middletown | norwalk

February 23, 2004

VIA HAND DELIVERY

Mr. S. Derek Phelps
Executive Director
Connecticut Siting Council
10 Franklin Square
New Britain, CT 06051

Re: 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 the Scovill Rock Switching Station in Middletown and the Norwalk Substation in Norwalk, including the reconstruction of portions of existing 115-kV and 345-kV electric transmission lines, the construction of 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

Dear Mr. Phelps:

Enclosed are an original and 15 copies of Addendum #3 to the December 16, 2003 Supplemental Filing by The Connecticut Light and Power Company and The United Illuminating Company pursuant to Section VIII(Q) of the Council's Application Guides for Terrestrial Electric Transmission Line Facilities dated September 9, 2003. Due to their size, the three reports with appendices will be sent individually via e-mail to the Siting Council and the electronic service list.

Very truly yours,

Anne Bartosewicz

Anne Bartosewicz, Project Director
The Connecticut Light & Power Company

John J. Prete, Project Director
The United Illuminating Company

Enclosure
cc: Service List

Connecticut Light & Power
The Northeast Utilities System

The United Illuminating Company

SERVICE LIST
Docket: 272

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STATE OF CONNECTICUT

SITING COUNCIL

Re:	The Connecticut Light and Power Company and The United Illuminating Company Application for a Certificate of Environmental Compatibility and Public Need for the Construction of a New 345-kV Electric Transmission Line and Associated Facilities Between Scovill Rock Switching Station in Middletown and Norwalk Substation in Norwalk, Connecticut Including the Reconstruction of Portions of Existing 115-kV and 345-kV Electric Transmission Lines, the Construction of the Beseck Switching Station in Wallingford, East Devon Substation in Milford, and Singer Substation in Bridgeport, Modifications at Scovill Rock Switching Station and Norwalk Substation and the Reconfiguration of Certain Interconnections	)	Docket 272 February 20, 2004

ADDENDUM # 3 TO
SUPPLEMENTAL FILING

The Connecticut Light and Power Company ("CL&P") and The United Illuminating Company ("UI") (together, the "Companies") submit this addendum to their Supplemental Filing to the Connecticut Siting Council ("Council") dated December 16, 2003. This submission is made pursuant to Section VIII (Q) of the Council's Application Guides for Terrestrial Electric Transmission Line Facilities, which provides that "the Applicant[s] shall provide supplemental information for the Council to make a reasonable comparison between the Applicant [s'] proposed route and any reasonable alternative route recommended by the site municipalities pursuant to C.G.S. section 16-50l."

In Part 5 of their Supplemental Filing of December 16, 2003, the Companies advised that certain thermal load flow studies relating to the possible use of the existing 387 line between

Scovill Rock Switching Station in Middletown and East Shore Substation in New Haven as a component of the SWCT 345-kV loop had been commissioned from PowerGEM. The Companies filed the first of these studies, dated December 31, 2003, as part of their Addendum #1 to the Supplemental Filing, dated January 8, 2003. On January 30, 2004, the Companies filed four more studies as part of Addendum #2 to their Supplemental Filing. The Companies have now received two additional PowerGEM studies, both dated February 16, 2004.[1] These two studies model the East Shore Alternative using previously modeled assumptions, but with an additional assumption of 700 MW transfers between New England and New York. Previous studies assumed zero net transfers between New England and New York.

In addition, ISO-New England's Southwest Connecticut (SWCT) Working Group has completed a study entitled "Comparison of Middletown to Norwalk Project vs. East Shore Alternative," dated February 18, 2004 ("ISO-NE SWCT Working Group Comparison Study"). This study analyzes the results of all of the PowerGEM studies of the East Shore Alternative and compares those results to the Working Group's own modeling of the Middletown to Norwalk Project.

Hard copies of the text of the two new PowerGEM studies and of the ISO-New England SWCT Working Group Comparison Study are attached hereto. Electronic copies of this filing and of the three studies, including the appendices, will be provided (in separate e-mails) to the Council and to the electronic service list.

The ISO-New England SWCT Working Group Comparison Study concludes: "The East Shore Alternative as studied was found to be an unacceptable substitute to the Middletown to

[1] "Southwest Connecticut Transmission Expansion: East Shore to Norwalk 345 KV OH /UG Alternative: Transmission Loading and Voltage Analysis @ 27.7 GW Load, NE - NY +/- 700MW" and "Southwest Connecticut Transmission Expansion: East Shore to Norwalk 345 KV OH /UG Alternative: Transmission Loading and Voltage Analysis @ 27.7 GW Load, 387 Line Reconductored NE - NY +/- 700MW"

Norwalk Project because it does not meet NERC, NPCC or NEPOOL criteria." (p. 13) Moreover, the study concludes that reconductoring of the 387 line would be insufficient to achieve such compliance, since modeled overloads occur due to the fact that "this alternative does not build a new source into SWCT." (*Id.*, p. 9)

The Companies' December 16 Supplemental Filing identified numerous studies that might be required for a full evaluation of the East Shore Alternative, and then noted: "If any of the study results disqualify the East Shore alternative from further consideration, subsequent studies would not be required." (Id., p. 14). Based on the ISO-New England SWCT Working Group Comparison study, the Companies have concluded that the East Shore Alternative as studied has been disqualified from further consideration, so that further thermal studies are not required. Thus, the PowerGEM and ISO-NE SWCT Working Group Comparison study results have confirmed the Companies' statement at page G-18 of Volume 1 of the Application that utilizing the existing 387 line "would not substantially reduce new 345- kV line construction because, in order to meet national and regional reliability standards, a second 345-kV line would have to be built on separate structures on the Beseck to East Shore ROW." In addition, as described in the application, substantial understreet and underwater construction would be required for the line segment between East Shore and East Devon. This construction would introduce additional technical and operational complexity to the transmission system. As with other routing issues, the Companies' personnel will be available at the spring hearings to respond to questions.

Southwest Connecticut Reliability Study

Comparison of Middletown to Norwalk Project vs. East Shore Alternative

February 18, 2004
Presented by the

ISO-NE Southwest Connecticut Working Group

Executive Summary

This study documents the results of testing performed by the ISO-NE SWCT Working Group to compare the proposed Middletown to Norwalk Project with an alternative referred to as the East Shore Alternative.

The East Shore Alternative as studied was found to be an unacceptable substitute to the Middletown to Norwalk Project because it does not meet NERC, NPCC, or NEPOOL criteria. The East Shore Alternative does not strengthen the power supply into SWCT by introducing a new source; it simply connects the load in SWCT to an already heavily loaded 387 line. The most notable overload in this report is the one on the 387 line. Even with the assumed reconductoring of the limiting portion of the 387 line, the line continues to overload. In addition, an outage of this line yields substantial overloads on the remaining corridors serving SWCT and the 345-kV across the state.

Since the East Shore Alternative is not considered acceptable, continued comparative testing was not performed. In order to completely evaluate the East Shore Alternative, further analysis would have to include thermal and voltage testing at a 30,000 MW New England load level, a transfer limit comparison, and possibly 2^{nd} contingency (N-2) testing.

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Appendices

1.0 Introduction

In December 2002, the Southwest Connecticut Working Group published the "Southwestern Connecticut Electric Reliability Study". The report identified the need to construct a 345-kV "loop" to address the reliability problems in Southwest Connecticut (SWCT). Northeast Utilities (NU) and the United Illuminating Company (UI) have filed an application with the Connecticut Siting Council to construct the Middletown to Norwalk portion of that project.

This study documents the results of testing performed by the ISO-NE SWCT Working Group to compare the proposed Middletown to Norwalk Project with an alternative referred to as the East Shore Alternative.

2.0 Description of Alternatives

2.1 Middletown to Norwalk Project

The Middletown to Norwalk Project begins by constructing a new switching station at Beseck Junction. This new switching station is connected to the existing 345-kV transmission at Southington via Meriden, Haddam Neck, and Millstone. From Beseck, a new 345-kV line is connected to Norwalk, after interconnecting to the proposed East Devon and Singer substations.

2.2 East Shore Alternative

Similar to the Middletown to Norwalk Project, the East Shore Alternative terminates at Norwalk substation with intermediate stops at Singer and East Devon substations. All system changes at these substations are identical to that of the Middletown to Norwalk Project. However, from East Devon, a new circuit is constructed to the existing East Shore Substation in New Haven. There are no further 345-kV transmission changes associated with this alternative.

3.0 Study Methodology

3.1 System Modeling

All evaluations of the Middletown to Norwalk Project were performed on behalf of the ISO-NE SWCT Working Group by EPRO using PTI's PSS/E Program. All study work performed by PowerGEM to evaluate the East Shore Alternative used PTI's MUST program. Both programs provide similar results, yet use different solution methods to arrive at their results. While this is acceptable to perform a comparison between two alternatives, caution must be used when evaluating the results. One solution method may determine a solution for a given set of system conditions while the other may not. In such a case, the results should be noted, but not used to discount the validity of a given project.

For a valid comparison, the same generator dispatches, system loads, and NE-NY interface flows were used in this analysis as in the studies published previously.

3.2 Power-Flow

Both studies used the same criteria for evaluating system performance. Table 1 contains the thermal loading performance criteria applied to both studies. The use of long-time emergency (LTE) thermal ratings in planning studies recognizes the limited line switching, re-dispatch and system re-configuration options available to operators. These ratings provide adequate flexibility to system operations to address unique circumstances encountered on a day-to-day basis.

Table 1
Thermal Loading Performance Criteria

System Condition	Maximum Allowable Facility Loading
Pre-Contingency (all-lines-in)	Normal Rating
Post-Contingency	LTE Rating

3.3 Voltage

Table 2 contains the voltage performance criteria used in both sets of analyses.

Table 2
Voltage Performance Criteria

Voltage Level	Bus Voltage Limits	
	Normal Conditions	Emergency Conditions
> 115 kV	95 to 105% of nominal	95 to 105% of nominal
≤ 115 kV	95 to 105% of nominal	90 to 105% of nominal
Millstone 345 kV	100 to 105% of nominal	100 to 105% of nominal

3.4 Contingency List

Both studies tested all single transmission line outages, stuck breaker events, double circuit tower events, and generator outages in Connecticut, including new scenarios due to the addition of the project under evaluation.

4.0 Study Results

Results of testing the Middletown to Norwalk Project versus the East Shore Alternative are contained in Appendices A through F. Although testing was performed for many sets of conditions and is documented in the Appendices, the discussion below only evaluates those cases which are necessary to provide a valid comparison of the two proposals.

4.1 New Haven Harbor generation on line, existing 387 line (East Shore to Scovill Rock)

Results of testing at New England load of 27,700 MW with New Haven Harbor in service and NY-NE=0 MW are contained in Appendices A1 and A2. Table 3 shows the worst case overloads for both alternatives.

