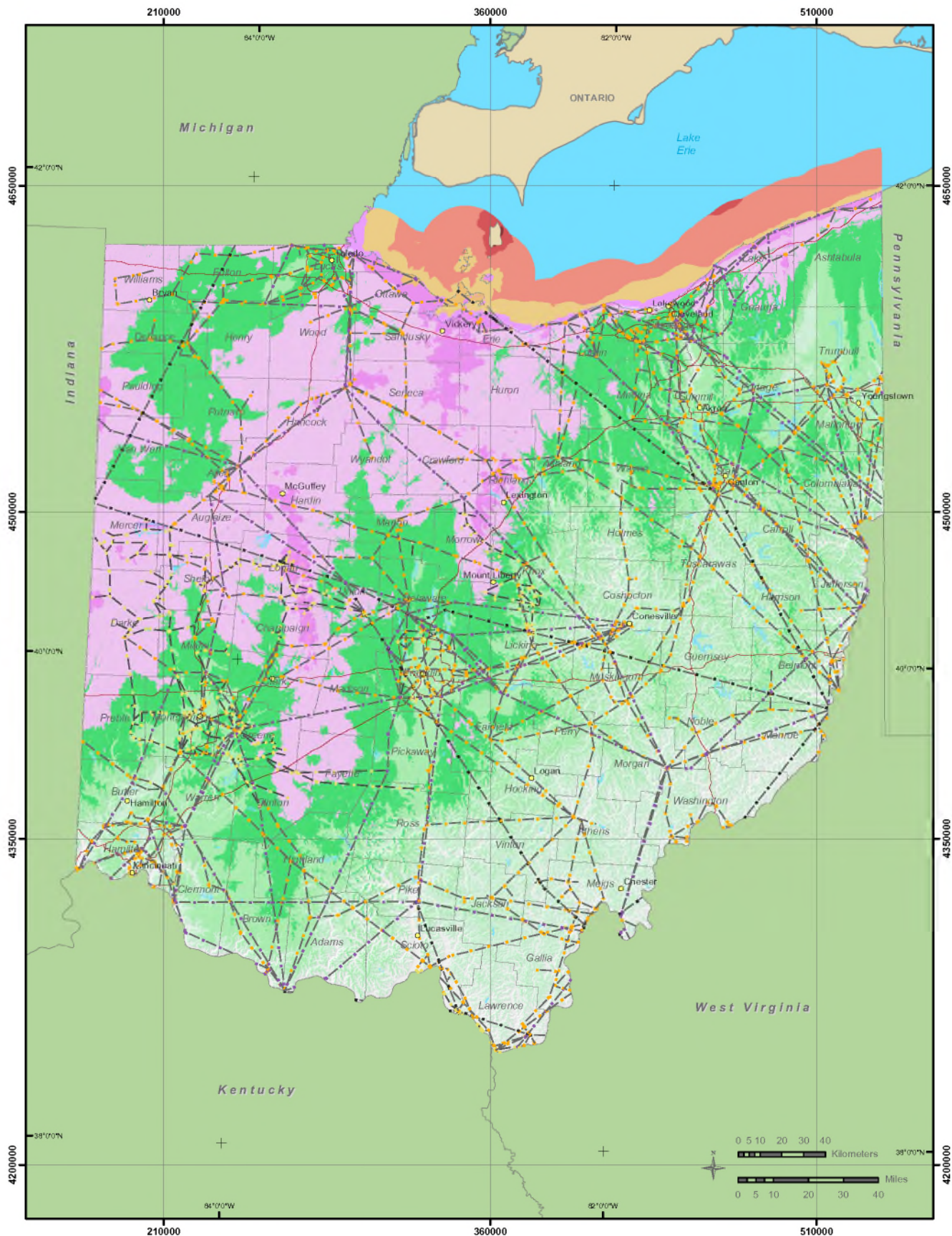
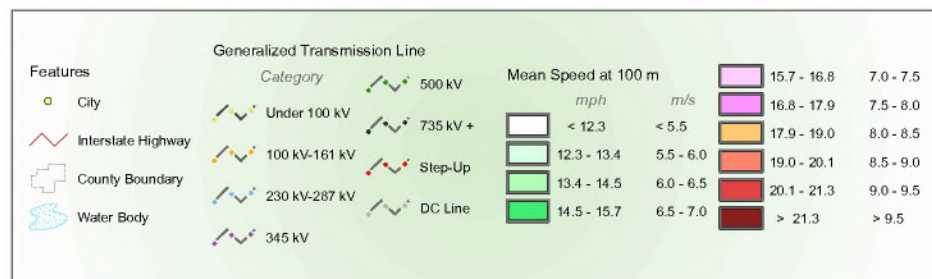


## **Exhibit A. Wind Resource Map**



## Wind Resource of Ohio

## Mean Annual Wind Speed at 100 Meters



**AWS Truewind**

**Projection:** Transverse Mercator, UTM Zone 17 WGS84

**Spatial Resolution of Wind Resource Data:** 200m

**This map was created by AWS Truewind using the MesoMap system and historical weather data. Although it is believed to represent an accurate overall picture of the wind energy resource, estimates at any location should be confirmed by measurement.**

**The transmission line information was obtained by AWS Truewind from the Global Energy Decisions Velocity Suite. AWS does not warrant the accuracy of the transmission line information.**

**AWS Truewind, LLC**

## **Exhibit B. Feasibility Study**

**#V4-010 Fremont Center-Tiffin Center (Seneca) 138kV**  
**Generation Interconnection**  
(Revised 04/29/10)

**Local AEP Impacts**

Unlike PJM, AEP performs AC analysis for interconnection projects in the feasibility stage. In analyzing the V2-019A Merchant Transmission Project with all other Wind Interconnection Projects in the AEP footprint at 13-20% (based on the queue position) of their total capacity, AEP identified numerous (>100) new overloads on the AEP bulk (100 kV and above) system. Furthermore, a number of other contingencies did not converge, and the project contributed to increased flows on several existing overload conditions on the AEP system. The less complete PJM analysis only recognized 3 new overloads on the AEP system. Considering the extensive differences between AEP and PJM analyses and methodologies, until these differences are addressed, AEP will be unable to verify the results of the PJM analyses for V2-019A and subsequent projects, including the subject of this report; V4-010.

While not validating the PJM results by performing any powerflow studies, AEP is complying with the PJM request to provide information for the V4-010 interconnection project regarding attachment facilities and transmission improvements that address system conditions identified by PJM. Please note that these transmission improvements are based on the information shared by PJM, were determined without the benefit of detailed engineering studies, and are therefore preliminary in nature. The extent of improvements needed for the interconnection may vary by type of project and its position in the queue. AEP will work with PJM to resolve the differences in results during the Impact Study stage.

The overloads foundFor the V2-019A project in the AEP analysis will be alleviated by installing 765kV transmission lines. Since it is likely that the V4-010 project will impact on some of those overloads, the V4-010 may be assigned a cost allocation

**Network Impacts**

The queue V4-010 project was studied as a 250MW (32.5MW of which was capacity) injection into AEP's system at the Tiffin Center 138kV substation. Project V4-010 was evaluated for compliance with reliability criteria for summer peak conditions in 2014. 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**

Stability analysis will be completed in the Impact Study

### **System Reinforcements**

None.

### **Potential Congestion due to Local Energy Deliverability**

*(PJM also studied the delivery of the energy portion of the surrounding generation. Any potential 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 Transmission Interconnection Request. Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full deliverability for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which analyzes all overload conditions associated with the identified overloaded element(s). As a result of the aggregate energy resources in the area, the following violations were identified:*

1. The Howard - Brookside 138kV line (from bus 243024 to bus 238586 ckt 1) loads from 200.14% to 215.58% (DC power flow) of its emergency rating (173MVA) for the operational contingency ('5242\_B2\_TOR4783B\_MOAB') as a result of V4-010. This project contributes approximately 43.2MW to cause this thermal violation.
2. The V1-010TAP - Howard 138kV line (from bus 292059 to bus 243024 ckt 1) loads from 99.07% to 114.36% (DC power flow) of its emergency rating (179MVA) for the operational contingency ('5242\_B2\_TOR4783B\_MOAB') as a result of V4-010. This project contributes approximately 43.2MW to cause this thermal violation.
3. The V1-010TAP - Howard 138kV line (from bus 292059 to bus 243024 ckt 2) loads from 159.53% to 181.39% (DC power flow) of its emergency rating (179MVA) for the operational contingency ('5147\_B2\_TOR707\_V1-010B') as a result of V4-010. This project contributes approximately 43.2MW to cause this thermal violation.
4. The Melmore – V1-010TAP 138kV line (from bus 243039 to bus 292059 ckt 1) loads from 69.97% to 132.77% (DC power flow) of its emergency rating (179MVA) for the operational contingency ('5149\_B2\_TOR709\_WOMOAB') as a result of V4-010. This project contributes approximately 43.2MW to cause this thermal violation.

5. The Melmore – Fostoria Central 138kV line (from bus 243039 to bus 243006 ckt 1) loads from 90.65% to 138.29% (DC power flow) of its emergency rating (245MVA) for the operational contingency ('5149\_B2\_TOR709\_WOMOAB') as a result of V4-010. This project contributes approximately 43.2MW to cause this thermal violation.

6. The Chatfield – S. Tiffin 138kV line (from bus 242984 to bus 243110 ckt 1) loads from 103.53% to 121.14% (DC power flow) of its emergency rating (192MVA) for the operational contingency ('5149\_B2\_TOR709\_WOMOAB') as a result of V4-010. This project contributes approximately 43.2MW to cause this thermal violation.

7. The Tiffin – Green Lawn 138kV line (from bus 243130 to bus 243015 ckt 1) loads from 51% to 109.98% (DC power flow) of its emergency rating (201MVA) for the operational contingency ('744\_B3') as a result of V4-010. This project contributes approximately 43.2MW to cause this thermal violation.

8. The Green Lawn - Melmore 138kV line (from bus 243015 to bus 243039 ckt 1) loads from 43.86% to 104.61% (DC power flow) of its emergency rating (201MVA) for the operational contingency ('744\_B3') as a result of V4-010. This project contributes approximately 43.2MW to cause this thermal violation.

**#V4-010 Fremont Center-Tiffin Center (Seneca) 138kV**  
**Generation Interconnection**

**Local AEP Impacts**

Unlike PJM, AEP performs AC analysis for interconnection projects in the feasibility stage. In analyzing the V2-019A Merchant Transmission Project with all other Wind Interconnection Projects in the AEP footprint at 13-20% (based on the queue position) of their total capacity, AEP identified numerous (>100) new overloads on the AEP bulk (100 kV and above) system. Furthermore, a number of other contingencies did not converge, and the project contributed to increased flows on several existing overload conditions on the AEP system. The less complete PJM analysis only recognized 3 new overloads on the AEP system. Considering the extensive differences between AEP and PJM analyses and methodologies, until these differences are addressed, AEP will be unable to verify the results of the PJM analyses for V2-019A and subsequent projects, including the subject of this report; V4-010.

While not validating the PJM results by performing any powerflow studies, AEP is complying with the PJM request to provide information for the V4-010 interconnection project regarding attachment facilities and transmission improvements that address system conditions identified by PJM. Please note that these transmission improvements are based on the information shared by PJM, were determined without the benefit of detailed engineering studies, and are therefore preliminary in nature. The extent of improvements needed for the interconnection may vary by type of project and its position in the queue. AEP will work with PJM to resolve the differences in results during the Impact Study stage.

**Network Impacts**

The queue V4-0 10 project was studied as a 250MW (32.5MW of which was capacity) injection into AEP's system at the Tiffin Center 138kV substation. Project V4-010 was evaluated for compliance with reliability criteria for summer peak conditions in 2014. 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**

Not required because the project is less than 30 MW.

## **System Reinforcements**

None.

## **Potential Congestion due to Local Energy Deliverability**

*(PJM also studied the delivery of the energy portion of the surrounding generation. Any potential 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 Transmission Interconnection Request. Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full deliverability for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which analyzes all overload conditions associated with the identified overloaded element(s). As a result of the aggregate energy resources in the area, the following violations were identified:*

1. The Howard - Brookside 138kV line (from bus 243024 to bus 238586 ckt 1) loads from 200.14% to 215.58% (DC power flow) of its emergency rating (173MVA) for the operational contingency ('5242\_B2\_TOR4783B\_MOAB') as a result of V4-010. This project contributes approximately 43.2MW to cause this thermal violation.
2. The V1-010TAP - Howard 138kV line (from bus 292059 to bus 243024 ckt 1) loads from 99.07% to 114.36% (DC power flow) of its emergency rating (179MVA) for the operational contingency ('5242\_B2\_TOR4783B\_MOAB') as a result of V4-010. This project contributes approximately 43.2MW to cause this thermal violation.
3. The V1-010TAP - Howard 138kV line (from bus 292059 to bus 243024 ckt 2) loads from 159.53% to 181.39% (DC power flow) of its emergency rating (179MVA) for the operational contingency ('5147\_B2\_TOR707\_V1-010B') as a result of V4-010. This project contributes approximately 43.2MW to cause this thermal violation.
4. The Melmore – V1-010TAP 138kV line (from bus 243039 to bus 292059 ckt 1) loads from 69.97% to 132.77% (DC power flow) of its emergency rating (179MVA) for the operational contingency ('5149\_B2\_TOR709\_WOMOAB') as a result of V4-010. This project contributes approximately 43.2MW to cause this thermal violation.
5. The Melmore – Fostoria Central 138kV line (from bus 243039 to bus 243006 ckt 1) loads from 90.65% to 138.29% (DC power flow) of its emergency rating (245MVA) for the operational contingency ('5149\_B2\_TOR709\_WOMOAB') as a result of V4-010. This project contributes approximately 43.2MW to cause this thermal violation.



6. The Chatfield – S. Tiffin 138kV line (from bus 242984 to bus 243110 ckt 1) loads from 103.53% to 121.14% (DC power flow) of its emergency rating (192MVA) for the operational contingency ('5149\_B2\_TOR709\_WOMOAB') as a result of V4-010. This project contributes approximately 43.2MW to cause this thermal violation.

7. The Tiffin – Green Lawn 138kV line (from bus 243130 to bus 243015 ckt 1) loads from 51% to 109.98% (DC power flow) of its emergency rating (201MVA) for the operational contingency ('744\_B3') as a result of V4-010. This project contributes approximately 43.2MW to cause this thermal violation.

8. The Green Lawn - Melmore 138kV line (from bus 243015 to bus 243039 ckt 1) loads from 43.86% to 104.61% (DC power flow) of its emergency rating (201MVA) for the operational contingency ('744\_B3') as a result of V4-010. This project contributes approximately 43.2MW to cause this thermal violation.

