typically in the encroachment permit. (Tr. 4/22/04, p. 169-170)

477. DOT requires open trenches to be as short as possible. In the Phase I (Docket 217) encroachment permit the DOT adopted steel plating guidelines for the construction of the cables in the roadways. (Tr. 4/22/04, p. 171; Oral Arguments, Tr. 03/31/05, p. 201)

Additional Underground Installation

478. With the proposed 24 miles of underground installation, the proposed system would incur only one violation in the safety zone, which is acceptable. In the safety margin, there were 134 violations. The safety margin is a cushion of .25 above the red zone. The red zone is an area of catastrophic failure of equipment. In the Case 5+5 miles scenario, there are 195 instances in the safety margin, and 15 other violations which the equipment is not rated for. (Tr. 2/17/05, p. 108-110) (See Appendix A)

479. An 18-mile underground scenario would approach zero safety margin violations. (Tr. 2/17/05, p. 109)

480. The Applicants did not propose 18 miles of underground installation instead of 24 miles, because an 18-mile scenario would terminate in the Bridgeport-Stratford area, without a substation to connect to Bridgeport Energy. (Tr. 2/17/05, p. 110)

481. An intrusion into the red zone, where equipment capability is exceeded beyond the safety margin, as shown in Appendix A, would lead to a failure of equipment downstream, including breakers and transformers. This would cause large system outages. (Tr. 2/17/05, p. 110)

482. To be technologically feasible, additional underground installation must employ technology that has been adequately proven in actual industry practice, including mitigating temporary overvoltages that occur after transients on the system. (Tr. 2/17/05, p. 16)

483. An additional 10 to 20 miles of underground installation may appear possible using only harmonic study data; however, transient and temporary overvoltage concerns negate the harmonic study results. (Tr. 2/17/05, p. 18-19)

484. KEMA found the studies provided by the Applicants and its consultants to be adequate to base a judgment on whether underground installation is technologically feasible. (Tr. 2/17/05, p. 20)

485. KEMA found additional underground installation beyond 24 miles would result in some changes in resonance characteristics of the system. An extension of two to three miles, extending from the East Devon substation, raises concerns on impacts to the harmonic characteristics of the system. (Tr. 2/17/05, p. 37)

486. Additional investigations of underground installation beyond 24 of lengths of five, ten and 20 miles are not recommended. Evidence to support this conclusion was found within Appendix E of the final ROC Report. (Tr. 2/17/05, p. 44-45)

487. The temporary overvoltage problems were found to be worse than originally expected. (Tr. 2/17/05, p. 47)

488. An additional underground length of three miles would be as problematic as five miles, resulting in more temporary overvoltages exceeding the safety margin. The total capacitance resulting in second and third harmonic resonance is the deciding factor. (Tr. 2/17/05, p. 93)

489. Additional studies by EnerNex showed approximately 100 violations within the safety margin of temporary overvoltages. The temporary overvoltages would exceed the equipment rating. (Tr. 2/17/05, p. 95)

490. Adding any additional miles over the 24-mile underground installation would only further endanger the SWCT system. (Tr. 2/17/05, p. 95-96)

Porpoising

491. Combining overhead and underground segments in the same circuit (porpoising) results in changing the impedance from overhead to underground, resulting in additional transients added to the system which can result in a doubling of the voltage wave which occurs when circuit breakers are closed. XLPE systems must be extremely well grounded to minimize the voltages that appear on the sheath of the cable. (Tr. 2/17/05, p. 96-97; 6/1/04, p. 238)

492. Splitting up the 24 miles of underground installation into various separate segments would add complexity to the system. (Tr. 01/11/05, p. 62)

493. Having any cable system connected directly to East Devon, Singer, or Norwalk substations, which have an extensive ground grid, would be the preferred engineering solution. Installing a section of cable between two overhead transmission lines adds risk and complexity. This makes it more difficult to identify where a fault is located. No re-closing of current breakers can take place until the site of the fault has been clearly identified. (Tr. 2/17/05, p. 30, p. 41, p.97-98)

494. A key issue with underground installation, and especially porpoising, is the switching transients associated with the operation of the system. Full transition stations with switching capability would be necessary. (Tr. 06/01/04, p. 238, 239)

495. Porpoising a transmission line may increase the risk of reliability by creating a weak point. The weak point is typically the hardware where the conversion is made from overhead to underground and at the opposite end from underground to overhead. Transition stations would consist of individual circuit breakers and/or shunt reactors at each terminal. Construction of transition stations would require four to eight acres of land. (Tr. 06/15/04, p. 156; Tr. 6/02/04, p. 21; 6/03/04, p. 9)

Vaults

496. A vault is a buried concrete enclosure where underground cable ends are spliced and cable grounding is installed. To determine the distances between vaults in underground installation, factors to be considered include subsurface data of what infrastructure is in the path of the line, the curves in the roadway, and depth below infrastructure. It is preferred that vaults avoid four-way intersections by going on one side or the other of the intersection. The Applicants would locate the vaults so they would have minimum impact on the community and traffic. (Tr. 4/22/04, p. 8-10; Applicants 1, Vo. I, Glossary, p. 8))

Horizontal Drilling and Boring

497. The Applicants are considering two trenchless techniques for boring under rivers, horizontal directional drilling and boring and jacking. (Tr. 4/20/04, p. 157)

498. HDD is a surface-to-surface process. Equipment is set up, a pilot hole is drilled and then reamed out to an appropriate size, and the duct or pipe pulled into the hole. It is a "steerable" drilling process. (Tr. 4/20/04, p. 158-159)

499. Boring and jacking involves construction of pits on either side of the obstacle and then thrusting and simultaneously installing pipe by use of a jacking process with an auger to bring spoil out or some type of slurry system to make a small tunnel. A 60-inch tunnel would be bored with a pipe casing. (Tr. 4/20/04, p. 159-160)

500. For HDD, two separate 36-inch holes would be drilled and each would contain three eight inch pipes. To facilitate pulling the pipes through the hole, the actual hole must be 150 percent larger than the diameter of the pipe being installed. (Tr. 4/20/04, p. 160)

501. If the soil is composed of larger grain material or gravel and cobble, pipes could get stuck during pull-back requiring pulling the pipes out of the hole. (Tr. 4/20/04, p. 161-163)

502. In HDD, while the pipe is being reamed out, bentonite drilling mud is pumped in. This allows the pipe to be pulled through sand or cohesion-less soil while in a fluid state even if the hole collapses. The depth is designed to be a minimum of 15 feet. (Tr. 4/20/04, p. 161-163)

503. It is possible for drilling mud to migrate upward into the body of water above it. (Tr. 4/20/04, p. 167-168)

504. The depth of jack and bore would be 8 to 10 feet below the waterway. (Tr. 4/20/04, p. 163, p. 168)

505. Heat dissipation can be a problem in a jack and bore or HDD operation. In HDD, there would be two bores, each containing one of two cable lines, about 15 to 20 feet apart, greatly reducing the heating effects and thereby maintain the rating of the cable. (Tr. 4/20/04, p. 169-170)

506. HDD typically is drilled at an angle of 10 to 14 degrees, from the horizontal at a depth of about 40 feet from the river surface. (Tr. 4/20/04, p. 174-175)

507. CL&P transmission lines in state roads include: 0.25 mile of 115-kV XLPE cable from the Exeter generating plant along Route 14 in Plainfield; a 69 kV HPFF cable connected to SCRRRA in Preston for 2.25 miles along Routes 12, 2A and 117; and one mile of 115-kV ethylene propylene rubber cable in New London along Route 32. No contaminated soils were discovered in these projects. (Tr. 4/20/04, p. 178-179)

508. The cost of an underground line ranges from $8,500,000 to 12,670,000 per mile. (Applicants 1, p. I-4, I-5, Applicants 172)

Split-Phasing

509. Split-phase consists of dividing a single circuit in a way that equal amounts of current flow on the conductors in parallel and that the phasing of these conductors are adjusted to maximize cancellation of magnetic fields. (Tr. 5/12/04, p. 51; Tr. 7/27/04, p. 39-40)

510. The use of split-phasing is an accepted industry practice in use for the past 15 years throughout New England and the United States. The reliability of split-phasing has been proven in thousands of miles of transmission lines across the nation, although not specifically for magnetic field mitigation. (Tr. 2/17/05, p. 104-105; Tr. 5/12/04, p. 50))

511. Costs of optimized split-phasing include the additional conductors required, the size of the pole, and the size of the foundation. (Tr. 7/27/04, p. 179)

512. The only place optimized split-phasing may not be possible is in locations with severe angles, or in going from a split phase to two separate vertical structures. (Tr. 7/27/04, p. 181-182)

513. The negative impacts of split-phasing in this project would include the increase of the height of the structures, the bulk of structures and the increase in cost, because two circuits would have to be built rather than one. (Tr. 05/13/04, p. 139)

514. Split-phase can be used for an indefinite length and it is possible to transition back out of it, for either a short length or a much longer length. The transition, mid-line rather than at terminals, into and out of split-phasing of the lines would require approximately three spans of structures, or 2,500 feet. (Tr. 7/27/04, p. 82-83; Tr. 02/17/05, p. 199)

515. Optimized split-phase has been used by a utility in New York. It would be expected to be as reliable as a double-circuit line, and is very similar to a double circuit line with three wires on each side of the structure. Split-phase lines show reductions in EMF levels and match calculated levels. (Tr. 7/27/04, p. 61-62)

516. There are currently no split phase installations of transmission lines, for mitigation of EMF, in Connecticut. (Tr. 5/12/04, p. 50; Tr. 05/13/04, p. 136)

517. In the EMF calculation model, the variables include the conductor geometry and current magnitude. (Tr. 7/27/04, p. 203)

518. A slight increase in line outages may occur if split-phasing is implemented, as it could increase the chances of an insulator flashover. (Tr. 7/27/04, 207-208)

519. The Connecticut grid has instances of split-phasing through bundled circuits from Frost Bridge to Devon. When the two circuits were bundled, the current split. (Tr. 7/27/04, p. 215-216)

520. In an AC system, each of the phases is 120 degrees out of phase with each other in a 360 degree vector notation. Each phase in a transmission line is determined by its connection to equipment at a substation. (Tr. 7/27/04, p. 216-217)

