Redington Wind Farm Power Project

Substation and Transmission Line

DESIGN CRITERIA

Second Draft

V90 UPDATE

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DESCRIPTION OF FACILITIES – Redington Wind Farm Project

The facilities described are for installation at the proposed Endless Energy Corporation's Nash Stream Substation, the proposed wind farm collector systems on Redington Pond Range and Black Nubble mountain ranges, and a proposed 115 kV transmission line between the Nash Stream Substation and Central Maine Power Company's Bigelow Substation:

The Nash Stream site will contain the following:

- Air insulated 115/34.5 kV substation.
- Connection to one (1) overhead 115 kV transmission line.
- Connection to two (2) overhead 34.5 kV generator exit lines.
- Integration of protection with CMP's Bigelow Substation.

The Redington Pond Range site will contain the following:

- Underground 34.5 kV collector system for 12 Vestas V90-3.0 MW wind turbines.
- Underground to Overhead generator exit transition.

The Black Nubble site will contain the following:

- Underground 34.5 kV collector system for 18 Vestas V90-3.0 MW wind turbines.
- Underground to Overhead generator exit transition.

CODES & STANDARDS

Design will comply with all applicable local, state, and federal laws and requirements, be consistent with accepted electric utility industry practices, and be consistent with the following codes and standards::

American Concrete Instiute (ACI):

ACI 301	Specification for Structural Concrete for Buildings
ACI 318	Building Code Requirement for Structural Concrete

American Institute of Steel Construction (AISC):

AISC	Manual of Steel Construction - 9th Edition

American National Standards Institute (ANSI):

ANSI-C2	National Electric Safety Code
ANSI-C37.04	Standard Rating Structure for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis (Including Supplements)
ANSI-C37.06	Standard for Switchgear-AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis-Preferred Ratings and Related Required Capabilities
ANSI-C37.09	Standard Test Procedure for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
ANSI-C37.010	Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
ANSI-C37.11	Standard Requirements for Electrical Control High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
ANSI-C37.12	Specifications Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
ANSI-C37.2	Standard Electrical Power System Device Function Numbers
ANSI-C37.30	Standard Requirements for High Voltage Switches
ANSI-C37.32	Standard for Switchgear-High Voltage Air Switches, Bus Supports, and Switch Accessories-Schedules of Preferred Ratings, Specifications, and Application Guide
ANSI-C37.33	Standard for Switchgear-High Voltage Air Switches-Rated Control Voltages and Their Ranges
ANSI-C37.34	Standard Test Code for High Voltage Air Switches
ANSI-C37.37	Standard Loading Guide for AC High Voltage Switches
ANSI-C37.73	Standard Requirements for Pad Mounted Fused Switchgear
ANSI-C37.74	Standard Requirements for Subsurface, Vault, and Pad Mounted Load Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems Up to 38 kV
ANSI-C37.100	Standard Definitions for Power Switchgear
ANSI-C57.13	Requirements for Instrument Transformers
ANSI-C57.13.1	Guide for Field Testing of Relaying Current Transformers
ANSI-C57.13.2	Conformance Test Procedures for Instrument Transformers
ANSI-C57.13.3	Guide for the Grounding of Instrument Transformer Secondary Circuits

American Society of Civil Engineers (ASCE):

- ASCE 7-95 Minimum Design Loads for Buildings and Other Structures
- ASCE 52 Guide for the Design of Steel Transmission Towers
- ASCE 10-90 Design of Latticed Steel Transmission Structures

American Society for Testing Materials (ASTM):

- ASTM A-36 Standard Specification for Structural Steel
- ASTM A-123 Standard Specification for Zinc Coatings (Hot Dip Galvanizing) on Iron and Steel Products
- ASTM A-143 Practice for Safeguarding against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
- ASTM A-153 Standard Specification for Zinc Coatings on Iron and Steel Hardware
- ASTM A-185 Welded Wire Fabric
- ASTM A-307 Specification for Carbon Steel Bolts and Studs 60,000 PSI Tensile Strength
- ASTM A-325 High Strength Bolts for Structural Steel Bolts
- ASTM A-394 Specification for Steel Transmission Tower Bolts Zinc Coated and Bare
- ASTM A-500 Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
- ASTM A-572 Specification for High-Strength Low-Alloy Columbium Vanadium Structural Steel
- ASTM A-615 Reinforcing Steel
- ASTM D2472 Sulfur Hexafluoride (SF6) Gas

National Electric Manufacturers Association (NEMA):