## **Exhibit C. System Impact Study**

***PJM Generator Interconnection Request  
Queue #V4-010  
Fremont Center-Tiffin Center (Seneca) 138kV  
Impact Study***

611338

September 2010

October 2010 Version 2

November 15, 2011 Version 3

## **V4-010 Fremont Center-Tiffin Center (Seneca) 138kV Impact Study** **Report**

### **General**

Nordex has proposed installing a 200 MW wind project, consisting of 80 2.5 MW Nordex wind turbines, in Seneca County, Ohio. The project will be connected directly to the Fremont Center-Tiffin Center 138kV transmission line. The western boundary of the project is 4.5 to 5 miles east of the Tiffin Center-Fremont Center line. The center of the project is about 10 miles east of the line. The in-service date for the project is December 31, 2013.

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 V4-010 project will be connected to the transmission system via a new 3-breaker, 138kV, ring bus station. The new station will be connected into the Fremont Center-Tiffin Center 138kV transmission line. Nordex will build a 138kV transmission line from the project collector station to the new interconnection station.

It is understood that Nordex will be responsible for all the costs associated with this construction, as well as facilities associated with connecting their 200MW of generation to the in-line facilities

The AEP design and construction scope for the attachment facilities:

- Construct a new 138 kV interconnection substation to include 3 circuit breakers, relaying, 138kV revenue metering and facilities to accommodate termination of a new 138 kV line from V4-010 collector station. (Network Upgrade #n3134)

Estimated Cost (2011 Dollars)\*: **\$5,000,000**

- Install transmission line structures to permit termination of the 138kV line in the interconnection substation. (Network Upgrade #n3135)

Estimated Cost (2011 Dollars)\*: **\$500,000**

- Replace relay and controls at Fremont Center Station. (Network Upgrade #n3136)

Estimated Cost (2011 Dollars)\*: **\$250,000**

- Replace relay and controls at Fremont Center Station. (Network Upgrade #n3137)

Estimated Cost (2011 Dollars)\*: **\$250,000**

- Replace relay and controls at West Fremont Station (FE).

Estimated Cost (2011 Dollars)\*: **\$250,000**

Total estimated cost is **\$6,250,000**

The requested in-service date is December 2013. The standard time required for construction is 18 months after signing of the Interconnection Service Agreement and Interconnection Construction Service Agreement.

An Interim Interconnection Service Agreement can be executed to facilitate meeting the requested date.

### **AEP Local Network Impacts**

The impact of the proposed generating facility was assessed for AEP planning criteria specifically that the transmission system meet single contingency performance based on the AEP FERC Form 715 criteria. The Everpower project was studied as both a 200 MW and a 26MW net energy injection. The results are summarized below.

#### **Normal System (NERC Category A)– Capacity Output (2013 Summer Conditions)**

- No problems identified.

#### **Single Contingency (NERC Category B) – Capacity Output (2013 Summer Conditions)**

- No problems identified.

#### **Multiple Contingency (NERC Category C) – Full Output (2013 Summer Conditions)**

- No problems identified.

### **Short Circuit Analysis**

- No problems identified.

### Stability Analysis

- For a double contingency outage of Tiffin Center – Fremont Center 138kV and the Melmore – Fostoria Central 138kV lines an unstable result is expected.
- For a double contingency outage of the Greenlawn – Melmore 138kV and the Fremont Center – Tiffin Center 138kV lines an unstable result is expected.

Both scenarios shown above can be solved by curtailment.

### Local/Network Upgrades

- None.

### Contributions to Previously Identified Local/Network Limitations (Full Output)

- None.

### Additional Limitations of Concern – Full Output

- None.

### **Network Impacts**

The Queue Project #V4-010 was studied as a(n) 200.0MW(Capacity=26.0MW) injection at Fremont Center-Tiffin Center 138 kV transmission line in the AEP area. Project #V4-010 was evaluated for compliance with reliability criteria for summer peak conditions in 2014. 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**

PJM queue projects V4-010 is a new 200 MW interconnection requests tapping the existing Tiffin Center 138 kV substation in the AEP system. This is a Nordex N90 2.5 MW based wind farm with 80 generators.

Stability analysis for the V4-010 queue project was performed at 2014 light and peak load conditions. The range of contingencies evaluated was limited to that necessary to assess compliance with AEP criteria. Simulation time was limited to 10 seconds for all faults.

Three fault types were considered in this study:

- Type A: Three-phase faults (3ph) with primary clearing time
- Type B: Stuck breaker fault cleared with backup clearing time
- Type C: Zone 2 faults cleared with secondary protection

Specific fault descriptions and breaker clearing times used for this study are provided in Appendix A.

## Results

### Transient Stability:

For all cases studied, transient stability is maintained with all oscillations stabilized in less than 10 seconds. Also, the voltage levels returned to normal for all cases following the fault clearance. Hence, no transient stability issues were concluded.

The maximum angle deviations for all three fault types are shown in Tables I - VI.

Table I. Maximum angle deviation for Type A faults  
2014 Light Load Conditions

Fault	Chan	Bus	ID	Initial Angle	Max Deviation	Time
1A	418	243515	1	84.12	-5.241	10.000
2A	356	242940	4	82.58	-2.034	0.7126
3A	357	242940	5	93.54	-2.684	0.5792
4A	357	242940	5	93.54	-2.666	0.5959
5A	357	242940	5	93.54	-2.723	0.5834
6A	376	243190	1	102.8	-2.450	2.1960
7A	376	243190	1	102.8	-2.722	2.1960
8A	376	243190	1	102.8	-2.719	2.1960
9A	412	243440	1	108.9	-2.608	4.2379



Table II. Maximum angle deviation for Type A faults  
2014 Summer Peak Load Conditions

Fault	Chan	Bus	ID	Initial Angle	Max Deviation	Time
1A	359	242940	D	52.16	-1.958	9.9882
2A	356	242940	4	51.15	-1.281	0.8167
3A	356	242940	4	51.15	-1.696	0.8084
4A	356	242940	4	51.15	-1.659	0.8167
5A	356	242940	4	51.15	-1.745	0.8167
6A	381	243195	2	51.32	-1.58	2.5919
7A	381	243195	2	51.32	-1.78	2.5919
8A	381	243195	2	51.32	-1.783	2.5919
9A	381	243195	2	51.32	-1.652	2.5919

Table III. Maximum angle deviation for Type B faults  
2014 Light Load Conditions

Fault	Chan	Bus	ID	Initial Angle	Max Deviation	Time
1B	412	243440	1	108.9	-4.798	9.9799
2B	412	243440	1	108.9	-4.716	9.9799
3B1	356	242940	4	82.58	-3.446	0.8417
3B2	356	242940	4	82.58	-3.522	0.8417
4B1	376	243190	1	102.8	-7.641	9.9799
4B2	356	242940	4	82.58	-3.221	0.8417
5B1	356	242940	4	82.58	-2.502	0.8042
5B2	412	243440	1	108.9	-7.497	9.9799
6B	412	243440	1	108.9	-6.236	9.9799
7B	376	243190	1	102.8	2.905	1.7918
8B	412	243440	1	108.9	-8.026	9.9799
9B	376	243190	1	102.8	-13.82	9.9799

Table IV. Maximum angle deviation for Type B faults  
2014 Summer Peak Load Conditions

Fault	Chan	Bus	ID	Initial Angle	Max Deviation	Time
1B	359	242940	D	52.16	-1.517	9.9799
2B	359	242940	D	52.16	-1.521	9.9799
3B1	356	242940	4	51.15	-1.814	0.9126
3B2	356	242940	4	51.15	-1.951	0.9209
4B1	359	242940	D	52.16	-3.949	9.9799
4B2	356	242940	4	51.15	-1.678	0.9167
5B1	356	242940	4	51.15	-1.277	0.8959

Table IV. Maximum angle deviation for Type B faults  
2014 Summer Peak Load Conditions

<b>Fault</b>	<b>Chan</b>	<b>Bus</b>	<b>ID</b>	<b>Initial Angle</b>	<b>Max Deviation</b>	<b>Time</b>
5B2	359	242940	D	52.16	-3.871	9.9799
6B	377	243191	2	63.19	-2.753	9.9799
7B	381	243195	2	51.32	-2.087	2.7086
8B	346	242933	1	42.31	-4.174	9.9799
9B	422	243654	3	64.88	-7.331	9.9799

Table V. Maximum angle deviation for Type C faults  
2014 Light Load Conditions

<b>Fault</b>	<b>Chan</b>	<b>Bus</b>	<b>ID</b>	<b>Initial Angle</b>	<b>Max Deviation</b>	<b>Time</b>
1C	418	243515	1	84.12	-4.226	9.9799
2C	356	242940	4	82.58	-1.059	0.7792
3C	356	242940	4	82.58	-2.985	1.0501
4C	356	242940	4	82.58	-2.104	0.9751
5C	356	242940	4	82.58	-1.903	0.7792
6C	356	242940	4	82.58	-1.222	1.1459
7C	356	242940	4	82.58	-1.741	1.2001
8C	356	242940	4	82.58	-1.141	1.1751
9C	356	242940	4	82.58	-1.500	1.1626

Table VI. Maximum angle deviation for Type C faults  
2014 Summer Peak Load Conditions

<b>Fault</b>	<b>Chan</b>	<b>Bus</b>	<b>ID</b>	<b>Initial Angle</b>	<b>Max Deviation</b>	<b>Time</b>
1C	359	242940	D	52.16	-1.541	9.9799
2C	422	243654	3	64.88	-0.6469	1.7168
3C	422	243654	3	64.88	-2.182	1.5251
4C	422	243654	3	64.88	-1.324	1.5585
5C	422	243654	3	64.88	-1.245	1.6335
6C	422	243654	3	64.88	0.9741	9.9799
7C	422	243654	3	64.88	-0.8438	1.9877
8C	381	243195	2	51.32	0.6573	1.0543
9C	381	243195	2	51.32	0.681	1.0543

The wind farm was modeled with two equivalent generators (WTGs) connected to Tiffin 138 kV bus through a single circuit transmission line and equivalent GSUs and main 34.5/138 kV step-up transformers. The reactive power range of each of the equivalent

generator was set at +32.84 Mvar/ -44 Mvar (0.95 lagging and 0.9 leading power factor). The terminal voltage of each generator was set at 1.000 pu.

**Low Voltage Ride-Through (LVRT):** The LVRT test for V4-010 was performed by applying a three-phase 9-cycle fault at Tiffin 138 kV bus (POI) using the light and peak load base cases. It is noted that V4-010 stayed connected during these fault conditions.

The voltages at the collector buses and generator terminals are not adequate for simulating low voltage ride through test if the WTGs are dispatched at 0.95 leading power factor using the 2014 Summer Peak base-case. If the nearby reactive resources and taps of the main transformers and GSUs (which should not be) are exploited then voltages become acceptable. Under these conditions, a three-phase 9-cycle fault at the 138 kV tap point resulted in tripping of the WTGs on low voltage, which is primarily due to protection settings of Nordex WTGs. The WTGs stay on-line for a 7-cycle three phase-fault. However, for all the cases simulated, the V4-010 queue project rides through the faults specified in Section A.4.

Based on the above, it is concluded that V4-010 meets the LVRT test specified in FERC order 661 and 661A.

**Note:** While the stability analysis has been performed at 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 may 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.

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.

### **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 Melmore-Fostoria Central 138 kV line (from bus 243039 to bus 243006 ckt 1) loads from 65.44% to 110.13% (AC power flow) of its emergency rating (245 MVA) for the single line contingency outage of CONTINGENCY DESCRIPTION ('5149\_B2\_TOR709\_WOMOAB'). This project contributes approximately 110.85 MW to the thermal violation.
2. The Melmore-Fostoria Central 138 kV line (from bus 243039 to bus 243006 ckt 1) loads from 82.04% to 116.22% (AC power flow) of its normal rating (167 MVA) for non-contingency condition. This project contributes approximately 58.42 MW to the thermal violation.
3. The Melmore-Howard 138 kV line (from bus 243039 to bus 243024 ckt 1) loads from 83.06% to 110.17% (AC power flow) of its normal rating (138 MVA) for non-contingency condition. This project contributes approximately 39.19 MW to the thermal violation.
4. The Howard-Brookside 138 kV line (from bus 243024 to bus 238586 ckt 1) loads from 145.11% to 150.01% (AC power flow) of its emergency rating (173 MVA) for the single line contingency outage of CONTINGENCY DESCRIPTION ('911\_B2'). This project contributes approximately 18.83 MW to the thermal violation.
5. The Howard-Brookside 138 kV line (from bus 243024 to bus 238586 ckt 1) loads from 168.42% to 174.47% (AC power flow) of its normal rating (133 MVA) for

non-contingency condition. This project contributes approximately 17.87 MW to the thermal violation.

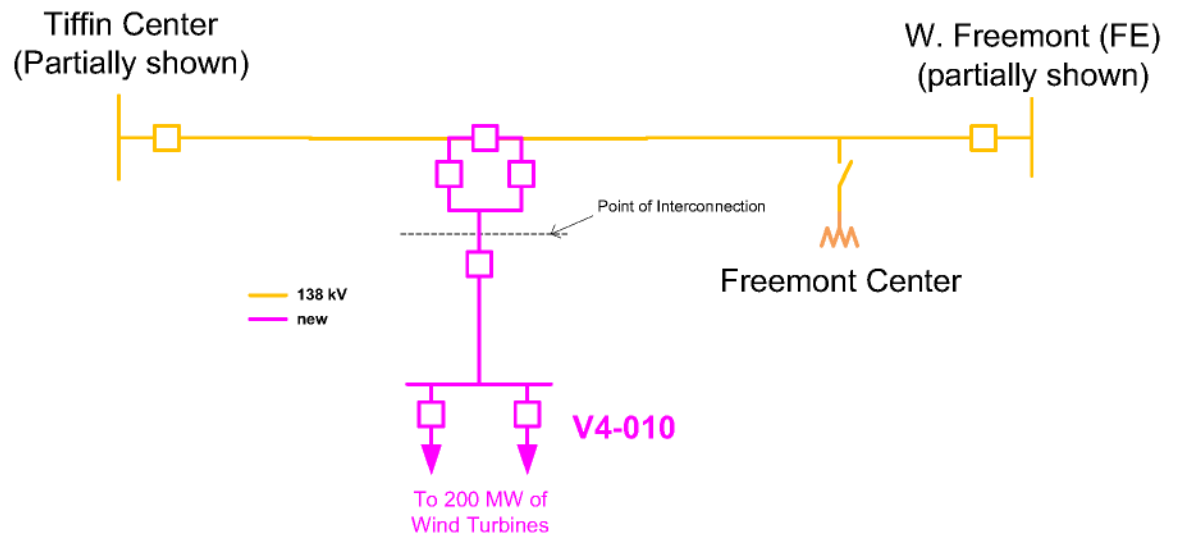
### **ATSI Integration**

V4-010 does not have any AEP violations, however, due to the recent integration of ATSI area into PJM, PJM is reviewing contingencies in the ATSI territory for all the queue projects in T, U, V, W1, W2, W3 queues that could affect ATSI facilities. Several violations due to contingencies in the ATSI area have been found. PJM is currently working with ATSI in resolving these issues. V4-010 could have some cost responsibility for the fixes to these violations. This analysis is ongoing and will be completed during the Facilities Study.

