#T184 Dequine 345kV

Generation Interconnection

This analysis was completed to assess the reliability impact for the increase in generation interconnecting to the PJM system as a capacity resource.

Local AEP Impacts

The impact of the proposed generating facility on the AEP System was assessed for adherence with applicable reliability criteria. AEP planning criteria require that the transmission system meet single contingency performance criteria in accordance with the AEP FERC Form 715. Therefore, this criterion was used to assess the impact of the proposed facility on the AEP System. The project was studied as a 202 MW net energy injection (40 MW capacity) consistent with the interconnection application. The results are summarized below.

Normal System (2011 Summer Conditions)

- AEP Olive – S06 345 kV line is overloaded to 109% (1055 MW) of its normal rating under system normal conditions.

Single Contingency (2011 Summer Conditions)

- AEP Olive – S06 345 kV line gets overloaded to 138% (1339 MW) of its normal rating for an outage of AEP Dequine – Reynolds – Olive 345 kV line. Without the addition of T184 Project the same facilities are loaded to 129% (1256 MW) of normal rating under the same contingency.

- AEP Dequine – Reynolds 345 kV line gets overloaded to 132% (1230 MW) of its normal rating for an outage of AEP Olive – S06 345 kV line. Without the addition of T184 Project the same facilities are loaded to 130% (1212 MW) of normal rating under the same contingency.

- AEP Dequine – S06 345 kV line gets overloaded to 150% (1461 MW) of its normal rating for an outage of AEP Olive – S06 345 kV line. Without the addition of T184 Project the same facilities are loaded to 130% (1258 MW) of normal rating under the same contingency.

- Assuming that the generators at bus S06 are operating at unity power factor, the voltage at AEP S06 345 kV bus and AEP Dequine 345 kV bus drops to 0.91 pu for an outage of Olive – S06 345 kV line. This is below the minimum acceptable voltage of 0.95 pu at an EHV bus in case of a single contingency as per AEP Transmission Planning guidelines discussed in FERC Form 715.

- AEP Olive – S06 345 kV line gets overloaded to 152% (1476 MW) of its normal rating for an outage of AEP Dequine – S06 345 kV line. Without the addition of T184 Project

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the same facilities are loaded to 132% (1281 MW) of normal rating under the same contingency.

- Assuming that the generators at bus S06 are operating at unity power factor, a voltage collapse takes place at AEP S06 345 kV bus for an outage of Dequine – S06 345 kV line. A more detailed analysis is required to recommend any improvements that will address this voltage collapse. This analysis is usually conducted as part of the stability analysis during the impact study phase.

- AEP Dequine – Reynolds 345 kV line gets overloaded to 107% (1001 MW) of its normal rating for an outage of AEP Greentown – Jefferson 765 kV line. Without the addition of T184 Project the same facilities are loaded to 105% (978 MW) of normal rating under the same contingency.

- AEP Olive – S06 345 kV line gets overloaded to 118% (1147 MW) of its normal rating for an outage of AEP Greentown – Jefferson 765 kV line. Without the addition of T184 Project the same facilities are loaded to 111% (1076 MW) of normal rating under the same contingency.

- AEP Dequine – Reynolds 345 kV line gets overloaded to 107% (1000 MW) of its normal rating for an outage of AEP Dumont – Greentown 765 kV line. Without the addition of T184 Project the same facilities are loaded to 104% (968 MW) of normal rating under the same contingency

- AEP Olive – S06 345 kV line gets overloaded to 119% (1152 MW) of its normal rating for an outage of AEP Dumont – Greentown 765 kV line. Without the addition of T184 Project the same facilities are loaded to 111% (1081 MW) of normal rating under the same contingency.

- AEP Dequine – Reynolds 345 kV line gets overloaded to 101% (937 MW) of its normal rating for an outage of AEP Dumont – Marysville 765 kV line.

- AEP Olive – S06 345 kV line gets overloaded to 110% (1067 MW) of its normal rating for an outage of AEP Dumont – Marysville 765 kV line.

- AEP Dequine – Reynolds 345 kV line gets overloaded to 101% (935 MW) of its normal rating for an outage of AEP Cook 765/345 kV Transformer.

- AEP Olive – S06 345 kV line gets overloaded to 110% (1065 MW) of its normal rating for an outage of AEP Cook 765/345 kV Transformer.

*** Please note that since the Olive – S06 345 kV line is overloaded under normal conditions, the same overload issue appears for several contingencies that are not discussed above. Only contingencies that overload Olive – S06 345 kV line above 110% of its normal rating are discussed above.

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Multiple Contingency (2011 Summer Conditions)

- AEP Dequine – S06 345 kV line gets overloaded to 149% (1446 MW) of its emergency rating for an outage of AEP Dequine – Reynolds – Olive 345 kV line and AEP Olive – S06 345 kV line. Without the addition of T184 Project the same facilities are loaded to 130% (1258 MW) of emergency rating under the same contingency.

- AEP Olive – S06 345 kV line gets overloaded to 152% (1474 MW) of its emergency rating for an outage of AEP Dequine – Reynolds – Olive 345 kV line and AEP Dequine – S06 345 kV line. Without the addition of T184 Project the same facilities are loaded to 132% (1281 MW) of emergency rating under the same contingency.

- AEP Olive – S06 345 kV line gets overloaded to 117% (1132 MW) of its emergency rating for an outage of AEP Dumont – Greentown 765 kV line and AEP Olive 345/138 kV Transformer. Without the addition of T184 Project the same facilities are loaded to 109% (1060 MW) of emergency rating under the same contingency.

