Attachment I

LGE-GIS-2019-029 GI Provisional
System Impact Study

LGE-GIS-2019-029
Provisional Request
System Impact Study Report

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1. Introduction

TranServ International, Inc. (TranServ), as an Independent Transmission Organization (ITO) of Louisville Gas & Electric/Kentucky Utilities (LG&E and KU), has received the following Provisional Generation Interconnection (GI) Request to provide a Network Resource Interconnection Service (NRIS) and Energy Resource Interconnection Service (ERIS) to the LG&E and KU Transmission Network. TranServ has evaluated the Provisional GI Request listed in Table 1-1. This report contains the System Impact Study (SIS) results for Provisional GI Request LGE-GIS-2019-029.

Table 1-1
Request Details

Queue Position	Queue Date	County	State	Max Output (MW)	Point of Inter-connection	In-Service Date	Inter-connection Service Type	Generator Type
LGE-GIS-2019-029	11/08/2019	Hardin County	KY	100	Black Branch-Hardinsburg 138kV	12/31/2021	NRIS/ERIS	Solar

As shown in Table 1-1, the Provisional LGE-GIS-2019-029 request seeks to provisionally interconnect a generator by tapping the Black Branch to Hardinsburg 138 kV line. The in-service date of the LGE-GIS-2019-029 request is December 31, 2021. A one-line diagram of the proposed interconnection is given in Appendix A. This SIS analyzed the impact of this addition, located in Hardin County, Kentucky, in accordance with the LG&E and KU Generator Interconnection Study Criteria and LG&E and KU Planning Guidelines. Both of these documents are posted on the LG&E and KU OASIS.

An Ad Hoc Study Group was involved in the study process.

The Provisional GI request, LGE-GIS-2019-029, is an NRIS and an ERIS request and thus was studied as sourcing from the new generation connecting to the Black Branch to Hardinsburg 138kV line and then sinking into the LG&E and KU system in merit order (NRIS) or beyond the LG&E and KU Balancing Authority (BA) equally in 4 directions (North, South, East, and West) (ERIS). The simulations performed considered steady-state contingencies in Categories P0, P1, P2 EHV, P3, and P4 EHV and stability disturbances in Categories P0, P1, P2, P3, P4, P5 and P7 of the current effective versions of North American Electric Reliability Corporation (NERC) TPL-004 standards and the LG&E and KU Planning Guidelines.

Only the year 2022 was studied for this Provisional request. The subject request was evaluated using a 2022 Summer Peak and 2022 Off Peak steady state power flow model with roots in the LG&E and KU 2020 Transmission Expansion Plan (TEP) Base Case Study (BCS) models, 2020 Summer, 2020 Summer Max and 2023 Light Load Stability models with roots in LG&E and KU's 2019 TEP Stability Models and a short circuit model with roots in LG&E and KU's 2019 TEP Short Circuit Models all of which include the 2019 TEP approved projects.

This study included the effect of all earlier queued LG&E and KU GI requests. This study also included the effect of all confirmed Transmission Service Requests (TSRs). There are no planned transmission improvements associated with any earlier queued LG&E and KU GI request. Thus no study to determine whether or not those facilities would be contingent facilities for this request was performed. Representation of the confirmed TSRs may have necessitated representation of associated planned transmission improvements. Thus, it is important to realize that if the planned improvements do not come to fruition, the subject request's impact on the transmission system as identified by this study may become invalid and a revised study may become necessary before GI service can be granted.

2. Description of Request

The request seeks to interconnect a 100 MW solar generator by connecting to Black Branch to Hardinsburg 138 kV line and then sink into the LG&E and KU system in merit order or sink as an energy resource. The request indicates that the generating plant will provide at the Point of Interconnection (POI) 100 MW. The solar plant was modeled at 0.954 Power Factor (PF) at the GI-2019-029 Generator in both the steady-state and stability analyses.

In order to obtain 100 MW injection at the POI, the study determined that the gross generation at the plant inverter bus would need to be 101.3 MW. The solar plant gross generation of 101.3 MW was modeled for this SIS. The data provided by the customer supports the 101.3 MW gross generation level.

The study determined that the inverters' 0.954 PF capability did not meet the +/- 0.95 power factor at the high side of the customer main transformer requirement. The study found that the customer would also need to provide a 14 MVAR capacitor at the collector bus to meet the at least +/- 0.95 power factor at the high side of the customer main transformer requirement. The 14 MVAR capacitor was included in the study models.

If the LGE-GIS-2019-029 request is granted, the new generation will have interconnection rights for 100 MW net output at the POI. The in-service date of the LGE-GIS-2019-029 request is December 31, 2021.

3. Study Criteria, Methodology, and Assumptions

3.1 Ad Hoc Study Group

An Ad Hoc Study Group was formed in accordance with the LG&E and KU GI Study Criteria document posted on the LG&E and KU OASIS. TranServ performed studies for this GI request and submitted a report for review to the Ad Hoc Study Group. Participation in the Ad Hoc Study Group was by invitation to all first tier Transmission Providers (TPs) and/or Transmission Owners (TOs) of LG&E and KU, i.e., MISO, PJM, Tennessee Valley Authority (TVA), TVA (RC), BREC, OMU, DUKE, VECTREN, AEP, OVEC, East Kentucky Power Cooperative (EKPC), and EEI/Department of Energy (DOE). Invitees whom indicated their interest in participating in the Ad Hoc Study Group by the date specified in the invitation and have a Critical Energy Infrastructure Information Non-Disclosure Agreement (CEII NDA) with LG&E and KU were allowed to participate in the Ad Hoc Study Group.

The purpose of forming an Ad Hoc Study Group and involving the other TOs is to meet the tariff requirement for third party coordination, to ensure that the study assumptions are valid and generally accepted; the study models are accurate; the study procedures are generally acceptable; and lastly, the impacts of the subject request on the transmission system have been appropriately addressed. This approach of forming an Ad Hoc Study Group is undertaken to gain regional acceptance of the study results.

TranServ managed the participation in the Ad Hoc Study Group so that the study could be completed in a timely manner. TranServ expected the Ad Hoc Study Group to respond to data and review requests as promptly as possible but certainly within five business days.

The Ad Hoc Group was requested to review and provide input to the following:

- Study Scope.
- Steady-state models, contingency files, and monitored element files (including flowgates)
- Stability models and disturbances.
- Study Report

The LG&E and KU GI study criteria outlines three paths upon which it can be determined that an affected system study is required for an LG&E and KU GI request. Two of these paths require that the ITO identify a potential for an affected system study within an ITO analysis using ITO models as detailed in Section 3.2. The third path is for an Ad Hoc Study Group member to perform their own test.

Table 3-1 documents the Ad Hoc Study Group Comments which relate to independent testing performed by the Ad Hoc Study Group members consistent with the allowance for such testing in the LG&E and KU GI Criteria document.

Table 3-1
Ad Hoc Study Group Independent Study Comments

Ad Hoc Group Member	Date Received	Ad Hoc Group Member Comment provided within the June 13, 2020 Deadline
PJM	05/28/2020	PJM plans to also study this project when the traditional SIS study commences.
EKPC	05/28/2020	EKPC does not see the need to perform an affected system study at this point. EKPC will wait to see if the project moves forward to a "traditional" SIS.
MISO	06/09/2020	MISO performed a Screening Analysis for LGE-2019-029 and found that this project meets MISO's Screening Criteria. MISO identifies itself as an affected party with LGE for this project and will perform a MISO AFS; however, MISO is not planning to perform an AFS as part of this Provisional Interconnection request. MISO will perform a study for this project when the regular System Impact Study is performed.
BREC	05/28/2020	BREC will not be performing an affected system study for the provisional request. MISO will be providing their feedback by June 12th. As in the past, we will likely follow their suggestion.
No other Ad Hoc Member chose to provide independent testing results for this request by the June 13, 2020 deadline.		

Regarding GI-2019-029, MISO has performed a preliminary screening and found that this project meets MISO's Screening Criteria requiring a study. However, as this is a provisional interconnection service request they have declined to perform an affected systems study at this time and indicated that MISO will perform an affected system study during the regular SIS. PJM has also declined to perform an affected systems study at this time without indicating whether the project would otherwise trigger screening criteria if the interconnection service request was not provisional. PJM has indicated that they will decide whether or not a study is required during the regular SIS.

Customer is solely responsible for any projects that may be identified in future affected systems studies during the SIS for GI-2019-029.

3.1 Affected System Analysis Methodology

As indicated above, the LG&E and KU GI study criteria outlines three paths upon which it can be determined that an affected system study may be required for an LG&E and KU GI request. Two

of these paths require that the ITO identify a potential for an affected system study within an ITO analysis using ITO models.

The first ITO determined path has two components.

- If the Point of Interconnection on the LG&E/KU Transmission System is within two buses of a neighboring system in the power flow model, the neighboring system is considered an Affected System.
- The second component involves an ITO affected system analysis using ITO models. For this component the ITO developed a neighboring system contingency list based on model branch sections using a 5% or greater PTDF on all neighboring BES facilities. The ITO then removed the neighboring system contingencies from the study P1 contingency file and added the newly developed neighboring system contingency list to create an Affected System contingency file. Using the Affected System contingency file, neighboring TOs were identified if any as an Affected System if that system's post contingent transmission facility was loaded at more than 100% of the rate B in the ITO PSS/E models with a 20% or greater DF due to the study request.

The results of the first ITO determined path to a Potential Affected System Study are given in Table 3-2 and 3-3.

Table 3-2
First ITO Determined path to Affected System Study Results (POI)

Neighboring System Buses within Two Buses of the POI			Bus Owner Response
Bus Owner	**Bus Name**	**Bus Number**	
BREC (MISO member)	4N.HARD	340615	BREC will not be performing an affected system study for the provisional request. MISO will be providing their feedback by June 12th. As in the past, we will likely follow their suggestion.
EKPC (PJM member)	4CENT HARDIN	324568	EKPC does not see the need to perform an affected system study at this point. EKPC will wait to see if the project moves forward to a "traditional" SIS..

As indicated in Table 3-2, BREC indicated that MISO would determine if an affected system study was needed.

Table 3-3
First ITO Determined path to Affected System Study Results (Analysis)

Facility	Owner	Rating	Pre GI-2019-029 Flow		Post GI-2019-029 Flow		DF	Contingency
			MVA	%	MVA	%		
None	All	NA	NA	NA	NA	NA	NA	None

The second ITO determined path to identify the potential need for an affected system study is through the ITO SIS steady state, stability and short circuit analyses. The results of these analyses are provided in Sections 4, 5 and 6 of this report respectfully.

In order for the ITO to perform the stability analysis, neighboring systems were given the opportunity to provide to the ITO the following within five business days after notification that the subject GI study scope was available:

- A list of faults to be analyzed including fault type (single to ground or three-phase), fault location, appropriate clearing times, switching sequence
- Potentially affected system's damping criteria
- Potentially affected system's channel files to be monitored;
- Potentially affected system's transient analysis voltage criteria and any other stability analysis criteria in addition to performance requirements of TPL-001-4

During the ITO's performance of the stability analysis, a neighboring TO would have been identified as a potentially affected system if constraints such as damping, transient voltage, or TPL-001-4 issues were identified on the neighbor's system. The ITO would have notified the neighboring TO through the Ad Hoc Process that they could be a potentially affected system.
The potentially affected system could then have required an affected system study to be performed that was entirely separate from the LG&E/KU SIS performed by the ITO. The ITO identified constraint on the potentially affected system would have been documented in the SIS report. The GIA would be contingent on mitigating the affected system constraints.

3.2 Computer Programs Used

The thermal and voltage analyses were performed using Siemens Power Technologies, Inc.'s (PTI's) Power System Simulator for Engineering (PSS/E®) Version 33 computer powerflow program and evaluation software. In addition, other programs were used to assist the engineers with processing and evaluating the system contingencies and special generation dispatch scenarios.

Power system analyses, utilizing PSS/E®, and ASPEN, were performed to determine whether the subject request's impact on the existing transmission system is within applicable limits in accordance with the study procedure as defined in the GI Study Criteria. The network analyses were used to predict both near-term and out-year monitored element performance. PSS/E® activity Alternative Current Contingency Calculation (ACCC) was used to determine system thermal and voltage performance with and without the subject request. Automated software consistent with the LG&E and KU planning process was used to run the ACCC activity for numerous dispatch scenarios. Dynamic simulations performed with PSS/E® software were used to determine the impact of the subject request on power system dynamic stability. A short circuit analysis utilizing ASPEN was performed to determine the subject request's impact on breaker duty levels.

3.3 Study Procedures

Power system analyses were performed to determine whether the subject request's impact on the transmission system is within applicable limits in accordance with the study procedure as defined in the LG&E and KU GI Study Criteria document. The network analyses results were used to predict monitored element performance. To facilitate the analysis, the 2022 Summer Peak and 2022 Off Peak were used.

This request was evaluated by comparing the equipment loading levels, voltage levels, and breaker duty levels of a Pre-LGE-GIS-2019-029 model to the equipment loading levels, voltage levels, and breaker duty levels of a Post-LGE-GIS-2019-029 model. Numerous dispatch scenarios were evaluated to determine system thermal and voltage performance with and without the subject request. The dispatch scenarios were analyzed in accordance with the LG&E and KU GI Study Criteria and Planning Guidelines.

3.4 Monitored Elements and Study Area

All study area elements as defined in Table 3-4 were monitored for the thermal and voltage analyses. GSUs were not monitored.

Table 3-4
Study Area

Owner	Area	Contingencies			Monitored Elements P1 and P3		Monitored Element P2 and P4	
		Explicitly Included	Broad All Singles/Ties Commands					
			kV min	kV max	kV min	kV max	kV min	kV max
EKPC	320	As submitted by EKPC to LG&E and KU for TEP	69	500	69	800	100	800
BREC	314	As submitted by MISO to LG&E and KU for TEP			100	800	100	800
OVEC	206	As Submitted by PJM to LG&E and KU for TEP	69	500	100	800	100	800
DEI	208	As submitted by MISO to LG&E and KU for TEP			100	800	100	800
LG&E and KU	363	As determined by LG&E and KU for use in TEP	69	500	69	800	100	800
OMU	364	As determined by LG&E and KU for use in TEP	69	500	69	800	100	800
TVA	347	As submitted by TVA to LG&E and KU for TEP			100	800	100	800
HE	207	As submitted by MISO to LG&E and KU for TEP			100	800	100	800
SIGE	210	As submitted by MISO to LG&E and KU for TEP			100	800	100	800
IPL	216	As submitted by MISO to LG&E and KU for TEP			100	800	100	800
NIPS	217	As submitted by MISO to LG&E and KU for TEP			100	800	100	800
AEP	205	As Submitted by PJM to LG&E and KU for TEP			100	800	100	800
DEO&	212	As Submitted by PJM to LG&E and KU for TEP			100	800	100	800

3.5 Contingencies Considered

The simulations performed considered contingencies in Categories P0, P1, P2 (300 kV and above), P3, and P4 (300 kV and above) of the current effective versions of NERC TPL-001-4 standard and the LG&E and KU Transmission System Planning Guidelines. The same contingencies were analyzed for the Pre-GIS-2019-029 models and the Post-GIS-2019-029 models, to the extent practical.

For NERC Category P0, the system is intact (no contingencies). Generators off-line for economic reasons were not considered a contingency. In addition to the NERC Category P1 single element contingencies, multi-element NERC Category P1 through P4 contingencies were analyzed as directed by the Ad Hoc Study Group. Category P1 single contingencies included multi-element single contingencies, in the study area, initiated by a fault with normal clearing such as multi-terminal lines to the extent the Ad Hoc Study Group requested such contingencies and provided the necessary information.