Table 3
Worst Case Overloads
New Haven Harbor In Service - NY to NE Flow = 0 MW

Dispatch	Contingency	Overloaded Element			Middletown-Norwalk Project (E/PRO)	East Shore Alternative (PowerGEM)
		From Bus	To Bus	Voltage (kV)	% of Rating[1]	% of Rating
BASE CASE OVERLOADS						
2	NONE	FLAX HILL	RYTN J B	115	**100.5**	
2	NONE	NORWALK	FLAX HILL	115	**121.0**	**120.5**
2	NONE	RYTN J A	NORWALK	115	**112.7**	**112.2**
CONTINGENCY OVERLOADS						
2	**SGTN4TSTK**	**SCOVL RK**	**E.SHORE**	**345**		**106.0**
5	SGTN5TSTK	SOUTHGTN	SGTN B	Auto	**102.0**	**121.1**
5	1272-1721DCT	BCNFL PF	DRBY J B	115	**131.0**	**132.1**
2	1620SLINE	HADDAM	BOKUM	115		**109.3**
5	FROSTBR27T	SHAWSHIL	BUNKER H	115		**104.3**
4	DEVON2TSTK	TRMB J A	PEQUONIC	115		**101.7**
3	NORSING1	SINGNOR2	NORSING2	345	**109.5**	
5	GRNDAV2TSTK	GRAND AV	WEST RIV	115	**106.8**	**101.7**
5	GRNDAV2TSTK	GRAND AV	WEST RIV - 2	115	**106.8**	**101.7**
2	GRNDAV2TSTK	WATER ST	WEST RIV	115	**100.6**	
2	TRIANGLE2T	MIDDLRIV	TRIANGLE	115	**NC**[2]	**223.2**
2	TRIANGLE2T	PLUMTREE	MIDDLRIV	115	**NC**	**284.3**
2	TRIANGLE3T	PLUMTREE	TRIANGLE	115	**NC**	**177.4**
2	1060-1270DCT	PLUMTREE	TRIANGLE - 2	115	**135.1**	**135.2**
2	1440-1450DCT	SO.END	GLNBRK J	115	**123.2**	**123.2**
2	SOUTHEND6T	WATERSDE	COS COB	115	**124.8**	**124.8**
2	SOUTHEND6T	WATERSDE	GLNBROOK	115	**102.5**	**102.5**
3	1389-1880DCT	CRRA JCT	ASHCREEK	115	**100.2**	**100.3**
2	1416-1880DCT	FLAX HIL	RYTN J B	115	**178.3**	**177.9**
5	1867-1880DCT	GLNBROOK	ELYAVE	115	**153.8**	**153.9**
5	1867-1890DCT	GLNBROOK	RYTN J A	115	**101.3**	**101.8**
5	1880-1890DCT	GLNBROOK	RYTN J B	115	**146.4**	**146.5**
2	1416-1880DCT	NORWALK	FLAX HIL	115	**195.6**	**195.3**
5	1867-1880DCT	NWLK HAR	ELYAVE	115	**158.1**	**158.4**
4	1880-1890DCT	NWLK HAR	RYTN J B	115	**104.4**	**104.3**
2	1416-1867DCT	RYTN J A	NORWALK	115	**181.2**	**180.8**
4	1867-1890DCT	RYTN J A	NWLK HAR	115	**144.0**	**144.4**

[1] For base case overloads, the "% of Rating" refers to the Normal rating, and for contingency overloads the "% of Rating" refers to the Long-Time Emergency (LTE) rating. This applies to Tables 3 through 7.
[2] Not converged in the analysis.

The results above show that the two projects have very similar performance characteristics. However, there are a few items which should be noted. The first and most significant issue is that the 345-kV East Shore to Scovill Rock 387 line is overloaded in the East Shore Alternative. This line is providing the majority of the power toward SWCT. In contrast to this, the Middletown to Norwalk Project provides an additional path for power to flow into SWCT.

The flow on the 387 line, which in the East Shore Alternative becomes a cornerstone of the solution, is very dependent on the status of the New Haven Harbor generator. This generator, which is defined as being outside of the SWCT electrical interface, is interconnected to the East Shore end of the 387 line; therefore, the 387 line flow increases dramatically when this 447 MW generator is out of service. Testing as described below documents the impact on both projects of having this generator out of service.

Another item of significance is the magnitude of the overload on the Southington autotransformer in the East Shore Alternative. If this contingency were to occur, automatic switching actions would mitigate small overloads. However, the severity of the overload in the East Shore Alternative may prove these actions to be inadequate.

The results of the East Shore Alternative analysis also indicate that the underlying 115-kV transmission system is forced to carry more power as compared to the Middletown to Norwalk Project. This is reflected in the fact that for various contingencies Haddam to Bokum, Shaws Hill to Bunker Hill, and Trumbull Junction to Pequonnock 115-kV lines are all overloaded in the East Shore Alternative only.

In the case of the Middletown to Norwalk Project, loss of one of the 345-kV cables between Singer and Norwalk substations causes the remaining cable to overload. The Middletown to Norwalk Project also includes series reactors that will be utilized to mitigate the overload. In the case of the East Shore Alternative, this overload does not occur.

The results of the Middletown to Norwalk Project also show minor overloads around Grand Ave. An existing Special Protection System (SPS) which reduces the output of generation at New Haven Harbor eliminates these overloads.

A few other items which need to be discussed are the Middle River – Triangle area, the area west of Glenbrook, and the lines between Norwalk, Glenbrook and Norwalk Harbor. The Middle River –Triangle area is a radial load pocket which is served from the Plumtree Substation. While the results indicate that there may be performance differences between the two alternatives, this is due to the different solution methods used. The results in this area should not be used as a means of comparison between these projects and will not be discussed further in this report.

The area west of Glenbrook is virtually a radial load pocket and there is no reason to compare the results of these two alternatives as neither project serves to address these issues. Therefore, this area will not be discussed any further.

The lines between Norwalk, Glenbrook, and Norwalk Harbor substations are over their normal rating pre-contingency and heavily overloaded following many contingencies. These lines provide the transmission path between the sources at Norwalk Harbor and Norwalk to the load being served via the Glenbrook Substation. These overloads can be remedied through the installation of cables between Norwalk and Glenbrook and between Norwalk Harbor and Glenbrook. Since neither the Middletown to Norwalk Project nor the East Shore Alternative includes these cables, further comparison of the overloads in this area is not warranted.

4.2 New Haven Harbor generation out of service, existing 387 line (East Shore to Scovill Rock)

As stated above, the results indicate that acceptability of the East Shore Alternative was highly dependent upon the availability of generation at New Haven Harbor. The Middletown to Norwalk Project had not been previously tested with this generator out of service as the status of this generation was expected to have little impact on the Project. To ensure that both projects were being evaluated against the same criteria, both projects were tested with the New Haven Harbor generator out of service in this comparison.

Table 4 below shows a comparison of the worst case overloads as a result of this testing. Appendices B1 and B2 document the results of testing with a New England load of 27,700 MW, New Haven Harbor out of service, and NE-NY=0 MW.

Table 4
Worst Case Overloads
New Haven Harbor Out of Service - NY to NE Flow = 0 MW

Dispatch	Contingency	Overloaded Element			Middletown-Norwalk (E/PRO)	East Shore Alternative (PowerGEM)
		From Bus	To Bus	Voltage (kV)	% of Rating	% of Rating
		BASE CASE OVERLOADS				
2	NONE	SCOVL RK	E.SHORE	345		**117.3**
2	NONE	FLAX HILL	RYTN J B	115	**103.9**	**102.8**
2	NONE	NORWALK	FLAX HILL	115	**124.4**	**123.2**
2	NONE	RYTN J A	NORWALK	115	**116.1**	**114.9**
		CONTINGENCY OVERLOADS				
2	SGTN4TSTK	SCOVL RK	E.SHORE	345		**124.5**
5	1460-387DCT	FRSTBDGE	SOUTHGTN	345		**106.0**
5	1460-387DCT	SOUTHGTN	MERID362	345		**105.5**
5	SGTN5TSTK	SOUTHGTN	SGTN B	Auto	**104.3**	**126.8**
2	1618-321DCT	BALDWNJA	FROST BR	115		**107.1**
5	1272-1721DCT	BCNFL PF	DRBY J B	115	**131.9**	**133.5**
2	1460-387DCT	GLEN JCT	SOUTHGTN	115		**120.1**
5	1620SLINE	HADDAM	BOKUM	115	**109.8**	**123.4**
2	1261LINE	HADDAM	BOKUM -2	115		**107.3**
5	FROSTBR27T	SHAWSHIL	BUNKER H	115		**111.9**
2	SCOVRK8TSTK	SOUTHGTN	WLNGF PF	115		**102.1**
3	387+AUTOS	WLNGF PF	WALLFRDJ	115	**119.6**	
5	SGTN7TSTK	E.MERIDN	NO.WALLF	115	**108.0**	
3	NORSING1	SINGNOR2	NORSING2	345	**108.6**	
2	TRIANGLE2T	MIDDLRIV	TRIANGLE	115	**NC**	**226.4**
2	TRIANGLE2T	PLUMTREE	MIDDLRIV	115	**NC**	**287.9**
2	TRIANGLE3T	PLUMTREE	TRIANGLE	115	**NC**	**188.7**
2	1060-1270DCT	PLUMTREE	TRIANGLE -2	115	**135.2**	**135.3**
2	1440-1450DCT	SO.END	GLNBRK J	115	**123.2**	**123.2**
2	SOUTHEND6T	WATERSDE	COS COB	115	**124.8**	**124.8**
2	SOUTHEND6T	WATERSDE	GLNBROOK	115	**102.5**	**102.5**
3	1389-1880DCT	CRRA JCT	ASHCREEK	115		**100.3**
2	1416-1880DCT	FLAX HIL	RYTN J B	115	**181.9**	**180.9**
5	1867-1880DCT	GLNBROOK	ELYAVE	115	**154.5**	**154.3**
5	1867-1890DCT	GLNBROOK	RYTN J A	115	**102.9**	**102.9**
5	1880-1890DCT	GLNBROOK	RYTN J B	115	**148.8**	**148.2**
2	1416-1880DCT	NORWALK	FLAX HIL	115	**199.3**	**198.2**
5	1867-1880DCT	NWLK HAR	ELYAVE	115	**160.3**	**159.7**
4	1880-1890DCT	NWLK HAR	RYTN J B	115	**104.4**	**104.3**
2	1416-1867DCT	RYTN J A	NORWALK	115	**184.8**	**183.8**
4	1867-1890DCT	RYTN J A	NWLK HAR	115	**143.5**	**144.2**

Results with New Haven Harbor generation out of service show the inherent weakness of the East Shore Alternative. First and foremost, the 387 line between Scovill Rock and East Shore is 17% over its normal rating prior to a contingency and up to 24.5% over its emergency rating following system contingencies. To resolve these overloads, either a second 345-kV line into SWCT would have to be built or the 387 line must be upgraded.

Even if the 387 line were to be upgraded, the loss of this line causes the 345-kV Southington to Frost Bridge 329 line and the 345-kV Meriden to Southington 362 line to become overloaded. This is because these lines provide the only remaining 345-kV path from the generation in eastern Connecticut to supply the load in SWCT. In the case of the Middletown to Norwalk Project, following the loss of the 387 line, the proposed 345-kV Beseck to East Devon line remains in service in addition to the path through Southington. The Middletown to Norwalk Project creates an additional line into SWCT and therefore does not have similar overloads.

In addition, the 115-kV transmission overloads associated with East Shore Alternative are significant. The 115-kV corridors containing multiple circuits from Frost Bridge and Southington toward the Devon Substation have overloads.

In the Middletown to Norwalk Project, there are only two 115-kV circuits overloaded which are not overloaded in the East Shore Alternative. These are the circuits between Wallingford and Wallingford Jct. and between East Meriden and North Wallingford.

