PJM Generator Interconnection Request
Queue #M08
Somerset-Allegheny (Stonycreek) 115 kV
20 MW
Impact Study Report

March 2005
DMS# 309946

Somerset-Allegheny (Stonycreek) 115 kV Impact Study

General

Stonycreek WindPower, LLC has proposed a 45 MW wind turbine generating station consisting of forty wind turbine generators. The plant will be utilizing the Vestas 1.8MW machines. The generating station is to be located in Stonycreek and Somerset Townships, Somerset County Pennsylvania. The generating plant, originally scheduled to be in service March 31, 2003, was rescheduled to be in service December 31, 2004 and has been rescheduled again for service be December 31, 2005. The project was evaluated as an 45 MW energy-only resource at Generation Interconnection queue position I04. At the K10 queue position the project was evaluated as a 13.6 MW capacity resource. At the M08 queue position a 20MW energy-only increase is being evaluated.

The intent of the impact study is to determine cost and construction time estimates of system reinforcements required to facilitate the addition of the new generating plant to the PJM system. The reinforcements include the direct connection of the generator to the system and any network upgrades necessary to maintain the reliability of the PJM system.

Direct Connection

The direct connection requirements for the project do not change when evaluated as a 20 MW energy-only increase from those described below, when evaluated as an energy-only resource at queue position I04 and a capacity resource at queue position K12. See Figure #3.

The direct connection requirements for the project do not change when evaluated as a 13.6 MW capacity resource from those described below, when evaluated as an energy-only resource at queue position I04. See Figure #2.

The Stonycreek project is to be located along the Somerset-Allegheny 115 kV line approximately 4 miles from the existing Somerset substation and 1 mile from a proposed Pride substation being requested for the Somerset REC. The Stonycreek project will be connected to the 34.5kV bus at the new Pride substation that is to be connected to the Somerset-Allegheny 115kV transmission line. See Figure #1.

Per FERC ruling, any new facilities that will experience through power flow are considered network upgrades. Therefore the 115 kV portion of the new Pride substation, except for the fault interrupters and 115/34.5kV transformers, the line connection into the substation and the relaying modifications at the Somerset and Allegheny substations are network upgrades.

One fault interrupter, one 115/34.5kV transformer, one 34.5kV transformer circuit breaker, 34.5kV bus work, one stepped capacitor bank and two 34.5kV connection circuit breakers are the direct connection facilities for the Stonycreek project.

The Pride substation, that will include 2 115kV circuit breakers, 115kV bus work, 2 fault interrupters, 2 115/34.5kV transformers, 2 34.5kV circuit breakers and 34.5kV bus work, is to be built by Somerset REC at an estimated cost of $2.5 million. If either one of the two proposed 115/34.5 kV transformers and associated equipment is not installed the total cost of the substation is estimated to be $2.0 million.

Installation of the Pride substation into the Somerset-Allegheny 115kV transmission line will require protective relay modifications at both Somerset and Allegheny substations. The relay modifications in which one terminal will require change of control and relay panels only at an estimated cost of $150,000 and the other terminal will require change of control and relay panels, wave trap, line tuner and carrier equipment at an estimated cost of $300,000. The total cost of the relaying modifications, work to be performed by FirstEnergy, is $450,000 ($220,000 for material, $140,000 for labor and $90,000 for design and engineering.) This work will be conducted in parallel with construction of the Pride substation.

The construction of the loop of the Somerset-Allegheny transmission line in and out of the Pride substation is estimated at $70,000 and will be done by FirstEnergy.

