
***Connecticut Cable Resonance Study for
XLPE Alternative in Middletown to
Norwalk Project - Case 7 with
Transmission Line Outages***

***Summary Report
October 2004***

**Prepared for:
Northeast Utilities**

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Foreword

This document was prepared by General Electric Company in Schenectady, New York. It is submitted to Northeast Utilities (NU). Technical and commercial questions and any correspondence concerning this document should be referred to:

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Introduction

GE Energy's Energy Consulting group has performed a resonance study of an XLPE alternative in the Northeast Utilities (NU) Middletown to Norwalk 345 kV transmission cable project that is proposed in southwestern Connecticut. The XLPE alternative has the two cables between Norwalk and Singer and the two cables between Singer and East Devon represented as 3000 kcmil XLPE cable rather than 2500 kcmil HPFF cable, and one of the two HPFF cables between Plumtree and Norwalk removed. In this study, the effect of transmission line outages were studied for Case 7 with 115 kV shunt capacitor banks at Frost Bridge, Glenbrook, Southington, Rocky River, and Stony Hill removed. Although Case 7 includes replacement of 115 kV shunt capacitors with statcoms, this study does not model the statcoms but represents the first step of evaluating the replacement of shunt capacitors with an alternate device for voltage regulation (such as a statcom) by considering only the removal of these shunt capacitors.

The following transmission line outages were considered:

- Outage of the 345 kV line from Devon to Beseck
- Outage of the 345 kV line from Long Mountain to Plumtree
- Outage of the 345 kV line from Southington to Frost Bridge
- Outage of the 138 kV line from Norwalk Harbor to Long Island

The main objective of this study was to investigate the change in the first resonance due to transmission outages.

The study has been performed with the Electromagnetic Transients Program (ATP/EMTP), which is recognized as an industry standard for simulating the transient performance and frequency response of electric utility systems [www.emtp.org].

System Representation

Table 1 shows various shunt capacitor bank conditions. The reduced capacitor bank condition for Case 7, which is studied in this report, is shown in the last column of Table 1. The reduced bank condition for Case 7 has no capacitors at Plumtree, Frost Bridge, Glenbrook, Southington, Rocky River, and Stony Hill.

Table 2 shows the generators included in the original ASPEN file, and the modified status originally provided for the Middletown to Norwalk (M/N) project, which indicates the generators that are on or off during peak and light load conditions. An additional generator dispatch scenario is given for "Light Post-Project," which depicts a more realistic scenario with more local generation off. This study considered the original light load dispatch of generators and the Light Post-Project dispatch with more local generation off.

Table 1. Modified Shunt Capacitor Conditions for System Model

Shunt Capacitors			All Banks (for reference)	Peak Load (for reference)	Light Load (for reference)	Reduced Banks: Case 7
Substation	Voltage (kV)	# Units	MVAR	MVAR	MVAR	MVAR
Southington 1	115	3	157.2	157.2		0
Southington 2	115	3	157.2	157.2		0
Frost Bridge	115	5	262.0	262.0		0
Berlin	115	3	132.0	132.0		132.0
Plumtree	115	2	92.2	0		0
Glenbrook	115	5	190.8*	151.2		0
Darien	115	1	39.6	39.6		39.6
Waterside	115	1	39.6	39.6		39.6
Norwalk	115	0	0	0		0
East Shore	115	2	84.0	84.0		84.0
No. Haven	115	1	42.0	42.0		42.0
Sackett	115	1	42.0	42.0		42.0
Rocky River	115	1	25.2	25.2		0
Stony Hill	115	1	25.2	25.2		0
Cross Sound Filters	200	3	103.0 (61 – 25 th , 32 – 41 st , 10 – 21 st)	103.0	103.0	103.0

* Actual maximum including Glenbrook Statcom is 335 MVAR (additional MVAR not included in analysis)

Table 2. Modified Generator Conditions for System Model

GENERATOR	KV	ID	ST	STATUS (PEAK)	STATUS (LIGHT)	Light Post-Project	IDENTIFICATION NOTES
MILLSTON	22.8	1	1	on	on	On	
MILLSTON	22.8	1	1	on	on	On	
RESCO	115	1	1	on	on	On	Bridgeport
ROCKY RV	13.8	1	1	on	on	Off	
ROCKY RV	13.8	1	1	on	on	Off	
ROCKY RV	13.8	1	1	on	on	Off	
STEVENSO	6.9	1	1	off	off	Off	
NORWALK	27.6	1	0	off	off	Off	
BULLS BR	27.6	1	1	on	on	Off	
FORESTVI	13.8	1	1	on	on	On	
brdgphbr	18.4	2	1	off	off	Off	
brdgphbr	20.2	3	1	on	on	Off	
brdgphbr	13.68	jt	1	off	off	Off	
COSCOBGE	13.8	1	1	off	off	Off	
COSCOBGE	13.8	2	1	off	off	Off	
COSCOBGE	13.8	3	1	off	off	Off	
DEVON 11	13.8	1	1	off	off	Off	
DEVON 12	13.8	1	1	off	off	Off	
DEVON 13	13.8	1	1	off	off	Off	
DEVON 14	13.8	1	1	off	off	Off	
English	13.68	8	1	off	off	Off	
English	13.68	7	1	off	off	Off	
ESHOREGE	13.8	1	1	on	on	Off	New Haven
G1/G2	13.8	1	1	off	off	Off	Wallingford
G3/G4	13.8	1	1	off	off	Off	Wallingford
G5	13.8	1	1	off	off	Off	Wallingford
GT1 (11)	16	1	1	off	off	Off	BE
GT2 (12)	16	1	1	off	off	Off	BE
Middleto	22	1	1	on	off	Off	Middletown
Milford	20.9	1	1	on	on	Off	
Milford	20.9	1	1	off	off	Off	
one (Meriden)	21	1	1	on	off	Off	Meriden
Shepaug	13.8	1	1	on	on	Off	
so norwa	4.8	1	1	off	off	Off	
so norwa	4.8	1	1	off	off	Off	
so norwa	13.8	1	1	off	off	Off	
ST1 (10)	16	1	1	off	off	Off	BE
Temp Gen (Waterside)	13.8	3	0	off	off	Off	Waterside
Temp Gen (Waterside)	13.8	1	0	off	off	Off	Waterside
Temp Gen (Waterside)	13.8	2	0	off	off	Off	Waterside
three (Meriden)	21	1	1	on	off	Off	Meriden

