PJM Generator Interconnection Request
Queue #U4-028 and U4-029
Fostoria Central-Greenlawn-Howard (Seneca) 138kV
System Impact Study

Revised May 2015

U4-028 Fostoria Central-Greenlawn-Howard (Chadwick) 138kV Impact Study Report

General

Exelon Renewables, LLC (the developer) proposes to connect PJM Projects #U4-028 and U4-029 to the American Electric Power's (AEP) Melmore 138 kV Tap Station. Melmore Tap is presently served off AEP's Fostoria Central – Greenlawn – Howard 138 kV line. The 200 MW generating facility will be located in Seneca County, Ohio. The projected in-service date is scheduled for October 1, 2012.

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

Attachment Facilities

Exelon Wind LLC proposes to install a 200 MW generating facility comprised of 88 Siemens SWT-22.3-93 2.3 MW wind turbine generators. Exelon is proposing a single connection for U4-028 and U4-029 to connect to the American Electric Power (AEP) Melmore Station on the Fostoria Central – Greenlawn - Howard 138 kV circuit. The Melmore Station, once proposed as part of the scope of this project, is now being developed by AEP under approved baseline project b1667. This revised report reflects the effects of the reduced scope of work and updates the proposed schedule. See Figure 1.

*The Generation Interconnection Agreement does not in or by itself establish a requirement for American Electric Power to provide power for consumption at the developer's facilities. A separate agreement may be reached with the local utility that provides service in the area to ensure that infrastructure is in place to meet this demand and proper metering equipment is installed. The metering work above and cost indicated below does not include any potential work or cost to address metering requirements of the local service provider. It is the responsibility of the developer to contact the local service provider to determine if a local service agreement is required.

Note that the developer's station facilities and any facilities outside the new station were not included in the cost estimate. These are assumed to be developer's responsibility.

The AEP design and construction scope for the attachment facilities:

- Install 2 circuit breakers, relaying, and facilities to accommodate termination of a new 138 kV line from U4-028 and U4-029 collector station. (Network Upgrade #n2115)

  Estimated Cost (2011 Dollars)*: **$853,001**

- Install 138kV revenue metering for U4-028 and U4-029 at Melmore Tap Substation. (Network Upgrade #n2121)

  Estimated Cost (2011 Dollars)*: **$255,303**

Total Attachment Facilities Cost (2011 Dollars)*: **1,108,304**

The standard time required for construction is 12 to 18 months after signing an interconnection agreement.

*The Attachment Facilities are non-direct connection network upgrades.

<u>AEP Local Network Impacts</u>

The impact of the proposed generating facility was assessed in accordance with AEP's Planning criteria published as the FERC Form 715. The developer's project was studied as a 100 MW net energy injection and as a 13 MW capacity resource. The results are summarized below.

Normal System – Capacity Output (2012 Summer Conditions)

- No problems identified.

Single Contingency – Capacity Output (2012 Summer Conditions)

- No problems identified.

Multiple Contingency – Full Output (2012 Summer Conditions)

- No problems identified.

Short Circuit Analysis

- No problems identified.

Stability Analysis

- No problems identified.

Local/Network Upgrades

- None required.

Contributions to Previously Identified Local/Network Limitations

- No problems identified.

Additional Limitations of Concern – Full Output

Normal System (2012 Summer Conditions)

- U4-028 overloads the Howard (AEP) – Brookside (FE) 138 kV to 115% (158.9 MVA) of the summer normal rating of 138 MVA.

Single Contingency (2012 Summer Conditions)

- U4-028 overloads the Howard (AEP) – Brookside (FE) 138 kV to 120% (200.4 MVA) of the summer emergency rating of 167 MVA for a single contingency outage of the First Energy Beaver – Davis Betsy 345 kV line.

Network Impacts

The Queue Project #U4-28 and U4-029 were studied as a(n) 200.0MW(Capacity = 26.0 MW) injection into the new Melmore Tap Substation in the AEP area. Project #U4-28 and U4-029 were evaluated for compliance with reliability criteria for summer peak conditions in 2013. Potential network impacts were as follows:

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

No problems identified.

Multiple Facility Contingency

(Double Circuit Tower Line, Line with Failed Breaker and Bus Fault contingencies for the full energy output)

1. The West Fremont – Kelsey Hayes 138 kV line (from bus 239154 to bus 238871 ckt 1) loads from 98.54% to 102.73% (AC power flow) of its emergency rating (289 MVA) for the line fault with failed breaker contingency outage ('C2-BRK-WR136'). This project contributes approximately 12 MW to the thermal violation.

2. The Kelsey Hayes - Ottawa 138 kV line (from bus 238871 to bus 239030 ckt 1) loads from 97.88% to 102.08% (AC power flow) of its emergency rating (289 MVA) for the line fault with failed breaker contingency outage ('C2-BRK-WR136'). This project contributes approximately 12 MW to the thermal violation.

Short Circuit

(Summary form of Cost allocation for breakers will be inserted here if any)

No problems identified.

Stability Analysis for U4-028 (These results have not changed from the previous version)

This study concerns the stability assessment for the PJM generator interconnection request – Queue Number U4-028 (Melmore 138 kV tap). The U4-028 project consists of a new 101 MW wind farm facility and its developer specified the use of 56 units of Vestas 90 1.8 MW wind turbine generators.

The objective of this study was to determine the system stability for the contingencies around the U4-028 project as shown in Attachment #1. All units and their control systems were updated according to the specifications of the developers; these updates are shown in Attachment #2 and Attachment #3 (Dynamic data format). The topology of the system is shown in Attachment #4.