521. The 27.7GW case assumes the worst possible stressed case, with a minimum generation on-line in SWCT, resulting in maximum currents flowing on the 345-kV and 115-kV systems to meet SWCT load requirements. (Tr. 7/27/04, p. 230-231)

522. Peak electrical usage in New England typically occurs in summer during the daytime. The winter peak typically occurs at night. (Tr. 7/27/04, p. 238)

Municipalities and Communities

Durham

523. There are a total of 15 residences along the ROW in Durham at 6mG or higher, calculated at the 15GW load level. (Tr. 2/1/05, p. 139, p. 167, p. 205)

524. The Applicants has identified one home at 15 Packing House Hill Road which encroaches onto the existing ROW. The Applicants have not identified any other homes encroaching onto the ROW, as determined by the use of aerial photographs. (Tr. 2/1/05, p. 171-172)

Royal Oak Bypass

525. The Royal Oak subdivision neighborhood is located in the northern portion of Durham and the southern portion of Middletown. The project as proposed by the Applicants would follow the existing ROW through the subdivision for a distance of about 3,000 feet. (Tr. 06/02/04, p. 27, p. 225)

526. The Applicants investigated a route that would bypass the Royal Oak neighborhood beginning on June 2, 2004. There is adequate space to take the 345-kV line to the north of the Royal Oak neighborhood and south of another development, through a hardwood forest. The bypass would require the clearing and crossing of seven acres of wetlands. This bypass would be a new right-of-way, which would have to be cleared. (Tr. 06/02/04, p. 27; Tr. 7/27/04, p. 59; Tr. 03/31/05, p. 265)

527. The bypass of the Royal Oak neighborhood would be located in Middletown and Middlefield and totals 1.1 miles. There are three structures within 300 feet of the Royal Oak bypass. ((Tr. 10/14/04, p. 32, 33; Tr. 06/02/04, p. 226, 228; Applicant 163, aerial photographs, map 2 of 13)

528. The Royal Oak Bypass would be just as reliable for the proposed facilities as the proposed route. (Tr. 06/02/04, p. 230)

529. The Royal Oak Bypass would be a new ROW with split phase 345-kV only. A split phase 115-kV would remain on the existing ROW. (Tr. 2/1/05, pp. 149-151)

530. The 115-kV line could be rebuilt and split-phased onto a single monopole. The bypass for only the 345-kV line would be 125 feet wide or 165 feet for both the 345- and 115-kV lines. (Tr. 2/1/05, pp. 149-151)

531. If both the 115-kV and 345-kV lines were placed on the same pole, with one line on each side, a 105-foot structure would be used. The 115-kV line could be placed underground for a total distance of about one mile. (Tr. 2/1/05, p. 155-156)

532. If a 345-kV line is placed on the bypass alone, a 150-foot pole would be needed for split-phasing. (Tr. 2/1/05, p. 157)

533. The diameter of a 150-foot pole would be between six and eight feet at the base. A 190-foot pole would have a diameter of approximately 10 feet at the base. (Tr. 2/1/05, p. 163-164)

534. If the bypass is used for the 345-kV line, the existing 115-kV line could either be reconstructed with a split phase configuration and remain where it is or follow the bypass route. (Tr. 09/28/04, p. 158, 159, 164)

535. Two H-frame structure 115-kV lines now constitute one circuit in the Royal Oaks area. The H-frames are about 57 feet tall. The 115-kV line could be placed underground in the streets, and the H-frames removed from the ROW, which is 125 feet wide. (Tr. 2/17/05, pp. 233-234)

536. The calculated magnetic field for the existing 115-kV line is 9.2 mG on the southeast edge of the ROW and 13.9 mG at the northwest edge. (Tr. 2/17/05, p. 235)

537. The low magnetic field design, with split-phase 345-kV at 130 to 140 feet above ground, would be 6.2 mG at both sides of the ROW. (Tr. 2/17/05, p. 235)

538. The Royal Oak Bypass is supported by the towns of Middletown, Durham and Middlefield. There is an agreement in place since 1997 between the residents of Royal Oak Subdivision and Northeast Utilities to preserve vegetation along this unique ROW in this area. The Applicants do not oppose construction of the Royal Oak Bypass. (Brief of City of Middletown, 3/16/05, p. 6; Tr. 2/27/04, p. 59; Tr. 3/31/05, p. 218, p. 221, p. 263)

Wilson Parcel

539. Linda D. Wilson owns a fifty percent interest in a parcel of land in Durham and Middletown. South Main Street Irrevocable Trust holds a 50 percent interest in the Wilson parcel. The Wilson parcel is zoned residential. The Wilson's sought approval for a 25 lot residential subdivision in 2004. The final subdivision plan was submitted to the Middletown Inland Wetlands agency in November 2004. (Tr. 1/19/05, pp. 34-35, 61-63; Wilson 3)

540. The proposed subdivision plan includes 25 lots and is known as Majestic Oak Estates. (Tr. 1/19/05, p. 63)

541. An existing 125-foot wide electric utility ROW runs through the Durham portion of the Wilson parcel, part of the ROW used for existing overhead lines extending through the Royal Oak subdivision. (Tr. 1/19/05, pp. 79-80; Wilson 2)

542. Wetlands on the subdivision include lot numbers 25, 18, 21, 23, 11 and 22. (Tr. 1/19/05, p. 66)

543. The Wilson property is predominantly forested. Placing the proposed ROW through the Wilson parcel would require clearing a new 125-foot wide ROW through the wooded parcel of a potential 165-foot wide ROW, if two lines are installed on the ROW. (Wilson 5; Tr. 1/19/05, p. 115; Tr. 2/1/05, p. 154)

544. Mr. Wilson has indicated to the Applicants that he does not want any construction on his subdivision, but has no objection to use of the present ROW. (Tr. 1/19/05, p. 100)

Middlefield

545. The proposed route, from Oxbow Junction to the proposed Beseck Switching Station is shorter, less expensive, and a more reliable route than a suggested "northerly route". The Northerly Route would require the location of four 345-kV circuits along a common ROW between Chestnut Junction and Black Pond Junction and between Black Pond Junction and the proposed Beseck Switching Station. (Applicants 90, p. 14)

546. Black Pond Junction and Beseck were both considered as switching station sites. There is insufficient land available at Black Pond Junction owned by the Applicants to construct a switching station. CL&P owns 52 acres of land at the Beseck site. (Applicants 90, p. 18)

547. Black Pond Junction borders Cockaponset State Forest and a switching station there would be visible from the Mattabessett Trail and from nearby Mt. Higby. (Applicants 90, p. 19)

Meriden

548. The proposed route through Meriden would run from Black Pond Junction to East Meriden Substation, 1.4 miles; and then another 0.9 miles to the Wallingford town line. (Applicants 1, Vol. I, p. I-14)

549. Meriden identifies two statutory facilities adjacent to the ROW: a day care facility, and a girls' softball complex. (Meriden 1, pp. 2-3; Meriden 2; Meriden 3; Tr. 1/18/05, p. 82-83)

550. The Connecticut Baptist Convalescent Home (60 bed facility), 38 affiliated independent living housing units and a 30 unit condominium complex on Thorpe Avenue in Meriden are adjacent to the ROW. Also, an estimated 54 residential structures are within 300 feet of the outermost conductor (Meriden 1, pp. 2-3; Meriden 2; Tr. 1/18/05, p. 82-83)

551. The City of Meriden suggests an alternate route, Research Parkway, which is 0.3 miles to the west, parallel to the proposed route. There are no residences or statutory facilities along this alternate route and the City suggests the lines be undergrounded and relocated along Research Parkway within the City of Meriden ROW. The City holds a 60-foot ROW along this road. (Meriden 1, p. 4; Tr. 1/18/05, p. 84-85)

Milford

552. The proposed transmission line ROW extends 5.5 miles through Milford. (Tr. 6/3/04, p. 231)

553. In Milford, the Applicants would remove the two H-frames and the lattice structure that exist today, and install a 135-foot tall split-phase 345-kV line and a double circuit 115-kV line. Lowering the structures by 30 feet would result in no greater than 6mG at the edge of the ROW, which is 165 feet wide. (Tr. 2/1/05, p. 201)

554. Eisenhower Park is Milford's largest open space and recreational parcel, including ball fields, a playground, tennis courts, equestrian area, picnic area, and hiking trails. (Milford 15, p. 2)

555. In the Eisenhower Park ball field, a statutory facility, using low magnetic field design, magnetic field calculations yield levels of 4.3mG in the center and moving to the northwest side in 25-foot increments, the levels would go from 4.3 to 5mG, 4.5 to 2.9mG at the edge of the ROW based on a 15 GW line load. (Tr. 2/1/05, p. 202-203)

556. The City of Milford is concerned that the restrictive buffer zone limitations associated with the proposed project would bisect Eisenhower Park, separating two recreational areas from each other. (Tr. 1/18/05, p. 5)

557. There are now three rows of electric transmission line structures crossing Eisenhower Park, bisecting the park. The Applicants proposal would result in to two rows. (Tr. 1/18/05, p. 65)

558. A 300-foot buffer zone, with acquisition of that buffer zone by the utility, would disrupt any plans for Eisenhower Park. Bisecting the park into two parcels would disrupt the park. (Tr. 1/18/05, p. 69)

559. A large well functioning vernal pool is located near a pole to be removed and another vernal pool and amphibian breeding area are located adjacent to the transmission ROW. (Tr. 6/1/04, P. 113; Milford 11, p. 11)

560. Approximately 2.8 acres of wetlands in Milford would be temporarily disturbed and approximately 1.4 acres of wetlands would be permanently filled. (Milford 11, pp. 10-11)

561. The City of Milford proposed installing approximately 3.6 miles of underground cable from East Devon Substation to a transition station site. The City identified several possible transition station sites, including a 66 acre parcel owned by the city near Eisenhower Park. (Applicants 97, p. 2, 97a; Tr. 1/18/05, pp. 43-46, 50; Milford 14)

Stratford

562. In Stratford, the line would pass about 70 feet from a school building (S-101 on the maps). Steel plating over the proposed underground line in front of the school would be possible. (Tr. 2/1/05, p. 270-271)