- AEP Dequine – Reynolds 345 kV line gets overloaded to 106% (985 MW) of its emergency rating for an outage of AEP Dumont – Greentown 765 kV line and AEP Olive 345/138 kV Transformer. Without the addition of T184 Project the same facilities are loaded to 102% (954 MW) of emergency rating under the same contingency.

- AEP Olive – S06 345 kV line gets overloaded to 122% (1185 MW) of its emergency rating for an outage of AEP Greentown – Jefferson 765 kV line and AEP Hanging Rock – Jefferson 765 kV line. Without the addition of T184 Project the same facilities are loaded to 114% (1111 MW) of emergency rating under the same contingency.

- AEP Dequine – Reynolds 345 kV line gets overloaded to 110% (1023 MW) of its emergency rating for an outage of AEP Greentown – Jefferson 765 kV line and AEP Hanging Rock – Jefferson 765 kV line. Without the addition of T184 Project the same facilities are loaded to 107% (994 MW) of emergency rating under the same contingency.

*** Please note that since the Olive – S06 345 kV line is overloaded under normal conditions, the same overload issue appears for several contingencies that are not discussed above.

Short Circuit Analysis

- No problems identified.

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Stability Analysis

- Stability studies were not performed as part of this Feasibility Study and are not normally performed as part of a Facility Study effort. The stability assessments are part of the System Impact Study. Based upon the results of this future System Impact Study, the extent of system upgrades could change and the associated costs could be significantly different.

Reactive Requirements

PJM requires a power factor correction to 95% lead/lag at the point of interconnection for wind generating facilities. It is expected that the Interconnection Customer will adhere to this standard.

Network Impacts

The Queue Project #T126 was studied as a(n) 200MW(Capactiy=40MW) injection at Olive – Dequine 345 kV line in the AEP area. Project #T126 was evaluated for compliance with reliability criteria for summer peak conditions in 2012. Potential network impacts were as follows:

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

None

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

None

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

No problems identified.

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)

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- The 932 MVA SN/SE rating for the Dequine – Reynolds 345 kV circuit is not correct. It is based on a relay limitation that has been eliminated. The present rating should be based on the conductor rating. However, the conductor for this circuit was installed following extensive ice storm damage and is not the original conductor. The original conductor was 1414 MCM ACSR (paper expanded), and this is what the transmission towers were designed for. However, the replacement conductor was 2303 MCM ACAR. Although similar in size, this conductor has different sag characteristics than the original conductor. Therefore, **a sag study is required for the Dequine – Reynolds 345 kV circuit** to determine the maximum conductor operating temperature(s), and the associated rating(s).

- To address the Olive – S06 345 kV circuit overload, structure & sag analyses will be required to determine if the circuit can be reconductored with a higher capacity conductor. If these analyses eliminate this alternative, then Olive – S06 345 kV will need to be rebuilt. The cost of rebuilding this double circuit line will be approximately **$1,700,000 per mile**. The Dequine – Olive 345 kV line is approximately **90 miles long**; however, the length of the Olive – S06 345 kV portion is indeterminate until the interconnection location can be determined with more accuracy. The cost of reconductoring will be less than rebuilding. However, the cost for reconductoring cannot be provided before the structure and sag studies are completed (some structures may still need to be replaced).

  The structure & sag studies required for the Olive – S06 345 kV overload and Dequine – Reynolds 345 kV overload can be performed in the Facility Study and is estimated to cost approximately **$350,000**. It will require approximately 20 weeks from initiation. Most of the conductor lengths for the two circuits involved are located on the same towers. Therefore, a single study should be required to address both overload issues.

<u>Upgrades to address voltage problem:</u>

OPTION 1:

Under the present conditions, Olive – S06 345 kV line gets overloaded to three (3) times Surge Impedance Loading under credible contingencies. If the Sag analysis dictates that the Olive – S06 345 kV Circuit be rebuilt, depending on the conductor used and tower configuration, the new line parameters might help improve the voltage profile at S06 Bus.

OPTION 2:

Dequine – Olive 345 kV line is a double circuit line. PJM Projects #S06, #T126 & #T127 are connected to Dequine – Olive 345 kV Circuit #1 (to the west). If, however, both circuits #1 (west circuit) and #2 (east circuit) are looped in and out of the new switching station for PJM Projects #S06, #T126 and #T127, and the portion of line from S06 345 kV Station to Reynolds 345 kV

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Station is rebuilt or reconductored; the voltage profile at S06 345 kV bus will improve in case of credible contingencies.

A detailed voltage profile analysis was not performed as part of this Feasibility Study and is not normally performed as part of a Feasibility Study effort. The voltage assessments are part of the System Impact Study. Based upon the results of this future System Impact Study, the extent of system upgrades could change and the associated costs could vary significantly.

OPTION 3:

Another viable option will be to rethink the present configuration for PJM Projects #S06, #T126, #T127, #T183 and #T184. Instead of connecting all generation to Dequine – Olive 345 kV Circuit #1, Projects #S06, #T126 and #T127 can be connected to Dequine – Olive 345 kV Circuit #1 and Projects #T183 and #T184 can be connected directly to Dequine 345 kV bus by constructing a new 345 kV line from S06 to AEP Dequine Station. This option has not been studied in detail and the preliminary analysis shows some benefits. However, a detailed analysis must be performed if the developer seeks to pursue this option any further.

A combination of Options #2 and #3 will be more beneficial than the individual options. Again, a detailed analysis is required if the Developer is willing to pursue any of the above mentioned options.

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

MISO Impacts

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

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