Winter Storm Elliott
Events in the LG&E and KU Balancing Authority Area (BAA)
December 23-24, 2022

Executive Summary

Winter Storm Elliott hit the Eastern Interconnect December 23-25, straining the grid, and resulting in load shedding events across the region. As the storm moved across Kentucky, it transitioned from rain to ice then snow. Elliot's conditions included:

- Temperatures as low as -8 degrees, the lowest in the Louisville area since 1994.
- Windchills exceeding 30 degrees below zero and wind gusts of 30-40 miles per hour.
- Snowfall of 1-5 inches.

The storm set new all-time December electric peaks within the LG&E and KU BAA on Friday, Dec. 23rd.

- Total Daily Energy Usage was 141,613 MWh, breaking the prior record of 134,600 MWh set on Dec. 14, 2010.
- Over half-a-billion cubic feet of gas was delivered to customers on December 23. This was the second highest amount of gas delivered to customers on record for December. 42% of that gas came from LG&E gas storage fields.

On the evening of December 22 temperatures began to drop rapidly across the state. In Louisville the temperatures dropped from the mid-40s at 16:00 to single digits by midnight and below zero by 04:00. Over the course of the next two days, the LG&E and KU BAA experienced significant challenges including interstate gas pipeline pressure limitations, mechanical and other cold weather issues.

This narrative is intended to provide a high-level overview with real time event history as it impacted the LG&E and KU BAA.

On the morning of December 22, the 14-day projected net peak was forecasted to be 5,899 MW on December 23 at 20:00. On December 23 at 00:00 there was 4,761 MW of generation in service and 7,239 MW available capacity (excluding contingency reserves). The actual peak was 6,559 MW on December 23 at 17:58, well within the projected available capacity. TC1, BR10 and Dix1 (444 MW net total) were offline to address pre-existing mechanical issues and were not expected to be needed.

EW Brown Station's fuel gas was supplied by Texas Eastern Transmission Pipeline ("TETCO") throughout the event and was unaffected by external supply issues.