GENERATOR	KV	ID	ST	STATUS (PEAK)	STATUS (LIGHT)	Light Post-Project	IDENTIFICATION NOTES
two (Meriden)	21	1	1	on	off	Off	Meriden
Unit 10	13.8	1	1	off	off	Off	Devon 10
Unit 6J- (Norwalk)	17.1	1	1	off	off	Off	Norwalk-1
Unit 6J- (Norwalk)	13.8	1	1	off	off	Off	Norwalk -10
Unit 6J- (Norwalk)	19	1	1	off	on	Off	Norwalk-2
Unit 7	13.2	1	1	on	off	Off	Devon
Unit 8	13.2	1	1	on	off	Off	Devon
walrecge	4.16	1	1	on	off	Off	

Resonance Results

The resonance effects of the XLPE alternative with the reduced capacitor bank configuration (Case 7) were evaluated under the original light load and light post-project generator dispatches, with the addition of transmission outage contingencies.

Table 3 shows the cases that were investigated and the resonant frequencies that were observed along with the corresponding impedance value at those frequencies, with the original light load generation dispatch. The resonant frequency is indicated by its harmonic number (HN), in per unit of 60 Hz, and impedance magnitude is in ohms. The corresponding driving-point impedance plots are provided in Appendix A. Table 4 shows the results with the local generation off (light post-project generator dispatch), and the corresponding driving-point impedance plots are provided in Appendix B.

Tables 3 and 4 includes cases with transmission lines taken out of service along with the case with all transmission lines in service for comparison. The transmission line outages have an impact of lowering the first resonance frequency in the order of 0.1-0.4 pu (6-24 Hz).

Table 3. Resonant Frequencies for M/N-XLPE Project with Light Load Generation

Case	Location	Line Outage	Resonant Frequency & Impedance (pu of 60Hz, Ohm)					
			Low		Middle		High	
			HN	Z(Ω)	HN	Z(Ω)	HN	Z(Ω)
M/N-XLPE_1E	Plumtree 345 kV	All Lines in Service	3.4	178			11.8	356
M/N-XLPE-O1_1E	Plumtree 345 kV	Devon-Beseck 345kV Line Out	3.0	218			11.9	313
M/N-XLPE-O2_1E	Plumtree 345 kV	Long Mtn-Plumtree 345kV Line Out	3.0	299			11.2	322
M/N-XLPE-O3_1E	Plumtree 345 kV	Southington-Frost Bridge 345 Line Out	3.3	186			11.3	293
M/N-XLPE-O4_1E	Plumtree 345 kV	Norwalk Harbor-Long Island 138kV LineOut	3.1	148			11.8	361
M/N-XLPE_2E	Plumtree 115 kV	All Lines in Service	3.3	19			11.7 15.1	129 114
M/N-XLPE-O1_2E	Plumtree 115 kV	Devon-Beseck 345kV Line Out	3.0	21			11.8 15.0	106 116
M/N-XLPE-O2_2E	Plumtree 115 kV	Long Mtn-Plumtree 345kV Line Out	2.9	26			11.6 15.0	98 108
M/N-XLPE-O3_2E	Plumtree 115 kV	Southington-Frost Bridge 345 Line Out	3.3	20			11.3 15.0	100 114
M/N-XLPE-O4_2E	Plumtree 115 kV	Norwalk Harbor-Long Island 138kV LineOut	3.0	17			11.7 15.0	129 114
M/N-XLPE_3E	Norwalk 345 kV	All Lines in Service	3.4	232				
M/N-XLPE-O1_2E	Norwalk 345 kV	Devon-Beseck 345kV Line Out	3.0	317				
M/N-XLPE-O2_2E	Norwalk 345 kV	Long Mtn-Plumtree 345kV Line Out	3.0	286				
M/N-XLPE-O3_2E	Norwalk 345 kV	Southington-Frost Bridge 345 Line Out	3.3	239				
M/N-XLPE-O4_2E	Norwalk 345 kV	Norwalk Harbor-Long Island 138kV LineOut	3.1	195				
M/N-XLPE_4E	Norwalk 115 kV	All Lines in Service	3.3	18	6.9	22		
M/N-XLPE-O1_4E	Norwalk 115 kV	Devon-Beseck 345kV Line Out	3.0	21	6.8	22		
M/N-XLPE-O2_4E	Norwalk 115 kV	Long Mtn-Plumtree 345kV Line Out	2.9	19	6.8	22		
M/N-XLPE-O3_4E	Norwalk 115 kV	Southington-Frost Bridge 345 Line Out	3.3	18	6.9	22		
M/N-XLPE-O4_4E	Norwalk 115 kV	Norwalk Harbor-Long Island 138kV LineOut	3.1	20	6.9	23		
M/N-XLPE_5E	Southington 345 kV	All Lines in Service	3.3	72			11.5	272
M/N-XLPE-O1_5E	Southington 345 kV	Devon-Beseck 345kV Line Out	2.9	44	5.3	107	10.5	277
M/N-XLPE-O2_5E	Southington 345 kV	Long Mtn-Plumtree 345kV Line Out	2.9	54	5.4	75	11.1	266
M/N-XLPE-O3_5E	Southington 345 kV	Southington-Frost Bridge 345 Line Out	3.2	69	5.5	78	11.2	253
M/N-XLPE-O4_5E	Southington 345 kV	Norwalk Harbor-Long Island 138kV LineOut	3.0	59	5.5	59	11.5	272
M/N-XLPE_6E	Southington 115 kV	All Lines in Service	3.3	10	5.6	29		