Wallingford

563. If the existing line is left in place, and a 345-kV delta design is used for the new line, the magnetic fields would be 4.2mG at the southeast edge and 21.2mG on the northwest edge. If two H-frames were used as proposed, the magnetic fields would be 15.9mG on the southeast edge and 27.8mG on the northwest edge. (Tr. 2/1/05, p. 184)

564. A 115-kV H-frame line exists in Cross Section 6 (west). The original proposal had one monopole with the 345-kV line on one side and the 115-kV line on the other. Using a low magnetic field design would require a two-pole structure, with the split-phase 345-kV line on one structure and the relocated 115-kV line on the second structure. Existing magnetic fields are 0.3mG on the southeast side and 2.4mG on the northwest side. The original configuration would have resulted in 5.1mG on the southeast side and 12.4mG on the northwest side. (Tr. 2/1/05, p. 186-187)

565. In Wallingford, in the Valley View Drive area, the existing poles are double H-frames 57 feet high. The application design is for a 140-foot monopole design with 345-kV and 115-kV on one pole. The low magnetic field design would employ a 182-foot pole to get existing houses within the 6mG level. The higher pole could be moved farther from existing homes in the area. (Tr. 2/1/05, p. 189-191)

566. The lowest engineering height achievable in this area is 117 feet. (Tr. 2/17/05, p. 185)

567. The existing H-frames in Cross Section 6 are about 57 feet high. (Tr. 2/17/05, p. 190)

568. The 182-foot tower would be a composite monopole, with one 345-kV circuit on one side and one 115-kV circuit on the other. (Tr. 2/17/05, p. 194)

569. The base of the composite monopole would be 8 to 12 feet in diameter, and the footing would be 12 to 16 feet in diameter. (Tr. 2/17/05, p. 195)

570. A transmission tower now on Beseck Mountain is approximately 80 feet high. Any low EMF design replacement tower in this location would require a 112 foot composite monopole. (Tr. 2/17/05, p. 196)

571. The low EMF design would produce a magnetic field of 6 mG or less at the nearest house. (Tr. 2/17/05, pp. 197-198; Applicants 202)

572. In order to move from a best design to a low magnetic field structure, a transition must be made with a number of structures, and structure shifts must be accommodated. Three spans on either side would be sufficient. (Tr. 2/17/05, p. 199)

573. The EMF levels provided were calculated at the lowest conductor to the closest point of a house. (Tr. 2/17/05, p. 200)

Westport

574. The proposed route along Route One in Westport would be south of the site of a former landfill bordered by the Saugatuck River and Deadman's Brook. The Applicants would consult with the EPA and the Town Engineer to avoid this site. (Tr. 4/20/04, p. 217-218)

575. It would take an estimated five days for construction to proceed along a 650-foot section of Lincoln Street in Westport. The Applicants would ensure residences have access in and out of their homes. Adjacent to the end of Lincoln Street either a receiving or jacking pit would be installed to accommodate construction of the Saugatuck River submarine crossing. (Tr. 4/20/04, 220-222)

576. There would be minimal disruption on Riverside Avenue in Westport because the boring would go under Riverside Avenue. The bore activity would take approximately 6 weeks. (Tr. 4/20/04, p. 223-224)

577. The Applicants would be working 24 hours a day to place the pipe in subsurface soils beneath the Saugatuck River. The residents likely would notice the construction on Lincoln Street, as engines would be running and equipment lights kept on at night. The drilling rig is planned to be placed on the west side of the Saugatuck River. (Tr. 4/20/04, p. 225-226)

578. To accommodate the work in the Saugatuck River crossing in Westport, the Applicants would consider placing some of the affected residents in local hotels during construction when the noise is greatest. (Tr. 4/20/04, p. 229)

579. Before starting, the Applicants would have open discussions with the towns concerning the best ways to proceed with the least disturbance. (Tr. 4/20/04, p. 230-232)

580. For the Saugatuck River crossing, the Applicants did consider the use of Burr Road versus Lincoln Street; however, Burr Road is much steeper. They also considered a route farther along Riverside Avenue, which is a busy street. (Tr. 4/20/04, p. 239-240)

581. The maximum distance for HDD is about 7000 feet. (Tr. 4/20/04, p. 240)

582. Depending on soil conditions, a 5000-foot river crossing may take three to five months. (Tr. 4/20/04, p. 240)

583. In Westport, a day care center (142 on map) is about 60 feet from the proposed line route. (Tr. 2/1/05, p. 277-278)

Woodbridge

584. The Town of Woodbridge submitted to the Applicants a proposed underground route along Town roads, including locations for two transition stations in the Town to enable the line to be "porpoised". This Town proposed route would result in approximately 3.4 miles of underground installation in Woodbridge. (Tr. 6/15/04, p. 189; Letter from David Ball to Applicants dated 5/25/04, Supplement to Town's Municipal Consultant Comments)

585. The Town's proposed 3.4 mile underground route would travel north from Johnson Road to Pease Road, east on Route 114, across Route 63, then north on Cedar Road, or Route 63, reaching CL&P owned property near the intersection of Route 63 and Clark Road. (Letter from David Ball to Applicants, dated May 25, 2004)

586. The purpose of the proposed Town of Woodbridge Route would be to avoid placing overhead lines at the B'Nai Jacob/Ezra Academy and the Jewish Community Center. (Tr. 6/15/04, p. 191; Woodbridge Ex. 17; Tr. 1/20/05, pp. 13/16)

587. The Town of Woodbridge has proposed a transition station near the intersection of Clark, Cedar and Amity Roads where CL&P already owns property. Another transition station would be located on 180 acres of property owned by the Regional Water Authority in Southern Woodbridge which the Town is in the process of purchasing. (Tr. 2/1/05, p. 211; Tr. 6/15/04, pp. 191-192)

588. The Town's proposed route would be designed to avoid impacts to Wetland Number 133, four vernal pools, and a habitat of the eastern box turtle. (Tr. 6/3/04, Testimony of Christopher Allan of Land Tech, pp. 227-228, pp. 230-231)

Jewish Community Center

589. An existing CL&P ROW crosses the property of the Jewish Community Center of Greater New Haven (JCC) on which there are existing 115-kV transmission lines. Both the ROW and transmission lines traverse through the JCC property at Amity Road in Woodbridge. (Pre-filed testimony of Witkin, 1/13/05)

590. The JCC's main building is approximately 45 feet from the edge of the existing CL&P ROW. Two playgrounds used by children attending the JCC are approximately 45 feet from the ROW. The JCC currently has 3599 children enrolled who are under age 18. (Pre-filed Testimony of Witkin, 1/13/05)

591. The JCC prefers the line be placed underground. Placing it overhead, away from the JCC building, would place it directly over the day camp, playing fields, picnic area, camp building, and pool area. About 400 children attend their day camp daily in the summer. Creating a jog in the line may require moving the day camp. (Tr. 2/17/05, p. 160-161)

592. If the lines cannot be placed underground, the JCC notes that the Applicants own land adjacent to the JCC property well within the buffer zone of the proposed new lines. If the Applicants could move the JCC

Camp, they could place the lines as proposed, and the camp and JCC building would both be far enough away from the lines. This would be the JCC's next preferable option. (Tr. 1/20, p. 39-41)

593. When asked whether the JCC would prefer putting the line closer to the building or closer to the day camp, the JCC responded that they would prefer that the line remain in the ROW at a point that is as close to the centerline as possible. (Tr. 2/17/05, pp. 164-166)

594. The JCC wants a buffer zone of at least 300 feet from all areas of the camp and the building due to their safety concerns. (Tr. 1/20, p. 43)

595. In the vicinity of the JCC property, the Applicants propose to construct 135-foot poles to hold the 345-kV lines and 105-foot poles to hold the two 115-kV circuits. (Tr. 1/20, p. 212)

596. The JCC asked the Applicants if the right-of-way could be moved farther away from their facilities. One option would be a jog in the right-of-way, moving it farther away from the JCC facility itself. Another option was moving the right-of-way as far back along the edge of the JCC property as possible. (Tr. 7/27/04, p. 99)

597. Option A would shift the ROW to the west over a swimming pool. Option B is a jog in the ROW to move the ROW away from the JCC building by using the infield portion of a ball field. Assuming split-phasing, the magnetic field at the pitcher's mound would be 4.4 mG for a 135-foot tower for the 345-kV line and 110-foot tower for the 115-kV line, based on a 15 GW load level. (Tr. 2/1/05, p. 221-222; Tr. 2/17/05, pp. 160-168)

598. In Option B, at 25 feet from the pitcher's mound moving toward second base, magnetic fields would be 5.6 mG, then decreasing to 4.6 and then 2.9 mG in centerfield. (Tr. 2/1/05, p. 225-226)

599. The JCC building is approximately 60 feet from the existing ROW. (Tr. 2/1/05, p. 241)

600. The JCC bypass would relocate a day camp (Option C), and assumed the existing JCC day camp could be relocated to the property south of the JCC property. The corner of the JCC day care facility would be approximately 270 feet from the relocated ROW on Option C. The Applicants are uncertain as to whether an existing day camp on the JCC property can be relocated onto a 60-acre parcel adjacent to the ROW. (Tr. 2/1/05, pp. 207-208; pp. 244-246)

601. The magnetic field at the corner of the building from the relocated ROW would be less than 0.1mG. Both options A and B, which are closer, are also at 0.1mG. (Tr. 2/1/05, p. 246-247)

602. Option C was presented by the Applicants at the request of JCC and would shift the ROW west over the outfield of the ball field. Options A and B were at the request of the Council. Options A, B, and C are not supported changes by the Applicants. The Applicants finds Option C, which would cross over the pool, less desirable. Relocating the pool and other facilities would constitute a great cost to the Applicants. (Tr. 2/1/05, p. 256-257)

603. Electric fields from a 345-kV line would be a concern for a parking area more than magnetic fields, especially for higher vehicles, such as a bus. (Tr. 2/1/05, p. 261, p. 263-264)

604. To place a ball field directly underneath the 345-kV lines, the JCC would have to request a waiver from the Applicants. (Tr. 2/1/05, p. 259)

605. The JCC currently has a waiver to use its parking facility on the ROW. The impact of locating a 345-kV line over the parking area would have to be re-investigated. (Tr. 2/1/05, p. 260-261)

606. The Applicants would prefer to keep the existing ROW in the JCC area and employ prudent avoidance techniques such as low magnetic field designs, including increasing pole heights by up to 30 feet.

