# *PJM Generator Interconnection Request*
# *Queue #G21*
# *Meyersdale North 115 kV*
# *Impact Study Report*

**April 2003**
**DMS# 206634**

***Confidential***

# Meyersdale North 115 kV Impact Study

## General

Meyersdale Windpower L.L.C. has proposed a new 48 MW generating facility consisting of 36 wind turbines, to be installed in the Summit Township, Somerset County, Pennsylvania. The project will be connected as an energy-only resource to the Meyersdale North 115 kV substation via a new 115/34.5 kV power transformer located at Meyersdale North and a new 34.5 kV underground transmission line from Meyersdale North to the wind turbine collector substation. The proposed service date for the project is the fourth quarter 2003.

## Direct Connection

The new generation facility will be connected to the transmission system by constructing a new 115/34.5 kV transformer located at the Meyersdale North substation and a new underground 34.5kV transmission line, approximately two and one-half miles long, to be built by the developer from the project site to the Meyersdale North 115 kV substation (see Figure 1). The direct attachment of the project to the system at the Myersdale North 115 kV substation will require the following work:

To be done by the project developer (Meyersdale Windpower LLC):

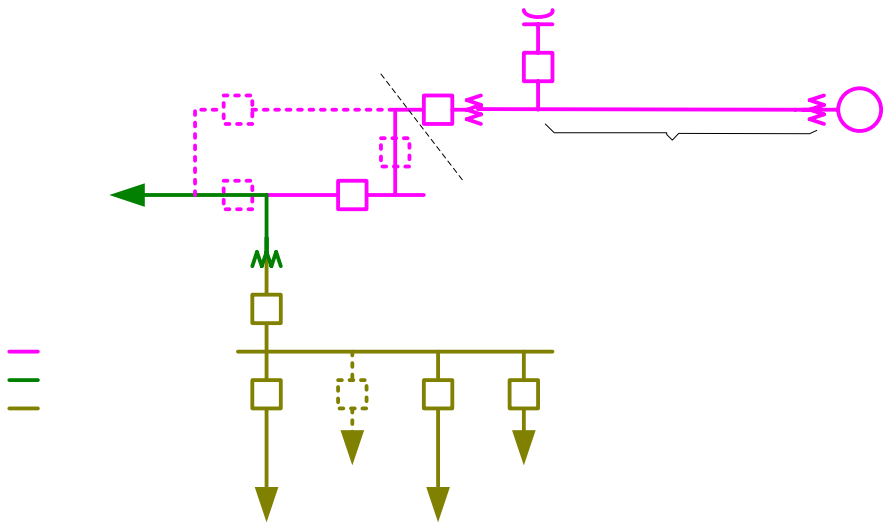
- A new 34.5 kV interconnection line between new wind turbine generator facilities and FE's existing Meyersdale North 115 kV Substation. The 34.5 kV interconnection line will have an approximate length of 2.5 miles.
- New generation relaying, control, interconnection metering, and supervisory control and data acquisition (SCADA) equipment.
- Dedicated communication circuits for direct transfer trip relaying from FE's Rockwood Substation, for SCADA communication to the transmission system control center, and for dialup access to revenue metering.
- A new control building to contain generation interconnection and substation relaying, control, and SCADA equipment as required at Meyersdale North 115 kV Substation.
- New 115/34.5 kV line terminal additions at Meyersdale North 115 kV Substation including the addition of one 115/34.5 kV power transformer, one 115 kV circuit breaker, one 115 kV motor operated disconnect switch, two 34.5 kV circuit breakers, one cable terminator structure, one capacitor bank, and associated 115 kV and 34.5 kV electrical bus, structure, foundation, oil containment system, grounding, conduit, and cable networks.
- Grading and site development activities at Meyersdale North 115 kV Substation as required to accommodate the new 115/34.5 kV line terminal additions, including permitting, earthwork, fencing, access drives, and stormwater management facilities as required.

- Easements and parcel acquisitions for the 34.5 kV line and for the substation facilities located on FE property at Meyersdale North 115 kV Substation.

To be done by First Energy at Meyersdale North substation at an estimated cost to Meyersdale Wndpower L.L.C. of **$869,000**:

- Install one 115 kV circuit breaker, one 115kV transmission line termination structure, three 115 kV disconnect switches, three 115 kV capacitor voltage transformers and associated electrical bus, structure, foundation additions.
- Remove and relocate the existing 115 kV line termination.
- New bus relaying and control and relaying associated with the generator interconnection.
- Grading and site development activities as required to accommodate the new 115 kV circuit breaker, disconnect switches and bus including permitting, earthwork, fencing, access drives, and storm water management facilities.

