A Feasibility Study on Connecting Two or Four 150 MW Combustion Turbine (CT) Generators in Pleasants County, West Virginia

October 1999

Prepared by Allegheny Power's Operations Planning Section of the System Planning and Operations Group of Allegheny Power

Introduction and Background

The Interconnection Customer (IC) contacted Allegheny Power (AP) and its System Planning and Operations group to determine the feasibility of interconnecting two or four 150 MW summer/190 MW winter rated, simple-cycle combustion turbine generators (CT) to the AP transmission system. The request was made to begin producing power and have the CTs in service by the summer of the year 2002. the IC also indicated in their initial request that an additional 300 MW in the form of two 150 MW Combined Cycle Steam Generators (CC) could be added in the future with the in-service date unspecified. The proposed project's site provided by the IC is located approximately 3.5 miles from AP's Belmont Substation. For discussion purposes in this report, AP will refer to this project as the Waverly CT or Waverly switching station site.

During a September 24, 1999 conference call between the IC and AP, it was decided that the preliminary results and initial cost estimates for the proposed 4-150 MW CTs would be presented in the report. However, it was also indicated by the IC that the four CTs alternative, paired with system enhancements required to install all four CTs of generation, would derail the project. It was, therefore, agreed that any additional study efforts involving the Waverly site would be limited to the installation of two 150 MW CTs. The concept of adding two 150 MW CC generators was completely dropped from the analysis. However, the results from those tests completed for the proposed four CTs installation completed to date will be presented as information to the developer.

The IC's representative also indicated that he would like to install additional generation at another site within the AP transmission system. The additional site, covered in a separate report and also mentioned within this report will be referred to as South Bend. The South Bend site will have proposed generation up to 600 MW of CT generation. The location of the site is near an AP-PJM interface, approximately 2 miles from GPU's Keystone Power Station. Because of that, in addition to studying the Waverly Project alone, power flow tests were also completed with both sites interconnected to the AP transmission system and those results are also discussed within this report.

Project Description

The four alternatives selected for interconnecting the proposed generation are shown on Figures 1, 2, 3 and 4. As indicated on the figures, either two or as many as four 150 MW CTs were requested to be connected, with the possibility that two 150 MW CCs could be added sometime in the future. The proposed project is located about 3.5 miles from Belmont Substation at a site AP will refer to in this report and call the Waverly CT site. Each of the first four generators would consist of 190 MW winter/150 MW summer, gas combustion turbines operating at 0.85 power factor. The first four units are designated as peaking units and, based upon the information provided by the IC, will operate during peak usage hours, approximately 10 to 15 % of the year and operate at full load. Transmission interconnection service to the units can be provided by multiple 138 kV lines terminating at a proposed Waverly 138 kV switching station. Because arrangements for Transmission Service have not been made and the destination of power output from the generators has not been designated, many assumptions concerning the power were required to complete the study. All assumptions used in this analysis are discussed in the Assumptions section of this report.

Figure 1

Figure 2

Figure 3

Figure 4

Results

The results of the power flow studies indicate that the installation of either 300 MW or 600 MW of CT generation has detrimental effects on the AP transmission system.

Power flow results indicate that the the IC request for the proposed 4-150 MW summer rated, CTs can be accommodated but will require system upgrades and reinforcements of $12-15 million at the IC's expense. These costs would include $13 million in transmission line reconductoring and rebuilding and about $2 million in miscellaneous substation equipment upgrades to increase the thermal capacity to eliminate thermal overloads. These costs are in addition to the cost of constructing the Waverly switching station, which would consist of nine 138 kV breakers and associated control equipment at a cost of $4 to 5 million. During a September 24, 1999 conference call, the IC's representative indicated that the proposed 4-150 MW summer rated, CTs was too costly and could be dropped from the remainder of the analysis.

The estimated cost to construct the Waverly switching station for the 300 MW (2-150 MW summer rated, CTs) Alternative, which would include five 138 kV breakers and associated control equipment, is about $2 to 2.5 million. Additionally, associated transmission upgrades and reinforcements are about $3 to 3.5 million as detailed below:

- Reconductor/Rebuild 6.92 miles of the Waverly-Trissler No. 1 (No. 604), 138 kV line: $1,400,000
- Reconductor/Rebuild 7.05 miles of the Riverview-Corner (No. 646) 138 kV line: $1,500,000
- Reconductor the 138 kV main bus at Trissler or equivalent: $ 250,000
- Miscellaneous upgrades at Corner and Riverview Substations: $ 100,000

Tables summarizing the power flow results can be found in Appendix A. Further discussion of these tables can be found in the Study Methodologies and Procedure Sections of this report.