4.3 New Haven Harbor generation out of service, 387 line (East Shore to Scovill Rock) reconductored

The results in Table 4 show that the 387 line is overloaded. As part of the evaluation of the East Shore Alternative, it was noted that approximately 10 miles of this circuit consists of 2156 ACSR conductor. This segment has significantly less capability than the remainder of the circuit which was constructed using bundled 2-954 ACSR. Therefore, the East Shore analysis was performed again for the same set of conditions used in Section 4.2, assuming the limiting 10 miles of conductor was replaced with bundled 2-954 ASCR. The results are listed in Appendices B1 and B2. Table 5 shows the worst case overloads with a New England load of 27,700 MW, New Haven Harbor out of service, and NE-NY=0 MW, and the limiting portion of the 387 line reconductored.

Table 5
Worst Case Overloads
New Haven Harbor Out of Service - NY to NE Flow = 0 MW - 387 Line Reconductored

Dispatch	Contingency	Overloaded Element			Middletown-Norwalk (E/PRO)	East Shore Alternative w/Recond. 387 Line (PowerGEM)
		From Bus	To Bus	Voltage (kV)	% of Rating	% of Rating
		BASE CASE OVERLOADS				
2	NONE	SCOVL RK	E.SHORE	345		**101.1**
2	NONE	FLAX HILL	RYTN J B	115	**103.9**	**103.5**
2	NONE	NORWALK	FLAX HILL	115	**124.4**	**123.9**
2	NONE	RYTN J A	NORWALK	115	**116.1**	**115.7**
		CONTINGENCY OVERLOADS				
2	SGTN4TSTK	SCOVL RK	E.SHORE	345		**106.9**
5	1460-387DCT	FRSTBDGE	SOUTHGTN	345		**106.1**
5	1460-387DCT	SOUTHGTN	MERID362	345		**105.5**
5	SGTN5TSTK	SOUTHGTN	SGTN B	Auto	**104.3**	**124.8**
2	1618-321DCT	BALDWNJA	FROST BR	115		**103.8**
2	SCOVRK8TSTK	BALDWNJB	BUNKER H	115		**101.4**
5	1272-1721DCT	BCNFL PF	DRBY J B	115	**131.9**	**133.4**
2	1460-387DCT	GLEN JCT	SOUTHGTN	115		**120.1**
5	1620SLINE	HADDAM	BOKUM	115	**109.8**	**121.4**
2	1261LINE	HADDAM	BOKUM -2	115		**105.6**
5	FROSTBR27T	SHAWSHIL	BUNKER H	115		**110.3**
2	SCOVRK8TSTK	SOUTHGTN	WLNGF PF	115		**104.5**
3	387+AUTOS	WLNGF PF	WALLFRDJ	115	**119.6**	
5	SGTN7TSTK	E.MERIDN	NO.WALLF	115	**108.0**	
3	NORSING1	SINGNOR2	NORSING2	345	**108.6**	
2	TRIANGLE2T	MIDDLRIV	TRIANGLE	115	**NC**	**226.3**
2	TRIANGLE2T	PLUMTREE	MIDDLRIV	115	**NC**	**287.7**
2	TRIANGLE3T	PLUMTREE	TRIANGLE	115	**NC**	**188.4**
2	1060-1270DCT	PLUMTREE	TRIANGLE -2	115	**135.2**	**135.2**
2	1440-1450DCT	SO.END	GLNBRK J	115	**123.2**	**123.2**
2	SOUTHEND6T	WATERSDE	COS COB	115	**124.8**	**124.8**
2	SOUTHEND6T	WATERSDE	GLNBROOK	115	**102.5**	**102.5**
3	1389-1880DCT	CRRA JCT	ASHCREEK	115		**100.6**
2	1416-1880DCT	FLAX HIL	RYTN J B	115	**181.9**	**182.1**
5	1867-1880DCT	GLNBROOK	ELYAVE	115	**154.5**	**154.3**
5	1867-1890DCT	GLNBROOK	RYTN J A	115	**102.9**	**102.8**
5	1880-1890DCT	GLNBROOK	RYTN J B	115	**148.8**	**148.2**
2	1416-1880DCT	NORWALK	FLAX HIL	115	**199.3**	**199.4**
5	1867-1880DCT	NWLK HAR	ELYAVE	115	**160.3**	**159.6**
4	1880-1890DCT	NWLK HAR	RYTN J B	115	**104.4**	**104.3**
2	1416-1867DCT	RYTN J A	NORWALK	115	**184.8**	**185.0**
4	1867-1890DCT	RYTN J A	NWLK HAR	115	**143.5**	**143.4**

Even with reconductoring the limiting portion of the 387 line, the resulting line rating is below that which is necessary to serve the load under these conditions. The line is over its normal rating with all transmission facilities in service and over its LTE rating following system contingencies.

In addition, there was little or no beneficial impact on the other overloads in the system, most of which occur when the 387 line is removed from service. Therefore, reconductoring the 387 line will not eliminate these remaining overloads, which are simply due to the fact that this alternative does not build a new source into SWCT.

4.4 New Haven Harbor generation out of service, 387 line (East Shore to Scovill Rock) reconductored, 700 MW Flow from New England to New York

Although the limitations of the East Shore Alternative have already been discussed, further analysis was performed varying flows between New England (NE) and New York (NY). Table 6 shows a comparison of the worst case overloads with a New England load of 27,700 MW, New Haven Harbor generation out of service, and NE-NY=700 MW. The full results of this testing are located in Appendices D1 and D2. Appendices C1 and C2 document similar conditions with generation at New Haven Harbor in service. These conditions were not discussed as they were not found to be the most limiting.

Table 6
Worst Case Overloads
New Haven Harbor Out of Service - NE to NY Flow = 700 MW - 387 Line Reconductored

Dispatch	Contingency	Overloaded Element			Middletown-Norwalk (E/PRO)	East Shore Alternative w/Recond. 387 Line (PowerGEM)
		From Bus	To Bus	Voltage (kV)	% of Rating	% of Rating
BASE CASE OVERLOADS						
2	NONE	SCOVL RK	E.SHORE	345		**107.3**
2	NONE	FLAX HILL	RYTN J B	115	**102.7**	**101.9**
2	NONE	NORWALK	FLAX HILL	115	**123.1**	**122.3**
2	NONE	RYTN J A	NORWALK	115	**114.9**	**114.0**
CONTINGENCY OVERLOADS						
5	SGTN4TSTK	SCOVL RK	E.SHORE	345		**115.0**
5	1460-387DCT	FRSTBDGE	SOUTHGTN	345		**120.4**
5	318LINE	HADAUTO	MILLSTNE	345		**103.4**
2	MONTVSTBKR	SCOVL RK	KLEEN	345		**100.3**
2	1460-387DCT	SOUTHGTN	MERID362	345		**114.5**
5	SGTN5TSTK	SOUTHGTN	SGTN B	Auto	**111.3**	**133.5**
2	1460-387DCT	BALDWNJA	FROST BR	115		**114.3**
2	1460-387DCT	BALDWNJA	STEVENSN	115		**104.3**
2	1460-387DCT	BALDWNJB	BUNKER H	115		**105.5**
5	1272-1721DCT	BCNFL PF	DRBY J B	115	**131.9**	**133.2**
2	1460-387DCT	GLEN JCT	MIX AVE	115		**102.1**
2	1460-387DCT	GLEN JCT	SOUTHGTN	115		**131.1**
5	SCOVRK8TSTK	BOKUM	GREEN HL	115		**102.3**
5	1620SLINE	HADDAM	BOKUM	115	**111.6**	**125.2**
5	1261LINE	HADDAM	BOKUM -2	115		**108.8**
5	FROSTBR27T	SHAWSHIL	BUNKER H	115		**111.5**
2	387LINE	SOUTHGTN	WLNGF PF	115		**110.4**
3	387+AUTOS	WLNGF PF	WALLFRDJ	115	**120.8**	
5	SGTN7TSTK	E.MERIDN	NO.WALLF	115	**108.2**	
2	DEVSING1	DEVSING2	SINGDEV2	345	**110.9**	
3	NORSING1	SINGNOR2	NORSING2	345	**119.8**	
2	TRIANGLE2T	MIDDLRIV	TRIANGLE	115	**NC**	**226.2**
2	TRIANGLE2T	PLUMTREE	MIDDLRIV	115	**NC**	**287.6**
2	TRIANGLE3T	PLUMTREE	TRIANGLE	115	**NC**	**188.0**
2	1060-1270DCT	PLUMTREE	TRIANGLE -2	115	**135.1**	**135.2**
2	1440-1450DCT	SO.END	GLNBRK J	115	**123.2**	**123.2**
2	SOUTHEND6T	WATERSDE	COS COB	115	**124.8**	**124.8**
2	SOUTHEND6T	WATERSDE	GLNBROOK	115	**102.5**	**102.5**
3	1389-1880DCT	CRRA JCT	ASHCREEK	115		**100.3**
2	1416-1880DCT	FLAX HIL	RYTN J B	115	**180.5**	**179.9**
5	1867-1880DCT	GLNBROOK	ELYAVE	115	**153.8**	**154.0**
5	1867-1890DCT	GLNBROOK	RYTN J A	115	**102.1**	**102.4**
5	1880-1890DCT	GLNBROOK	RYTN J B	115	**147.8**	**147.5**
2	1416-1880DCT	NORWALK	FLAX HIL	115	**197.9**	**197.2**
5	1867-1880DCT	NWLK HAR	ELYAVE	115	**158.3**	**158.8**
5	1880-1890DCT	NWLK HAR	RYTN J B	115	**104.3**	**104.4**
2	1416-1867DCT	RYTN J A	NORWALK	115	**183.4**	**182.8**
5	1867-1890DCT	RYTN J A	NWLK HAR	115	**141.9**	**143.8**

With a 700 MW flow from NE to NY, the East Shore Alternative yields numerous 115-kV and 345-kV overloads. The most significant changes in overloads occur on the 345-kV system. The following 345-kV lines are overloaded in the East Shore Alternative which are not overloaded with the Middletown to Norwalk Project:

- 329 line between Frost Bridge and Southington
- 348 line between the Haddam autotransformer and Millstone
- 353 line between Scovill Rock and Kleen Energy
- 387 line between East Shore and Scovill Rock (over its normal and emergency rating)
- 362 line between Meriden and Southington

While some minor upgrades may eliminate a few of the overloads associated with the East Shore Alternative, these results demonstrate that this alternative does not provide acceptable system performance without significant system upgrades to serve as part of a long range plan for Connecticut.

4.5 New Haven Harbor generation out of service, 387 line (East Shore to Scovill Rock) reconductored, 700 MW Flow from New York to New England

Continuing with varying NE to NY flows, flows were changed to NY-NE=700. All other conditions are as listed in Section 4.4. Worst case overloads are compared in Table 7. Again, results with New Haven Harbor in service are not discussed for these conditions as they were not the most limiting; although they are documented in Appendices E1 and E2.