## Figure #1



## Network Impacts

The system, as planned, was evaluated for compliance with MAAC reliability criteria. **The Meyersdale North G21 project was studied as 48 MW energy only facility.** The results are summarized below.

**Normal System**
No identified problems.

**Single Contingency (MAAC Criteria IIA)**
No identified problems.

**Second Contingency (MAAC Criteria IIB)**
No identified problems.

**Multiple Facility Contingency (MAAC Criteria IIC)**
No identified problems.

**Generator Deliverability**
No identified problems.

**Stability (MAAC Criteria IV)**
No identified problems.

See attachment #1 for the fault cases evaluated.

Stability analysis was performed at light load conditions. The range of contingencies evaluated was limited to that necessary to demonstrate compliance with MAAC Reliability Criteria II and IV.

Note: While the stability analysis has been performed at extreme system conditions, there is a potential that evaluation at higher levels of generator output over a range of load levels would disclose unforeseen stability problems. The MAAC yearly reliability analysis to be performed to test all system changes will include this evaluation. Any problems uncovered will need to be resolved. Moreover, when the proposed generating station is designed and unit specific dynamics data for the turbine generators are available, and if it is different than the data provided for this study, a transient stability study at a variety of expected operating conditions using the more accurate data should be performed to verify impact on the dynamic performance of the system. As more accurate or unit specific dynamic data for the proposed facility, as well as Plant layout becomes available, it should be forwarded to PJM.

**CETO/CETL (MAAC Criteria III / VIIB)**
No identified problems.

**Short Circuit Analysis**
No breaker duty problems identified.

**Protective Relaying**

1. Addition of the generation at Meyersdale North115kV substation results in a transmission line with four terminals that have a source to supply energy to faults. This arrangement, due to infeed considerations, results in inadequate fault clearing. The most effective manner to overcome the situation is to install a 115kV circuit breaker at Rockwood 115kV substation to create a separate Rockwood-Penn Mar circuit.

2. Due to the addition of the generation at Meyersdale North 115kV substation there is a greater potential that the generation at Meyersdale and the generation connected at the Arnold substation could be self-sustaining if isolated from the rest of the transmission system. To prevent this possibility Direct Transfer Trip will need to be installed at the Arnold substation.

## System Reinforcements

1. To alleviate the relaying concern described in 1 above the following equipment will be installed at Rockwood 115kV substation at an estimated cost of **$423,000** to Meyersdale Windpower L.L.C.
   - ? One 115 kV circuit breaker with disconnect switches in the existing Penn Mar 115kV circuit exit with associated electrical bus, structure, foundation additions.
   - ? New and relocated line terminal relaying including direct transfer trip to the Meyersdale Windpower L.L.C. and Arnold REC generator interconnections.

2. To alleviate the concern described in 2 above the following equipment will be installed at Arnold 115kV substation at an estimated cost of **$37,000** to Meyersdale Windpower L.L.C..
   - ? Dedicated communication circuit and receiver for direct transfer trip relaying from First Energy's Rockwood Substation.

## Cost Allocation

Meyersdale Windpower LLC is responsible for the full amount of the direct connection requirements described above. As the initial project that causes the need for the network reinforcements, it is also responsible for 100% of the cost of the network upgrades described above. The total estimated cost for interconnection of the project $869,000 for the direct connection and $460,000 for the network upgrades for a total estimated cost of **$1, 329,000**.

# Attachment #1

**Meyersdale North-G21**
2007 Light Load Stability Faults

**Breaker Clearing Times (cycles)**

| Station | Primary (3ph/slg) | Stuck Breaker (total) | Zone 2 (total) |
|---|---|---|---|
| Rockwood 115 kV | 7 | 20 | 36 |
| Somerset 115 kV | 7 | 20 | 36 |
| Penn-Mar 115 kV | 7 | 20 | 36 |
| Hooversville 115 kV | 7 | 20 | 36 |
| F04 115 kV | 7 | 20 | 36 |

**CRITERIA TEST FAULTS (ALL STABLE)**

g21-1a 3ph @ Rockwood 115 kV on Rockwood – Penn-Mar 115 kV
g21-1c slg @ 80% of Rockwood 115 kV on Rockwood – Penn-Mar 115 kV, zone 2 operation