### **Cost**

The V4-010 project is responsible for 100% of the direct connection cost of **\$6,000,000**. There are no network upgrades for the project. The total cost responsibility for the V4-010 project is **\$6,000,000**.

**Figure #1**  
**V4-010 Freemont Center-**  
**Tiffin Center (Seneca)**  
**138kV**



**APPENDIX A**  
**V4-010**  
**(Tiffin Center 138 kV)**

**A.1) POWER FLOW CONDITIONS**

2014 Light and Peak Load Base Cases

**A.2) BREAKER CLEARING TIMES (CYCLES)**

Table A.1. AEP Clearing Times (Cycles)

Station	Primary (3ph/slg)	Stuck Breaker (Total)	Zone 2 (Total)	Re-closing
500 kV	4	14	4	N/A
345 kV	4	15	4	N/A
230 kV	5	15	5	N/A
115kV & 138 kV	5	18	63	N/A

**A.3) NETWORK CONDITIONS**

All facilities in service (base case)

**A.4) FAULTS CONSIDERED**

*Note: For simplicity of fault type identification, PJM has adopted the following notation:*

A faults: *three-phase faults with normal clearing time*

B faults: *slg faults due to stuck breaker with delayed clearing time*

C faults: *slg faults with delayed clearing time due to protection system failure*

*This notation is for internal purposes only, and does not necessarily correspond with the NERC category definition stated in TPL-001.*

Tiffin Center 138 kV

- 1a     3ph fault @ Tiffin Center 138 kV  
          Fault cleared within 138 kV breaker primary clearing time  
          Loss of: Tiffin Center - Fremont Center 138 kV ckt 1  
                  Fremont Center - Fremont 138 kV ckt 1  
                  Tiffin Center 138 kV  
                  Fremont Center 138 kV  
                  V4-010

- 1b     slg fault @ Tiffin Center 138 kV



Fault cleared within 138 kV breaker primary clearing time  
Loss of: Fremont Center - Fremont 138 kV ckt 1

V4-010

Breaker Failure

slg fault @ Tiffin Center 138 kV

Fault cleared within 138 kV breaker backup clearing time

Loss of: Tiffin Center - Fremont Center 138 kV ckt 1

Tiffin Center 138 kV

Fremont Center 138 kV

Greenlawn 138 kV

- 1c slg fault @ 80% of Tiffin Center - Fremont Center 138 kV ckt 1  
Fremont Center breaker tripped within 138 kV primary time  
Tiffin Center breaker tripped within 138 kV secondary time  
Loss of: Tiffin Center - Fremont Center 138 kV ckt 1  
Fremont Center - Fremont 138 kV ckt 1  
Tiffin Center 138 kV  
Fremont Center 138 kV  
V4-010

- 2a 3ph fault @ Tiffin Center 138 kV  
Fault cleared within 138 kV breaker primary clearing time  
Loss of: Tiffin Center - Greenlawn 138 kV ckt 1  
Greenlawn - Melmore Tap 138 kV ckt 1  
Greenlawn 138 kV

- 2b slg fault @ Tiffin Center 138 kV  
Fault cleared within 138 kV breaker primary clearing time  
Loss of: Greenlawn - Melmore Tap 138 kV ckt 1  
V4-010  
Breaker Failure  
slg fault @ Tiffin Center 138 kV  
Fault cleared within 138 kV breaker backup clearing time  
Loss of: Fremont Center 138 kV  
Tiffin Center 138 kV  
Greenlawn 138 kV

- 2c slg fault @ 80% of Tiffin Center - Greenlawn 138 kV ckt 1  
Greenlawn breaker tripped within 138 kV primary time  
Tiffin Center breaker tripped within 138 kV secondary time  
Loss of: Tiffin Center - Greenlawn 138 kV ckt 1  
Greenlawn - Melmore Tap 138 kV ckt 1  
Greenlawn 138 kV

Melmore 138 kV

- 3a     3ph fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker primary clearing time  
 Loss of: Melmore - Greenlawn 138 kV ckt 1
- 3b1    slg fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker primary clearing time  
 Loss of: Melmore - Greenlawn 138 kV ckt 1  
 Breaker Failure  
 slg fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker backup clearing time  
 Loss of: Melmore - Fostoria Central 138 kV ckt 1
- 3b2    slg fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker primary clearing time  
 Loss of: Melmore - Greenlawn 138 kV ckt 1  
 Breaker Failure  
 slg fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker backup clearing time  
 Loss of: Melmore - V1-010 138 kV ckt 1
- 3c     slg fault @ 80% of Melmore - Greenlawn 138 kV ckt 1  
 Greenlawn breaker tripped within 138 kV primary time  
 Melmore breakers tripped within 138 kV secondary time.  
 Loss of: Melmore - Greenlawn 138 kV ckt 1
- 4a     3ph fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker primary clearing time  
 Loss of: Melmore - Fostoria Central 138 kV ckt-1
- 4b1    slg fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker primary clearing time  
 Loss of: Melmore - Fostoria Central 138 kV ckt-1  
 Breaker Failure  
 slg fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker backup clearing time  
 Loss of: U4-028 & U4-029
- 4b2    slg fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker primary clearing time  
 Loss of: Melmore - Fostoria Central 138 kV ckt-1  
 Breaker Failure  
 slg fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker backup clearing time  
 Loss of: Melmore - Greenlawn 138 kV ckt-1
- 4c     slg fault @ 80% of Melmore - Fostoria Central 138 kV ckt-1

- Fostoria breakers tripped within 138 kV primary time  
 Melmore breakers tripped within 138 kV secondary time.  
 Loss of: Melmore - Fostoria Central 138 kV ckt-1
- 5a 3ph fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker primary clearing time  
 Loss of: Melmore - V1-010 138 kV Tap 138 kV ckt 1
- 5b1 slg fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker primary clearing time  
 Loss of: Melmore - V1-010 138 kV Tap 138 kV ckt 1  
 Breaker Failure  
 slg fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker backup clearing time  
 Loss of: Melmore - Greenlawn 138 kV ckt-1
- 5b2 slg fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker primary clearing time  
 Loss of: Melmore - V1-010 138 kV Tap 138 kV ckt 1  
 Breaker Failure  
 slg fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker backup clearing time  
 Loss of: U4-028 & U4-029
- 5c slg fault @ 80% of Melmore - V1-010 138 kV Tap 138 kV ckt 1  
 V1-010 breakers tripped within 138 kV primary time  
 Melmore breakers tripped within 138 kV secondary time.  
 Loss of: Melmore - V1-010 138 kV Tap 138 kV ckt 1

#### West Freemont 138 kV

(assumed 138 kV line-end breaker at Ottawa)

- 6a 3ph fault @ West Freemont 138 kV  
 Fault cleared within 138 kV breaker primary clearing time  
 Loss of: West Freemont - Freemont Center 138 kV ckt 1  
 Freemont 138 kV
- 6b slg fault @ West Freemont 138 kV  
 Fault cleared within 138 kV breaker primary clearing time  
 Loss of: Freemont - Freemont Center 138 kV ckt 1  
 Breaker Failure  
 slg fault @ West Freemont 138 kV  
 Fault cleared within 138 kV breaker backup clearing time  
 Loss of: West Freemont - Freemont 138 kV ckt 1  
 Freemont 138 kV  
 West Freemont CT A18

- 6c     slg fault @ 80% of West Freemont - Freemont Center 138 kV ckt 1  
         Freemont Center breaker tripped within 138 kV primary time  
         West Freemont breakers tripped within 138 kV secondary time.  
         Loss of: West Freemont - Freemont Center 138 kV ckt 1  
                 Freemont 138 kV
- 7a     3ph fault @ West Freemont 138 kV  
         Fault cleared within 138 kV breaker primary clearing time  
         Loss of: West Freemont - Woodville 138 kV ckt 1
- 7b     slg fault @ West Freemont 138 kV  
         Fault cleared within 138 kV breaker primary clearing time  
         Loss of: West Freemont - Woodville 138 kV ckt 1  
         Breaker Failure  
         slg fault @ West Freemont 138 kV  
         Fault cleared within 138 kV breaker backup clearing time  
         Loss of: None (T3)
- 7c     slg fault @ 80% of West Freemont - Woodville 138 kV ckt 1  
         Woodville breaker tripped within 138 kV primary time  
         West Freemont breakers tripped within 138 kV secondary time.  
         Loss of: West Freemont - Woodville 138 kV ckt 1
- 8a     3ph fault @ West Freemont 138 kV  
         Fault cleared within 138 kV breaker primary clearing time  
         Loss of: West Freemont - Lemoyne 138 kV ckt 1
- 8b     slg fault @ West Freemont 138 kV  
         Fault cleared within 138 kV breaker primary clearing time  
         Loss of: West Freemont - Lemoyne 138 kV ckt 1  
         Breaker Failure  
         slg fault @ West Freemont 138 kV  
         Fault cleared within 138 kV breaker backup clearing time  
         Loss of: West Freemont CT A17
- 8c     slg fault @ 80% of West Freemont - Lemoyne 138 kV ckt 1  
         Lemoyne breaker tripped within 138 kV primary time  
         West Freemont breakers tripped within 138 kV secondary time.  
         Loss of: West Freemont - Lemoyne 138 kV ckt 1
- 9a     3ph fault @ West Freemont 138 kV  
         Fault cleared within 138 kV breaker primary clearing time  
         Loss of: West Freemont - Ottawa 138 kV ckt 1
- 9b     slg fault @ West Freemont 138 kV

- Fault cleared within 138 kV breaker primary clearing time  
Loss of: West Freemont - Ottawa 138 kV ckt 1  
Breaker Failure  
slg fault @ West Freemont 138 kV  
Fault cleared within 138 kV breaker backup clearing time  
Loss of: West Freemont ST A16
- 9c     slg fault @ 80% of West Freemont - Ottawa 138 kV ckt 1  
         **Ottawa** breaker tripped within 138 kV primary time  
         West Freemont breakers tripped within 138 kV secondary time.  
         Loss of: West Freemont - Ottawa 138 kV ckt 1

#### **A.4.1) Maintenance outage faults**

No faults with outages due to maintenance were studied.

#### **A.5) Reinforcements**

The following reinforcements were considered in the study:

None

## Appendix B

### PROJECT DATA

#### B.1) Wind farm and wind turbine data for U1-060

Queue Letter/Position/Unit ID: \_\_\_\_\_ V4-010

##### Wind farm data

Primary Fuel Type: \_\_\_\_\_ Wind

Maximum Net MW Output: \_\_\_\_\_ 200

Maximum Gross MW Output: \_\_\_\_\_ 200

Station Service Load in MW/MVAR: \_\_\_\_\_ 5/1

##### Wind turbine data

Wind Turbine Type: \_\_\_\_\_ Nordex N90

MW Size: \_\_\_\_\_ 2.5

MVA Base: \_\_\_\_\_ 2.5

Nominal Power Factor: \_\_\_\_\_ 0.95-0.95 at gen. Term.

Terminal Voltage (kV): \_\_\_\_\_ 0.66

Control Mode: \_\_\_\_\_ Power Factor

Number of Turbines (total): \_\_\_\_\_ 80

Positive Sequence Impedance R1 (on MVA base): \_\_\_\_\_ .0074

Saturated Sub-Transient Reactance X''d(v): \_\_\_\_\_ 0.316

##### Wind farm capacitors

Queue Letter/Position/Unit ID: \_\_\_\_\_ V4-010

Additional Capacitor: \_\_\_\_\_ N/A

Location of Additional Capacitor: \_\_\_\_\_ N/A

Type of Additional Capacitor: \_\_\_\_\_ N/A

Steps of Switching Shunt: \_\_\_\_\_ N/A

**Unit GSU data**

Queue Letter/Position/Unit ID: \_\_\_\_\_ V4-010  
Generator Step-up Transformer MVA Base: \_\_\_\_\_ 2.75  
Generator Step-up Transformer Impedance ( $R+jX$ , on MVA Base): \_\_\_\_\_  $0.575+jX5.75$   
Generator Step-up Transformer Reactance-to-Resistance Ratio ( $X/R$ ): \_\_\_\_\_ 10  
Generator Step-up Transformer Rating (MVA): \_\_\_\_\_ 2.75  
Generator Step-up Transformer Low-side Voltage (kV): \_\_\_\_\_ 0.66  
Generator Step-up Transformer High-side Voltage (kV): \_\_\_\_\_ 34.5  
Generator Step-up Transformer Off-nominal Turns Ratio: \_\_\_\_\_ 52.27  
Generator Step-up Transformer Number of Taps and Step Size: \_\_\_\_\_ 5/2.5%

**Main transformer data**

Queue Letter/Position/Unit ID: \_\_\_\_\_ V4-010  
Generator Step-up Transformer MVA Base: \_\_\_\_\_ 2-60  
Generator Step-up Transformer Imp.( $R+jX$ , in p.u, on Xfmr MVA Base): H-L \_\_\_\_\_  $0.283+j8.5$   
Generator Step-up Transformer Imp.( $R+jX$ , in p.u, on Xfmr MVA Base): H-L \_\_\_\_\_  $0.283+j8.5$   
Generator Step-up Transformer Imp.( $R+jX$ , in p.u, on Xfmr MVA Base): L-L \_\_\_\_\_  $0.283+j8.5$   
Generator Step-up Transformer Reactance-to-Resistance Ration ( $X/R$ ): \_\_\_\_\_ 30  
Generator Step-up Transformer Rating (MVA): \_\_\_\_\_ 60/80/100  
Generator Step-up Transformer Low-side Voltage (kV): \_\_\_\_\_ 34.5  
Generator Step-up Transformer High-side Voltage (kV): \_\_\_\_\_ 138  
Generator Step-up Transformer Tertiary Voltage (kV): \_\_\_\_\_ 13.8  
Generator Step-up Transformer Off-nominal Turns Ratio: \_\_\_\_\_ 4  
Generator Step-up Transformer Number of Taps: \_\_\_\_\_ 5  
Generator Step-up Transformer Step Size: \_\_\_\_\_ 0.025

**Transmission line data:**

Queue Letter/ ID: \_\_\_\_\_ V4-010  
Transmission Line MVA Base: \_\_\_\_\_ 100MVA  
Transmission Line kV Base: \_\_\_\_\_ 138kV  
Transmission Line length (mi): \_\_\_\_\_ 7.6



Conductor Type: \_\_\_\_\_ ACSR  
Transmission Line Positive Seq. Impedance (R+jX, p.u. on MVA Base): \_\_\_\_\_ 0.00059+j0.0036  
Transmission Line Zero Seq. Impedance (R+jX, p.u. on MVA Base): \_\_\_\_\_ 0.00288+j0.01163  
Transmission Line Positive Seq. Charging Admittance (B, p.u. on MVA Base): \_\_\_\_\_ .1619

**Wind project cable:**

Queue Letter/ ID: \_\_\_\_\_ V4-010  
Cable Type: \_\_\_\_\_ 1000 kmil AL  
Cable Impedance: \_\_\_\_\_ 0.1274+j.20302

***PJM Generator Interconnection Request  
Queue #V4-010  
Tiffin Center (Seneca) 138kV  
Impact Study***

611338

September 2010

## **V4-010 Tiffin Center (Seneca) 138kV Impact Study Report**

### **General**

EverPower Ohio, LLC has proposed installing a 250 MW wind project, consisting of 100 2.5 MW Nordex wind turbines, in Seneca County, Ohio. The project will be connected directly to the Tiffin Center station. Interconnection to the Tiffin Center station will need to account for the transformer presently installed at the station. The western boundary of the project is 4.5 to 5 miles east of the Tiffin Center-Freemont Center line. The center of the project is about 10 miles east of the line. The in-service date for the project is December 31, 2013.

