Load Flow Analysis of Phase II Undergrounding Alternatives

By **KEMA, Inc**.

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CONNECTICUT SITING COUNCIL

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KEMA, INC.

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Executive Summary

The Connecticut Siting Council ("Siting Council") is conducting a hearing under Docket 272, on the application for a Certificate of Environmental Compatibility and Public Need ("Certificate") for the construction of new 345 kV and 115 kV electric transmission facilities, located between the Scovill Rock Switching Station in Middletown and the Norwalk Substation in Norwalk, Connecticut. This project is also referred to as "Phase II". The Connecticut Light and Power and the United Illuminating Company ("Applicant") submitted the application on October 9, 2003.

In order to fulfill the requirements on burial of the 345 kV lines as directed by the State of Connecticut Public Act No. 04-246, the Siting Council retained KEMA, Inc. to determine the maximum length of the Phase II line that could be installed underground, focusing solely on establishing technical feasibility rather than optimizing the system based on technical performance and economics.

KEMA performed harmonic impedance studies and submitted its report on October 18, 2004. In addition, KEMA conducted load flow studies to investigate whether additional undergrounding beyond the 24 miles proposed in the Application would:

1. worsen thermal and voltage conditions from those indicated in prior Applicant studies of the proposed alternative, or
2. cause voltage and thermal problems that make such undergrounding infeasible.

KEMA performed its load flow analyses by modifying selected load flow cases provided by the Applicant in response to the Towns' data requests in the discovery process. In making these studies, KEMA substituted XLPE cables for HPFF cables to reduce capacitive charging and improve system harmonic performance.

It is important to note that the original Applicant's load flow base cases that model the proposed alternative, contain both thermal and voltage criteria violations, under normal and contingency conditions. These violations occur mainly on the local 115 kV lines (six overloads), and on the 115/69 (34.5) kV transformers. The Applicant must address these local criteria violations prior to the final design acceptance. KEMA has assumed that these local violations can be satisfactorily mitigated, but KEMA has made no independent investigation of how this would be accomplished. Instead, KEMA focused on identifying those additional facilities that became overloaded, and the additional voltage violations that occur when XLPE cable was substituted for HPFF cable and when various lengths of the Devon-Beseck corridor were constructed using underground cable.

For the case where the proposed HPFF cable from Norwalk to Devon was replaced with XLPE cable, the load flow studies indicate that the number of overloaded facilities increases in comparison to the number of violations identified in the load flow case for the proposed alternative. Most of the overloaded lines are local 115 kV (and below) facilities. Another concern is the overloading of the Plumtree to Triangle line upon the simultaneous loss of two lines (loss of the Plumtree-Middle River line and the Plumtree – Triangle circuit two), and the Plumtree to Middle River line, upon the loss of the double circuit line from Plumtree to Triangle. Mitigation of this overload would likely require either reconductoring the existing lines (if possible) or adding a new circuit.

KEMA's load flow studies indicate that when an additional 20-mile section of the line extending from Devon toward Beseck was modeled as underground XLPE cable and the rest was modeled as overhead line, the number of contingency overloads increased in comparison to the number of violations identified for the proposed alternative. However, all of the additional overloaded lines continue to be local 115 kV (and below) facilities. Specifically, an additional seven 115 kV facilities became overloaded with such additional undergrounding.

When the full length of the 40-mile corridor from Devon to Beseck was modeled with underground XLPE cable, the number of contingency facility overloads increased further, and two 345 kV circuits overload on contingency. Because of the low impedance of three parallel XLPE cables, the Devon to Beseck underground section reacts as a "sink", transferring more power to the Southwest Connecticut load pocket, than either the proposed overhead Devon to Beseck line alternative, or the combination 20 miles underground/20 miles overhead alternative. In this case, an overload occurs on each of the two proposed 345 kV underground circuits between Devon and Singer, for a single contingency outage of the identical parallel 345 kV circuit. However, the simultaneous loss of both underground circuits from Devon to Singer, does not result in a thermal overload.

Based on the results of the KEMA's load flow studies, there is no indication that placing up to 20 miles of the 345 kV line from Devon to Beseck underground would lead to a situation that could not be mitigated either by system reinforcements at voltages of 115 kV (and below) or by adding appropriate voltage support. However, the Applicant would need to address the identified thermal overloads and voltage violations on the local 115 kV(and below) system for its proposed alternative and for the alternatives with extended undergrounding prior to final design. If underground XLPE cable were used for all 40 miles of the Devon-Beseck corridor, a solution would be required for the single contingency 345kV overloads described previously. Such a solution could, in turn, affect system harmonic performance, and further study would be required to determine its acceptability.

1. Introduction

The Connecticut Siting Council ("Siting Council") is conducting a hearing under Docket 272, on the application for a Certificate of Environmental Compatibility and Public Need ("Certificate") for the construction of new 345 kV and 115 kV electric transmission facilities, located between the Scovill Rock Switching Station in Middletown and the Norwalk Substation in Norwalk, Connecticut. This project is also referred to as "Phase II". The Connecticut Light and Power and the United Illuminating Company ("Applicant") submitted the application on October 9, 2003.

In order to fulfill the requirements on burial of the 345 kV lines as determined by the State of Connecticut Public Act No. 04-246, the Siting Council retained KEMA to investigate what is the maximum length of the Phase II 345 line that could be installed underground, focusing solely on technical feasibility rather than optimizing the system based on technical performance and economics.

KEMA performed harmonic impedance studies and submitted its report on October 18, 2004. In addition, KEMA conducted load flow studies to investigate whether additional undergrounding beyond the 24 miles proposed in the Application would:

1. worsen thermal and voltage conditions from those indicated in prior Applicant studies of the proposed alternative, or

2. cause voltage and thermal problems that make such undergrounding infeasible.