The IC must sign on as an AP Open Access Transmission Tariff (OATT) customer or hire an agent with an existing OATT to act as an agent to market and sell their generation. The IC should also designate whether the new installation will become a control area capacity resource or indicate to AP how the plant will be operated. Note that any firm transmission reservations made by other marketers or developers prior to an AP/IC agreement could invalidate the results of this study, require further analysis, and increase reinforcement costs.

The IC needs to be aware that in the event that there is congestion on the Eastern Interconnection, generation dispatch out of Waverly at times might be restricted. In that case, AP will follow the North American Electric Reliability Council's (NERC) Transmission Line Loading Relief Procedure (TLR) and the guidelines set forth within that procedure. A copy of this procedure can be downloaded via the Internet from the NERC website at http://www.nerc.com. Additionally the IC may choose to implement the NERC Market Re-dispatch or the AP Security Coordinator might implement the Lake Erie Emergency Re-dispatch (LEER) procedures that could request the units at Waverly to participate. Involvement in either procedure is voluntary. Allegheny Energy (AE) has incorporated these procedures in its OATT. More information on the NERC market re-dispatch procedure can be obtained from the NERC website at http://www.nerc.com. Information on the LEER can be obtained from the FERC-filed LEER procedure.

In addition to the thermal constraints mentioned in this report, transient stability problems **do exist** and will impact the proposed Waverly site. When one of the two 500 kV outlets from Belmont is out of service, **there are restrictions on power output from generators in the area**. This limitation will affect whatever generation the IC proposes to install at the Waverly site, even after the system reinforcements, totaling either $12 to 15 million for the 600 MW installation or $3 to 3.5 million for the 300 MW installation.

If the IC chooses to move forward with this project, more detailed studies would be required to refine the costs, to expand the seasonal analysis, and to further quantify stability constraints.

Assumptions

All future studies require assumptions concerning the control area load, facility additions and transmission sales. This analysis is no exception. The system models from the 1998 series base case database for the 2003 summer and 2008 summer seasons were selected as those to be tested. AP control area loads in those models ranged from 7,700 MW in the 2003 summer model to more than 8,000 MW in the 2008 summer model. AP facility additions were assumed to be those as planned in the 1998 series of cases, which followed the AP 1998 Planning Guide. A review of these cases indicates that AP, PJM, FE and DQE plan no major (Bulk Power) facility additions. However, AEP and VP are planning to install major system additions in the Appalachian Power Company Area of AEP and the northern area of Virginia Power Company. Those planned facilities are modeled in the 2008 summer model but not in the 2003 model. Transmission sales modeled for those years are those included in the summer base case models and include only confirmed firm transmission service reservations. The destination of the power that is being produced by the proposed two or four 150 MW CTs at the Waverly site was not provided by the IC. Therefore, several transfer scenarios were studied. Generation output from the CTs was assumed to stay within the AP control area in one scenario, and in alternative scenarios the power was assumed to be sold off-system to each of the five interconnected control areas. Those Transfer scenarios modeling the 600 MW or 300 MW of generation output from the Waverly site to the east assumed all the power was being sold to either PJM or VP exclusively. Those Transfer scenarios modeling the 600 MW or 300 MW output from the Waverly site to the west assumed all the power output was being sold to either AEP, FE or DQE.

The IC provided AP generator and step-up transformer data for their proposed installation. Appendix B is an aggregation of the data provided by the IC.

Study Methodology and Procedure

The in-service date for the proposed CT installation is projected to be the summer of the year 2002. Based upon an in-service date of June 2002, power flow base models were selected and studies completed for the summer of the years 2003 and 2008. The assumptions, summarized above, regarding forecasted control area loads, maintenance schedules, confirmed Firm Point-To-Point Transmission reservations and generation dispatch, were all used in the feasibility analysis.

As indicated in the assumptions, the destination of the power output from the proposed CT installation at Waverly is unknown. The IC has indicated that the power output from the generators could be made up of long-term and short-term Point-to-Point energy sales and spot market hourly sales. It should also be noted that the IC has not made transmission arrangements with AP, nor are they an OATT customer of AP.

