Maine Mountain Power, LLC

Preliminary Engineering for the Black Nubble Wind Farm 34.5 kV Collector System and 115 kV Interconnection Facility 54 MW Facility

June18, 2007

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V90-3.0 MW UPDATE – COLLECTOR SYSTEM & SUBSTATION

1.0 Executive Summary

Maine Mountain Power, LLC Corporation is considering the construction of a 54 MW wind farm facility comprised of 18 Vestas V90-3.0 MW wind turbines. This preliminary engineering document identifies the necessary facilities and estimated cost to construct: (a) 34.5 kV collector systems, (b) 34.5 kV generator exit transmission lines, (c) a 115/34.5 kV step-up substation with a power transformer, and (d) a 115 kV transmission line to accommodate a 54 MW wind farm..

The projected cost of these facilities is estimated to be:

Collector Systems	
Single or Multiple String Collector System	$ 1,957,000
Generator Exit Lines	$ 2,004,000
115/34.5 kV Substation	$ 2,685,000
115 kV Overhead Transmission Line	$ 3,860,000
115 kV Underground Transmission Line	$ 980,000

The remainder of this document details the design and the design criteria applied to develop the interconnection facilities located between the wind farm and Bigelow Substation. The design and cost estimates do not reflect facilities that will be added at Bigelow substation (i.e. 115 kV breaker & associated relaying) to accommodate the interconnection, nor does the design address CMP system modifications deemed necessary beyond Bigelow Substation as the design and cost estimates of these changes will be defined by CMP.

1.1 Background

Maine Mountain Power, LLC of Yarmouth, Maine is developing plans to construct a wind energy facility ("facility") in the hills of Redington Township, Maine. This Preliminary Design calls for a facility based upon the placement of 18 VestasV90-3.0 MW 60 hz OptiTip wind turbines along Black Nubble. Specifications on the wind turbine units are provided in Appendix A. Design Criteria for the interconnection facilities are provided in Appendix B

The wind turbine units generate electricity at a voltage of 1000 volts and this output will be transformed to 34,500 volts by a 3.16 MVA transformer located in the Nacelle of the wind turbine. The transformer output will be cabled down to the base of the steel tower supporting the wind turbine and interconnected to a 34.5 kV collector system. The 34.5 kV collector system on the ridge line will interconnect the wind turbines to an overhead 34.5 kV transmission line that will transmit the wind turbine output down the mountain to a high voltage substation (Electric Harvest Substation) that will transform the 34.5 kV wind farm output to 115 kV. A short 115 kV transmission line (approximately 8 miles) will be constructed to interconnect the Facility to Central Maine Power Company's transmission system at the Bigelow Substation. The Bigelow Substation is located along the east side of Route 16/27 at the Carrabassett Valley northerly town boundary.

The Facility on Black Nubble will consist of 18 units placed along the ridge line as depicted in Figure 2. Access to the Black Nubble site will be made via a combination of existing private roads and newly constructed access ways from the north side of the mountain. The 34.5 kV transmission line between the ridge top and the Nash Stream Substation will need to be located to the northeast of the ridge line.

E/PRO Engineering & Environmental Consulting, LLC (E/PRO) has been retained by the Maine Mountain Power, LLC Corporation to assist with the licensing phase of this project by updating the preliminary design and cost estimate of the 34.5 kV collector system, the 34.5 kV transmission lines, the 34.5/115 kV substation and the115 kV transmission line. The specific deliverables requested include the following items:

1. Preliminary design for:
    a. Wind Farm Collector System
    b. New 115/34.5 kV Substation
    c. New 115 kV Transmission Line
2. Identification of significant electrical components for collector system.
3. Development of General Arrangement, Elevation and Plan views for typical components associated with the collector system, substation and transmission lines.
4. Development of electrical system design criteria.
5. Development of electrical system budget estimate.

2.0 Facility Collector System :

2.1 General

The purpose of the collector system is to electrically interconnect the wind turbines to a medium voltage (34.5 kV) generator exit transmission line. The collector system at this facility will consist of a medium voltage, direct buried, three phase cable system that will daisy chain the wind turbines to the transmission line. The cables will interconnect with switchgear located at the base of each wind turbine unit via medium voltage separable connectors.

