

Appendix K: System Strength

Long Island Offshore Wind Export Public Policy Transmission Need Evaluation

**A Report from the New York
Independent System Operator**

DRAFT for May 16, 2023 ESPWG

Appendix K: Operability & Resiliency – System Strength

System Strength

System Strength refers to system voltage and reactive strength performance. Short circuit ratio is a common screening method to obtain a high-level understanding of the system strength. In order to measure system strength with multiple inverter-based resources (IBRs) in close proximity to each other, the weighted short circuit ratio (WSCR) is calculated at critical points in the system. The WSCR is calculated with the formula below:

$$WSCR = \frac{\sum_i^n SCMVA_i \times P_{RMVAi}}{(\sum_i^n P_{RMVAi})^2}$$

Where $SCMVA_i$ is the short circuit capacity at bus i before the connection of IBR i and P_{RMVAi} is the MVA rating of IBR i to be connected, n is the number of IBRs, and i is IBR.

Figure 1 shows the relative short circuit results at Barrett offshore wind Point of Interconnection (POI), Ruland Rd offshore wind POI, Holbrook offshore wind POI, and applicable HVDC POI(s) for the pre-project Baseline case and each post-project case. The WSCR was calculated under operating conditions with reduced synchronous generation using CY21 ATBA light load case for all-lines-in-service (N-0), and system outages loss of Y49 (N-1), outage of Y49 and Y50 (N-2), and loss of Y49, Y50, and a project tie line (N-3). The higher the WSCR number, the stronger the system is and generally the easier it is to integrate IBRs such as energy storage and offshore wind generation. The lower the WSCR number, the weaker the system is and there may additional system monitoring or studies required. NERC does not have a WSCR reliability criteria.

Figure 1: Summary of WSCR under Spring Light Load Condition (SLL)

Project	WSCR			
	N-0	N-1	N-2	N-3
Pre-Project	1.94	1.83	1.61	N/A
T035 - LS Power	0.82	0.78	0.70	N/A
T036 - NextEra Core 1	2.49	2.46	2.39	2.12
T037 - NextEra Core 2	2.65	2.63	2.59	2.47
T038 - NextEra Core 3	2.50	2.45	2.38	2.26
T039 - NextEra Core 4	2.55	2.49	2.40	2.17
T040 - NextEra Core 5	2.54	2.48	2.40	2.16
T041 - NextEra Core 6	1.79	1.75	1.68	1.45
T042 - NextEra Core 7	1.79	1.75	1.68	1.45
T043 - NextEra Enh 1	1.47	1.47	1.44	1.39
T044 - NextEra Enh 2	1.91	1.90	1.87	1.78
T047 - Propel Base 1	2.26	2.23	2.11	1.95

T048 - Propel Base 2	2.21	2.15	2.02	1.78
T049 - Propel Base 3	2.24	2.20	2.06	1.87
T051 - Propel Alt 5	2.29	2.26	2.17	2.09
T052 - Propel Alt 6	2.59	2.55	2.42	2.32
T053 - Propel Alt 7	1.34	1.31	1.21	1.07

Detailed calculation for pre-project cases and the case for each project are detailed in the following figures. In reviewing the following figures, the column titled, “Elements Out-of-Service,” indicates system conditions as N-0, N-1, N-2, and applicable N-3; column titled, “POI Name,” refers to the bus name where offshore wind or HVDC facilities connect; column titled, “ P_{RMVA} ,” is the MVA rating of offshore wind or HVDC facilities; column titled, “SCMVA,” is the short circuit capacity at each POI bus; column titled, “ $SCMVA \times P_{RMVA}$,” is the short circuit capacity at each POI bus by MVA rating of offshore wind or HVDC facilities at the same bus; column titled, “WSCR,” indicates the comparable system strength for each project under each system condition.