However, Options A, B, and C are all considered buildable, despite increased costs. Based on the evidence, the Council finds use of the center of the ROW with low magnetic field design to be prudent. (Tr. 2/1/05, p. 257-258)

B'Nai Jacob/Ezra Academy

607. Congregation B'Nai Jacob is located at 75 Rimmon Road in Woodbridge and has approximately 400 students. Ezra Academy has 227 students. (Pre-filed Testimony of Waynick, et al, dated 1/13/05)

608. A ROW of four existing 115-kV lines in a ROW currently crosses the B'Nai Jacob/Ezra property, crossing over a basketball court, sports field and a preschool nature field. The school's classrooms are approximately 60 feet from the edge of the ROW, and a playground is directly adjacent. (JCC 14, 1-26-05)

609. The B'Nai Jacob/Ezra Academy first preference is that the proposed lines be buried underground in the middle of the existing ROW across the campus. Their second preference would be to have the overhead lines relocated away from the daycare and school facilities as far as possible on the B'Nai Jacob property. The Reis property, an undeveloped parcel to the north, is encumbered by a portion of the existing ROW, and B'Nai Jacob/Ezra suggests moving the ROW onto this property. (JCC 14, 1/26/05)

610. If the existing ROW were moved onto the Reis property, it would be about 350 feet from the edge of the ROW to the corner of the building. The magnetic field would be about 0.1mG at the building edge using a split-phase configuration. (Applicant ex. 73, p. 13; Tr. 2/1/05, p. 248-250)

611. Homes on a cul-de-sac on Twin Brook in Woodbridge to the north would be about 180 feet from the relocated line. (Tr. 2/1/05, p. 250)

612. The Applicants approached the property owner of an adjacent parcel and asked about relocating the ROW entirely onto their property. The owner, Mr. Reis, indicated he is not interested in changing the easements that presently exist, due to residential development plans. (Tr. 2/1/05, p. 209-210)

613. The Applicants have offered a deviation from the existing right-of-way to be relocated roughly to the north side of the Ezra Academy and B'Nai Jacob property. The magnetic field would be approximately 0.1 mG at the nearest edge of the building using a split-phase configuration. Based on the evidence, the Council finds relocating the overhead lines away from day care and school facilities as far as possible on the B'Nai Jacob property to be prudent. (Applicant ex. 73, p. 11; Tr. 10/14/04, p. 69; Applicant 163, aerial photograph, p. 10 of 13)

Electric and Magnetic Fields

614. The Applicants transmit electricity in the form of an alternating current (AC) operating at 60 hertz (Hz), meaning the power flows at 60 cycles per second. Electric fields are produced by voltage and increase in strength as the voltage increases. The electric field is expressed in units of volts per meter (V/m) or kilovolts per meter (kV/m; 1 kV = 1000 V). Most objects including fences, shrubbery, and buildings easily block electric fields. (Applicants 1 Vol. 6, p. 3; Council's Administrative Notice 2, pp. 4-5; Tr. 06/03/04, p. 56)

615. Magnetic fields result from the flow of electric current through a conductor and increase in strength as the current increases and the distance from the conductor decreases. The strength of magnetic fields is commonly expressed as magnetic flux density in units called gauss (G), or Tesla (T). In the case for 60 Hz, an extremely low frequency, a fraction of these units is used (1G=1000 milligauss (mG) and 1T=1,000,000 microtesla (μT). The conversion from microtesla to milligauss is 1μT = 10mG at 50Hz or 8.33mG at 60Hz. (Applicants 1 Vol. 6, p. 3; (Council's Administrative Notice 2, pp. 4-5; Tr. 06/03/04, p. 56, Ex. 183)

616. Current in a transmission conductor will be determined by, among other things, the load (customer demand) that is being served at a given time, and the location of the sources of the generation that is being dispatched to serve that load. (Applicants 156, p. 2)

617. Magnetic fields from overhead transmission lines attenuate with distance and achieve levels similar to background levels found inside or outside the home at a distance of approximately 200 to 300 feet from the power line depending on the current in the line. (Applicants Administrative Notice 1, Tr. 01/05/05, p. 105, 106; Tr. 2/1/05, p. 251; Tr. 05/13/04, p. 55)

618. The magnetic fields expected to be associated with the proposed overhead and underground transmission lines are similar to those present along transmission lines today in Connecticut and throughout the nation, and comparable to those produced by other sources of exposure, such as household appliances and distribution lines. (Applicants 1, Vol. 6, "Electric and Magnetic Field Assessment: Middletown-Norwalk Transmission Reinforcement," p. 4, p. 82; Applicants 190)

619. At a 300-foot distance from transmission lines exposures would be basically at background levels. The Connecticut Department of Public Health (DPH) is focused more on the EMF level at residential properties than the 300 foot distance from the transmission lines. (Tr. 10/14/04, p. 143, 145, 146)

620. Over the last 30 years, research efforts to investigate suggestions that magnetic fields may cause adverse health effects, particularly childhood leukemia, has not produced scientific or medical evidence to support this conclusion. The weight of the evidence by multidisciplinary national and international scientific panels of scientists that have reviewed the totality of the EMF research, including the National Institute of Environmental Health and Sciences (NIEHS); the National Academy of Sciences (NAS); (United Kingdom) National Radiological Protection Board (NRPB); the Health Council of the Netherlands (HCN); and the International Agency for Research on Cancer (IARC); do not support the assumption that EMF is harmful. (Applicants Administrative Notice 18, 19, 20, 21, 23, 24, 25; Applicants ex. 1, p. 81-105; Applicants ex. 40; Applicants ex. 169; Applicants ex. 183; Council Administrative Notice 3, 4; Council ex. 5; Ezra Academy et al 1, appendices)

621. Dr. Phillip Cole testified that for many years, a succession of EMF studies have each shown a weaker relationship than the previous ones, until the period of 1990-1995. All of the studies afterward, including national collaboration studies in the US and UK have failed to support a relationship between EMF and childhood leukemia. (Ezra Academy et al. 1, appendix #8; Tr. 3/25/04, testimony of Dr. Cole (Applicants), p. 28-29)

622. Dr. Cole testified the most recent meta-analyses have concluded that a causal relationship cannot be established for EMF and cancer, and that if there is any association, it will be extremely small, extremely rare, and extremely difficult to establish. (Tr. 3/25/04, testimony of Dr. Cole (Applicants), p. 29)

623. Dr. Gary Ginsberg testified the single largest study was the United Kingdom (UK) study of 2,000 enrollees which found a negative association of childhood leukemia with EMF exposure. (Tr. 5/12/04, testimony of Dr. Ginsberg (DPH), p. 146-147)

624. Dr. Ginsberg testified the UK study found no association between EMF and childhood leukemia. The study has little statistical power to determine whether exposures over 4 mG are associated with an increased risk of childhood leukemia. The Greenland and Ahlbom meta-analyses suggest positive findings for exposures above 3 or 4 mG. (Ezra Academy et al. 1, appendix #17, #18; Tr. 06/17/04, testimony of Dr. Ginsberg (DPH), p. 10-13)

625. Dr. Ginsberg testified two meta-analyses both found a relatively small but significant association between EMF and childhood leukemia. These studies were Ahlbom et al, 2000, and Greenland et al, 2000. (Ezra Academy et al. 1, appendix #17, #18; Tr. 3/25/04, testimony of Dr. Ginsberg (DPH), p. 317)

626. Dr. Cole testified the meta-analyses which have been completed have shown that there is a weak inconsistent relationship at best between EMF from power lines and childhood leukemia. (Tr. 3/25/04, testimony of Dr. Cole (Applicants), p. 95)

627. A meta-analysis by Ahlbom of the risks of acute lymphocytic leukemia considered three levels of magnetic fields: less than 2.0 milligauss (mG), 2.0 to 4.0 mG, and greater than 4.0 mG. The relative risks were 1.08, 1.12, and 2.08, respectively, meaning no dose response relationship was evident. (Ezra Academy et al. 1, appendix #17; Tr. 3/25/04, testimony of Dr. Cole (Applicants), p. 197, p. 199-200)

628. A meta-analysis combines epidemiology data sets from different studies to increase the number of exposed and unexposed individuals so that more than one study is relied upon. (Tr. 5/12/04, testimony of Dr. Ginsberg (DPH), p. 140)

629. In the Ahlbom (2000) study, exposures of 4 mG demonstrated relative risks near the no-effect level. For a very small proportion, (0.8 percent) of subjects exposed to magnetic field levels above 4 mG, the data show a two-fold increase which is unlikely to be due to random variability. Ahlbom stated the explanation for the elevated risk estimate is unknown, but selection bias may have accounted for some of the increase. (Ezra Academy et al. 1, appendix #17; Tr. 5/12/04, testimony of Dr. Ginsberg (DPH), p. 147-148)

630. The Ahlbom Study (2000) used 3 mG as a cut point between those subjects who are more highly exposed and those who are lesser exposed, and found an odds ratio of 1.87 for those exposed to greater than 3 mG, which Dr. Ginsberg testified is statistically significant. (Ezra Academy et al. 1, appendix #17; Tr. 5/12/04, testimony of Dr. Ginsberg (DPH), p. 176)

631. The Greenland meta-analysis stated trend analyses indicate that there are some associations comparing fields above 3 mG to lower exposures, although Greenland found there are as yet insufficient data to provide more than a vague sense of its form and possible sources. The Greenland analysis had an average level of exposure of 5.8 mG and an elevated odds ratio of close to two. (Tr. 5/12/04, testimony of Dr. Ginsberg (DPH), p. 177; Ezra Academy et al. 1, appendix #18; Tr. 5/12/04, testimony of Dr. Ginsberg, p. 148)

632. Dr. Leonard Bell testified that all of the meta-analyses have shown a statistically significant association between leukemia and EMF values above 2 to 3 mG. (Tr. 1/20/05, testimony of Dr. Bell (Ezra Academy et al), p. 148)