KEMA's study focused on analysis of the above effects for the conditions that significantly stress the Southwest Connecticut ("SWCT") transmission system, including:

- Peak load consistent with the NEPOOL load forecast of 27.7 GW;
- Minimum local generation dispatched;
- ISO-NE exports to the New York ISO of 700 MW.

KEMA performed its load flow analyses by modifying selected load flow cases provided by the Applicant in response to the Towns' data requests in the discovery process. In making these studies, KEMA substituted XLPE cables for HPFF cables to reduce capacitive charging and to improve system harmonic performance.

2. Analytical Approach

2.1 Methodology

KEMA's load flow studies included the following steps:

1. The HPFF cables proposed for the 24 miles long line section between Norwalk and Devon, were replaced by XLPE cables to reduce capacitive charging;

2. The overhead line section between Devon and Beseck was replaced with a combination of underground and overhead lines, gradually increasing the length of the underground portion from Devon towards Beseck;

3. Steady-state load flow results for each of the XLPE underground options were compared to the steady-state load flow results for the Applicant's originally proposed alternative.

For steady-state load flow analysis, KEMA used PTI's PSS/E software (Rev. 29). Normal and contingency analysis were performed using the following criteria:

- For base case loading performance, transmission lines and transformers were checked against 100% of their normal ratings;

- For post-contingency loading performance, overloads of transmission lines and transformers were checked against 100% of the long-term emergency ratings;

- Buses 230 kV and above were checked for voltages less than 95% and greater than 105%. Buses in the 115 kV system were checked for voltages less than 90% and greater than 105%.

Buses and transmission branches on the Connecticut 115 kV system and above were monitored. For the analysis, all tap-changing transformers and phase-shifting transformer adjustments were held fixed. For contingencies involving loss of generation/load the imbalance was made up by the system swing generator located outside New England.

2.2 System Data

KEMA used the load flow base cases provided by the Applicants in response to the Towns' Data Request No. "Towns-059." The cases differ based upon: (i) the level and direction of the power transfer between New York and New England, (ii) dispatching scenarios. The base cases are listed in Table 1.

Table 1: Load Flow Base Cases

Load Flow Base Case	Transfer between New England and New York	Total Generation in CL&P, UI, CMEEC, & Wallingford Zones for Dispatching Scenarios 2-5 (MW)			
	(MW)	2	3	4	5
ph2-alt2	0	6563	7618	7947	6400
ph2-alt2-ne-ny	700				
ph2-alt2-ny-ne	-700				

2.3 Load data

Each load flow base case assumes a total ISO-NE load level of 27.7 GW. The Applicant chose to increase the peak load data from the original peak load estimated for 2006 of 25,718 MW[1] to an extreme weather peak of 27,700 MW.[2] In actuality, this peak of 27,700 MW approximates IS0-NE's expected peak load in the year 2012.

2.4 Generation Dispatch

The Applicant used four dispatching scenarios, as shown in Attachment A. Multiple generating units interconnected to the SWCT transmission system were assumed to be out-of-service. The SWCT transmission system is stressed the most when Norwalk Harbor units No. 1 (161MW) and No. 2 (168MW) are not operating, and all the replacing power is transferred from outside resources, as modeled in the Dispatch Scenario 2. In addition, the Dispatch Scenarios 2 and 3 incorporate the assumption that approximately 200 MW is transferred to Northport (LIPA's substation on Long Island), over the 138 kV submarine cable between Norwalk Harbor and Northport, which simultaneously increases loads on the transmission lines serving SWCT.

2.5 Power Transfers Between New England and New York

With respect to the power transfers between New England and New York the Applicant assumed:

1. Transfers of zero MW;
2. Net transfers from New England to New York of 700 MW;
3. Net transfers from New York to New England of 700 MW.

[1] 2001 CELT Report and CSC 20-Year Forecast of Loads and Resources.
[2] Southwestern Connecticut Reliability Study, January 2002, page 17.

3. Load Flow Studies

Results for the Applicant's load flow studies indicated that assuming

1) Dispatch Scenario 2 (dispatch with Norwalk Harbor generation units out-of-service while exporting 200 MW to LIPA through the 138 kV submarine cable), and

2) net power transfers of 700 MW from New England to New York (NE-NY)

would create the most stressful[3] conditions for the SWCT transmission system.

Consequently, KEMA focused on analyzing the system conditions that resulted from load flow analysis under these assumptions. Those assumptions are incorporated in the Applicant's original load flow base case titled "ph2-alt2-ne-ny-091503-2.SAV", provided in response to the Towns' Data Request No. 05--Q-Towns-059.

3.1 Proposed Alternative using HPFF Cables

The original Applicant's load flow cases that model the proposed Phase II alternative with the HPFF cables contain both thermal and voltage criteria violations, under both normal conditions and contingency conditions. These violations occur primarily on the local 115 kV lines, and on the 115/69 (34.5) kV transformers. A summary of thermal overloadings under normal and contingency conditions for the load flow base case is provided in Table 2.

Table 2: Thermal overloadings under normal and contingency conditions in proposed alternative

From Bus			To Bus			Conditions				
Bus No.	Bus Name	kV	Bus No.	Bus Name	kV	Normal	Contingency	Rating (MVA)	Post-Cont. Flow (MVA)	Overloading%
73172	NORWALK	115	73207	FLAX HIL	115	BASE CASE		256	267	101.4
73188	BCNFL PF	115	73192	DRBY JB	115		1272-172 1DCT	112	132	129.6
73207	FLAX HIL	115	73271	RYTN JB	115		1416-1880DCT	256	467	178.6
73176	TRIANGLE	115	73268	MIDDLRIV	115		1060-1165DCT	134	147	111.3
73680	WATER ST	115	73681	WEST RIV	115		GRNDAV2TSTK	273	282	100.6
73162	WATERSDE	115	73168	GLNBROOK	115		SOUTHEND6T	352	367	102.5

Voltage violations under normal and contingency conditions at the 115 kV and above buses are reported in Table 3.