Facility collector systems can be structured in different configurations depending upon the desired level of collector system reliability. Typical configurations are:

1. Loop System. This system provides a redundant path for the generator output for each turbine by establishing a looped circuit between the wind turbines. In the event of a cable failure, the loop can be opened and the full output of the wind farm can be maintained.

2. Single String. This system places all of the wind turbines on a single series circuit. In the event of a cable failure the wind turbines located beyond the faulted cable would not be available until the cable is repaired.

3. Multiple String. This system distributes the wind turbines over several series circuits and permits the use of lower rated equipment. Similar to the Single String Configuration, in the event of a cable failure the wind turbines beyond the faulted cable will not be available until the cable is repaired.

In addition to reliability considerations of the collector system, continuous and interrupting ampere ratings of cabling, cable terminations, and equipment must be considered. The collector system will largely consist of 34.5 kV direct buried cable(s) with insulated separable connections. These separable connectors are typically available in ratings of 200 amp and 600 amp capability. Similarly, 34.5 kV switchgear connections are rated at 200 and 600 amps.

Power cable ampacity ratings are influenced by installation, load factor (24 hour) and ambient temperature of the ground. For purposes of this design, cables have been sized based upon the use of Kerite Cable Company 35 kV URD cables and (1) an installation in sand with a minimum cover of 36 inches, (2) a load factor of 100%, and (3) a maximum ambient earth temperature of 20° C. Based upon these conditions, the 34.5 kV cables would have a continuous ampacity rating as follows:

Aluminum Strand Conductor Size	Continuous Ampacity (@ 100% LF, 20°C)
1/0	150 Amps

4/0	211 Amps
500 kcmil	332 Amps
750 kcmil	405 Amps
1000 kcmil	462 Amps

As part of the wind turbine unit, Vestas will provide the unit 34.5 kV switchgear and the cabling between the switchgear and the unit transformer. The switchgear will be placed in the bottom of the tower to allow for collector system interconnection.

Fault duty calculations were performed based upon utility system information provided by Central Maine Power Company and the proposed facility electrical system. The symmetrical fault current available at the wind turbine units is projected to range between 5.6 and 6.5 kA at an X/R of 4.3 to 6.0. This suggests that the fault duty is sufficiently low enough to employ the S&C Vista Fault Interrupter Switchgear rated at 12.5 kA.

Based upon discussions with Steve Saylors of Vestas, the 34.5 kV switchgear is typically provided by Vestas with 600 amp connectors. Therefore, the design of the collector system need only focus on cabling and connectors. A review of 600 amp versus 200 amp connectors suggests minor savings and verifies limited application of the 200 amp connectors to different cable sizes. It therefore makes good design sense to standardize on 600 amp connectors in the design of the collector system. The components of the separable connection system is illustrated in Appendix C. The connectors can be purchased in single connector, twin connector and triple connector kits. Each wind turbine will need 3 connectors for each in coming circuit and 3 connectors for each out going circuit.

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2.2 Black Nubble Wind Farm

It is planned that 18 wind turbine units will occupy the Black Nubble site as illustrated in Figure 2. Assuming the units will be V90-3.0 MW units capable of 3,000 kilowatts (3125 kVA @ .96 power factor), design load current is projected to be a maximum of 52.3 amperes per unit at 34.5 kV.

2.2.1 Single String Approach

Based upon the turbine locations depicted in Figure 2, cable run distances were estimated for a single string approach and are summarized in Table 3 below. Due to the larger size of the units and a 600 amp limitation on the 34.5 kV connectors, a single string design is not possible. Alternatively, a design employing two strings is employed in this application of 18 V90 units. The interconnection of units is illustrated in Appendix D.

Table 3

Black Nubble
Single String Collector System

		(feet)
Riser	Turbine 11	900
Turbine 11	Turbine 12	700
Turbine 12	Turbine 13	900
Turbine 13	Turbine 14	900
Turbine 14	Turbine 15	700
Turbine 15	Turbine 16	800
Turbine 16	Turbine 17	900
Turbine 17	Turbine 18	1000
Riser	Turbine 9	900
Turbine 9	Turbine 8	700
Turbine 8	Turbine 7	800
Turbine 7	Turbine 6	4000

The single string approach employs multiple size cables (500 kcmil, 750 kcmil and 1000 kcmil alum) to provide the sufficient levels of ampacity from the collector system as the unit connections multiply toward the medium voltage transmission line.