633. Dr. Bell's analysis of a study originally conducted by Greenland showed that magnetic field exposures at the 2 to 5 mG range, there was a statistically significant 30 percent increase in the risk of leukemia in children. In the 3 to 5mG range, Bell found a statistically significant 80 percent increased risk of leukemia in children. (Tr. 1/20/05, testimony of Dr. Bell (Ezra Academy et al), p. 149-150)

634. Dr. Bell's analysis of the Greenland Study found an 80 percent increase in risk in leukemia to children exposed to 3 mG magnetic fields than those exposed to background levels. (Tr. 7/28/04, testimony of Dr. Bell (Ezra Academy et al), p. 215-216)

635. Dr. Ginsberg testified that any increase in exposure to a carcinogen that specifically targets children is a potential health concern. The level of uncertainty about EMF increases above levels of 3 to 4mG, because of fewer subjects participating in those studies. (Tr. 5/12, p. 178, testimony of Dr. Ginsberg)

636. Dr. Ginsberg believes there is less confidence to determine whether long term average exposure to EMF levels of 5 or 6mG is safe. (Tr. 5/12/04, testimony of Dr. Ginsberg (DPH), p. 179)

637. There are no known causes for childhood leukemia. However there is concern based on suggestions in the literature that there might be a possibility EMF exposure is one of the few environmental signals regarding childhood leukemia. (Tr. 5/12, testimony of Dr. Ginsberg (DPH), p. 182, 183; Tr. 5/13/04, p. 244)

638. The DPH has statewide statistics on age-specific tumors. The rate of childhood leukemia cases in Connecticut is approximately one case per 10,000 children. There are approximately 30 cases of childhood leukemia reported in Connecticut for the year 2000. For the five years prior to 2000, there were approximately 16 reported cases per year on average. The next five year reporting period would have to be included to determine if the 2000 data is anomalously high or if there is an increasing trend. The DPH is not aware of any clusters of childhood leukemia in the State of Connecticut. (Tr. 5/12/04, testimony of Dr. Ginsberg (DPH), pp. 91-92; Tr. 05/13/04, testimony of Dr. Ginsberg (DPH), p. 68, 69; Tr. 3/25, testimony of Dr. Ginsberg (DPH), p. 314)

639. Acute lymphocytic leukemia occurs in children and young adults from ages 0 to 14. A theory put forth by Dr. Bell of why that particular age group is more susceptible than others hypothesizes that young children are developing rapidly, have a rapid turnover of cells and a greater surface to weight ratio. In addition, the immune system in children is not fully developed. (Tr. 5/12/04, testimony of Dr. Ginsberg (DPH), p. 192; Tr. 06/16/04, testimony of Dr. Bell (Ezra Academy et al), p. 184, 193-195)

640. Dr. Ginsberg testified the association between childhood leukemia and EMF appears weak, with the association being more noticeable at higher EMF exposure levels. (Tr. 3/25/04, testimony of Dr. Ginsberg (DPH), p. 300)

641. Dr. Ginsberg testified that if magnetic field exposure is found to be a cause of childhood leukemia, some studies have suggested that approximately three to ten percent of all childhood leukemia cases may then be attributed to EMF sources. (Tr. 5/12/04, testimony of Dr. Ginsberg, p. 185-187)

642. The National Toxicology Program conducts cancer studies and genetic toxicology studies for the National Cancer Institute. EMF is not on their list of known or reasonably anticipated carcinogens. (Tr. 5/12/04, testimony of Dr. Ginsberg, p. 157-158)

643. An evaluation by the International Agency for Research on Cancer (IARC) found there was inadequate evidence to consider EMF exposure in animal studies as a possible link to human cancer. IARC found limited evidence in humans for the carcinogenicity of extremely low-frequency magnetic field in relation to childhood leukemia and designated extremely low-frequency magnetic as an agent that may be possibly carcinogenic to humans and static electric and magnetic fields and extremely low-frequency electric fields as not classifiable as to their carcinogenicity to humans. Once a particular agent is rated by the IARC it can be upgraded or downgraded on the list with more research. (Tr. 5/12/04, testimony of Dr. Ginsberg, p. 133; Applicants Administrative Notice 20; Tr. 06/16/04, testimony of Dr. Rabinowitz (Ezra Academy et al, p. 138-140)

644. In its conclusions and recommendations, "the NIEHS suggests that the level and strength of evidence supporting ELF-EMF exposure as a human health hazard are insufficient to warrant aggressive regulatory actions; thus, we do not recommend actions such as stringent standards on electric appliances and a national program to bury all transmission and distribution lines. Instead, the evidence suggests passive measure such as a continued emphasis on educating both the public and the regulated community on means aimed at reducing exposures. The NIEHS suggests that the power industry continue its current practice of siting power lines to reduce exposures and continue to explore ways to reduce the creation of magnetic fields around transmission and distribution lines without creating new hazards. The NIEHS encourages technologies that lower exposures from neighborhood distribution lines provided that they do not increase other risks, such as those from accidental electrocution or fire." (Appendix No. 1 to Testimony of Drs. Bell, Rabinowitz, Baum, Gerber, and Carpenter, 03/16/04, Tab 2, pp. 37-38)

645. NIEHS determined EMF fields may be classified as a possible human carcinogen, Group 2B. Group 2B is a list of approximately 250 chemicals. The category includes "agents, mixtures, and exposure circumstances for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals. It may also be used when there is inadequate evidence of carcinogenicity in humans but there is sufficient evidence of carcinogenicity in experimental animals." The other groupings are known human carcinogen and probable human carcinogen. Group 3 lists items which do not have enough evidence to show a clear carcinogenic effect. Group 4 includes proven not to be a carcinogen. (Ezra Academy et al, ex. 1, appendix 1, #1; Tr. 5/12, testimony of Dr. Ginsberg, p. 158-159)

646. The World Health Organization has identified 14 studies which are ongoing for EMF. The NIH has one funded ongoing EMF study. (Tr. 5/12/04, p. 210-211)

647. Dr. Aaronson testified that studies done in the United States of whole animals over the lifetime of an animal have shown no evidence of any adverse effects from EMF, including brain damage. In tests on animal subjects, magnetic fields of at least 1,000 times higher than normal human exposure have been completely negative with respect to developmental abnormalities. (Tr. 5/12/04, testimony of Dr. Aaronson (Applicants), p. 218; Tr. 3/25/04, testimony of Dr. Aaronson (Applicants), p. 42)

648. Dr. Bell testified among all homes surveyed in a group of 1,000 homes conducted by the Electric Power Research Institute (Zaffanela, 1993), 50 percent have magnetic field levels of 0.6 mG. About 50 percent of school-age children are exposed to magnetic fields of about 0.8 mG over a 24 hour day. Adult exposure is about 1mG. (Appendix to supplementary testimony of Dr. Bell, 7/19/04, p. 35; Tr. 7/28/04, testimony of Dr. Bell (Ezra Academy et al), p. 253)

649. Dr. Bell testified most children are exposed to levels of one mG and below, over a 24 hour period, in their homes. Only a small percentage of children are exposed to greater than 2 to 3 mG over 24 hours. (Tr. 1/20/05, testimony of Dr. Rabinowitz (Ezra Academy et al), p. 185-186)

650. Dr. Ginsberg testified that there is no clear documentation that exposures to time-weighted magnetic fields below 3.0 mG pose a health risk. A time weighted exposure is averaged over a duration of time. Levels above 6.0 mG are a clear public health concern. Best management practices try to limit the number of people exposed in the range between 3.0 and 6.0mG. (Tr. 7/29/04, testimony of Dr. Ginsberg (DPH), p. 14-16; Tr. 5/12/04, p. 181)

651. Dr. Ginsberg testified that the DPH recommends that Best Management Practices should be used to minimize any increase in magnetic field exposure, and to be aware of the potential health risks and what background levels of exposure tend to be and try to strike that balance so that there is minimal exposure or minimal increase in exposure. (Tr. 5/12, p. 168)

652. Dr. Ginsberg testified that, prudent avoidance, as defined by the DPH, means that magnetic field exposure should be avoided under circumstances that one can normally take within one's power and control, without consideration of economic investment. The DPH recommends prudent avoidance of EMF exposure between 3 mG and 6 mG can be reasonably anticipated not to present an increased public health risk. EMF levels above 6 mG have a larger public health concern. (Tr. 3/25, p. 317; Tr. 5/12/04 p. 181; Tr. 06/17/04, p. 13; Tr. 7/29/04 p. 15; Tr. 10/14/04, p. 92, 139, 144)

653. Dr. Ginsberg testified that controlling external fields entering homes may be the best way to minimize children's EMF exposures because it may be too difficult to instruct parents to keep their children away from home appliances that generate EMF. (Tr. 06/17/04, testimony of Dr. Ginsberg (DPH), p. 14, 15)

654. Dr. Ginsberg testified that because of the increased shielding of home appliances over time, the increased use of electricity may not have led to an increase in EMF exposure to children. (Tr. 5/12/04, testimony of Dr. Ginsberg (DPH), p. 174-175)

655. Dr. Ginsberg testified that there is a possible link between EMF exposure and the incidence of brain cancer in adult electrical workers and childhood leukemia due to general neighborhood and household exposures. The fact that a number of studies have shown a link to childhood leukemia is of potential concern. Animal toxicology studies have generally not supported a carcinogenic effect from EMF. However, Lei and Singh (2004) found exposure of rats to EMF led to an increase in DNA damage which would be consistent with cancer. (Tr. 3/25/04, testimony of Dr. Ginsberg (DPH), p. 315)

656. A study by Lei and Singh, "Magnetic Field Induced DNA Strand Breaks in Brain Cells of the Rat", in Environmental Health Perspectives, January 2004, exposed rats to levels of 100 mG for a period of 42 to 48 hours. The longer the exposure, the greater the damage, so, in Dr. Ginsberg's opinion, a dose response took place. (Tr. 5/12/04, testimony of Dr. Ginsberg (DPH), p. 108-109)

657. A NIEHS evaluation of the body of animal experimental evidence concluded that studies on animals do not show an effect from magnetic fields that would be consistent with the effects suggested in humans, and that no mechanism now emerging could explain the human data. (Tr. 5/12/04, testimony of Dr. Ginsberg, p. 132)

