

## Wagner & Crane Potential Retirement Sensitivity Study

This analysis was prepared in response to a request from the Maryland Public Service Commission to study potential retirement scenarios of the Crane and Wagner units (The MD PSC letter may be found at: <http://www.pjm.com/~media/committees-groups/committees/teac/20111215/20111215-md-psc-to-pjm-request-for-evaluation.ashx> ). PJM has not received a deactivation notice from the units' owner.

1. Retirement Units
  - Wagner all units: 998.1 MW in 2016 RTEP case)
  - Crane all units: 399 MW in 2016 RTEP case)
2. Proposed study case: 2016 RTEP case.
  - The 2016 RTEP case is based on the 2011 load forecast and the MAPP and PATH projects are not in the case. The case also assumes the retirement of the Benning, Buzard Point, Potomac River and Indian River generator. .
3. Studies:
  - Generator Deliverability for each requested deactivation scenario
  - Baseline N-1 thermal and voltage baseline analysis
  - Load Deliverability testing for the Mid-Atlantic (MAAC), Southwest Mid-Atlantic (SWMAAC), BGE and PEPCO LDAs
  - N-1-1 voltage analysis considering only 500 kV contingencies

Note: Thermal and voltage analysis using below 500 kV contingencies was not done given that the analysis would be dependent on the upgrades that would be selected to address the N-1 baseline, generator deliverability, and load deliverability violations.

- **Generator Deliverability and Common Mode Outage Study**
  - **Generation deliverability testing was completed for the three scenarios requested. The results of these analyses are summarized below. Violations were identified for each scenario (i.e. either Crane or Wagner alone deactivated and with both Crane and Wagner deactivated).**

<b>Generation Deliverability Results</b>	
Generator Retirement Scenario	Number of Planning Criteria Violations
Both Wagner and Crane Retired	9
Either Wagner or Crane Alone Retired	4
Wagner Alone Retired	8
<b>TOTAL</b>	<b>21</b>

- Either Crane or Wagner Retired (4 overloads)

- The Glenarm – Windy Edge 115 kV circuit '110517' is overloaded for several contingencies with the highest loading for the loss of the Conastone – Northwest 230kV tower line
- The Glenarm – Windy Edge 115 kV circuit '110511' is overloaded for several contingencies with the highest loading for the loss of the Windy Edge '110592' 115 kV circuit with a stuck breaker at Windy Edge
- The Five Forks – Rock Ridge 115 kV circuit is overloaded for several contingencies with the highest loading for the loss of the Windy Edge '110512' 115 kV circuit with a stuck breaker at Windy Edge
- The Conemaugh 500/230 kV transformer is overloaded for the loss of the Conemaugh – Keystone 500 kV circuit and Conemaugh generator # 2 (line fault stuck breaker contingency).
- Only Wagner Retired
  - The Conastone – Graceton 230 kV circuit is overloaded for the loss of the Conastone – Northwest 230 kV tower line
  - The High Ridge – Sandy Spring 230 kV circuit '2334' is overloaded for several contingencies with the highest loading for the loss of the Sandy Spring to Burtonsville 230 kV circuit '2314'.
  - The High Ridge – Sandy Spring 230 kV circuit '2314' is overloaded for several contingencies with the highest loading for the loss of the Sandy Spring to Burtonsville 230 kV circuit '2334'.
  - The Howard – Pumphrey 230 kV circuit is overloaded for several contingencies with the highest loading for the loss of the Waugh Chapel to Brandon Shores 230 kV tower line
  - The Pumphrey 230/115 kV transformer is overloaded for several contingencies with the highest loading for the loss of the Waugh Chapel to Brandon Shores 230 kV tower line
  - The Wagner 230/115 kV transformer # 1 is overloaded for several contingencies with the highest loading for the loss of the Brandon Shores to Riverside 230 kV circuit '2344' and Wagner 230/115 kV transformer # 2 (line fault stuck breaker contingency)
  - The Cedar Park - Cedar 115 kV is overloaded for the loss of the 115 kV circuits 110544&110546 with a stuck breaker at Waugh Chapel.
  - The Shade Gap – Roxbury 115 kV circuit is overloaded for several contingencies with the highest loading for the loss of the Juniata 230 kV station (fault at Juniata bus tie breaker).
- Only Both Retired
  - The Conastone – Northwest 230 kV circuit '2322' is overloaded for the loss of the Conastone – Northwest 230 kV circuit '2310'
  - The Waugh Chapel – Brandon shores 230 kV circuit '2342' is overloaded for the loss of the Waugh Chapel – Brandon shores 230 kV circuit '2343' and Brandon Shore unit # 1 (line fault stuck breaker contingency).