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 attachment facilities will consist of a direct connection to the Tiffin Center 138kV station. The new connection will consist of one (1) 138kV circuit breaker with 138kV metering and associated equipment at Tiffin Center station (See Figure 1). The cost for these attachment facilities is approximately **\$1,500,000**

This estimate is preliminary in nature, as it was determined without the benefit of detailed engineering studies. Final estimates will require an on-site review and coordination to determine final construction requirements

It may take approximately one year after obtaining the authorization to construct the facilities as outlined above

It is understood that Everpower Ohio will be responsible for all the costs associated with this construction, as well as facilities associated with connecting their 250MW of generation to the in-line facilities

These 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

### **Network Impacts**

The Queue Project #V4-010 was studied as a(n) 200.0MW(Capacity=26.0MW) injection at **Tiffin Center 138 kV** substation in the AEP area. Project #V4-010 was evaluated for compliance with reliability criteria for summer peak conditions in 2014. 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**

The stability and Low Voltage Ride Through (LVRT) will be done in the Facilities Study

**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 Melmore-Fostoria Central 138 kV line (from bus 243039 to bus 243006 ckt 1) loads from 65.44% to 110.13% (AC power flow) of its emergency rating (245 MVA) for the single line contingency outage of CONTINGENCY DESCRIPTION ('5149\_B2\_TOR709\_WOMOAB'). This project contributes approximately 110.85 MW to the thermal violation.
2. The Melmore-Fostoria Central 138 kV line (from bus 243039 to bus 243006 ckt 1) loads from 82.04% to 116.22% (AC power flow) of its normal rating (167 MVA) for non-contingency condition. This project contributes approximately 58.42 MW to the thermal violation.
3. The Melmore-Howard 138 kV line (from bus 243039 to bus 243024 ckt 1) loads from 83.06% to 110.17% (AC power flow) of its normal rating (138 MVA) for non-contingency condition. This project contributes approximately 39.19 MW to the thermal violation.
4. The Howard-Brookside 138 kV line (from bus 243024 to bus 238586 ckt 1) loads from 145.11% to 150.01% (AC power flow) of its emergency rating (173 MVA) for the single line contingency outage of CONTINGENCY DESCRIPTION ('911\_B2'). This project contributes approximately 18.83 MW to the thermal violation.
5. The Howard-Brookside 138 kV line (from bus 243024 to bus 238586 ckt 1) loads from 168.42% to 174.47% (AC power flow) of its normal rating (133 MVA) for non-contingency condition. This project contributes approximately 17.87 MW to the thermal violation.

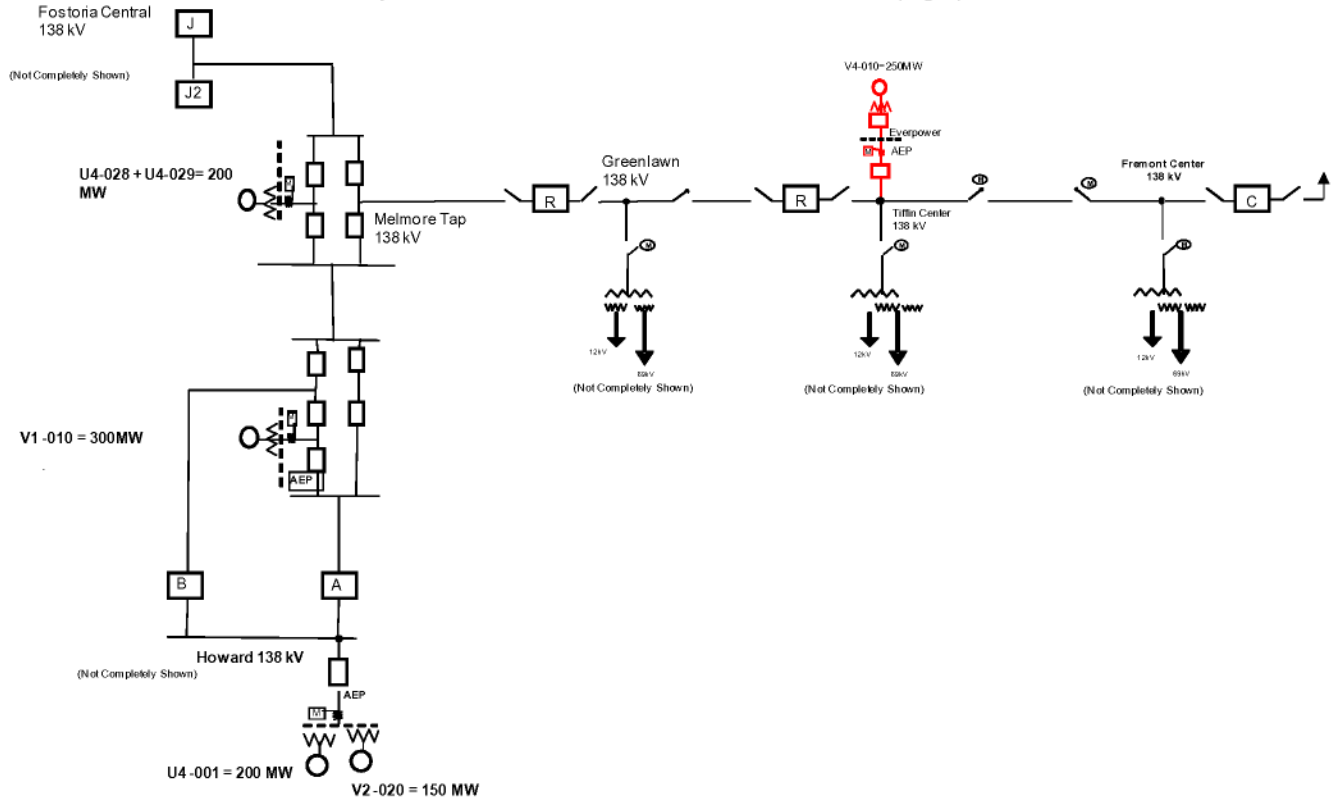
### **Cost**

The V4-010 project is responsible for 100% of the direct connection cost of **\$1,500,000**. There are no network upgrades for the project. The total cost responsibility for the V4-010 project is **\$1,500,000**, pending the results of the Stability and LVRT analysis.

# Figure #1

## Project One-Line Diagram

Option 2: Connect to the Tiffin Center 138 kV bus (Fig 1)



Disclaimer:

The above one-line diagram shows the requirements for interconnection to the AEP system. The developer is responsible for configuration at the collector station.

## PROJECT DATA

### B.1) Wind farm and wind turbine data for U1-060

Queue Letter/Position/Unit ID: \_\_\_\_\_ V4-010

#### Wind farm data

Primary Fuel Type: \_\_\_\_\_ Wind

Maximum Net MW Output: \_\_\_\_\_ 200

Maximum Gross MW Output: \_\_\_\_\_ 200

Station Service Load in MW/MVAR: \_\_\_\_\_ 5/1

#### Wind turbine data

Wind Turbine Type: \_\_\_\_\_ Nordex N90

MW Size: \_\_\_\_\_ 2.5

MVA Base: \_\_\_\_\_ 2.5

Nominal Power Factor: \_\_\_\_\_ 0.95-0.95 at gen. Term.

Terminal Voltage (kV): \_\_\_\_\_ 0.66

Control Mode: \_\_\_\_\_ Power Factor

Number of Turbines (total): \_\_\_\_\_ 80

Positive Sequence Impedance R1 (on MVA base): \_\_\_\_\_ .0074

Saturated Sub-Transient Reactance X''d(v): \_\_\_\_\_ 0.316

#### Wind farm capacitors

Queue Letter/Position/Unit ID: \_\_\_\_\_ V4-010

Additional Capacitor: \_\_\_\_\_ N/A

Location of Additional Capacitor: \_\_\_\_\_ N/A

Type of Additional Capacitor: \_\_\_\_\_ N/A

Steps of Switching Shunt: \_\_\_\_\_ N/A

#### Unit GSU data

Queue Letter/Position/Unit ID: \_\_\_\_\_ V4-010



Generator Step-up Transformer MVA Base: \_\_\_\_\_ 2.75  
 Generator Step-up Transformer Impedance ( $R+jX$ , on MVA Base): \_\_\_\_\_  $0.575+jX5.75$   
 Generator Step-up Transformer Reactance-to-Resistance Ratio ( $X/R$ ): \_\_\_\_\_ 10  
 Generator Step-up Transformer Rating (MVA): \_\_\_\_\_ 2.75  
 Generator Step-up Transformer Low-side Voltage (kV): \_\_\_\_\_ 0.66  
 Generator Step-up Transformer High-side Voltage (kV): \_\_\_\_\_ 34.5  
 Generator Step-up Transformer Off-nominal Turns Ratio: \_\_\_\_\_ 52.27  
 Generator Step-up Transformer Number of Taps and Step Size: \_\_\_\_\_ 5/2.5%

### Main transformer data

Queue Letter/Position/Unit ID: \_\_\_\_\_ V4-010  
 Generator Step-up Transformer MVA Base: \_\_\_\_\_ 2-60  
 Generator Step-up Transformer Imp. ( $R+jX$ , in p.u. on Xfmr MVA Base): H-L \_\_\_\_\_  $0.283+j8.5$   
 Generator Step-up Transformer Imp. ( $R+jX$ , in p.u. on Xfmr MVA Base): H-L \_\_\_\_\_  $0.283+j8.5$   
 Generator Step-up Transformer Imp. ( $R+jX$ , in p.u. on Xfmr MVA Base): L-L \_\_\_\_\_  $0.283+j8.5$   
 Generator Step-up Transformer Reactance-to-Resistance Ration ( $X/R$ ): \_\_\_\_\_ 30  
 Generator Step-up Transformer Rating (MVA): \_\_\_\_\_ 60/80/100  
 Generator Step-up Transformer Low-side Voltage (kV): \_\_\_\_\_ 34.5  
 Generator Step-up Transformer High-side Voltage (kV): \_\_\_\_\_ 138  
 Generator Step-up Transformer Tertiary Voltage (kV): \_\_\_\_\_ 13.8  
 Generator Step-up Transformer Off-nominal Turns Ratio: \_\_\_\_\_ 4  
 Generator Step-up Transformer Number of Taps: \_\_\_\_\_ 5  
 Generator Step-up Transformer Step Size: \_\_\_\_\_ 0.025

### Transmission line data:

Queue Letter/ ID: \_\_\_\_\_ V4-010  
 Transmission Line MVA Base: \_\_\_\_\_ 100MVA  
 Transmission Line kV Base: \_\_\_\_\_ 138kV  
 Transmission Line length (mi): \_\_\_\_\_ 7.6  
 Conductor Type: \_\_\_\_\_ ACSR  
 Transmission Line Positive Seq. Impedance ( $R+jX$ , p.u. on MVA Base): \_\_\_\_\_  $0.00059+j0.0036$

Transmission Line Zero Seq. Impedance ( $R+jX$ , p.u. on MVA Base): \_\_\_\_\_ 0.00288+j0.01163

Transmission Line Positive Seq. Charging Admittance ( $B$ , p.u. on MVA Base): \_\_\_\_\_ .1619

**Wind project cable:**

Queue Letter/ ID: \_\_\_\_\_ V4-010

Cable Type: \_\_\_\_\_ 1000 kmil AL

Cable Impedance: \_\_\_\_\_ 0.1274+j.20302

***PJM Generator Interconnection Request  
Queue #V4-010  
Tiffin Center (Seneca) 138kV  
Impact Study***

611338

September 2010

October 2010 Version 2

## **V4-010 Tiffin Center (Seneca) 138kV Impact Study Report**

### **General**

Nordex has proposed installing a 200 MW wind project, consisting of 80 2.5 MW Nordex wind turbines, in Seneca County, Ohio. The project will be connected directly to the Tiffin Center station. Interconnection to the Tiffin Center station will need to account for the transformer presently installed at the station. The western boundary of the project is 4.5 to 5 miles east of the Tiffin Center-Freemont Center line. The center of the project is about 10 miles east of the line. The in-service date for the project is December 31, 2013.

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**

A new 138kV bus will need to be established at Tiffin Center Station. The station design will be completed by the addition of two 138 kV circuit breakers (see Figure 1) and associated equipment at Tiffin Center, including 138kV metering and necessary relaying. Nordex may be required to obtain any additional land at Tiffin Center station needed for the expansion of the station, if necessary, in order to accommodate the new 138kV bus, the circuit breakers and their associated equipment. Nordex shall obtain all necessary permits, including those from the Ohio Power Siting Board (OPSB).

It is understood that Nordex will be responsible for all the costs associated with this construction, as well as facilities associated with connecting their 200MW of generation to the in-line facilities

These 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

- Installation of the proposed 138kV bus with (2) 138kV breakers, 138kV metering and other associated equipment:

Estimated attachment facilities cost	<b>\$2,300,000</b>
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The requested in-service date is December 2013. The standard time required for construction is 18 months after signing of the Interconnection Service Agreement and Interconnection Construction Service Agreement.

An Interim Interconnection Service Agreement can be executed to facilitate meeting the requested date.