Power flow cases were created and contingency tests were evaluated based upon the AP planning criteria reported in FERC Form 715, Part 4 which is available to the general public for a nominal fee. This criteria was applied to studies using the 2003 and 2008 models to evaluate the long-term effect the power output from Waverly might have on AP transmission facilities. During a September 24, 1999 conference call with the IC, it was determined that only the results from the power flow tests for the proposed two and four CTs alternatives would be included in this report.

Studies for the Waverly site and 600 MW of proposed generation

The preliminary study work, prior to the conference call (09-24-99), revolved around the IC's request to install four 150 MW CTs. This initial analysis was first performed on the proposed four 150 MW CTs that totaled 600 MW (150 MW summer output capability) with a generator nameplate total of 840 MVA at an 85 % power factor. The single contingency studies were reviewed and adverse loading due to the proposed installation and unit output, and its effect on system facilities were determined.

In all, over thirty transfer test scenarios were completed and analyzed. Results of the single contingency tests concluded that facility upgrades and system reinforcement would be required in order to accommodate the request of 600 MW. Cost estimates for the upgrades and reinforcements, which would be the total responsibility of the IC, are in the neighborhood of $12 to 15 million. These costs are in addition to the construction cost of the Waverly site. Cost estimates to construct the Waverly site, which would include nine 138 kV breakers and associated control equipment etc. is in the $4 to 5 million.

Details of this initial phase of the study included the review and evaluation of four substations and line configuration as interconnection alternatives. Each was considered and used for the power flow testing. The first series of power flow tests was conducted on the Alternative 1 (Figure 2), which loops two 138 kV lines into the Waverly site. This created a total of four 138 kV lines to distribute the power into or across the AP transmission system. Power flow test results show that with 600 MW of generation and only two 138 kV lines looped into Waverly, severe overloads occurred during the single contingency testing. An outage of either of the two Belmont-Waverly-Trissler 138 kV lines resulted in a remaining line loading above 100 % of its continuous rating. Other single contingency tests resulted with facility overloads and, therefore, this alternative was deemed unacceptable and no further tests were made.

Alternative Two (Figure 3) with three 138 kV lines into the Waverly site was tested next. This option created six 138 kV outlets for the power produced at the Waverly site. Power flow simulations were completed and results showed that with the proper system upgrades and reinforcements, totaling $12 to 15 million, the AP transmission system could accommodate the request to install 600 MW of CT generation at the Waverly site.

Alternative Three (Figure 4) with four 138 kV lines into the Waverly site was also evaluated. All power flow simulations conducted on this option indicated that with the proper facility upgrades and reinforcements, totaling $12 to 15 million, the entire proposed installation could be connected to the AP transmission system.

However, this feasible interconnection scenario does not provide a guarantee that the IC will have the ability to sell the full power output of the plant at all times. Interim transmission service agreements or generator additions preceding the IC's request for transmission service will take precedence. Additionally, transient stability problems that currently exist in the Belmont area could also limit the power produced by the plant when system topology creates limits on total generation output in the area.

Additionally, the proposed installation effect on system losses was considered. Power flow evaluations indicate that when the output of the plant is being retained within the AP control area, AP system losses increase due to the location of the plant with regard to the control area load. AP transmission system losses are also increased when the plant output is being sold off system. For these reasons, the IC will be required to either purchase system losses as an ancillary service from the AP Control Area or generate additional MW to cover the estimated losses caused by the proposed installation.

After the conference call with the IC, as mentioned above, it was decided to concentrate the additional study work on the proposed two 150 MW CTs installation. Analysis conducted on the proposed two 150 MW CTs installation had a generation total of 300 MW (150 MW summer output capability) or a generator nameplate rating of 420 MVA at an 85 % power factor. The single contingency studies looked for adverse loading due to the proposed installation's unit output and its effect on AP system facilities.

Studies for the Waverly site and 300 MW of proposed generation

The series of more than thirty transfer test scenarios was re-evaluated. Results of the single contingency tests concluded that facility upgrades and system reinforcement would be required in order to accommodate the request for 300 MW.

Cost estimates for the proposed 300 MW of CT generation and associated transmission upgrades and reinforcements, which would be the total responsibility of the IC, are in the area of about $3 to 3.5 million. These costs are in addition to the construction cost of the Waverly site. Cost estimates to construct the Waverly site, which would include five 138 kV breakers and associated control equipment etc. is in the $2 to 2.5 million.