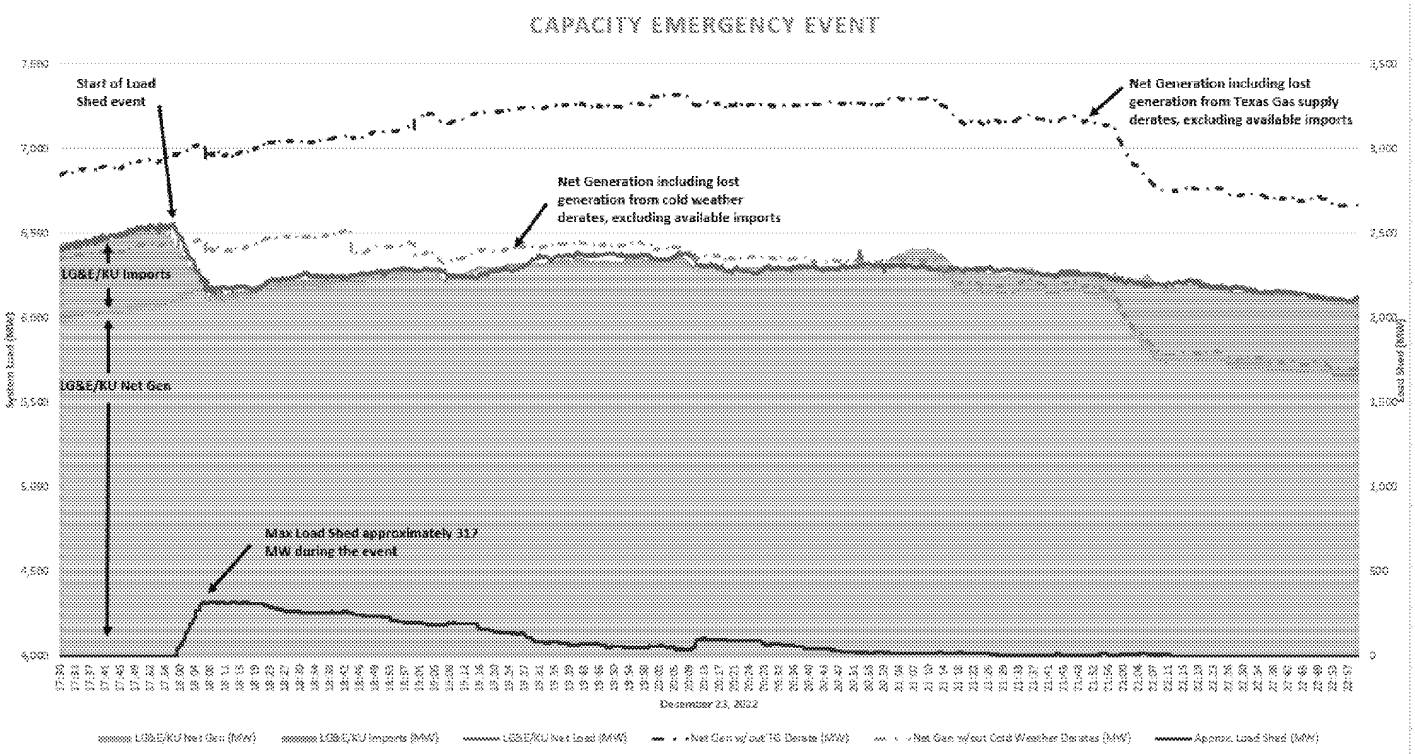
Cane Run and Trimble County plants are supplied by the Texas Gas Transmission Pipeline ("Texas Gas"). The companies' transportation contracts with Texas Gas specify minimum pressure for deliveries to Cane Run at 550 psi and Trimble County at 530 psi. Texas Gas deliveries to Cane Run fell below the minimum required pressure at 11:09 on 12/23. As a result, Cane Run experienced derates between 12/23 at 13:08 and 12/25 at 04:06. Deliveries to Cane Run did not return to full contracted pressure until 12/25 at approximately 13:00. Texas Gas deliveries to Trimble County fell below the minimum required pressure at approximately 11:15 on 12/23, requiring several derates at the plant between 12/23 at 13:47 and 12/25 at approximately 16:00, when the deliveries returned to full contracted pressure. Note that per NERC GADS rules, 'Failure of fuel supplier to fulfill contractual obligations' is considered 'Outside Plant Management Control' and does not contribute to the plant EFOR. See appendix A for fuel gas supply pressure trends.

Further contributing to the shortfall was the interruption in energy deliveries from OVEC, which was projected to supply 156 MW on 12/23 but in fact ranged from 91 MW to as little as 6 MW over the course of the event. Additionally, several times during the event TVA could not support its contingency reserve requirements, withdrawing its contribution to the Contingency Reserve Sharing Group ("CRSG") and necessitating LG&E/KU to cover a significantly increased amount of contingency reserve for our BAA (equal to our Most Severe Single Contingency, or MSSC, of 710 MW – an increase of over 450 MW in contingency reserve requirements).

As conditions across the regional grid began deteriorating on December 23, LG&E and KU executed the Capacity and Energy Emergency Operating Plan (which includes NERC required measures). The urgent actions required when facing these rare, emergency conditions necessitate swift, thoughtful response to restore system balance as quickly as possible or risk wide scale impacts over an extended period. The LG&E and KU Balancing Authority ("BA") had to shed load on 12/23 from 17:58 through 22:11 by as much as 317 MW. While this event impacted less than 5% of LG&E and KU customers, it was a first-of-its kind occurrence within the LG&E and KU system. See Appendix B for graph of customers affected by utility.

During the time of the load shedding event, derates attributable to the inability of Texas Gas to meet contractual delivery obligations ranged from 785MW to 943 MW. Derates unrelated to Texas Gas supply ranged from 45MW to 361MW.

The following graph demonstrates the impact that the gas supply issue had on the system in conjunction with the load shedding event. This graph covers the period of 12/23 from 17:30 to 22:58 and encompasses the entirety of the load shedding event. It also reflects the impact of the non-gas supply derates.