- NEMA SG6 Power Switching Equipment
- NEMA TT1 Tapered Tubular Steel Structures

National Fire Protection Asociation (NFPA):

- NFPA-1 Fire Prevention Code
- NFPA-10 Portable Fire Extinguishers
- NFPA-13 Installation of Sprinkler Systems
- NFPA-25 Maintenance of Water Based Fire Protection Systems
- NFPA-30 Flammable and Combustible Liquids
- NFPA-70 National Electric Code
- NFPA-72 National Alarm Code
- NFPA-101 Life Safety Code

Central Maine Power Company (CMP)

- Line and Substation Standards
- Interconnection Requirements for Generation

New England Power Pool (NePOOL)

- Reliability Standards

Institute of Electric and Electronic Engineers (IEEE):

IEEE C62	Guides and Standards for Surge Protection
IEEE 80	Guide for Safety in AC Substation Grounding
IEEE 81	Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE 81.2	Guide for Measurement of Impedance and Safety Characteristics of Large, Extended, or Interconnected Grounding Systems
IEEE 142	Recommended Practice for Grounding of Indusrial and Commercial Power Systems
IEEE 484	Recommended Practice for Installation Design and Installation of Vented Lead Acid Batteries for Stationary Applications
IEEE 485	Recommended Practice for Sizing Lead Acid Batteries for Stationary Applications
IEEE 487	Recommended Practice for the Protection of Wire Line Communication Facilities Serving Electric Power Stations
IEEE 525	Guide for the Design and Installation of Cable Systems in Substations
IEEE 605	Guide for the Design of Substation Rigid Bus Structures
IEEE 693	Recommended Practice for Seismic Design of Substations
IEEE 979	Guide for Substation Fire Protection
IEEE 998	Guide for Direct Lightning Stroke Shielding of Substations

International Electro-Technical Commission (IEC) Standards:

IEC 51	Direct Acting Indicating Analog Electrical Measuring Instruments and Their Accessories
IEC 56	High Voltage Alternating Current Circuit Breakers
IEC 68	Environmental Testing
IEC 99-4	Metal Oxide Surge Arrester Without Gaps for AC Systems
IEC 129	Alternating Current Isolators and Earthing Switches
IEC 137	Bushings for Alternating Voltages Above 1000 volts
IEC 185	Current Transformers
IEC 186	Voltage Transformers
IEC 255	Electrical Relays
IEC 269	Low Voltage Fuses
IEC 376	Specification and Acceptance of New Sulfur Hexafloride Equipment (Including Supplements 376A & 376B)
IEC 414	Safety Requirements for Indicating and Recording Electrical Measuring Instruments and Their Accessories
IEC 473	Dimensions for Panel Mounted Indicating and Recording Electrical Instruments
IEC 480	Guide to Checking Sulfur Hexafloride Taken from Electrical Equipment
IEC 651	Precision Sound Level Meters
IEC 688	Electrical Measuring Transducers for Converting AC Electrical Quantities into DC Electrical Quantities

GENERAL CRITERIA

Owner/Purchaser	Endless Energy	Endless Energy	Endless Energy
Site Name Geographic Location	Nash Stream Redington	Redington Pond Redington	Black Nubble Redington
Elevation above mean sea level (MSL)	2100 feet	3800 feet	3600 feet
Max outside ambient air temperature (°F)	98	98	98
Min outside ambient air temperature (°F)	-37	-37	-37
Max relative humidity (percent)	To Be Defined	To Be Defined	To Be Defined
Min relative humidity (percent)	To Be Defined	To Be Defined	To Be Defined
Maximum allowable sound level at site boundary (dB)	To Be Defined	To Be Defined	To Be Defined
Atmospheric pollution level	N/A	N/A	N/A
Max wind design speed (mph/psf) no ice, 60 °F	To Be Defined	To Be Defined	To Be Defined
Shape Factors for Wind Loads:			
Flat Surfaces	1.6	1.6	1.6
Cylindrical	1.0	1.0	1.0
Gust Factors	1.3	1.3	1.3
Max design ice load @ 4 psf wind & 0 °F (in)	0.5	0.5	0.5
Soil resistivity (ohm-meters)	To be Defined	To be Defined	To be Defined
Soil Criteria:	To be Defined	To be Defined	To be Defined
Net bearing capability (lbs/ft^2): (1/2 ultimate maximum)	To Be Defined	To Be Defined	To Be Defined
Dry Density:	To Be Defined	To Be Defined	To Be Defined
Buoyant density	To Be Defined	To Be Defined	To Be Defined
Frost penetration (inches)	60	60	60

