After Action Review Recommendations for Generation from Winter Storm Elliott (8/7/23):

- **Fleetwide Review (plant by plant) of Cold Weather checklists**
  - Status: Complete
  - Description: All plants have reviewed their cold weather checklists in light of lessons learned from this event. Note that further changes will be incorporated going forward as related to NERC Reliability Standard EOP-012-1 which will be effective October 2024.
  - Reference documents:
    - Plant checklists available but not attached.
    - NERC Reliability Standard EOP-012-1 (effective October 2024) EOP-012-1

- **Replace temporary freeze protection measures with permanent at the fuel gas reducing station regulating valves for EWB 5, 8-11 Simple Cycle Gas Turbines.**
  - Status: In progress. Target completion October 2023.
  - Description: Station has completed applicable heat trace. Station has invested $165K in constructing a permanent metal building to replace the temporary structure. Building scheduled for completion in October 2023.
  - Reference documents: Project documentations available but not attached.

- **CR review low fuel gas supply pressure operational procedures.**
  - Status: Complete
  - Description: Following an internal review of the Gas Turbine control system and local gas compressor design, no actions were identified to better respond to such an event should it occur again.

- **TC Research automatic load control for variable fuel gas inlet pressure for Simple Cycle Gas Turbines.**
  - Status: In progress. Target completion Fall 2023.
  - Description: At the time of the event the station's General Electric (GE) CT's were programmed with a fixed minimum inlet fuel pressure below which they would trip. Based on the event the TC team investigated sliding fuel pressure operation through GE. It was determined that this software change would have likely provided an additional 300MW capacity during the event. TC is pursuing this upgrade and expects it to be operational Fall 2023.
  - Reference documents: GE OpFlex Sliding Fuel Pressure (Appendix I).

- **TC Review low ambient temperature design and operation of TC2 water coil air heater**.
  - Status: In progress.
  - Description: TC2 was load limited during the event due to issues with maintaining the deaerator storage tank water level related to the water-cooled air heater (WCAH). Generation Engineering is currently modeling the system to determine the root cause of the issue. The prevailing theory follows the WCAH high water demand due to the low ambient air temperature. The condensate pumps responsible for feeding the system have been evaluated and determined to be operating at design to supply sufficient flow. The rest of the system is now being modeled to determine what caused the high demand and whether it can meet the stated design conditions. This includes, but is not limited to, air heater and boiler controls, system valves, and coil surface area. The study will be concluded as soon as possible, and information/action items will be communicated to the plant for final resolution.

- **Additional compression studies**.
  - Status: In progress.
  - Description: As part of the project development for MC5 and EWB12, Project Engineering is researching additional on-site fuel gas compression. Based on the outcome of this research CR and TC may be evaluated. Initial findings indicate that additional compression at the sites may mitigate a similar event in the future.

- **Routine Compliance Review of the Event**.
  - Status: In progress.
  - Description: This review has been incorporated into the implementation of NERC Reliability Standard EOP-011-2 (effective April 2023), NERC Level 3 alert issued May 15, 2023 and NERC Reliability Standard EOP-012-1 (effective October 2024).
  - Reference documents (hyperlinks):
    - NERC Reliability Standard EOP-011-2 (effective April 2023) EOP-011-2
    - NERC Level 3 alert issued May 15, 2023 https://www.nerc.com/pa/rrm/bpsa/Alerts%20DL/Level%203%20Alert%20Essential%20Actions%20to%20Industry%20Cold%20Weather%20Preparations%20for%20Extreme%20Weather%20Events%20III.pdf
    - NERC Reliability Standard EOP-012-1 (effective October 2024) EOP-012-1

- **FERC weatherization standard compliance.**
  - Status: In Progress
  - Description: The fleet was fully compliant with NERC Reliability Standard EOP-011-2 when it went into effect on April 1, 2023. The fleet is on schedule to be

compliant with NERC Reliability Standard EOP-012-1 when it becomes effective October 1, 2024. In an effort to accelerate implementation of EOP-012-1 ahead of the 2023-2024 winter season, NERC issued a Level 3 alert on May 15, 2023 asking utilities to respond to a list of 'essential actions' outlined in the alert. Generation will satisfy all of NERC's recommendations except for Essential Action #2, related to identification and freeze protection of critical components. Generation is on target to have up to 20% of the critical components identified by the October 2023 submittal date. This is not to say that the unidentified components are at high-risk but rather they are not documented as required by EOP-012-1. Based on conversations with peer utilities this is a challenge across the industry.