Stability (AEP Stability Criteria)

Stability analysis was performed at 2013 summer peak load conditions. The maximum generation output was considered. Throughout the study, the U4-028 wind farm had an initial output of 100.8 MW and 0 MVAR operated at a terminal voltage of about 1.0 pu and under power factor control. The range of contingencies evaluated was limited to that necessary to assess expected compliance with AEP criteria. This study involves transient simulations of approximately 50 contingencies that includes (a) tripping of lines without fault, (b) 3-phase faults with unsuccessful autoreclosure, and (c) SLG faults with stuck breaker. The simulation time period was 12 seconds for each contingency.

Result and Analysis

No transient instability was identified in this study. For all contingencies simulated, the voltage profile recovered to satisfactory steady state levels, hence there were no voltage recovery issues. Table-1 in Attachment #1 tabulates the clearing times for the contingencies. A brief description of each contingency simulated is also provided in this attachment.

Whenever the U4-028 wind farm was islanded with a load, it is recommended that the following trip settings be used at the interconnection point:

- Voltage at the point of interconnection: 0.8 pu or lower for 2 seconds; 1.11 pu or higher for 0.1 second; 1.2 pu or higher for 0.02 second
- Frequency at the point of interconnection: 57Hz or lower for 0.05 seconds; 62Hz or higher for 0.05 second

Note: While the stability analysis has been performed at expected extreme system conditions, there is a potential that evaluation at a different level of generator MW and/or MVAR output at different system 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 that or other operating or planning studies will need to be resolved.

The generating facility shall be operated with a power factor between 0.95 lag and 0.95 lead.

Moreover, when the proposed generating station is designed and plant specific dynamics data for the plant and its controls are available, and if it is different than the data provided for this study, a transient stability analysis at a variety of expected operating conditions using the more accurate data shall 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 become available, it must be forwarded to PJM.

Maintenance Outage

Maintenance outage conditions were not studied during the impact study phase since the project equipment data provided by the project developer is preliminary in nature. The stability and LVRT study including the maintenance outage test will be re-evaluated during the facility study phase (or at later stage), when more accurate dynamic data becomes available. Note that any and all changes to the generation equipment's dynamic data, including the GSU data, must be submitted to PJM for evaluation.

Stability Analysis for U4-029(These results have not changed from the previous version)

This study concerns the stability assessment for the PJM generator interconnection request – Queue Number U4-029 (Melmore 138 kV tap). The U4-029 project consists of a new 101 MW wind farm facility and its developer specified the use of 56 units of Vestas 90 1.8 MW wind turbine generators.

The objective of this study was to determine the system stability for the contingencies around the U4-029 project as shown in Attachment #1. All units and their control systems were updated according to the specifications of the developers; these updates are shown in Attachment #2 and Attachment #3 (Dynamic data format). The topology of the system is shown in Attachment #4.

Stability (AEP Stability Criteria)

Stability analysis was performed at 2013 summer peak load conditions. The maximum generation output was considered. Throughout the study, the U4-029 wind farm had an initial output of 100.8 MW and 0 MVAR operated at a terminal voltage of about 1.0 pu and under power factor control. The range of contingencies evaluated was limited to that necessary to assess expected compliance with AEP criteria. This study involves transient simulations of approximately 50 contingencies that includes (a) tripping of lines without fault, (b) 3-phase faults with unsuccessful autoreclosure, and (c) SLG faults with stuck breaker. The simulation time period was 12 seconds for each contingency.

Result and Analysis

No transient instability was identified in this study. For all contingencies simulated, the voltage profile recovered to satisfactory steady state levels, hence there were no voltage recovery issues. Table-1 in Attachment #1 tabulates the clearing times for the contingencies. A brief description of each contingency simulated is also provided in this attachment.

Whenever the U4-029 wind farm was islanded with a load, it is recommended that the following trip settings be used at the interconnection point:

- Voltage at the point of interconnection: 0.8 pu or lower for 2 seconds; 1.11 pu or higher for 0.1 second; 1.2 pu or higher for 0.02 second

- Frequency at the point of interconnection: 57Hz or lower for 0.05 seconds; 62Hz or higher for 0.05 second

Note: While the stability analysis has been performed at expected extreme system conditions, there is a potential that evaluation at a different level of generator MW and/or MVAR output at different system 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 that or other operating or planning studies will need to be resolved.

The generating facility shall be operated with a power factor between 0.95 lag and 0.95 lead.

Moreover, when the proposed generating station is designed and plant specific dynamics data for the plant and its controls are available, and if it is different than the data provided for this study, a transient stability analysis at a variety of expected operating conditions using the more accurate data shall 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 become available, it must be forwarded to PJM.

Maintenance Outage

Maintenance outage conditions were not studied during the impact study phase since the project equipment data provided by the project developer is preliminary in nature. The stability and LVRT study including the maintenance outage test will be re-evaluated during the facility study phase (or at later stage), when more accurate dynamic data becomes available. Note that any and all changes to the generation equipment's dynamic data, including the GSU data, must be submitted to PJM for evaluation.

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

None

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

None

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)
(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

None

Delivery of Energy Portion of Interconnection Request

(PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.
Only the most severely overloaded conditions are listed. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed, which will study all overload conditions associated with the overloaded element(s) identified.)

1. The West Fremont - Ottawa 138 kV line (from bus 239154 to bus 239030 ckt 1) loads from 99.15% to 103.43% (AC power flow) of its emergency rating (289 MVA) for the single line contingency outage ('B_LINE2_WR_034'). This project contributes approximately 12.1 MW to the thermal violation.

MISO Impacts

None.

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

1. Overloads in item#1 and #2 will require a reconfiguration at West Fremont substation that will take 12 months to complete (cost shown below).