The four interconnection alternatives were considered and used for the proposed two 150 MW CT installation. Initial tests were made using Alternative One (Figure 1) which looped two 138 kV lines into the Waverly site. This created a total of four 138 kV lines to distribute the power into or across the AP transmission system. Power flow test results show that facility upgrades and reinforcements would be required with only the two 138 kV lines into Waverly. Overloads occurred during the single contingency testing that require AP to enhance the Transmission system. Additional single contingency testing with the $3 to 3.5 million of system upgrades indicated that with no additional modifications, this option or alternative could be deemed acceptable.

Alternative Two (Figure 3), the scenario with three 138 kV lines looped into Waverly was tested next. Note that Figure 3 shows 600 MW of CT generation. For this analysis only 300 MW of CT generation was modeled in the power flow tests. This option created six 138 kV outlets for the power produced at the Waverly site. Power flow simulations were completed and results showed that without the proper system upgrades and reinforcements, the AP transmission system could not accommodate the request to install 300 MW of CT generation at the Waverly site. Additional review of these results showed that the same system enhancements and reinforcements would be required as those required under the two-line scenarios.

Alternative Three (Figure 4), the scenario with four 138 kV lines into the Waverly site was evaluated to determine if the 300 MW of proposed CT installation could be accommodated. All power flow simulations conducted on this option indicated that the same system upgrades and reinforcements would be required as those in both prior alternatives. Note that Figure 4 shows 600 MW of CT generation. For this analysis only 300 MW of CT generation was modeled in the power flow tests.

The above indicates that the interconnection request by the IC could be accommodated using Alternative One, the two line-looped option (Figure 1). However, it should be noted that a feasible interconnection scenario does not guarantee that the IC would have the ability to produce and sell the full power output of the plant at all times. Firm transmission service that was sold or other confirmed generation additions who purchase firm transmission service between the time this study is completed and the IC's commitment to the project and their purchase of transmission service may at times prohibit full output of the plant and/or void these study results.

Additionally, transient stability problems that currently exist in the Belmont area would also limit the power produced by the plant when system topology creates limits on total generation output in the area.

Additionally, the proposed installation effect on system losses was considered. Power flow evaluations indicate that when the output of the plant is being retained within the AP control area, AP system losses increase due to the location of the plant with regard to the control area load. AP transmission system losses are also increased when the plant output is being sold off system. For these reasons, the IC will be required to either purchase system losses as an ancillary service from the AP Control Area or generate additional MW to cover the estimated losses caused by the proposed installation.

Studies for the Waverly site and 300 MW coupled with the South Bend site and 600 MW of proposed generation

A final analysis was conducted by evaluating the proposed installation of both the Waverly site specified within this report and another site located within AP approximately 2 miles outside GPU's Keystone Power Station (South Bend). With the system upgrades determined to be needed by the individual site studies put in place, it appears that no new or additional reinforcements would be required for both projects to interconnect to the AP transmission system. All together the installations proposed by the IC totaled 900 MW (2-150 MW CTs summer output capability at Waverly and 4-150 MW CTs summer output capability at South Bend) or 6-210 MVA (generation nameplate) at an 85% power factor. Single contingency studies looked for adverse loading due to simultaneous full output of both of the proposed installations and its effect on the AP transmission system facilities.

A series of more than twenty power flow test scenarios was evaluated. Results of the single contingency tests concluded that with those facility upgrades and system reinforcements mentioned above assumed to be in place, the two proposed projects, 2-150 MW CTs at Waverly and 4-150 MW CTs at South Bend, could be accommodated by the AP transmission system.

However, as mentioned earlier in this report, a feasible interconnection scenario does not guarantee that the IC would have the ability to produce and sell the full power output of the plant at all times. Firm transmission service that was sold or other confirmed generation additions who purchase firm transmission service between the time this study is completed and the IC's commitment to the project and their purchase of transmission service may at times prohibit full output of the plant and/or void these study results. Additionally, transient stability problems that currently exist in the Belmont area would also limit the power produced by the Waverly site plant when system topology creates limits on total generation output in the area.

Short Circuit Studies

Results of the short circuit evaluation are tabulated below. The fault current values determined in the study indicate that the substation equipment at AP's neighboring substations is adequate, and that the addition of 2 – 210 MVA CTs at the proposed Waverly site will not cause any of the equipment to exceed short circuit ratings. Note that the generator nameplate value of 210 MVA per turbine was used for fault current calculations while the stated generator output of 150 MW per turbine was used in the power flow analysis.