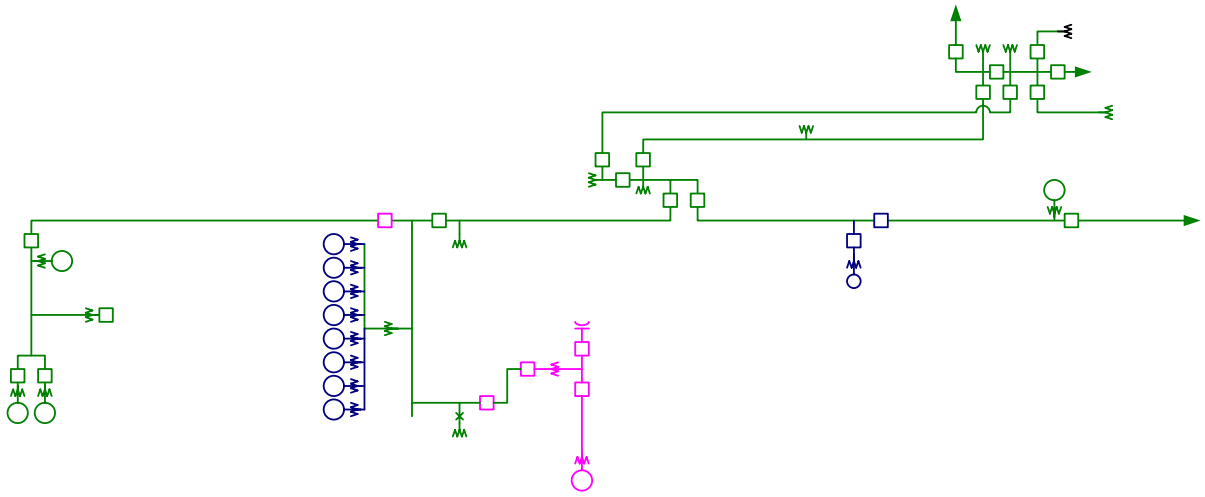
g21-2a 3ph @ Somerset 115 kV on Somerset – Hooversville 115 kV
g21-2b slg @ Somerset 115 kV on Somerset – Hooversville 115 kV, stuck at Somerset (loss of one Somerset transformer)
g21-2c slg @ 80% of Somerset 115 kV on Somerset – Hooversville 115 kV, zone 2 operation

g21-3a 3ph @ Somerset 115 kV on Somerset – Ralphton – Hooversville 115 kV
g21-3b slg @ Somerset 115 kV on Somerset – Ralphton – Hooversville 115 kV, stuck at Somerset (loss of Somerset – Rockwood, Somerset – F04, and one Somerset transformer)
g21-3c slg @ 80% of Somerset 115 kV on Somerset – Ralphton – Hooversville 115 kV, zone 2 operation

g21-4a 3ph @ Somerset 115 kV on Somerset – F04 115 kV
g21-4b slg @ Somerset 115 kV on Somerset – F04 115 kV, stuck at Somerset (loss of Somerset – Rockwood, Somerset – Ralphton, and one Somerset transformer)
g21-4c slg @ 80% of Somerset 115 kV on Somerset – F04 115 kV, zone 2 operation

**ADDITIONAL TEST FAULTS**

g21-1d same as g21-1c, but 3ph rather than slg fault (UNSTABLE)
g21-2d same as g21-2c, but 3ph rather than slg fault (UNSTABLE)
g21-3d same as g21-3c, but 3ph rather than slg fault (MARGINALLY STABLE)
g21-4d same as g21-4c, but 3ph rather than slg fault (UNSTABLE)



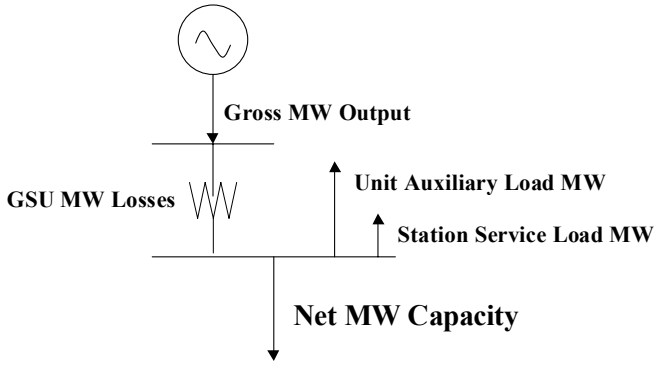
**Penn Mar**

**Garrett**

**Deep Creek**

# Attachment #2

## Unit Capability Data




Net MW Capacity = (Gross MW Output - GSU MW Losses* – Unit Auxiliary Load MW - Station Service Load MW)