Table 7
Worst Case Overloads
New Haven Harbor Out of Service - NY to NE Flow = 700 MW - 387 Line Reconductored

Dispatch	Contingency	Overloaded Element			Middletown-Norwalk (E/PRO)	East Shore Alternative w/Recond. 387 Line (PowerGEM)
		From Bus	To Bus	Voltage (kV)	% of Rating	% of Rating
		BASE CASE OVERLOADS				
2	NONE	FLAX HILL	RYTN J B	115	**105.6**	**104.8**
2	NONE	NORWALK	FLAX HILL	115	**126.0**	**125.2**
2	NONE	RYTN J A	NORWALK	115	**117.7**	**116.9**
		CONTINGENCY OVERLOADS				
5	SGTN5TSTK	SOUTHGTN	SGTN B	Auto		**114.6**
2	1618-321DCT	BALDWNJA	FROST BR	115	**110.9**	**107.6**
2	1618-321DCT	BALDWNJA	STEVENSN	115	**102.2**	
5	1272-1721DCT	BCNFL PF	DRBY J B	115	**131.9**	**133.4**
2	1460-387DCT	GLEN JCT	SOUTHGTN	115		**111.0**
5	1620SLINE	HADDAM	BOKUM	115	**107.5**	**117.2**
2	1261LINE	HADDAM	BOKUM -2	115		**101.8**
5	FROSTBR27T	SHAWSHIL	BUNKER H	115		**108.8**
5	LONGMT5TSTK	NORHR138	NWLK HAR	Auto	**109.3**	**122.5**
5	LONGMT5TSTK	NRTHPT P	NRTHPRT1	138		**111.4**
3	387+AUTOS	WLNGF PF	WALLFRDJ	115	**118.0**	
5	SGTN7TSTK	E.MERIDN	NO.WALLF	115	**108.2**	
2	TRIANGLE2T	MIDDLRIV	TRIANGLE	115	**NC**	**226.4**
2	TRIANGLE2T	PLUMTREE	MIDDLRIV	115	**NC**	**287.8**
2	TRIANGLE3T	PLUMTREE	TRIANGLE	115	**NC**	**188.7**
2	1060-1270DCT	PLUMTREE	TRIANGLE -2	115	**135.4**	**135.3**
2	1440-1450DCT	SO.END	GLNBRK J	115	**123.2**	**123.2**
2	SOUTHEND6T	WATERSDE	COS COB	115	**124.8**	**124.8**
2	SOUTHEND6T	WATERSDE	GLNBROOK	115	**102.5**	**102.5**
3	1389-1880DCT	CRRA JCT	ASHCREEK	115		**100.5**
2	1416-1880DCT	FLAX HIL	RYTN J B	115	**183.8**	**183.7**
5	1867-1880DCT	GLNBROOK	ELYAVE	115	**155.1**	**154.7**
5	1867-1890DCT	GLNBROOK	RYTN J A	115	**103.8**	**103.4**
5	1880-1890DCT	GLNBROOK	RYTN J B	115	**150.0**	**149.0**
2	1416-1880DCT	NORWALK	FLAX HIL	115	**201.1**	**201.0**
5	1867-1880DCT	NWLK HAR	ELYAVE	115	**161.9**	**160.7**
5	1880-1890DCT	NWLK HAR	RYTN J B	115	**104.3**	**104.4**
2	1416-1867DCT	RYTN J A	NORWALK	115	**186.7**	**186.5**
5	1867-1890DCT	RYTN J A	NWLK HAR	115	**143.4**	**143.9**

These conditions show that the East Shore Alternative results in more 115-kV overloads than the Middletown to Norwalk Project.

In both system alternatives, overloads are shown on equipment associated with the 138-kV Norwalk Harbor to Northport 1385 underwater cable to Long Island. However, these overloads appear following a failure of the 5T circuit breaker at Long Mountain to operate. One of the projects associated with implementation of the Bethel to Norwalk 345-kV Project is the reconfiguration of the Long Mountain Substation to prevent this contingency from occurring. Therefore this contingency and the associated overloads can be disregarded.

4.6 Voltage Analysis

Voltage comparisons were performed between each of the options studied. These are documented in Appendices A2, B2, C2, D2, E2, and F2. In most cases, performance was similar between the two alternatives. In many cases with the East Shore Alternative a stuck 8T circuit breaker at Scovill Rock resulted in system-wide low voltages. The results of this contingency should be ignored as relatively minor configuration changes at Scovill Rock substation could eliminate this contingency.

5.0 Conclusion

This study documents the results of testing performed by the ISO-NE SWCT Working Group to compare the proposed Middletown to Norwalk Project with an alternative referred to as the East Shore Alternative. The East Shore Alternative as studied was found to be an unacceptable substitute to the Middletown to Norwalk Project because it does not meet NERC, NPCC, or NEPOOL criteria. The East Shore Alternative does not strengthen the power supply into SWCT by introducing a new source; it simply connects the load in SWCT to an already heavily loaded 387 line. The most notable overload in this report is the one on the 387 line. Even with the assumed reconductoring of the limiting portion of the 387 line, the line continues to overload. In addition, an outage of this line yields substantial overloads on the remaining corridors serving SWCT and the 345-kV across the state.

Since the East Shore Alternative is not considered acceptable, continued comparative testing was not performed. In order to completely evaluate the East Shore Alternative, further analysis would have to include thermal and voltage testing at a 30,000 MW New England load level, a transfer limit comparison, and possibly 2nd contingency (N-2) testing.

PowerGEM

Power Grid Engineering & Markets

Southwest Connecticut Transmission Expansion

East Shore to Norwalk 345 KV OH/UG Alternative :

Transmission Loading and Voltage Analysis @ 27.7 GW Load, NE-NY ± 700 MW

Prepared for:

The United Illuminating Company

and

Northeast Utilities

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Executive Summary

This report summarizes power flow analysis conducted for The United Illuminating Company (UI) and Northeast Utilities (NU) for one option for expanding the New England 345 kV transmission system into southwest Connecticut (SWCT). The transmission option examined, called "East Shore 27-OH/UG" in this report, is for a 345 kV transmission path from East Shore to Norwalk substations, with interconnecting substations between these stations.[1] The "East Shore 27-OH/UG" transmission option, which consists primarily of underground cables with one section of overhead line, is described as follows:

From	To	Distance	Transmission
East Shore	Orange (cable to overhead line transition station)	7 miles	345 kV underground, 2500 kcmil HPFF, three parallel cables
Orange (cable to overhead line transition station)	East Devon	9.4 miles	345 kV overhead bundled 1590 ACSR conductor, single circuit
East Devon	Singer	8 miles	345 kV underground, 2500 kcmil HPFF, two parallel cables
Singer	Norwalk	15 miles	345 kV underground, 2500 kcmil HPFF, two parallel cables

The focus of this report is to examine the effect of ±700 MW transfers between New England (NE) and New York (NY), as well as the status of generation at the 447 MW New Haven Harbor Station (NHHS) for a 27.7 GW New England load level. When NHHS is off-line, the generation deficiency is made up by the Kleen Energy generation project, which is expected to be connected to the Scovill Rock to Manchester 345 kV line very near the Scovill Rock Substation.

Companion reports (References 1 thru 4) summarize similar analyses with zero power transfer from New England to New York. Reference 5 is a study similar to this study except that the existing 387 line has been reconductored.

In addition to the variations in NE-NY transfer and the status of NHHS generation, power flow analysis was conducted with four southwest Connecticut generation dispatches. Loading and voltage performance of the Connecticut system was monitored for the 115 kV and 345 kV transmission systems. In total, this results in sixteen dispatch conditions studied.

[1] A planned 345 kV transmission expansion from the Plumtree to Norwalk substations, which is called Bethel to Norwalk, is assumed to be in-service in this analysis.

The East Shore to Scovill Rock 345 kV line is also above normal rating in six of sixteen base cases, in the range of 5% to 25%. Several 115 kV lines were also above normal rating in at least one base case dispatch.

The table below summarizes the number of overloaded lines in the study area for the various conditions analyzed:

	Number of Overloaded Branches					
	NE-NY 0 MW (Note 1)		NE-NY 700 MW		NY-NE 700 MW	
	NHHS On	NHHS Off	NHHS On	NHHS Off	NHHS On	NHHS Off
SWCT Dispatch ID	**2B-5B**	**6B-9B**	**10B-13B**	**14B-17B**	**18B-21B**	**22B-25B**
345 kV Line	1	3	3	4	0	1
115 kV Line	23	24	24	28	23	24
345/115 AutoTrans	1	1	1	1	1	1
138 kV CT-LI Tie (2)	0	0	0	0	2	2

(1) Based on the results of studies in References 3 and 4.
(2) Overloads are of transformers at each end of the cable (line 1385).

A review of the table indicates that NNHS off and NE-NY 700 MW results in the most overloads.

The table below summarized the number of bus voltage violations in the study area for the various conditions analyzed:

	Number of Bus Voltage Violations					
	NE-NY 0 MW (Note1)		NE-NY 700 MW		NY-NE 700 MW	
	NHHS On	NHHS Off	NHHS On	NHHS Off	NHHS On	NHHS Off
SWCT Dispatch ID	**2B-5B**	**6B-9B**	**10B-13B**	**14B-17B**	**18B-21B**	**22B-25B**
345 kV Violations						
115 kV Violations	9	10	9	7	9	10

(1) Based on the results of studies in References 1 and 2.

There are three contingencies that trip the East Shore to Scovill Rock 345 kV line (387 line), with the most severe being a stuck breaker contingency that trips the Scovill Rock to Haddam Neck and Scovill Rock to East Shore 345 kV lines including the Cross-Sound Cable (SCOVRK8TSTK). Though not converged to normal mismatch criteria, results indicate that for some dispatch and transfer conditions loss of the 387 line results in widespread 345 kV and 115 kV low voltage violations in the study area.

1. Introduction

This report summarizes power flow analysis conducted for The United Illuminating Company (UI) and Northeast Utilities (NU) for one option for expanding the New England 345 kV transmission system into southwest Connecticut (SWCT). The transmission option examined, called "East Shore 27-OH/UG" in this report, is for a 345 kV transmission path from East Shore to Norwalk substations, with interconnecting substations between these stations.[2] The "East Shore 27-OH/UG" transmission option, which consists primarily of underground cables with one section of overhead line, is described as follows:

From	To	Distance	Transmission
East Shore	Orange (cable to overhead line transition station)	7 miles	345 kV underground, 2500 kcmil HPFF, three parallel cables
Orange (cable to overhead line transition station)	East Devon	9.4 miles	345 kV overhead bundled 1590 ACSR conductor, single circuit
East Devon	Singer	8 miles	345 kV underground, 2500 kcmil HPFF, two parallel cables
Singer	Norwalk	15 miles	345 kV underground, 2500 kcmil HPFF, two parallel cables

The focus of this report is to examine the effect of ±700 MW transfers from New England to New York, as well as the status of generation at the 447 MW New Haven Harbor Station (NHHS) for a 27.7 GW New England load level. When NHHS is off-line, the generation deficiency is made up by the Kleen Energy generation project, which is expected to be connected to the Scovill Rock to Manchester 345 kV line very near the Scovill Rock Substation.

Companion reports (References 1 thru 4) summarize similar analyses with zero power transfer from New England to New York. Reference 5 is a study similar to this one except that the limiting portion of the existing 387 line has been reconductored.

The objective of this study is to analyze and document the performance of this transmission configuration for steady-state base case and post-contingency transmission power flows and voltages. Performance is examined for a 27.7 GW New England load level.

The following Appendices are included in this report:

Appendix A **"East Shore 27-OH/UG" Transmission Modeling Data**
Appendix B **Power Flow Base Case One-Line Diagrams**

[2] A planned 345 kV transmission expansion from Plumtree to Norwalk substations, which is called Bethel to Norwalk , is assumed to be in-service in this analysis.

2. Database

This section discusses the data developed and used in the study.