Figure #1

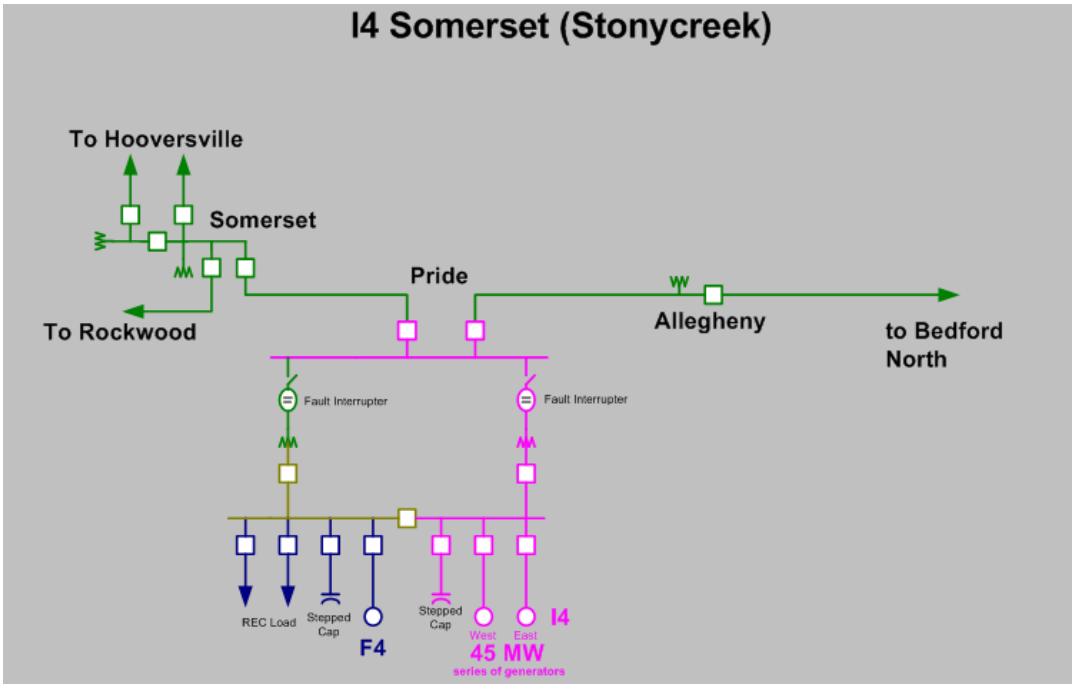


Figure #2

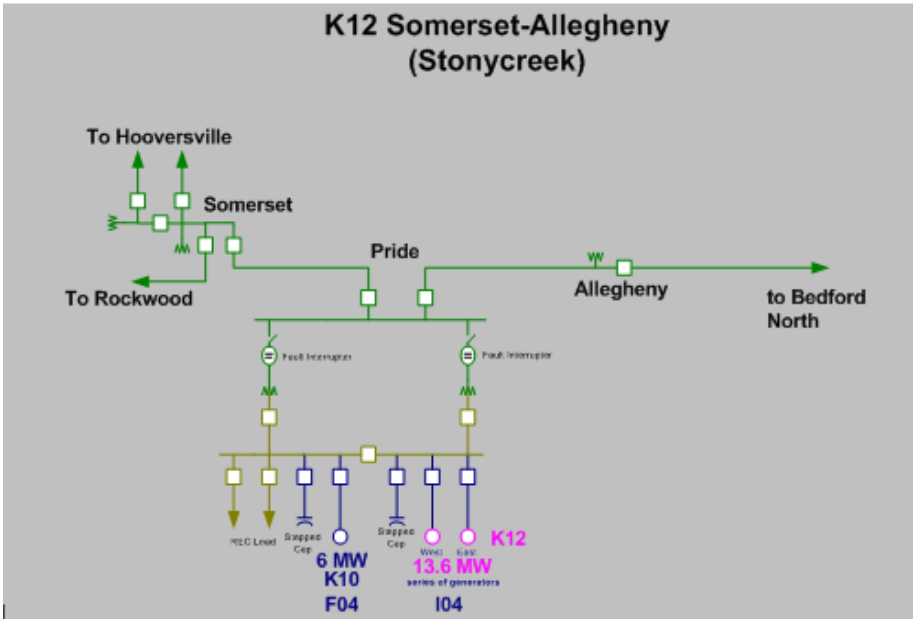
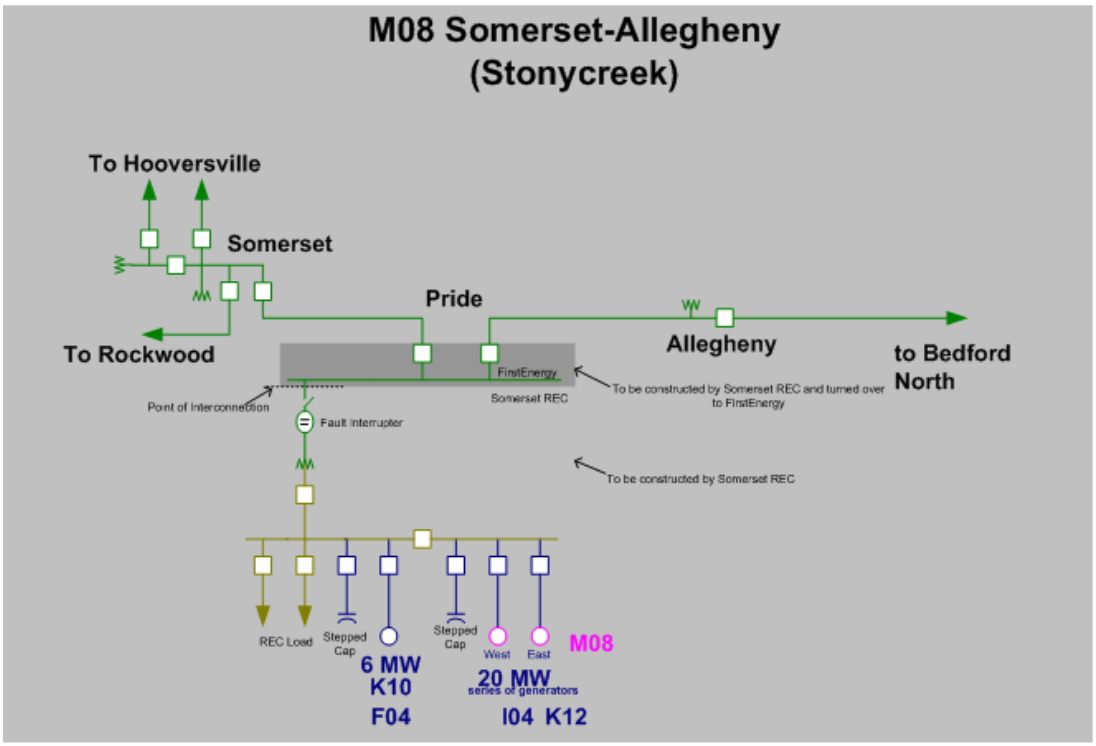