658. Dr. Ginsberg testified that possible carcinogenic effects of EMF are characterized by a high degree of uncertainty. Since background concentrations of EMF are highly variable in most people throughout the day, there is no true control group with consistently low exposure. The studies generally have a low statistical power to find an effect due to the small number of subjects in the most highly exposed EMF categories. (Tr. 3/25/04, testimony of Dr. Ginsberg (DPH), p. 316)

659. Dr. Ginsberg testified that background EMF levels, based on time-weighted averages appear to be in the 1 to 5 mG range with most homes at or below 3 mG. (Tr. 3/25/04, testimony of Dr. Ginsberg (DPH), p. 317)

660. Dr. Ginsberg testified that short-term peak EMF exposures may be of greatest concern if the EMF cancer mechanism involves a threshold. If a high baseline exposure exists due to nearby power lines and home appliances add to this exposure, then the EMF levels may be more likely to exceed cellular thresholds and lead to genetic effects. (Tr. 06/17/04, testimony of Dr. Ginsberg (DPH), p. 14, 15)

661. Dr. Cole testified that a child born in 1990 is exposed to all sources of EMF an estimated 20 times greater than a child born in 1950. Half of childhood leukemia occurs before the age of five. Since 1950 there has been no increase in the incidence of the disease. (Tr. 3/25, testimony of Dr. Cole (Applicants), p. 240-241)

662. Dr. Bailey testified that for the proposed overhead route there are two public and private schools with reading of 0 and 0.6mG levels of EMF. There are three licensed daycare facilities between 0 and 0.6mG; two licensed youth camps and public playgrounds between 0 to 0.6mG, and one between 0.7 and 3.0mG; seven residential areas between 0 and 0.6mG; 13 residential areas between 0.7 and 3.0mG; four residential areas between 3.1 and 6.0mG; and two between 6.1 and 6.2mG. (Testimony of Dr. Bailey, Tr. 7/28, p. 10-12; Applicants Ex. 138)

663. It is not unusual for magnetic field levels to reach the 2 to 4mG range under distribution lines, and may range from 8 to more than 20mG. Magnetic field levels directly under 115-kV lines may range as high as 20 to 80mG, depending on load. (Tr. 7/28, p. 26-28; Applicants 164, p. 2)

664. In establishing buffer zones, PA 04-246 states the Council must take into consideration residential areas, private or public schools, licensed child day care facilities, licensed youth camps, or public playgrounds adjacent to the proposed route of overhead portions, with further definition by the Council. (Tr. 7/27/04, p. 17)

665. Based on the weight of the evidence presented above, the Council finds no definitive causal link has been determined between EMF and human health effects as shown in the literature and research on this subject. However, the Council finds the Prudent Avoidance policy, as outlined in its Best Management Practices of February 11, 1993, to be sufficient to protect public health and safety. (Findings 614-664; Council Best Management Practices, February 11, 1993)

International and United States Standards/Prudent Avoidance

666. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has a health-based standard of 833mG for a frequency of 60 Hz. (Tr. 2/1/05, p. 77)

667. Great Britain and approximately 30 other countries have adopted or are in the process of adopting the ICNIRP guidelines. A few countries have recommended more restrictive exposure values as a precautionary approach. For example, Italy has established "quality goals" in the design of a new power line. In the vicinity of children's playgrounds, residential dwellings, school premises and in areas where people are staying for 4 hours or more per day the "quality goal" of 3 μT (approximately 24.9 mG) is adopted. This "quality goal" value is the median of values recorded over 24 hours, under normal operating conditions." Poland has set a magnetic field exposure limit of 251 mG for exposures longer than 8 hours. Applicants 183, pp. 9-11 and Attachment 1); Council Administrative 27; Tr. 2/1/05 pp. 79-80)

668. Italian EMF exposure regulations have a standard of 10 microtesla for children's playgrounds, residential dwellings and school premises. This is equivalent to 83mG for 60 Hz fields. New power lines have a standard of 3 microtesla, equivalent to 24.9mG at 60 Hz. (Tr. 2/1/05, p. 79)

669. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines recommend limiting the magnetic field exposure of the general public to 100μT (1,000 mG at 50 Hz; 833 mG at 60 Hz); and the International Commission on Electromagnetic Safety (ICES) recommend limiting magnetic field exposure of the general public to 9,040 mG. Applicants 40 pp. 4-7; Applicants 75, Attachment 5; Tr. 2/1/05, p. 80)

670. The World Health Organization explains that prudent avoidance "does not imply setting exposure limits at an arbitrarily low level, and requiring that they be achieved regardless of cost, but rather adopting measures to reduce public exposure to EMF at modest cost." (Woodbridge 1, Appendix 2, Tab 32, p. 4).

671. On January 28, 2005, the Vermont Public Service Commission approved the Velco Northwest Reliability Project, new 115-kV and 345-kV transmission lines, adopting a policy of "prudent avoidance" in the siting of transmission lines. The proposed lines are expected to produce edge of ROW magnetic fields of 14mG to 42 mG at average loads, and 183 mG to 286 mG at maximum loads. (Applicants Administrative Notice, pp. 6, 64)

672. In 1999, the Public Service Commission of Wisconsin repealed its order to require low-EMF design structures where practicable. (Applicants 75 Attachment 3, p. 6 and 7)

673. New York has set standards of 1.6 kilovolt per meter for electric fields and 200 mG for magnetic fields, at maximum load and at edge of ROW. Florida has set a standard of 2 kilovolts per meter for electric fields and between 150 to 250 mG (dependent on voltage) for magnetic fields at maximum load and at the edge of the right-of-way. The basis of this recommendation is an objective of maintaining the status quo – assuring that magnetic fields for new lines will be within the range of those that could be associated with existing lines. Massachusetts observes a "threshold" of 85 mG, and considers edge of ROW fields below that threshold to be acceptable. (Woodbridge 8, Appendix 5; Applicants 74, p. 5; Applicants Administrative Notice 16)

674. The Council's Electric and Magnetic Field Best Management Practices in effect at the time this Application was filed were those adopted on February 11, 1993. (Applicants 1, Vol. 6, "Electric and Magnetic Field Assessment: Middletown-Norwalk Transmission Reinforcement"; Applicants Administrative Notice 1)

A Summary Table of International
60 Hz EMF Exposure Guidelines and Recommendations of Selected Organizations

	ICNIRP[1] (1998)	EC[2] (1999)	SSK[3] (2001)	ICES[4] (2002)	ACGIH[5] (2003)	NRPB[3] (2004)
Controlled Environment						
Magnetic Field	0.42 mT (4200 mG)	-	-	2.71 mT (27,100 mG)	1 mT (10,000 mG)	0.42 mT (4200 mG)
Electric Field	8.3 kV/m	-	-	20 kV/m	25 kV/m	8.3 kV/m
Contact Current	1.0 mA	-	-	1.5 mA	1.0 mA	1.0 mA
General Public						
Magnetic Field	0.083 mT (830 mG)	83.3 μT (833 mG)	0.083 mT (830 mG)	0.904 mT (9,040 mG)	-	0.083 mT (830 mG)
Electric Field	4.2 kV/m	4.2 kV/m	4.2 kV/m	5 kV/m[4]	-	4.2 kV/m
Contact Current	0.5 mA	-	-	0.5 mA	0.5 mA	0.5 mA

0.1 mT = 1G or 1,000 mG
1 microTesla (μT) = 10 milliGauss (mG) at 50 HZ or 8.33 mG at 60 Hz
[1]ICNIRP = International Commission on Nonionizing Radiation Protection. Countries that have adopted the ICNIRP standards include Belgium, The Netherlands, Germany, Sweden, France, Spain, Switzerland, Czech Republic, South Africa, Japan, United Kingdom, Australia, and New Zealand (WHO, 2004).
[2]EC = European Commission. Adopted ICNIRP (1998) guidelines but applied subject to: "This recommendation has as its objective the protection of the health of the public and it therefore applies, in particular, to relevant areas where members of the public spend significant time in relation to the effects covered by this recommendation" (p. 60, EC, 1999)
[3]SSK = Swedish Commission on Radiological Protection. Adopted ICNIRP (1998) guidelines
[4]ICES = International Commission on Electromagnetic Safety. Within power line rights-of-way, the MPE for the general public is 10 kV/m under normal load conditions.
[5]ACGIH = American Conference of Governmental Industrial Hygienists
[6]NRPB = National Radiological Protection Board of Great Britain. Adopted ICNIRP (1998) guidelines

(Applicants Ex. 75)

System Loading

675. The calculations assumed loads of 15 gigawatts (GW) and 27.7 GW. The 15 GW load represents typical conditions when this line is put into service. (Tr. 5/12/04, p. 33-34, p. 39; Tr. 10/14/04, p. 241-243)

676. The 15 GW load in 2002 occurred a total of 4187 hours of the year, which is 48 percent of the hours in a year. ISO-NE indicates New England could approach a peak load of 27.7 GW anytime between 2005 and 2010. A 30 GW peak load is expected by 2013, for which the average load would be 18 GW. The generation that is scheduled to be online is more important than the magnitude of the load because it determines what flows are on the transmission lines. The EMF level produced by a line is proportional to the current flow on that line. (Tr. 5/12/04, p. 39; Tr. 05/13/04, p. 15-19; Tr. 09/29/04, p. 162)

677. Load flows on a transmission line can change from minute to minute, hour to hour and seasonally, thereby changing the calculated EMF values. (Tr. 5/12/04, p. 58)

EMF Cross Sections 1-8

678. The transmission configurations and EMF levels of cross sections 1 through 8 are shown in Appendix B, and include low magnetic field designs. All the calculated fields for this analysis are based on the 15GW average New England load case. (Tr. 7/27/04, p. 18-19, 34)

679. Statutory facilities, as defined by Public Act 04-246, include residential areas, public or private schools, licensed child day care facilities, licensed youth camps, and public playgrounds. (Tr. 07/27/04, p. 17)

680. The design of the overhead portion of the proposed route was intended by the Applicants to minimize visual impacts by using the lowest structure height possible without having to increase the width of the right-of-way significantly through developed areas, and to use the existing structure locations for the new structures. The Applicants have proposed consolidated circuits on towers and have optimally phased the lines for magnetic field cancellation where possible to comply with the Council's Best Management Practices. (Applicants ex. 1 Vol. 6, p. 9, 24, 97)