M/N-XLPE-01_6E	Southington 115 kV	Devon-Beseck 345kV Line Out	2.9	8	5.3	32		
M/N-XLPE-02_6E	Southington 115 kV	Long Mtn-Plumtree 345kV Line Out	2.9	8	5.5	30		
M/N-XLPE-03_6E	Southington 115 kV	Southington-Frost Bridge 345 Line Out	3.2	10	5.5	30		
M/N-XLPE-04_6E	Southington 115 kV	Norwalk Harbor-Long Island 138kV LineOut	3.0	9	5.6	29		
M/N-XLPE_7E	East Shore 345 kV	All Lines in Service	3.2	75	5.5 6.2	172 168	14.5	625
M/N-XLPE-01_7E	East Shore 345 kV	Devon-Beseck 345kV Line Out	2.9	59	5.3 6.2	182 165	14.5	641
M/N-XLPE-02_7E	East Shore 345 kV	Long Mtn-Plumtree 345kV Line Out	2.9	62	5.4 6.2	178 166	14.5	624
M/N-XLPE-03_7E	East Shore 345 kV	Southington-Frost Bridge 345 Line Out	3.2	74	5.5 6.2	172 168	14.5	615
M/N-XLPE-04_7E	East Shore 345 kV	Norwalk Harbor-Long Island 138kV LineOut	3.0	65	5.5 6.2	171 168	14.5	625
M/N-XLPE_8E	Devon 115 kV	All Lines in Service	3.3	13				
M/N-XLPE-01_8E	Devon 115 kV	Devon-Beseck 345kV Line Out	3.0	14				
M/N-XLPE-02_8E	Devon 115 kV	Long Mtn-Plumtree 345kV Line Out	2.9	13				
M/N-XLPE-03_8E	Devon 115 kV	Southington-Frost Bridge 345 Line Out	3.2	13				
M/N-XLPE-04_8E	Devon 115 kV	Norwalk Harbor-Long Island 138kV LineOut	3.0	12				
M/N-XLPE_9E	Frost Bridge 115 kV	All Lines in Service	3.3	12			11.4	33
M/N-XLPE-01_9E	Frost Bridge 115 kV	Devon-Beseck 345kV Line Out	2.9	10			10.3	30
M/N-XLPE-02_9E	Frost Bridge 115 kV	Long Mtn-Plumtree 345kV Line Out	2.9	9			11.0	32
M/N-XLPE-03_9E	Frost Bridge 115 kV	Southington-Frost Bridge 345 Line Out	3.2	12			11.4	34
M/N-XLPE-04_9E	Frost Bridge 115 kV	Norwalk Harbor-Long Island 138kV LineOut	3.0	10			11.4	33
M/N-XLPE_10E	Glenbrook 115 kV	All Lines in Service	3.3	17	6.9	49		
M/N-XLPE-01_10E	Glenbrook 115 kV	Devon-Beseck 345kV Line Out	3.0	19	6.9	49		
M/N-XLPE-02_10E	Glenbrook 115 kV	Long Mtn-Plumtree 345kV Line Out	2.9	17	6.9	49		
M/N-XLPE-03_10E	Glenbrook 115 kV	Southington-Frost Bridge 345 Line Out	3.3	17	6.9	49		
M/N-XLPE-04_10E	Glenbrook 115 kV	Norwalk Harbor-Long Island 138kV LineOut	3.1	22	6.9	52		
M/N-XLPE_11E	Singer 345 kV	All Lines in Service	3.4	230				
M/N-XLPE-01_11E	Singer 345 kV	Devon-Beseck 345kV Line Out	3.0	335				
M/N-XLPE-02_11E	Singer 345 kV	Long Mtn-Plumtree 345kV Line Out	3.0	267				
M/N-XLPE-03_11E	Singer 345 kV	Southington-Frost Bridge 345 Line Out	3.3	236				
M/N-XLPE-04_11E	Singer 345 kV	Norwalk Harbor-Long Island 138kV LineOut	3.1	191				

M/N-XLPE_12E	Devon 345 kV	All Lines in Service	3.4	219				
M/N-XLPE-O1_12E	Devon 345 kV	Devon-Beseck 345kV Line Out	3.0	334				
M/N-XLPE-O2_12E	Devon 345 kV	Long Mtn-Plumtree 345kV Line Out	3.0	249				
M/N-XLPE-O3_12E	Devon 345 kV	Southington-Frost Bridge 345 Line Out	3.3	224				
M/N-XLPE-O4_12E	Devon 345 kV	Norwalk Harbor-Long Island 138kV LineOut	3.1	181				
M/N-XLPE_13E	Beseck 345 kV	All Lines in Service	3.3	76			11.6	343
M/N-XLPE-O1_13E	Beseck 345 kV	Devon-Beseck 345kV Line Out	2.9	42	5.3	105	10.5	374
M/N-XLPE-O2_13E	Beseck 345 kV	Long Mtn-Plumtree 345kV Line Out	2.9	65	5.4	51	11.1	322
M/N-XLPE-O3_13E	Beseck 345 kV	Southington-Frost Bridge 345 Line Out	3.3	74	5.4	50	11.2	315
M/N-XLPE-O4_13E	Beseck 345 kV	Norwalk Harbor-Long Island 138kV LineOut	3.0	63	5.5	42	11.6	343