Figure #3



Network Impacts

The network impacts for the evaluation of the increase of 20 MW of energy only output, for a total of 65 MW, from the project are listed below in plum font.

The network impacts for the evaluation of project K12 as a 13.6 MW capacity resource are the same as those described below when evaluated as a 45 MW energy only resource.

The system, as planned, was evaluated for compliance with reliability criteria. **The Somerset – Allegheny I04 project was studied as 45MW energy only**. The results are summarized below.

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)
Stability analysis was performed at 2008 light load conditions and for maximum output of 65 MW for the proposed project (I04 and M08). A 10.0 MVAR shunt capacitor is assumed to be connected to the low side of GSU to achieve a unity power factor at the interconnection point for the base case. The capacitive affect of the 34.5kV cable connecting the wind turbines was not modeled.

Attachment #1A lists the fault cases evaluated. The range of contingencies evaluated included all that were deemed necessary to assess expected compliance with MAAC criteria.

The M08 and F04 generators become unstable for the contingency 6c. Under contingencies 3b, 4b, and 6a, buses Pride (M08 and F04), Somerset, and Allegheny 115kV buses show unacceptable voltage profile.

PJM assessed the following solutions to mitigate the stability problems.
1. Adding capacitor banks at Pride bus wouldn't solve all problems.
2. A 50MVAR SVC installed a Pride substation, would eliminate possibilities of instability of the F04 and M08 generators, however the voltage profiles are not acceptable for all contingencies.
3. For the listed faults, it was also tested to lower the output level of the project M08. The stability problem remains the same for 6c case.

4. With manufacturer recommended under-voltage relay scheme, all the other cases are stable. However tripping of the M08 (and I04) generators after the faults does not maintain stability of the F04 generators for case 6c.

Since, the stability problems occur as a result of the loss of the Pride – Somerset 115kV line for delayed fault clearing, it is, therefore, **required that:**

- **the M08 (and I04) project generators shall be equipped with manufacturer recommended under voltage relay scheme on the interconnection breaker;**
- **dual primary relay should be installed for the Pride – Somerset 115kV line.**

Note that the under-voltage relays on individual wind generators will trip the units in the events of delayed clearing of faults or unit instability resulting in low voltages. However, in such cases, the generation is restored after several minutes.