[3] See the PowerGEM Report 10021.001-9, July 20, 2004, Page 11

Table 3: Voltage violations under normal and contingency conditions at the 115 kV

Bus No.	Bus Name	kV	Initial Voltage	Post Contingency (p.u.)	Total No of Violations
73160	BALDWINB	115	1.0085	0.8808	2
73185	BUNKERH	115	1.0179	0.8811	1
73156	COHNZ JA	115	1.0103	1.0501	2
73189	FREIGHT	115	1.0195	0.8795	1
73278	MONT DSL	115	1.0159	1.0553	1
73177	MYSTICCT	115	1.0176	1.0507	1
73151	UNCASVLA	115	1.0155	1.0549	2
73216	WHIP JCT	115	1.0144	1.0516	1

The Applicant must address these local criteria violations prior to the final design acceptance. KEMA has assumed that these local violations can be satisfactorily mitigated, but KEMA has made no independent investigation of how this would be accomplished. Instead, KEMA focused on identifying those additional facilities that became overloaded, and the additional voltage violations that occur when XLPE cable was substituted for HPFF cable and when various lengths of the Devon-Beseck corridor were constructed using underground XLPE cable.

A load flow diagram showing power flows over the proposed Phase I and Phase II lines is provided in Attachment B.

3.2 Alternative with XLPE Technology

3.2.1 Proposed Alternative with XLPE Technology

For the case where the HPFF cable from Norwalk to Devon was replaced with XLPE cable, the load flow studies indicate that the number of overloaded facilities increases in comparison to the number of violations identified in the load flow case for the proposed (overhead) alternative. Most of the overloaded lines are local 115 kV (and below) facilities, as summarized in Table 4. Another concern is the overloading of the Plumtree to Triangle line upon the simultaneous loss of two lines (loss of the Plumtree-Middle River line and the Plumtree – Triangle circuit two), and the Plumtree to Middle River line, upon the loss of the double circuit line from Plumtree to Triangle. Mitigation of this overload would likely require either reconductoring the existing lines (if possible) or adding a new circuit.

Replacement of the HPFF cable with the XLPE cable creates two additional voltage violations on the 115 kV buses. (See Table 5.)

Table 4: Comparison of thermal criteria violations between proposed HPFF alternative and XLPE alternative

Proposed Alternative-HPFF, Dispatch 2, Ne-Ny 700 MW								Phase II : Alternative-XLPE Norwalk to Devon, Dispatch 2, Ne-Ny 700 MW								
From Bus	kV	To Bus	kV	Conditions: Base Case/ Worst Contingency	Rating (MVA)	Post-Cont. Flow (MVA)	Overloading%	From Bus	kV	To Bus	kV	ckt	Conditions: Base Case/ Worst Contingency	Rating (MVA)	Post-Cont. Flow (MVA)	Overloading %
NORWALK	115	FLAX HIL	115	BASE CASE	256.0	266.8	101.4	NORWALK	115	FLAX HIL	115	1	BASE CASE	256.0	265.7	101.2
BCNFL PF	115	DRBY JB	115	1272-172 1DCT	112.0	132.1	129.6	BCNFL PF	115	DRBY J B	115	1	1272-1721DCT	112.0	132.1	129.7
FLAX HIL	115	RYTN JB	115	1416-1880DCT	256.0	467.4	178.6	FLAX HIL	115	RYTN J B	115	1	1880-1977DCT	256.0	440.1	168.3
TRIANGLE	115	MIDDLRIV	115	1060-1165DCT	134.0	146.8	111.3	TRIANGLE	115	MIDDLRIV	115	1	1060-1165DCT	134.0	146.8	110.8
WATER ST	115	WEST RIV	115	GRNDAV2TSTK	273.0	282.3	100.6	WATER ST	115	WEST RIV	115	1	GRNDAV2TSTK	273.0	282.2	100.6
WATERSDE	115	GLNBROOK	115	SOUTHEND6T	352.0	367.3	102.5	WATERSDE	115	GLNBROOK	115	1	SOUTHEND6T	352.0	367.3	102.5
								BARBR HL	69	*ROCKVILL	69	1	1625LINE	84.0	93.1	124.8
								CRRA JCT	115	*ASHCREEK	115	1	1389-1880DCT	439.0	449.1	100.4
								GLNBROOK	115	*RYTN J B	115	1	1880-1977DCT	289.0	315.5	106.5
								GRAND AV	115	*WEST RIV	115	1	GRNDAV2TSTK	258.0	272.5	102.6
								MONTVLLE	115	*DUDLEY T	115	1	1070-1080DCT	183.0	189.2	106.7
								PLUMTREE	115	*TRIANGLE	115	2	1060-1270DCT	166.0	224.9	134.5
								PLUMTREE	115	*MIDDLRIV	115	1	1060-1165DCT	126.0	226.0	180.2
								RYTN J A	115	*NORWALK	115	1	1416-1867DCT	256.0	473.7	181.6
								SOUTHGTN	345	*SGTN B	115	2	SGTN5TSTK	585.0	585.4	100.1
								WATERSDE	115	*COS COB	115	1	SOUTHEND6T	239.0	299.1	124.9

Table 5: Comparison of Voltage Violations for Proposed Alternative with XLPE vs. HPFF Cable