Figure 2: Pre-Project Detailed WSCR under SLL

Elements Out-of-Service	POI Name	Inverter MVA	SCMVA	SCMVAXP _{RMVA}	WSCR
Base Case N-0	Barrett 138 kV	1399	6564	9186447	2.00
	Ruland Road 138 kV	889	6636	5896658	
	Holbrook 138 kV	977	6397	6250045	
Y49: EGC-Sprain Brook 345 kV	Barrett 138 kV	1399	6200	8676162	1.92
	Ruland Road 138 kV	889	6338	5631914	
	Holbrook 138 kV	977	6334	6187888	
Y49: EGC-Sprain Brook 34 5kV Y50: Shore Rd-Dunwoodie 345 kV	Barrett 138 kV	1399	5155	7213852	1.69
	Ruland Road 138 kV	889	5469	4859222	
	Holbrook 138 kV	977	6034	5895394	

Figure 3: T035 LS Power Detailed WSCR under SLL

Elements Out-of-Service	POI Name	Inverter MVA	SCMVA	SCMVAXP _{RMVA}	WSCR
Base Case N-0	Barrett 138 kV	1399	6328	8856091	0.82
	Ruland Road 138 kV	889	6167	5479261	
	Holbrook 138 kV	977	6328	6182671	
	Southgate 345 kV	4314	6167	26604007	
Y49: EGC-Sprain Brook 345kV	Barrett 138 kV	1399	6197	8673125	0.78
	Ruland Road 138 kV	889	5811	5163622	
	Holbrook 138 kV	977	6197	6054938	
	Southgate 345 kV	4314	5811	25068438	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV	Barrett 138 kV	1399	5877	8224263	0.70
	Ruland Road 138 kV	889	5034	4473005	
	Holbrook 138 kV	977	5877	5741575	
	Southgate 345 kV	4314	5034	21715813	

Figure 4: T036 NextEra Core 1 Detailed WSCR under SLL

Elements Out-of-Service	POI Name	Inverter MVA	SCMVA	SCMVAxP _{RMVA}	WSCR
Base Case N-0	Barrett 138 kV	1399	7912	11072528	2.49
	Ruland Road 138 kV	889	9837	8740666	
	Holbrook 138 kV	977	6850	6692450	
Y49: EGC-Sprain Brook 345kV	Barrett 138 kV	1399	7727	10813627	2.45
	Ruland Road 138 kV	889	9749	8662474	
	Holbrook 138 kV	977	6840	6682680	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV	Barrett 138 kV	1399	7334	10263640	2.37
	Ruland Road 138 kV	889	9525	8463439	
	Holbrook 138 kV	977	6743	6587911	
Y49: EGC-Sprain Brook 345kV, Y50: Shore Rd-Dunwoodie 345kV Project Tie: Sprain Brook to Ruland Road 345 kV	Barrett 138 kV	1399	7098	9933367	2.10
	Ruland Road 138 kV	889	7128	6333584	
	Holbrook 138 kV	977	6269	6124813	

Figure 5: T037 NextEra Core 2 Detailed WSCR under SLL

Elements Out-of-Service	POI Name	Inverter MVA	SCMVA	SCMVAxP _{RMVA}	WSCR
Base Case N-0	Barrett 138 kV	1399	9175	12840046	2.65
	Ruland Road 138 kV	889	9722	8638483	
	Holbrook 138 kV	977	6947	6787219	
Y49: EGC-Sprain Brook 345kV	Barrett 138 kV	1399	9112	12751880	2.64
	Ruland Road 138 kV	889	9680	8601164	
	Holbrook 138 kV	977	6930	6770610	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV	Barrett 138 kV	1399	8926	12491580	2.60
	Ruland Road 138 kV	889	9563	8497204	
	Holbrook 138 kV	977	6868	6710036	
Y49: EGC-Sprain Brook 345kV, Y50: Shore Rd-Dunwoodie 345kV Project Tie: Sprain Brook to Ruland Road 345 kV	Barrett 138 kV	1399	8894	12446797	2.48
	Ruland Road 138 kV	889	8341	7411396	
	Holbrook 138 kV	977	6686	6532222	