Note: While the stability analysis has been performed at expected extreme system conditions, there is a potential that evaluation at different level of generator MW and/or MVAR output at different load levels and operating conditions would disclose unforeseen stability problems. The regional reliability analysis routinely performed to test all system changes will include one such evaluation. Any problems uncovered in this or other operating or planning studies will need to be resolved.

Moreover, when the proposed generating station is designed and unit specific dynamics data for the turbine generators and its controls 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 dynamics data for the proposed facility, as well as Plant layout becomes available, it shall be forwarded to PJM

Stability analysis was performed at 2007 light load conditions and for maximum output of 45 MW for the proposed project. Attachment #1 lists the fault cases evaluated. The range of contingencies evaluated included all that were deemed necessary to assess expected compliance with MAAC criteria.

The I04 and F04 generators become unstable for several of the criteria contingencies (i.e. 1c, 3b, 4b, 4c, 6a, 6c, S-2a and S-2c). When only the F04 project generators are in services, these contingencies do not result in instability. The instability of the generators also causes unacceptably low voltages at Pride (I04 and F04), Somerset, and Allegheny 115kV buses.

PJM assessed the following solutions to mitigate the stability problems.

1. Adding capacitor banks at Pride bus would eliminate some of the problems, however wouldn't solve all problems.

2. A STATCOM, installed a Pride substation, would eliminate possibilities of instability of the F04 and I04 generators, however it is not deemed to be an economically justifiable alternative at this point.

3. Tripping of the I04 generators after the faults does not maintain stability of the F04 generators.

Since, the stability problems occur as a result of the loss of the Pride – Somerset 115kV line for fault clearing, it is, therefore, **recommended that the I04 project generators shall be tripped without intentional time delay whenever the Pride – Somerset 115kV line becomes unavailable, and should not be reconnected to the 115 kV system until the line is back in service.**

Note that the under-voltage relays on individual wind generators will trip the units in the events of delayed clearing of faults or unit instability resulting in low voltages. However, in such cases, the generation is restored after several minutes.

The above listed faults were also tested for I04 project output level of 30MW instead of 45MW, and the stability problem remains the same for 1c, 6a, 6c, S-2a and S-2c cases.

Note: While the stability analysis has been performed at expected extreme system conditions, there is a potential that evaluation at different level of generator MW and/or MVAR output at different load levels and operating conditions would disclose unforeseen stability problems. The regional reliability analysis routinely performed to test all system changes will include one such evaluation. Any problems uncovered in this or other operating or planning studies will need to be resolved.

Moreover, when the proposed generating station is designed and unit specific dynamics data for the turbine generators and its controls 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 dynamics data for the proposed facility, as well as Plant layout becomes available, it shall be forwarded to PJM.

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

Short Circuit Analysis
No identified problems

System Reinforcements and Cost Allocation

1. Installation of two 115kV circuit breakers, 115kV bus work, and associated line protection and control at the Pride Substation (Somerset REC) at an estimated cost of $2,000,000. (Upgrade # 337)

2. Protective relay modifications at Somerset substation on the Somerset-Allegheny line (FirstEnergy) at an estimated cost of $300,000. (Upgrade #338)

3. Protective relay modifications at Allegheny substation on the Somerset-Allegheny line (FirstEnergy) at an estimated cost of $150,000. (Upgrade #339)

4. Construction of the loop of the Somerset-Allegheny line by FirstEnergy into Pride substation at an estimated cost of $70,000. (Upgrade #340)

The work described above is estimated to take approximately one year to complete and cost $2,520,000. Since the network upgrades are required for the interconnection of both the Stonycreek project and the F04 project, the costs for the upgrades will be allocated equally between the projects. Therefore, the total estimated cost for the upgrades allocated to the Stonycreek project is **$1,260,000.**

The Stonycreek project is also responsible for 100% of the direct connection costs estimated to be $500,000.

The instability concerned described above will be alleviated by installing dual pilot relaying on the Somerset-Pride 115kV transmission line by adding a fiber optic communication path between the two substations. The total cost is estimated to be **$426,000** based upon their being 4 miles between Somerset and Pride substations.