Table 4. Resonant Frequencies for M/N-XLPE Project with Local Generators Off

Case	Location	Line Outage	Resonant Frequency & Impedance (pu of 60Hz, Ohm)					
			Low		Middle		High	
			HN	Z(Ω)	HN	Z(Ω)	HN	Z(Ω)
M/N-XLPE2_1E	Plumtree 345 kV	All Lines in Service	3.0	129			11.7	321
M/N-XLPE2-O1_1E	Plumtree 345 kV	Devon-Beseck 345kV Line Out	2.7	154			11.8	284
M/N-XLPE2-O2_1E	Plumtree 345 kV	Long Mtn-Plumtree 345kV Line Out	2.7	214			11.2	314
M/N-XLPE2-O3_1E	Plumtree 345 kV	Southington-Frost Bridge 345 Line Out	3.0	134			11.3	277
M/N-XLPE2-O4_1E	Plumtree 345 kV	Norwalk Harbor-Long Island 138kV LineOut	2.7	106			11.7	325
M/N-XLPE2_2E	Plumtree 115 kV	All Lines in Service	3.0	15			11.7	119
M/N-XLPE2-O1_2E	Plumtree 115 kV	Devon-Beseck 345kV Line Out	2.7	16			11.8	99
M/N-XLPE2-O2_2E	Plumtree 115 kV	Long Mtn-Plumtree 345kV Line Out	2.6	20			11.3	93
M/N-XLPE2-O3_2E	Plumtree 115 kV	Southington-Frost Bridge 345 Line Out	2.9	16			11.3	97
M/N-XLPE2-O4_2E	Plumtree 115 kV	Norwalk Harbor-Long Island 138kV LineOut	2.6	13			11.7	119
M/N-XLPE2_3E	Norwalk 345 kV	All Lines in Service	3.1	167				
M/N-XLPE2-O1_2E	Norwalk 345 kV	Devon-Beseck 345kV Line Out	2.8	222				
M/N-XLPE2-O2_2E	Norwalk 345 kV	Long Mtn-Plumtree 345kV Line Out	2.7	206				
M/N-XLPE2-O3_2E	Norwalk 345 kV	Southington-Frost Bridge 345 Line Out	3.0	172				
M/N-XLPE2-O4_2E	Norwalk 345 kV	Norwalk Harbor-Long Island 138kV LineOut	2.7	138				
M/N-XLPE2_4E	Norwalk 115 kV	All Lines in Service	3.0	15	6.7	20		
M/N-XLPE2-O1_4E	Norwalk 115 kV	Devon-Beseck 345kV Line Out	2.7	17	6.7	21		
M/N-XLPE2-O2_4E	Norwalk 115 kV	Long Mtn-Plumtree 345kV Line Out	2.6	16	6.7	21		
M/N-XLPE2-O3_4E	Norwalk 115 kV	Southington-Frost Bridge 345 Line Out	3.0	15	6.7	20		
M/N-XLPE2-O4_4E	Norwalk 115 kV	Norwalk Harbor-Long Island 138kV LineOut	2.7	17	6.7	21		
M/N-XLPE2_5E	Southington 345 kV	All Lines in Service	3.0	60			11.5	270
M/N-XLPE2-O1_5E	Southington 345 kV	Devon-Beseck 345kV Line Out	2.6	40	5.1	95	10.5	271
M/N-XLPE2-O2_5E	Southington 345 kV	Long Mtn-Plumtree 345kV Line Out	2.6	47	5.3	67	11.0	264
M/N-XLPE2-O3_5E	Southington 345 kV	Southington-Frost Bridge 345 Line Out	2.9	59	5.3	69	11.2	252
M/N-XLPE2-O4_5E	Southington 345 kV	Norwalk Harbor-Long Island 138kV LineOut	2.6	48	5.4	53	11.5	269
M/N-XLPE2_6E	Southington 115 kV	All Lines in Service	2.9	9	5.4	23		
M/N-XLPE2-O1_6E	Southington 115 kV	Devon-Beseck 345kV Line Out	2.6	7	5.1	26		

M/N-XLPE2-O2_6E	Southington 115 kV	Long Mtn-Plumtree 345kV Line Out	2.5	7	5.3	25		
M/N-XLPE2-O3_6E	Southington 115 kV	Southington-Frost Bridge 345 Line Out	2.9	9	5.3	25		
M/N-XLPE2-O4_6E	Southington 115 kV	Norwalk Harbor-Long Island 138kV LineOut	2.6	7	5.4	23		
M/N-XLPE2_7E	East Shore 345 kV	All Lines in Service	2.9	83	5.4	217	14.0	532
M/N-XLPE2-O1_7E	East Shore 345 kV	Devon-Beseck 345kV Line Out	2.6	65	5.1	227	14.0	556
M/N-XLPE2-O2_7E	East Shore 345 kV	Long Mtn-Plumtree 345kV Line Out	2.5	68	5.3	224	14.0	542
M/N-XLPE2-O3_7E	East Shore 345 kV	Southington-Frost Bridge 345 Line Out	2.9	81	5.3	216	14.0	522
M/N-XLPE2-O4_7E	East Shore 345 kV	Norwalk Harbor-Long Island 138kV LineOut	2.6	67	5.4	214	14.0	532
M/N-XLPE2_8E	Devon 115 kV	All Lines in Service	3.0	14				
M/N-XLPE2-O1_8E	Devon 115 kV	Devon-Beseck 345kV Line Out	2.7	15				
M/N-XLPE2-O2_8E	Devon 115 kV	Long Mtn-Plumtree 345kV Line Out	2.6	14				
M/N-XLPE2-O3_8E	Devon 115 kV	Southington-Frost Bridge 345 Line Out	2.9	14				
M/N-XLPE2-O4_8E	Devon 115 kV	Norwalk Harbor-Long Island 138kV LineOut	2.6	13				
M/N-XLPE2_9E	Frost Bridge 115 kV	All Lines in Service	2.9	10			11.3	32
M/N-XLPE2-O1_9E	Frost Bridge 115 kV	Devon-Beseck 345kV Line Out	2.6	9	5.0	10	10.3	30
M/N-XLPE2-O2_9E	Frost Bridge 115 kV	Long Mtn-Plumtree 345kV Line Out	2.5	8	5.2	10	11.0	32
M/N-XLPE2-O3_9E	Frost Bridge 115 kV	Southington-Frost Bridge 345 Line Out	2.9	11			11.3	33
M/N-XLPE2-O4_9E	Frost Bridge 115 kV	Norwalk Harbor-Long Island 138kV LineOut	2.6	8			11.3	32
M/N-XLPE2_10E	Glenbrook 115 kV	All Lines in Service	3.0	15	6.8	46		
M/N-XLPE2-O1_10E	Glenbrook 115 kV	Devon-Beseck 345kV Line Out	2.7	16	6.7	46		
M/N-XLPE2-O2_10E	Glenbrook 115 kV	Long Mtn-Plumtree 345kV Line Out	2.6	15	6.7	46		
M/N-XLPE2-O3_10E	Glenbrook 115 kV	Southington-Frost Bridge 345 Line Out	2.9	15	6.8	46		
M/N-XLPE2-O4_10E	Glenbrook 115 kV	Norwalk Harbor-Long Island 138kV LineOut	2.7	19	6.7	48		
M/N-XLPE2_11E	Singer 345 kV	All Lines in Service	3.1	167				
M/N-XLPE2-O1_11E	Singer 345 kV	Devon-Beseck 345kV Line Out	2.8	235				
M/N-XLPE2-O2_11E	Singer 345 kV	Long Mtn-Plumtree 345kV Line Out	2.7	194				
M/N-XLPE2-O3_11E	Singer 345 kV	Southington-Frost Bridge 345 Line Out	3.0	171				
M/N-XLPE2-O4_11E	Singer 345 kV	Norwalk Harbor-Long Island 138kV LineOut	2.7	136				
M/N-XLPE2_12E	Devon 345 kV	All Lines in Service	3.1	160				
M/N-XLPE2-O1_12E	Devon 345 kV	Devon-Beseck 345kV Line Out	2.7	236				