UpgradeID	Description	Total with Tax	Tax	Total Cost
TE-S-277	Add new 138kV breaker and electrically re-route high side of Transformer #2 to the 138kV East Bus. @ West Fremont	675,500	124,600	550,900

Queue#	MW Impact	Percentage of Cost (%)	Cost ($550.9 K)
U4-028	7.89	39.67	218.54
U4-029	12	60.33	332.36

This upgrade at the West Fremont substation does not actually need to be constructed. The overloads in items #1 and #2 are actually resolved by PJM baseline upgrades B1281 (Build new Hayes 345/138 kV substation with new 138 kV lines to: Greenfield #1, Greenfield #2, and Avery) and B1282 (Build Beaver - Hayes - Davis - Besse #2 345 kV line), which are both in-service as of May 2014.
U4-028 will have a cost responsibility of $550,900 and this cost will be applied towards baseline upgrades B1281 and B1282.

<u>Contribution to Previously Identified System Reinforcements</u>
(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)
(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

None

Delivery of Energy Portion of Interconnection Request

PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Only the most severely overloaded conditions are listed. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed, which will study all overload conditions associated with the overloaded element(s) identified.

1. The West Fremont - Ottawa 138 kV line (from bus 239154 to bus 239030 ckt 1) loads from 99.15% to 103.43% (AC power flow) of its emergency rating (289 MVA) for the single line contingency outage ('B_LINE2_WR_034'). This project contributes approximately 12.1 MW to the thermal violation.

Cost

The U4-028 and U4029 projects are responsible for 100% of the estimated direct connection cost of **$1,108,304, and the** cost responsibility of $550,900 for baseline network upgrades b1281 and b1282. The total estimated cost responsibility for the U4-028 and U4-029 is **$1,659,204,** pending the results of the final Stability and LVRT analysis**.**

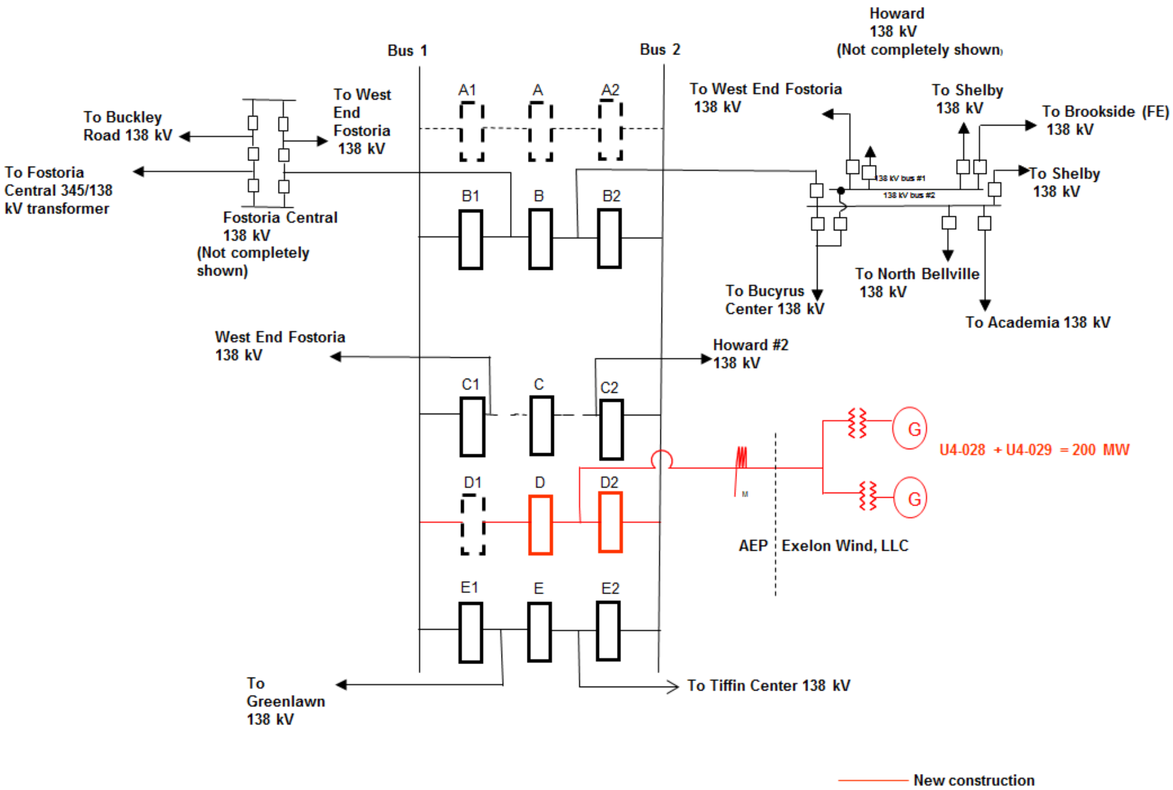

Figure 1

PJM Generator Interconnection Request Queue #U4-028 Fostoria Central-Greenlawn-Howard (Chadwick) 138kV Impact Study

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January 2011

U4-028 Fostoria Central-Greenlawn-Howard (Chadwick) 138kV Impact Study Report

General

Exelon Renewables, LLC (the developer) proposes to connect PJM Project #U4-028 to the American Electric Power's (AEP) Melmore 138 kV Tap Station. Melmore Tap is presently served off AEP's Fostoria Central – Greenlawn – Howard 138 kV line. The 100 MW generating facility will be located in Seneca County, Ohio. The projected in-service date is scheduled for October 1, 2012.

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

Attachment Facilities

The U4-028 project has requested interconnection to AEP's Fostoria Central – Greenlawn – Howard 138 kV line. Considering the proximity of Melmore 138 kV Tap Station from the developer's facilities, it is proposed that Melmore 138 kV Tap Station be converted to an in-line switching station. The new in-line switching station will consist of four (4) 138 kV circuit breakers configured in a breaker and a half arrangement operated as a ring bus with 138 kV metering as demonstrated in Exhibit 3. Additionally, line relays and remote terminal units (RTU) at Fostoria Central, Greenlawn and Howard stations will require upgrades.