Figure 6: T038 NextEra Core 3 Detailed WSCR under SLL

Elements Out-of-Service	POI Name	Inverter MVA	SCMVA	SCMVAxP _{RMVA}	WSCR
Base Case N-0	Barrett 138 kV	1399	7921	11085123	2.50
	Ruland Road 138 kV	889	9603	8532746	
	Holbrook 138 kV	977	7205	7039285	
Y49: EGC-Sprain Brook 345kV	Barrett 138 kV	1399	7695	10768845	2.46
	Ruland Road 138 kV	889	9488	8430562	
	Holbrook 138 kV	977	7177	7011929	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV	Barrett 138 kV	1399	7296	10210460	2.38
	Ruland Road 138 kV	889	9285	8250187	
	Holbrook 138 kV	977	7098	6934746	
Y49: EGC-Sprain Brook 345kV, Y50: Shore Rd-Dunwoodie 345kV Project Tie: Sprain Brook to Ruland Road 345 kV	Barrett 138 kV	1399	7199	10074713	2.27
	Ruland Road 138 kV	889	8207	7292330	
	Holbrook 138 kV	977	6980	6819460	

Figure 7: T039 NextEra Core 4 Detailed WSCR under SLL

Elements Out-of-Service	POI Name	Inverter MVA	SCMVA	SCMVAxP _{RMVA}	WSCR
Base Case N-0	Barrett 138 kV	1399	7732	10820625	2.55
	Ruland Road 138 kV	889	10365	9209821	
	Holbrook 138 kV	977	7361	7191697	
Y49: EGC-Sprain Brook 345kV	Barrett 138 kV	1399	7420	10383993	2.50
	Ruland Road 138 kV	889	10216	9077427	
	Holbrook 138 kV	977	7324	7155548	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV	Barrett 138 kV	1399	6930	9698258	2.41
	Ruland Road 138 kV	889	9985	8872172	
	Holbrook 138 kV	977	7236	7069572	
Y49: EGC-Sprain Brook 345kV, Y50: Shore Rd-Dunwoodie 345kV Project Tie: Sprain Brook to Ruland Road 345 kV	Barrett 138 kV	1399	6684	9353991	2.17
	Ruland Road 138 kV	889	7908	7026653	
	Holbrook 138 kV	977	6952	6792104	

Figure 8: T040 NextEra Core 5 Detailed WSCR under SLL

Elements Out-of-Service	POI Name	Inverter MVA	SCMVA	SCMVAxP _{RMVA}	WSCR
Base Case N-0	Barrett 138 kV	1399	7717	10799633	2.55
	Ruland Road 138 kV	889	10321	9170725	
	Holbrook 138 kV	977	7334	7165318	
Y49: EGC-Sprain Brook 345kV	Barrett 138 kV	1399	7408	10367200	2.49
	Ruland Road 138 kV	889	10174	9040108	
	Holbrook 138 kV	977	7298	7130146	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV	Barrett 138 kV	1399	6915	9677266	2.40
	Ruland Road 138 kV	889	9939	8831298	
	Holbrook 138 kV	977	7210	7044170	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV Project Tie: Sprain Brook to Ruland Road 345 kV	Barrett 138 kV	1399	6669	9332999	2.17
	Ruland Road 138 kV	889	7869	6992000	
	Holbrook 138 kV	977	6926	6766702	