DECEMBER 1999 SYSTEM CONDITIONS 2 - 138/18.0 kV Transformers(Z1=10%,Z0=10% @100 MVA)		
	BASE CONDITIONS **(Without the new CTs)** **(3-phase symmetrical faults)**	**(With the new CTs)** Z1=20.5% @210 MVA Z2=20.5% @210 MVA Z0=5.10% @210 MVA **(3-phase symmetrical faults)**
<u>Waverly 138 kV</u>		
Three Phase Fault	26798 Amps ∠ -85.09°	31019 Amps ∠ -85.76°
Phase to Ground Fault	24575 Amps ∠ -83.50°	26817 Amps ∠ -83.74°
<u>Waverly(G1) 18.0 kV</u>		
Three Phase Fault	27756 Amps ∠ -89.34°	60893 Amps ∠ -89.74°
Phase to Ground Fault	0 Amps ∠ 0°	52.0 Amps ∠ -0.04° *
<u>Waverly(G2) 18.0 kV</u>		
Three Phase Fault	27756 Amps ∠ -89.34°	60893 Amps ∠ -89.74°
Phase to Ground Fault	0 Amps ∠ 0°	52.0 Amps ∠ -0.04° *
* Note: It was assumed that a grounding resistor of 200 ohms is installed on generator neutral.		

Stability Considerations

The transmission system must be designed so that generating units remain in synchronism and that cascading outages do not occur for credible contingencies such as electrical faults or sudden network changes caused by fault clearing and line reclosings.

Transient stability is simulated to assess expected performance of generating units whenever the transmission network is subjected to severe disturbances. Test results are used to determine critical fault clearing times and the ability of the system to prevent cascading outages. They are also used to study the effectiveness of alternative transmission plans to optimize the system's transient performance. Since it is impossible to anticipate and test for all combinations of contingencies that could occur on an interconnected network, those cases judged to be less severe using AP transient stability criteria as a guide, are not routinely tested.

There are also areas of the system that are considered strong enough from system dynamics considerations to support the proposed amounts of generation without the need for stability analysis. It may, therefore, be deemed unnecessary to perform any stability simulations. This will be evaluated on a case by case assessment.

Transient stability testing done in the past has indicated that transient stability problem **do exist** in the area of the proposed Waverly project. Because of that, whenever one of the two 500 kV outlets from Belmont is out of service, **total power output from generators in the area is restricted**. This limitation will include whatever generation the IC proposes to install at the Waverly site, even after the system reinforcements are in service. Additionally, as a future extension of this study because the proposed project is close to Pleasants Power Station, there are stability concerns that will need to be addressed as part of the Facilities Study. If the proposed installation by the IC becomes a reality, those studies will be performed and necessary actions taken at that time.

When the proposed generating station is designed and dynamics data for turbine generators are available, the IC should perform a transient stability study to determine critical fault clearing times and effects of line reclosings on the transient stability of the Project units. In addition, any dynamic machine data should be forwarded to AP for their dynamics testing and analysis.

APPENDIX A

TABLES OF RESULTS FOR THE 2-150 MW CT POWER TESTS

2003 Summer Outage Facility	Monitored Facility	W/O Waverly 0 MW (loading in %)	Generation retained within Allegheny Power With Waverly 2 @150 MW and @.85 P.F. 2-138 kV looped (loading in %)	Generation wheeled to American Electric Power With Waverly 2 @150 MW and @.85 P.F. 2-138 kV looped (loading in %)	Generation wheeled to PJM With Waverly 2 @150 MW and @.85 P.F. 2-138 kV looped (loading in %)	Generation wheeled to FirstEnergy With Waverly 2 @150 MW and @.85 P.F. 2-138 kV looped (loading in %)	Generation wheeled to Duquesne Light With Waverly 2 @150 MW and @.85 P.F. 2-138 kV looped (loading in %)	Generation wheeled to Virginia Power With Waverly 2 @150 MW and @.85 P.F. 2-138 kV looped (loading in %)
Belmont-Edgelawn 138 kV	Edgelawn-Trissler 138 kV	90.4	97.6	98.7	99.8	97.3	98.3	99.9
	Waverly-Trissler 138 kV #1	-----	97.1	97.6	97.7	96.3	97.5	97.7
Belmont-Trissler 138 kV #2	Belmont-Trissler 138 kV #1	91.6	-----	-----	-----	-----	-----	-----
Edgelawn-Trissler 138 kV	Corner-Parkersburg 138 kV	92	-----	-----	-----	-----	-----	-----
Waverly-Trissler 138 kV #1	Waverly-Trissler 138 kV #2	-----	95.4	95.9	96.7	111.7	112.9	112.9
Waverly-Trissler 138 kV #2	Waverly-Trissler 138 kV #1	-----	112.5	113.1	113.9	94.6	95.7	95.7
Belmont-Parkersburg 138 kV	Waverly-Trissler 138 kV #1	-----	94.6	95.2	95.1	-----	95	95
Kammer-Belmont 765 kV & Belmont-Mountaineer 765 kV	Willow Island-Natrium 138 kV	-----	-----	90.5	-----	-----	90.1	-----