M/N-XLPE2-O2_12E	Devon 345 kV	Long Mtn-Plumtree 345kV Line Out	2.7	183				
M/N-XLPE2-O3_12E	Devon 345 kV	Southington-Frost Bridge 345 Line Out	3.0	164				
M/N-XLPE2-O4_12E	Devon 345 kV	Norwalk Harbor-Long Island 138kV LineOut	2.7	131				
M/N-XLPE2_13E	Beseck 345 kV	All Lines in Service	3.0	63			11.6	341
M/N-XLPE2-O1_13E	Beseck 345 kV	Devon-Beseck 345kV Line Out	2.6	38	5.1	96	10.5	365
M/N-XLPE2-O2_13E	Beseck 345 kV	Long Mtn-Plumtree 345kV Line Out	2.6	53	5.2	46	11.1	318
M/N-XLPE2-O3_13E	Beseck 345 kV	Southington-Frost Bridge 345 Line Out	2.9	61	5.3	45	11.2	310
M/N-XLPE2-O4_13E	Beseck 345 kV	Norwalk Harbor-Long Island 138kV LineOut	2.6	50	5.3	39	11.6	341

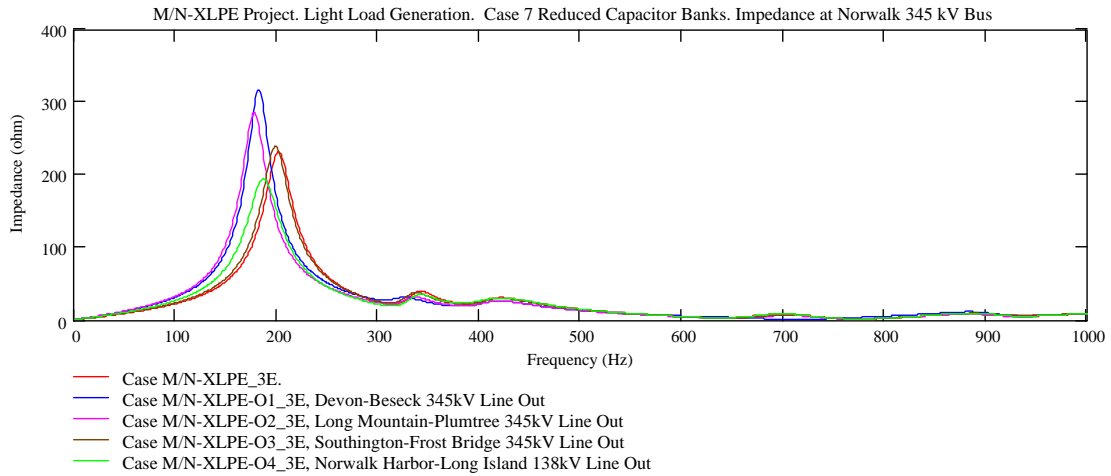
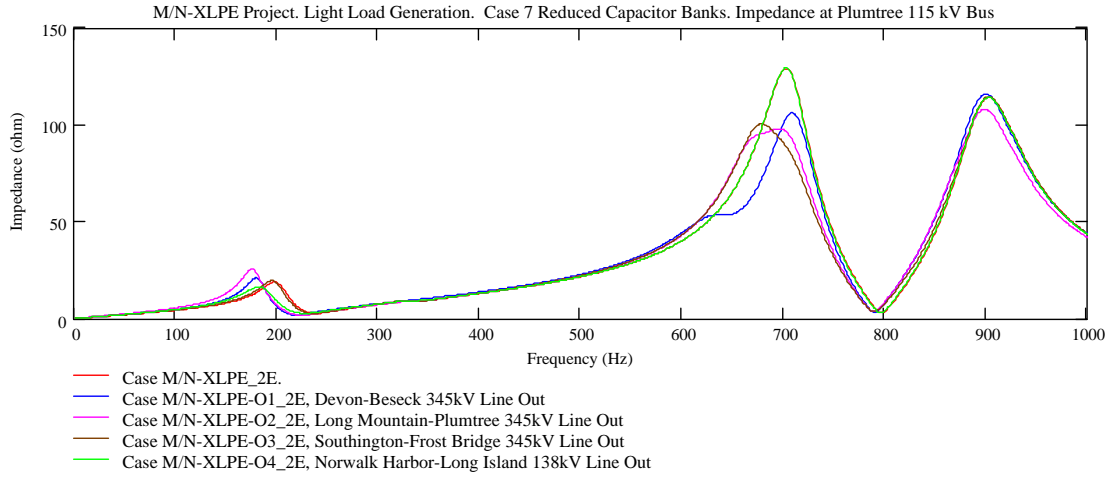
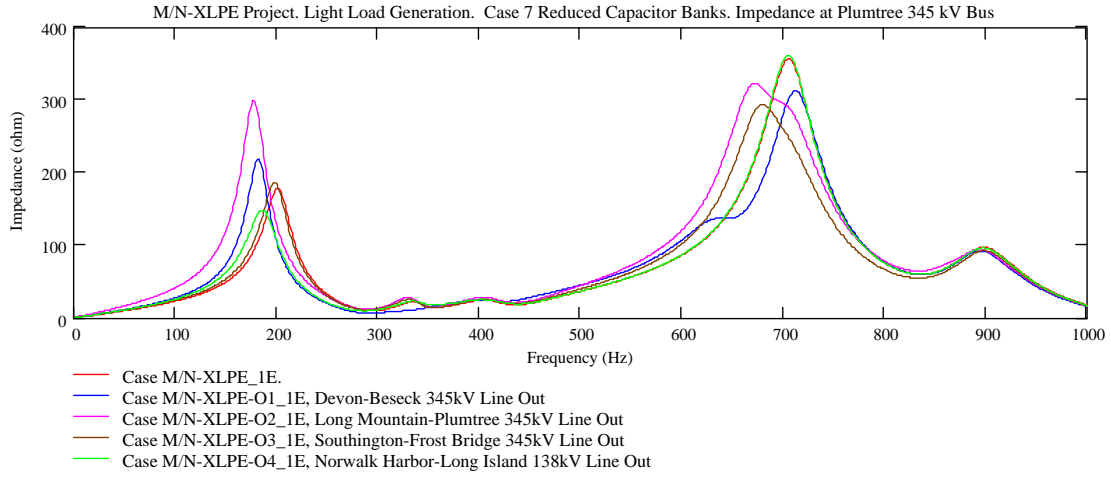
Conclusions