Only the following Category P3 contingencies as identified in the LG&E and KU Transmission System Planning Guidelines were considered:

- An outage of one generator followed by another generator.
- An outage of one generator followed by one transmission circuit.
- An outage of one generator followed by one transmission transformer.

TranServ simulated the selected Category P3 contingencies as listed above when requested to do so by the Ad Hoc Study Group. For generation outages, the replacement generation required to offset the outage was simulated from the most restrictive of internal sources or a combination of internal sources and select external sources.

3.6 Dispatch Scenarios Considered

Several generation dispatch scenarios were evaluated. Appendix B shows the generation dispatch codes and the generation changes for each dispatch scenario. Each single dispatch was analyzed in combination with each study area contingency. Double dispatches were analyzed as one generator outage followed by another generator outage only.

3.7 Powerflow Model Development Details

3.7.1 Pre LGE-GIS-2019-029 Model Development

The following Pre GI models were developed for this study:

- 2022 Summer Peak Pre GI 2019-029 NRIS Model
- 2022 Summer Peak Pre GI 2019-029 ERIS Model
- 2022 Off Peak Pre GI 2019-029 NRIS Model
- 2022 Off Peak Pre GI 2019-029 ERIS Model

The Pre GI LGE-2019-029 models were created from the LG&E and KU 2020 Transmission Expansion Plan (TEP) BCS models which were provided to the ITO on June 13, 2019. The June 13, 2019 LG&E and KU 2020 TEP BCS models were named 2019 BCS r20190610 by LG&E and KU and are referred to as the 2020 TEP BCS models throughout the remainder of this document. These models reflect the LSEs' August 2018 MOD-032 Load Forecast submittal. These models also reflect LG&E and KU's 2019 TEP Attachment 2 projects with the exception of the projects which the TO indicated had been modified. These projects are listed in Table 3-5. The Table 3-5 modifications are included in the 2020 TEP BCS models.

Table 3-5
2019 TEP Modified Projects in 2020 TEP BCS Models

Project Number	Description	Modification
406	Install a 69 kV, 9 MVAR capacitor bank at Paint Lick.	This project has been replaced with Project 1126: Install a 69kV, 36.0 MVAR capacitor bank at Richmond Industrial.
590	Increase the MOT of the 3/0 6X1 ACSR conductor in the Skylight to Harmony Landing 69 kV line to 212 deg. F.	This project has been replaced with a Lines maintenance project to reconductor the Skylight to Harmony Landing 69 kV
623	Increase the maximum operating temperature of the 397.5 MCM ACSR conductor on the Finchville to Southville 69kV section of the Finchville to Bonds Mill 69kV line to at least 160°F	Operate the Finchville to Southville 69 kV line normally opened
631	Increase the maximum operating temperature of the 397.5 MCM ACSR conductor on the Southville to Bonds Mill 69kV section of the Finchville to Bonds Mill 69kV line to at least 150°F.	Operate the Finchville to Southville 69 kV line normally opened
845	Replace 2.86 miles of 266.8 MCM 26X7 ACSR conductor in the Adams - Delaplain Tap section of the Adams - Oxford 69 kV line. Use 397.5 MCM 26X7 ACSR or better.	This project has been replaced with Project 1125: Convert the Rogers Gap 69 kV distribution station to a 138 kV station by tapping the existing Scott Co-Toyota North 138 kV line, adding 138 kV terminal equipment and replacing the distribution transformers.

Subsequently LKE has provided and the ITO has approved changes to the 2019 TEP Projects as detailed in Table 3-5A. These approved changes to 2019 TEP projects will be included in the GI-2019-029 Models as shown in Table 3-5A.

Table 3-5A
Approved changes to 2019 TEP projects to be modeled the GI-2019-029 Models

2019 TEP Approved Project		Recently Approved Project Change		
Project #	**DESCRIPTION**	**Project #**	**DESCRIPTION**	**ETI**
981	Install a 69 kV, 33.6 MVAR capacitor bank at Lemons Mill	NA	Install a 69 kV, 36.0 MVAR capacitor bank at Hoover	ASAP
406	Install a 69 kV, 9 MVAR capacitor bank at Paint Lick	406	Install a 69 kV, 9 MVAR capacitor bank at Paint Lick	ASAP
507	Install a 69 kV, 14.4 MVAR capacitor bank at Middlesboro #780	507	Install a 69 kV, 14.4 MVAR capacitor bank at Middlesboro #780	ASAP
990	Install a 16.8 MVAR capacitor bank at Taylorsville KU 69 kV.	1134	Install a 42 MVAR capacitor bank at Bardstown 69 kV	11/30/2020

As shown in Table 3-6, some rating updates were applied to the Pre GI-2019-029 models.

Table 3-6
Rating updates which were applied to all GI-2019-029 Models

From Bus Name	From Bus Number	To Bus Name	To Bus Number	Circuit ID	Season	Updated Rate A	2019 TEP BCS Rate A	Updated Rate B	2019 TEP BCS Rate B
2FARLEY KU 69.000	324527	2LIBERCH T 69.000	341755	1	Off-Peak	77	66	85	76
2FARLEY KU 69.001	324527	2LIBERCH T 69.000	341755	1	Summer	63	66	74	76
2FARLEY KU 69.002	324527	2LIBERCH T 69.000	341755	1	Winter	86	88	92	94
4AMERICAN AV138.00	324203	2AMERICAN AV69.000	324409	1	Off-Peak	143	160	184	184
4AMERICAN AV138.00	324203	2AMERICAN	324409	1	Winter	143	186	193	186

From Bus Name	From Bus Number	To Bus Name	To Bus Number	Circuit ID	Season	Updated Rate A	2019 TEP BCS Rate A	Updated Rate B	2019 TEP BCS Rate B
		AV69.002							
05WOOTON 161.00	243668	5HYDEN 161.00	324148	1	Off Peak	300	300	405	418
05WOOTON 161.00	243668	5HYDEN 161.00	324148	1	Summer	300	300	405	418
05WOOTON 161.00	243668	5HYDEN 161.00	324148	1	Winter	379	379	405	418
05MOREHE 69.000	243740	2RODBURN 69.000	324707	Z1	Off Peak	68	69	83	90
05MOREHE 69.000	243740	2RODBURN 69.000	324707	Z1	Summer	68	69	83	90
05MOREHE 69.000	243740	2RODBURN 69.000	324707	Z1	Winter	90	92	100	106

The 2020 TEP BCS Model series includes 2021 models but not 2022 models. The 2022 Off Peak and Summer Peak GI 2019-029 Models were derived from the 2021 Off Peak and Summer Peak 2020 TEP BCS Models. The 2020 TEP BCS 2021 Models were modified to include 2022 loads and the Table 3-7 projects, all of which are expected to be placed in-service between February 2021 and May 2022.

Table 3-7
Projects which were added to the 2020 TEP BCS 2021 Models
To form the 2022 GI-2019-029 Models

Project Number	2019 TEP Description	Estimated Timetable for Implementation	Included	
			2022S	2022OP
178	Install a second 138/69 kV, 185 MVA transformer at Hardin County.	01/01/2022	X	X
952	Install a second West Lexington 450 MVA, 345/138 kV transformer and necessary 345 kV breakers to create a 345 kV ring bus configured such that the two transformers do not share a single breaker. Reconfigure the Brown N to West Lexington and Ghent to W Lexington 345 kV lines as necessary.	01/01/2022	X	X
958	Construct Elizabethtown - Hardin Co 69 kV #2 using 1272 MCM ACSR 26X7 conductor.	01/01/2022	X	X
976	Rebuild the existing double 69 kV circuits from KY Dam to South Paducah, on the existing structures. Resulting configuration will be a single 69 kV circuit, using 397.5 MCM 26X7 ACSR or better conductor.	01/01/2022	X	X
200	Increase the MOT of the 636 MCM 24X7 ACSR conductor (0.66 mi. at unverified 176°F) to minimum 190°F, and the 795 61X AA conductor (1.67 mi. at unverified 165°F) to a minimum 176°F, in the Oxmoor to Breckenridge 69 kV line (6653).	01/01/2022	X	X
325	Increase the MOT of the 266.8 MCM ACSR in the Elizabethtown - Elizabethtown #2 Tap section (2.24 mi. 176F), in the Elizabethtown - Rogersville 69 kV line, to 212F.	01/01/2022	X	X
796	Replace 5.19 miles of 795 MCM 26X7 ACSR conductor in the West Lexington-Viley Road section of the West Lexington - Viley Road - Haefling 138 kV line, using high-temperature conductor capable of at least 1500 A.	01/01/2022	X	X
875	Increase the MOT of the 795 MCM 26X7 ACSR to 176°F in the Nelson County to Elizabethtown 138 kV line.	01/01/2022	X	X
902	Increase the MOT of the 397.5 MCM 26X7 ACSR conductor (6.28 mi.) in the Marion - Mexico section of the Princeton - Crittenden County 69 kV line, to a minimum of 140F.	01/01/2022	X	X
847	Install a 13.5 MVAR, 69 kV capacitor bank at or near the delivery point for EKPC's West Mount Washington load on the Bullitt County 69 kV loop south of Louisville.	05/30/2022	X	
1000	Increase the MOT of the 266.8 26X7 ACSR (6.98 mi.) in the Brush Creek to KU Park 69 kV line, to a minimum of 155°F.	05/30/2022	X	

As appropriate, all long-term firm network TSRs which were confirmed at the time of the 2020 TEP SPM build were included in the 2020 TEP BCS power flow models. Additional TSRs have been confirmed and those TSRs were included in the GI-2019-029 models. The TSRs which were added to the 2020 TEP BCS models to create the Pre GI LGE-2019-029 models are listed in Table 3-9.

Table 3-9
Confirmed TSRs added to the 2020 TEP BCS Models to form the Pre GI-2019-029 Models

NITS on OASIS Number	SIS	MW	Type
87066029	2018-002	7	MODIFY NITS LOAD
87184882	2018-003	-239	Terminate NITS DNR
87184883	2018-003	175	ADD NITS DNR
87518537	2018-005	3	ADD NITS DNR
87583219	2018-006	17	MODIFY NITS LOAD
87583232	2018-006	17	MODIFY NITS LOAD
87583242	2018-006	17	MODIFY NITS LOAD
87635911	2018-007	54	ADD NITS DNR
87723703	2018-008	32	ADD NITS DNR
87734272	2018-009	195	MODIFY NITS LOAD
88124771	2018-010	20	MODIFY NITS LOAD
88124774	2018-010	22	MODIFY NITS LOAD
88526896	2019-001	75	ADD NITS DNR
88624138	No study	-107	Terminate NITS DNR
88624165	No study	-168	Terminate NITS DNR
88761551	2019-003	12	ADD NITS LOAD
88965179	2019-004	7.5	ADD NITS DNR
89014834	2019-006	4	MODIFY NITS LOAD
89014927	2019-006	6	MODIFY NITS LOAD
89475755	2019-007	28	ADD NITS LOAD
90030484	2019-009	-13	Terminate NITS DNR
90030485	2019-009	13	ADD NITS DNR
90089795	2019-010	11	MODIFY NITS LOAD
90089812	2019-010	11	MODIFY NITS LOAD
90089821	2019-010	-11	MODIFY NITS LOAD
90089823	2019-010	-11	MODIFY NITS LOAD
90221160	2019-011	15	MODIFY NITS LOAD
90401751	2019-012	17	MODIFY NITS LOAD

Since this is a provisional request, this study is a near term only study with a restudy requirement. This study covered the present time frame as provided below.

1. Present Time Frame:
    - The in-service date of the GI-2019-029 request is 12/31/2021.
    - The timeframe of this Provisional SIS covered the period from 12/31/2021 to 12/31/2022.

If any study assumptions change a restudy may be required. Subsequent studies will be performed on a regular basis. The first such study will cover 12/31/2022 to 12/31/2023. Ultimately a SIS will be performed which is not provisional.

All LG&E and KU prior queued generators with completed SISs which are expected to be in-service by 2022 will be included in the Pre GI-2019-029 power flow models with the exception of LGE-GIS-2017-002 and LGE-GIS-2019-003. The LGE-GIS-2017-002 and LGE-GIS-2019-003 requests won't be included in the Pre GI-2019-029 power flow models due to the in-service date of these requests occurring in the 2022 winter season. The modeling of the LG&E and KU prior queued generators to be added to the 2020 TEP BCS models to form the Pre GI-2019-029 models is shown in Table 3-10.

Table 3-10
Prior Queued generators added to the 2020 TEP BCS models to form the Pre GI-2019-029 Models

Queue Position	Queue Date	County	State	Max Output (MW) S/W	Point of Inter-connection	In-Service Date	Inter-connection Service Type	Inclusion in Model
LGE-GIS-2017-002	03/01/2017	Lyon	KY	86/86	North Princeton-Livingston County 161 kV	12/01/2022	NRIS	Not included in Steady-State due to in-service date
LGE-GIS-2017-003	04/27/2017	Harrison	KY	35/35	Cynthiana EK Tap - Millersburg 69 kV	06/01/2019	NRIS/ERIS	Included
LGE-GIS-2017-006	08/04/2017	Muhlenberg	KY	100/100	Green River 138 kV substation	08/31/2019	NRIS/ERIS	Included
LGE-GIS-2019-001	01/15/2019	Washington	KY	110/110	Lebanon-Danville Tap 138 kV Line	12/01/2021	NRIS/ERIS	Included
LGE-GIS-2019-002	02/06/2019	Ballard	KY	104/104	Grahamville-Wickliffe 161 kV Line	06/01/2022	NRIS/ERIS	Included
LGE-GIS-2019-003	02/07/2019	Meade	KY	121/121	Cloverport-Tip Top 138 kV Line	12/01/2022	NRIS/ERIS	Not included in Steady-State due to in-service date
LGE-GIS-2019-004	02/07/2019	Breckinridge	KY	200/200	Hardinsburg 138 kV Substation	12/01/2022	NRIS/ERIS	Excluded due to SIS not Completed.
LGE-GIS-2019-005	03/13/2019	Webster	KY	80/80	Green River – Corydon Tap 161 kV line	12/31/2021	NRIS/ERIS	Excluded due to SIS not Completed.
LGE-GIS-2019-008	03/22/2019	Caldwell	KY	100	North Princeton 161 kV Substation	12/31/2021	NRIS/ERIS	Excluded due to SIS not Completed.
LGE-GIS-2019-015	03/22/2019	Grayson	KY	100	Ohio County to Shrewsbury 138 kV	12/31/2021	NRIS/ERIS	Excluded due to SIS not Completed.

Queue Position	Queue Date	County	State	Max Output (MW) S/W	Point of Inter-connection	In-Service Date	Inter-connection Service Type	Inclusion in Model
LGE-GIS-2019-020	03/22/2019	Hopkins	KY	100	Corydon Tap to Green River 161 kV	12/31/2021	NRIS/ERIS	Excluded due to SIS not Completed.
LGE-GIS-2019-022	03/29/2019	Fayette	KY	75	Adams – Innovation Tap 138 kV line	12/15/2021	NRIS/ERIS	Excluded due to SIS not Completed.
LGE-GIS-2019-023	03/29/2019	Lyon	KY	150	Livingston Co. - North Princeton 161 kV line	12/15/2021	NRIS/ERIS	Excluded due to SIS not Completed.
LGE-GIS-2019-025	05/02/2019	Mercer	KY	98.42	Bardstown-Brown CT 138 kV Line	12/01/2022	NRIS/ERIS	Excluded due to SIS not Completed.
LGE-GIS-2019-027	08/30/2019	Scott	KY	200	Adams-Scott County 138kV	12/31/2022	NRIS/ERIS	Excluded due to SIS not Completed.
LGE-GIS-2019-028	08/30/2019	Caldwell	KY	150	North Princeton 161kV Substation	12/31/2022	NRIS/ERIS	Excluded due to SIS not Completed.