	Nash Stream	Redington Pond	Black Nubble
GENERAL CRITERIA			
Foundation Stability (Factor of Safety):			
NESC Heavy Load:	1.5	1.5	1.5
NESC High Wind:	1.5	1.5	1.5
Transmission Exit Structures:			
Safety Factor:	1.65	1.65	1.65
Maximum Horizontal Deflection:			
Phase Conductors	2.0 %	2.0 %	2.0 %
Static Wires	4.0 %	4.0 %	4.0 %
Wind & Conductor Loading Factor	1.25	1.25	1.25
Reinforced Concrete Criteria:			
Compressive strength @ 28 days:	4000 psi	4000 psi	4000 psi
Dry Density:	145 pcf	145 pcf	145 pcf
Buoyant density:	83 pcf	83 pcf	83 pcf
Clear Cover (minimum):	3 inches	3 inches	3 inches
Reinforcing:	ASTM A615 Grade 60	ASTM A615 Grade 60	ASTM A615 Grade 60
Design Approach:	USD	USD	USD
Vegetation Screening	No	No	No
Substation Yard fencing	8’	8’	8’
Final Grade Substation Yard	6” Crushed stone	6” Crushed stone	4” Crushed stone
Resistivity of crushed stone	> 2500 ohm meters	> 2500 ohm meters	> 2500 ohm meters

	Nash Stream		Redington Pond	Black Nubble
GENERAL ELECTRICAL CRITERIA				
Maximum voltage (kV)	121	38.0	38.0	38.0
Nominal voltage (kV)	115	34.5	34.5	34.5
Number of phases	3	3	3	3
Frequency (Hz)	60	60	60	60
Continuous bus ampacity (A)	600 A	1200 A	600 A	600 A
Number of generator connections	0		15	14
Number of outgoing transmission lines	1		1	1
Basic impulse insulation level (BIL – kV)	550	200	150	150
3 phase fault current (rms symmetrical) (amps)	3.3 kA	7.5 kA	6.3 kA	5.7 kA
Minimum bushing leakage distance (in)	70			
Minimum insulator leakage distance (in)	99			
Minimum phase to ground clearance (in)	47	15	15	15
Minimum horizontal phase to phase clearance (center to center in)	84	36	36	36
Minimum Size wire:				
Current Transformer Leads	10 AWG		N/A	N/A
Power & Control Wiring	12 AWG		N/A	N/A
Alarm wiring	14 AWG		N/A	N/A
Minimum vertical clearance from finish grade to energized conductor (in)	140	115	115	115
DC Source	1– 125 v battery			
Station service power source – Primary 200 A 120/240 v (single phase)	34.5 kV Bus			

Transmission	Nash Stream 115 kV	Redington Pond 34.5 kV	Black Nubble 34.5 kV
Structure Configuration	Rigid H-Frame	Single Pole	Single Pole
Structure Material	Wood	Wood	Wood
Conductor Bundle Arrangement	Single Conductor	Single Conductor	Single Conductor
Conductor Size	477 ACSR	795 ACSR	1,113 ACSR
Conductor Stranding	26/7	26/7	54/19
Conductor Name	Hawk	Mallard	Finch
Loading Criteria:			
NESC Minimum Requirements:	TBD	TBD	TBD
Radial Ice loading (in)	TBD	TBD	TBD
Wind (psf)	TBD	TBD	TBD
Temperature °F	TBD	TBD	TBD
Additional Loading	TBD	TBD	TBD
Heavy Ice:			
Radial Ice loading (in)	TBD	TBD	TBD
Wind (psf)	TBD	TBD	TBD
Temperature °F	TBD	TBD	TBD
High Wind:			
Radial Ice loading (in)	TBD	TBD	TBD
Wind (mph)	TBD	TBD	TBD
Temperature °F	TBD	TBD	TBD

	Nash Stream	Redington Pond	Black Nubble
CONTROL BUILDING	Site Constructed	**N/A**	**N/A**
Size:	To Be Determined		
Length:			
Width:			
Height:			
Building Type	To Be Determined		
Toilet, water or drain facilities	To Be Determined		
Heating	To Be Determined		
Venting	To Be Determined		
Air Conditioning	To Be Determined		
Fire Protection:			
Fire Extinguisher	To Be Determined		
Smoke Detector wired to Supervisory System	To Be Determined		
Battery:			
Number of Battery Systems	1		
Separate Room for Batteries	No		
Portable Eyewash Station	Yes		
No Smoking Sign	Yes		
Doors	To Be Determined		
Windows	To Be Determined		
Floors	Hard Trowel Concrete		
Ceiling	To Be Determined		
Heat/Smoke Detectors			