			Proposed Alternative with HPFF			Proposed Alternative with XLPE		
Bus No.	Bus Name	kV	Initial Voltage p.u.	Post Contingency Voltage p.u. Worst Violation	No. of Violations	Initial Voltage p.u.	Post Contingency Voltage p.u. Worst Violation	No. of Violations
73160	BALDWINB	115	1.0085	0.8808	2	1.0075	0.8807	2
73185	BUNKERH	115	1.0179	0.8811	1	1.0169	0.8810	1
73156	COHNZ JA	115	1.0103	1.0501	2	1.0116	1.0501	2
73189	FREIGHT	115	1.0195	0.8795	1	1.0184	0.8794	1
73278	MONT DSL	115	1.0159	1.0553	1	1.0172	1.0553	1
73177	MYSTICCT	115	1.0176	1.0507	1	1.0188	1.0507	1
73151	UNCASVLA	115	1.0157	1.0551	2	1.0170	1.0551	1
73216	WHIP JCT	115	1.0144	1.0516	1	1.0157	1.0516	1
73210	MONTVLLE	115				1.0172	1.0553	1
73161	ROCKVILL	115				0.9865	0.7647	1

Table 6 summarizes power flows over the proposed Phase I and Phase II lines, modeled with XLPE cables, versus HPFF cables.

Table 6: Comparison of Load Flow on System

Transmission Corridor		Net Power Flow (MW)	
From	**To**	**Base Case HPFF Cables**	**Base Case XLPE Cable**
Beseck 345 kV	Devon 345 kV	877	862
Devon 345 kV	Singer 345 kV	772	752
Singer 345 kV	Norwalk 345 kV	592	570
Plumtree 345 kV	Norwalk 345 kV	121	132
Devon 345 kV	Devon 115 kV	97.5	102
Singer 345 kV	Pequonic & Pequonic Tap 115 kV	179	180
Norwalk 345 kV	Norwalk 115 kV	712	702
Plumtree 345 kV	Plumtree 115 kV	446	446

3.2.2 Devon – Beseck Section 20 miles Underground / 20 miles Overhead

KEMA's load flow studies indicate that when 20 miles of the 345 kV line extending from Devon toward Beseck was modeled as three parallel XLPE cables (of 1750 kcmil) and the remainder was modeled as the proposed overhead line, the number of contingency overloads increases in comparison to the number of violations identified for the proposed alternative. Specifically, an additional seven 115 kV facilities became overloaded with undergrounding of the 20 miles of the line extending from Devon toward Beseck, as summarized in Table 7. All of the overloaded lines are local 115 kV (and below) facilities. The same concern described in Section 3.2.1 is the overloading of the Plumtree to Triangle line upon the simultaneous loss of two lines (loss of the Plumtree-Middle River line and the Plumtree – Triangle circuit two), and the Plumtree to Middle River line, upon the loss of the double circuit line from Plumtree to Triangle. Mitigation of this overload would likely require either reconductoring the existing lines (if possible) or adding a new circuit.

Extension of the XLPE cable creates three additional voltage violations compared to the proposed alternative with HPFF cable, and one compared to the proposed alternative with XLPE cable. This violation is insignificant. (See Table 8.)

Table 7: Comparison of thermal criteria violations between proposed HPFF alternative and alternative with additional 20 miles undeground XPLE

Proposed Alternative-HPFF, Dispatch 2, Ne-Ny 700 MW								Phase II: 20 miles Underground from Devon to Beseck, XLPE							
From Bus	kV	To Bus	kV	Conditions: Base Case/ Worst Contingency	Rating (MVA)	Post-Cont. Flow (MVA)	Overloading %	From Bus	kV	To Bus	kV	Conditions: Base Case/ Worst Contingency	Rating (MVA)	Post-Cont. Flow (MVA)	Over. %
NORWALK	115	FLAX HIL	115	BASE CASE	256.0	266.8	101.4	NORWALK	115	FLAX HIL	115	BASE CASE	256.0	267.6	101.5
BCNFL PF	115	DRBY JB	115	1272-172 1DCT	112.0	132.1	129.6	BCNFL PF	115	DRBY J B	115	1272-1721DCT	112.0	131.9	129.4
FLAX HIL	115	RYTN JB	115	1130LINE	256.0	277.6	105.7	FLAX HIL	115	RYTN J B	115	1130LINE	256.0	467.9	178.5
TRIANGLE	115	MIDDLRIV	115	1060-1165DCT	134.0	146.8	111.3	TRIANGLE	115	MIDDLRIV	115	1060-1165DCT	134.0	146.9	111.4
WATER ST	115	WEST RIV	115	GRNDAV2TSTK	273.0	282.3	100.6	WATER ST	115	WEST RIV	115	GRNDAV2TSTK	273.0	284.2	101.3
WATERSDE	115	GLNBROOK	115	SOUTHEND6T	352.0	367.3	102.5	WATERSDE	115	GLNBROOK	115	SOUTHEND6T	352.0	367.3	102.5
								BARBR HL	69	*ROCKVILL	69	1625LINE	84.0	93.1	124.8
								GLNBROOK	115	*RYTN J B	115	1416-1880DCT	289.0	342.1	115.3
								MONTVLLE	115	*DUDLEY T	115	1070-1080DCT	183.0	189.3	106.9
								PLUMTREE	115	*TRIANGLE-ckt 1	115	1165LINE	138.0	145.0	104.9
								PLUMTREE	115	*MIDDLRIV	115	1060-1165DCT	126.0	226.2	181.2
								RYTN J A	115	*NORWALK	115	1130LINE	256.0	380.8	145.0
								WATERSDE	115	*COS COB	115	SOUTHEND6T	239.0	299.1	124.9