The medium voltage cable installation is assumed to be direct buried in a cable trench 18 inches wide and 42 inches deep. The trench will be layered with 6 inches of sand prior to cable installation and the cable will have 36 inches of cover after installation. In areas where the medium voltage cable is to pass under roads or areas subject to heavy wheel loads, the cable shall be placed in steel conduit or PVC conduit encased in concrete.

The only overload or fault protection for the collector system will exist at the Nash Brook Substation. All of the separable connectors will be rated for 600 amps continuous and 10 kA symmetrical @ 10 cycles. The 500 kcmil cable will have the lowest rating and thus will dictate the fault current protection setting at the substation.

The estimated construction cost of the Black Nubble single string collector system is projected to be:

34.5 kV Cables:	
1000 kcmil (1,600 ft)	$ 60,060.00
2-500 kcmil (12,200 ft)	295,240.00
500 kcmil (3,200 ft)	83,490.00
1/0 AWG (7,600 ft)	34,155.00
Connectors (87 units)	72,600.00
Trenching & Cable Installation	587,664.00
Connector Installation	49,896.00
Riser pole	17,000.00
Other Misc	10,000.00
Design & Procurement	26,500.00
Total Single String Collector System	$ 719,838.00

2.2.2 Multiple String Approach

Based upon the turbine locations depicted in Figure 1, cable run distances were estimated for a multiple string approach and are summarized in Table 2 below. The interconnection of units is illustrated in Appendix E

Table 4

Black Nubble
Multiple String Collector System

From	To	Cable Run (feet)
Riser	Turbine 10	1,000
Turbine 10	Turbine 11	900
Turbine 11	Turbine 12	700
Turbine 12	Turbine 13	900
Turbine 13	Turbine 14	1,200
Riser	Turbine 15	5,400
Turbine 15	Turbine 16	800
Turbine 16	Turbine 17	900
Turbine 17	Turbine 18	1000
Riser	Turbine 9	7,800
Turbine 9	Turbine 8	2,500
Turbine 8	Turbine 7	1,100
Turbine 7	Turbine 6	1,200
Turbine 6	Turbine 5	2,700
Riser	Turbine 4	15,400
Turbine 4	Turbine 3	700
Turbine 3	Turbine 2	2,800
Turbine 2	Turbine 1	700

The multiple string approach employs a combination of 500 kcmil, 4/0 AWG and 1/0 AWG aluminum cable to provide the sufficient levels of ampacity from the collector system as the unit connections multiply toward the medium voltage transmission line. Except for Turbines 1, 5, 14 and 18, each wind turbine unit will have two sets of collector system cables connected to the switchgear. Turbines 1, 5, 14 and 18 will have only one set of collector cables since they are located at the end of the series.

The medium voltage cable installation is assumed to be direct buried in a cable trench 18 inches wide and 42 inches deep. The trench will be layered with 6 inches of sand prior to cable installation and the cable will have 36 inches of cover after installation. In areas where the medium voltage cable is to pass under roads or areas subject to heavy wheel loads, the cable shall be placed in steel conduit or PVC conduit encased in concrete.

Fault protection for the collector system will be necessary and will consist of fused disconnects at the riser poles. All of the separable connectors will be rated for 600 amps continuous and 10 kA symmetrical @ 10 cycles.

The estimated construction cost of the Black Nubble multiple string collector system is projected to be:

34.5 kV Cable:	
500 kcmil (33,000 ft)	$ 399,300.00
4/0 AWG (3,300 ft)	35,393.00
1/0 AWG (11,400 ft)	71,105.00
Connectors (96 units)	55,367.00
Trenching & Cable Installation	713,592.00
Connector Installation	38,016.00
Riser poles (3)	32,000.00
Other Misc	10,000.00
Design & Procurement	28,500.00
Total Multiple String Collector System	$ 1,384,273.00

3.0 Interconnection with Central Maine Power Company

Maine Mountain Power, LLC, has elected to interconnect with Central Maine Power Company's high voltage facilities at the Bigelow Substation located adjacent to Route 16/27 near the northerly town boundary of Carrabasset Valley. Central Maine Power Company defines a number of requirements for generator interconnections as outlined in their handbook entitled: "Interconnection Requirements for Generation". Some of the requirements deal specifically with synchronous generators and interconnections with Bulk Power Supply (BPS) Systems, neither of which are involved with this project as the generators are induction machines and Bigelow Substation is a radial (non-BPS) transmission line.