Generation Events

This narrative details the events across the LG&E and KU Generation Fleet over the course of the cold weather event. It does not directly reflect customer impact. Starting Friday, 12/23 the following generating issues developed:

- 12/23/22 at 00:00 the generation fleet condition was as follows:
  - Per Generation Dispatch there was 4,761 MW of generation in service and 7,239 MW available capacity.
  - **TC1** (370 MW net exclusive of partners) had been in outage since 12/22/22 at 15:35 due to failure of submerged drag chain conveyor hydraulic gearbox. Repairs were in progress at the time of this event, but the unit was available for up to 75 MW (exclusive of partners) firing gas only.
  - **BR10** (138 MW net) had been in an outage since 12/3/22 when a borescopic inspection identified issues with turbine seals. Repairs were in progress at the time of this event.
  - **Dix 1** (11 MW net) had been in a planned outage since 11/14/22. The unit could not be commissioned at the available lake level.
- 01:28 **BR5** (130 MW net) and **BR8** (128 MW net) tripped offline due to an interruption in fuel gas. This same failure rendered **BR9** (138 MW net) and **BR11** (128 MW net) unavailable. A pilot light that preheats fuel gas to act as control gas for fuel gas supply regulators blew out, making the regulators to the BR CT's inoperable and stopping fuel gas supply to the units. Station Maintenance built enclosures, installed heat trace, and wrapped in insulating blanket. This system was released back into service 12/23 at 16:58.
  - **BR9** came online firing fuel oil at 03:50.
  - **BR11** was made available at 03:50 and came online firing fuel oil at 07:40. It tripped at 15:39 due to a flame scanner issue and returned to service at 17:03 firing gas.
  - **BR8** came online firing fuel oil at 07:02. It hit a controls alarm for emissions limitations at 10:51, derating it to 100 MW.
- 03:10 **TC2** derated by 37 MW net (exclusive of partners) due to low inlet air temperature into the air heater. With the very low ambient air temperatures the water coil air heater could not provide sufficient heat input to maintain full load. This variable derate continued through 12/27/22 at 16:30.
- OF (45 MW net) The Army Corps lost power to the dams due to inclement weather issues. OF units were taken offline between 04:32 and 15:20 by order of Army Corps as a method of regulating the pool.
- 05:10 Generation Dispatch went into Alert Status, an internal status requesting that plant personnel avoid unnecessary risks with generating units.
- 05:15 PR13 (175 MW net) online. Tripped at 06:36 due to low generator gas temperature. This was caused by a manual valve in the cooling water circuit. The valve was set to its winter flow setting, but the extreme cold necessitated an additional adjustment. The unit came back online at 07:13.

- Secondary CT's:
    - 06:15 the HA units (2x14 MW net) were requested. Note that this site is unmanned and requires local operation. The delay to start was based on dispatching personnel to the site.
    - HA1 came on at 10:33 and ran until 12/24/22 at 14:57
    - HA2 was made unavailable from 10:33 until 14:57 due to a substation breaker issue, at which point the lube oil temperature to the unit could not make minimum temperature due to the extreme cold.
    - 07:52 PR12 (28 MW net) online.
    - 09:46 Dix2 and 09:52 Dix3 (11 MW net each) online.
- 07:17 BR3 (400 MW net) derated by 62 MW due to problems with combustion process instrumentation (not believed to be weather related at this time). This led to additional combustion related issues and derates through 12/25/22 at 21:15 when the unit was taken offline due to excessive slagging. The maximum derate prior to coming offline was 76 MW.
- At 11:09 gas pressure CR dropped below their contract limit of 550psi and soon after TC dropped below their contract limit of 530psi. By 13:08 this began to affect generating units, first when TC5 tripped (179 MW) followed by a derate at CR7 at 13:47 (253 MW). This derate varied as gas supply pressure changed over the course of the event. At 13:48 the operating gas turbines at TC collectively took a 439 MW derate to manage dropping gas pressure. As previously noted, TC1 was available for 100 MW firing gas had supply been available.
- 15:48 TC2 experienced a derate of 269 MW net due to a frozen boiler feed pump transmitter. This caused a unit runback that tripped a coal mill. The mill needed to be manually purged before returning to service. This lasted until 22:26 when the unit returned to its previous 37 MW derate due to inlet air temperature.
- At 16:13 MC4 lost a coal feeder due to cold weather-related bunker issues (coal tripper froze up) and took a 121 MW derate. This was resolved as of 18:44 and the unit returned to full load.