Table 8: Effects of Additional 20 miles of Undegrounding with XLPE on Contingency Voltage Violations

			Proposed Alternative with XLPE			Alternative with 20 miles UG from D-B		
Bus No.	Bus Name	kV	Initial Voltage p.u.	Post Contingency Voltage p.u. Worst Violation	No. of Violations	Initial Voltage p.u.	Post Contingency Voltage p.u. Worst Violation	No. of Violations
73160	BALDWINB	115	1.0075	0.8807	2	1.0054	0.8803	2
73185	BUNKERH	115	1.0169	0.8810	1	1.0146	0.8807	1
73156	COHNZ JA	115	1.0116	1.0501	2	1.0098	1.0501	2
73189	FREIGHT	115	1.0184	0.8794	1	1.0161	0.8791	1
73278	MONT DSL	115	1.0172	1.0553	1	1.0155	1.0553	1
73177	MYSTICCT	115	1.0188	1.0507	1	1.0173	1.0507	1
73151	UNCASVLA	115	1.0170	1.0551	1	1.0152	1.0551	2
73216	WHIP JCT	115	1.0157	1.0516	1	1.0140	1.0516	1
73210	MONTVLLE	115	1.0172	1.0553	1	1.0155	1.0553	1
73161	ROCKVILL	115	0.9865	0.7647	1	0.9864	0.7646	1
73476	TRACY05	115				0.9452	0.8996	2

Table 9 summarizes power flows over the proposed Phase I and Phase II lines, modeled with XLPE cables and 20 miles of additional underground line from Devon toward Beseck, and compares these with power flows for the case with only the undergrounding proposed by the Applicant.

Table 9: Comparison of load flow on system, with additional 20 miles of underground cable

Transmission Corridor		Net Power Flow (MW)	
From	**To**	**Base Case XLPE Cable**	**Base Case XLPE Cables + 20 Miles**
Beseck 345 kV	Devon 345 kV	862	975
Devon 345 kV	Singer 345 kV	752	854
Singer 345 kV	Norwalk 345 kV	570	658
Plumtree 345 kV	Norwalk 345 kV	132	64.4
Devon 345 kV	Devon 115 kV	102	121
Singer 345 kV	Pequonic & Pequonic Tap 115 kV	180	197
Norwalk 345 kV	Norwalk 115 kV	702	720
Plumtree 345 kV	Plumtree 115 kV	446	452

3.2.3 Devon – Beseck Section 40 miles

When the entire length of the 40-mile corridor from Devon to Beseck is modeled with underground XLPE cable, the number of contingency facility overloads increases further, as summarized in Table 10. Because of the low impedance of three parallel XLPE cables, the Devon to Beseck underground section reacts as a "sink", transferring more power to the Southwest Connecticut load pocket, than either the proposed overhead Devon to Beseck line alternative, or the combination 20 miles underground/20 miles overhead alternative. In this case, an overload occurs on each of the two 345 kV underground circuits between Devon and Singer, for a single contingency outage of the identical parallel 345 kV circuit. However, the simultaneous loss of both underground circuits from Devon to Singer, does not result in a thermal overload.

Further extension of the XLPE cable generally enhances voltage conditions and eliminates some of the violations associated with the proposed alternative. However, such extension also causes several new 115 kV voltage violations, as summarized in Table 11.

Table 10: Comparison of thermal criteria violations between proposed HPFF alternative and alternative with additional 40 miles undeground XPLE

Proposed Alternative-HPFF, Dispatch 2, Ne-Ny 700 MW								Phase II :40 miles Underground from Devon to Beseck, XLPE								
From Bus	kV	To Bus	kV	Conditions: Base Case/ Worst Contingency	Rating (MVA)	Post-Cont. Flow (MVA)	Overloading %	From Bus	kV	To Bus	kV	ckt	Conditions: Base Case/ Worst Contingency	Rating (MVA)	Post-Cont. Flow (MVA)	Overloading %
NORWALK	115	FLAX HIL	115	BASE CASE	256.0	266.8	101.4	NORWALK	115	73207 FLAX HIL	115	1	BASE CASE	256.0	272.4	102.9
BCNFL PF	115	DRBY JB	115	1272-172 1DCT	112.0	132.1	129.6	BCNFL PF	115	DRBY JB	115	1	1272-172 1DCT	112.0	131.6	128.9
FLAX HIL	115	RYTN JB	115	1130LINE	256.0	277.6	105.7	FLAX HIL	115	73271 RYTN JB	115	1	1130LINE	256.0	472.3	179.7
TRIANGLE	115	MIDDLRIV	115	1060-1165DCT	134.0	146.8	111.3	TRIANGLE	115	73268 MIDDLRIV	115	1	1060-1165DCT	134.0	146.8	111.2
WATER ST	115	WEST RIV	115	GRNDAV2TSTK	273.0	282.3	100.6									
WATERSDE	115	GLNBROOK	115	SOUTHEND6T	352.0	367.3	102.5	WATERSDE	115	73168 GLNBROOK	115	1	SOUTHEND6T	352.0	367.3	102.5
								BARBR HL	69	ROCKVILL	69.9	1	1625LINE	84.0	93.0	124.4
								BLM JCT	115	NW.HTFD	115	1	1207-1775DCT	228.0	246.2	111.2
								BLOOMFLD	115	N.BLMFLD	115	1	1207-1775DCT	193.0	216.6	115.4
								DEVSING2	345	SINGDEV2	345	2	DEVSING1	910.0	1061.6	114.0
								GLNBROOK	115	73271*RYTN JB	115	1	1416-1880DCT	289.0	342.2	115.2
								MONTVLLE	115	73611*DUDLEYT	115	1	1070-1080DCT	183.0	189.1	106.5
								PLUMTREE	115	73176*TRIANGLE	115	1	1165LINE	138.0	145.0	104.7
								PLUMTREE	115	73268*MIDDLRIV	115	1	1060-1165DCT	126.0	226.1	180.9
								RYTN J A	115	73172*NORWALK	115	1	1130LINE	256.0	474.1	179.6
								SINGER	345	73313 SINGDEV2	345	1	DEVSING1	910.0	1050.5	112.8
								WATERSDE	115	73163*COS COB	115	1	SOUTHEND6T	239.0	299.1	124.9