SF_6 Circuit Breakers	Nash Stream 34.5 kV	Redington Pond	Black Nubble
Quantity of SF_6 circuit breakers	2	N/A	N/A
Circuit breaker type (dead tank / live tank)	dead tank		
Number of Poles	3		
Ratings:			
Nominal system voltage (kV)	34.5		
Maximum system voltage (kV)	38.0		
Maximum operating voltage (kV)	38.0		
Frequency (Hz)	60		
Continuous Current (A)	600		
Short circuit current @ max voltage (kA)	20.0		
Three second short time current (kA)	20.0		
Closing and latching capability (kA)	32.0		
Interrupting time (cycles)	All – 3		
Range Factor (K)	1.0		
Low frequency withstand volts – 60 sec (kV)	80		
Basic impulse insulation level-full wave (kV)	200		
Minimum bushing creepage distance (in)	50		

SF_6 Circuit Breakers	Nash Stream 34.5 kV	Redington Pond	Black Nubble
Bushing current transformers:			
Quantity of relaying accuracy BCTs/phase	4		
Rating or Thermal Factor	2.0		
Required relaying accuracy class	C800		
Relaying current transformer ratio (primary amperes / secondary amperes)	600/5 MR		
Trip Coils per breaker	2		
Pre Insertion Resistors	No		
Bushing Potential Devices	No		
Duty Cycle	To be Determined		
Operating and Control Power Requirements			
Operating Mechanism	Stored energy spring type		
Motor/compressor supply voltage (Vac)	240/120 v single phase		
Space heater supply voltage (Vac)	240/120 v. single phase		
Control voltage (Vdc)	125		
Trip voltage range (Vdc to Vdc)	70-140		
Close voltage range (Vdc to Vdc)	90-130		
Auxiliary Switches			
Minimum number of “a” contacts in excess of those required for circuit breaker operation and control	20		
Minimum number of “b” contacts in excess of those required for circuit breaker operation and control	20		

Power Transformer Three Phase	Nash Stream	Redington Pond	Black Nubble
Total Quantity	2		
Ratings			
Nominal system voltage (kV)	115		
Maximum system voltage (kV)	121		
Maximum Operating voltage (kV)	121		
Frequency (Hz)	60		
Basic impulse insulation level (kV)	550		
Primary voltage (kV)	115		
Secondary output voltage (volts)	34500 Grd Y/19920		
Power Rating (MVA)	37.5/50/62.5		
Bushing current transformers:			
Quantity of relaying accuracy BCTs/phase			
High Voltage Bushings	3		
Rating or Thermal Factor	2.0		
Required relaying accuracy class	C800		
Relaying current transformer ratio (primary amperes / secondary amperes)	600/5 MR		
Low Voltage Bushings	1		
Rating or Thermal Factor	2.0		
Required relaying accuracy class	C800		
Relaying current transformer ratio (primary amperes / secondary amperes)	1200/5 MR		

Lightning Arresters	Nash Stream	Nash Stream	Nash Stream
	115 kV	34.5 kV Bus	34.5 kV Line
Total Quantity of Surge Arresters	6	3	6
Surge Arrester Class	Station	Intermediate	Distribution
Surge Arrester type	Metal-Oxide	Metal-Oxide	Metal-Oxide
Ratings:			
Nominal system voltage (kV)	115	34.5	34.5
Max system voltage (kV)	121	38	38
Max Continuous Operating Voltage (MCOV) kV	96	36	36
Max Operating voltage (kV)	121	38	38
Frequency (Hz)	60	60	60
Rated Discharge Current (8/20 wave)	10 kA	10 kA	10kA
Minimum Creepage Distance (in)	105		
Discharge Counter Required	No	No	No
Discharge Ammeter Required	No	No	No
Configuration	Grd Y	Grd Y	Grd Y

Bus System/Grounding System	Nash Stream	Redington Pond	Black Nubble
Nominal system voltage (kV)	115		
Maximum system voltage (kV)	121		
Maximum Operating voltage (kV)	121		
Basic impulse insulation level (kV)	550		
Frequency (Hz)	60		
Continuous Current (A) (@40 degree C rise & 40 degree C ambient)	600		
Overhead Bus:			
Bus Material & Size	To Be Determined		
Bolting Hardware	Stainless Steel		
Station Post Insulators			
Cantilever Strength (X working load)	2.5		
Minimum Creep Distance (in)	99		
Color	light gray		
Grounding System:			
Design Line to ground Current (kA)	10		
Minimum Size Ground Conductor:			
Inside Fence	4/0 AWG		
Outside Fence	4/0 AWG		
Ground Rods	¾” x 10’		
Perimeter Ground (feet beyond fence)	3		
Below Grade Connections	Compression or Bolted		
Above Grade Connections	Bolted		