Since the interconnection will be to CMP's 115 kV System, the interconnection will be regarded as a Type IV installation. This installation will require a line breaker, fault interrupters on each generator, line relaying with transfer trip capability and specific relaying to protect the system. The design described herein complies with these requirements and proposes that only one 115 kV breaker be employed to protect the new transmission line and transformer. The 115 kV breaker will be located at the Bigelow Substation and will communicate with relays at the Nash Stream Substation via fiber optic communications installed in the static wires of the new 115 kV line.

Since the generators are not synchronous machines, synchronizing will not be necessary.

Since the interconnection is not with a BPS facility, two independent AC and DC power supplies will not be necessary. However, the 115 kV breaker will need to be equipped with two trip coils and have two independent relay systems (primary) and (back-up)

In order to interconnect the wind energy facility to Central Maine Power Company's high voltage transmission system, the collector system must be integrated with an electrical interface that will tie into the CMP system. This interface will require (1) medium voltage generator exit transmission lines, (2) a transformation from medium voltage to high voltage and (3) a high voltage transmission line.

The first element of the interface is the medium voltage, 34.5 kV generator exit transmission lines that will transmit the wind energy turbine output from the mountain ridge to the site of medium to high voltage transformation. With an anticipated 18-3.0 megawatt unit Wind Farm, the maximum output of the wind energy facility is projected to be 54.0 MW (1,565 amps @ 34.5 kV or 469 amps @ 115 kV).

The second element of the interface will be the step-up substation which will be largely limited by the size of transformer installed.

The third element will be the 115 kV line which will be capable of transmitting 120 MVA.

4.0 34.5 kV Generator Exit Transmission Lines :

4.1 General

Maine Mountain Power, LLC, plans to interconnect with Central Maine Power Company's high voltage facilities at the Bigelow Substation in Carrabasset Valley. In order to interconnect the wind energy facility to Central Maine Power Company's high voltage transmission system, the collector system must be integrated with an electrical interface that will tie into the CMP system. This interface will require medium voltage generator exit transmission lines, a transformation from medium voltage to high voltage and a high voltage transmission line. The first element of the interface is the medium voltage, 34.5 kV generator exit transmission lines that will transmit the wind energy turbine output from the mountain ridge to the site of medium to high voltage transformation. As previously discussed, the Black Nubble 34.5 kV generator exit line will need to be capable of transmitting up to 56.3 MVA.

4.2 Black Nubble Generator Exit Line

Based upon the turbine placement depicted in Figure 2, the 34.5 kV line will descend from a location approximately 1000 feet north of Turbine 10 to the Nash Stream Substation. This segment of line will span a distance of approximately 17,000 feet (3.2 miles) and descend along an access road from an approximate elevation of 3100 feet to an approximate elevation of 2100 feet just west of Nash Stream.

The line will be constructed with a 1,113 kcmil, 54/19, ASCR conductor (known as "Finch") which will provide sufficient strength and capacity to accommodate up to 70 megawatts of capacity. As discussed above, two line configuration approaches are possible for the construction of the line.

Similar to the Redington generator exit line, construction using the single pole line approach may be more practical. Based upon a circuit length of 17,000 feet and an average span of 200 feet, it is estimated that 86 structures would be required to construct the line. In order to define the exact number and placement of the structures, a detailed plan and profile of the route would need to be created and a detailed transmission line design developed.

Based upon an average 45', class 2 pole with an average span of 200 feet and a cleared right-of-way of 75 feet, the estimated cost of the Black Nubble 34.5 kV generator exit line is projected to be:

Engineering & Inspection	$ 125,000
Materials*	423,000
Construction	525,000
Contingency	180,000
Total	$ 1,243,000

*1,113 kcmil conductor cost figured @ $ 65,000 per circuit mile
structure cost (material only) figured @ $ 2,500 per unit.

Note: Cost estimate does not reflect land acquisition or licensing costs.

5.0 Electric Harvest 115/34.5 kV Substation

The designated location of the medium voltage to high voltage transformation is north of the two mountain ridges adjacent to the west side of Nash Stream. With an anticipated 18-3.0 megawatt unit Wind Farm, the maximum output of the Facility is projected to be 54.0 MW (1,565 amps @ 34.5 kV or 469 amps @ 115 kV).