- Reference documents (hyperlinks):
  - NERC Reliability Standard EOP-011-2 (effective April 2023) EOP-011-2
  - NERC Level 3 alert issued May 15, 2023 https://www.nerc.com/pa/rrm/bpsa/Alerts%20DL/Level%203%20Alert%20Essential%20Actions%20to%20Industry%20Cold%20Weather%20Preparations%20for%20Extreme%20Weather%20Events%20III.pdf
  - NERC Reliability Standard EOP-012-1 (effective October 2024) EOP-012-1

Appendix I

GE OpFlex Sliding Fuel Pressure

The existing control logic for the Trimble County Combustion Turbines includes a default constant minimum fuel pressure requirement upstream of the unit gas control valves. This constant is set to ensure adequate supply pressure over the entire range of operation from initial light off to full load. This default value is necessary during startup or shutdown to pass through the ~12% load point, but is a higher pressure than what is necessary in the normal operating range. If the pressure drops below the default value the unit will go into an automatic shutdown.

The sliding fuel pressure software replaces this default minimum pressure with logic that continuously calculates the actual required pressure at the current operating point. If the supply pressure drops below the required pressure it will utilize a load limiter function in place of an automatic shutdown. This load limiter will reduce load / output until the required pressure and current pressure match.

GE conducted an engineering study to generate an estimated required pressure curve over the entire load range for the combustion turbines. This curve was then utilized to evaluate how the units would have performed during Winter Storm Elliott with this software enhancement versus the current capability. This evaluation factors in the supply pressure drop that occurs from the Texas Gas point of connection at the Bedford City Gate to the inlet to the unit.

As shown in Chart 1, during the period of Winter Storm Elliot the sliding fuel pressure software would have allowed for a variable amount of increased capacity across the five operating units. At the point of the lowest fuel supply pressure this would have amounted to 300 MWs of capacity. Just as important, with the load limiter functionality had the units been in base load command they would have automatically followed the max capacity curve (grey curve) without risk of initiating an automatic shutdown. In comparison, the existing software would have required manual adjustment of the unit load to follow the existing capability curve (orange curve) with the risk of initiating an automatic shutdown if the pressure were allowed to drop below the default minimum fuel pressure.

Going a step further, Chart 2 illustrates the capacity capability for all six units with the existing software versus the sliding fuel pressure software across a range of supply pressures at the Texas Gas Bedford City Gate point of connection. The minimum supply pressure at the Bedford City Gate experienced during Winter Storm Elliott was 425 psig, which reduced the existing capability to ~50% capacity. However, a further pressure reduction of 20 psig would have resulted in completely losing the five units that were operating. In comparison, with the sliding fuel pressure enhancement the units could stay online operating (at a reduced load) down to 305 psig. If pressure were to drop lower than 305 psig the units would trip as they would not have enough pressure to make it through the operating mode change experienced during shutdown.

These charts were generated assuming -20 °F ambient temperature and 120 °F fuel gas inlet temperature, which yield the highest required fuel supply pressures. Operating conditions with higher ambient temperatures and / or lower fuel gas inlet temperatures would yield lower pressure requirements over the load range. Important to note that the software enhancement does not change the required pressure to make it through a startup. This means that the units must be online in the normal operating load range prior to the fuel supply pressure dropping below that critical minimum pressure for startup.