As per the LG&E and KU Generation Interconnection Study Criteria document, no winter models were studied and all exclusively solar generation within Area 363, except the request under study, was modeled at 80% in the summer models.

Non-Solar Generation in the vicinity of the Point of Interconnection (POI) of the subject request was maximized in the Pre GI 2019-029 models to the extent possible within the area in which they are connected. The specific generators that were maximized are given in Table 3-11.

Table 3-11
Modeling of Prior Queued Generation in the vicinity of the
POI of the Subject Request in the 2020 TEP BCS Summer and Off-peak Models

Bus Number	Bus Name	Id	Area	2022S Pgen	2022S Pmax	2022OP Pgen	2022OP Pmax
324024	1MILL CRK 1 22.000	1	LGEE	327	327	327	327
324025	1MILL CRK 2 22.000	2	LGEE	331	331	269	331
324026	1MILL CRK 3 22.000	3	LGEE	422	422	429	429
324027	1MILL CRK 4 22.000	4	LGEE	514	514	514	514
325093	1CANERUN7CT118.000	71	LGEE	204	204	235	235
325094	1CANERUN7CT218.000	72	LGEE	204	204	235	235
325095	1CANERUN7ST 18.000	7S	LGEE	231	231	235	235
253625	10CAN_G1 6.9000	1	SIGE	18	30	18	30
253626	10CAN_G2 6.9000	2	SIGE	18	30	18	30
253627	10CAN_G3 6.9000	3	SIGE	18	30	18	30

3.7.2 Post LGE-GIS-2019-029 Model Development

The following Post LGE-GIS-2019-029 models were developed for this study:

- 2022 Summer Peak Post GI 2019-029 NRIS Model
- 2022 Summer Peak Post GI 2019-029 ERIS Model
- 2022 Off Peak Post GI 2019-029 NRIS Model
- 2022 Off Peak Post GI 2019-029 ERIS Model

The Post GI-2019-029 NRIS Models were modified to include the GI-2019-029 Solar generation, sinking into the LG&E and KU generation fleet in merit order to form the Post GI-2019-029 NRIS Models. The Pre GI-2019-029 ERIS Models were modified to include the GI- GI-2019-029 Solar generation, sinking based on scaling the generation of the local Balancing Authorities to the north, south, east, and west of the LG&E and KU control area each by 25% of the request to form the Post GI-2019-029 ERIS Models.

Before the start of the study, the preliminary Pre and Post LGE GIS-2019-029 models were sent to the Ad Hoc Study Group for review. The models were updated to incorporate any modeling adjustments indicated by the Ad Hoc Study Group as appropriate.

3.8 Network Analysis Criteria

A Network Analysis was performed to determine the impact of the subject request on all Study Area system intact and post-contingent branch loadings and bus voltages. This analysis was performed in accordance with criteria and methodology given in the LG&E and KU GI Study Criteria and the LG&E and KU Planning Guidelines. The Study Area is defined in Section 3.4 of this report. If provided by the Ad Hoc Study Group, criteria specific to a facility owner was used to evaluate facilities not owned by LG&E and KU. If no criteria information was provided by the Ad Hoc Study Group for a particular TO, the criteria and methodology given in the LG&E and KU GI Study Criteria was assumed to apply.

3.9 Reliability Margins for LG&E and KU Flowgates

Requests for Capacity Benefit Margin (CBM) set-aside that go beyond the 18 month ATC calculation horizon were accounted for by developing additional generation scenarios that mimic the requesting entities original request which must include the assumed sources of the CBM. No requests for CBM that go beyond the 18 month ATC calculation horizon have been received. So no LKE CBM analysis was performed for this study.

Transmission Reliability Margin (TRM) outside of the 18 month ATC calculation horizon were accounted for by the generation replacement scenarios that include both internal and CRSG partner sources for the replacement generation.

3.10 Flowgate Analysis

A Non-LG&E and KU flowgate analysis was performed to determine if sufficient Available Flowgate Capability (AFC) would exist on regional Non- LG&E and KU flowgates with the addition of the subject request. An impact analysis on Reciprocally Coordinated Flowgates (RCF) was performed to determine if the subject request significantly impacts those posted flowgates in accordance with the LG&E and KU GI Study Criteria posted on the LG&E and KU OASIS.

There are two types of flowgates, Power Transfer Distribution Factor (PTDF) flowgates and Outage Transfer Distribution Factor (OTDF) flowgates. A PTDF flowgate monitors a system intact condition and an OTDF flowgate monitors a contingency condition. If the loading on any Non-LG&E and KU flowgates exceed the PTDF and OTDF thresholds of 5% and 20% respectively and the flowgate ratings the results will be listed in the report and provided to the flowgate owner to determine if they are constraints to granting the request.

4. Powerflow Analysis Results

4.1 Contingency Analysis

Contingency analyses were performed using models, criteria, and methodology described in Section 3. The incremental impact of the LGE-GIS-2019-029 request was evaluated by comparing flows and voltages with and without the requested interconnection. Analyses were performed using Siemen's PSS/E® and programs to assist engineers with processing and evaluating the system contingencies and special generation dispatch scenarios.

It is also important to note that not all contingencies considered resulted in a convergent powerflow solution. Most initially divergent contingencies converged when other solution techniques some of which included locking switched shunts were applied. If potential constraints were identified through a shunts locked solution, further analysis was performed to obtain a powerflow solution with shunts enabled. Only the results obtained through a shunts enabled powerflow solution were considered as valid results. The contingencies that were divergent in both the initial shunts enabled and shunt locked solution attempts were solved using other solution techniques. Appendix C lists those solution techniques which required model modifications.

4.1.1 2022 Summer Peak Analysis

No 2022 Winter Peak, system intact or contingency, thermal or voltage constraints due to the subject request were found.

4.1.2 2022 Off-Peak Analysis

No 2022 Off-Peak, system intact or contingency, thermal or voltage constraints due to the subject request were found.

4.2 Non-LG&E and KU Flowgate Analysis

As per the LG&E and KU GI Study Criteria document, the flowgate analysis is limited to the NRIS request. Reciprocally coordinated Non-LG&E and KU constrained interface analyses were performed using models, criteria, and methodology described in Section 3. The incremental impact was evaluated by comparing interface MW flows with and without the subject request. No flowgates which have a Distribution Factor (DF) greater than the 20%/5% OTDF/PTDF criteria due to the subject request were found.

A complete listing of all reciprocally coordinated Non-LG&E and KU constrained interface results is given in Appendix D.

4.3 Results Deemed Invalid

No results were deemed invalid after removal of the shutdown generation outages erroneously considered for generation already off-line in the 2022OP NRIS model.

4.4 Conclusion

For all tested contingencies, all monitored elements were found to be within acceptable limits with the addition of the 100.0 MW solar generation at the point of interconnection.

5. Stability Analysis

5.1 Introduction

As defined in the LG&E and KU GI Study Criteria posted on the LG&E and KU OASIS, a stability analysis was performed to evaluate the impact of the new generation on the transient stability of the existing power system under various disturbance conditions. The stability analysis was performed for both near term and out year summer peak, summer generation maximization, and light load system conditions with appropriate earlier queued generators included in the model. The stability models emulated the steady-state modeling as closely as practical and appropriate. The disturbances were defined by TranServ and reviewed by the Ad Hoc Study Group.

5.2 Model Development

5.2.1 Pre GI-2019-029 Stability Models

The following Pre GI-2019-029 stability models were developed for the LG&E and KU GI-2019-029 SIS Stability Analysis:

- 2020 Summer Peak Pre GI 2019-029 Model
- 2020 Maximized Generator Pre GI 2019-029 Model
- 2023 Light Load Pre GI 2019-029 Model

The Pre LGE-GIS-2019-029 models listed above were created from LG&E and KU's 2019 TEP 2020S, 2020S Max and 2023LL stability models. All LGE&KU prior queued generators with completed SISs were added to the 2019 TEP models to form the Pre GI-2019-029 models as shown in Table 5-1.

Table 5-1
Prior Queued generators to be added to the
2019 TEP models to form the Pre GI-2019-030 Stability Models

Queue Position	Queue Date	County	State	Max Output (MW) S/W	Point of Inter-connection	In-Service Date	Inter-connection Service Type	Inclusion in Model
LGE-GIS-2017-002	03/01/2017	Lyon	KY	86/86	North Princeton-Livingston County 161 kV	12/01/2022	NRIS	Included
LGE-GIS-2017-003	04/27/2017	Harrison	KY	35/35	Cynthiana EK Tap - Millersburg 69 kV	06/01/2019	NRIS/ERIS	Included

Queue Position	Queue Date	County	State	Max Output (MW) S/W	Point of Inter-connection	In-Service Date	Inter-connection Service Type	Inclusion in Model
LGE-GIS-2017-006	08/04/2017	Muhlenberg	KY	100/100	Green River 138 kV substation	08/31/2019	NRIS/ERIS	Included*
LGE-GIS-2019-001	01/15/2019	Washington	KY	110/110	Lebanon-Danville Tap 138 kV Line	12/01/2023	NRIS/ERIS	Excluded due to in-service date
LGE-GIS-2019-002	02/06/2019	Ballard	KY	104/104	Grahamville-Wickliffe 161 kV Line	06/01/2023	NRIS/ERIS	Excluded due to in-service date
LGE-GIS-2019-003	02/07/2019	Meade	KY	121/121	Cloverport-Tip Top 138 kV Line	12/01/2022	NRIS/ERIS	Included*
LGE-GIS-2019-004	02/07/2019	Breckinridge	KY	200/200	Hardinsburg 138 kV Substation	12/01/2022	NRIS/ERIS	Excluded due to SIS not Completed
LGE-GIS-2019-005	03/13/2019	Webster	KY	80/80	Green River – Corydon Tap 161 kV line	12/31/2021	NRIS/ERIS	Excluded due to SIS not Completed
LGE-GIS-2019-008	03/22/2019	Caldwell	KY	100	North Princeton 161 kV Substation	12/31/2021	NRIS/ERIS	Excluded due to SIS not Completed
LGE-GIS-2019-015	03/22/2019	Grayson	KY	100	Ohio County to Shrewsbury 138 kV	12/31/2021	NRIS/ERIS	Excluded due to SIS not Completed
LGE-GIS-2019-020	03/22/2019	Hopkins	KY	100	Corydon Tap to Green River 161 kV	12/31/2021	NRIS/ERIS	Excluded due to SIS not Completed
LGE-GIS-2019-022	03/29/2019	Fayette	KY	75	Adams – Innovation Tap 138 kV line	12/15/2021	NRIS/ERIS	Excluded due to SIS not Completed
LGE-GIS-2019-023	03/29/2019	Lyon	KY	150	Livingston Co. - North Princeton 161 kV line	12/15/2021	NRIS/ERIS	Excluded due to SIS not Completed.
LGE-GIS-2019-025	05/02/2019	Mercer	KY	98.42	Bardstown-Brown CT 138 kV Line	12/01/2022	NRIS/ERIS	Excluded due to SIS not Completed.
LGE-GIS-2019-027	08/30/2019	Scott	KY	200	Adams-Scott County 138kV	12/31/2022	NRIS/ERIS	Excluded due to SIS not Completed.

Queue Position	Queue Date	County	State	Max Output (MW) S/W	Point of Inter-connection	In-Service Date	Inter-connection Service Type	Inclusion in Model
LGE-GIS-2019-028	08/30/2019	Caldwell	KY	150	North Princeton 161kV Substation	12/31/2022	NRIS/ERIS	Excluded due to SIS not Completed.
LGE-GIS-2019-029	11/08/2019	Hardin	KY	100	Black Branch-Hardinsburg 138kV	12/31/2021	NRIS/ERIS	GI-SIS-2019-029 and GI-SIS- 2019-030 are mutually exclusive

* If issues were found a sensitivity would have been performed without this request.

The TSR and prior queued GI request modeling was as close to the Steady-State modeling as appropriate. Generation in the vicinity of the Point of Interconnection (POI) of the subject request was maximized in the Pre GI 2019-029 stability models. The specific generators which were maximized are given in Table 5-2.

Table 5-2
Modeling of Pre-Queue Generation in the vicinity of the POI of the Subject Request in the 2019 TEP Stability Models

Bus Number	Bus Name	Id	Area	2020S Pgen	2020S Pmax	2020S Max Pgen	2020S Max Pgen	2023LL Pgen	2023LL Pmax
324024	1MILL CRK 1 22.000	1	LGEE	333	333	343	343	333	333
324025	1MILL CRK 2 22.000	2	LGEE	336	336	341	341	336	336
324026	1MILL CRK 3 22.000	3	LGEE	425	425	445	445	425	425
324027	1MILL CRK 4 22.000	4	LGEE	526	526	541	541	526	526
325093	1CANERUN7CT118.000	71	LGEE	231.5	231.5	230	230	188	231
325094	1CANERUN7CT218.000	72	LGEE	231.5	231.5	230	230	135	231
325095	1CANERUN7ST 18.000	7S	LGEE	241	241	231	231	154	225
253625	10CAN_G1 6.9000	1	SIGE	28	28	28	28	28	28
253626	10CAN_G2 6.9000	2	SIGE	28	28	28	28	28	28
253627	10CAN_G3 6.9000	3	SIGE	29	29	29	29	29	29

5.2.2 Post GI-2019-029 Stability Models

The following Post LGE-GIS 2019-029 stability models were developed for this study:

- 2020 Summer Peak Post GI 2019-029 Model
- 2020 Summer Maximized Generation Pre GI 2019-029 Model
- 2023 Light Load Post GI 2019-029 Model

The Pre GI-2019-029 Models were modified to include the GI-2019-029 Solar generation, sinking based on scaling the generation of the local Balancing Authorities to the north, south, east and west of the LG&E and KU control area each by 25% of the request to form the Post GI-2019-029 Stability Models. Preliminary GI-2019-029 stability models were sent to the Ad Hoc Study Group for review.

Specifically the following areas were used:

- North – Area 600 XCEL.

- South – Area 346 SOCO.
- East – Area 342 DUKE.
- West – Area 330 AECI.

If modeling adjustments were indicated by the Ad Hoc Study Group, the models were updated to incorporate those adjustments as appropriate.

Additional 2020S Max Pre and Post GI-2019-029 models were created by removing the Hardin County Substation additions, (the second 345/138 kV & 138/69 kV transformers and associated breakers at Hardin County and second 69 kV line from Elizabethtown to Hardin County) from the 2020S Max Pre and Post GI-2019-029 models. Sensitivity analyses on selected disturbances were performed using these additional models.

5.3 Disturbance Definitions

The transient stability impacts of GI-2019-029 were evaluated for all selected disturbances. The selected disturbances were defined by TranServ, and reviewed by the Ad Hoc Study Group. The definitions of all disturbances evaluated are listed in Tables 5-3, 5-4, 5-5, 5-6, 5-7A and 5-8.

Tables 5-7B and 5-7C list the Hardin Co 138 kV and 345 kV P4 disturbances which were initially screened using the same screening technique applied by LG&E and KU in the 2020 TEP, on the 2020S Maximized model applying a SLG fault for 1 second. No criteria violations were observed for any of these disturbances and thus these disturbances were not chosen for analysis in this study.