Table 11: Effects of Additional 20 miles and 40 miles of Undegrounding on Contingency Voltage Violations

			Proposed Alternative with XLPE			Alternative with 20 miles UG from D-B			Alternative with 40 miles UG from D-B		
Bus No.	Bus Name	kV	Initial Voltage p.u.	Post Contingency Voltage p.u. Worst Violation	No. of Violations	Initial Voltage p.u.	Post Contingency Voltage p.u. Worst Violation	No. of Violations	Initial Voltage p.u.	Post Contingency Voltage p.u. Worst Violation	No. of Violations
73160	BALDWINB	115	1.0075	0.8807	2	1.0054	0.8803	2	1.0078	0.8820	2
73185	BUNKERH	115	1.0169	0.8810	1	1.0146	0.8807	1	1.0170	0.8823	1
73156	COHNZ JA	115	1.0116	1.0501	2	1.0098	1.0501	2			
73189	FREIGHT	115	1.0184	0.8794	1	1.0161	0.8791	1	1.0186	0.8808	1
73278	MONT DSL	115	1.0172	1.0553	1	1.0155	1.0553	1			
73177	MYSTICCT	115	1.0188	1.0507	1	1.0173	1.0507	1			
73151	UNCASVLA	115	1.0170	1.0551	1	1.0152	1.0551	2			
73216	WHIP JCT	115	1.0157	1.0516	1	1.0140	1.0516	1			
73210	MONTVLLE	115	1.0172	1.0553	1	1.0155	1.0553	1			
73161	ROCKVILL	115	0.9865	0.7647	1	0.9864	0.7646	1	0.9873	0.7671	1
73476	TRACY05	115				0.9452	0.8996	2			
73682	ELMWST A	115							1.0305	0.8810	3
73683	ELMWST B	115							1.0305	0.8774	3
73671	NO.HAVEN	115							1.0337	1.0518	1

Table 12 summarizes power flows over the proposed Phase I and Phase II lines, modeled with XLPE cables and 40 miles of additional underground line from Devon toward Beseck, and compares these with power flows for the prior two cases.

Table 12: Comparison of load flow on system, with additional 20 and additional 40 miles of underground cable

Transmission Corridor		Net Power Flow (MW)		
From	**To**	**Base Case XLPE Cable**	**Base Case XLPE Cables + 20 Miles**	**Base Case XLPE Cables + 40 Miles**
Beseck 345 kV	Devon 345 kV	862	975	1263
Devon 345 kV	Singer 345 kV	752	854	1094
Singer 345 kV	Norwalk 345 kV	570	658	854
Plumtree 345 kV	Norwalk 345 kV	132	64.4	-104
Devon 345 kV	Devon 115 kV	102	121	169
Singer 345 kV	Pequonic & Pequonic Tap 115 kV	180	197	237
Norwalk 345 kV	Norwalk 115 kV	702	720	750
Plumtree 345 kV	Plumtree 115 kV	446	452	468

Note: A negative value indicates a power flow in the opposite direction.

4. Conclusion

The original Applicant's load flow base cases that model the proposed alternative, contain both thermal and voltage criteria violations, under normal and contingency conditions. These violations occur mainly on the local 115 kV lines (six overloads), and on the 115/69 (34.5) kV transformers. The Applicant must address these local criteria violations prior to the final design acceptance. KEMA has assumed that these local violations can be satisfactorily mitigated, but KEMA has made no independent investigation of how this would be accomplished. Instead, KEMA focused on identifying those additional facilities that became overloaded, and the additional voltage violations that occur when XLPE cable was substituted for HPFF cable and when various lengths of the Devon-Beseck corridor were constructed using underground cable.

For the case where the proposed HPFF cable from Norwalk to Devon was replaced with XLPE cable, the load flow studies indicate that the number of overloaded facilities increases in comparison to the number of violations identified in the load flow case for the proposed alternative. Most of the overloaded lines are local 115 kV (and below) facilities. Another concern is the overloading of the Plumtree to Triangle line upon the simultaneous loss of two lines (loss of the Plumtree-Middle River line and the Plumtree – Triangle circuit two), and the Plumtree to Middle River line, upon the loss of the double circuit line from Plumtree to Triangle. Mitigation of this overload would likely require either reconductoring the existing lines (if possible) or adding a new circuit.

KEMA's load flow studies indicate that when an additional 20-mile section of the line extending from Devon toward Beseck was modeled as underground XLPE cable and the rest was modeled as overhead line, the number of contingency overloads increased in comparison to the number of violations identified for the proposed alternative. However, all of the additional overloaded lines continue to be local 115 kV (and below) facilities. Specifically, an additional seven 115 kV facilities became overloaded with such additional undergrounding.

When the full length of the 40-mile corridor from Devon to Beseck was modeled with underground XLPE cable, the number of contingency facility overloads increased further, and two 345 kV circuits overload on contingency. Because of the low impedance of three parallel XLPE cables, the Devon to Beseck underground section reacts as a "sink", transferring more power to the Southwest Connecticut load pocket, than either the proposed overhead Devon to Beseck line alternative, or the combination 20 miles underground/20 miles overhead alternative. In this case, an overload occurs on each of the two proposed 345 kV underground circuits between Devon and Singer, for a single contingency outage of the identical parallel 345 kV circuit. However, the simultaneous loss of both underground circuits from Devon to Singer, does not result in a thermal overload.