External Impacts

The timeline below details the interaction between LG&E/KU BA and the external entities whose actions impacted the LG&E/KU system including times when customers were impacted. For simplicity and readability, it excludes real time LG&E/KU generation status information.

- 12/23/22
    - 05:07 TVA declared EEA-1
    - 05:38 TVA declared EEA-2
    - 06:12 TVA declared EEA-3
    - 06:26 LG&E/KU Out of CRSG - carrying 700 MW reserves for CR7 (at current time MSSC)
    - 09:00 LKE Curtailable Service Rider (CSR) customers - directed to reduce load consistent with their contract and tariff.

- 10:15-11:45, 11:50-13:30 requested CSR assistance, LKE supplied 243 MW contingency reserves

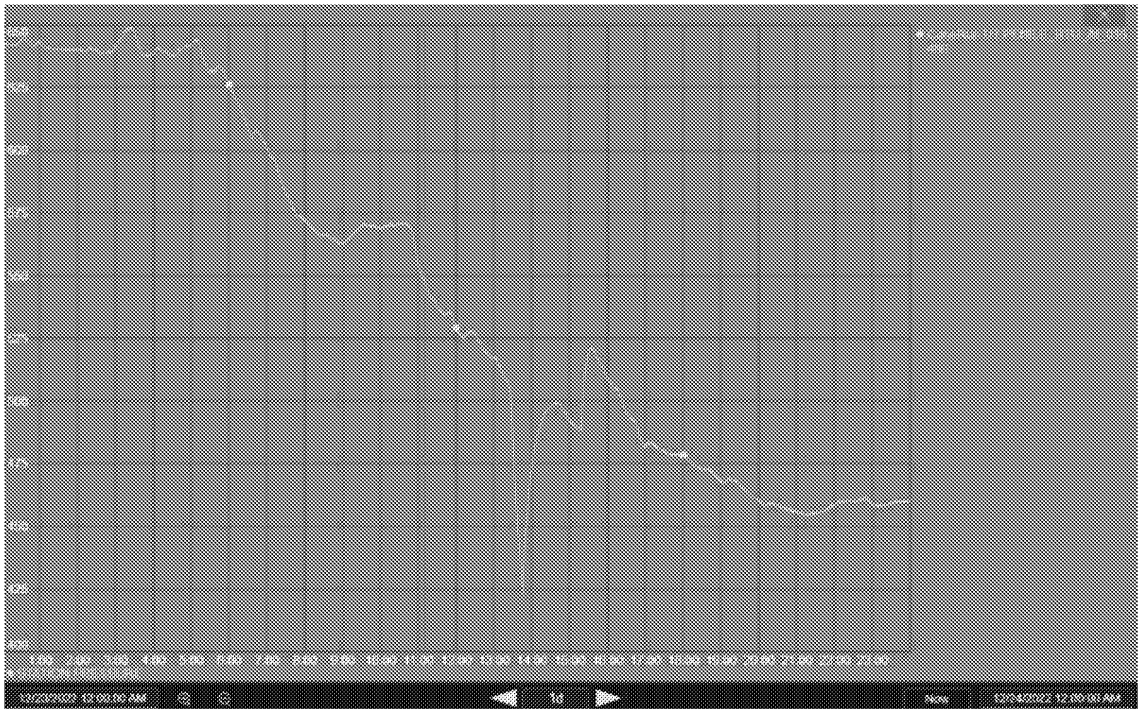
- 11:09-11:15 Texas Gas supply pressure to TC and CR dropped below the contract limit
- 13:08 Generation derates due to Texas Gas supply pressure issues begin
- 13:36 LG&E/KU BA declared EEA 3, pulled reserves from the CRSG
- 13:51 TVA declared EEA-2
- 14:48 TVA supplied extra 243 MW to CRSG
- 14:52 LG&E/KU BA changes from EEA 3 to EEA 2 and supplied our 243 MW to CRSG
- 16:29 PJM curtailed import to LG&E/KU for 400 MW
- 16:29 ARS called for 400 MW
- 16:45 LG&E/KU BA declares EEA 3
- 17:18 TVA declares EEA-3
- 17:58 LG&E/KU BA starts Load Shed process. The peak system load of 6,552 MW with a system capacity of 6,129 MW was achieved at this point
- 18:05 End of TVA curtailment tag
- 21:30 TETCO force majeure issue in Ohio (no impact to Brown as supply was coming from the south).
- 22:11 Per BA/TO all breakers opened during load shed were back closed