AEP will retain ownership of the proposed in-line switching station. It is understood that Exelon Renewables, LLC will be responsible for all costs associated with this construction, as well as facilities associated with connecting the 100 MW of generation to the in-line facilities.

Note that the developer's station facilities and any facilities outside the new station were not included in the cost estimate. These are assumed to be developer's responsibility.

The AEP design and construction scope for the attachment facilities:

- Construct a new 138 kV substation to include 4 circuit breakers, relaying, 138kV revenue metering and facilities to accommodate termination of a new 138 kV line from U4-028 collector station. (Network Upgrade #n2115)

  Estimated Cost (2011 Dollars)*: **$5,863,700**

- Construct a temporary transmission line to facilitate construction of the interconnection station. (Network Upgrade #n2116)

  Estimated Cost (2011 Dollars)*: **$384,000**

- Install transmission line structures to permit termination of the lines in the interconnection station. (Network Upgrade #n2117)

  Estimated Cost (2011 Dollars)*: **$236,400**

- Upgrade relays and RTU at Fostoria Central Station. (Network Upgrade #n2118)

  Estimated Cost (2011 Dollars)*: **$593,400**

- Upgrade relays and RTU at Greenlawn Station. (Network Upgrade #n2119)

  Estimated Cost (2011 Dollars)*: **$570,500**

- Upgrade relays and RTU at Howard Station. (Network Upgrade #n2120)

  Estimated Cost (2011 Dollars)*: **$396,900**

Total Attachment Facilities Cost (2011 Dollars)*: **8,044,900**

The standard time required for construction is 12 to 18 months after signing an interconnection agreement.

*The estimates are preliminary in nature, as they were determined without the benefit of detailed engineering studies. Final estimates will require an on-site review and coordination to determine final construction requirements. It will take approximately one year after obtaining the authorization to construct the facilities as outlined above.

<u>AEP Local Network Impacts</u>

The impact of the proposed generating facility was assessed in accordance with AEP's Planning criteria published as the FERC Form 715. The developer's project was studied as a 100 MW net energy injection and as a 13 MW capacity resource. The results are summarized below.

Normal System – Capacity Output (2012 Summer Conditions)

- No problems identified.

Single Contingency – Capacity Output (2012 Summer Conditions)

- No problems identified.

Multiple Contingency – Full Output (2012 Summer Conditions)

- No problems identified.

Short Circuit Analysis

- No problems identified.

Stability Analysis

- No problems identified.

Local/Network Upgrades

- None required.

Contributions to Previously Identified Local/Network Limitations

- No problems identified.

Additional Limitations of Concern – Full Output

Normal System (2012 Summer Conditions)

- U4-028 overloads the Howard (AEP) – Brookside (FE) 138 kV to 115% (158.9 MVA) of the summer normal rating of 138 MVA.

Single Contingency (2012 Summer Conditions)

- U4-028 overloads the Howard (AEP) – Brookside (FE) 138 kV to 120% (200.4 MVA) of the summer emergency rating of 167 MVA for a single contingency outage of the First Energy Beaver – Davis Betsy 345 kV line.

Network Impacts

The Queue Project #U4-28 was studied as a(n) 100.0MW(Capacity=13.0) injection into the 3 point tap of the tapping Howard - Fostoria Central - Greenlawn 138kV line in the AEP area. Project #U4-28 was evaluated for compliance with reliability criteria for summer peak conditions in 2013. Potential network impacts were as follows:

Generator Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

No problems identified.

Multiple Facility Contingency

(Double Circuit Tower Line, Line with Failed Breaker and Bus Fault contingencies for the full energy output)

No problems identified

Short Circuit

(Summary form of Cost allocation for breakers will be inserted here if any)

No problems identified.

Stability

This study concerns the stability assessment for the PJM generator interconnection request – Queue Number U4-028 (Melmore 138 kV tap). The U4-028 project consists of a new 101 MW wind farm facility and its developer specified the use of 56 units of Vestas 90 1.8 MW wind turbine generators.

The objective of this study was to determine the system stability for the contingencies around the U4-028 project as shown in Attachment #1. All units and their control systems were updated according to the specifications of the developers; these updates are shown in Attachment #2 and Attachment #3 (Dynamic data format). The topology of the system is shown in Attachment #4.

Stability (AEP Stability Criteria)

Stability analysis was performed at 2013 summer peak load conditions. The maximum generation output was considered. Throughout the study, the U4-028 wind farm had an initial output of 100.8 MW and 0 MVAR operated at a terminal voltage of about 1.0 pu and under power factor control. The range of contingencies evaluated was limited to that necessary to assess expected compliance with AEP criteria. This study involves transient simulations of approximately 50 contingencies that includes (a) tripping of lines without fault, (b) 3-phase faults with unsuccessful autoreclosure, and (c) SLG faults with stuck breaker. The simulation time period was 12 seconds for each contingency.

Result and Analysis

No transient instability was identified in this study. For all contingencies simulated, the voltage profile recovered to satisfactory steady state levels, hence there were no voltage recovery issues. Table-1 in Attachment #1 tabulates the clearing times for the contingencies. A brief description of each contingency simulated is also provided in this attachment.

Whenever the U4-028 wind farm was islanded with a load, it is recommended that the following trip settings be used at the interconnection point:

- Voltage at the point of interconnection: 0.8 pu or lower for 2 seconds; 1.11 pu or higher for 0.1 second; 1.2 pu or higher for 0.02 second
- Frequency at the point of interconnection: 57Hz or lower for 0.05 seconds; 62Hz or higher for 0.05 second

Note: While the stability analysis has been performed at expected extreme system conditions, there is a potential that evaluation at a different level of generator MW and/or MVAR output at different system 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 that or other operating or planning studies will need to be resolved.

The generating facility should be operated with a power factor between 0.95 lag and 0.95 leaad.