Based on the results of the KEMA's load flow studies, there is no indication that placing up to 20 miles of the 345 kV line from Devon to Beseck underground would lead to a situation that could not be mitigated either by system reinforcements at voltages of 115 kV (and below) or by adding appropriate voltage support. However, the Applicant would need to address the identified thermal overloads and voltage violations on the local 115 kV (and below) system for its proposed alternative and for the alternatives with extended undergrounding prior to final design. If underground XLPE cable were used for all 40 miles of the Devon-Beseck corridor, a solution would be required for the single contingency 345kV overloads described previously. Such a solution could, in turn, affect system harmonic performance, and further study would be required to determine its acceptability.

Attachments

Attachment A

Dispatching Scenarios

Table A-1: Dispatching Scenarios

			Dispatch (MW)			
Bus Name [4]	KV	BUS#	2	3	4	5
AESTH PF	20	73538	180	180	180	180
BATES DA	0.48	73351	0	0	0	0
BCNFL PF	115	73188	0.9	0.9	0.9	0.9
BCNFL PF	115	73188	1.5	1.5	1.5	1.5
BCNFL PF	115	73188	1	1	1	1
BE 10 ST	16	73654	0	180	180	0
BE 11	16	73652	0	170	170	0
BE 12	16	73653	0	170	170	0
BPTHBR#2	20	73647	0	0	0	0
BPTHBR#3	22	73648	375	375	375	375
BPTHBR#4	13.8	73649	0	0	0	0
BULLS BR	27.6	73381	5	5	5	5
CAMPV PH	115	73203	3	3	3	3
CAMPV PH	115	73203	3	3	3	3
CAP D PF	13.8	73545	28.2	28.2	28.2	28.2
CAP D PF	13.8	73545	21.8	21.8	21.8	21.8
COS COB	115	73163	0	0	0	0
COS COB	115	73163	0	0	0	0
COS COB	115	73163	0	0	0	0
CRRA PF	11.5	73547	32	32	32	32
CRRA PF	11.5	73548	32	32	32	32
CRRRA PF	13.8	73650	57	57	57	57
DEVGAS11	13.8	73570	0	0	0	0
DEVGAS12	13.8	73571	0	0	0	0
DEVGAS13	13.8	73572	0	0	0	0
DEVGAS14	13.8	73573	0	0	0	0
DEVON	345	73297	0	0	0	0
DEVON#7	13.8	73553	106	106	106	0
DEVON#8	13.8	73554	106	106	106	0
DEVON10	115	73277	0	0	0	0
DEXTR PF	13.8	73539	26.2	26.2	26.2	26.2
DEXTR PF	13.8	73539	11.8	11.8	11.8	11.8
ENGLISH7	13.8	73657	0	0	0	0
ENGLISH8	13.8	73658	0	0	0	0
EXETR PF	115	73281	26	26	26	26
FORST PF	13.8	73536	13	13	13	13
FRKLN DR	13.2	73543	0	0	0	0
GLNBROOK	115	73168	0	0	0	0
LAKERD#1	21	73565	280	280	280	280
LAKERD#2	21	73566	280	280	280	280
LAKERD#3	21	73567	280	280	280	280
LISBN PF	115	73276	13.5	13.5	13.5	13.5

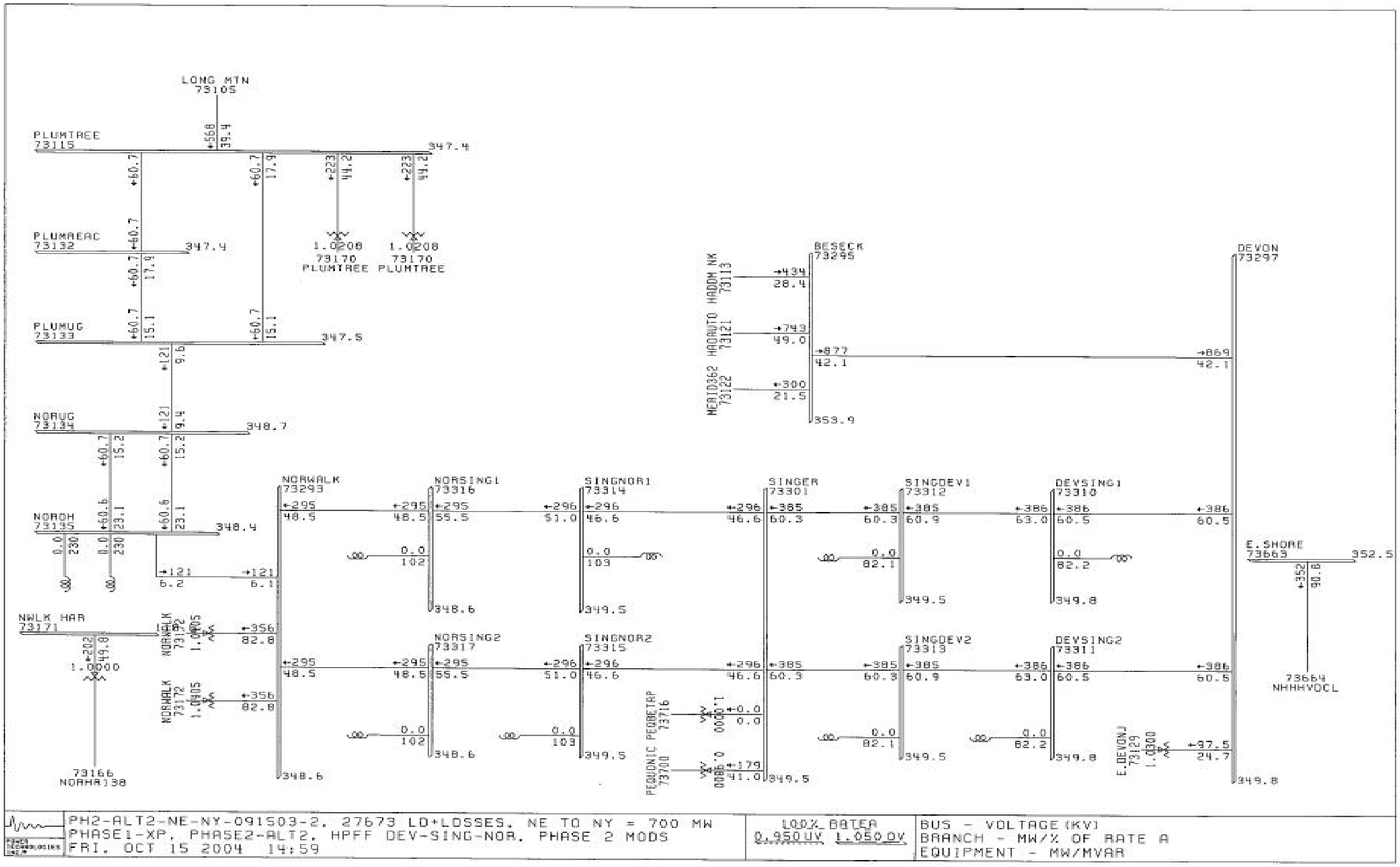
[4] These are the bus names assigned by the Applicant in their power flow cases, which was provided in the Townships' data request number ##. For a definition of the acronyms in use, please see the response to the original data request.