- The Wagner 230/115 kV transformer # 2 is overloaded for the loss of the Wagner to Brandon Shore 230 kV circuit '2346' and Wagner 230/115 kV transformer # 1
- The Waugh Chapel – Crownsville 115 kV circuit is overloaded for the loss of the Waugh Chapel 115 kV circuit 110543&110548 with a stuck breaker at Waugh Chapel.
- The Rock Ridge - Colonial Pipeline 115 kV circuit '110512' is overloaded for the loss of the Conastone – Northwest tower line
- The Colonial Pipe – Glenarm 115 kV circuit is overloaded for the loss of the Conastone – Northwest 230kV tower line
- The Face Rock – Five Fork 115 kV circuit # 1 is overloaded pre-contingency
- The Face Rock – Five Fork 115 kV circuit # 2 is overloaded pre-contingency
- The Edward's Ferry – Dickerson 230 kV circuit is overloaded for the loss of the Possum Point –Burches Hill 500 kV circuit.

- **Baseline N-1 Thermal and Voltage Study**

**The Baseline N-1 thermal and voltage testing was done for the scenario with both C.P. Crane and H.A. Wagner deactivated. Violations were identified on the same facilities as those identified for the Generator Deliverability testing however in general the overloads were not as severe for the Baseline N-1 Thermal study. Given that, Baseline N-1 Thermal testing was not done for the scenario with just C.P. Crane or H.A. Wagner deactivated.**

**Thermal:**

- The Conastone – Graceton 230 kV circuit is overloaded for the loss of the Conastone – Northwest 230 kV tower line.
- The High Ridge – Sandy Spring 230 kV circuit '2334' is overloaded for several contingencies with the highest loading for the loss of the Sandy Spring to Burtonsville 230 kV circuit '2314'.
- The High Ridge – Sandy Spring 230 kV circuit '2314' is overloaded for several contingencies with the highest loading for the loss of the Sandy Spring to Burtonsville 230 kV circuit '2334'
- The Howard – Pumphrey 230 kV circuit is overloaded for several contingencies with the highest loading for the loss of Waugh Chapel to Brandon Shores 230 kV tower line.
- The Pumphrey 230/115 kV transformer is overloaded for several contingencies with the highest loading for the loss of the Waugh Chapel to Brandon Shores 230 kV tower line.
- The Waugh Chapel – Brandon shores 230 kV circuit '2342' is overloaded for the loss of the Waugh Chapel – Brandon shores 230 kV circuit '2343' and Brandon Shore unit # 1 (line fault stuck breaker contingency).

- The Wagner 230/115 kV transformer # 1 is overloaded for the loss of the Brandon Shores to Riverside 230 kV circuit '2344' and Wagner 230/115 kV transformer # 2 (line fault stuck breaker contingency).

**Voltage:**

- Voltage violations were identified in the Mid-Atlantic Area, APS and Dominion areas for multiple contingencies.

- **Load Deliverability Study**

Load deliverability analysis performed for the Mid-Atlantic (MAAC), Southwest Mid-Atlantic (SWMAAC), Baltimore Gas and Electric (BGE) and Potomac Electric Power Company (PEPCO) LDAs. This analysis was done for the most limiting scenario with both the C.P. Crane and H.A. Wagner units deactivated.

- MAAC Thermal : Pleasant View – Edwards Ferry – Dickerson 230 kV for the loss of Possum Point to Burches Hill 500 kV
- MAAC Voltage: Voltage collapse for the loss of any of the following facilities:
  - o Possum Point –Burches Hill 500 kV
  - o Brandon Shore generator # 1
  - o Brandon Shore generator # 2
- SWMAAC Thermal: None
- SWMAAC Voltage: Voltage collapse for the loss of any of the following facilities:
  - o Possum Point –Burches Hill 500 kV
  - o Brandon Shore generator # 1
  - o Brandon Shore generator # 2
- BGE Thermal: Howard - Pumphery 230 kV and Pumphery 230/115 kV Transformer is overloaded pre-contingency
- BGE Voltage: Voltage collapse for the loss of Brandon Shore generator # 1 or # 2
- PEPCO Thermal : Pleasant View – Edwards Ferry – Dickerson 230 kV for the loss of Possum Point to Burches Hill 500 kV
- PEPCO Voltage: Voltage collapse for the loss of any of the following facilities:
  - o Possum Point –Burches Hill 500 kV
  - o Bedington – Black Oak 500 kV
  - o Brandon Shore generator # 1 or Brandon Shore generator # 2

- **N-1-1 Voltage Study**

- Voltage analysis performed for the PJM 500 kV and above contingencies and identified several voltage collapse violations.

### **Potential System Upgrades to mitigate the identified violations:**

The following system upgrades and cost estimates are for the worst case scenario (both Wagner and Crane retired). The total cost of all of the upgrades is \$328.6 million.

- Build Emory Grove 500/230 kV substation (\$82.5 M)\*
- Build a parallel Conastone –Graceton – Bagley – Raphael Rd 230 kV circuit (\$121 M)\*
- Install 500 MVAR SVC at Brighton 500 kV substation (\$60 M)
- Install 200 MVAR capacitor at Hunterstown 500 kV substation (\$4 M)
- Replace Conemaugh 500/230 kV transformer (\$16 M)
- Rebuild Shade Gap – Roxbury 115 kV circuit (\$8 M)
- Rebuild the Howard – Pumphrey 230 kV circuit (\$12 M)
- Install a third Wagner 230/115 transformer (\$25 M)
- Remove terminal limitation on Pumphrey 230/115 kV transformer (\$0.1 M)

\* Approved RTEP baseline project