### **AEP Local Network Impacts**

The impact of the proposed generating facility was assessed for AEP planning criteria specifically that the transmission system meet single contingency performance based on the AEP FERC Form 715 criteria. The Everpower project was studied as both a 200 MW and a 26MW net energy injection. The results are summarized below.

#### **Normal System – Capacity Output (2013 Summer Conditions)**

- No problems identified.

#### **Single Contingency – Capacity Output (2013 Summer Conditions)**

- No problems identified.

#### **Multiple Contingency – Full Output (2013 Summer Conditions)**

- No problems identified.

#### **Short Circuit Analysis**

- No problems identified.

#### **Stability Analysis**

- For a double contingency outage of Tiffin Center – Fremont Center 138kV and the Melmore – Fostoria Central 138kV lines an unstable result is expected.
- For a double contingency outage of the Greenlawn – Melmore 138kV and the Fremont Center – Tiffin Center 138kV lines an unstable result is expected.

#### **Local/Network Upgrades**

- None.

#### **Contributions to Previously Identified Local/Network Limitations (Full Output)**

- V4-010 contributes to the overload of the Howard – Brookside 138kV circuit increasing the loading from 217 % to 231.4 % (300.2 MVA) of its summer normal rating of 133 MVA for base case conditions.
- V4-010 contributes to the overload of the V1-010 - Chatfield 138kV circuit increasing the loading from 132 % to 158.8 % (284 MVA) of its summer emergency rating of 179 MVA for a double contingency outage of the Tiffin Center – Fremont Center 138kV circuit and the Fostoria Central – Melmore Tap 138kV circuit.
- V4-010 contributes to the overload of the Chatfield – South Tiffin 138kV circuit increasing the loading from 116 % to 149 % (248 MVA) of its summer emergency rating of 167 MVA for a double contingency outage of the Tiffin Center – Fremont Center 138kV circuit and the Fostoria Central – Melmore Tap 138kV circuit

#### Additional Limitations of Concern – Full Output

- V4-010 overloads the Tiffin Center 138/69kV transformer to 180.8 % (130.2 MVA) of its summer emergency rating of 72 MVA for a double contingency outage of the Tiffin Center – Fremont Center 138kV circuit and the Fostoria Central – Melmore Tap 138kV circuit.
- V4-010 overloads the South Tiffin – Airco N.C. COOP – West End Fostoria 138kV circuit transformer to 133 % (222 MVA) of its summer emergency rating of 167 MVA for a double contingency outage of the Tiffin Center – Fremont Center 138kV circuit and the Fostoria Central – Melmore Tap 138kV circuit.
- V4-010 overloads the Fremont Center – Tiffin Center 138kV circuit to 121.3% (248 MVA) of its summer normal rating of 205 MVA for base case conditions.
- V4-010 overloads the Tiffin Center 138/69kV transformer to 127.9 % (92.1 MVA) of its summer emergency rating of 72 MVA for a single contingency outage of the Tiffin Center – Fremont Center 138kV circuit.
- V4-010 overloads the Tiffin Center – Greenlawn 138kV circuit 112 % (160 MVA) of its summer emergency rating of 143 MVA for a single contingency outage of the Tiffin Center – Fremont Center 138kV circuit.
- V4-010 overloads the Melmore Tap – Fostoria Central 138kV circuit 152 % (254MVA) of its summer emergency rating of 167 MVA for a single contingency outage of the Tiffin Center – Fremont Center 138kV circuit.

- V4-010 overloads the Tiffin Center – Riverview 69 kV line 186 % (129 MVA) of its summer emergency rating of 73 MVA for a single contingency outage of the Tiffin Center – Fremont Center 138kV circuit.

### **Network Impacts**

The Queue Project #V4-010 was studied as a(n) 200.0MW(Capacity=26.0MW) injection at **Tiffin Center 138 kV** substation in the AEP area. Project #V4-010 was evaluated for compliance with reliability criteria for summer peak conditions in 2014. 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**

PJM queue projects V4-010 is a new 200 MW interconnection requests tapping the existing Tiffin Center 138 kV substation in the AEP system. This is a Nordex N90 2.5 MW based wind farm with 80 generators.

Stability analysis for the V4-010 queue project was performed at 2014 light and peak load conditions. The range of contingencies evaluated was limited to that necessary to assess compliance with AEP criteria. Simulation time was limited to 10 seconds for all faults.

Three fault types were considered in this study:

- Type A: Three-phase faults (3ph) with primary clearing time
- Type B: Stuck breaker fault cleared with backup clearing time
- Type C: Zone 2 faults cleared with secondary protection

Specific fault descriptions and breaker clearing times used for this study are provided in Appendix A.

### **Results**

### Transient Stability:

For all cases studied, transient stability is maintained with all oscillations stabilized in less than 10 seconds. Also, the voltage levels returned to normal for all cases following the fault clearance. Hence, no transient stability issues were concluded.

The maximum angle deviations for all three fault types are shown in Tables I - VI.

Table I. Maximum angle deviation for Type A faults  
2014 Light Load Conditions

Fault	Chan	Bus	ID	Initial Angle	Max Deviation	Time
1A	418	243515	1	84.12	-5.241	10.000
2A	356	242940	4	82.58	-2.034	0.7126
3A	357	242940	5	93.54	-2.684	0.5792
4A	357	242940	5	93.54	-2.666	0.5959
5A	357	242940	5	93.54	-2.723	0.5834
6A	376	243190	1	102.8	-2.450	2.1960
7A	376	243190	1	102.8	-2.722	2.1960
8A	376	243190	1	102.8	-2.719	2.1960
9A	412	243440	1	108.9	-2.608	4.2379

Table II. Maximum angle deviation for Type A faults  
2014 Summer Peak Load Conditions

Fault	Chan	Bus	ID	Initial Angle	Max Deviation	Time
1A	359	242940	D	52.16	-1.958	9.9882
2A	356	242940	4	51.15	-1.281	0.8167
3A	356	242940	4	51.15	-1.696	0.8084
4A	356	242940	4	51.15	-1.659	0.8167
5A	356	242940	4	51.15	-1.745	0.8167
6A	381	243195	2	51.32	-1.58	2.5919
7A	381	243195	2	51.32	-1.78	2.5919
8A	381	243195	2	51.32	-1.783	2.5919
9A	381	243195	2	51.32	-1.652	2.5919

Table III. Maximum angle deviation for Type B faults  
2014 Light Load Conditions

Fault	Chan	Bus	ID	Initial Angle	Max Deviation	Time
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Table III. Maximum angle deviation for Type B faults  
2014 Light Load Conditions

<b>Fault</b>	<b>Chan</b>	<b>Bus</b>	<b>ID</b>	<b>Initial Angle</b>	<b>Max Deviation</b>	<b>Time</b>
1B	412	243440	1	108.9	-4.798	9.9799
2B	412	243440	1	108.9	-4.716	9.9799
3B1	356	242940	4	82.58	-3.446	0.8417
3B2	356	242940	4	82.58	-3.522	0.8417
4B1	376	243190	1	102.8	-7.641	9.9799
4B2	356	242940	4	82.58	-3.221	0.8417
5B1	356	242940	4	82.58	-2.502	0.8042
5B2	412	243440	1	108.9	-7.497	9.9799
6B	412	243440	1	108.9	-6.236	9.9799
7B	376	243190	1	102.8	2.905	1.7918
8B	412	243440	1	108.9	-8.026	9.9799
9B	376	243190	1	102.8	-13.82	9.9799

Table IV. Maximum angle deviation for Type B faults  
2014 Summer Peak Load Conditions

<b>Fault</b>	<b>Chan</b>	<b>Bus</b>	<b>ID</b>	<b>Initial Angle</b>	<b>Max Deviation</b>	<b>Time</b>
1B	359	242940	D	52.16	-1.517	9.9799
2B	359	242940	D	52.16	-1.521	9.9799
3B1	356	242940	4	51.15	-1.814	0.9126
3B2	356	242940	4	51.15	-1.951	0.9209
4B1	359	242940	D	52.16	-3.949	9.9799
4B2	356	242940	4	51.15	-1.678	0.9167
5B1	356	242940	4	51.15	-1.277	0.8959
5B2	359	242940	D	52.16	-3.871	9.9799
6B	377	243191	2	63.19	-2.753	9.9799
7B	381	243195	2	51.32	-2.087	2.7086
8B	346	242933	1	42.31	-4.174	9.9799
9B	422	243654	3	64.88	-7.331	9.9799

Table V. Maximum angle deviation for Type C faults  
2014 Light Load Conditions

<b>Fault</b>	<b>Chan</b>	<b>Bus</b>	<b>ID</b>	<b>Initial Angle</b>	<b>Max Deviation</b>	<b>Time</b>
1C	418	243515	1	84.12	-4.226	9.9799
2C	356	242940	4	82.58	-1.059	0.7792
3C	356	242940	4	82.58	-2.985	1.0501
4C	356	242940	4	82.58	-2.104	0.9751

Table V. Maximum angle deviation for Type C faults  
2014 Light Load Conditions

Fault	Chan	Bus	ID	Initial Angle	Max Deviation	Time
5C	356	242940	4	82.58	-1.903	0.7792
6C	356	242940	4	82.58	-1.222	1.1459
7C	356	242940	4	82.58	-1.741	1.2001
8C	356	242940	4	82.58	-1.141	1.1751
9C	356	242940	4	82.58	-1.500	1.1626

Table VI. Maximum angle deviation for Type C faults  
2014 Summer Peak Load Conditions

Fault	Chan	Bus	ID	Initial Angle	Max Deviation	Time
1C	359	242940	D	52.16	-1.541	9.9799
2C	422	243654	3	64.88	-0.6469	1.7168
3C	422	243654	3	64.88	-2.182	1.5251
4C	422	243654	3	64.88	-1.324	1.5585
5C	422	243654	3	64.88	-1.245	1.6335
6C	422	243654	3	64.88	0.9741	9.9799
7C	422	243654	3	64.88	-0.8438	1.9877
8C	381	243195	2	51.32	0.6573	1.0543
9C	381	243195	2	51.32	0.681	1.0543

The wind farm was modeled with two equivalent generators (WTGs) connected to Tiffin 138 kV bus through a single circuit transmission line and equivalent GSUs and main 34.5/138 kV step-up transformers. The reactive power range of each of the equivalent generator was set at +32.84 Mvar/ -44 Mvar (0.95 lagging and 0.9 leading power factor). The terminal voltage of each generator was set at 1.000 pu.

Low Voltage Ride-Through (LVRT): The LVRT test for V4-010 was performed by applying a three-phase 9-cycle fault at Tiffin 138 kV bus (POI) using the light and peak load base cases. It is noted that V4-010 stayed connected during these fault conditions.

The voltages at the collector buses and generator terminals are not adequate for simulating low voltage ride through test if the WTGs are dispatched at 0.95 leading power factor using the 2014 Summer Peak base-case. If the nearby reactive resources and taps of the main transformers and GSUs (which should not be) are exploited then voltages become acceptable. Under these conditions, a three-phase 9-cycle fault at the 138 kV tap point resulted in tripping of the WTGs on low voltage, which is primarily due to protection settings of Nordex WTGs. The WTGs stay on-line for a 7-cycle three phase-fault. However, for all the cases simulated, the V4-010 queue project rides through the faults specified in Section A.4.

Based on the above, it is concluded that V4-010 meets the LVRT test specified in FERC order 661 and 661A.

**Note:** While the stability analysis has been performed at 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 may 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.

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.

### **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 Melmore-Fostoria Central 138 kV line (from bus 243039 to bus 243006 ckt 1) loads from 65.44% to 110.13% (AC power flow) of its emergency rating (245 MVA) for the single line contingency outage of CONTINGENCY DESCRIPTION ('5149\_B2\_TOR709\_WOMOAB'). This project contributes approximately 110.85 MW to the thermal violation.
2. The Melmore-Fostoria Central 138 kV line (from bus 243039 to bus 243006 ckt 1) loads from 82.04% to 116.22% (AC power flow) of its normal rating (167 MVA) for non-contingency condition. This project contributes approximately 58.42 MW to the thermal violation.
3. The Melmore-Howard 138 kV line (from bus 243039 to bus 243024 ckt 1) loads from 83.06% to 110.17% (AC power flow) of its normal rating (138 MVA) for non-contingency condition. This project contributes approximately 39.19 MW to the thermal violation.
4. The Howard-Brookside 138 kV line (from bus 243024 to bus 238586 ckt 1) loads from 145.11% to 150.01% (AC power flow) of its emergency rating (173 MVA) for the single line contingency outage of CONTINGENCY DESCRIPTION ('911\_B2'). This project contributes approximately 18.83 MW to the thermal violation.
5. The Howard-Brookside 138 kV line (from bus 243024 to bus 238586 ckt 1) loads from 168.42% to 174.47% (AC power flow) of its normal rating (133 MVA) for non-contingency condition. This project contributes approximately 17.87 MW to the thermal violation.