2.1. Power Flow Base Cases

Four power flow base cases, which included the approved Bethel to Norwalk 345-kV project in service, were utilized. PowerGEM revised each of the four cases to add the "East Shore 27-OH/UG" transmission project. Details regarding the modeling of these circuits are provided in Appendix A. In addition to this, the rating of the East Shore to Scovill Rock 345 kV line was increased to reflect the line rating by reconfiguring the East Shore Substation and removing the 345/115 kV autotransformers from the 387 line path. The line ratings used were 1240 MVA normal and 1604 MVA long-time emergency.

Each of the four base cases provided had different Connecticut generation dispatches (designated dispatches 2, 3, 4, and 5). For each of these cases other base case variations were prepared: a) 447 MW New Haven Harbor Station generator on-line or off-line and b) NE-NY ±700 MW transfers.

For all of these cases, when the 447 MW New Haven Harbor Station (NHHS) was turned off it was replaced by generation from the Kleen Energy project. Both generators are outside the SWCT interface. Appendix D contains a list of the on-line generation. Significant changes to the four SWCT dispatch cases (2, 3, 4, and 5) were restricted to New England generation.

Thus a total of sixteen base cases were developed for the analysis in this report. To help organize the work and clearly identify the results, case or "dispatch" identifiers were assigned as summarized in the table below.

	Case or "Dispatch" Identifier			
	NE-NY 700 MW		NY-NE 700 MW	
SWCT Generation Dispatch ID	NHHS On-line	NHHS Off-Line	NHHS On-line	NHHS Off-Line
2	10B	14B	18B	22B
3	11B	15B	19B	23B
4	12B	16B	20B	24B
5	13B	17B	21B	25B

The "B" in the identifier signifies that the modeling of the 387 line assumes the existing conductor of the line is used.

A one-line diagram showing power flows and voltages on the "East Shore 27-OH/UG" (and Bethel to Norwalk) transmission for each of the sixteen base cases is included in Appendix B. Also, the generation dispatch changes to create the New York to New England and New England to New York power transfers is included in Appendix B.

2.2. Contingency File

A contingency file was modified as appropriate for this study, including those contingencies required to model the Kleen Energy project on the Scovill Rock to Manchester 345 kV line, and is contained in Appendix C.

- Loss of multiple 345 kV underground cables on the "East Shore 27-OH/UG" configuration between Orange and East Shore, or loss of parallel cables between Devon and Norwalk, is not considered. (Simultaneous loss of one cable from Devon to Singer and Singer to Norwalk is included as a contingency).

- For loss of the Orange to East Devon 345 kV overhead line, all three 345 kV underground cables from Orange to East Shore were opened.

3. Methodology and Results Files

This section describes the technical approach to the study, performance criteria, solution assumptions, and the format of the results.

3.1. Software

Set up of the power flow base cases used PTI's PSS/E software (Rev. 28). Base case and contingency analysis was conducted using PTI's MUST software (Rev. 5). Results from the MUST program are stored in Excel spreadsheets.

3.2. Performance Criteria

The criteria for checking overload and voltage performance were as follows:

- Buses and transmission branches in Connecticut 115 kV and above were monitored.
- 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-time 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 more than 105%.

3.3. Solution Options

For the analysis, tap-changing transformer 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.

4. Transmission Loading Results

The results of the analysis for transmission system loading violations, for both the base case and contingency conditions, are provided below.

4.1. Base Case Results

Loading on the 387 line for base case conditions is an important consideration for this transmission alternative, and is summarized in the following table. One-lines showing the flows on this line for each case are in Appendix B.

	Base Case Loading of 387 Line (% of normal rating)			
	NE-NY 700 MW		NY-NE 700 MW	
SWCT Generation Dispatch ID	NHHS On-line	NHHS Off-Line	NHHS On-line	NHHS Off-Line
2	**105%**	**125%**	89%	**109%**
3	76%	95%	60%	79%
4	60%	79%	44%	63%
5	**103%**	**123%**	87%	**106%**

As indicated in the table, the 387 line is overloaded in the base case for six of the sixteen base case conditions studied.

Base case overloads for all circuits in the study system are summarized in the table below.

	NE-NY 700 MW						**NY-NE 700 MW**				
	NHHS On			**NHHS Off**			**NHHS On**		**NHHS Off**		
From bus To bus CKT	**10B**	**11B**	**13B**	**14B**	**15B**	**17B**	**18B**	**19B**	**22B**	**23B**	**25B**
73107 SCOVL RK 345 73663 E.SHORE 345 1	105.4		103.1	124.8		122.5			108.5		106.2
73169 RYTN J A 115 73172 NORWALK 115 1	111.9	107.2		114.6	109.2		113.4	108.8	116.3	111.2	
73172 NORWALK 115 73207 FLAX HIL 115 1	120.2	115.7		122.8	117.6		121.7	117.2	124.5	119.6	
73207 FLAX HIL 115 73271 RYTN J B 115 1				102.5			101.1		104.1		

As the table indicates, in addition to the 387 line there are three 115 kV transmission lines that experience base case overloads.

4.2. Post-Contingency Results

4.2.1. Table of Results

A summary of the overload results is shown in Table 1. The values shown are the percentage overload over the long-time emergency rating. If a table entry is blank, there is no overload. More detailed results are provided in Appendix E.

Any transmission line or transformer in the study area at 115 kV or above that experiences a post-contingency overload in this study is listed in the first column of Table 1.

The second column is the maximum overload over all of the cases examined.

The remaining columns, one for each of the generation dispatches studied, show the **maximum overload of the branch in %** (considering all contingencies) for each dispatch. If the entry is shaded, this is the dispatch for which the maximum overload occurs. If multiple entries are shaded, then each of them is at or very near the maximum overload. If a Table 1 entry is blank, then the branch is not overloaded for that dispatch. To find more detail, for example which contingency causes the overload, and whether other contingencies overload the branch, the reader should refer to Appendix E.

4.2.2. Discussion of Results

There are four existing 345 kV lines that experience post-contingency overloads (the East Shore to Scovill Rock 345 kV line also experiences base case overloads, as discussed above) as well as one new circuit in the transmission alternative under study. These are summarized in the table below:

Maximum Post-Contingency Overloads 345 kV Transmission		
Line Name	**Contingency Rating**	**Max Overload**
Frost Bridge to Southington (existing O/H Line)	1446 MVA	20.5%
Southington to Meriden (existing O/H Line)	1912 MVA	15.1%
Scovill Rock to East Shore (existing O/H Line)	1604 MVA	34.3%
Haddam Auto to Millstone (existing O/H Line)	1524 MVA	5.5%
Norwalk to Singer (underground cable in transmission alternative in this study)	794 MVA	1.8%

One 345/115kV transformer at Southington experiences post-contingency overloads in almost all of the dispatches studied, with the maximum overload being 35.8 percent.

Thirty-one 115 kV transmission lines indicate post-contingency overloads for at least one generation dispatch.

Finally, for dispatches 21B and 25B the transformers associated with the Connecticut to Long Island AC cables (1385 line) are overloaded by up to 24%, which occurs when New York is exporting power to New England.

A general review of Table 1 indicates, for the most part, more overloads and overloads of higher severity for some circuits, when New England is exporting 700 MW to New York as opposed to the reverse transfer of 700 MW from New York to New England.

345 kV Line
345/115 kV Autotransformer
CT-LI cable (line 1385) transformer

Table 1

Highest Overload: 27.7 GW NE Load, Dispatches 10B - 25B, Existing 387 Line

		NE-NY 700 MW								NY-NE 700 MW							
		NHHS On				NHHS Off				NHHS On				NHHS Off			
115 kV Line	Max Ovld.	10B	11B	12B	13B	14B	15B	16B	17B	18B	19B	20B	21B	22B	23B	24B	25B
73104 FRSTBDGE 345 73106 SOUTHGTN 345 1	20.5	2.5			4.2	19.7			20.5								
73106 SOUTHGTN 345 73122 MERID362 345 1	15.1					15.1			14.4								
73106 SOUTHGTN 345 73154 SGTN B 115 2	35.8	27.8	19.1	14.9	29.9	33.6	24.1	20	35.8	9.3	0.6		11	14.7	5.7	1.6	16.5
73107 SCOVL RK 345 73663 E.SHORE 345 1	34.3	15.4			14.7	34.3	6		34.3					13.1			12.4
73121 HADAUTO 345 73110 MILLSTNE 345 1	5.5					3.5			5.5								
73162 WATERSDE 115 73163 COS COB 115 1	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8
73162 WATERSDE 115 73168 GLNBROOK 115 1	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
73164 BALDWNJA 115 73187 STEVENSN 115 1	4.5					4.5								2.2			
73164 BALDWNJA 115 73202 FROST BR 115 1	14.5					14.5			9.5					10.9			
73166 NORHR138 138 73171 NWLK HAR 115 1	24.1												17.8				24.1
73167 SO.END 115 73294 GLNBRK J 115 1	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2
73168 GLNBROOK 115 73169 RYTN J A 115 1	3.4				1.1				2.2				2.3				3.4
73168 GLNBROOK 115 73237 ELYAVE 115 1	54.7			50.6	53.2			51.1	53.7			51.6	54.2			51.9	54.7
73168 GLNBROOK 115 73271 RYTN J B 115 1	49.1	18.5	15.1	37.3	45.8	20.4	16.7	38.7	47.5	20.1	16.6	39	47.4	21.9	18.2	40.4	49.1
73169 RYTN J A 115 73171 NWLK HAR 115 1	45.2			44	42.8			44.1	42.7			45.2	43.8			44.5	43.9
73169 RYTN J A 115 73172 NORWALK 115 1	85.5	80.7	75.5			83.6	77.5			82.3	77.1			85.5	79.8		
73170 PLUMTREE 115 73176 TRIANGLE 115 1	89.2	77	75	73.4	75.8	88.5	86.3	74.6	87.7	78.2	75.1	71.8	75.4	89.2	76.8	72.8	85.4
73170 PLUMTREE 115 73176 TRIANGLE 115 2	35.4	35.1	35	34.8	35	35.3	35.3	35	35.2	35.3	34.9	34.5	34.8	35.4	35.2	34.7	35
73170 PLUMTREE 115 73268 MIDDLRIV 115 1	188.0	184.1	183.6	183.2	183.7	187.8	187.2	183.6	187.5	184.5	183.5	182.5	183.5	188	184.1	182.9	187.2
73171 NWLK HAR 115 73237 ELYAVE 115 1	60.7			49.1	56.4			50.5	57.8			51.9	59.1			52.7	60.7
73171 NWLK HAR 115 73271 RYTN J B 115 1	4.5			4.3	4.2			4.2	4.5			4.3	4.2			4.2	4.4
73172 NORWALK 115 73207 FLAX HIL 115 1	100.0	95.1	89.9			98	92			96.8	91.6			100	94.3		
73183 SHAWSHIL 115 73185 BUNKER H 115 1	13.4	5.5			5.7	13.2			13.4	2.7			2.9	10.2			10.4
73188 BCNFL PF 115 73192 DRBY J B 115 1	33.4	29.9	27.6	26.5	32.1	31.4	28.1	27	33.3	29.9	27.6	26.5	32.1	31.3	28.1	27	33.4
73196 GLEN JCT 115 73198 SOUTHGTN 115 1	31.3	2.5			2	31.3			29.8					11			10.3
73196 GLEN JCT 115 73675 MIX AVE 115 1	2.2					2.2											
73198 SOUTHGTN 115 73631 WLNGF PF 115 1	11.5					11.5			10								
73207 FLAX HIL 115 73271 RYTN J B 115 1	82.7	77.7	72.4			80.7	74.6			79.3	74.1			82.7	76.8		
73224 TRMB J A 115 73700 PEQUONIC 115 1	2.3			2.3								0.8					
73228 BALDWNJB 115 73185 BUNKER H 115 1	6.0					6			3.7								
73230 HADDAM 115 73231 BOKUM 115 1	27.4	13.1			12.9	27.3	3.3		27.4	4.9			4.8	19			19
73230 HADDAM 115 73231 BOKUM 115 2	10.7					10.7			10.7					3.4			3.4
73231 BOKUM 115 73265 GREEN HL 115 1	2.8					2.1			2.8								
73268 MIDDLRIV 115 73176 TRIANGLE 115 1	126.5	123	122.6	122.3	122.8	126.3	125.8	122.6	126.1	123.4	122.6	121.9	122.6	126.5	123	122.1	125.9
73317 NORSING2 345 73315 SINGNOR2 345 1	1.8		1.8														
73669 GRAND AV 115 73681 WEST RIV 115 1	2.8				2.8								0.6				
73669 GRAND AV 115 73681 WEST RIV 115 2	2.8				2.8								0.6				
73701 CRRA JCT 115 73703 ASHCREEK 115 1	0.9	0.4	0.9			0	0.5				0.4				0.2		
75053 NRTHPT P 138 75051 NRTHPRT1 138 1	12.9												7.1				12.9

5. Transmission Voltage Results

5.1. Tables of Results

A summary of the most severe 115 kV low voltage violations is provided in Table 2 (shown later in this report) for all contingencies except SCOVRK8TSTK.