Table 5-3
GI-2019-029 Category P1 Disturbances

Faulted Bus	kV	Fault Type	Initial Clearing Time (Cycles)	Fault Name	Reclosing Time (Cycles)	Final Clearing Time (Cycles)
4CENT HARDIN	138	3PH	6	4CENT HARDIN138 -4HARDIN CO138 Line	26	32
4CENT HARDIN	138	3PH	6	4CENT HARDIN138-69kV XFMR	26	32
4HARDIN CO	138	3PH	6	4HARDIN CO138 -4ROGERSVILLE138 Line	26	32
4HARDIN CO	138	3PH	6	4HARDIN CO138 -4CENT HARDIN138 Line	26	32
4HARDIN CO	138	3PH	6	4HARDIN CO138 -4ETOWN138 Line	26	32
4HARDIN CO	138	3PH	6	4HARDIN CO138 -2HARDIN CO 69 XFMR1	26	32
4HARDIN CO	138	3PH	6	4HARDIN CO138 -2HARDIN CO 69 XFMR2	26	32
4HARDIN CO	138	3PH	6	4HARDIN CO138 -7HARDIN CO345 XFMR1	26	32
4HARDIN CO	138	3PH	6	4HARDIN CO138 -7HARDIN CO345 XFMR2	26	32
7HARDIN CO	345	3PH	6	7HARDIN CO345- 4HARDIN CO138 XFMR2	26	32
7HARDIN CO	345	3PH	6	7HARDIN CO345- 4HARDIN CO138 XFMR1	26	32
7HARDIN CO	345	3PH	6	7HARDIN CO345 -7MILL CREEK345/OTTERCRK via RedmondRd	26	32
7HARDIN CO	345	3PH	6	7HARDIN CO345 -7BROWN NORTH345 Line	26	32
7HARDIN CO	345	3PH	6	7HARDIN CO345 -7DAVIESS345 Line	26	32
4HARDINSBURG	138	3PH	6	Hardinsburg-Central Hardin138kV line	26	32
4HARDINSBURG	138	3PH	6	4HARDINSBURG138 -4N.HARD138 Line	26	32
4HARDINSBURG	138	3PH	6	4HARDINSBURG138 -4CLOVERPORT138 Line	26	32
4N.HARD	138	3PH	6	4N.HARD138 -4CLOVERPORT138 Line	26	32
4N.HARD	138	3PH	6	4N.HARD138 -4HARDINSBURG138 Line	26	32
4N.HARD	138	3PH	6	5N.HARD161-4N.HARD138 XFMR	26	32
4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -10CANTAP138 Line	26	32
4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -4GR RVR STL138 Line	26	32
4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -4HARDINSBURG138 Line	26	32
4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -4N.HARD138 Line	26	32

Faulted Bus	kV	Fault Type	Initial Clearing Time (Cycles)	Fault Name	Reclosing Time (Cycles)	Final Clearing Time (Cycles)
4CLOVERPORT	138	3PH	6	4CLOVERPORT138-GI-2019-003 138 Line	26	32
GI-2019-029P	138	3PH	6	GI-2019-029P 138-4HARDINSBURG138 Line	26	32
GI-2019-029P	138	3PH	6	GI-2019-029P 138-4CENT HARDIN138 Line	26	32
4HARDINSBURG	138	3PH	6	4HARDINSBURG138-GI-2019-029P 138 Line	26	32
4CENT HARDIN	138	3PH	6	4CENT HARDIN138-GI-2019-029P 138 Line	26	32
10CANTAP	138	3PH	6	4CLOVERPORT138 -10CANTAP138 Line	26	32

Table 5-4
GI-2019-029 Category P2.1 Disturbances

Faulted Bus	kV	Initial Clearing Time (Cycles)	Fault Name
GI-2019-029POI	138	6	Hardinsburg to GI-2019-029POI
GI-2019-029POI	138	6	Central Hardin to GI-2019-029POI

Table 5-5
GI-2019-029 Category P2.2 -2.4 Disturbances

Faulted Bus	kV	Fault Type	Initial Clearing Time (Cycles)	Delayed Clearing Time (Cycles)	Fault Name
4CLVRPRT	138	SLG	6	20	016_Cloverport_138kV
4CLVRPRT	138	SLG	6	20	019_Cloverport-138kV-3850
4CLVRPRT	138	SLG	6	20	020_Cloverport-138kV-3851
4CLVRPRT	138	SLG	6	20	021_Cloverport-138kV-3852

Faulted Bus	kV	Fault Type	Initial Clearing Time (Cycles)	Delayed Clearing Time (Cycles)	Fault Name
4CLVRPRT	138	SLG	6	20	022_Cloverport-138kV-3854
7HARDIN	345	SLG	6	20	037_Hardin-178-718
4HARDN	138	SLG	6	20	Hardin-178-722
4HARDN	138	SLG	6	20	Hardin-178-712
4HARDN	138	SLG	6	20	Hardin-178-702
4HARDN	138	SLG	6	20	Hardin-178-704
4HARDN	138	SLG	6	20	Hardin-178-714
4HARDN	138	SLG	6	20	Hardin-178-724
4HARDN	138	SLG	6	20	Hardin-178-718
4HARDN	138	SLG	6	20	Hardin-178-754
4HARDN	138	SLG	6	20	Hardin-178-744
4HARDN	138	SLG	6	20	Hardin-178-728

Table 5-6
GI-2019-029 Category P3 and P6 Disturbances

Prior Element/Gen Outage	Faulted Bus	kV	Fault Type	Initial Clearing Time (Cycles)	Fault Name	Reclosing Time (Cycles)	Final Clearing Time (Cycles)
Brown 3	4CENT HARDIN	138	3PH	6	4CENT HARDIN138 -4HARDIN CO138 Line	26	32
Brown 3	4CENT HARDIN	138	3PH	6	4CENT HARDIN138-69kV XFMR	26	32
Brown 3	4HARDIN CO	138	3PH	6	4HARDIN CO138 -4ROGERSVILLE138 Line	26	32
Brown 3	4HARDIN CO	138	3PH	6	4HARDIN CO138 -4CENT HARDIN138 Line	26	32
Brown 3	4HARDIN CO	138	3PH	6	4HARDIN CO138 -4ETOWN138 Line	26	32
Brown 3	4HARDIN CO	138	3PH	6	4HARDIN CO138 -2HARDIN CO 69 XFMR1	26	32
Brown 3	4HARDIN CO	138	3PH	6	4HARDIN CO138 -2HARDIN CO 69 XFMR2	26	32
Brown 3	4HARDIN CO	138	3PH	6	4HARDIN CO138 -7HARDIN CO345 XFMR1	26	32

Prior Element/Gen Outage	Faulted Bus	kV	Fault Type	Initial Clearing Time (Cycles)	Fault Name	Reclosing Time (Cycles)	Final Clearing Time (Cycles)
Brown 3	4HARDIN CO	138	3PH	6	4HARDIN CO138 -7HARDIN CO345 XFMR2	26	32
Brown 3	7HARDIN CO	345	3PH	6	7HARDIN CO345- 4HARDIN CO138 XFMR2	26	32
Brown 3	7HARDIN CO	345	3PH	6	7HARDIN CO345- 4HARDIN CO138 XFMR1	26	32
Brown 3	7HARDIN CO	345	3PH	6	7HARDIN CO345 -7MILL CREEK345/OTTERCRK via RedmondRd	26	32
Brown 3	7HARDIN CO	345	3PH	6	7HARDIN CO345 -7BROWN NORTH345 Line	26	32
Brown 3	7HARDIN CO	345	3PH	6	7HARDIN CO345 -7DAVIESS345 Line	26	32
Brown 3	4HARDINSBURG	138	3PH	6	Hardinsburg-Central Hardin138kV line	26	32
Brown 3	4HARDINSBURG	138	3PH	6	4HARDINSBURG138 -4N.HARD138 Line	26	32
Brown 3	4HARDINSBURG	138	3PH	6	4HARDINSBURG138 -4CLOVERPORT138 Line	26	32
Brown 3	4N.HARD	138	3PH	6	4N.HARD138 -4CLOVERPORT138 Line	26	32
Brown 3	4N.HARD	138	3PH	6	4N.HARD138 -4HARDINSBURG138 Line	26	32
Brown 3	4N.HARD	138	3PH	6	5N.HARD161-4N.HARD138 XFMR	26	32
Brown 3	4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -10CANTAP138 Line	26	32
Brown 3	4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -4GR RVR STL138 Line	26	32
Brown 3	4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -4HARDINSBURG138 Line	26	32
Brown 3	4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -4N.HARD138 Line	26	32
Brown 3	4CLOVERPORT	138	3PH	6	4CLOVERPORT138-GI-2019-003 138 Line	26	32
Brown 3	GI-2019-029P	138	3PH	6	GI-2019-029P 138-4HARDINSBURG138 Line	26	32
Brown 3	GI-2019-029P	138	3PH	6	GI-2019-029P 138-4CENT HARDIN138 Line	26	32
Brown 3	4HARDINSBURG	138	3PH	6	4HARDINSBURG138-GI-2019-029P 138 Line	26	32
Brown 3	4CENT HARDIN	138	3PH	6	4CENT HARDIN138-GI-2019-029P 138 Line	26	32
Brown 3	10CANTAP	138	3PH	6	4CLOVERPORT138 -10CANTAP138 Line	26	32
Mill Creek 4	4CENT HARDIN	138	3PH	6	4CENT HARDIN138 -4HARDIN CO138 Line	26	32
Mill Creek 4	4CENT HARDIN	138	3PH	6	4CENT HARDIN138-69kV XFMR	26	32
Mill Creek 4	4HARDIN CO	138	3PH	6	4HARDIN CO138 -4ROGERSVILLE138 Line	26	32

Prior Element/Gen Outage	Faulted Bus	kV	Fault Type	Initial Clearing Time (Cycles)	Fault Name	Reclosing Time (Cycles)	Final Clearing Time (Cycles)
Mill Creek 4	4HARDIN CO	138	3PH	6	4HARDIN CO138 -4CENT HARDIN138 Line	26	32
Mill Creek 4	4HARDIN CO	138	3PH	6	4HARDIN CO138 -4ETOWN138 Line	26	32
Mill Creek 4	4HARDIN CO	138	3PH	6	4HARDIN CO138 -2HARDIN CO 69 XFMR1	26	32
Mill Creek 4	4HARDIN CO	138	3PH	6	4HARDIN CO138 -2HARDIN CO 69 XFMR2	26	32
Mill Creek 4	4HARDIN CO	138	3PH	6	4HARDIN CO138 -7HARDIN CO345 XFMR1	26	32
Mill Creek 4	4HARDIN CO	138	3PH	6	4HARDIN CO138 -7HARDIN CO345 XFMR2	26	32
Mill Creek 4	7HARDIN CO	345	3PH	6	7HARDIN CO345- 4HARDIN CO138 XFMR2	26	32
Mill Creek 4	7HARDIN CO	345	3PH	6	7HARDIN CO345- 4HARDIN CO138 XFMR1	26	32
Mill Creek 4	7HARDIN CO	345	3PH	6	7HARDIN CO345 -7MILL CREEK345/OTTERCRK via RedmondRd	26	32
Mill Creek 4	7HARDIN CO	345	3PH	6	7HARDIN CO345 -7BROWN NORTH345 Line	26	32
Mill Creek 4	7HARDIN CO	345	3PH	6	7HARDIN CO345 -7DAVIESS345 Line	26	32
Mill Creek 4	4HARDINSBURG	138	3PH	6	Hardinsburg-Central Hardin138kV line	26	32
Mill Creek 4	4HARDINSBURG	138	3PH	6	4HARDINSBURG138 -4N.HARD138 Line	26	32
Mill Creek 4	4HARDINSBURG	138	3PH	6	4HARDINSBURG138 -4CLOVERPORT138 Line	26	32
Mill Creek 4	4N.HARD	138	3PH	6	4N.HARD138 -4CLOVERPORT138 Line	26	32
Mill Creek 4	4N.HARD	138	3PH	6	4N.HARD138 -4HARDINSBURG138 Line	26	32
Mill Creek 4	4N.HARD	138	3PH	6	5N.HARD161-4N.HARD138 XFMR	26	32
Mill Creek 4	4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -10CANTAP138 Line	26	32
Mill Creek 4	4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -4GR RVR STL138 Line	26	32
Mill Creek 4	4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -4HARDINSBURG138 Line	26	32
Mill Creek 4	4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -4N.HARD138 Line	26	32
Mill Creek 4	4CLOVERPORT	138	3PH	6	4CLOVERPORT138-GI-2019-003 138 Line	26	32
Mill Creek 4	GI-2019-029P	138	3PH	6	GI-2019-029P 138-4HARDINSBURG138 Line	26	32
Mill Creek 4	GI-2019-029P	138	3PH	6	GI-2019-029P 138-4CENT HARDIN138 Line	26	32
Mill Creek 4	4HARDINSBURG	138	3PH	6	4HARDINSBURG138-GI-2019-029P 138 Line	26	32

Prior Element/Gen Outage	Faulted Bus	kV	Fault Type	Initial Clearing Time (Cycles)	Fault Name	Reclosing Time (Cycles)	Final Clearing Time (Cycles)
Mill Creek 4	4CENT HARDIN	138	3PH	6	4CENT HARDIN138-GI-2019-029P 138 Line	26	32
Mill Creek 4	10CANTAP	138	3PH	6	4CLOVERPORT138 -10CANTAP138 Line	26	32
GI-2019-029P-Central Hardin	4CENT HARDIN	138	3PH	6	4CENT HARDIN138 -4HARDIN CO138 Line	26	32
GI-2019-029P-Central Hardin	4CENT HARDIN	138	3PH	6	4CENT HARDIN138-69kV XFMR	26	32
GI-2019-029P-Central Hardin	4HARDIN CO	138	3PH	6	4HARDIN CO138 -4ROGERSVILLE138 Line	26	32
GI-2019-029P-Central Hardin	4HARDIN CO	138	3PH	6	4HARDIN CO138 -4CENT HARDIN138 Line	26	32
GI-2019-029P-Central Hardin	4HARDIN CO	138	3PH	6	4HARDIN CO138 -4ETOWN138 Line	26	32
GI-2019-029P-Central Hardin	4HARDIN CO	138	3PH	6	4HARDIN CO138 -2HARDIN CO 69 XFMR1	26	32
GI-2019-029P-Central Hardin	4HARDIN CO	138	3PH	6	4HARDIN CO138 -2HARDIN CO 69 XFMR2	26	32
GI-2019-029P-Central Hardin	4HARDIN CO	138	3PH	6	4HARDIN CO138 -7HARDIN CO345 XFMR1	26	32
GI-2019-029P-Central Hardin	4HARDIN CO	138	3PH	6	4HARDIN CO138 -7HARDIN CO345 XFMR2	26	32
GI-2019-029P-Central Hardin	7HARDIN CO	345	3PH	6	7HARDIN CO345- 4HARDIN CO138 XFMR2	26	32
GI-2019-029P-Central Hardin	7HARDIN CO	345	3PH	6	7HARDIN CO345- 4HARDIN CO138 XFMR1	26	32
GI-2019-029P-Central Hardin	7HARDIN CO	345	3PH	6	7HARDIN CO345 -7MILL CREEK345/OTTERCRK via RedmondRd	26	32
GI-2019-029P-Central Hardin	7HARDIN CO	345	3PH	6	7HARDIN CO345 -7BROWN NORTH345 Line	26	32
GI-2019-029P-Central Hardin	7HARDIN CO	345	3PH	6	7HARDIN CO345 -7DAVIESS345 Line	26	32
GI-2019-029P-Central Hardin	4HARDINSBURG	138	3PH	6	Hardinsburg-Central Hardin138kV line	26	32
GI-2019-029P-Central Hardin	4HARDINSBURG	138	3PH	6	4HARDINSBURG138 -4N.HARD138 Line	26	32
GI-2019-029P-Central Hardin	4HARDINSBURG	138	3PH	6	4HARDINSBURG138 -4CLOVERPORT138 Line	26	32
GI-2019-029P-Central Hardin	4N.HARD	138	3PH	6	4N.HARD138 -4CLOVERPORT138 Line	26	32
GI-2019-029P-Central Hardin	4N.HARD	138	3PH	6	4N.HARD138 -4HARDINSBURG138 Line	26	32
GI-2019-029P-Central Hardin	4N.HARD	138	3PH	6	5N.HARD161-4N.HARD138 XFMR	26	32
GI-2019-029P-Central Hardin	4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -10CANTAP138 Line	26	32
GI-2019-029P-Central Hardin	4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -4GR RVR STL138 Line	26	32
GI-2019-029P-Central Hardin	4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -4HARDINSBURG138 Line	26	32