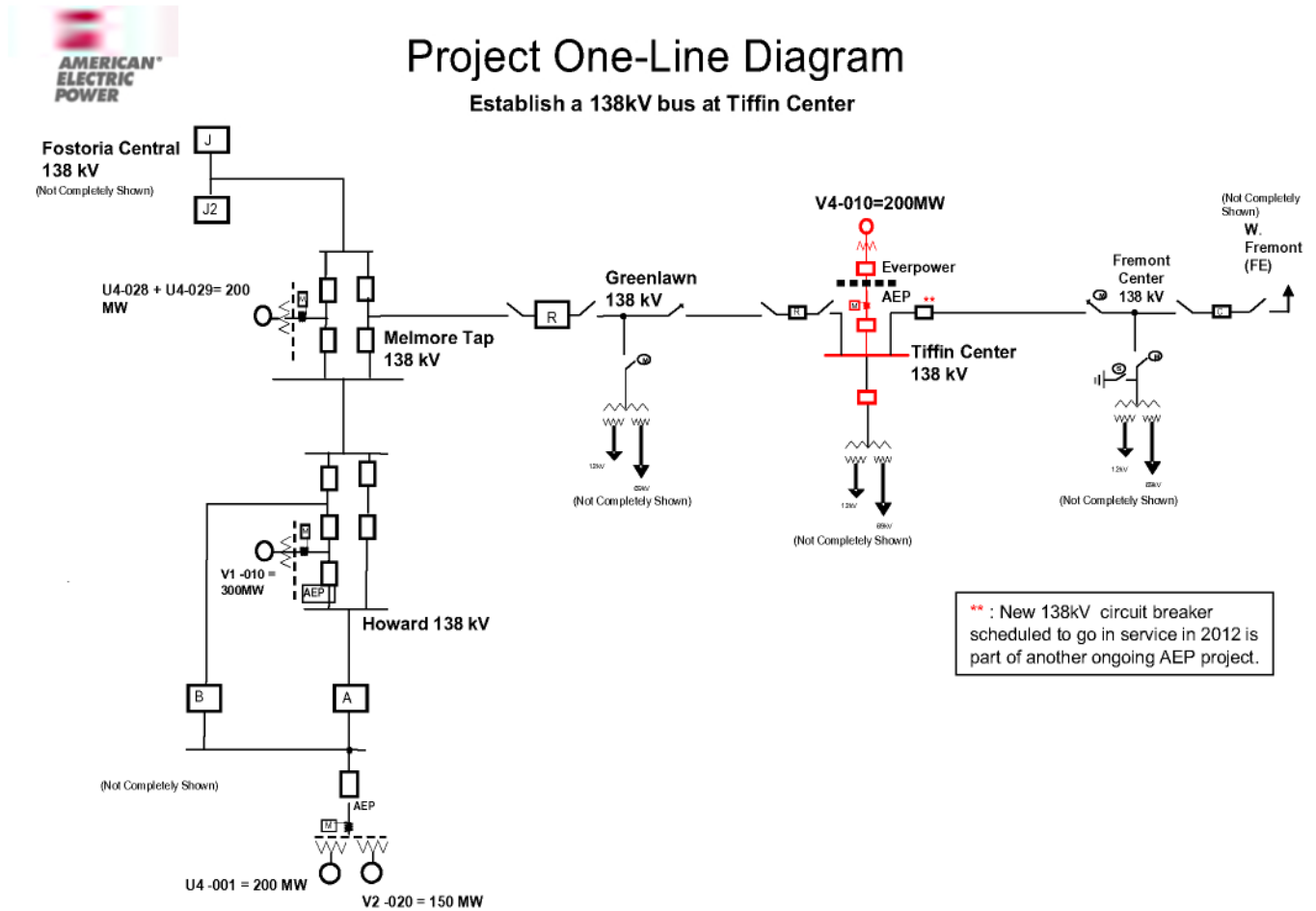
### **Cost**

The V4-010 project is responsible for 100% of the direct connection cost of **\$2,300,000**. There are no network upgrades for the project. The total cost responsibility for the V4-010 project is **\$2,300,000**, pending the results of the Stability and LVRT analysis.

Figure #1

# Project One-Line Diagram

Establish a 138kV bus at Tiffin Center



12/28/2010

Disclaimer:

The above one-line diagram shows the requirements for interconnection to the AEP system. The developer is responsible for configuration at the collector station.

1

Sheet 2

**APPENDIX A**  
**V4-010**  
**(Tiffin Center 138 kV)**

**A.1) POWER FLOW CONDITIONS**

2014 Light and Peak Load Base Cases

**A.2) BREAKER CLEARING TIMES (CYCLES)**

Table A.1. AEP Clearing Times (Cycles)

Station	Primary (3ph/slg)	Stuck Breaker (Total)	Zone 2 (Total)	Re-closing
500 kV	4	14	4	N/A
345 kV	4	15	4	N/A
230 kV	5	15	5	N/A
115kV & 138 kV	5	18	63	N/A

**A.3) NETWORK CONDITIONS**

All facilities in service (base case)

**A.4) FAULTS CONSIDERED**

*Note: For simplicity of fault type identification, PJM has adopted the following notation:*

A faults: *three-phase faults with normal clearing time*

B faults: *slg faults due to stuck breaker with delayed clearing time*

C faults: *slg faults with delayed clearing time due to protection system failure*

*This notation is for internal purposes only, and does not necessarily correspond with the NERC category definition stated in TPL-001.*

Tiffin Center 138 kV

- 1a     3ph fault @ Tiffin Center 138 kV  
          Fault cleared within 138 kV breaker primary clearing time  
          Loss of: Tiffin Center - Fremont Center 138 kV ckt 1  
                  Fremont Center - Fremont 138 kV ckt 1  
                  Tiffin Center 138 kV  
                  Fremont Center 138 kV  
                  V4-010

- 1b     slg fault @ Tiffin Center 138 kV

Fault cleared within 138 kV breaker primary clearing time  
Loss of: Fremont Center - Fremont 138 kV ckt 1

V4-010

Breaker Failure

slg fault @ Tiffin Center 138 kV

Fault cleared within 138 kV breaker backup clearing time

Loss of: Tiffin Center - Fremont Center 138 kV ckt 1

Tiffin Center 138 kV

Fremont Center 138 kV

Greenlawn 138 kV

- 1c slg fault @ 80% of Tiffin Center - Fremont Center 138 kV ckt 1  
Fremont Center breaker tripped within 138 kV primary time  
Tiffin Center breaker tripped within 138 kV secondary time  
Loss of: Tiffin Center - Fremont Center 138 kV ckt 1  
Fremont Center - Fremont 138 kV ckt 1  
Tiffin Center 138 kV  
Fremont Center 138 kV  
V4-010

- 2a 3ph fault @ Tiffin Center 138 kV  
Fault cleared within 138 kV breaker primary clearing time  
Loss of: Tiffin Center - Greenlawn 138 kV ckt 1  
Greenlawn - Melmore Tap 138 kV ckt 1  
Greenlawn 138 kV

- 2b slg fault @ Tiffin Center 138 kV  
Fault cleared within 138 kV breaker primary clearing time  
Loss of: Greenlawn - Melmore Tap 138 kV ckt 1  
V4-010

Breaker Failure

slg fault @ Tiffin Center 138 kV

Fault cleared within 138 kV breaker backup clearing time

Loss of: Fremont Center 138 kV

Tiffin Center 138 kV

Greenlawn 138 kV

- 2c slg fault @ 80% of Tiffin Center - Greenlawn 138 kV ckt 1  
Greenlawn breaker tripped within 138 kV primary time  
Tiffin Center breaker tripped within 138 kV secondary time  
Loss of: Tiffin Center - Greenlawn 138 kV ckt 1  
Greenlawn - Melmore Tap 138 kV ckt 1  
Greenlawn 138 kV

Melmore 138 kV

- 3a 3ph fault @ Melmore 138 kV  
Fault cleared within 138 kV breaker primary clearing time  
Loss of: Melmore - Greenlawn 138 kV ckt 1
- 3b1 slg fault @ Melmore 138 kV  
Fault cleared within 138 kV breaker primary clearing time  
Loss of: Melmore - Greenlawn 138 kV ckt 1  
Breaker Failure  
slg fault @ Melmore 138 kV  
Fault cleared within 138 kV breaker backup clearing time  
Loss of: Melmore - Fostoria Central 138 kV ckt 1
- 3b2 slg fault @ Melmore 138 kV  
Fault cleared within 138 kV breaker primary clearing time  
Loss of: Melmore - Greenlawn 138 kV ckt 1  
Breaker Failure  
slg fault @ Melmore 138 kV  
Fault cleared within 138 kV breaker backup clearing time  
Loss of: Melmore - V1-010 138 kV ckt 1
- 3c slg fault @ 80% of Melmore - Greenlawn 138 kV ckt 1  
Greenlawn breaker tripped within 138 kV primary time  
Melmore breakers tripped within 138 kV secondary time.  
Loss of: Melmore - Greenlawn 138 kV ckt 1
- 4a 3ph fault @ Melmore 138 kV  
Fault cleared within 138 kV breaker primary clearing time  
Loss of: Melmore - Fostoria Central 138 kV ckt-1
- 4b1 slg fault @ Melmore 138 kV  
Fault cleared within 138 kV breaker primary clearing time  
Loss of: Melmore - Fostoria Central 138 kV ckt-1  
Breaker Failure  
slg fault @ Melmore 138 kV  
Fault cleared within 138 kV breaker backup clearing time  
Loss of: U4-028 & U4-029
- 4b2 slg fault @ Melmore 138 kV  
Fault cleared within 138 kV breaker primary clearing time  
Loss of: Melmore - Fostoria Central 138 kV ckt-1  
Breaker Failure  
slg fault @ Melmore 138 kV  
Fault cleared within 138 kV breaker backup clearing time  
Loss of: Melmore - Greenlawn 138 kV ckt-1
- 4c slg fault @ 80% of Melmore - Fostoria Central 138 kV ckt-1



- Fostoria breakers tripped within 138 kV primary time  
 Melmore breakers tripped within 138 kV secondary time.  
 Loss of: Melmore - Fostoria Central 138 kV ckt-1
- 5a 3ph fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker primary clearing time  
 Loss of: Melmore - V1-010 138 kV Tap 138 kV ckt 1
- 5b1 slg fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker primary clearing time  
 Loss of: Melmore - V1-010 138 kV Tap 138 kV ckt 1  
 Breaker Failure  
 slg fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker backup clearing time  
 Loss of: Melmore - Greenlawn 138 kV ckt-1
- 5b2 slg fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker primary clearing time  
 Loss of: Melmore - V1-010 138 kV Tap 138 kV ckt 1  
 Breaker Failure  
 slg fault @ Melmore 138 kV  
 Fault cleared within 138 kV breaker backup clearing time  
 Loss of: U4-028 & U4-029
- 5c slg fault @ 80% of Melmore - V1-010 138 kV Tap 138 kV ckt 1  
 V1-010 breakers tripped within 138 kV primary time  
 Melmore breakers tripped within 138 kV secondary time.  
 Loss of: Melmore - V1-010 138 kV Tap 138 kV ckt 1

#### West Freemont 138 kV

(assumed 138 kV line-end breaker at Ottawa)

- 6a 3ph fault @ West Freemont 138 kV  
 Fault cleared within 138 kV breaker primary clearing time  
 Loss of: West Freemont - Freemont Center 138 kV ckt 1  
 Freemont 138 kV
- 6b slg fault @ West Freemont 138 kV  
 Fault cleared within 138 kV breaker primary clearing time  
 Loss of: Freemont - Freemont Center 138 kV ckt 1  
 Breaker Failure  
 slg fault @ West Freemont 138 kV  
 Fault cleared within 138 kV breaker backup clearing time  
 Loss of: West Freemont - Freemont 138 kV ckt 1  
 Freemont 138 kV  
 West Freemont CT A18

- 6c     slg fault @ 80% of West Freemont - Freemont Center 138 kV ckt 1  
         Freemont Center breaker tripped within 138 kV primary time  
         West Freemont breakers tripped within 138 kV secondary time.  
         Loss of: West Freemont - Freemont Center 138 kV ckt 1  
                 Freemont 138 kV
- 7a     3ph fault @ West Freemont 138 kV  
         Fault cleared within 138 kV breaker primary clearing time  
         Loss of: West Freemont - Woodville 138 kV ckt 1
- 7b     slg fault @ West Freemont 138 kV  
         Fault cleared within 138 kV breaker primary clearing time  
         Loss of: West Freemont - Woodville 138 kV ckt 1  
         Breaker Failure  
         slg fault @ West Freemont 138 kV  
         Fault cleared within 138 kV breaker backup clearing time  
         Loss of: None (T3)
- 7c     slg fault @ 80% of West Freemont - Woodville 138 kV ckt 1  
         Woodville breaker tripped within 138 kV primary time  
         West Freemont breakers tripped within 138 kV secondary time.  
         Loss of: West Freemont - Woodville 138 kV ckt 1
- 8a     3ph fault @ West Freemont 138 kV  
         Fault cleared within 138 kV breaker primary clearing time  
         Loss of: West Freemont - Lemoyne 138 kV ckt 1
- 8b     slg fault @ West Freemont 138 kV  
         Fault cleared within 138 kV breaker primary clearing time  
         Loss of: West Freemont - Lemoyne 138 kV ckt 1  
         Breaker Failure  
         slg fault @ West Freemont 138 kV  
         Fault cleared within 138 kV breaker backup clearing time  
         Loss of: West Freemont CT A17
- 8c     slg fault @ 80% of West Freemont - Lemoyne 138 kV ckt 1  
         Lemoyne breaker tripped within 138 kV primary time  
         West Freemont breakers tripped within 138 kV secondary time.  
         Loss of: West Freemont - Lemoyne 138 kV ckt 1
- 9a     3ph fault @ West Freemont 138 kV  
         Fault cleared within 138 kV breaker primary clearing time  
         Loss of: West Freemont - Ottawa 138 kV ckt 1
- 9b     slg fault @ West Freemont 138 kV

- Fault cleared within 138 kV breaker primary clearing time  
Loss of: West Freemont - Ottawa 138 kV ckt 1  
Breaker Failure  
slg fault @ West Freemont 138 kV  
Fault cleared within 138 kV breaker backup clearing time  
Loss of: West Freemont ST A16
- 9c     slg fault @ 80% of West Freemont - Ottawa 138 kV ckt 1  
       **Ottawa** breaker tripped within 138 kV primary time  
       West Freemont breakers tripped within 138 kV secondary time.  
       Loss of: West Freemont - Ottawa 138 kV ckt 1

#### **A.4.1) Maintenance outage faults**

No faults with outages due to maintenance were studied.

#### **A.5) Reinforcements**

The following reinforcements were considered in the study:

None

## Appendix B

### PROJECT DATA

#### B.1) Wind farm and wind turbine data for U1-060

Queue Letter/Position/Unit ID: \_\_\_\_\_ V4-010

##### Wind farm data

Primary Fuel Type: \_\_\_\_\_ Wind

Maximum Net MW Output: \_\_\_\_\_ 200

Maximum Gross MW Output: \_\_\_\_\_ 200

Station Service Load in MW/MVAR: \_\_\_\_\_ 5/1

##### Wind turbine data

Wind Turbine Type: \_\_\_\_\_ Nordex N90

MW Size: \_\_\_\_\_ 2.5

MVA Base: \_\_\_\_\_ 2.5

Nominal Power Factor: \_\_\_\_\_ 0.95-0.95 at gen. Term.