Moreover, when the proposed generating station is designed and plant specific dynamics data for the plant and its controls are available, and if it is different than the data provided for this study, a transient stability analysis at a variety of expected operating conditions using the more accurate data shall 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 become available, it must be forwarded to PJM.

Maintenance Outage

Maintenance outage conditions were not studied during the impact study phase since the project equipment data provided by the project developer is preliminary in nature. The stability and LVRT study including the maintenance outage test will be re-evaluated during the facility study phase (or at later stage), when more accurate dynamic data becomes available. Note that any and all changes to the generation equipment's dynamic data, including the GSU data, must be submitted to PJM for evaluation.

Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

None

New System Reinforcements

(Upgrades required to mitigate reliability criteria violations, i.e. Network Impacts, initially caused by the addition of this project generation)

None

Contribution to Previously Identified System Reinforcements

(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)
(Summary form of Cost allocation for transmission lines and transformers will be inserted here if any)

None

Delivery of Energy Portion of Interconnection Request

(PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.
Only the most severely overloaded conditions are listed. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed, which will study all overload conditions associated with the overloaded element(s) identified.)

None

MISO Impacts

Any impacts on the MISO system will be identified in the Facilities Study.

Cost

The U4-028 project is responsible for 100% of the estimated direct connection cost of **$8,044,900.** There are no network upgrades for the project. The total estimated cost responsibility for the U4-028 project is **$8,044,900,** pending the results of the Stability and LVRT analysis**.**

Exhibit 1: Current system

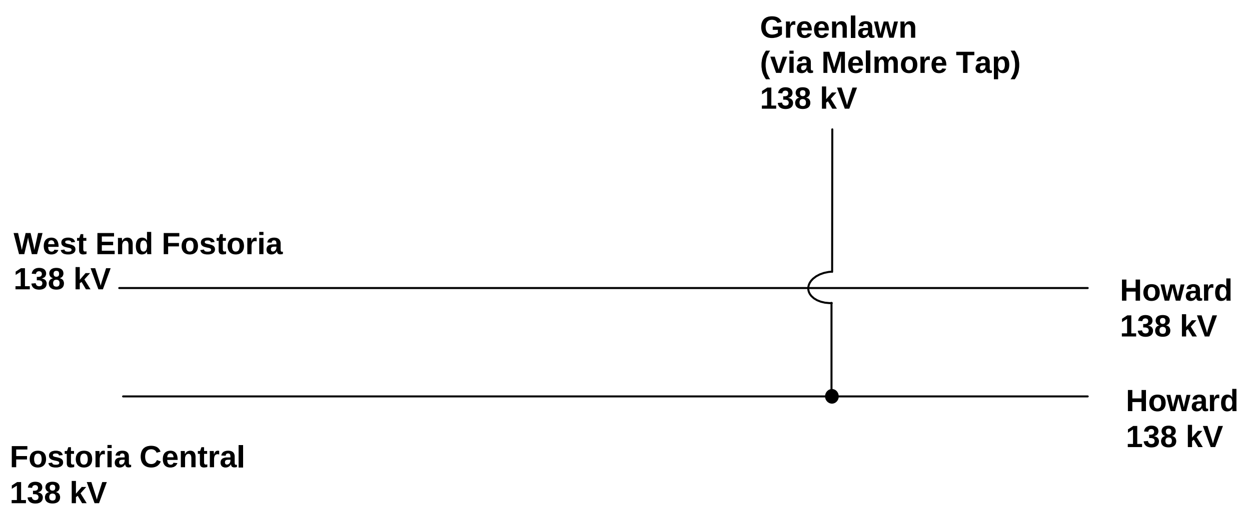
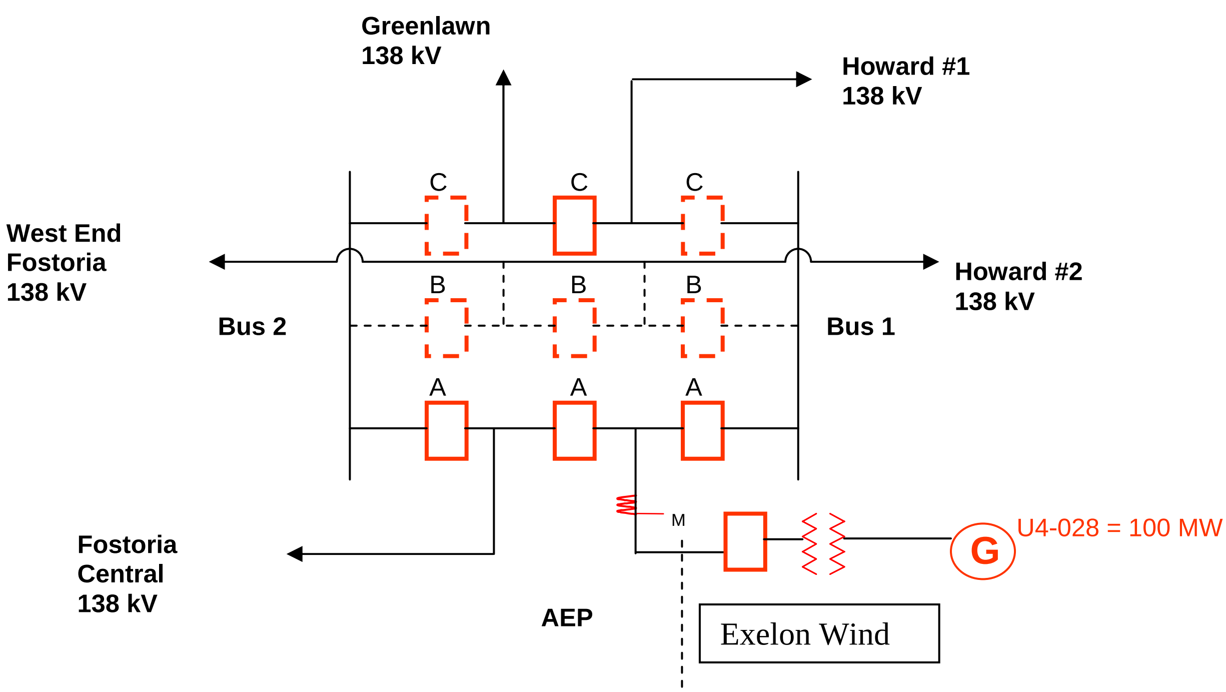