Prior Element/Gen Outage	Faulted Bus	kV	Fault Type	Initial Clearing Time (Cycles)	Fault Name	Reclosing Time (Cycles)	Final Clearing Time (Cycles)
GI-2019-029P-Central Hardin	4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -4N.HARD138 Line	26	32
GI-2019-029P-Central Hardin	4CLOVERPORT	138	3PH	6	4CLOVERPORT138-GI-2019-003 138 Line	26	32
GI-2019-029P-Central Hardin	GI-2019-029P	138	3PH	6	GI-2019-029P 138-4HARDINSBURG138 Line	26	32
GI-2019-029P-Central Hardin	4HARDINSBURG	138	3PH	6	4HARDINSBURG138-GI-2019-029P 138 Line	26	32
GI-2019-029P-Central Hardin	10CANTAP	138	3PH	6	4CLOVERPORT138 -10CANTAP138 Line	26	32
GI-2019-029P-Hardinsburg	4CENT HARDIN	138	3PH	6	4CENT HARDIN138 -4HARDIN CO138 Line	26	32
GI-2019-029P-Hardinsburg	4CENT HARDIN	138	3PH	6	4CENT HARDIN138-69kV XFMR	26	32
GI-2019-029P-Hardinsburg	4HARDIN CO	138	3PH	6	4HARDIN CO138 -4ROGERSVILLE138 Line	26	32
GI-2019-029P-Hardinsburg	4HARDIN CO	138	3PH	6	4HARDIN CO138 -4CENT HARDIN138 Line	26	32
GI-2019-029P-Hardinsburg	4HARDIN CO	138	3PH	6	4HARDIN CO138 -4ETOWN138 Line	26	32
GI-2019-029P-Hardinsburg	4HARDIN CO	138	3PH	6	4HARDIN CO138 -2HARDIN CO 69 XFMR1	26	32
GI-2019-029P-Hardinsburg	4HARDIN CO	138	3PH	6	4HARDIN CO138 -2HARDIN CO 69 XFMR2	26	32
GI-2019-029P-Hardinsburg	4HARDIN CO	138	3PH	6	4HARDIN CO138 -7HARDIN CO345 XFMR1	26	32
GI-2019-029P-Hardinsburg	4HARDIN CO	138	3PH	6	4HARDIN CO138 -7HARDIN CO345 XFMR2	26	32
GI-2019-029P-Hardinsburg	7HARDIN CO	345	3PH	6	7HARDIN CO345- 4HARDIN CO138 XFMR2	26	32
GI-2019-029P-Hardinsburg	7HARDIN CO	345	3PH	6	7HARDIN CO345- 4HARDIN CO138 XFMR1	26	32
GI-2019-029P-Hardinsburg	7HARDIN CO	345	3PH	6	7HARDIN CO345 -7MILL CREEK345/OTTERCRK via RedmondRd	26	32
GI-2019-029P-Hardinsburg	7HARDIN CO	345	3PH	6	7HARDIN CO345 -7BROWN NORTH345 Line	26	32
GI-2019-029P-Hardinsburg	7HARDIN CO	345	3PH	6	7HARDIN CO345 -7DAVIESS345 Line	26	32
GI-2019-029P-Hardinsburg	4HARDINSBURG	138	3PH	6	Hardinsburg-Central Hardin138kV line	26	32
GI-2019-029P-Hardinsburg	4HARDINSBURG	138	3PH	6	4HARDINSBURG138 -4N.HARD138 Line	26	32
GI-2019-029P-Hardinsburg	4HARDINSBURG	138	3PH	6	4HARDINSBURG138 -4CLOVERPORT138 Line	26	32
GI-2019-029P-Hardinsburg	4N.HARD	138	3PH	6	4N.HARD138 -4CLOVERPORT138 Line	26	32
GI-2019-029P-Hardinsburg	4N.HARD	138	3PH	6	4N.HARD138 -4HARDINSBURG138 Line	26	32
GI-2019-029P-Hardinsburg	4N.HARD	138	3PH	6	5N.HARD161-4N.HARD138 XFMR	26	32

Prior Element/Gen Outage	Faulted Bus	kV	Fault Type	Initial Clearing Time (Cycles)	Fault Name	Reclosing Time (Cycles)	Final Clearing Time (Cycles)
GI-2019-029P-Hardinsburg	4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -10CANTAP138 Line	26	32
GI-2019-029P-Hardinsburg	4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -4GR RVR STL138 Line	26	32
GI-2019-029P-Hardinsburg	4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -4HARDINSBURG138 Line	26	32
GI-2019-029P-Hardinsburg	4CLOVERPORT	138	3PH	6	4CLOVERPORT138 -4N.HARD138 Line	26	32
GI-2019-029P-Hardinsburg	4CLOVERPORT	138	3PH	6	4CLOVERPORT138-GI-2019-003 138 Line	26	32
GI-2019-029P-Hardinsburg	GI-2019-029P	138	3PH	6	GI-2019-029P 138-4CENT HARDIN138 Line	26	32
GI-2019-029P-Hardinsburg	4CENT HARDIN	138	3PH	6	4CENT HARDIN138-GI-2019-029P 138 Line	26	32
GI-2019-029P-Hardinsburg	10CANTAP	138	3PH	6	4CLOVERPORT138 -10CANTAP138 Line	26	32

Table 5-7A
GI-2019-029 Category P4 and P5 Disturbances with Breaker Failure

Fault Name	Fault
Cloverport138_P5	Protection System Failure of Cloverport 138 kV bus
HardinCo to MC 345_MC-4560_P4-P5	Breaker Failure/Protection System Failure at MC 4560 Breaker
01 Cloverport to Hardinsburg_LE fault failure at CP	Breaker Failure at Cloverport 138 kV
02 Hardinsburg to Cloverport_LE fault failure at HB	Breaker Failure at Hardinsburg 138 kV
03 Cloverport to New Hardinsburg_LE fault failure at CP	Breaker Failure at Cloverport 138 kV
04 New Hardinsburg to Cloverport_LE fault failure at NHB	Breaker Failure at New Hardinsburg 138 kV
05 Cent Hardin to Hardinsburg_LE fault failure at CH	Breaker Failure at Cent Hardin 138 kV
06 Hardinsburg to Cent Hardin_LE fault failure at HB	Breaker Failure at Hardinsburg 138 kV
08-HardinCo-Rogersville-BFat Rogersville138	Breaker Failure at Rogersville 138 kV
09-HardinCo-Central Hardin-BF at Central Hardin 138	Breaker Failure at Central Hardin 138 kV
10-HardinCo-Etown-BF at Etown 138	Breaker Failure at Etown 138 kV

Table 5-7B
138 kV P4 Disturbances initially screened but not ultimately included in GI-2019-029 SIS

Fault Name	Fault
11-SLG fault-HardinCo138-Etown138kV-BF-HardinCo#702	Breaker Failure of HardinCo 138kV #702
12-SLG fault-HardinCo138-Etown138kV-BF-HardinCo#704	Breaker Failure of HardinCo 138kV #704
13-SLG fault-HardinCo138-CentralHardin138kV-BF-HardinCo#712	Breaker Failure of HardinCo 138kV #712
14-SLG fault-HardinCo138-CentralHardin138kV-BF-HardinCo#711	Breaker Failure of HardinCo 138kV #711
15-SLG fault-HardinCo138-Rogersville138kV-BF-HardinCo#722	Breaker Failure of HardinCo 138kV #722
16-SLG fault-HardinCo138-Rogersville138kV-BF-HardinCo#754	Breaker Failure of HardinCo 138kV #754
17-SLG fault-HardinCo138-69kV#1-BF-HardinCo#722	Breaker Failure of HardinCo 138kV #722
18-SLG fault-HardinCo138-69kV#1-BF-HardinCo#724	Breaker Failure of HardinCo 138kV #724
19-SLG fault-HardinCo138-69kV#2-BF-HardinCo#712	Breaker Failure of HardinCo 138kV #712
20-SLG fault-HardinCo138-69kV#2-BF-HardinCo#714	Breaker Failure of HardinCo 138kV #714
21-SLG fault-HardinCo345-138xfmr#1-BF-HardinCo#718	Breaker Failure of HardinCo 138kV #718
22-SLG fault-HardinCo345-138xfmr#2-BF-HardinCo#702	Breaker Failure of HardinCo 138kV #702
23-SLG fault-HardinCo345-138xfmr#2-BF-HardinCo#728	Breaker Failure of HardinCo 138kV #728

Table 5-7C
345 kV P4 Disturbances initially screened but not ultimately included in GI-2019-029 SIS

Fault Name	Fault
04-HardinCO-BrownN#914	Breaker Failure of HardinCo 345kV #914
05-HardinCO-Daviess#934	Breaker Failure of HardinCo 345kV #934
06-HardinCO-MC#954	Breaker Failure of HardinCo 345kV #954
07-HardinCO-BrownN#904	Breaker Failure of HardinCo 345kV #904
08-HardinCO-Daviess#924	Breaker Failure of HardinCo 345kV #924
09-HardinCO-MC#944	Breaker Failure of HardinCo 345kV #944
10-HardinCO345-138#944	Breaker Failure of HardinCo 345kV #944
11-HardinCO-345-138#924	Breaker Failure of HardinCo 345kV #924
12-HardinCO345-138#904	Breaker Failure of HardinCo 345kV #904
13-HardinCO345-138#908	Breaker Failure of HardinCo 345kV #908

Table 5-8
GI-2019-029 Category P7 Disturbances

Faulted Bus	kV	Initial Clearing Time (Cycles)	Fault Name	Reclosing Time (Cycles)	Final Clearing Time (Cycles)
Central Hardin	138	6	Central Hardin-Hardin County 138 kV_ Mill Creek-Hardin County 345 kV 1	26	32
Hardin County	138	6	Central Hardin-Hardin County 138 kV_ Mill Creek-Hardin County 345 kV 2	26	32
Hardin County	345	6	Central Hardin-Hardin County 138 kV_ Mill Creek-Hardin County 345 kV 3	26	32
Central Hardin	138	6	Central Hardin-Hardinsburg 138 kV_ Mill Creek-Hardin County 345 kV 1	26	32

Faulted Bus	kV	Initial Clearing Time (Cycles)	Fault Name	Reclosing Time (Cycles)	Final Clearing Time (Cycles)
Hardinsburg	138	6	Central Hardin-Hardinsburg 138 kV_ Mill Creek-Hardin County 345 kV 2	26	32
Cloverport	138	6	Tip Top-Cloverport 138 kV_ Mill Creek-Hardin County 345 kV 2	26	32

5.4 Powerflow Solution Method

Models were solved with automatic control of Load Tap Changers (LTCs), area interchange, phase shifters and switched shunts enabled.

5.5 Monitored Elements

The transient stability performance of the transmission system was monitored at some key generating facilities in the LG&E and KU control area and neighboring control areas which are in the vicinity of the subject request.

5.6 Performance Criteria

Disturbances were evaluated as per criteria given in the LG&E and KU Transmission Planning Guidelines.

5.7 Detailed Results

5.7.1 Solar Bus Angle Drift Issues

A simulation with no fault applied showed a slight drift in the bus angles for some solar generation buses in PSSE 33.12.1. This issue was found prior to adding the GI-2019-029 generation to the models and remained after the addition of the GI-2019-029 generation. As discussed with LG&E and KU and explained in Section 5.7.1 of the GI-2019-003 SIS Report, solar bus angle drift is considered to be a non-issue.

5.7.2 Cannelton Tap- Cloverport 138kV Disturbance

Reclosing capability is currently disabled on the Cannelton Tap-Cloverport 138 kV line. For any disturbance involving the Cannelton Tap-Cloverport 138 kV line in all models and scenarios, simulation were performed without reclosing this line.

5.7.3 J753 BREC Unit Oscillations

Two prior queued MISO requests: J753 and J762 were added to the GI-2019-029 SIS Stability Models as per Ad Hoc Study Group Instructions. On performing some simulations, oscillations were identified at the J753 generation for some disturbances.

As discussed and explained in Section 5.7.4 of GI-2019-003, the ITO decided to GNET (essentially removing the dynamic modeling but retaining the steady state modeling of) the J753 generator in the GI-2019-029 Post model. When GNET was applied for the J753 unit, no oscillations were found.

MISO has confirmed that no mitigation is needed for these oscillations and are in agreement with the ITO process of performing GNET for J753 unit.

5.7.4 Sensitivity Analysis Results

GI-2019-029 Post 2020S Max stability voltage criteria violations were found in the sensitivity analysis (prior to the addition of the Hardin County Projects). The violations were identified only during the P6 disturbance prior outage of the Black Branch to Hardinsburg 138 kV line with a fault on the Hardin County 345/138 kV transformer. Table 5.9 lists the sensitivity analysis results for this P6 disturbance. The sensitivity included only the GI-2019-029 2020S Max model.

Table 5-9
2020S Max Sensitivity Analysis Criteria Violations

Pre GI-2019-029 Model				Post GI-2019-029 Model			
Bus Number	**Bus Name**	**Voltage (p.u.)**	**Seconds**	**Bus Number**	**Bus Name**	**Voltage (p.u.)**	**Seconds**
324303	[4ROGERSVILLE138.00]	0.6954	13.6998	324303	[4ROGERSVILLE138.00]	0.6896	5.1
342568	[4CENT HARDIN138.00]	0.7081	13.6998	342568	[4CENT HARDIN138.00]	0.7036	5.1
324261	[4HARDIN CO 138.00]	0.7088	13.6998	324261	[4HARDIN CO 138.00]	0.7037	5.1
324244	[4ETOWN 138.00]	0.7117	13.6998	324244	[4ETOWN 138.00]	0.7065	5.1
324288	[4NELSON CO 138.00]	0.7675	13.6998	324288	[4NELSON CO 138.00]	0.763	5.1
				999133	[GI-2019-029P138.00]	0.7045	5.1
				999132	[GI-2019-029M138.00]	0.7051	5.1
				999131	[GI-2019-029C34.500]	0.7151	5.1
				999130	[GI-2019-029G34.500]	0.7151	5.1
				999129	[GI-2019-029S0.5500]	0.6794	5.1

LG&E and KU criteria allows 6 BES substations to drop below 0.8 pu. Thus no criteria violations were identified in the Pre GI-2019-029 sensitivity analysis. However additional substations were found to drop below 0.8 pu in the Post GI-2019-029 sensitivity analysis resulting in a criteria violation.