EMF Mitigation Configuration

681. There are three strategies to reduce overhead transmission line magnetic fields: distance, optimum phasing, and optimization of structures. Distance is achieved by widening the right-of-way, increasing the pole height, or relocating the line. Conductors may be arranged in a vertical, H-frame or delta configuration and achieve different levels of EMF cancellation. (Tr. 7/27/04, p. 17-18)

682. "Split-phasing" is a configuration in which a line is constructed using six, rather than the conventional three, phase conductor positions. The conductors are positioned on opposite sides of a transmission structure, phased for optimal field cancellation, and the current flow is split among the six conductors. The resulting cancellation effect reduces the magnetic fields associated with the lines. (Applicants 73, p. 3; Tr. 7/27/04, p. 37-38)

683. In principle, the split phase design is no different from a double-circuit transmission line. In this case, the similar phases are connected together in a symmetrical arrangement to mitigate EMF. (Tr. 05/13/04, p. 137)

684. If a pole holding transmission lines is near a residence, magnetic fields near the pole would be less than at the low point of a line. Moving the poles to increase height can thereby reduce EMF levels. (Tr. 2/1/05, p. 147-148)

685. Transmission lines in this area have existed for at least 80 years. (Applicants 1, Vol 1, p. 356)

686. In some areas, EMF values may increase using the low magnetic field mitigation techniques proposed. (Tr. 2/1/05, p. 255)

687. In order to reduce magnetic fields to a level of 6mG or less, the poles must be moved longitudinally up or down the ROW, or the pole height increased, or a combination of both options. (Tr. 2/1/05, p. 17-168)

688. Considering EMF from a perspective of specific sources or environments does not fully reflect the variations in a person's personal exposure as encountered in everyday life. Sources of magnetic fields include transmission lines, distribution lines, home appliances, wiring in the home, exposure at grocery stores, visits around town, etc (Applicants 1 Vol. 6, "Electric and Magnetic Field Assessment: Middletown-Norwalk Transmission Reinforcement," pp. 1-5); Applicants 190; Council's Administrative Notice 2).

689. Modeling of EMF levels was calculated using a computer program developed by the Bonneville Power Administration, an agency of the US Department of Energy. The program has been shown to accurately predict electric and magnetic fields measured near power lines. The inputs to the program are data regarding voltage, current flow, phasing, and conductor configurations. The fields associated with power lines were estimated along profiles perpendicular to lines at the point of lowest conductor sag, i.e., closest to the ground or opposite points of interest. All calculations were referenced to a height of 1 m (3.28 ft) above ground according to standard. (Applicants 1, Vol. 6, "Electric and Magnetic Field Assessment: Middletown-Norwalk Transmission Reinforcement," pp. 8-9; Applicants Administrative Notice 28).

690. Calculations of EMF are developed by taking the design of the line and its operating conditions, including the projected loading and by using standard techniques computing the calculated electric and magnetic field values at one or more locations. The model used takes into consideration the distance of the calculation points and the current on the conductors. It assumes the conductors are flat and parallel to the ground and that the ground is essentially flat. For the calculation of electric fields, it was assumed the nominal voltage of the line was increased by five percent. (Tr. 5/12/04, p. 30-32)

Underground Cable EMF and Mitigation

691. The magnetic field from an underground cable diminishes at less distance away from the line than the magnetic field from an overhead line; however, people are expected to spend little time on a transmission line right-of-way beneath overhead lines and may spend more time driving down roadways or walking directly above the conductors of an underground line. (Tr. 01/05/05, p. 110-112)

692. Placing the conductors closer together would result in lower magnetic fields from improved mutual cancellation. (Tr. 3/25/04, p. 66)

693. Magnetic fields from XLPE cables would be essentially in the double digits directly over the cable, even with the reduced phase spacing. This is because the cables buried underground are very close to the receptors. (Tr. 09/29/04, p. 124, 125)

694. Directly over underground cables, substantial levels of magnetic fields would be expected. Background levels might not be reached until a distance of 40 to 100 feet, depending on the design of the line and the current flowing through it. (Tr. 3/25/04, p. 112-113)

695. Soil types have no effect on underground magnetic fields. (Tr. 3/25/04, p. 113)

696. Magnetic field levels would likely be highest for underground cable systems in a manhole or vault where they are spliced together, and the separation of the cables would be greater than any place else. The separation would cause the fields to be higher. (Tr. 3/25/04, p. 119-120)

697. Techniques to shield or reduce magnetic fields from underground sources include the installation of steel, or aluminum plates above cable, increasing the depth of the conductors, spacing the conductors closer together, and encasing the conductors in a steel pipe. (Tr. 01/05/05, p. 34)

698. There have been some cases in the United States where shielding is used, usually in buildings over duct banks or for short runs of cable. Shielding has been used in few cases for an extended distance over conductors. (Tr. 01/05/05, p. 34, 35)

699. Aluminum plating would not be practical, due to soil reaction. Steel plating would perform better with a seamless joint in between sections but it is not as critical as with the aluminum plating. The corrosion effects would be similar for aluminum plating and steel plating. (Tr. 01/05/05, p. 42, 43; Tr., 09/29/04, p. 77)

700. A protective plate made of steel installed above an underground cable would reduce magnetic fields directly over the plate by a factor of two to five. Such plate would also re-shape the magnetic field and increase levels beyond the edge of the plate. (Tr. 09/29/04, p. 88, 90)

701. Plates would have to be covered with mastic to protect the metal from corrosion. Once the plates are in place above the cable sections, they have to be welded together and then mastic has to be put over the welded area above and beneath the plates. The welded plates would have to be lifted up to be certain that the mastic is covering the entire plate, which would be difficult. Tests would have to be done every six months to a year to make sure there are no voids in the mastic. (Tr. 09/29/04, p. 97-99)

702. Plating used for magnetic field mitigation for underground transmission cables over a long distance has not been used before. Consolidated Edison (Con Ed) in New York City has one steel plate installation, with overlapping plates, that is approximately two miles long. The purpose of the Con Ed installation was to mitigate magnetic field exposure directly above a duct bank. (Tr. 09/29/04, p. 113; Tr. 01/05/05, p. 82, 83)

703. Installation of plates above a cable would complicate work of other utilities that are buried along the roadway. (Tr. 01/05/05, p. 46)

<u>Buffer Zones for EMF</u>

704. In establishing buffer zones, Public Act 04-246 states the Council must take into consideration residential areas, private or public schools, licensed child day care facilities, licensed youth camps, or public playgrounds adjacent to the proposed route of overhead portions. (Tr. 7/27/04, p. 17)

705. In its buffer zone analysis, the Applicants considered an area of 300 feet out from the edge of the right-of-way, extended for a length of 2000 feet along the right-of-way. If there were a group of homes in that category, they were included as a statutory facility adjacent to the right-of-way. (Tr. 7/27/04, p. 132)

Costs

706. The estimated capital costs of the Proposed Route (as modified by the Final ROC Report dated December 20, 2004, in which the Proposed Route is referred to as "Case 5"), Alternative A, and Alternative B, expressed in 2004 dollars, are set forth in the table below, which provides a breakdown of cost by route segment. The table also includes cost estimates for constructing low magnetic field designs in segments 1 and 2:

Summary of Cost Estimates[1] by Route Segment
(Millions of 2004 Dollars)

Segment	Proposed Route (24 Miles UG 45 Miles OH)	Alternative A (13 Miles UG 60 Miles OH)	Alternative B (4 Miles UG 72 Miles OH)	All Incremental Cost for Constructing Low Magnetic Field Designs
1 including Scovill Rock and Beseck Switching Stations	92 to 105	92 to 105	94 to 108	20 to 23[2]
2 including East Devon Substation	241 to 275	244 to 278	247 to 281	48 to 57[2]
3 including Singer Substation and Interconnections	229 to 275	222 to 266	149 to 170	not estimated
4 including Norwalk Substation	276 to 339	253 to 299	264 to 305	not estimated
TOTAL	837 to 993[3]	811 to 947	754 to 864	68 to 80

1. The range of costs reflects conceptual engineering, differing assumptions, and unknown field conditions.
2. Includes cost for the 345-kV line without the 115-kV line at the Royal Oak bypass and does not include costs associated with relocation of lines at the JCC or Congregation B'Nai Jacob/Ezra locations.
3. Does not include equipment upgrades (i.e. surge arresters) at nearly half of CL&P's substations and all of UI's substations at a cost of $7 to $10 million.

(Applicants 172, pp. 2-3 and Appendix A)

707. The life cycle costs of the Proposed Route (as modified by the Final ROC Report), Alternative A, and Alternative B are set forth in the following table:

Summary of Life Cycle Costs by Route Segment [1, 2, &3]
(Millions of 2004 Dollars)

Segment	Proposed Route (24 Miles UG 45 Miles OH	Alternative A (13 Miles UG 60 Miles OH)	Alternative B (4Miles UG 72 Miles OH)	Incremental Cost for Low Magnetic Field Designs
1 including Scovill Rock and Beseck Switching Stations	133 to 151	134 to 152	137 to 155	31 to 36
2 including East Devon Substation	333 to 382	336 to 386	349 to 397	74 to 85
3 ncluding Singer Substation and Interconnections	318 to 383	316 to 380	$188 to 214	Not Estimated
4 including Norwalk Substation	395 to 488	360 to 427	361 to 417	Not Estimated
TOTAL *	1,180 to 1,405	1,146 to 1,346	1,036 to 1,185	106 to 122

1. Cost estimates calculated in accordance with Acres International Life-Cycle Report 1996 and 2001 but includes land acquisition cost.
2. The range of costs reflects conceptual engineering, differing assumptions, and unknown field conditions.
3. Total may not add due to rounding

(Applicants 181, Q. 15; Tr. 02/01/05, p. 96)

708. If transmission facilities are unable to transport power from the lowest price generation source into a given area, higher priced generating units within that congested area or "load pocket" may have to be dispatched to meet demand and maintain a reliable power supply. ISO-NE identifies SWCT as a deficient load pocket due to transmission constraints. The additional costs to run these more expensive generators in "out of merit order" are paid by customers in the form of "congestion" charges. ISO-NE's Standard Market Design (SMD) rules, which became effective on March 1, 2003, stipulate the congestion charges for SWCT are paid for by Connecticut customers alone. Previously, such costs were socialized among all New England consumers. ISO-NE concluded in RTEP02 that the most effective long-term strategy for reducing congestion costs was to improve import limits in SWCT by constructing a 345-kV loop. (Applicants 1, Vol. 1, p. F-33)