2003 Summer Outage Facility	Monitored Facility	W/O Waverly 0 MW (loading in %)	Generation retained within Allegheny Power With Waverly 2 @150 MW and @.85 P.F. 3-138 kV looped (loading in %)	Generation wheeled to American Electric Power With Waverly 2 @150 MW and @.85 P.F. 3-138 kV looped (loading in %)	Generation wheeled to PJM With Waverly 2 @150 MW and @.85 P.F. 3-138 kV looped (loading in %)	Generation wheeled to FirstEnergy With Waverly 2 @150 MW and @.85 P.F. 3-138 kV looped (loading in %)	Generation wheeled to Duquesne Light With Waverly 2 @150 MW and @.85 P.F. 3-138 kV looped (loading in %)	Generation wheeled to Virginia Power With Waverly 2 @150 MW and @.85 P.F. 3-138 kV looped (loading in %)
Belmont-Edgelawn 138 kV	Edgelawn-Trissler 138 kV	90.4	92.1	97.5	98.6	96.1	97.1	97.2
	Waverly-Trissler 138 kV #1	-----	95.9	93.2	93.4	91.9	93	93
Belmont-Trissler 138 kV #2	Belmont-Trissler 138 kV #1	91.6	-----	-----	-----	-----	-----	-----
Edgelawn-Trissler 138 kV	Corner-Parkersburg 138 kV	92	-----	-----	-----	-----	-----	-----
Waverly-Trissler 138 kV #1	Waverly-Trissler 138 kV #2	-----	-----	90.5	-----	-----	-----	-----
Waverly-Trissler 138 kV #2	Waverly-Trissler 138 kV #1	-----	102.7	103.8	104.4	102.4	103.7	103.7
Belmont-Parkersburg 138 kV	Waverly-Trissler 138 kV #1	-----	94	95.1	95.2	93.8	-----	95.2
Kammer-Belmont 765 kV & Belmont-Mountaineer 765 kV	Willow Island-Natrium 138 kV	-----	-----	90.5	-----	-----	90.1	-----

2003 Summer Outage Facility	Monitored Facility	W/O Waverly 0 MW (loading in %)	Generation retained within Allegheny Power With Waverly 2 @150 MW and @.85 P.F. 4-138 kV looped (loading in %)	Generation wheeled to American Electric Power With Waverly 2 @150 MW and @.85 P.F. 4-138 kV looped (loading in %)	Generation wheeled to PJM With Waverly 2 @150 MW and @.85 P.F. 4-138 kV looped (loading in %)	Generation wheeled to FirstEnergy With Waverly 2 @150 MW and @.85 P.F. 4-138 kV looped (loading in %)	Generation wheeled to Duquesne Light With Waverly 2 @150 MW and @.85 P.F. 4-138 kV looped (loading in %)	Generation wheeled to Virginia Power With Waverly 2 @150 MW and @.85 P.F. 4-138 kV looped (loading in %)
Belmont-Edgelawn 138 kV	Edgelawn-Trissler 138 kV	90.4	95	96.4	97.6	95	98.3	96.1
	Waverly-Trissler 138 kV #1	-----	91.1	92	92.2	90.7	97.5	91.9
Belmont-Trissler 138 kV #2	Belmont-Trissler 138 kV #1	91.6	-----	-----	-----	-----	-----	-----
Edgelawn-Trissler 138 kV	Corner-Parkersburg 138 kV	92	-----	-----	-----	-----	-----	-----
Waverly-Trissler 138 kV #1	Waverly-Trissler 138 kV #2	-----	-----	-----	-----	-----	-----	-----
Waverly-Trissler 138 kV #2	Waverly-Trissler 138 kV #1	-----	100.3	101.2	101	99.8	101.1	101
Belmont-Parkersburg 138 kV	Waverly-Trissler 138 kV #1	-----	91	92.4	92.4	91.1	92.2	92.4
Kammer-Belmont 765 kV & Belmont-Mountaineer 765 kV	Willow Island-Natrium 138 kV	-----	-----	90.5	-----	-----	90.1	-----