Exhibit 2: Ring Bus Arrangement



Attachment #1

U4-028

2013 Peak Load Stability Faults

Table 1: BREAKER CLEARING TIMES (CYCLES)

Station	Primary (3ph/slg)	3-ph with unsuccessful Autoreclosure (total)	SLG Fault with Stuck Breaker (total)
138 kV	5	20	18

All cases stable

1a. Line tripping of Melmore - Howard 138 kV without fault
1b. 3ph @ Melmore - Howard 138 kV with unsuccessful autoreclosure
1c1. SLG @ Melmore - Howard 138 kV with stuck breaker (2), fault cleared by opening Melmore – Fostoria Central 138 kV line
1c2. SLG @ Melmore - Howard 138 kV with stuck breaker (2), fault cleared by opening Melmore – Greenlawn 138 kV line

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2a. Line tripping of Melmore – Fostoria Central 138 kV without fault
2b. 3ph @ Melmore – Fostoria Central 138 kV with unsuccessful autoreclosure
2c. SLG @ Melmore – Fostoria Central 138 kV with stuck breaker (2), fault cleared by opening Melmore – Howard 138 kV line [same as contingency 1c1]

3a. Line tripping of Melmore – Greenlawn 138 kV without fault
3b. 3ph @ Melmore – Greenlawn 138 kV with unsuccessful autoreclosure
3c. SLG @ Melmore – Greenlawn 138 kV with stuck breaker (3), fault cleared by opening Melmore – Howard 138 kV line

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4a. Line tripping of Howard - Brookside 138 kV without fault
4b. 3ph @ Howard - Brookside 138 kV with unsuccessful autoreclosure
4c. SLG @ Howard - Brookside 138 kV with stuck breaker (D), fault cleared by opening Howard – N. Bellville and Howard – Chatfield – S. Tiffin – Airco – West End Fostoria 138 kV lines

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5a. Line tripping of Howard – N. Lexington – Academia 138 kV without fault
5b. 3ph @ Howard – N. Lexington – Academia 138 kV with unsuccessful autoreclosure
5c. SLG @ Howard - Brookside 138 kV with stuck breaker (I), fault cleared by opening Howard – Bucyrus Center, Howard – Melmore, and Howard – U4-001 Tap 138 kV lines

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6a. Line tripping of Howard – N. Bellville 138 kV without fault
6b. 3ph @ Howard – N. Bellville 138 kV with unsuccessful autoreclosure

6c. SLG @ Howard – N. Bellville 138 kV with stuck breaker (H), fault cleared by opening Howard – Brookside and Howard – West End Fostoria 138 kV lines [same as contingency 4c]

7a. Line tripping of Howard – Chatfield – S. Tiffin – Airco – West End Fostoria 138 kV without fault
7b. 3ph @ Howard – Chatfield – S. Tiffin – Airco – West End Fostoria 138 kV with unsuccessful autoreclosure
7c. SLG @ Howard – Chatfield – S. Tiffin – Airco – West End Fostoria 138 kV with stuck breaker (B), fault cleared by opening Howard – Brookside and Howard – N. Bellville 138 kV lines [same as contingency 4c]

8a. Line tripping of West End Fostoria – Lemoyne 138 kV without fault
8b. 3ph @ West End Fostoria – Lemoyne 138 kV with unsuccessful autoreclosure
8c. SLG @ West End Fostoria – Lemoyne 138 kV with stuck breaker (D), fault cleared by disconnecting West End Fostoria 138 kV bus

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9a. Line tripping of West End Fostoria – Fostoria Central 138 kV without fault
9b. 3ph @ West End Fostoria – Fostoria Central 138 kV with unsuccessful autoreclosure
9c. SLG @ West End Fostoria – Fostoria Central 138 kV with stuck breaker (A), fault cleared by disconnecting West End Fostoria 138 kV bus [same as contingency 8c]

10a. Line tripping of Fostoria Central – New Liberty/Findlay Center 138 kV without fault
10b. 3ph @ Fostoria Central – New Liberty/Findlay Center 138 kV with unsuccessful autoreclosure
10c1. SLG @ Fostoria Central – New Liberty/Findlay Center 138 kV with stuck breaker (K2), fault cleared by opening Fostoria Central 138/345 kV transformer
10c2. SLG @ Fostoria Central – New Liberty/Findlay Center 138 kV with stuck breaker (J2), fault cleared by opening Fostoria Central – Melmore 138 kV lines

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11a. Line tripping of Fostoria Central – N. Findlay without fault
11b. 3ph @ Fostoria Central – N. Findlay 138 kV with unsuccessful autoreclosure
11c1. SLG @ Fostoria Central – N. Findlay 138 kV with stuck breaker (K1), fault cleared by opening Fostoria Central – Buckley Rd 138 kV line
11c2. SLG @ Fostoria Central – N. Findlay 138 kV with stuck breaker (J1), fault cleared by opening Fostoria Central – West End Fostoria 138 kV line

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12a. Tripping of Fostoria Central 138/345 kV transformer without fault
12c1. SLG @ Fostoria Central 138/345 kV transformer with stuck breaker (K2), fault cleared by opening Fostoria Central – Findlay/New Liberty 138 kV line [same as contingency 10c1]
12c2. SLG @ Fostoria Central 138/345 kV transformer with stuck breaker (K), fault cleared by opening Fostoria Central – Buckley Rd 138 kV line