5.7.5 Impedance swing

To address Sections 4.1.2 and 4.3.1.3 of the TPL-001-4 standard, stability analysis was performed to assess tripping due to transient swings. The goal of the apparent impedance swing test is to determine if there are any breaker mis-operations as a result of an apparent impedance swing during the stability simulation. The breakers need to be able to clear the fault during normal or delayed clearing events. However, non-faulted facilities need to remain in service. Distance relays, which are designed to determine if a fault is on the system, could mis-operate due to an apparent impedance swing resulting in tripping of facilities that are not needed in order to clear the fault.

5.7.6 Distance Relay Setup

The PSSE distance relay model DISTR1 was used. Each BES transmission line in LKE's control area was assumed to be equipped with two DISTR1 relays, one at each end, and the setting for these relays were assumed to be as provided in Table 5-10.

Table 5-10: Assumed Distance Relay Input Values

Value	Description
2	Zone 1 pick-up time (cycles)
90%	Zone 1 reach (diameter or reactance)
75	Zone 1 centerline angle (degrees)
50%	Zone 1 center distance
22	Zone 2 pick-up time (cycles)
120%	Zone 2 reach (diameter or reactance)
75	Zone 2 centerline angle (degrees)
60%	Zone 2 center distance
4	Self-trip breaker time (cycles)

The GI-2019-029 results did not include any extra tripping due to impedance swings. There were no inadvertent trips found in the analysis results.

5.8 Conclusion

The ITO studied the P1 - P7 category disturbances as mentioned in the Section 5.3. In the sensitivity analysis (without the Hardin county Projects) criteria violations were found for one P6 conditions. An operating guide will be needed to ameliorate these criteria violations prior to the addition of the Hardin County Projects currently expected to be in-service by June 2022. All other tested disturbances passed the stability criterion in the sensitivity analysis and all tested disturbances passed the stability criterion in the analysis which included the addition of the Hardin County Projects. Plots of all simulation results are available upon request.

These study results rely on the following:

- MISO's determination that the oscillations emanating from J753 were not considered constraints to the GI-2019-003 request, as the GI-2019-003 request did not cause instability. Thus the J753 generation was modeled as GNetted in the GI-2019-029 models.
- For simulation with no fault, slight drift in bus angles for some solar generation buses in PSSE 33.12.1 were ignored as discussed in Section 5.7.1.
- The fact that reclosing capability is currently disabled on the Cannelton Tap-Cloverport 138 kV line.

6. Short Circuit Analysis

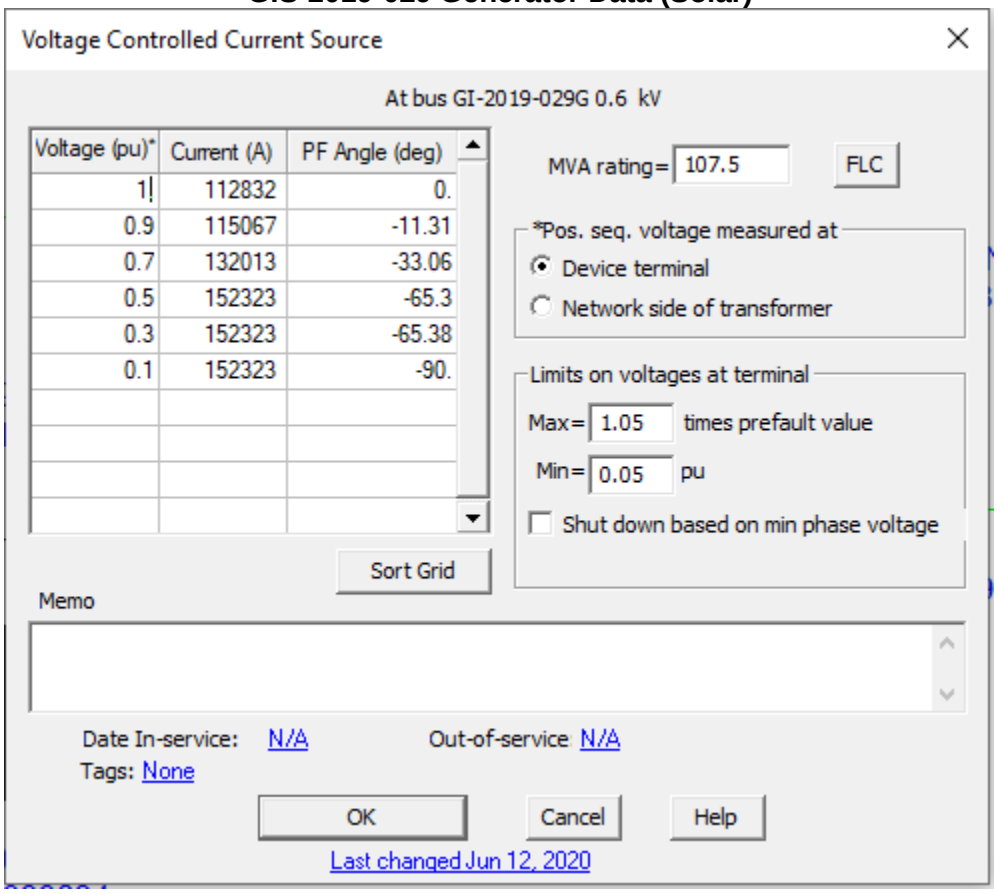
A short circuit analysis was performed using ASPEN by simulating three-phase faults and single line-to-ground faults for buses within a five-bus radius of the POI to determine the breaker duty in both the pre and post LGE-GIS-2019-029 models. The breaker duty for these simulations was compared to the rated breaker interrupting capability to determine whether or not the circuit breakers may be overstressed. A breaker is considered a Significantly Affected Facility (SAF) if the breaker duty at that breaker is equal to or greater than the rated breaker interrupting capability, and the impact of the new generation is greater than or equal to 5% of the rated breaker interrupting capability. The short circuit models emulated the steady-state modeling as closely as practical and appropriate. The analysis results are summarized in Table 6-2.

6.1 Model Development

The TEP_2019.olr model provided by LG&E and KU for the LG&E and KU 2019 TEP was modified by adding the prior queued GI projects listed in Table 3-10 and the GIS-2019-029 POI bus to form the Pre GIS-2019-029 model. The Pre GIS-2019-029 model was modified by adding the GIS-2019-029 generation to form the Post GIS-2019-029 model. Also, Pre and Post GI-2019-029 sensitivity models were created from Pre and Post GIS-2019-029 models respectively which included the Hardin County Projects. The solar inverters were modeled as a voltage controlled source in Aspen as shown in Table 6-1.

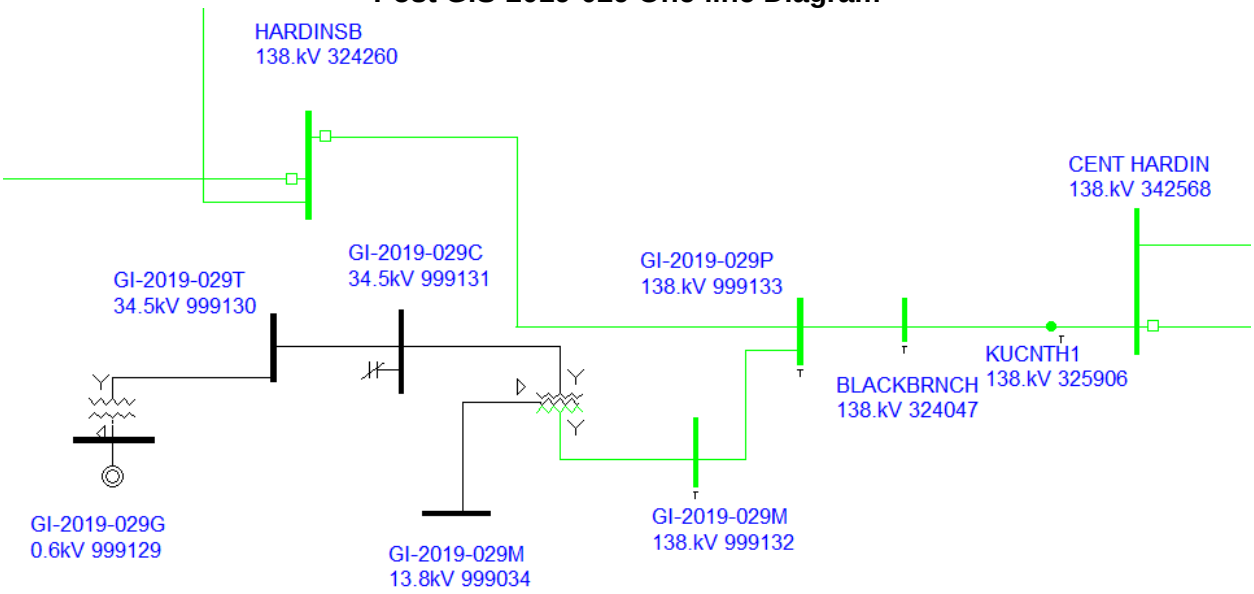
The GIS-2019-029 Solar project data is given in the following table:

Table 6-1
GIS-2019-029 Generator Data (Solar)



Figures 6-1 illustrates the connection of the GIS-2019-029 request in the Post GIS-2019-029 short circuit model.

Figure 6-1
Post GIS-2019-029 One-line Diagram



6.2 Short Circuit Calculations

Short circuit calculations were performed to determine the impact of the proposed project on the breaker duties at nearby substations (within five buses). Single-phase and three-phase symmetrical breaker duty levels were calculated at local area buses, both with and without the proposed project.

No breakers were found to be overstressed in the Post GIS-2019-029 short circuit analysis.

For informational purposes only, Tables 6-2 and 6-3 list breakers near the POI and shows the % impacts of the GI-2019-029 generation addition on their breaker duties for the original and sensitivity analyses respectively. The impact of the GI-2019-029 generation is given in the “Impact of Request as a % of Breaker Capability” column. The maximum breaker duty for all faults tested is given for each breaker in both Amperes and as a percentage of the applicable breaker interrupting capability rating.

Table 6-2
Pre and Post GIS-2019-029 Breaker Duty for Substations near POI

BKR_ID	Bus	BKR Capacity	Pre		Post		Impact as a % of Breaker Duty
			Duty Ampere	% Duty	Duty Ampere	% Duty	
178-724	"HARDN CO 138.kV"	18688.9	18032.8	96.5	18547.1	99.2	3%
178-708	"HARDN CO 138.kV"	20000	17449	87.2	17916.9	89.6	2%
034-714	"ETOWN 138.kV"	19484.2	14215.9	73	14440.7	74.1	1%
178-704	"HARDN CO 138.kV"	63000	16887.4	26.8	17409.8	27.6	1%
034-644	"ETOWN 69.kV"	26474.7	23088.8	87.2	23220.3	87.7	0%
455-708	"BLACKBRNCH 138.kV"	63000	13373.1	21.2	13683.1	21.7	0%
034-654	"ETOWN 69.kV"	26474.7	22124.3	83.6	22244.8	84	0%
178-624	"HARDN CO 69.kV"	28247.6	21129.6	74.8	21252.1	75.2	0%
178-604	"HARDN CO 69.kV"	26474.7	21388.6	80.8	21495.3	81.2	0%
184-724	"HARDINSB 138.kV"	40000	10548.2	26.4	10548	26.4	0%
184-714	"HARDINSB 138.kV"	19484.2	9053.6	46.5	9053.5	46.5	0%
184-704	"HARDINSB 138.kV"	19484.2	11449.9	58.8	11442.7	58.7	0%

Table 6-3
Pre and Post Sensitivity GIS-2019-029 Breaker Duty for Substations near POI

BKR_ID*	Bus	BKR Capacity	Pre		Post		Impact as a % of Breaker Duty
			Duty Ampere	% Duty	Duty Ampere	% Duty	
178-724	"HARDN CO 138.kV"	40000	24166	60	24624	62	1%
178-704	"HARDN CO 138.kV"	63000	23333	37	23783	38	1%
178-718	"HARDN CO 138.kV"	63000	19192	31	19572	31	1%
178-624	"HARDN CO 69.kV"	40000	30186	75	30381	76	0%
178-604	"HARDN CO 69.kV"	40000	30949	77	31119	78	0%
178-614	"HARDN CO 69.kV"	40000	27659	69	27827	70	0%
034-634	"ETOWN 69.kV"	40000	27548	69	27684	69	0%
034-602	"ETOWN 69.kV"	40000	27547	69	27684	69	0%
034-624	"ETOWN 69.kV"	40000	27090	68	27226	68	0%
034-614	"ETOWN 69.kV"	40000	26805	67	26939	67	0%
034-644	"ETOWN 69.kV"	40000	28007	70	28136	70	0%
034-654	"ETOWN 69.kV"	40000	27061	68	27182	68	0%
178-608	"HARDN CO 69.kV"	40000	24075	60	24185	61	0%
034-674	"ETOWN 69.kV"	40000	24181	61	24280	61	0%
034-604	"ETOWN 69.kV"	40000	25211	63	25296	63	0%

***** Breaker 178-708 will no longer be in-service after the addition of the Hardin County Projects

As shown in Tables 6-2 and 6-3, the breaker duties seen by all breakers listed are less than their rated interrupting capabilities in both the pre and post analyses. Thus, there are no short circuit constraints to granting the GI-2019-029 GI request.

6.3 Conclusion

There are no short circuit constraints to granting the GI-2019-029 GI request.

7. Stiffness Verification due to Inverter Based Resource Interconnection:

The stiffness of the grid decreases with the higher penetration of Inverter Based Resources (IBRs) or with larger electrical distance to the synchronous generation. Short circuit ratio (SCR) is used as a traditional metric to determine the relative strength of a power system. It is the ratio between short circuit apparent power (SCMVA) from a three line to ground fault at a given location in the power system to the rating of the IBR connected to that location. It is defined as

$SCR=S_{SCMVA\_POI}/P_{RMW\_VER}$

Where S_{SCMVA_POI} is the short circuit MVA level at the POI without the new IBR interconnection, and PRMW_VER is the nominal power rating of the IBR being connected at the POI. As per LG&E and KU's GI Study Criteria the SCR metric is appropriate for a single IBR operating in the portion of the grid without other IBRs or power electronic-based equipment electrically close to the POI.

LG&E/KU adopts NERC's recommendation to apply a Weighted SCR (WSCR) method for high IBR penetration, which considers the interaction and oscillation between IBRs where the POIs are electrically close to each other. The WSCR is defined as

$WSCR = (\Sigma S_{SCMVAi} * P_{RMW}) / (\Sigma P_{RMWi})^2$

As per LG&E and KU's GI Study Criteria the $WSCR_{MVA}$ would be calculated where appropriate and if the SCR or WSCR, whichever applies, is less than 2.0, mitigations are required.

GI-2019-029 Stiffness Verification Procedure:

- The GI-2019-029 Generations were taken offline in the Aspen model
- A 3 Phase fault was applied at the GI-2019-029 POI bus in Aspen and the short circuit MVA level at the GI-2019-029 POI bus was calculated.
- The Short circuit MVA at the GI-2019-029 POI bus was determined to be 2953.3 MVA
- The GI-2019-029 inverter rating in MW connected is 100 MW.

Using the $SCR=S_{SCMVA\_POI}/P_{RMW\_VER}$ = (2953.3MVA) / (100 MW) = 29.53

7.1 Conclusion

Since the GI-2019-029 SCR is 29.53, which exceeds the requirement of 2.0, there are no Grid Stiffness constraints to granting the GI-2019-029 GI request.