125 Vdc Batteries and Battery Chargers	Nash Stream	Redington Pond	Black Nubble
Total Quantity of battery banks	1		
Total Quantity of battery chargers	1		
Design Parameters:			
Ambient Temperature (degrees C)	50		
Design margin	1.25		
Aging Factor	0.8		
Duty Cycle (hours)	8		
Battery Ratings:			
Nominal system voltage (volts dc)	125		
Number of cells per battery bank	60		
Capacity (A-H at 8 hour rate to 1.75 volts per cell @ 77 degr F	To be determined		
Final voltage	105		
Battery Type	Lead calcium		
Mounting rack			
Battery Charger Ratings:			
Time from full discharge to full recharge (hours)	12		
Nominal input supply voltage (volts-ac)	120/240		
Nominal output voltage (volts-dc)	125		
Equalizing voltage (volts-dc)	140		
Float voltage (volts-dc)	132 to 135		

125 Vdc Batteries and Battery Chargers Nash Stream Redington Pond Black Nubble

Battery Charger Accessories:

AC & DC Circuit Breakers	Yes
Ground Detector	Yes
Output voltmeter & ammeter	Yes
"Failure to charge" alarm	Yes
Equalizing timer	
Alarm for ground detection	Yes
Alarm for battery low voltage	Yes
Alarm for battery high voltage	Yes
Indication lights for ac input	Yes
Indication lights for equalization	Yes

Relay and Control Design

Communications

One Fiber Optic cable will be installed in the overhead shield wire between the Nash Stream Substation and Bigelow Substation. These fiber optic cables will serve protective relaying and supervisory functions. The multplexing equipment is to be determined.

The circuits required:

Circuit No.	Service Type	Function
1	Dedicated	DDT 115 kV Line

Relaying – Nash Brook Substation

Primary system relaying will consist of a line differential relay, a transformer differential relay and a sudden pressure relay. The line differential relay will communicate with the Bigelow substation via a dedicated fiber pair to execute a Direct Transfer Trip protection scheme. The relays via the DTT scheme will trip the line breaker at Bigelow and trip the two 115 kV Circuit Switchers at Electric Harvest Substation

Back-up System relaying will consist of phase and ground overcurrent relays on the transformer. The relays via an 86 device will trip the respective circuit switcher and trip the associated 34.5 kV breaker at Electric Harvest Substation.

The two 34.5 kV breakers will have directional overcurrent relaying to serve as local back-up protection. These relays will not execute a transfer trip

Relaying – Bigelow Substation

The line terminal at Bigelow Substation will offer primary system relaying in the form of a line differential relay. This relay will communicate with the Nash Brook substation via a dedicated fiber pair to execute a Direct Transfer Trip protection scheme. The relays via the DTT scheme will trip the line breaker at Bigelow and trip the two 115 kV circuit switchers at Electric Harvest Substation.

Back-up System relaying will consist of phase directional overcurrent, distance and breaker failure relays on the line. These relays will communicate with the Bigelow substation via a dedicated fiber pair to execute a Direct Transfer Trip protection scheme. The relays via the DTT scheme will trip the line breaker at Bigelow and trip the two 115 kV circuit switchers at Electric Harvest Substation. The Breaker failure function will additionally execute a transfer trip to Wyman Hydro Substation in the event of a stuck breaker

34.5 kV Collector System	Redington Pond	Black Nubble
Cable System:		
Voltage Rating	34.5 kV	34.5 kV
Insulation	345 mils (100%) EPR	345 mils (100%) EPR
Conductor	Compressed Aluminum	Compressed Aluminum
Connectors:		
Voltage Rating:	34.5 kV	34.5 kV
Max voltage (kV)		
Phase-Phase	36.6	36.6
Phase-Ground	21.1	21.1
BIL	150	150
AC Withstand	50	50
Frequency (Hz)	60	60
Continuous Current (Amperes)	600	600
Short Circuit Current (kA Sym)	25	25
Switchgear:		
Voltage Rating:	34.5 kV	34.5 kV
Max voltage (kV)		
Phase-Phase	38	38
BIL	150	150
Frequency (Hz)	60	60
Continuous Current (Amperes)	600	600
Short Circuit Current (kA Sym)	25	25