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13a. Line tripping of Brookside - Cloverdale 138 kV without fault
13b. 3ph @ Brookside - Cloverdale 138 kV with unsuccessful autoreclosure

13c. SLG @ Brookside - Cloverdale 138 kV with stuck breaker (30), fault cleared by opening Brookside – Longview, Brookside – Howard, and Brookside – Beaver 138 kV lines

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14a. Line tripping of Brookside - Burger 138 kV without fault
14b. 3ph @ Brookside - Burger 138 kV with unsuccessful autoreclosure
14c. SLG @ Brookside - Burger 138 kV with stuck breaker (3), fault cleared by opening Brookside – Wellington, Brookside – Madison – Longview, and Brookside – Leaside 138 kV lines

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15a. Line tripping of Brookside - Longview 138 kV without fault
15b. 3ph @ Brookside - Longview 138 kV with unsuccessful autoreclosure
15c. SLG @ Brookside - Longview with stuck breaker (28), fault cleared by opening Brookside – Cloverdale, Brookside – Howard, and Brookside – Beaver 138 kV lines [same as contingency 13c]

16a. Line tripping of Brookside – Milliron - Leaside 138 kV without fault
16b. 3ph @ Brookside – Milliron - Leaside 138 kV with unsuccessful autoreclosure
16c. SLG @ Brookside – Milliron - Leaside 138 kV with stuck breaker (36), fault cleared by opening Brookside – Burger, Brookside – Wellington, and Brookside- Madison – Longview 138 kV lines [same as contingency 14c]

17a. Line tripping of Brookside – Troy – Brighton - Beaver 138 kV without fault
17b. 3ph @ Brookside – Troy – Brighton - Beaver 138 kV with unsuccessful autoreclosure
17c. SLG @ Brookside – Troy – Brighton - Beaver 138 kV with stuck breaker (59), fault cleared by opening Brookside – Cloverdale, Brookside – Howard, Brookside – Longview 138 kV lines [same as contingency 13c]

18a. Line tripping of Academia – W. Mt. Vernon 138 kV without fault
18b. 3ph @ Academia – W. Mt. Vernon 138 kV with unsuccessful autoreclosure
18c. SLG @ Academia – W. Mt. Vernon 138 kV with stuck breaker (R), fault cleared by disconnecting Academia 138 kV bus

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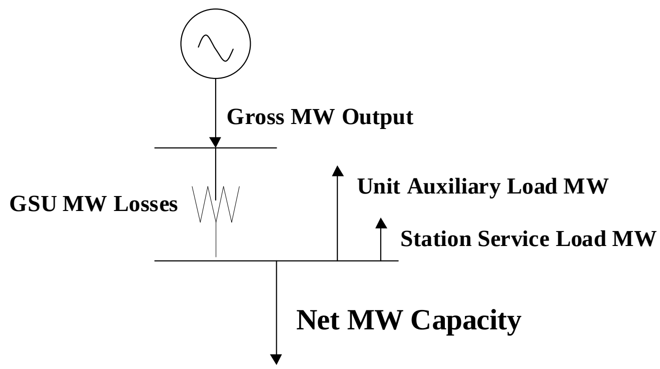
19a. Line tripping of Academia – Ohio Central 138 kV without fault
19b. 3ph @ Academia – Ohio Central 138 kV with unsuccessful autoreclosure
19c1. SLG @ Academia – Ohio Central 138 kV with stuck breaker (R), fault cleared by disconnecting Academia 138 kV bus [same as contingency 18c]
19c2. SLG @ Academia – Ohio Central 138 kV with stuck breaker (S), fault cleared by disconnecting Academia 138 kV bus [same as contingency 18c]

Attachment #2

U4-028 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: ____ U4-028

Primary Fuel Type: __________________________________ Vestas 90 1.8 MW (Wind)

Maximum Summer (92º F ambient air temp.) Net MW Output**: ________________ 101

Maximum Summer (92º F ambient air temp.) Gross MW Output: ________________ 101

Minimum Summer (92º F ambient air temp.) Gross MW Output: __________________ 0

Maximum Winter (30º F ambient air temp.) Gross MW Output: _________________ 101

Minimum Winter (30º F ambient air temp.) Gross MW Output: ___________________ 0

Gross Reactive Power Capability at Maximum Gross MW Output – Please include Reactive Capability Curve (Leading and Lagging): ___________________ +/- 0 Mvar

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

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

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

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

Station Service Load: ____ N/A

* 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 92º F Ambient

Air Temperature rating of the unit(s) or, if less, the declared Capacity rating of your project.

U4-028 Unit Generator Dynamics Data

Queue Letter/Position/Unit ID: ________________ U4-028

MVA Base (upon which all reactances, resistance and inertia are calculated): ___ 1.8x56

Nominal Power Factor: ________________ N/A

Terminal Voltage (kV): ________________ 0.69

Unsaturated Reactances (on MVA Base)

- Direct Axis Synchronous Reactance, $X_{d(i)}$: ________________ N/A
- Direct Axis Transient Reactance, X'd(i): ________________ N/A
- Direct Axis Sub-transient Reactance, X"d(i): ________________ N/A
- Quadrature Axis Synchronous Reactance, Xq(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, Xl: ________________ N/A
- Negative Sequence Reactance, X2(i): ________________ N/A
- Zero Sequence Reactance, X0: ________________ N/A

Saturated Sub-transient Reactance, X"d(v) (on MVA Base): ________________ N/A

Armature Resistance, Ra (on MVA Base): ________________ N/A

Time Constants (seconds)

- Direct Axis Transient Open Circuit, T'_{do}: ________________ N/A
- Direct Axis Sub-transient Open Circuit, T''_{do}: ________________ N/A
- Quadrature Axis Transient Open Circuit, T'_{qo}: ________________ N/A
- Quadrature Axis Sub-transient Open Circuit, T''_{qo}: ________________ N/A
- Inertia, H (kW-sec/kVA, on KVA Base): ________________ N/A