Queue Letter/Position/Unit ID: Queue G21 (32 units)

Primary Fuel Type: Wind

Maximum Summer (92? F ambient air temp.) Net MW Output**:

Maximum Summer (92? F ambient air temp.) Gross MW Output: 48

Minimum Summer (92? F ambient air temp.) Gross MW Output:

Maximum Winter (30? F ambient air temp.) Gross MW Output:

Minimum Winter (30? F ambient air temp.) Gross MW Output:

Gross Reactive Power Capability at Maximum Gross MW Output – Please include Reactive Capability Curve (Leading and Lagging):

Individual Unit Auxiliary Load at Maximum Summer MW Output (MW/MVAR):

Individual Unit Auxiliary Load at Minimum Summer MW Output (MW/MVAR):

Individual Unit Auxiliary Load at Maximum Winter MW Output (MW/MVAR):

Individual Unit Auxiliary Load at Minimum Winter MW Output (MW/MVAR):

Station Service Load (MW/MVAR):

Please provide any comments on the expected capability of the unit:

* GSU losses are expected to be minimal.

** Your project's declared MW, as first submitted in Attachment N, and later confirmed or modified by the Impact Study Agreement, should be based on either the 92 $^{o}$F Ambient Air Temperature rating of the unit(s) or, if less, the declared Capacity rating of your project.

# Unit Generator Dynamics Data

Queue Letter/Position/Unit ID: G21

MVA Base (upon which all reactances, resistance and inertia are calculated): 1.667 MVA

Nominal Power Factor: 1.0

Terminal Voltage (V): 600

Unsaturated Reactances (on MVA Base)

- Direct Axis Synchronous Reactance, $X_{d(i)}$: 0.434
- Direct Axis Transient Reactance, $X'_{d(i)}$: 0.222
- Direct Axis Sub-transient Reactance, $X''_{d(i)}$: 0.178
- Quadrature Axis Synchronous Reactance, $X_{q(i)}$: N/A
- Quadrature Axis Transient Reactance, $X'_{q(i)}$: N/A
- Quadrature Axis Sub-transient Reactance, $X''_{q(i)}$: N/A
- Stator Leakage Reactance, $X_l$: 0.143
- Negative Sequence Reactance, $X_{2(i)}$:
- Zero Sequence Reactance, $X_0$:

Saturated Sub-transient Reactance, $X''_{d(v)}$ (on MVA Base):

Armature Resistance, $R_a$ (on MVA Base):

Time Constants (seconds)

- Direct Axis Transient Open Circuit, $T'_{do}$: 0.0511
- Direct Axis Sub-transient Open Circuit, $T''_{do}$: 0.0116
- Quadrature Axis Transient Open Circuit, $T'_{qo}$: N/A
- Quadrature Axis Sub-transient Open Circuit, $T''_{qo}$: N/A

Shaft Inertia, (Combined Generator/Prime Mar) H (kW-sec/kVA, on KVA Base): 5.26

Speed Damping, D (typically 0 to 2): 0.0

Saturation Values at Per-Unit Field Voltage [S(1.0), S(1.2); typically 0.##, 0.##]: 0.17, 0.44

In addition, if available please supply the following:

? Exciter/Governor/Other Models and Block Diagrams
? Generator Performance Curves
? Schematic One-line Diagram showing Unit/GSU/Breakers/Interconnection
? Operating Restrictions and/or Procedures

# Unit GSU Data

Queue Letter/Position/Unit ID: G06

Generator Step-up Transformer MVA Base: 100

Generator Step-up Transformer Impedance (R+jX, on transformer MVA Base): 0+j0.114 p.u.

Generator Step-up Transformer Reactance-to-Resistance Ratio(X/R):

Generator Step-up Transformer Rating (MVA):

Generator Step-up Transformer Low-side Voltage (V): 600 V

Generator Step-up Transformer High-side Voltage (kV): 34.5 KV

Generator Step-up Transformer Off-nominal Turns Ratio: 1.0

Generator Step-up Transformer Number of Taps and Step Size: 5@?5%