A preliminary design comprised of a one-line diagram, a general arrangement diagram, a general elevation plan and a relay one line diagram of the Electric Harvest Substation is depicted in Appendix G. Based upon a 54 megawatt wind energy facility design, a pair of 115,000 VΔ – 34,500/19,920 Grd Y, 37.5/50.0/62.5 MVA (8.5 % Z) transformers have been selected.

The 34.5 kV line breakers are SF6 gas insulated 1200 amp breakers and will need 1200 amp disconnects for isolation. The 34.5 kV main disconnect should be rated 1200 amps and the main transformer 115 kV disconnect should be a 600 amp rated disconnect. The 34.5 kV bus will require potential transformers for bus potential sensing and the 34.5 kV transformers will require bushing current transformers for current sensing. The main transformer will also need bushing current transformers for current sensing and metering.

The estimated cost of the substation is projected to be:

Transformers	$ 975,000
Balance of Substation	1,710,000 (Refer to Appendix H)
Total	$ 2,685,000

6.0 115 kV Transmission Line

The high voltage line between the Electric Harvest Substation and CMP's Bigelow Substation is expected to run along a route that follows Nash Brook to the Redington township/Coplin Plantation northerly boundary line, then east along the boundary line across into Carrabasset Valley, then north along the Carrabasset Valley/Coplin Plantation boundary line, then east along the Carrabasset boundary line across Stoney Brook, then northeast into Wyman Plantation to Route 16/27, across Route 16/27 then south to Bigelow Substation. This Route is projected to be 42,000 feet in length.

6.1 Overhead Facilities

The overhead segment of the line will be constructed with a 477 kcmil, 26/7, ASCR conductor (known as "Hawk") which will provide sufficient strength and capacity to accommodate up to 138 megawatts of capacity.

The overhead line should be constructed using a H-Frame construction approach (Appendix I). This approach will minimize structure height and require a cleared R-O-W of 100 to 150 feet. Based upon an overhead circuit length of 39,500 feet and an average span of 550 feet, it is estimated that 72 structures would be required to construct the line. In order to define the exact number and placement of the structures, a detailed plan and profile of the route would need to be created and a detailed transmission line design developed.

Based upon an average 65', class 3 pole with an average span of 550 feet and a cleared right-of-way of 125 feet, the estimated cost of the Nash Stream/Bigelow 115 kV transmission line is projected to be:

Engineering & Inspection	$ 340,000
Materials*	950,000
Construction	2,220,000
Contingency	350,000
Total	$ 3,860,000

*477 kcmil conductor cost figured @ $ 30,000 per circuit mile
structure cost (material only) figured @ $ 10,000 per unit.

Note: Cost estimate does not reflect land acquisition or licensing costs.

7.0 Underground Facilities

Due to esthetics and property rights issues, the 115 kV transmission line will transition from an overhead line to an underground cable system some 600 feet west of Route 27. The underground facility will proceed underneath Route 27 to the east side shoulder where the line will parallel Route 27 in the shoulder to the entranceway of Bigelow substation. The underground line will then continue from Route 27 to a location within the Bigelow Substation and interconnect with the Central Maine Power Company 115 kV transmission System. The total underground cable system is expected to run approximately 2,500 feet.

The underground cable system will consist of a 2 x 3 duct bank with 4 manholes and 4 - 115 kV solid dielectric cables installed between the last 115 kV overhead structure and the Bigelow substation. The duct bank configuration and route are illustrated in Appendix J. The cost of the 115 kV underground system is projected to be:

Engineering & Inspection	$	25,000
Duct bank & Manholes*		500,000
Cable**		100,000
Cable Installation & Termination		280,000
Contingency		75,000
Total	$	980,000

* 2 x 3 Duct bank & Manhole cost figured @ $ 200 per foot
** Estimated @ $40 per circuit foot
Note: Cost estimate does not reflect land acquisition or licensing costs.

8.0 Appendices

Appendix A – V90-3.0 MW Wind Turbine Specifications
Appendix F – Single Pole 34.5 kV Transmission Line Construction Details
Appendix I – Rigid 115 kV H-Frame Transmission Line Construction Details
Appendix J – Underground 115 kV Transmission Line Construction Details