Figure 9: T041 NextEra Core 6 Detailed WSCR under SLL

Elements Out-of-Service	POI Name	Inverter MVA	SCMVA	SCMVAxP _{RMVA}	WSCR
Base Case N-0	Barrett 138 kV	1399	7623	10668084	1.79
	Ruland Road 138 kV	889	9690	8610050	
	Holbrook 138 kV	977	6846	6688542	
	NPT_GIS 138 kV	1265	8543	10806895	
Y49: EGC-Sprain Brook 345kV	Barrett 138 kV	1399	7306	10224455	1.75
	Ruland Road 138 kV	889	9513	8452776	
	Holbrook 138 kV	977	6805	6648485	
	NPT_GIS 138 kV	1265	8442	10679130	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV	Barrett 138 kV	1399	6793	9506532	1.69
	Ruland Road 138 kV	889	9212	8185323	
	Holbrook 138 kV	977	6684	6530268	
	NPT_GIS 138 kV	1265	8232	10413480	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV Project Tie: Sprain Brook to Ruland Road 345 kV	Barrett 138 kV	1399	6437	9008324	1.45
	Ruland Road 138 kV	889	6653	5911523	
	Holbrook 138 kV	977	6141	5999757	
	NPT_GIS 138 kV	1265	7051	8919515	

Figure 10: T042 NextEra Core 7 Detailed WSCR under SLL

Elements Out-of-Service	POI Name	Inverter MVA	SCMVA	SCMVAxP _{RMVA}	WSCR
Base Case N-0	Barrett 138 kV	1399	7626	10672282	1.79
	Ruland Road 138 kV	889	9693	8612715	
	Holbrook 138 kV	977	6848	6690496	
	NPT_GIS_138 138.00	1265	8545	10809425	
Y49: EGC-Sprain Brook 345kV	Barrett 138 kV	1399	7308	10227254	1.76
	Ruland Road 138 kV	889	9516	8455442	
	Holbrook 138 kV	977	6807	6650439	
	NPT_GIS_138 138.00	1265	8444	10681660	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV	Barrett 138 kV	1399	6796	9510730	1.69
	Ruland Road 138 kV	889	9215	8187988	
	Holbrook 138 kV	977	6686	6532222	
	NPT_GIS_138 138.00	1265	8235	10417275	
Y49: EGC-Sprain Brook 345kV, Y50: Shore Rd-Dunwoodie 345kV Project Tie: Sprain Brook to Ruland Road 345 kV	Barrett 138 kV	1399	6439	9011123	1.45
	Ruland Road 138 kV	889	6655	5913300	
	Holbrook 138 kV	977	6142	6000734	
	NPT_GIS_138 138.00	1265	7052	8920780	

Figure 11: T043 NextEra Enh 1 Detailed WSCR under SLL

Elements Out-of-Service	POI Name	Inverter MVA	SCMVA	SCMVAxP _{RMVA}	WSCR
Base Case N-0	Barrett 138 kV	1399	8687	12157109	1.48
	Ruland Road 138 kV	889	9257	8225307	
	Holbrook 138 kV	977	7511	7338247	
	BAR_GIS_138	1265	8687	10989055	
Y49: EGC-Sprain Brook 345kV	NPT_GIS_138 138.00	1265	8651	10943515	1.47
	Barrett 138 kV	1399	8609	12047951	
	Ruland Road 138 kV	889	9213	8186211	
	Holbrook 138 kV	977	7497	7324569	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV	BAR_GIS_138	1265	8609	10890385	1.44
	NPT_GIS_138 138.00	1265	8625	10910625	
	Barrett 138 kV	1399	8393	11745668	
	Ruland Road 138 kV	889	9074	8062703	
Y49: EGC-Sprain Brook 345kV, Y50: Shore Rd-Dunwoodie 345kV Project Tie: Sprain Brook to Ruland Road 345 kV	Holbrook 138 kV	977	7414	7243478	1.39
	BAR_GIS_138	1265	8393	10617145	
	NPT_GIS_138 138.00	1265	8516	10772740	
	Barrett 138 kV	1399	8384	11733073	