Attachment #1

I04 Somerset-Allegheny Study
2007 Light Load Stability Faults

BREAKER CLEARING TIMES (CYCLES)

Station	Primary (3ph/slg)	Stuck Breaker (total)	Zone 2 (total)
ALL 115 kV	7	20	36

Criteria Test Faults

I04-1a 3ph @ I04 115 kV on I04-Allegheny 115 kV
I04-1c slg @ 80% of I04 115 kV on I04 – Allegheny 115 kV, Zone 2 operation

I04-2a 3ph @ Allegheny 115kV on Allegheny – Bedford North 115 kV
I04-2b slg @ Allegheny 115kV on Allegheny – Bedford North 115 kV, stuck at Allegheny
I04-2c slg @ 80% of Allegheny 115kV on Allegheny – Bedford North 115 kV, Zone 2 operation

I04-3a 3ph @ Somerset 115kV on Somerset – Hooversville 115 kV
I04-3b slg @ Somerset 115kV on Somerset – Hooversville 115 kV, stuck at Somerset
I04-3c slg @ 80% of Somerset 115kV on Somerset – Hooversville 115 kV, Zone 2 operation

I04-4a 3ph @ Somerset 115kV on Somerset – Rockwood 115 kV
I04-4b slg @ Somerset 115kV on Somerset – Rockwood 115 kV , stuck at Somerset
I04-4c slg @ 80% of Somerset 115kV on Somerset – Rockwood 115 kV, Zone 2 operation

I04-5a 3ph @ Somerset 115kV on Somerset – Ralphton 115 kV
I04-5b slg @ Somerset 115kV on Somerset – Ralphton 115 kV , stuck at Somerset
I04-5c slg @ 80% of Somerset 115kV on Somerset – Ralphton 115 kV, Zone 2 operation

I04-6a 3ph @ I04 115 kV on I04-Somerset 115 kV
I04-6c slg @ 80% of I04 115 kV on I04 – Somerset 115 kV, Zone 2 operation

Additional Test Faults with I04 – Somerset 115kV out

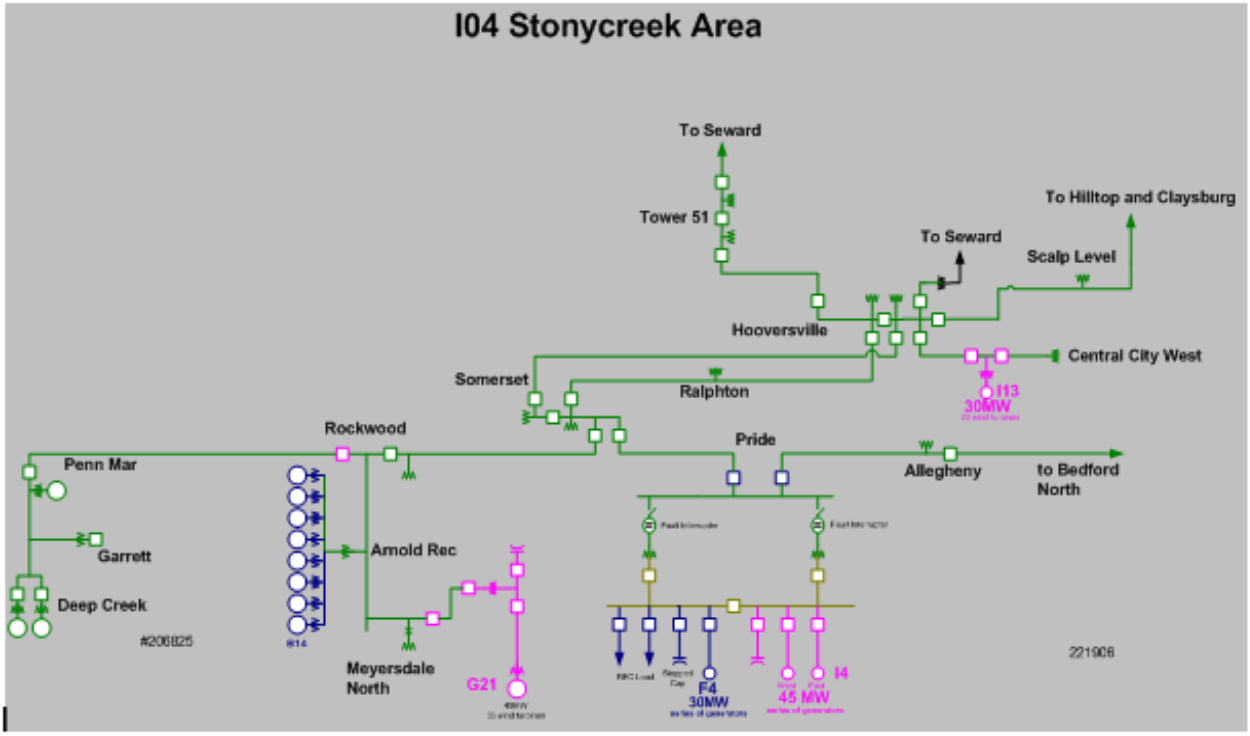
I04_S-2a Same as I04-2a, with I04 – Somerset 115 kV o/s
I04_S-2c Same as I04-2c, with I04 – Somerset 115 kV o/s