- 12/24/22
  - 00:53 LG&E/KU BA declares EEA 2
  - 01:55 LG&E/KU BA declares EEA 3
  - 06:00 PJM adjusted OVEC tags by as much as 59 MW between 06:00 and 12:00. The GO worked with the BA and TVA RC to resolve but it is unknown at this time why PJM was changing tags.
  - 12:10 TVA declares EEA 2
  - 12:22 LG&E/KU BA declares EEA 2
  - 13:07 TVA declares EEA 1
  - 13:45 TVA declares EEA 0
  - 14:06 LG&E/KU BA declares EEA 0
- 12/25/22
  - 13:15 LG&E/KU ended Generation Alert Status
  - 16:00 Generation derates due to Texas Gas supply pressure issues end

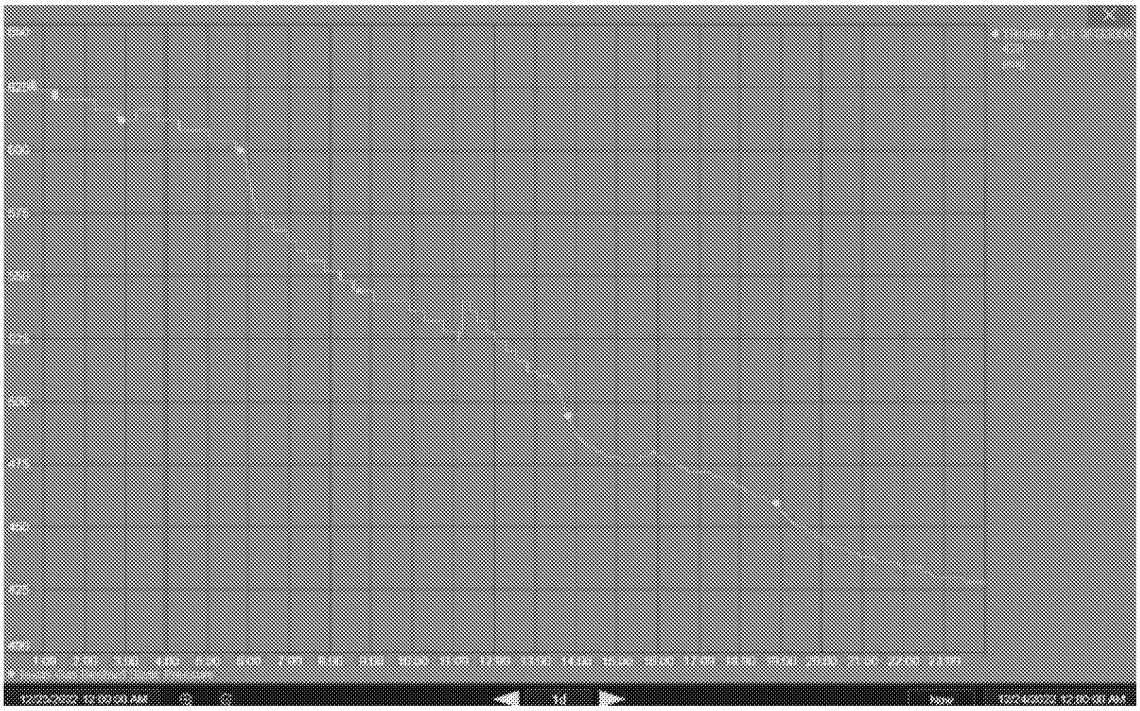
Appendix A:

Supplied Gas Pressure from Texas Gas on 12/23/22 at 00:00 through 23:59

Cane Run



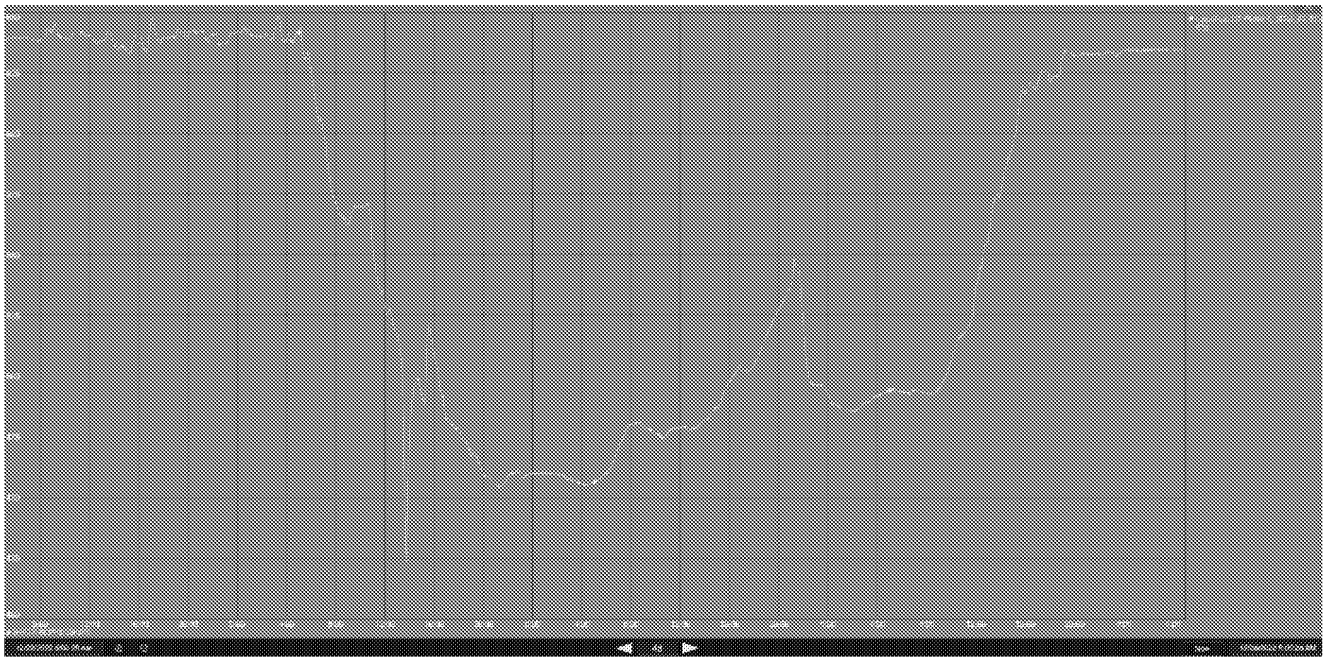
Trimble County



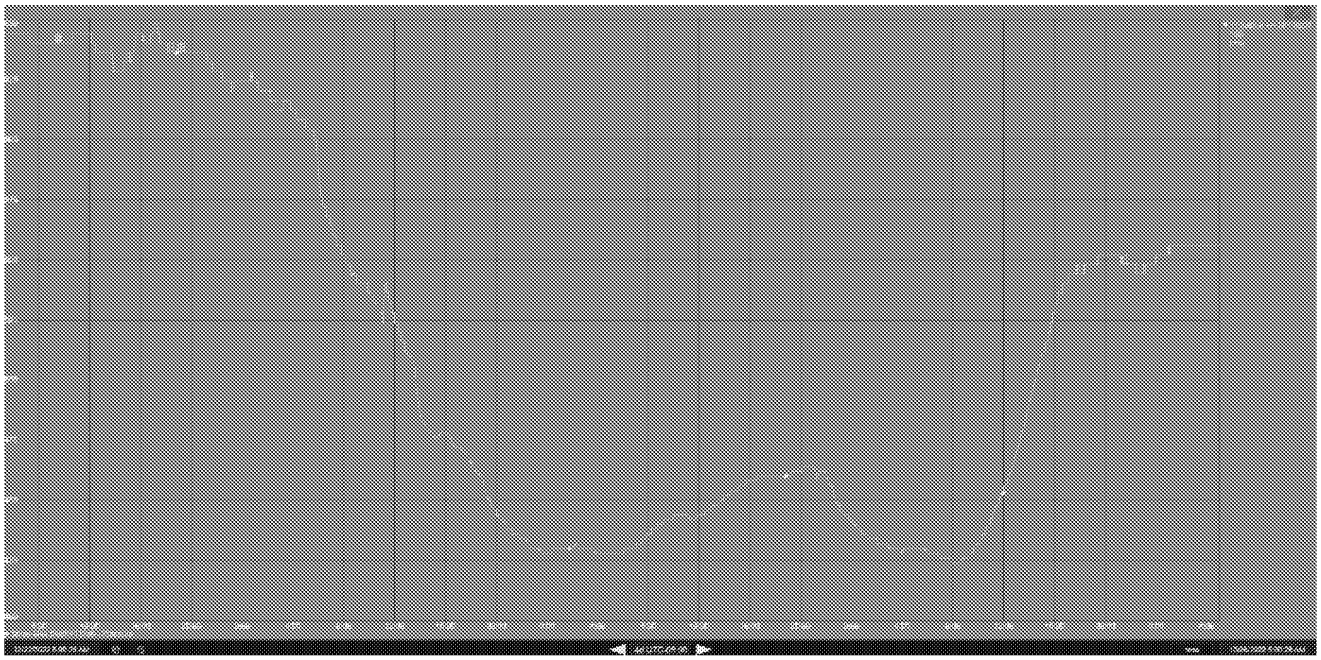
Restricted

Supplied Gas Pressure from Texas Gas on 12/22/22 at 08:00 through 12/26 at 04:00