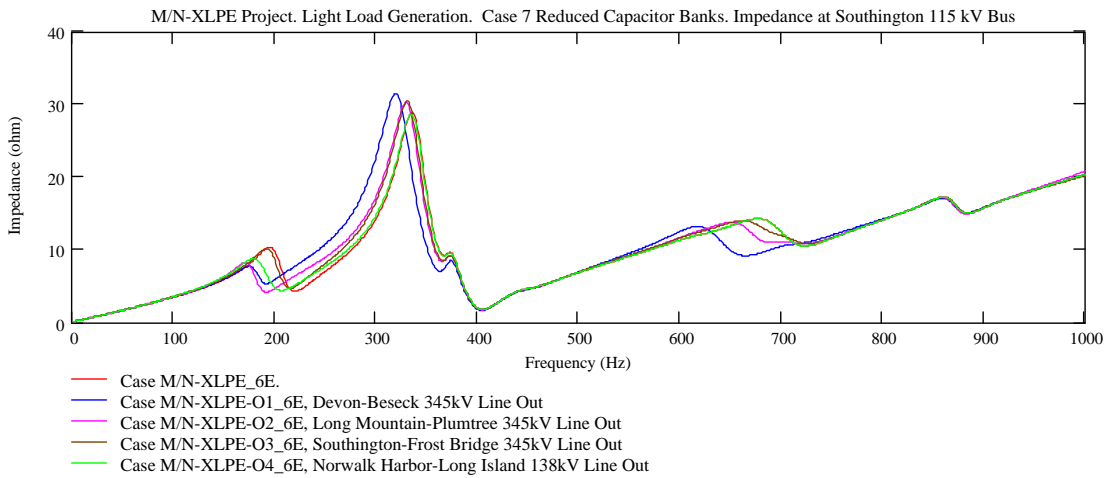
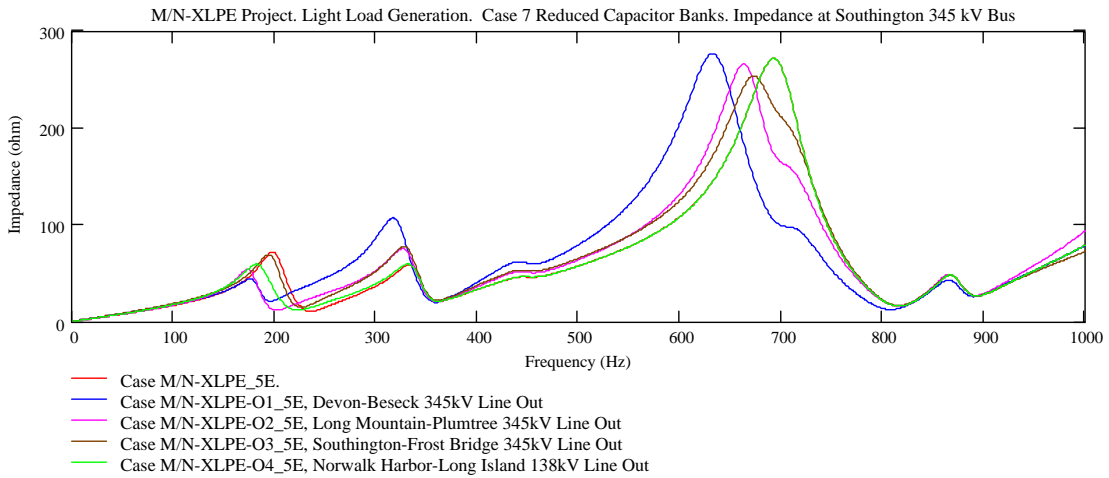
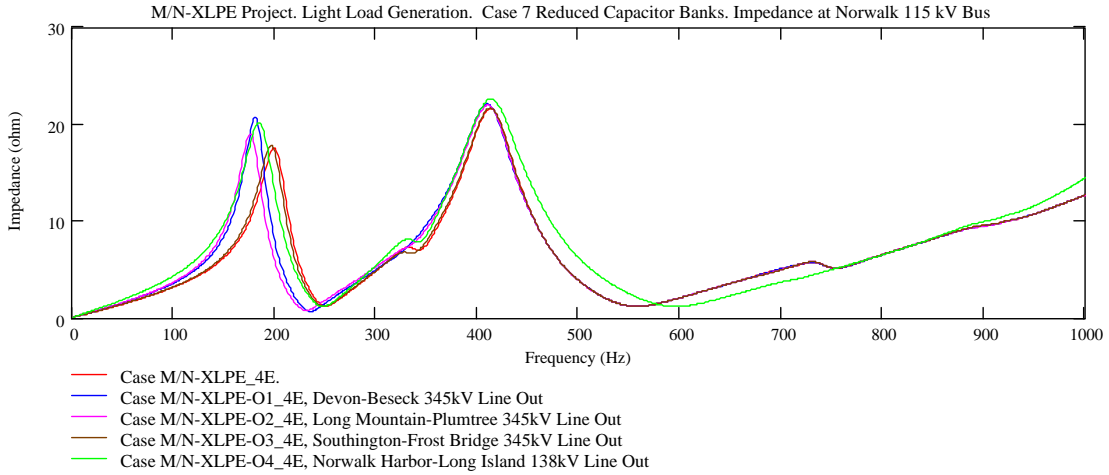
Table 5 summarizes the variation in frequencies of the first resonance points for the M/N project and for the XLPE alternative, with the original light load generator dispatch and with more local generation off. With all lines in service, the first resonance is slightly above the the 3rd harmonic frequency (3.2 pu - 3.4 pu) for the light load generator dispatch, but it is almost right on the 3rd harmonic (2.9 pu - 3.1 pu) with more local generation off. The transmission line outages lower the first resonance frequency in the order of 0.1-0.4 pu (6-24 Hz). This lowering of the first resonance frequency is generally accompanied with increased resonance impedance amplitude. It can be concluded that the likelihood and severity of system resonance at the 3rd harmonic frequency will increase with transmission line outages in the NU System (XLPE Alternative Case 7).