Figure 12: T044 NextEra Enh 2 Detailed WSCR under SLL

Elements Out-of-Service	POI Name	Inverter MVA	SCMVA	SCMVAxP _{RMVA}	WSCR
Base Case N-0	Barrett 138 kV	1399	8841	12372626	1.91
	Ruland Road 138 kV	889	9389	8342596	
	Holbrook 138 kV	977	7600	7425200	
	NPT_GIS_138 138.00	1265	8770	11094050	
Y49: EGC-Sprain Brook 345kV	Barrett 138 kV	1399	8757	12255071	1.90
	Ruland Road 138 kV	889	9338	8297280	
	Holbrook 138 kV	977	7580	7405660	
	NPT_GIS_138 138.00	1265	8737	11052305	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV	Barrett 138 kV	1399	8542	11954187	1.87
	Ruland Road 138 kV	889	9201	8175549	
	Holbrook 138 kV	977	7498	7325546	
	NPT_GIS_138 138.00	1265	8630	10916950	
Y49: EGC-Sprain Brook 345kV, Y50: Shore Rd-Dunwoodie 345kV Project Tie: Sprain Brook to Ruland Road 345 kV	Barrett 138 kV	1399	8523	11927598	1.78
	Ruland Road 138 kV	889	8097	7194589	
	Holbrook 138 kV	977	7270	7102790	
	NPT_GIS_138 138.00	1265	8203	10376795	

Figure 13: T047 Propel Base 1 Detailed WSCR under SLL

Elements Out-of-Service	POI Name	Inverter MVA	SCMVA	SCMVAxP _{RMVA}	WSCR
Base Case N-0	Barrett 138 kV	1399	7911	11071128	2.33
	Ruland Road 138 kV	889	8160	7250568	
	Holbrook 138 kV	977	6678	6524406	
Y49: EGC-Sprain Brook 345kV	Barrett 138 kV	1399	7728	10815027	2.28
	Ruland Road 138 kV	889	7952	7065750	
	Holbrook 138 kV	977	6621	6468717	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV	Barrett 138 kV	1399	7093	9926370	2.15
	Ruland Road 138 kV	889	7546	6704998	
	Holbrook 138 kV	977	6486	6336822	
Y49: EGC-Sprain Brook 345kV, Y50: Shore Rd-Dunwoodie 345kV Project Tie: Sprain Brook to Shore Road 345 kV	Barrett 138 kV	1399	6469	9053107	1.98
	Ruland Road 138 kV	889	6685	5939957	
	Holbrook 138 kV	977	6265	6120905	

Figure 14: T048 Propel Base 2 Detailed WSCR under SLL

Elements Out-of-Service	POI Name	Inverter MVA	SCMVA	SCMVAxP _{RMVA}	WSCR
Base Case N-0	Barrett 138 kV	1399	7375	10321647	2.21
	Ruland Road 138 kV	889	7650	6797683	
	Holbrook 138 kV	977	6555	6403952	
Y49: EGC-Sprain Brook 345kV	Barrett 138 kV	1399	7093	9926468	2.15
	Ruland Road 138 kV	889	7517	6679221	
	Holbrook 138 kV	977	6509	6359352	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV	Barrett 138 kV	1399	6442	9015069	2.02
	Ruland Road 138 kV	889	7132	6337236	
	Holbrook 138 kV	977	6356	6210173	
Y49: EGC-Sprain Brook 345kV, Y50: Shore Rd-Dunwoodie 345kV Project Tie: Sprain Brook to Ruland Rd 345 kV	Barrett 138 kV	1399	6138	8589536	1.78
	Ruland Road 138 kV	889	5224	4641341	
	Holbrook 138 kV	977	5902	5766655	

Figure 15: T049 Propel Base 3 Detailed WSCR under SLL

Elements Out-of-Service	POI Name	Inverter MVA	SCMVA	SCMVAxP _{RMVA}	WSCR
Base Case N-0	Barrett 138 kV	1399	7697	10771644	2.29
	Ruland Road 138 kV	889	8032	7136834	
	Holbrook 138 kV	977	6628	6475556	
Y49: EGC-Sprain Brook 345kV	Barrett 138 kV	1399	7539	10550529	2.25
	Ruland Road 138 kV	889	7870	6992889	
	Holbrook 138 kV	977	6599	6447223	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV	Barrett 138 kV	1399	6723	9408570	2.08
	Ruland Road 138 kV	889	7334	6516626	
	Holbrook 138 kV	977	6417	6269409	
Y49: EGC-Sprain Brook 345kV, Y50: Shore Rd-Dunwoodie 345kV Project Tie: Sprain Brook to Shore Road 345 kV	Barrett 138 kV	1399	6012	8413554	1.89
	Ruland Road 138 kV	889	6439	5721373	
	Holbrook 138 kV	977	6170	6028090	