Low voltage violations in the 345 kV system for the SCOVRK8TSTK contingency are provided in the table below:

345 kV Bus Voltage Violations Contingency SCOVRK8TSTK		
	Dispatch	
Bus Name	14B	17B
DEVON	0.063	0.056
E.SHORE	0.073	0.067
FRSTBDGE	0.047	0.047
HADAUTO	0.009	0.011
LONG MTN	0.040	0.036
MERID362	0.019	0.022
NORWALK	0.061	0.050
PLUMTREE	0.062	0.052
SINGER	0.062	0.053
SOUTHGTN	0.032	0.034
Values are violation below the 0.95 low voltage limit for 345 kV buses		

More detailed results on the voltage analysis are provided in Appendix F. Since violations of high voltage limits were minor, they are not included in Table 2 but are included in Appendix F.

The values in Tables 2 indicate the amount, in per-unit, that the bus voltage is below the low voltage criteria. More detailed information on the results of the voltage analysis may be found in tables in Appendix F, *including explanations on interpreting values in the tables*.

5.2. Discussion of Results

Focusing on the results in Table 2, all low voltages for contingencies not involving loss of the 387 line (East Shore to Scovill Rock 345 kV) are for 115 kV buses. The worst voltages are for conditions when NHHS is off-line (shaded area in Table 2). However, most buses that experience post-contingency under-voltages with NHHS off-line also experience under-voltages for other dispatch conditions.

In addition to the SCOVRK8TSTK contingency, there are two other contingencies involving loss of the 387 line that result in low voltages:

- 387LINE: This contingency trips the East Shore to Scovill Rock 345 kV line including the Cross Sound Cable.

- 1460-387DCT: This is a contingency tripping the East Shore to Branford Railroad 115 kV line as well as the 387 line including the Cross Sound Cable.

The SCOVRK8TSTK contingency, which trips the Scovill Rock to Haddam Neck 345 kV line, and the Scovill Rock to East Shore 345 kV line, including the Cross Sound Cable to Long Island, is the most severe of these in terms of voltage performance. This contingency results in widespread low voltages in the 345 kV system for two SWCT dispatches when (1) NHHS is off-line and (2) there is a NE-NY transfer of 700 MW. It is notable that the pre-contingency loading on the 387 line for these two conditions is the highest of all the conditions studied in the report, making loss of it a more severe condition. There were many low 115 kV voltages as well, which are not shown above, but are contained in Appendix F. In addition to the 345 kV and 115 kV low voltages, the power flow program was not able to converge to its normal tolerance, which can be an indication of voltage instability.

TABLE 2

Worst 115 kV Bus Low Voltage Violations, Dispatches 10B - 25B, Existing 387 Line
(excludes contingency SCOVRK8TSTK)

		NE-NY 700 MW								NY-NE 700 MW							
		NHHS On				NHHS Off				NHHS On				NHHS Off			
	Worst Viol	10B	11B	12B	13B	14B	15B	16B	17B	18B	19B	20B	21B	22B	23B	24B	25B
BALDWINB	0.047	0.024	0.016	0.016	0.036		0.017	0.017	0.047	0.023	0.015	0.015	0.035	0.029	0.016	0.015	0.042
BCNFL PF	0.012				0.007								0.005				0.012
BUNKER H	0.047	0.023	0.016	0.016	0.036	0.03	0.016	0.016	0.047	0.023	0.015	0.015	0.034	0.028	0.016	0.015	0.042
CONGRESS	0.023								0.023								0.013
ELMWST A	0.027				0.005		0.001						0.003	0.019			0.027
ELMWST B	0.030		0.001		0.007		0.003	0					0.005	0.021			0.03
FREIGHT	0.048	0.025	0.017	0.017	0.037	0.031	0.018	0.018	0.048	0.024	0.016	0.016	0.036	0.03	0.017	0.017	0.043
SO.NAUG	0.011				0.006								0.005				0.011

Note: No 345 kV voltage violations were found for contigencies not involving loss of the 387 line.

6. References

1. Southwest Connecticut Transmission Expansion, East Shore to Norwalk 345 KV OH/UG Alternative: Transmission Loading and Voltage Analysis @ 27.7 GW Load, New Haven Harbor Station On-Line, NE-NY 0 MW, PowerGEM Report 10021.001-1 Revised, dated January 28, 2004.

2. Southwest Connecticut Transmission Expansion, East Shore to Norwalk 345 KV OH/UG Alternative: Transmission Loading and Voltage Analysis @ 27.7 GW Load, New Haven Harbor Station Off-Line, NE-NY 0 MW, PowerGEM Report 10021.001-2, dated January 28, 2004.

3. Southwest Connecticut Transmission Expansion, East Shore to Norwalk 345 KV OH/UG Alternative: Transmission Loading and Voltage Analysis @ 27.7 GW Load, 387 Line Re-conductored, New Haven Harbor Station On-Line, NE-NY 0 MW, PowerGEM Report 10021.001-3 dated January 28, 2004

4. Southwest Connecticut Transmission Expansion, East Shore to Norwalk 345 KV OH/UG Alternative: Transmission Loading and Voltage Analysis @ 27.7 GW Load, 387 Line Re-conductored, New Haven Harbor Station Off-Line, NE-NY 0 MW, PowerGEM Report 10021.001-4 dated January 28, 2004

5. Southwest Connecticut Transmission Expansion, East Shore to Norwalk 345 KV OH/UG Alternative: Transmission Loading and Voltage Analysis @ 27.7 GW Load, 387 Line Reconductored, NE-NY ± 700 MW, PowerGEM Report 10021.001-6 dated February 16, 2004.

PowerGEM

Power Grid Engineering & Markets

Southwest Connecticut Transmission Expansion

East Shore to Norwalk 345 KV OH/UG Alternative :

Transmission Loading and Voltage Analysis @ 27.7 GW Load, 387 Line Reconductored, NE-NY ± 700 MW

Prepared for:

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PowerGEM Report 10021.001-6
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Executive Summary

This report summarizes power flow analysis conducted for The United Illuminating Company (UI) and Northeast Utilities (NU) for one option for expanding the New England 345 kV transmission system into southwest Connecticut (SWCT). The transmission option examined, called “East Shore 27-OH/UG” in this report, is for a 345 kV transmission path from East Shore to Norwalk substations, with interconnecting substations between these stations.[1] The “East Shore 27-OH/UG” transmission option, which consists primarily of underground cables with one section of overhead line, is described as follows:

From	To	Distance	Transmission
East Shore	Orange (cable to overhead line transition station)	7 miles	345 kV underground, 2500 kcmil HPFF, three parallel cables
Orange (cable to overhead line transition station)	East Devon	9.4 miles	345 kV overhead bundled 1590 ACSR conductor, single circuit
East Devon	Singer	8 miles	345 kV underground, 2500 kcmil HPFF, two parallel cables
Singer	Norwalk	15 miles	345 kV underground, 2500 kcmil HPFF, two parallel cables

In addition to the above transmission alternative, the study assumes re-conductoring of the limiting portion of the East Shore to Scovill Rock 345 kV line (387 line) from a single 2156 ACSR conductor to a bundled 2 x 954 ACSR conductor. This raises the normal rating of the line from 1240 MVA to 1488 MVA, and the long-time emergency rating from 1604 MVA to 1912 MVA. It also results in a reduction in the impedance of the line of about 9%.

The focus of this report is to examine the effect of ±700 MW transfers between New England (NE) and New York (NY), as well as the status of generation at the 447 MW New Haven Harbor Station (NHHS) for a 27.7 GW New England load level. When NHHS is off-line, the generation deficiency is made up by the Kleen Energy generation project, which is expected to be connected to the Scovill Rock to Manchester 345 kV line very near the Scovill Rock Substation.

Companion reports (References 1 thru 4) summarize similar analyses with zero power transfer from New England to New York. Reference 5 is a study similar to this study except that the existing 387 line conductor is modeled.

[1] A planned 345 kV transmission expansion from the Plumtree to Norwalk substations, which is called Bethel to Norwalk, is assumed to be in-service in this analysis.

In addition to the variations in NE-NY transfer and the status of NHHS generation, power flow analysis was conducted with four southwest Connecticut generation dispatches. Loading and voltage performance of the Connecticut system was monitored for the 115 kV and 345 kV transmission systems. In total, this results in sixteen dispatch conditions studied.

The loading analysis found that the East Shore to Scovill Rock 345 kV line is above normal rating in two base cases in the range of 5% to 7%. Several 115 kV lines were also above normal rating in at least one base case dispatch.

The table below summarizes the number of overloaded lines in the study area for the various conditions analyzed:

	Number of Overloaded Branches					
	NE-NY 0 MW (Note 1)		**NE-NY 700 MW**		**NY-NE 700 MW**	
	NHHS On	**NHHS Off**	**NHHS On**	**NHHS Off**	**NHHS On**	**NHHS Off**
SWCT Dispatch ID	**2C-5C**	**6C-9C**	**10C-13C**	**14C-17C**	**18C-21C**	**22C-25C**
345 kV Line	0	3	2	5	0	0
115 kV Line	23	25	24	28	23	23
345/115 AutoTrans	1	1	1	1	1	1
138 kV CT-LI Tie (2)	0	0	0	0	2	2

(1) Based on the results of studies in References 3 and 4.
(2) Overloads are of transformers at each end of the cable (line 1385).

A review of the table indicates that NHHS off and NE-NY 700 MW results in the most overloads.

The table below summarizes the number of bus voltage violations in the study area for the various conditions analyzed:

	Number of Bus Voltage Violations					
	NE-NY 0 MW (Note1)		**NE-NY 700 MW**		**NY-NE 700 MW**	
	NHHS On	**NHHS Off**	**NHHS On**	**NHHS Off**	**NHHS On**	**NHHS Off**
SWCT Dispatch ID	**2C-5C**	**6C-9C**	**10C-13C**	**14C-17C**	**18C-21C**	**22C-25C**
345 kV Violations						
115 kV Violations	9	11	9	7	9	10

(1) Based on the results of studies in References 3 and 4.