Terminal Voltage (kV): \_\_\_\_\_ 0.66

Control Mode: \_\_\_\_\_ Power Factor

Number of Turbines (total): \_\_\_\_\_ 80

Positive Sequence Impedance R1 (on MVA base): \_\_\_\_\_ .0074

Saturated Sub-Transient Reactance X''d(v): \_\_\_\_\_ 0.316

##### Wind farm capacitors

Queue Letter/Position/Unit ID: \_\_\_\_\_ V4-010

Additional Capacitor: \_\_\_\_\_ N/A

Location of Additional Capacitor: \_\_\_\_\_ N/A

Type of Additional Capacitor: \_\_\_\_\_ N/A

Steps of Switching Shunt: \_\_\_\_\_ N/A

**Unit GSU data**

Queue Letter/Position/Unit ID: \_\_\_\_\_ V4-010  
Generator Step-up Transformer MVA Base: \_\_\_\_\_ 2.75  
Generator Step-up Transformer Impedance ( $R+jX$ , on MVA Base): \_\_\_\_\_  $0.575+jX5.75$   
Generator Step-up Transformer Reactance-to-Resistance Ratio ( $X/R$ ): \_\_\_\_\_ 10  
Generator Step-up Transformer Rating (MVA): \_\_\_\_\_ 2.75  
Generator Step-up Transformer Low-side Voltage (kV): \_\_\_\_\_ 0.66  
Generator Step-up Transformer High-side Voltage (kV): \_\_\_\_\_ 34.5  
Generator Step-up Transformer Off-nominal Turns Ratio: \_\_\_\_\_ 52.27  
Generator Step-up Transformer Number of Taps and Step Size: \_\_\_\_\_ 5/2.5%

**Main transformer data**

Queue Letter/Position/Unit ID: \_\_\_\_\_ V4-010  
Generator Step-up Transformer MVA Base: \_\_\_\_\_ 2-60  
Generator Step-up Transformer Imp.( $R+jX$ , in p.u, on Xfmr MVA Base): H-L \_\_\_\_\_  $0.283+j8.5$   
Generator Step-up Transformer Imp.( $R+jX$ , in p.u, on Xfmr MVA Base): H-L \_\_\_\_\_  $0.283+j8.5$   
Generator Step-up Transformer Imp.( $R+jX$ , in p.u, on Xfmr MVA Base): L-L \_\_\_\_\_  $0.283+j8.5$   
Generator Step-up Transformer Reactance-to-Resistance Ration ( $X/R$ ): \_\_\_\_\_ 30  
Generator Step-up Transformer Rating (MVA): \_\_\_\_\_ 60/80/100  
Generator Step-up Transformer Low-side Voltage (kV): \_\_\_\_\_ 34.5  
Generator Step-up Transformer High-side Voltage (kV): \_\_\_\_\_ 138  
Generator Step-up Transformer Tertiary Voltage (kV): \_\_\_\_\_ 13.8  
Generator Step-up Transformer Off-nominal Turns Ratio: \_\_\_\_\_ 4  
Generator Step-up Transformer Number of Taps: \_\_\_\_\_ 5  
Generator Step-up Transformer Step Size: \_\_\_\_\_ 0.025

**Transmission line data:**

Queue Letter/ ID: \_\_\_\_\_ V4-010  
Transmission Line MVA Base: \_\_\_\_\_ 100MVA  
Transmission Line kV Base: \_\_\_\_\_ 138kV  
Transmission Line length (mi): \_\_\_\_\_ 7.6

Conductor Type: \_\_\_\_\_ ACSR  
Transmission Line Positive Seq. Impedance (R+jX, p.u. on MVA Base): \_\_\_\_\_ 0.00059+j0.0036  
Transmission Line Zero Seq. Impedance (R+jX, p.u. on MVA Base): \_\_\_\_\_ 0.00288+j0.01163  
Transmission Line Positive Seq. Charging Admittance (B, p.u. on MVA Base): \_\_\_\_\_ .1619

**Wind project cable:**

Queue Letter/ ID: \_\_\_\_\_ V4-010  
Cable Type: \_\_\_\_\_ 1000 kmil AL  
Cable Impedance: \_\_\_\_\_ 0.1274+j.20302

## **Exhibit D. Facilities Study**

***PJM Generator Interconnection Request  
Queue #V4-010  
Fremont Center-Tiffin Center 138 kV  
Facilities Study***

September 2015



## **V4-010 Fremont Center – Tiffin Center 138 kV Facilities Study Report**

### **A. Facilities Study Summary**

#### **1. Project Description**

Republic Wind, LLC proposes to install PJM Project #V4-010, a 200 MW wind generating facility. This generation facility would connect to the American Electric Power (AEP) Fremont Center – Tiffin Center 138 kV circuit via a new 138 kV switching station consisting of three (3) 138 kV circuit breakers to be physically configured in a breaker and one half bus arrangement, initially operated as a ring bus configuration (Figure 2). The proposed location of the generating facilities is located in Seneca County, Ohio (Figure 1). The projected in-service date is scheduled for December 31, 2016. Republic Wind, LLC has elected the “Option to Build” option, and will be responsible for the construction of the new 138 kV switching station.

#### **2. Amendments/Changes to the Impact Study Report**

#### **3. Interconnection Customer Schedule**

PJM and AEP currently understand that Republic Wind, LLC has established the following schedule dates:

**Back feed In-service Date: July 8, 2016**

**Commercial Operation Date: December 31, 2016**

#### **4. AEP’s Scope of Work to Facilitate Republic Wind, LLC’s Interconnection**

- AEP will review Interconnection Customer's drawings and will, at Interconnection Customer's request, provide advice and input concerning construction of Transmission Owner Interconnection Facilities to be built by Interconnection Customer, including the first span of conductors and communication cable connecting the transmission switching station to the generation collector station. **(n3134)**
- AEP shall construct 138 kV revenue metering. **(n3134)**
- AEP shall construct transmission line extension to connect the new 138 kV switching station to the Fremont Center – Tiffin Center 138 kV circuit. **(n3135)**
- AEP shall replace relay and controls at Fremont Center 138 kV Station. **(n3137)**
- AEP shall replace relay and controls at Tiffin Center 138 kV Station. **(n3136)**
- Republic Wind, LLC shall be responsible for obtaining the right-of-way, designing and constructing the transmission line between the wind project collector station and the new 138 kV switching station.

#### **5. Description of Transmission Owner Facilities Included in the Facilities Study**

##### **Direct Connection Work**

None required.

## Network Upgrade Work

None required.

### 6. **Total Cost of Transmission Owner Facilities Included in the Facilities Study:**

Direct Connection facilities	\$2,194,900
Network Upgrade facilities	<u>0</u>
Total Cost	\$2,194,900

The estimates do not include the impact that delays in obtaining ROW, permits or other approvals may have.

### 7. Summary of Schedule Milestones for Completion of Transmission Owner Work Included in Facilities Study:

V4-010 Schedule		
ISA signed	November 16, 2015	
Engineering Start	November 16, 2015	
AEP Material Ordered	November 30, 2015	
Construction Start	December 31, 2015	
Outage (T-Line Foundations)	May 9, 2016	May 21, 2016
Outage (T-Line, Remote Ends, Testing)	September 6, 2016	October 15, 2016
Ready for back feed	October 15, 2016	
Commercial Operation Date	December 31, 2016	
Submission of Interconnection Customer as-built drawings	January 31, 2016	

## B. Transmission Owner Facilities Study Results

### 1. **Transmission Lines – New**

None required.

### 2. **Transmission Lines – Upgrades**

None required.

### 3. **Substation Facilities – New**

Republic Wind, LLC will be responsible for construction of the New 138 kV Switching Station consisting of three (3) new 138 kV circuit breakers to be physically configured in a breaker and one half bus arrangement, initially and operated as a ring bus to facilitate future expansion, relays, SCADA, 138 kV revenue metering, and associated equipment connecting to the Fremont Center – Tiffin Center 138 kV circuit. (n3134)

#### **4. Substation Facilities – Non-Direct Connection Network Upgrades**

AEP shall replace relay and controls at Fremont Center 138 kV Station. (n3137)

AEP shall replace relay and controls at Tiffin Center 138 kV Station. (n3136)

#### **5. Metering & Communications**

All metering equipment to be installed at the AEP Interconnect Station and the Republic Wind, LLC generation station shall meet the requirements as specified by AEP in the “AEP Metering and Telemetry Requirements for AEP Transmission Customers” document (SS-490011).

#### **6. Environmental, Real Estate and Permitting Issues**

#### **7. Summary of Results of Study**

Attachment Facilities	Network Upgrade Number (NUN)	Engineering	Material	Construction	Misc.	Total
New Station – Revenue Metering	n3134	\$50,400	\$90,100	\$22,500	\$48,700	\$211,700
Fremont Center –Remote End Work	n3137	\$37,500	\$182,200	\$144,000	\$146,700	\$510,400
Tiffin Center-Remote End Work	n3136	\$37,100	\$169,600	\$122,400	\$132,600	\$461,700
Transmission Line Extension to New 138 kV Station	n3135	\$90,300	\$274,100	\$260,800	\$135,900	\$761,100
Option to Build Oversight for New 138 kV Switching Station	n3134	\$0	\$0	\$250,000	\$0	\$250,000
Total		\$215,300	\$716,000	\$549,700	\$463,900	\$2,194,900

#### **Schedules**

November 16, 2015	Funding Approved
November 16, 2015	Outage requests made by
July 8, 2016	Backfeed
December 31, 2016	In-Service Date

#### **Assumptions**

None

## 8. Information Required for Interconnection Service Agreement

### New Switching Station Interconnection Cost Breakdown

Direct Material	\$729,209
Direct Labor	\$768,015
Indirect Material	\$69,647
Indirect Labor	<u>\$628,029</u>
Total	\$2,194,900

## Approximate interconnection location of the proposed facilities

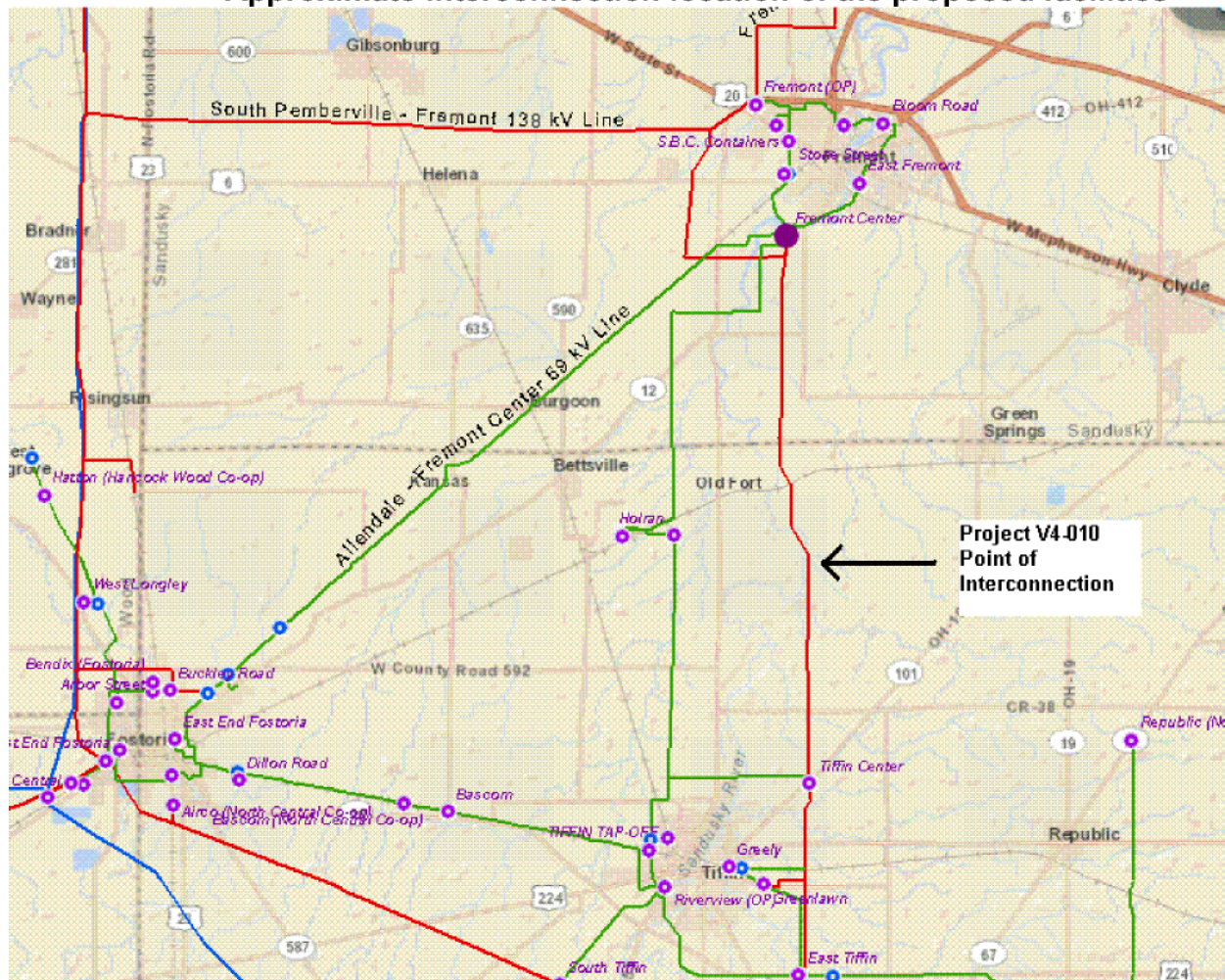
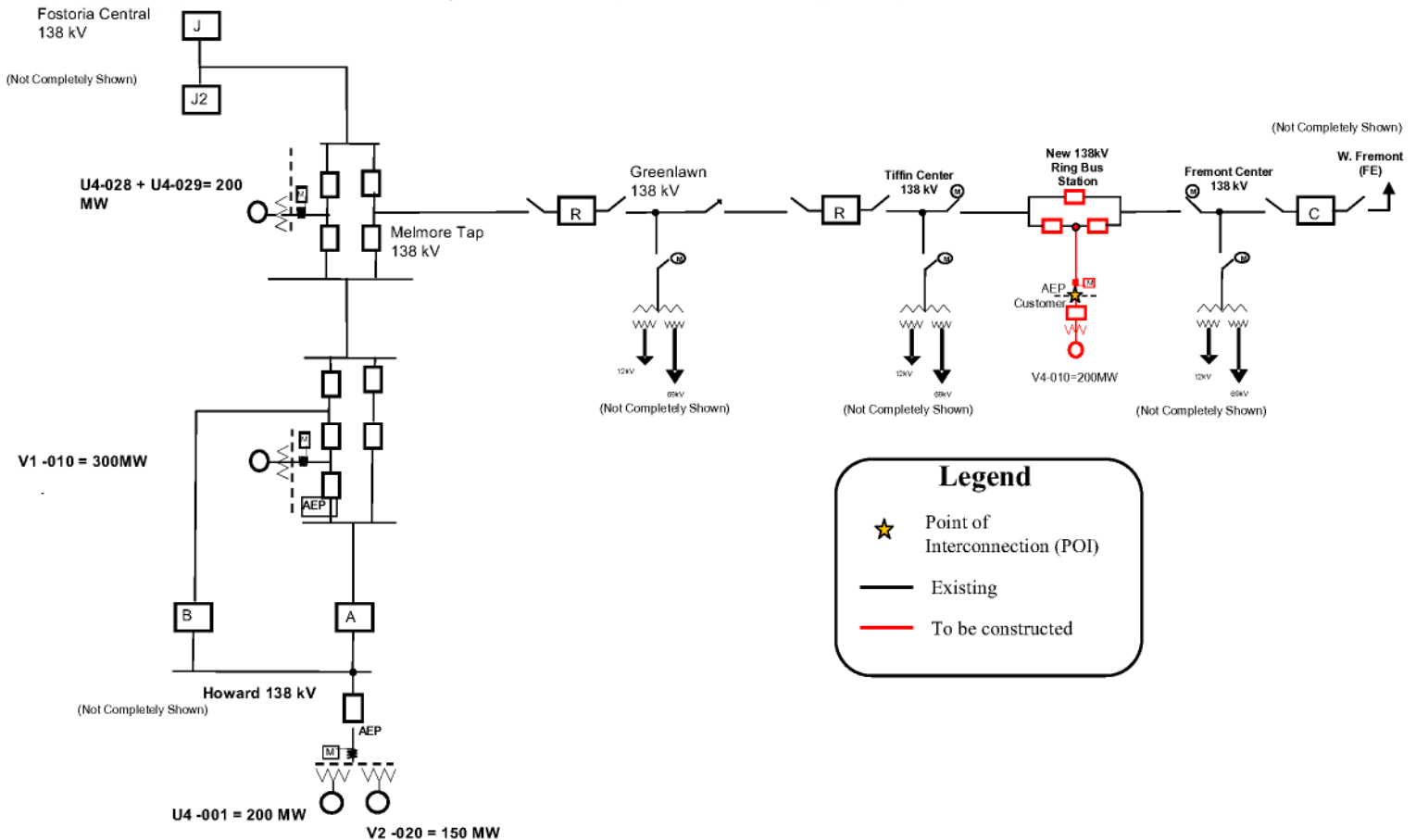


Figure 1



# Project V4-010 One-Line Diagram

Tap the Tiffin Center-Fremont Center 138 kV line



The above one-line diagram shows the requirements for interconnection to the AEP system. The developer is responsible for configuration at the collector station.