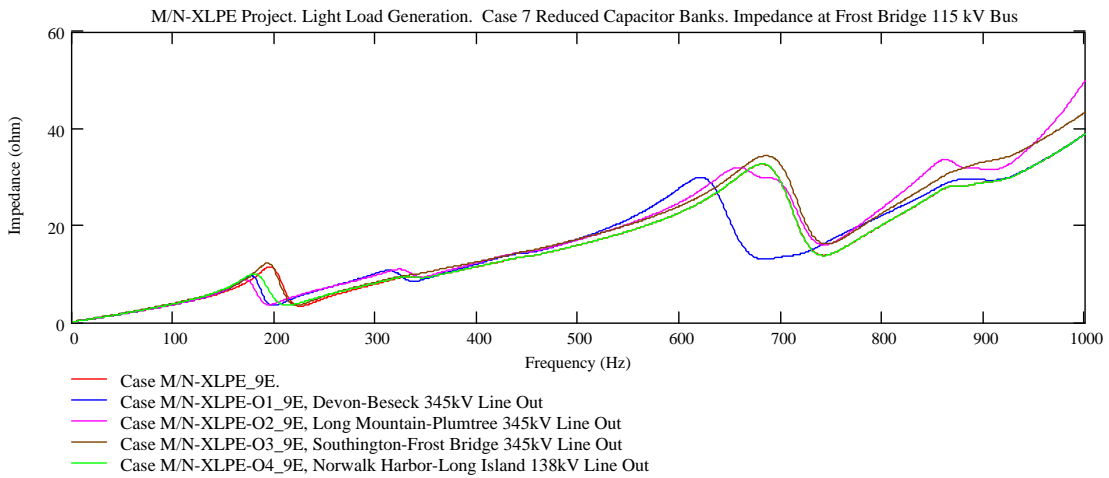
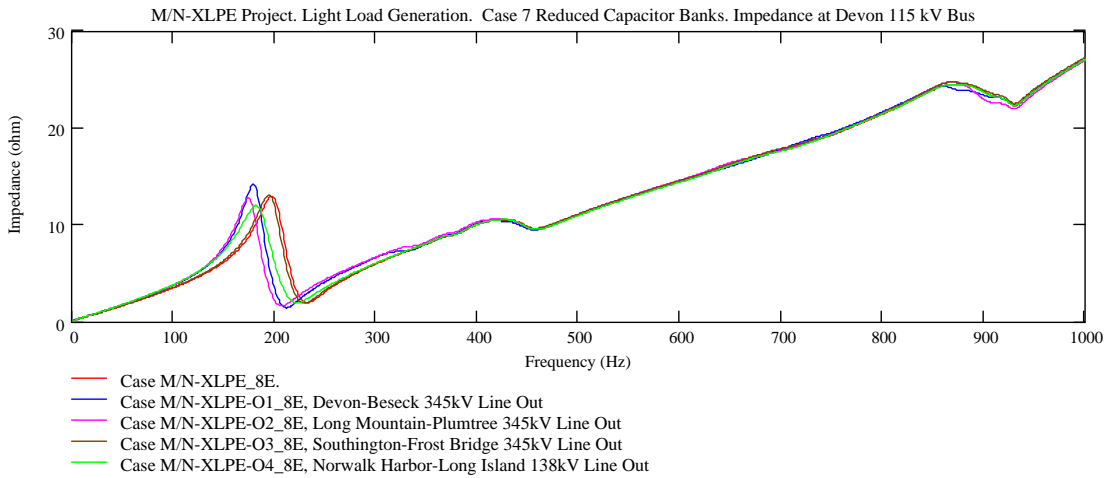
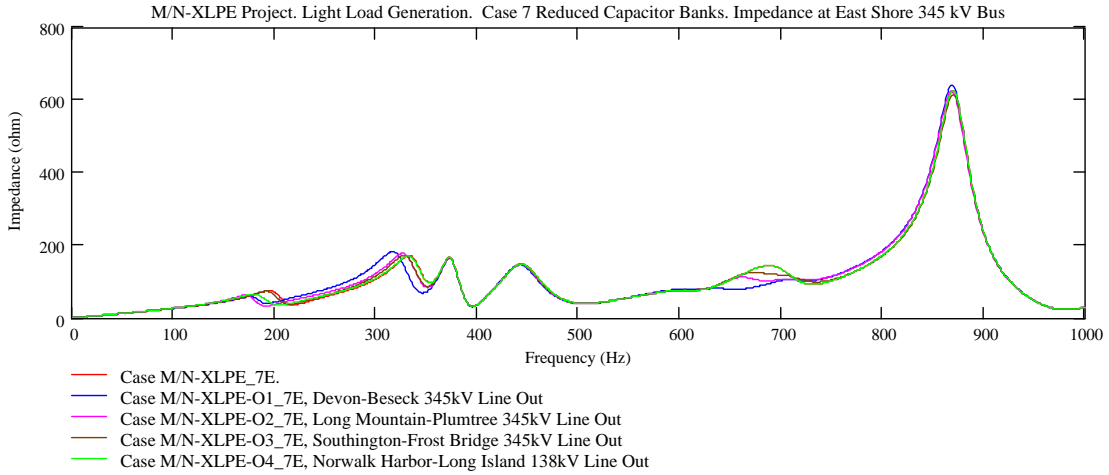
Table 5. Variation in Frequency of First Resonance Points (pu 60 Hz)