8. Conceptual Cost Estimate

This report does not consider any issues related to the proposed routing of the generator lead-line to connect to the Transmission Owners Transmission System. If it is later determined that there are line clearance issues related to the generator's proposed lead-line, the customer must provide an alternate route that avoids such issues. In the event an alternate route is not available, the Transmission Owner may need to modify its transmission facilities to maintain adequate clearances. The Customer will be responsible for the costs and any schedule delay as a result.

Since no LG&E and KU network constraints which require upgrades were identified in the steady state, stability or short circuit analyses, no cost estimate to mitigate LG&E and KU network constraints is provided. It should be noted that an operating guide will be required until completion of the Hardin County Projects. This non-binding good faith cost estimate is provided for interconnection facilities of request LGE-GIS-2019-029. This is only a conceptual cost estimate for planning purposes. These costs were compiled by LG&E and KU and will be further developed and refined in the Facility Study.

8.1 Methodology

The cost estimates are allocated based on the "*Allocation of Costs for Generator Interconnections"* dated 01/01/2018 posted on OASIS.

8.2 Generator Owner Facilities

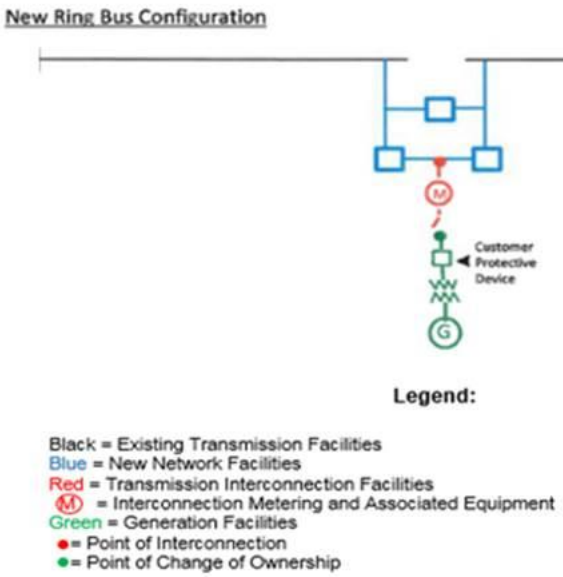
The generator owner is responsible for the installation and costs for the generator, step up transformer and customer protective devices up to the Transmission Owner (TO) metering equipment. The customer is responsible for determining the generator owner costs for the facilities owned and operated by the customer.

8.3 Total Conceptual Cost Estimate: (Total Estimated Cost $8,615,508 USD)

The costs and facilities identified are as follows.

Unless the customer chooses a more reliable interconnection, the minimum generator interconnection facilities are shown in Figure 8-1.

Figure 8-1: Minimum Generator Interconnection Facilities



8.3.1 Transmission Interconnection Facilities: (Total Estimated Cost $1,151,967)

The customer is responsible for transmission interconnection facilities between the generator owner facilities and the point of interconnection. The LG&E and KU non-binding planning level cost estimate for transmission interconnection facilities is shown in Table 8-1 and includes the following:

- Face of Steel (FOS) structure: A-frame, switch stand, metering supports, etc. for GI exit.
- (1) set of 138kV motor-operated disconnect switches.
- (1) set of 138kV line arresters.
- (1) set of 138kV Metering instrument potential transformers (PTs).
- (1) set of 138kV Metering instrument current transformers (CTs).
- (1) Existing Control House Space Allocation consisting of below relay panels:
- (1) line protection panel for GI Interconnect.
- (1) metering panel for GI.
- (2) RTU panel.
- AC/DC systems.

Table 8-1
Transmission Interconnection Facility Cost Estimate

Description	Cost
Company Labor	$81,587
Contract Labor	$609,103
Materials	$356,553
Contingency	$104,724
Total	$1,151,967

8.3.2 Network Facilities: (Total Estimated Cost $7,463,541 USD)

8.3.2.1 Network Interconnection Facilities: (Total Estimated Cost $7,463,541)

The same network interconnection facilities are required for both NRIS and ERIS. The LG&E/KU non-binding planning level cost estimate for network interconnection facilities is shown in Table 8-2 and includes the following:

- Ring bus configuration with (3) 138kV lines (EKP Central Hardin, Hardinsburg, & GI Interconnect)
- (3) 138kV circuit breakers
- Steel structures: A-frames, switch stands, bus supports, etc.
- (6) sets of 138kV manually operated disconnect switches
- (2) sets of 138kV line arresters
- (2) sets of 138kV Line potential transformers (PTs)
- (2) 138kV substation voltage transformers (SSVTs)
- (1) set of metering equipment for the GI
- (1) Medium control house consisting of below relay panels:
    - (3) line protection panels for EKP Central Hardin, Hardinsburg & GI Interconnect
    - (2) Digital communications paths, (1) associated with the EKP Central Hardin line and (1) associated with the Hardinsburg line
    - (1) metering panel for GI
    - (1) RTU panel
    - (1) DFR panel
    - AC/DC systems

This cost estimate was prepared with the assumption that the customer would purchase land and perform site preparations for the substation at the POI.

Table 6-2
Network Interconnection Facility Cost Estimate

Description	NNF Lines Cost	NNF Subs Cost	NNF Total Cost
Company Labor	$70,121	$481,900	$552,021
Contract Labor	$650,947	$3,120,007	$3,770,954
Materials	$126,895	$2,335,168	$2,462,063
Contingency	$84,796	$593,707	$678,503
Total	$932,759	$6,530,782	$7,463,541

LG&E and KU has indicated that the interconnection facilities can be completed within 24 - 36 months after the Provisional GIA is signed and the Customer provides a construction-ready site.

8.3.2.2 LG&E and KU Network Upgrade Facilities: (Total Estimated Cost $0 USD)

No LG&E and KU network constraints which are the responsibility of the GI-2019-029 customer were identified in this Provisional SIS. Thus no cost estimate is provided to mitigate LG&E and KU network constraints.

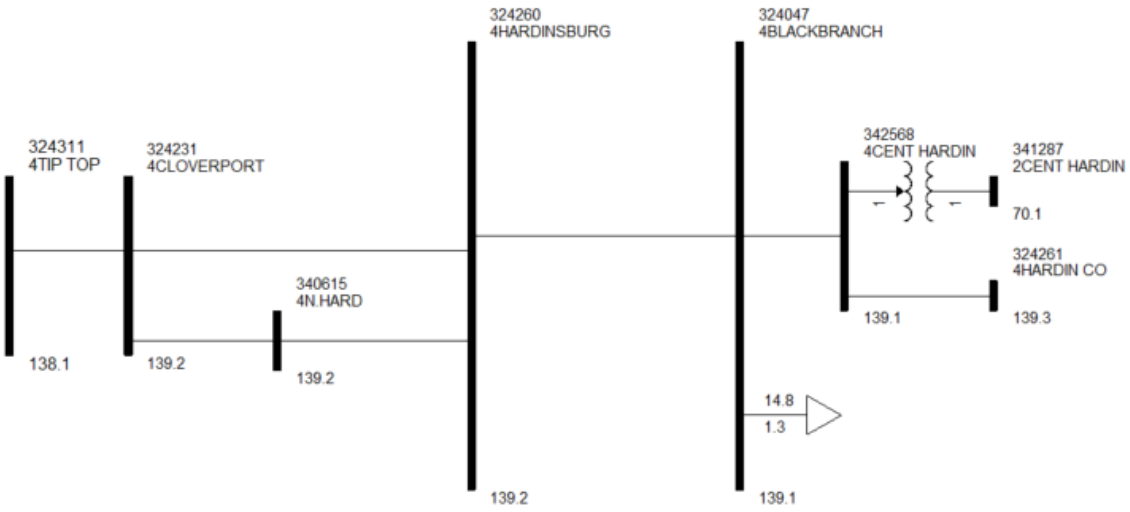
8.3.3 Distribution Facilities: (Total Estimated Cost $0 USD)

No distribution facility upgrades have been identified.

Appendix A: One Line Diagram

One Line Diagram for the proposed GI-2019-029 Solar GI Request

Point of Interconnection



Appendix B: Generation Dispatch Scenarios

Table B-1
Generation Dispatch Scenarios Studied

Dispatch Code	Description
BG12_MISO	Outage Bluegrass units 1 & 2, replace with import from MISO (XEL).
BG12_PJM	Outage Bluegrass units 1 & 2, replace with import from PJM (AEP).
BG12_TVA	Outage Bluegrass units 1 & 2, replace with import from TVA.
BR3_LV_TC_MISO	Outage Brown #3, replace with small Louisville units, Trimble County CTs, and import remainder from MISO (XEL).
BR3_MISO	Outage of Brown Unit #3 and replace with import from MISO (XEL).
BR3_PJM	Outage of Brown Unit #3 and replace with import from PJM (AEP).
BR3_PR13_MISO	Outage of Brown Unit #3, replace with Paddys Run 13, and import remainder from MISO (XEL).
BR3_PR13_TC_MISO	Outage of Brown Unit #3, replace with Paddys Run 13, Trimble Co CTs, and import remainder from MISO (XEL).
BR3_TC_MISO	Outage of Brown Unit #3, replace with Trimble Co CTs, and import remainder from MISO (XEL).
BR3_TVA	Outage of Brown Unit #3 and replace with import from TVA.
CR7_BR_TVA	Outage of Cane Run Unit #7, replace with Brown CTs, and import remainder from TVA.
CR7_MISO	Outage of Cane Run Unit #7 and replace with import from MISO (XEL).
CR7_PR13_MISO	Outage of Cane Run Unit #7, replace with Paddys Run #13, and import remainder from MISO (XEL).
CR7_PR13_TC_MISO	Outage of Cane Run Unit #7, replace with Paddys Run #13, Trimble Co CTs, and import remainder from MISO (XEL).
CR7_TC_MISO	Outage of Cane Run Unit #7, replace with Trimble Co CTs, and import remainder from MISO (XEL).
CR7_TC_PJM	Outage of Cane Run Unit #7, replace with Trimble Co CTs, and import remainder from PJM (AEP).
GH1_BR_TVA	Outage of Ghent Unit #1, replace with Brown CTs, and import remainder from TVA.
GH1_MISO	Outage of Ghent Unit #1 and replace with import from MISO (XEL).
GH1_TC_MISO	Outage of Ghent Unit #1, replace with Trimble Co CTs and import from MISO (XEL).
GH3_BR_TVA	Outage of Ghent Unit #3, replace with Brown CTs, and import remainder from TVA.
GH3_MISO	Outage of Ghent Unit #3 and replace with import from MISO (XEL).
GH3_TC_MISO	Outage of Ghent Unit #3, replace with Brown CTs, and import remainder from MISO (XEL).
MBG_NITS	Maximize Bluegrass units, reduce import from EKPC and proportionally scale EKPC generation.
MBR_CR7	Maximize Brown Plant with an outage of Cane Run #7 and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.

Dispatch Code	Description
MBR_GH1	Maximize Brown Plant with an outage of Ghent #1 and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MBR_GH3	Maximize Brown Plant with an outage of Ghent #3 and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MBR_MC4	Maximize Brown Plant with an outage of Mill Creek 4 and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MBR_NITS	Maximize Brown and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MBR_TC2	Maximize Brown Plant with an outage of Trimble Co #2 and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MC4_BR_MISO	Outage of Mill Creek Unit #4, replace with Brown CTs, and import remainder from MISO (XEL).
MC4_BR_PJM	Outage of Mill Creek Unit #4, replace with Brown CTs, and import remainder from PJM (AEP).
MC4_BR_TVA	Outage of Mill Creek Unit #4, replace with Brown CTs, and import remainder from TVA.
MC4_MISO	Outage of Mill Creek Unit #4 and replace with import from MISO (XEL).
MC4_TC_MISO	Outage of Mill Creek Unit #4, replace with Trimble Co CTs, and import remainder from MISO (XEL).
MC4_TVA	Outage of Mill Creek Unit #4 and replace with import from TVA.
MCR_NITS	Maximize Cane Run units and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MDX_NITS	Maximize Dix Dam units and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MGH_NITS	Maximize Ghent units and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MHF_NITS	Maximize Haefling units and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MMC_NITS	Maximize Mill Creek units and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MOF_NITS	Maximize Ohio Falls units and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MPD_NITS	Maximize Paducah Power units and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MPR_NITS	Maximize Paddys Run units and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MPS_NITS	Maximize Paris units and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MTC_BR3	Maximize Trimble Co Plant for an outage of Brown #3 and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MTC_CR7	Maximize Trimble Co Plant for an outage of Cane Run 7 and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MTC_GH1	Maximize Trimble Co Plant for an outage of Ghent 1 and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.

Dispatch Code	Description
MTC_GH3	Maximize Trimble Co Plant for an outage of Ghent 3 and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MTC_MC4	Maximize Trimble Co Plant for an outage of Mill Creek 4 and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MTC_NITS	Maximize Trimble Co Plant and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
MZR_NITS	Maximize Zorn and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants.
PP12_MISO	Outage Paducah Power units and replace with import from MISO (XEL).
PP12_PJM	Outage Paducah Power units and replace with import from PJM (AEP).
PP12_TVA	Outage Paducah Power units and replace with import from TVA.
PR13_MISO	Outage of Paddys Run #13 and replace with import from MISO (XEL).
PR13_TC_MISO	Outage of Paddys Run #13, replace with Trimble Co CTs, and import remainder from MISO (XEL).
SM2_MISO	Outage Smith #2 and replace import from MISO (XEL).
SM2_PJM	Outage Smith #2 and replace import from PJM (AEP).
SM2_TVA	Outage Smith #2 and replace import from TVA.
TC2_BR_MISO	Outage of Trimble Co Unit #2, replace with Brown CTs, and import remainder from MISO (XEL).
TC2_BR_TVA	Outage of Trimble Co Unit #2, replace with Brown CTs, and import remainder from TVA.
TC2_HF_MISO	Outage of Trimble Co Unit #2, replace with Haefling units, and import remainder from MISO (XEL).
TC2_MISO	Outage of Trimble Co Unit #2 and replace with import from MISO (XEL).
TC2_PR13_MISO	Outage of Trimble Co Unit #2, replace with Paddys Run #13, and import remainder from MISO (XEL).
TC2_PR13_TVA	Outage of Trimble Co Unit #2, replace with Paddys Run #13, and import remainder from TVA.
TC2_TVA	Outage of Trimble Co Unit #2 and replace with import from TVA.
S_CR7_BR_TVA	Start up Cane Run 7, replace with Brown CTs, and import remainder from TVA.
S_CR7_MISO	Start up Cane Run 7, replace with import from MISO (XEL).
S_CR7_PR13_MISO	Start up Cane Run 7, replace with Paddys Run 13, and import remainder from MISO (XEL).
S_CR7_PR13_TC_MISO	Start up Cane Run 7, replace with Paddys Run 13, Trimble Co CTs, and import remainder from MISO (XEL).
S_CR7_TC_MISO	Start up Cane Run 7, replace with Trimble Co CTs, and import remainder from MISO (XEL).
S_CR7_TC_PJM	Start up Cane Run 7, replace with Trimble Co CTs, and import remainder from PJM (AEP).
S_GH1_BR_TVA	Start up of Ghent 1, replace with Brown CTs, and import remainder from TVA.