Figure 2

***PJM Generator Interconnection Request  
Queue #V4-010  
Fremont Center-Tiffin Center 138 kV  
Facilities Study***

September 2015

## **V4-010 Fremont Center – Tiffin Center 138 kV Facilities Study Report**

### **A. Facilities Study Summary**

#### **1. Project Description**

Apex Wind II, LLC proposes to install PJM Project #V4-010, a 200 MW wind generating facility. This generation facility would connect to the American Electric Power (AEP) Fremont Center – Tiffin Center 138 kV circuit via a new 138 kV switching station consisting of three (3) 138 kV circuit breakers to be physically configured in a breaker and one half bus arrangement, initially operated as a ring bus configuration (Figure 2). The proposed location of the generating facilities is located in Seneca County, Ohio (Figure 1). The projected in-service date is scheduled for December 31, 2016. Apex Wind II, LLC has elected the “Option to Build” option, and will be responsible for the construction of the new 138 kV switching station.

#### **2. Amendments/Changes to the Impact Study Report**

#### **3. Interconnection Customer Schedule**

PJM and AEP currently understand that Apex Wind II, LLC has established the following schedule dates:

**Back feed In-service Date: July 8, 2016**

**Commercial Operation Date: December 31, 2016**

#### **4. AEP’s Scope of Work to Facilitate Apex Wind II, LLC’s Interconnection**

- AEP shall provide construction oversight for the new 138 kV switching station connecting to the Fremont Center – Tiffin Center 138 kV circuit, including three (3) 138 kV circuit breakers to be physically configured in a breaker and one half bus arrangement, initially and operated as a ring bus to facilitate future expansion, relays, SCADA, and associated equipment. **(n3134)**
- AEP shall construct 138 kV revenue metering. **(n3134)**
- AEP shall construct transmission line extension to connect the new 138 kV switching station to the Fremont Center – Tiffin Center 138 kV circuit. **(n3135)**
- AEP shall replace relay and controls at Fremont Center 138 kV Station. **(n3137)**
- AEP shall replace relay and controls at Tiffin Center 138 kV Station. **(n3136)**
- Apex Wind II, LLC shall be responsible for obtaining the right-of-way, designing and constructing the transmission line between the wind project collector station and the new 138 kV switching station.

#### **5. Description of Transmission Owner Facilities Included in the Facilities Study**

##### **Direct Connection Work**

None required.

##### **Network Upgrade Work**



None required.

**6. Total Cost of Transmission Owner Facilities Included in the Facilities Study:**

Direct Connection facilities	\$2,194,900
Network Upgrade facilities	<u>0</u>
Total Cost	\$2,194,900

The estimates do not include the impact that delays in obtaining ROW, permits or other approvals may have.

**7. Summary of Schedule Milestones for Completion of Transmission Owner Work Included in Facilities Study:**

<b>V4-010 Schedule</b>		
<b>ISA signed</b>	November 16, 2015	
<b>Engineering Start</b>	November 16, 2015	
<b>Material Ordered</b>	November 30, 2015	
<b>Construction Start</b>	December 31, 2015	
<b>Outage (T-Line Foundations)</b>	May 9, 2016	May 21, 2016
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<b>Ready for back feed</b>	October 15, 2016	
<b>Commercial Operation Date</b>	December 31, 2016	

**B. Transmission Owner Facilities Study Results**

**1. Transmission Lines – New**

None required.

**2. Transmission Lines – Upgrades**

None required.

**3. Substation Facilities – New**

Apex Wind II, LLC will be responsible for construction of the New 138 kV Switching Station consisting of three (3) new 138 kV circuit breakers to be physically configured in a breaker and one half bus arrangement, initially and operated as a ring bus to facilitate future expansion, relays, SCADA, 138 kV revenue metering, and associated equipment connecting to the Fremont Center – Tiffin Center 138 kV circuit. (n3134)

**4. Substation Facilities – Upgrades**

AEP shall replace relay and controls at Fremont Center 138 kV Station.

AEP shall replace relay and controls at Tiffin Center 138 kV Station.

## 5. Metering & Communications

All metering equipment to be installed at the AEP Interconnect Station and the Apex Wind II, LLC generation station shall meet the requirements as specified by AEP in the “AEP Metering and Telemetering Requirements for AEP Transmission Customers” document ([SS-490011](#)).

## 6. Environmental, Real Estate and Permitting Issues

## 7. Summary of Results of Study

Attachment Facilities	Network Upgrade Number (NUN)	Engineering	Material	Construction	Misc.	Total
New Station – Revenue Metering	n3134	\$50,400	\$90,100	\$22,500	\$48,700	\$211,700
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### Schedules

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### Assumptions

None

## 8. Information Required for Interconnection Service Agreement

### New Switching Station Interconnection Cost Breakdown

Direct Material	\$729,209
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## Approximate interconnection location of the proposed facilities

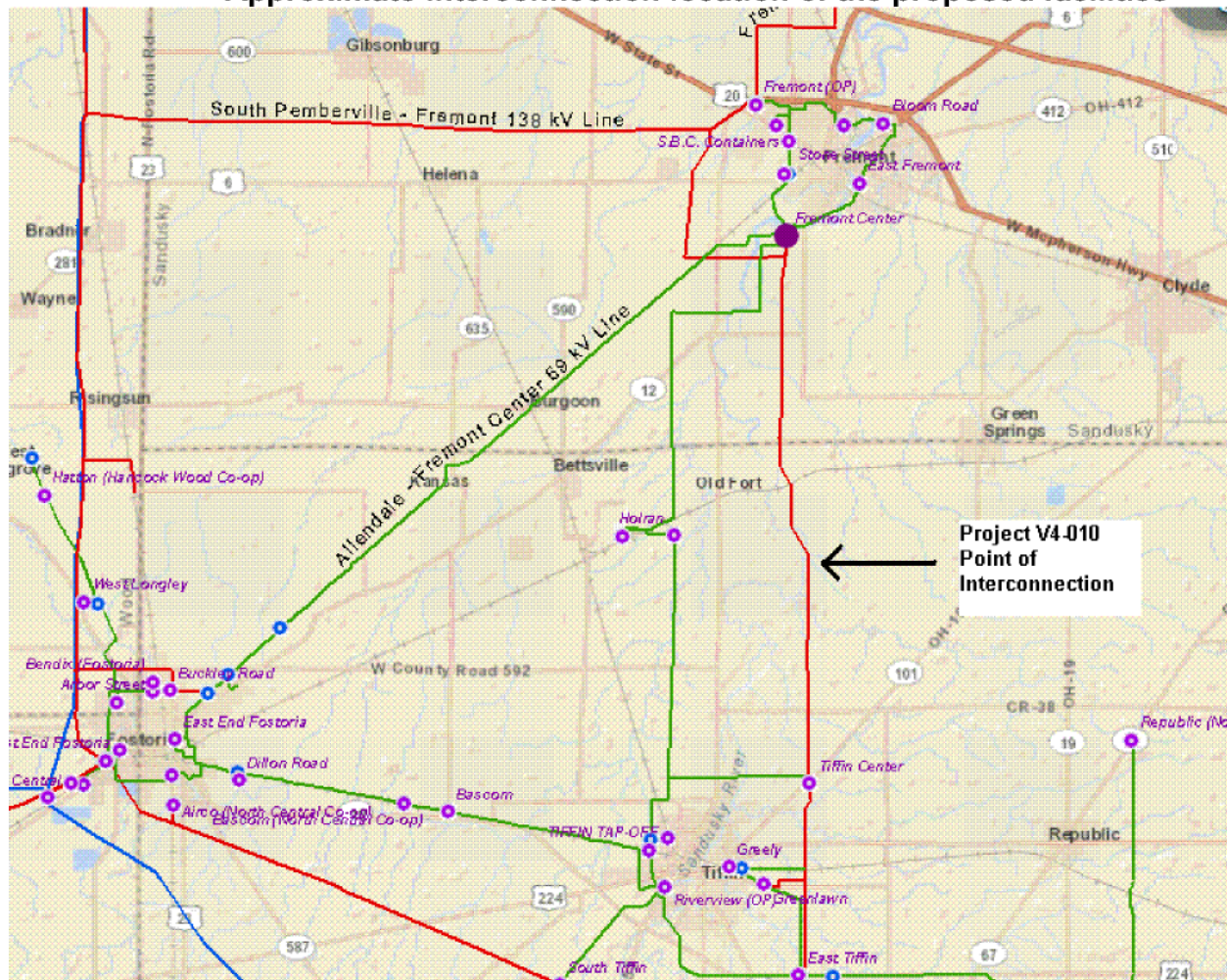
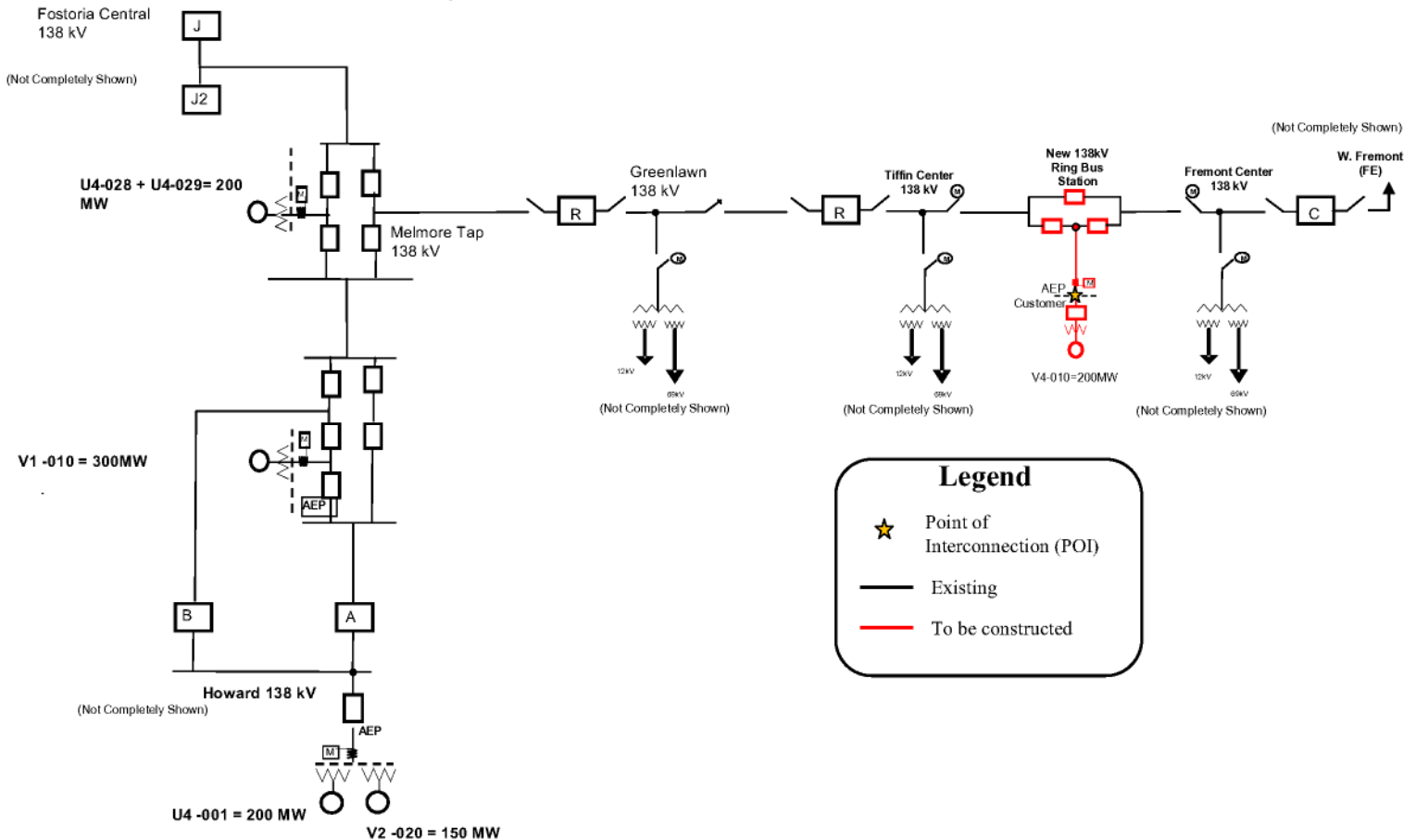


Figure 1



# Project V4-010 One-Line Diagram

Tap the Tiffin Center-Fremont Center 138 kV line



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Figure 2

**This foregoing document was electronically filed with the Public Utilities**

**Commission of Ohio Docketing Information System on**

**12/26/2018 12:03:02 PM**

**in**

**Case No(s). 17-2295-EL-BGN**

Summary: Application Exhibits A through D electronically filed by Teresa Orahood on behalf of Dylan F. Borchers