Cane Run (Low pressure persisted until 12/25/2022 at approximately 13:00)

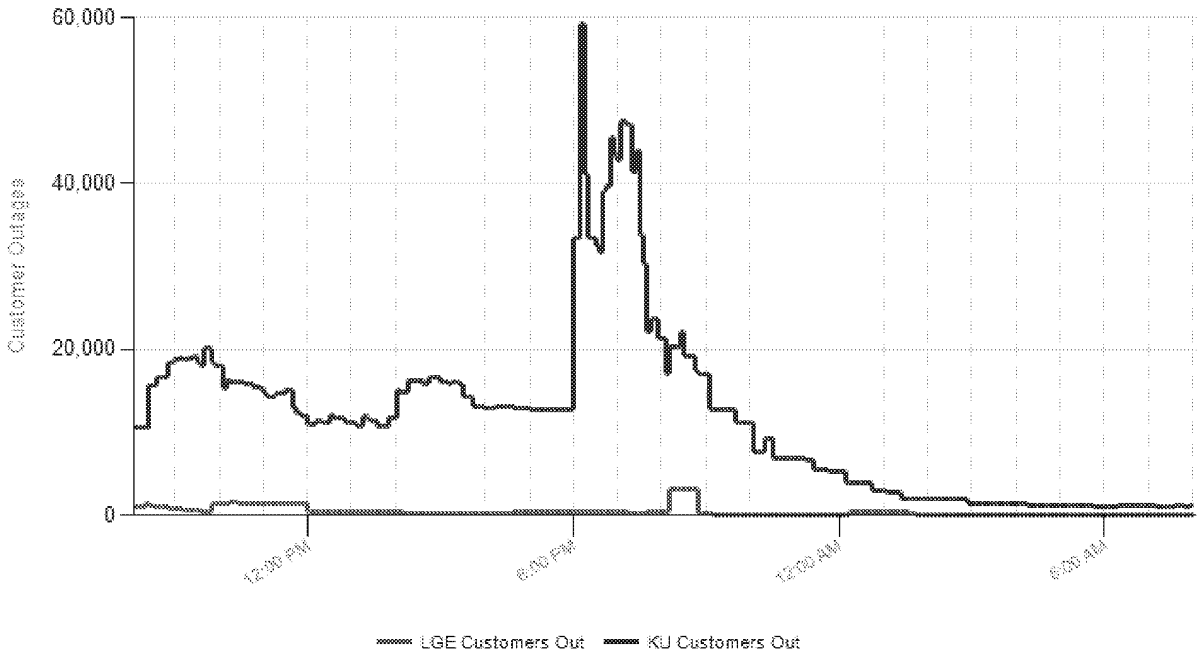


Trimble County (Low pressure persisted until 12/25/2022 at approximately 16:00)



Appendix B:

Customer Outages by Utility for 12/23-24/22



Restricted