Figure 16: T051 Propel Alt 5 Detailed WSCR under SLL

Elements Out-of-Service	POI Name	Inverter MVA	SCMVA	SCMVAxP _{RMVA}	WSCR
Base Case N-0	Barrett 138 kV	1399	7625	10670980	2.29
	Ruland Road 138 kV	889	8125	7219869	
	Holbrook 138 kV	977	6633	6480802	
Y49: EGC-Sprain Brook 345kV	Barrett 138 kV	1399	7536	10546093	2.26
	Ruland Road 138 kV	889	8019	7125362	
	Holbrook 138 kV	977	6611	6459357	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV	Barrett 138 kV	1399	7095	9929770	2.17
	Ruland Road 138 kV	889	7713	6853306	
	Holbrook 138 kV	977	6507	6357583	
Y49: EGC-Sprain Brook 345kV, Y50: Shore Rd-Dunwoodie 345kV Project Tie: Sprain Brook to Shore Road 345 kV	Barrett 138 kV	1399	6827	9554589	2.09
	Ruland Road 138 kV	889	7290	6477343	
	Holbrook 138 kV	977	6411	6264016	

Figure 17: T052 Propel Alt 6 Detailed WSCR under SLL

Elements Out-of-Service	POI Name	Inverter MVA	SCMVA	SCMVAxP _{RMVA}	WSCR
Base Case N-0	Barrett 138 kV	1399	9859	13796660	2.59
	Ruland Road 138 kV	889	8195	7281685	
	Holbrook 138 kV	977	6652	6499141	
Y49: EGC-Sprain Brook 345kV	Barrett 138 kV	1399	9652	13507308	2.55
	Ruland Road 138 kV	889	8109	7205545	
	Holbrook 138 kV	977	6633	6480763	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV	Barrett 138 kV	1399	8962	12541835	2.42
	Ruland Road 138 kV	889	7755	6890963	
	Holbrook 138 kV	977	6520	6370138	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV Project Tie: Sprain Brook to Shore Road 345 kV	Barrett 138 kV	1399	8459	11837640	2.32
	Ruland Road 138 kV	889	7383	6560262	
	Holbrook 138 kV	977	6433	6285344	

Figure 18: T053 Propel Alt 7 Detailed WSCR under SLL

Elements Out-of-Service	POI Name	Inverter MVA	SCMVA	SCMVAxP _{RMVA}	WSCR
Base Case N-0	Barrett 138 kV	1399	7256	10154846	1.34
	Ruland Road 138 kV	889	7501	6664765	
	Holbrook 138 kV	977	6495	6345146	
	Northport 345 kV	1500	4807	7209855	
Y49: EGC-Sprain Brook 345kV	Barrett 138 kV	1399	6941	9714156	1.31
	Ruland Road 138 kV	889	7349	6529838	
	Holbrook 138 kV	977	6442	6293492	
	Northport 345 kV	1500	4754	7131375	
Y49: EGC-Sprain Brook 345kV Y50: Shore Rd-Dunwoodie 345kV	Barrett 138 kV	1399	6008	8407382	1.21
	Ruland Road 138 kV	889	6852	6088389	
	Holbrook 138 kV	977	6243	6099606	
	Northport 345 kV	1500	4553	6829365	
Y49: EGC-Sprain Brook 345kV, Y50: Shore Rd-Dunwoodie 345kV Project Tie: Sprain Brook to Ruland Rd 345 kV	Barrett 138 kV	1399	5643	7896803	1.07
	Ruland Road 138 kV	889	4989	4432612	
	Holbrook 138 kV	977	5763	5630500	
	Northport 345 kV	1500	4208	6311820	