There are three contingencies that trip the East Shore to Scovill Rock 345 kV line (387 line), with the most severe being a stuck breaker contingency that trips the Scovill Rock to Haddam Neck and Scovill Rock to East Shore 345 kV lines including the Cross-Sound Cable (SCOVRK8TSTK). Though not converged to normal mismatch criteria, results indicate that for some dispatch and transfer conditions loss of the 387 line results in widespread 345 kV and 115 kV low voltage violations in the study area.

1. Introduction

This report summarizes power flow analysis conducted for The United Illuminating Company (UI) and Northeast Utilities (NU) for one option for expanding the New England 345 kV transmission system into southwest Connecticut (SWCT). The transmission option examined, called "East Shore 27-OH/UG" in this report, is for a 345 kV transmission path from East Shore to Norwalk substations, with interconnecting substations between these stations.[2] The "East Shore 27-OH/UG" transmission option, which consists primarily of underground cables with one section of overhead line, is described as follows:

From	To	Distance	Transmission
East Shore	Orange (cable to overhead line transition station)	7 miles	345 kV underground, 2500 kcmil HPFF, three parallel cables
Orange (cable to overhead line transition station)	East Devon	9.4 miles	345 kV overhead bundled 1590 ACSR conductor, single circuit
East Devon	Singer	8 miles	345 kV underground, 2500 kcmil HPFF, two parallel cables
Singer	Norwalk	15 miles	345 kV underground, 2500 kcmil HPFF, two parallel cables

In addition to the above transmission alternative, the study assumes re-conductoring of the limiting portion of the East Shore to Scovill Rock 345 kV line (387 line) from a single 2156 ACSR conductor to a bundled 2 x 954 ACSR conductor. This raises the normal rating of the line from 1240 MVA to 1488 MVA, and the long-time emergency rating from 1604 MVA to 1912 MVA. It also results in a reduction in the impedance of the line of about 9%.

The focus of this report is to examine the effect of ±700 MW transfers between New England (NE) and New York (NY), as well as the status of generation at the 447 MW New Haven Harbor Station (NHHS) for a 27.7 GW New England load level. When NHHS is off-line, the generation deficiency is made up by the Kleen Energy generation project, which is expected to be connected to the Scovill Rock to Manchester 345 kV line very near the Scovill Rock Substation.

Companion reports (References 1 thru 4) summarize similar analyses with zero power transfer from New England to New York. Reference 5 is a study similar to this one except that the existing 387 line conductor is modeled.

[2] A planned 345 kV transmission expansion from Plumtree to Norwalk substations, which is called Bethel to Norwalk , is assumed to be in-service in this analysis.

The objective of this study is to analyze and document the performance of this transmission configuration for steady-state base case and post-contingency transmission power flows and voltages. Performance is examined for a 27.7 GW New England load level.

The following Appendices are included in this report:

Appendix A	**"East Shore 27-OH/UG" Transmission Modeling Data**
Appendix B	**Power Flow Base Case One-Line Diagrams**
Appendix C	**Contingency File**
Appendix D	**Generation Dispatches**
Appendix E	**Summary of Overloads**
Appendix F	**Summary of Voltage Violations**

2. Database

This section discusses the data developed and used in the study.

2.1. Power Flow Base Cases

Four power flow base cases, which included the approved Bethel to Norwalk 345-kV project in service, were utilized. PowerGEM revised each of the four cases to add the "East Shore 27-OH/UG" transmission project. Details regarding the modeling of these circuits are provided in Appendix A. In addition the 345/115 kV autotransformers were removed from the 387 line path (currently tripping of the 387 line also trips these transformers, which are in series with the line).

Each of the four base cases provided had different Connecticut generation dispatches (designated dispatches 2, 3, 4, and 5). For each of these cases other base case variations were prepared: a) 447 MW New Haven Harbor Station generator on-line or off-line and b) NE-NY ±700 MW transfers.

Further, the impedance and ratings of the East Shore to Scovill Rock 345 kV line (387 line) were revised to reflect re-conductoring. The existing line has a portion with a single 2156 ACSR conductor (Black Pond Junction to Scovill Rock Switching station) and a portion with 2x 954 bundled ACSR conductor (Black Pond Junction to East Shore Substation). The data used in this analysis for re-conductoring assumed that the 2156 ACSR conductor is replaced by 2 x 954 conductor ACSR. The data is given below.

East Shore to Scovill Rock 345 kV Line Modeling Data						
	Impedances (p.u)			Ratings MVA		
	R	X	B	Normal	LTE	STE
Existing Line	0.00137	0.01767	0.26688	1240	1604	1966
Re-conductored Line	0.00136	0.01618	0.28561	1488	1912	2098

The re-conductoring results in about a 9% decrease in the line impedance, and about a 20% increase in the line loading capability.

For all of these cases, when the 447 MW New Haven Harbor Station (NHHS) was turned off it was replaced by generation from the Kleen Energy project. Both generators are outside the SWCT interface. Appendix D contains a list of the on-line generation. Significant changes to the four SWCT dispatch cases (2, 3, 4, and 5) were restricted to New England generation.

Thus a total of sixteen base cases were developed for the analysis in this report. To help organize the work and clearly identify the results, case or "dispatch" identifiers were assigned as summarized in the table below.

	Case or "Dispatch" Identifier			
	NE-NY 700 MW		NY-NE 700 MW	
SWCT Generation Dispatch ID	NHHS On-line	NHHS Off-Line	NHHS On-line	NHHS Off-Line
2	10C	14C	18C	22C
3	11C	15C	19C	23C
4	12C	16C	20C	24C
5	13C	17C	21C	25C

The "C" in the identifier signifies that the modeling of the 387 line assumes that the line has been reconductored, as discussed above.

A one-line diagram showing power flows and voltages on the "East Shore 27-OH/UG" (and Bethel to Norwalk) transmission for each of the sixteen base cases is included in Appendix B. Also, the generation dispatch changes to create the New York to New England and New England to New York power transfers is included in Appendix B.

2.2. Contingency File

A contingency file was modified as appropriate for this study, including those contingencies required to model the Kleen Energy project on the Scovill Rock to Manchester 345 kV line, and is contained in Appendix C.

- Loss of multiple 345 kV underground cables on the "East Shore 27-OH/UG" configuration between Orange and East Shore, or loss of parallel cables between Devon and Norwalk, is not considered. (Simultaneous loss of one cable from Devon to Singer and Singer to Norwalk is included as a contingency).

- For loss of the Orange to East Devon 345 kV overhead line, all three 345 kV underground cables from Orange to East Shore were opened.

3. Methodology and Results Files

This section describes the technical approach to the study, performance criteria, solution assumptions, and the format of the results.

3.1. Software

Set up of the power flow base cases used PTI's PSS/E software (Rev. 28). Base case and contingency analysis was conducted using PTI's MUST software (Rev. 5). Results from the MUST program are stored in Excel spreadsheets.

3.2. Performance Criteria

The criteria for checking overload and voltage performance were as follows:

- Buses and transmission branches in Connecticut 115 kV and above were monitored.
- 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-time 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 more than 105%.

3.3. Solution Options

For the analysis, tap-changing transformer 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.

4. Transmission Loading Results

The results of the analysis for transmission system loading violations, for both the base case and contingency conditions, are provided below.

4.1. Base Case Results

Loading on the 387 line for base case conditions is an important consideration for this transmission alternative, and is summarized in the following table. One-lines showing the flows on this line for each case are in Appendix B.

	Base Case Loading of 387 Line (% of normal rating)			
	NE-NY 700 MW		NY-NE 700 MW	
SWCT Generation Dispatch ID	NHHS On-line	NHHS Off-Line	NHHS On-line	NHHS Off-Line
2	91%	**107%**	77%	93%
3	66%	82%	52%	68%
4	52%	68%	38%	54%
5	89%	**105%**	75%	91%

As indicated in the table, the 387 line is overloaded in the base case for two of the sixteen base case conditions studied.

Base case overloads for all circuits in the study system are summarized in the table below.

			NE-NY 700 MW					**NY-NE 700 MW**			
			NHHS On		**NHHS Off**			**NHHS On**		**NHHS Off**	
From Bus	To Bus	Ckt	**10C**	**11C**	**14C**	**15C**	**17C**	**18C**	**19C**	**22C**	**23C**
73107 SCOVL RK 345	73663 E.SHORE 345	1			107.3		105.3				
73169 RYTN J A 115	73172 NORWALK 115	1	111.4	106.8	114.0	108.9		113.8	109.1	116.9	111.6
73172 NORWALK 115	73207 FLAX HIL 115	1	119.8	115.2	122.3	117.3		122.2	117.6	125.2	120.0
73207 FLAX HIL 115	73271 RYTN J B 115	1			101.9			101.5		104.8	

As the table indicates, in addition to the 387 line there are three 115 kV transmission lines that experience base case overloads.

4.2. Post-Contingency Results

4.2.1. Table of Results

A summary of the overload results is shown in Table 1. The values shown are the percentage overload over the long-time emergency rating. If a table entry is blank, there is no overload. More detailed results are provided in Appendix E.

Any transmission line or transformer in the study area at 115 kV or above that experiences a post-contingency overload in this study is listed in the first column of Table 1.

The second column is the maximum overload over all of the cases examined.

The remaining columns, one for each of the generation dispatches studied, show the **maximum overload of the branch in %** (considering all contingencies) for each dispatch. If the entry is shaded, this is the dispatch for which the maximum overload occurs. If multiple entries are shaded, then each of them is at or very near the maximum overload. If a Table 1 entry is blank, then the branch is not overloaded for that dispatch. To find more detail, for example which contingency causes the overload, and whether other contingencies overload the branch, the reader should refer to Appendix E.

4.2.2. Discussion of Results

There are five existing 345 kV lines that experience post-contingency overloads (the East Shore to Scovill Rock 345 kV also experiences base case overloads, as discussed above) as well as one new circuit in the transmission alternative under study. These are summarized in the table below:

Maximum Post-Contingency Overloads 345 kV Transmission		
Line Name	**Contingency Rating**	**Max Overload**
Frost Bridge to Southington (existing O/H Line)	1446 MVA	20.4%
Southington to Meriden (existing O/H Line)	1912 MVA	14.5%
Scovill Rock to Kleen Energy and Manchester (existing O/H Line)	1446 MVA	0.3%
Scovill Rock to East Shore (reconductored O/H Line)	1912 MVA	15.0%
Haddam Auto to Millstone (existing O/H Line)	1524 MVA	3.4%
Norwalk to Singer (underground cable in transmission alternative in this study)	794 MVA	3.8%

One 345/115kV transformer at Southington experiences post-contingency overloads in almost all of the dispatches studied, with the maximum overload being 33.5 percent.

Thirty-one 115 kV transmission lines indicate post-contingency overloads for at least one generation dispatch.

Finally, for dispatches 21C and 25C the transformers associated with the Connecticut to Long Island AC cables (1385 line) are overloaded by up to 23% which occurs when New York is exporting power to New England.

A general review of Table 1 indicates, for the most part, more overloads and overloads of higher severity for some circuits, when New England is exporting 700 MW to New York as opposed to the reverse transfer of 700 MW from New York to New England.