Business Use

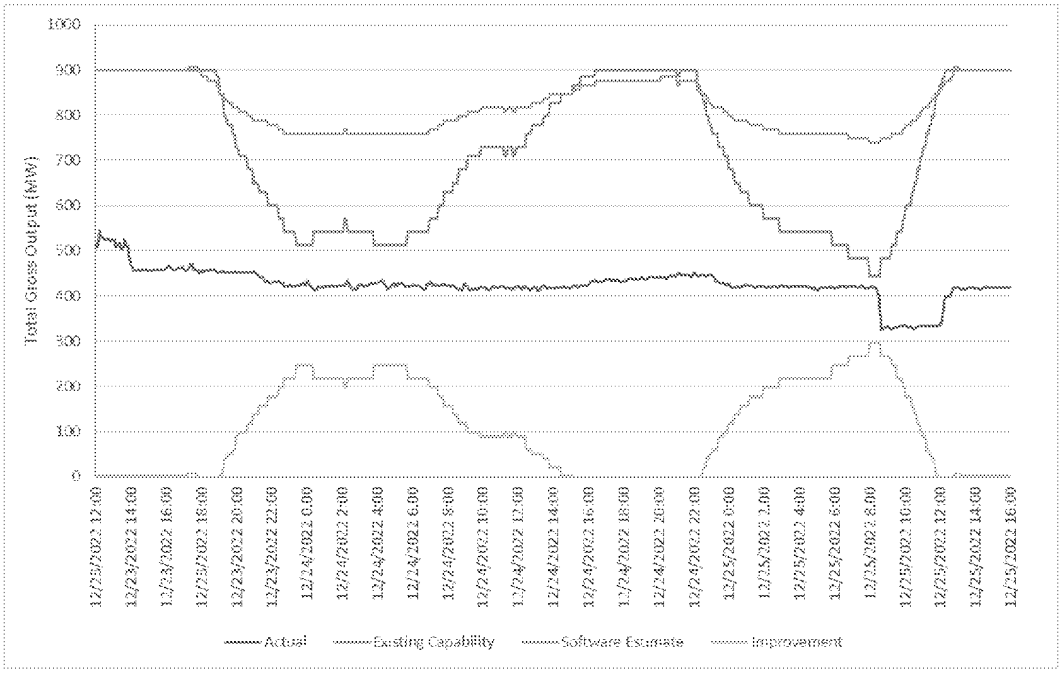

Chart 1. Existing Capability versus Software Capability During Winter Storm Elliott

Note: Chart total gross output lines based on five (5) combustion turbines operating. TC5 was offline during this time period due to the low fuel supply pressure from Texas Gas. Software estimate based on -20 °F ambient temperatures with 120 °F fuel gas temperature entering the unit.

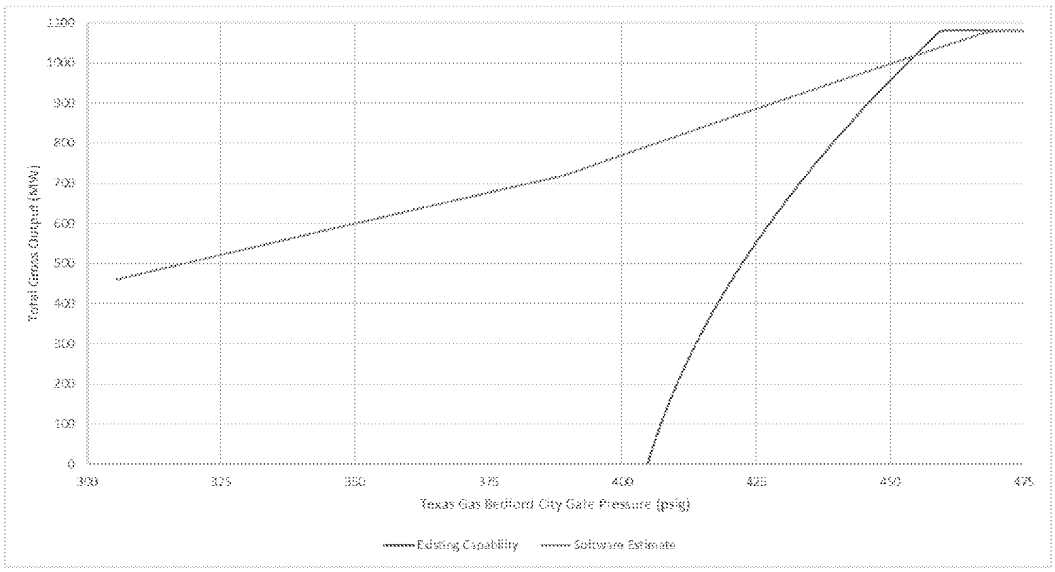

Chart 2. Existing Capability versus Software Capability Across Texas Gas Supply Pressure Range

Note: Chart total gross output lines based on all six (6) combustion turbines operating. Software estimate based on -20 °F ambient temperatures with 120 °F fuel gas temperature entering the unit.