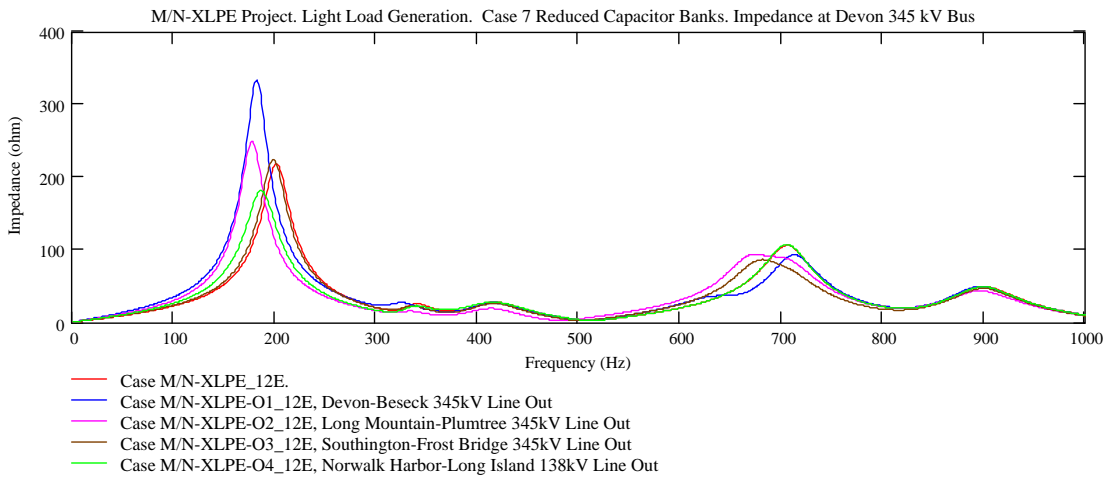
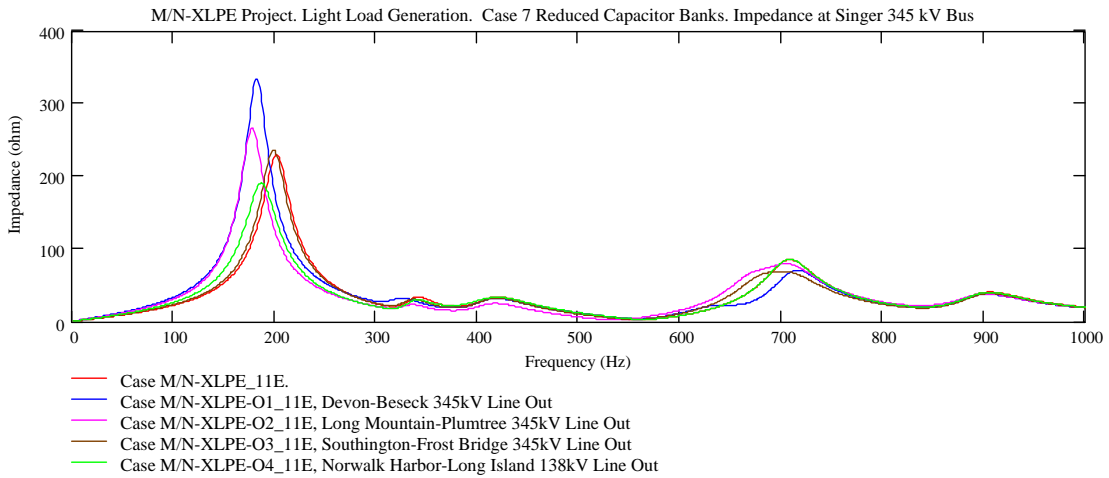
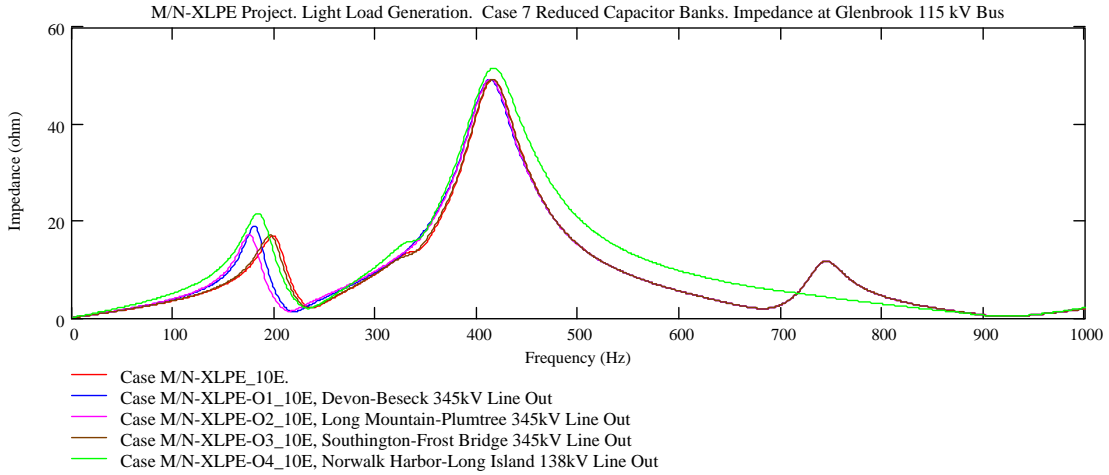
Transmission Line Outage	M/N Project with XLPE Cable (Original Light Load Generator Dispatch)	M/N Project with XLPE Cable (Local Generators Off)
All lines in service	3.2-3.4	2.9-3.1
Devon-Beseck 345kV Line Out	2.9-3.0	2.6-2.8
Long Mtn-Plumtree 345kV Line Out	2.9-3.0	2.5-2.7
Southington-Frost Bridge 345 Line Out	3.2-3.3	2.9-3.0
Norwalk Harbor-Long Island 138kV LineOut	3.0-3.1	2.6-2.7

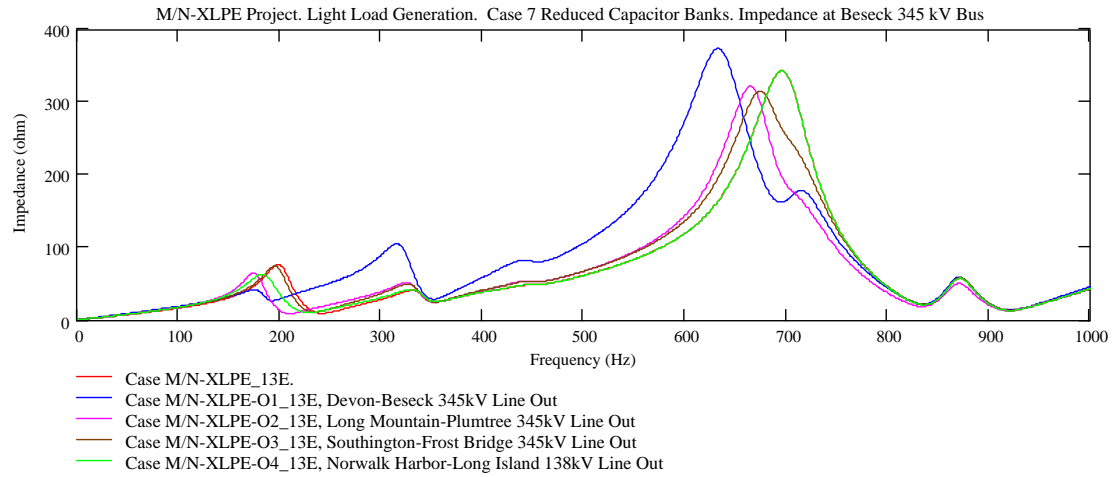
Appendix A Driving-Point Impedance Plots with Light Load Generation











Appendix B Driving-Point Impedance Plots with Local Generators Off