Table 1

Highest Overload: 27.7 GW NE Load, Dispatches 10C - 25C, Reconductored 387 Line

345 kV Line
345/115 kV Autotransformer
CT-LI cable (line 1385) transformer
115 kV Line

		NE-NY 700 MW								NY-NE 700 MW							
		NHHS On				NHHS Off				NHHS On				NHHS Off			
115 kV Line	Max Ovld	10C	11C	12C	13C	14C	15C	16C	17C	18C	19C	20C	21C	22C	23C	24C	25C
73104 FRSTBDGE 345 73106 SOUTHGTN 345 1	20.4	2.4			4.2	19.7			20.4								
73106 SOUTHGTN 345 73122 MERID362 345 1	14.5					14.5			14.2								
73106 SOUTHGTN 345 73154 SGTN B 115 2	33.5	26.0	17.8	13.7	28.0	31.3	22.5	18.6	33.5	7.8			9.6	12.9	4.4	0.5	14.6
73107 SCOVL RK 345 73114 KLEEN 345 1	0.3					0.3			0.1								
73107 SCOVL RK 345 73663 E.SHORE 345 1	15.0					14.9			15.0								
73121 HADAUTO 345 73110 MILLSTNE 345 1	3.4					1.6			3.4								
73162 WATERSDE 115 73163 COS COB 115 1	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8
73162 WATERSDE 115 73168 GLNBROOK 115 1	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
73164 BALDWNJA 115 73187 STEVENSN 115 1	4.3					4.3											
73164 BALDWNJA 115 73202 FROST BR 115 1	14.3					14.3			9.1					7.6			
73166 NORHR138 138 73171 NWLK HAR 115 1	22.5												16.0				22.5
73167 SO.END 115 73294 GLNBRK J 115 1	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2
73168 GLNBROOK 115 73169 RYTN J A 115 1	3.4				1.2				2.4				2.1				3.4
73168 GLNBROOK 115 73237 ELYAVE 115 1	54.7			50.4	53.5			50.9	54.0			51.4	53.8			51.7	54.7
73168 GLNBROOK 115 73271 RYTN J B 115 1	49.0	18.5	15.1	37.3	45.8	20.4	16.7	38.7	47.5	20.0	16.6	39.0	47.4	21.9	18.2	40.4	49.0
73169 RYTN J A 115 73171 NWLK HAR 115 1	44.6			43.3	43.7			43.3	43.8			44.6	42.7			43.8	43.9
73169 RYTN J A 115 73172 NORWALK 115 1	86.5	80.0	74.7			82.8	77.0			82.9	77.6			86.5	80.5		
73170 PLUMTREE 115 73176 TRIANGLE 115 1	88.7	76.7	74.8	73.4	75.6	88.0	86.1	74.5	87.3	78.0	75.0	71.8	75.2	88.7	76.6	72.7	85.1
73170 PLUMTREE 115 73176 TRIANGLE 115 2	35.3	35.1	35.0	34.8	34.9	35.2	35.2	35.0	35.1	35.2	34.9	34.5	34.8	35.3	35.2	34.7	34.9
73170 PLUMTREE 115 73268 MIDDLRIV 115 1	187.8	184.0	183.6	183.2	183.7	187.6	187.1	183.6	187.3	184.4	183.5	182.5	183.4	187.8	184.1	182.8	187.0
73171 NWLK HAR 115 73237 ELYAVE 115 1	60.7			48.5	57.2			49.8	58.8			51.4	58.1			52.1	60.7
73171 NWLK HAR 115 73271 RYTN J B 115 1	4.4			4.3	4.2			4.2	4.4			4.3	4.2			4.2	4.4
73172 NORWALK 115 73207 FLAX HIL 115 1	101.0	94.4	89.2			97.2	91.5			97.5	92.1			101.0	95.0		
73183 SHAWSHIL 115 73185 BUNKER H 115 1	11.5	4.0			4.2	11.3			11.5	1.5			1.8	8.7			8.8
73188 BCNFL PF 115 73192 DRBY J B 115 1	33.4	29.8	27.5	26.4	32.0	31.2	28.0	26.9	33.2	29.8	27.6	26.5	32.0	30.9	28.1	26.9	33.4
73196 GLEN JCT 115 73198 SOUTHGTN 115 1	31.1	2.3			1.8	31.1			29.3					11.0			10.1
73196 GLEN JCT 115 73675 MIX AVE 115 1	2.1					2.1											
73198 SOUTHGTN 115 73631 WLNGF PF 115 1	10.4					10.4			9.4								
73207 FLAX HIL 115 73271 RYTN J B 115 1	83.7	77.0	71.7			79.9	74.1			80.0	74.6			83.7	77.5		
73224 TRMB J A 115 73700 PEQUONIC 115 1	3.0			3.0								1.4					
73228 BALDWNJB 115 73185 BUNKER H 115 1	5.5					5.5			3.2								
73230 HADDAM 115 73231 BOKUM 115 1	25.2	11.3			11.1	25.1	1.7		25.2	3.4			3.4	17.2			17.1
73230 HADDAM 115 73231 BOKUM 115 2	8.8					8.7			8.8					1.8			1.8
73231 BOKUM 115 73265 GREEN HL 115 1	2.7					2.7			2.3								
73268 MIDDLRIV 115 73176 TRIANGLE 115 1	126.4	123.0	122.6	122.3	122.7	126.2	125.8	122.5	126.0	123.3	122.6	121.8	122.6	126.4	123.0	122.1	125.8
73317 NORSING2 345 73315 SINGNOR2 345 1	3.8		3.8														
73669 GRAND AV 115 73681 WEST RIV 115 1	3.8				3.8								1.5				
73669 GRAND AV 115 73681 WEST RIV 115 2	3.8				3.8								1.5				
73701 CRRA JCT 115 73703 ASHCREEK 115 1	0.6	0.1	0.6				0.3			0.1	0.6			0.2	0.5		
75053 NRTHPT P 138 75051 NRTHPRT1 138 1	11.4												5.3				11.4

5. Transmission Voltage Results

5.1. Tables of Results

A summary of the most severe 115 kV low voltage violations is provided in Table 2 (shown later in this report) for all contingencies except SCOVRK8TSTK.

Low voltage violations in the 345 kV system for the SCOVRK8TSTK contingency are provided in the table below.

345 kV Bus Voltage Violations Contingency SCOVRK8TSTK		
	Dispatch	
	14C	17C
DEVON	0.074	0.057
E.SHORE	0.085	0.069
FRSTBDGE	0.055	0.048
HADAUTO	0.015	0.012
HADDM NK	0.001	
LONG MTN	0.047	0.037
MERID362	0.026	0.023
NORWALK	0.071	0.051
PLUMTREE	0.071	0.053
SINGER	0.073	0.054
SOUTHGTN	0.039	0.035

Values are violation below the 0.95 low voltage limit for 345 kV buses

More detailed results on the voltage analysis are provided in Appendix F. Since violations of high voltage limits were minor, they are not included in Table 2 but are included in Appendix F.

The values in the table above and Table 2 indicate the amount, in per-unit, that the bus voltage is below the low voltage criteria. More detailed information on the results of the voltage analysis may be found in tables in Appendix F, *including explanations on interpreting values in the tables*.

5.2. Discussion of Results

Focusing on the results in Table 2, all low voltages for contingencies not involving loss of the 387 line (East Shore to Scovill Rock 345 kV) are for 115 kV buses. The worst voltages are for conditions when NHHS is off-line (shaded area in Table 2). However, most buses that experience post-contingency under-voltages with NHHS off-line also experience under-voltages for other dispatch conditions.

In addition to the SCOVRK8TSTK contingency, there are two other contingencies involving loss of the 387 line that result in low voltages:

- 387LINE: This contingency trips the East Shore to Scovill Rock 345 kV line including the Cross Sound Cable.
- 1460-387DCT: This is a contingency tripping the East Shore to Branford Railroad 115 kV line as well as the 387 line including the Cross Sound Cable.

The SCOVRK8TSTK contingency, which trips the Scovill Rock to Haddam Neck 345 kV line, and the Scovill Rock to East Shore 345 kV line, including the Cross Sound Cable to Long Island, is the most severe of these in terms of voltage performance. This contingency results in widespread low voltages in the 345 kV system for two SWCT dispatches when (1) NHHS is off-line and (2) there is a NE-NY transfer of 700 MW. It is notable that the pre-contingency loading on the 387 line for these two conditions is the highest of all the conditions studied in the report, making loss of it a more severe condition. There were many low 115 kV voltages as well, which are not shown above but are contained in Appendix F. In addition to the 345 kV and 115 kV low voltages, the power flow program was not able to converge to its normal tolerance, which can be an indication of voltage instability.

TABLE 2
Worst 115 kV Bus Low Voltage Violations, Dispatches 10C - 25C, Reconductored 387 Lune
(excludes contingency SCOVRK8TSTK)

		NE-NY 700 MW							NY-NE 700 MW							
		NHHS On				NHHS Off			NHHS On				NHHS Off			
115 kV Bus	Worst Viol	10C	11C	12C	13C	15C	16C	17C	18C	19C	20C	21C	22C	23C	24C	25C
BALDWINB	0.046	0.023	0.016	0.016	0.036	0.016	0.016	0.046	0.023	0.015	0.015	0.034	0.028	0.016	0.015	0.040
BCNFL PF	0.011				0.006							0.005				0.011
BUNKER H	0.045	0.023	0.015	0.016	0.035	0.016	0.016	0.045	0.022	0.015	0.015	0.034	0.027	0.016	0.015	0.040
CONGRESS	0.018							0.018								0.009
ELMWST A	0.023				0.004	0.001						0.003	0.017			0.023
ELMWST B	0.025				0.006	0.003						0.005	0.019			0.025
FREIGHT	0.047	0.025	0.017	0.017	0.037	0.018	0.018	0.047	0.024	0.016	0.016	0.036	0.029	0.017	0.017	0.042
SO.NAUG	0.010				0.006							0.004				0.010

Note: No 345 kV voltage violations were found for contingencies not involving loss of the 387 line.

6. References

1. Southwest Connecticut Transmission Expansion, East Shore to Norwalk 345 KV OH/UG Alternative: Transmission Loading and Voltage Analysis @ 27.7 GW Load, New Haven Harbor Station On-Line, NE-NY 0 MW, PowerGEM Report 10021.001-1 Revised, dated January 28, 2004.

2. Southwest Connecticut Transmission Expansion, East Shore to Norwalk 345 KV OH/UG Alternative: Transmission Loading and Voltage Analysis @ 27.7 GW Load, New Haven Harbor Station Off-Line, NE-NY 0 MW, PowerGEM Report 10021.001-2, dated January 28, 2004.

3. Southwest Connecticut Transmission Expansion, East Shore to Norwalk 345 KV OH/UG Alternative: Transmission Loading and Voltage Analysis @ 27.7 GW Load, 387 Line Re-conductored, New Haven Harbor Station On-Line, NE-NY 0 MW, PowerGEM Report 10021.001-3 dated January 28, 2004

4. Southwest Connecticut Transmission Expansion, East Shore to Norwalk 345 KV OH/UG Alternative: Transmission Loading and Voltage Analysis @ 27.7 GW Load, 387 Line Re-conductored, New Haven Harbor Station Off-Line, NE-NY 0 MW, PowerGEM Report 10021.001-4 dated January 28, 2004

5. Southwest Connecticut Transmission Expansion, East Shore to Norwalk 345 KV OH/UG Alternative: Transmission Loading and Voltage Analysis @ 27.7 GW Load, NE-NY ± 700 MW, PowerGEM Report 10021.001-5 dated February 16, 2004.