Table A-1: Dispatching Scenarios (Continued)

			Dispatch (MW)			
Bus Name	KV	BUS#	2	3	4	5
MERIDEN1	21	73588	195	195	195	195
MERIDEN2	21	73589	195	195	195	195
MERIDEN3	21	73590	196	196	196	196
MIDD#10J	13.2	73564	17	17	17	17
MIDDTN#2	13.8	73555	117	117	117	117
MIDDTN#3	22	73556	233	233	233	233
MIDDTN#4	22	73557	400	400	400	400
MILFD#1	13.8	73574	280	280	280	0
MILFD#2	13.8	73575	0	280	280	0
MILL#2	24	73562	860	860	860	860
MILL#3	24	73563	1140	1140	1140	1140
MONT DSL	115	73278	0	0	0	0
MONT DSL	115	73278	0	0	0	0
MONTV#5	13.8	73558	81	81	81	81
MONTV#6	22	73559	402	402	402	402
NH HARBR	22	73651	447	447	447	447
NORHAR#1	18	73551	0	0	161	161
NORHAR#2	20	73552	0	0	168	168
NORWALK	345	73293	0	0	0	0
RKRIV PF	115	73280	2.6	2.6	2.6	2.6
ROCK RIV	13.8	73541	25	25	25	25
RVRSD PF	23	73537	0	0	0	0
SANDH DB	0.48	73352	0	0	0	0
SANDH DC	0.48	73353	0	0	0	0
SCRRA PF	69	73616	13.2	13.2	13.2	13.2
SHEPAUG	69	73341	32	32	32	32
SMD1112J	13.8	73549	0	0	0	0
SMD1112J	13.8	73549	0	0	0	0
SMD1314J	13.8	73550	0	0	0	0
SMD1314J	13.8	73550	0	0	0	0
SMEAD PF	23	73546	3	3	3	3
SMEAD PF	23	73546	10	10	10	10
STEVENSN	115	73187	0	0	0	0
TUNNEL	23	73544	0	0	0	0
TUNNEL	69	73617	17	17	17	17
WALL LV1	13.8	73594	0	51	51	0
WALL LV1	13.8	73594	0	51	51	0
WALL LV2	13.8	73595	0	51	51	0
WALL LV2	13.8	73595	0	51	51	0
WALL LV3	13.8	73596	0	51	51	0
WLNGF PF	115	73631	6.4	6.4	6.4	6.4
WNDSRLK	27.6	73459	8	8	8	8

Attachment B

Load Flow Diagram for Applicant's Proposed Alternative
Peak Load, No Contingencies


LONG MTN
73105
PLUMTREE
73115
347.4
PLUMREAC
73132
347.4
1.0208
73170
PLUMTREE
PLUMUG
73133
347.5
NORUG
73134
348.7
NORWALK
73293
NORSING1
73316
SINGNOR1
73314
SINGER
73301
SINGDEV1
73312
DEVSING1
73310
NOROH
73135
348.4
BESECK
73295
353.9
DEVON
73297
E.SHORE
73663
352.5
73664
NHHHVDCL
NWLK HAR
73171
NORSING2
73317
SINGNOR2
73315
SINGDEV2
73313
DEVSING2
73311
PEQUONIC PEQBETAP
73716
PEQUONIC
73700
E.DEVONJ
73129
73166
NORHAR138
PH2-ALT2-NE-NY-091503-2. 27673 LD+LOSSES. NE TO NY = 700 MW
PHASE1-XP. PHASE2-ALT2. HPFF DEV-SING-NOR. PHASE 2 MODS
FRI. OCT 15 2004 14:59
100% RATEA
0.950UV 1.050OV
BUS - VOLTAGE (KV)
BRANCH - MW/% OF RATE A
EQUIPMENT - MW/MVAR