Additional Test Faults with I04 – Allegheny 115kV out

I04_A-3a Same as I04-3a, with I04 – Allegheny 115 kV o/s
I04_A-3c Same as I04-3c, with I04 – Allegheny 115 kV o/s

I04_A-4a Same as I04-4a, with I04 – Allegheny 115 kV o/s
I04_A-4c Same as I04-4c, with I04 – Allegheny 115 kV o/s

I04_A-5a Same as I04-5a, with I04 – Allegheny 115 kV o/s
I04_A-5c Same as I04-5c, with I04 – Allegheny 115 kV o/s


I04 Stonycreek Area
To Seward
Tower 51
To Hilltop and Claysburg
To Seward
Scalp Level
Hooversville
Central City West
I13
30MW
Somerset
Ralphton
Rockwood
Pride
Allegheny
to Bedford North
Penn Mar
Garrett
Deep Creek
#2068825
Arnold Rec
Meyersdale North
G21
F4
30MW
I4
45 MW
221906

Attachment 1A

M08 Somerset-Allegheny Study
2008 Light Load Stability Faults

BREAKER CLEARING TIMES (CYCLES)

Station	Primary (3ph/slg)	Stuck Breaker (total)	Zone 2 (total)
PN ALL 115 kV	7	20	36

Criteria Test Faults (Faults in Red are unstable)

M08-1a 3ph @ Pride 115 kV on Pride-Allegheny 115 kV
M08-1c slg @ 80% of Pride 115 kV on Pride – Allegheny 115 kV, Zone 2 operation

M08-2a 3ph @ Allegheny 115kV on Allegheny – Bedford North 115 kV
M08-2b slg @ Allegheny 115kV on Allegheny – Bedford North 115 kV, stuck at Allegheny
M08-2c slg @ 80% of Allegheny 115kV on Allegheny – Bedford North 115 kV, Zone 2 operation

M08-3a 3ph @ Somerset 115kV on Somerset – Hooversville 115 kV
M08-3b slg @ Somerset 115kV on Somerset – Hooversville 115 kV, stuck at Somerset
M08-3c slg @ 80% of Somerset 115kV on Somerset – Hooversville 115 kV, Zone 2 operation

M08-4a 3ph @ Somerset 115kV on Somerset – Rockwood 115 kV
M08-4b slg @ Somerset 115kV on Somerset – Rockwood 115 kV , stuck at Somerset
M08-4c slg @ 80% of Somerset 115kV on Somerset – Rockwood 115 kV, Zone 2 operation

M08-5a 3ph @ Somerset 115kV on Somerset – Ralphton 115 kV
M08-5b slg @ Somerset 115kV on Somerset – Ralphton 115 kV , stuck at Somerset
M08-5c slg @ 80% of Somerset 115kV on Somerset – Ralphton 115 kV, Zone 2 operation

M08-6a 3ph @ Pride 115 kV on Pride-Somerset 115 kV
M08-6c slg @ 80% of Pride 115 kV on Pride – Somerset 115 kV, Zone 2 operation

Additional Test Faults with Pride – Allegheny 115kV out

M08P-3a Same as M08-3a, with M08 – Allegheny 115 kV o/s
M08P-3c Same as M08-3c, with M08 – Allegheny 115 kV o/s

M08P-4a Same as M08-4a, with M08 – Allegheny 115 kV o/s
M08P-4c Same as M08-4c, with M08 – Allegheny 115 kV o/s

M08P-5a Same as M08-5a, with M08 – Allegheny 115 kV o/s
M08P-5c Same as M08-5c, with M08 – Allegheny 115 kV o/s