Economic Benefits

709. Completion of the Bethel to Norwalk line (Docket No. 217) will eliminate transmission constraints and associated congestion costs at the present Norwalk-Stamford sub-area interface. The proposed project would greatly reduce remaining transmission constraints at the SWCT interface. Additional transmission upgrades would enhance Connecticut's import capability and would relieve other transmission problems in Connecticut. (Applicants 1, Vol. 1, p. F-33; Tr. 2/17/05 pp. 86-88)

710. The annual "inefficiency cost" of the existing transmission system in Connecticut is approximately $308 million, including the costs of RMR contracts, interim RFPs, congestion costs, and the costs of running uneconomic generators. The proposed project will not eliminate these costs but would lead to reducing them by reducing dependence on RMR contracts. Connecticut will remain a net importer of power until further facilities are constructed. The planned Card Street to Sherman Road line is expected to improve

the import capability by providing a new 345-kV interconnection between Connecticut from Rhode Island. (Applicants 1, Vol. 1, F-33; ISO 13, p. 3; Tr.1 /11/05 pp. 24-25; Tr. 2/17/05, p. 84)

711. In deregulated environment for electric generation, the competitive generation marketplace can demand a very high price for energy in a generation-deficit area such as SWCT. The proposed 345-kV loop would foster competition in the power markets in SWCT and the rest of Connecticut through increased supply options hence tending to lower costs. The 345-kV loop improves the options in the marketplace by providing higher deliverability to the area, eliminating the conditional dependency that currently prevents the concurrent operation of all existing generation in SWCT, and enabling the interconnection of new generation in SWCT. (Applicants 1, Vol. 1, pp. F-30 to F-31, F-34; Applicants Administrative Notice 12)

712. A 345-kV transmission system is more efficient than systems operating at a lower voltage. Losses at 345-kV system are only about 1/9 of those at 115-kV for the same energy transfer. This reduction in losses reduces the generation requirement lowering costs and reducing air emissions. In the ISO-NE study (SCERS), base power flow cases that were modeled for the peak loading periods revealed losses approximately 35 MW lower with the 345-kV system than with the 115-kV system, savings enough to provide power to about 35,000 homes. (Applicants 1, Vol. 1, F-34)

713. The proposed project would reduce the risk of cascading outages such as the blackout that occurred in August of 2003. The economic cost of such blackouts far exceeds the costs associated with the inefficiencies associated with the existing transmission system in Connecticut. (Tr. 2/17/05, p. 88)

Socialization of Costs

714. The cost of transmission facilities in New England deemed to provide a regional benefit has been paid for on a New England-wide basis since 1997. Assets that are determined to qualify as Pool Transmission Facilities (PTF) qualify for regional cost support. Under current rules, Connecticut customers pay approximately 27 percent of a project to the extent it qualifies for regional cost support from all wholesale customers. (Council Administrative Notice 15 Finding of Fact 47 and 51; ISO Administrative Notice 12, Section II, Schedule 12; Tr. 3/23/04 pp. 51-52)

715. Two classes of projects are eligible under FERC for regional cost support: (1) Regional Benefit Upgrades (RBUs); and (2) projects listed in Schedule 12B of the NEPOOL Tariff from the Regional Transmission Expansion Plan (RTEP02 Upgrades). The Middletown-Norwalk Project is listed in Schedule 12B as an RTEP02 Upgrade. ISO Administrative Notice 5; ISO Administrative Notice 12)

716. If a project qualifies for regional cost support, localized costs are not recoverable under Schedule 12C. Even if a project qualifies for regional cost support, ISO-NE conducts a review of the cost of a project pursuant to Schedule 12C of the NEPOOL tariff to determine if some portion of the project costs should be treated as localized costs. Localized costs are defined as "incremental costs resulting from a RTEP02 Upgrade or a Regional Benefit Upgrade that exceeds those requirements that the ISO deems reasonable and consistent with Good Utility Practice and the current engineering design and construction practices in the area in which the Transmission Upgrade is Built." ISO would consider the reasonableness of the proposed engineering design and construction method with respect to alternate feasible Transmission Upgrades and the relative costs, operation, timing of implementation, efficiency and reliability of the proposed Transmission Upgrade. (Applicants 54 p. 38; Applicants Administrative Notice 30 p. 9; ISO-NE's Ex. 8; ISO Administrative Notice 12, Section II, Schedule 12; Tr. 3/23/04 pp. 50, 53, 135, 141, 142, 147 and 177; Tr. 4/20/04 pp. 42-43; Tr. 6/17/04 pp. 36-37; Tr. 7/29/04 pp. 72-74)

717. Initially in the Schedule 12 or Schedule 12C process, a transmission owner is expected to include a final engineered design and a cost estimate. The proposed project has not yet been submitted to ISO for determination regarding costs under Schedule 12 or Schedule 12C. (ISO Administrative Notice 12, Section II, Schedule 12; Tr. 3/23/04 p. 191; Tr. 6/17/04 p. 37)

718. Following approval, a project is brought before ISO-NE for cost analysis, and ISO-NE would then decide the Connecticut costs. The NEPOOL Reliability Committee examines engineering questions and their costs. Government officials from all the New England states also submit questions. A final determination is then rendered by ISO-NE and the results provided to the Applicants. The FERC examines the project after ISO-NE makes its determination. (Tr. 2/17/05, p. 101/102)

719. The following list of examples of types of projects that would be considered to contain Localized Costs under PP-4 includes: (a) the project costs more than a feasible or practical transmission alternative and has equal or less robust bulk power system performance than the transmission alternative; (b) the project does not address a bulk power system need; (c) the project includes underground transmission cable which is selected either at the direction of a local or state siting board or to address other local concerns, and the cost of overhead transmission lines is less expensive; (d) the project is a gas-insulated or covered substation when an open-air substation would be feasible and practical for lower cost. (Applicants Administrative Notice 30, Attachment A).

720. An applicant for regional cost allocation must include a discussion describing why the project was selected over other transmission alternatives, defined as an alternative "that is feasible and practical from an engineering design and construction perspective." PP-4 further notes that "(a)n alternative that is or may not be approved by a Siting or local review board may still be considered a feasible and practical alternative." (Applicants Administrative Notice 30, pp. 8-9).

Concluding Findings

721. There is a public need for the facility approved by this Council in the Opinion, Decision and Order. (See Findings of Fact Nos. 12-56; 709-713, and provisions of the Record cited by those Findings.)

722. The facility approved by this Council in the Opinion, Decision and Order will be reliable. (See Findings of Fact Nos. 56-84; 350-522, and provisions of the Record cited by those Findings.)

723. The nature of the probable environmental impact of the facility alone and cumulatively with other existing facilities has been reviewed by this Council in approving this facility. (See Findings of Fact Nos. 270-319; 615-706, and provisions of the Record cited by those findings.) Included in the review of the probable environmental impact was a review of electromagnetic fields. (See Findings of Fact Nos. 615-706, and provisions of the Record cited by those Findings.) The Council has examined the policies of the State concerning the natural environment, ecological balance, public health and safety, air and water purity, and fish, aquaculture and wildlife, together with all other environmental concerns, and balanced the interests in accordance with Conn. Gen. Stat. § 16-50p(a)(3)(B) and Conn. Gen. Stat. § 16-50p(a)(3)(C). (See Findings of Fact Nos. 269-318; 614-705, and provisions of the Record cited by those findings.)

724. The environmental effects that are the subject of Conn. Gen. Stat. § 16-50p(a)(3)(B) can be sufficiently mitigated and do not overcome the public need for the facility approved by the Council in the Opinion, Decision and Order. (See Findings of Fact Nos. 269-318; 614-705, and provisions of the Record cited by those findings; also see Findings of Fact Nos. 12-56, 709-713, and provisions of the Record cited by those Findings.)

725. Conn. Gen. Stat. § 16-50p(a)(3)(D)(i) requires that the Council specify what part, if any, of the facility approved shall be located overhead. That is designated in the Opinion, Decision and Order.

726. The facility approved by the Council in the Opinion, Decision and Order conforms to a long-range plan for expansion of the electric power grid of the electric systems serving the State of Connecticut and its people and interconnected utility systems and will serve the interests of electric system economy and reliability. (See Findings of Fact Nos. 12-56; 709-713; 56-81; 350-522, and provisions of the Record cited by those Findings.)

727. The overhead portions of the facility approved by this Council in its Opinion, Decision and Order are cost effective and the most appropriate alternative based on a life-cycle cost analysis of the facility and underground alternatives to the facility and comply with the provisions of Public Act No. 04-246. (See Findings of Fact Nos. 350-729, and provisions of the Record cited by those Findings; see also Opinion, Decision and Order.)

728. The overhead portions of the facility approved by this Council in its Opinion, Decision and Order are consistent with the purposes of Chapter 227a of the General Statutes of Connecticut, and with Council regulations and standards adopted pursuant to Conn. Gen. Stat. § 16-50t, including the Council's best management practices for electric and magnetic fields for electric lines and with the Federal Power Commission "Guidelines for the Protection of Natural Historic Scenic and Recreational Values in the Design and Location of Rights-of-Way and Transmission Facilities" or any successor guidelines and any other applicable federal guidelines. (See Findings of Fact Nos. 350-729, and provisions of the Record cited by those Findings; see also Opinion, Decision and Order.)

729. The overhead portions of the facility approved by this Council in its Opinion, Decision and Order are contained within an area, no less in area than the existing right-of-way that provides a buffer zone that protects the public health and safety. In establishing this buffer zone, the Council took into consideration, among other things, residential areas, private or public schools, licensed child daycare facilities, licensed youth camps or public playgrounds adjacent to the proposed overhead route of the overhead portions and the level of voltage of the overhead portions and any existing overhead transmission lines on the approved route. (See Findings of Fact Nos. 350-729, and provisions of the Record cited by those Findings; see also Opinion, Decision and Order.)