Speed Damping, D: ________________ N/A

Saturation Values at Per-Unit Voltage [S(1.0), S(1.2)]: ________________ N/A

Units utilize a Generator model

U4-028 Unit GSU Data

Queue Letter/Position/Unit ID: ________________________________ U4-028(56 GSU)

Generator Step-up Transformer MVA Base:________________________________ 2.1x56

Generator Step-up Transformer Impedance (R+jX, or %, on transformer MVA Base): ___7.8%

Generator Step-up Transformer Reactance-to-Resistance Ration (X/R): ____________10

Generator Step-up Transformer Rating (MVA):___________________________ 2.1x56

Generator Step-up Transformer Low-side Voltage (kV): ______________________ 0.69

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

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

Generator Step-up Transformer Number of Taps and Step Size: ______________5, 2.5%

U4-028 Main Transformer Data

Queue Letter/Position/Unit ID: ____U4-028

Main Transformer MVA Base: ____100

Main Transformer Impedance (R+jX, or %, on transformer MVA Base):_______________ 8%

Main Transformer Reactance-to-Resistance Ration (X/R):_____________________ N/A

Main Transformer Rating (MVA): ____100

Main Transformer H-side Voltage (kV):____________________________________138

Main Transformer X-side Voltage (kV):___________________________________ 34.5

Main Transformer Off-nominal Turns Ratio: ______________________________ 1.0

Main Transformer Number of Taps and Step Size:___________________________ N/A

Attachment #3

All the control systems were updated according to the developer’s specification; these updates are shown in Dynamic Data Format.

/ Vestas V90

```
930888 'USRMDL' '1'  'VWCORE' 1 1 2 20 3 23 1 0
 1800.0000 692.8203 899.6269 700.0000 2.6200 0.7620 0.0188
 6.0050 8.3264 6.0050 8.3264 100.0000 0.4000 1.2000
 0.1000 0.0000 0.0000 0.0000 0.0000 0.0000 /
0 'USRMDL' 0 'VWVARS' 8 0 2 0 0 18 930888 '1' /
0 'USRMDL' 0 'VWLVRT' 8 0 3 21 0 10 930888 '1' 1
 0.85 0.001 0.2 12.5 50.0000 0.0000 0.0000
 0.5 0.0000 2.6200 0.8079 1.2 0.5 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 /
0 'USRMDL' 0 'VWPWRC' 8 0 3 21 2 5 930888 '1' 0
 1.0000 0.0000 0.0000 1.000 1.000 1.000 1.0000
 1.0000 1.0000 1.0000 0.0000 0 0 0.1000
 0.1000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 /
0 'USRMDL' 0 'VWMECH' 8 0 2 7 3 0 930888 '1'
  1800.0000 351.8584 5684.1051 427.0000 65.0000 6358.0000 36.2900 /
0 'USRMDL' 0 'VWMEAS' 8 0 2 3 3 0 930888 '1'
 0.1000 0.1000 0.2000 /
0 'USRMDL' 0 'VWVPRT' 0 2 7 20 0 11 930888 '1'  1 1 0 0 0
 0.7500 0.0001 0.8500 0.4000 0.9000 60.0000 1.1000
 60.0000 1.1350 0.2000 1.2000 0.0800 0.0000 0.2000
 0.7000 2.6500 0.8000 11.0000 0.9000 60.0000 /
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 56.4000 0.2000 61.2000 0.2000 /
```
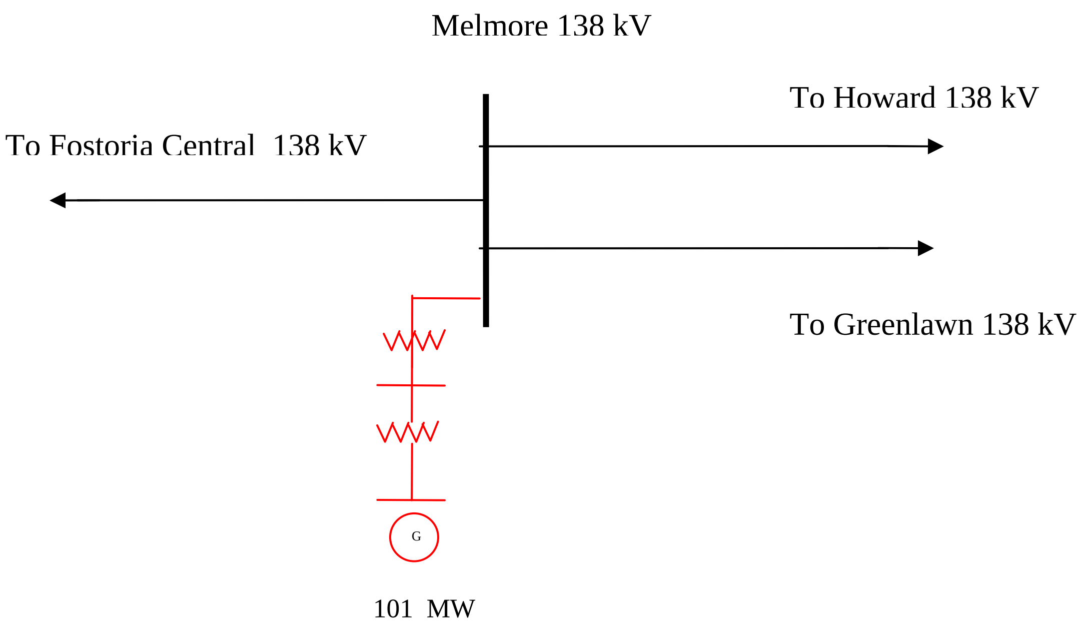

Attachment #4



U4-028 Project