Dispatch Code	Description
S_GH1_MISO	Start up of Ghent 1 and replace with import from MISO (XEL).
S_GH1_TC_MISO	Start up of Ghent 1, replace with Trimble Co CTs, and import remainder from MISO (XEL).
S_GH3_BR_TVA	Start up of Ghent 3, replace with Brown CTs, and import remainder from TVA.
S_GH3_MISO	Start up of Ghent 3 and replace with import from MISO (XEL).
S_GH3_TC_MISO	Start up of Ghent 3, replace with Trimble Co CTs, and import remainder from MISO (XEL).
S_MBR_CR7	Start up of Cane Run 7, maximize Brown Plant, and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants as required.
S_MBR_GH1	Start up of Ghent 1, maximize Brown Plant, and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants as required.
S_MBR_GH3	Start up of Ghent 3, maximize Brown Plant, and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants as required.
S_MBR_MC4	Start up of Mill Creek 4, maximize Brown Plant, and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants as required.
S_MC4_BR_MISO	Start up of Mill Creek 4, replace with Brown CTs, and import remainder from MISO (XEL).
S_MC4_BR_PJM	Start up of Mill Creek 4, replace with Brown CTs, and import remainder from PJM (AEP).
S_MC4_BR_TVA	Start up of Mill Creek 4, replace with Brown CTs, and import remainder from TVA.
S_MC4_MISO	Start up of Mill Creek 4 and replace with import from MISO (XEL).
S_MC4_TC_MISO	Start up of Mill Creek 4, replace with Trimble Co CTs, and import remainder from MISO (XEL).
S_MC4_TVA	Start up of Mill Creek 4 and replace with import from TVA.
S_MTC_CR7	Start up of Cane Run 7, maximize Trimble Co Plant, and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants as required.
S_MTC_GH1	Start up of Ghent 1, maximize Trimble Co Plant, and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants as required.
S_MTC_GH3	Start up of Ghent 3, maximize Trimble Co Plant, and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants as required.
S_MTC_MC4	Start up of Mill Creek 4, maximize Trimble Co Plant, and proportionally decrease generation at the remaining LG&E/KU affiliate generating plants as required.
BG12_BG3_MISO_2U	Two unit outage - Bluegrass 1&2 and Bluegrass 3, replace with import from MISO (XEL).
BG12_BG3_PJM_2U	Two unit outage - Bluegrass 1&2 and Bluegrass 3, replace with import from PJM (AEP).
BG12_BG3_TVA_2U	Two unit outage - Bluegrass 1&2 and Bluegrass 3, replace with import from TVA.

Dispatch Code	Description
Br3_Gh1_MISO_2U	Two unit outage - Brown 3 and Ghent 1, replace with import from MISO (XEL).
Br3_Gh1_PJM_2U	Two unit outage - Brown 3 and Ghent 1, replace with import from PJM (AEP).
Br3_Gh1_tc_MISO_2U	Two unit outage - Brown 3 and Ghent 1, replace with Trimble Co CTs, and import remainder from MISO (XEL).
Br3_Gh1_tc_TVA_2U	Two unit outage - Brown 3 and Ghent 1, replace with Trimble Co CTs, and import remainder from TVA.
Br3_Gh1_TVA_2U	Two unit outage - Brown 3 and Ghent 1, replace with import from TVA.
Br3_Gh3_MISO_2U	Two unit outage - Brown 3 and Ghent 3, replace with import from MISO (XEL).
Br3_Gh3_PJM_2U	Two unit outage - Brown 3 and Ghent 3, replace with import from PJM (AEP).
Br3_Gh3_tc_MISO_2U	Two unit outage - Brown 3 and Ghent 3, replace with Trimble Co CTs, and import remainder from MISO.
Br3_Gh3_tc_TVA_2U	Two unit outage - Brown 3 and Ghent 3, replace with Trimble Co CTs, and import remainder from TVA.
Br3_Gh3_TVA_2U	Two unit outage - Brown 3 and Ghent 3, replace with import from TVA.
CR7_BG12_MISO_2U	Two unit outage - Cane Run 7 and Bluegrass 1&2, replace with import from MISO (XEL).
CR7_BG12_PJM_2U	Two unit outage - Cane Run 7 and Bluegrass 1&2, replace with import from PJM (AEP).
CR7_BG12_TVA_2U	Two unit outage - Cane Run 7 and Bluegrass 1&2, replace with import from TVA.
CR7_MC4_MISO_2U	Two unit outage - Cane Run 7 and Mill Creek 4, replace with import from MISO (XEL).
CR7_MC4_PJM_2U	Two unit outage - Cane Run 7 and Mill Creek 4, replace with import from PJM (AEP).
CR7_MC4_TVA_2U	Two unit outage - Cane Run 7 and Mill Creek 4, replace with import from TVA.
CR7_PR_MISO_2U	Two unit outage - Cane Run 7 and Paddys Run 13, replace with import from MISO (XEL).
CR7_PR_PJM_2U	Two unit outage - Cane Run 7 and Paddys Run 13, replace with import from PJM (AEP).
CR7_PR_tc_br_MISO_2U	Two unit outage - Cane Run 7 and Paddys Run 13, replace with Trimble Co CTs, Brown CTs, and import remainder from MISO (XEL).
CR7_PR_tc_br_TVA_2U	Two unit outage - Cane Run 7 and Paddys Run 13, replace with Trimble Co CTs, Brown CTs, and import remainder from TVA.
CR7_PR_tc_MISO_2U	Two unit outage - Cane Run 7 and Paddys Run 13, replace with Trimble Co CTs, and import remainder from MISO (XEL).
CR7_PR_tc_TVA_2U	Two unit outage - Cane Run 7 and Paddys Run 13, replace with Trimble Co CTs, and import remainder from TVA.
CR7_PR_TVA_2U	Two unit outage - Cane Run 7 and Paddys Run 13, replace with import from TVA.
CR7_TC2_br_MISO_2U	Two unit outage - Cane Run 7 and Trimble Co 2, replace with Brown CTs, and import remainder from MISO (XEL).
CR7_TC2_br_TVA_2U	Two unit outage - Cane Run 7 and Trimble Co 2, replace with Brown CTs, and import remainder from TVA.
CR7_TC2_MISO_2U	Two unit outage - Cane Run 7 and Trimble Co 2, replace with import from MISO (XEL).
CR7_TC2_PJM_2U	Two unit outage - Cane Run 7 and Trimble Co 2, replace with import from PJM (AEP).

Dispatch Code	Description
CR7_TC2_TVA_2U	Two unit outage - Cane Run 7 and Trimble Co 2, replace with import from TVA.
Gh1_3_MISO_2U	Two unit outage - Ghent 1 and Ghent 3, replace with import from MISO (XEL).
Gh1_3_PJM_2U	Two unit outage - Ghent 1 and Ghent 3, replace with import from PJM (AEP).
Gh1_3_tc_br_MISO_2U	Two unit outage - Ghent 1 and Ghent 3, replace with Trimble Co CTs, Brown CTs, and import remainder from MISO (XEL).
Gh1_3_tc_br_TVA_2U	Two unit outage - Ghent 1 and Ghent 3, replace with Trimble Co CTs, Brown CTs, and import remainder from TVA.
Gh1_3_TVA_2U	Two unit outage - Ghent 1 and Ghent 3, replace with import from TVA.
Gh4_3_MISO_2U	Two unit outage - Ghent 4 and Ghent 3, replace with import from MISO (XEL).
Gh4_3_PJM_2U	Two unit outage - Ghent 4 and Ghent 3, replace with import from PJM (AEP).
Gh4_3_tc_br_MISO_2U	Two unit outage - Ghent 4 and Ghent 3, replace with Trimble Co CTs, Brown CTs, and import remainder from MISO (XEL).
Gh4_3_tc_br_TVA_2U	Two unit outage - Ghent 4 and Ghent 3, replace with Trimble Co CTs, Brown CTs, and import remainder from TVA.
Gh4_3_TVA_2U	Two unit outage - Ghent 4 and Ghent 3, replace with import from TVA.
MC4_BG12_MISO_2U	Two unit outage - Mill Creek 4 and Bluegrass 1&2, replace with import from MISO (XEL).
MC4_BG12_PJM_2U	Two unit outage - Mill Creek 4 and Bluegrass 1&2, replace with import from PJM (AEP).
MC4_BG12_TVA_2U	Two unit outage - Mill Creek 4 and Bluegrass 1&2, replace with import from TVA.
MC4_MC3_MISO_2U	Two unit outage - Mill Creek 4 and Mill Creek 3, replace with import from MISO (XEL).
MC4_MC3_PJM_2U	Two unit outage - Mill Creek 4 and Mill Creek 3, replace with import from PJM (AEP).
MC4_MC3_tc_br_MISO_2U	Two unit outage - Mill Creek 4 and Mill Creek 3, replace with Trimble Co CTs, Brown CTs, and import remainder from MISO (XEL).
MC4_MC3_tc_br_TVA_2U	Two unit outage - Mill Creek 4 and Mill Creek 3, replace with Trimble Co CTs, Brown CTs, and import remainder from TVA.
MC4_MC3_TVA_2U	Two unit outage - Mill Creek 4 and Mill Creek 3, replace with import from TVA.
MC4_TC2_br_MISO_2U	Two unit outage - Mill Creek 4 and Trimble Co 2, replace Brown CTs, and import remainder from MISO (XEL).
MC4_TC2_br_TVA_2U	Two unit outage - Mill Creek 4 and Trimble Co 2, replace with Brown CTs, and import remainder from TVA.
MC4_TC2_MISO_2U	Two unit outage - Mill Creek 4 and Trimble Co 2, replace with import from MISO.
MC4_TC2_PJM_2U	Two unit outage - Mill Creek 4 and Trimble Co 2, replace with import from PJM (AEP).
MC4_TC2_TVA_2U	Two unit outage - Mill Creek 4 and Trimble Co 2, replace with import from TVA.
s_CR7_BG12_MISO_2U	Two unit outage - Start up of Cane Run 7, outage of Bluegrass 1&2, replace with import from MISO (XEL).
s_CR7_BG12_PJM_2U	Two unit outage - Start up of Cane Run 7, outage of Bluegrass 1&2, replace with import from PJM (AEP).
s_CR7_BG12_TVA_2U	Two unit outage - Start up of Cane Run 7, outage of Bluegrass 1&2, replace with import from TVA.

Dispatch Code	Description
s_CR7_BR3_LV_TC_MISO_2U	Two unit outage - Start up of Cane Run 7, outage of Brown 3, replace with small Louisville units, Trimble Co CTs, and import remainder from MISO (XEL).
s_CR7_BR3_LV_TC_PJM_2U	Two unit outage - Start up of Cane Run 7, outage of Brown 3, replace with small Louisville units, Trimble Co CTs, and import remainder from PJM (AEP).
s_CR7_BR3_LV_TC_TVA_2U	Two unit outage - Start up of Cane Run 7, outage of Brown 3, replace with small Louisville units, Trimble Co CTs, and import remainder from TVA.
s_CR7_BR3_MISO_2U	Two unit outage - Start up of Cane Run 7, outage of Brown 3, and import remainder from MISO (XEL).
s_CR7_BR3_PJM_2U	Two unit outage - Start up of Cane Run 7, outage of Brown 3, replace with import from PJM (AEP).
s_CR7_BR3_TVA_2U	Two unit outage - Start up of Cane Run 7, outage of Brown 3, replace with import from TVA.
s_CR7_MC4_MISO_2U	Two unit outage - Start up of Cane Run 7, outage of Mill Creek 4, replace with import from MISO (XEL).
s_CR7_MC4_PJM_2U	Two unit outage - Start up of Cane Run 7, outage of Mill Creek 4, replace with import from PJM (AEP).
s_CR7_MC4_TVA_2U	Two unit outage - Start up of Cane Run 7, outage of Mill Creek 4, replace with import from TVA.
s_CR7_PR_MISO_2U	Two unit outage - Start up of Cane Run 7, outage of Paddys Run 13, replace with import from MISO (XEL).
s_CR7_PR_PJM_2U	Two unit outage - Start up of Cane Run 7, outage of Paddys Run 13, replace with import from PJM (AEP).
s_CR7_PR_tc_br_MISO_2U	Two unit outage - Start up of Cane Run 7, outage of Paddys Run 13, replace with Trimble Co CTs, Brown CTs, and import remaining from MISO (XEL).
s_CR7_PR_tc_br_TVA_2U	Two unit outage - Start up of Cane Run 7, outage of Paddys Run 13, replace with Trimble Co CTs, Brown CTs, and import remaining from TVA.
s_CR7_PR_tc_MISO_2U	Two unit outage - Start up of Cane Run 7, outage of Paddys Run 13, replace with Trimble Co CTs, and import remaining from MISO (XEL).
s_CR7_PR_tc_TVA_2U	Two unit outage - Start up of Cane Run 7, outage of Paddys Run 13, replace with Trimble Co CTs, and import remaining from TVA.
s_CR7_PR_TVA_2U	Two unit outage - Start up of Cane Run 7, outage of Paddys Run 13, replace with import from TVA.
s_CR7_TC2_BR_MISO_2U	Two unit outage - Start up of Cane Run 7, outage of Trimble Co 2, replace with Brown CTs, and import remaining from MISO (XEL).
s_CR7_TC2_BR_PJM_2U	Two unit outage - Start up of Cane Run 7, outage of Trimble Co 2, replace with Brown CTs, and import remaining from PJM (AEP).
s_CR7_TC2_BR_TVA_2U	Two unit outage - Start up of Cane Run 7, outage of Trimble Co 2, replace with Brown, and import remaining from TVA.
s_CR7_TC2_MISO_2U	Two unit outage - Start up of Cane Run 7, outage of Trimble Co 2, replace with import from MISO (XEL).
s_CR7_TC2_PJM_2U	Two unit outage - Start up of Cane Run 7, outage of Trimble Co 2, replace with import from PJM (AEP).

Dispatch Code	Description
s_CR7_TC2_TVA_2U	Two unit outage - Start up of Cane Run 7, outage of Trimble Co 2, replace with import from TVA.
s_GH1_3_MISO_2U	Two unit outage - Start up of Ghent 1, outage of Ghent 3, replace with import from MISO (XEL).
s_GH1_3_PJM_2U	Two unit outage - Start up of Ghent 1, outage of Ghent 3, replace with import from PJM (AEP).
s_GH1_3_TC_BR_MISO_2U	Two unit outage - Start up of Ghent 1, outage of Ghent 3, replace with Trimble Co CTs, Brown CTs, and import remaining from MISO (XEL).
s_GH1_3_TC_BR_TVA_2U	Two unit outage - Start up of Ghent 1, plus outage of Ghent 3, replace with Trimble Co CTs, Brown CTs, and import remaining from TVA.
s_GH1_3_TVA_2U	Two unit outage - Start up of Ghent 1, outage of Ghent 3, replace with import from TVA.
s_GH1_BR3_MISO_2U	Two unit outage - Start up of Ghent 1, outage of Brown 3, replace with import from MISO (XEL).
s_GH1_BR3_PJM_2U	Two unit outage - Start up of Ghent 1, outage of Brown 3, replace with import from PJM (AEP).
s_GH1_BR3_TC_MISO_2U	Two unit outage - Start up of Ghent 1, outage of Brown 3, replace with Trimble Co CTs, and import remaining from MISO (XEL).
s_GH1_BR3_TC_TVA_2U	Two unit outage - Start up of Ghent 1, outage of Brown 3, replace with Trimble Co CTs, and import remaining from TVA.
s_GH1_BR3_TVA_2U	Two unit outage - Start up of Ghent 1, outage of Brown 3, replacing with import from TVA.
s_GH3_1_MISO_2U	Two unit outage - Start up of Ghent 3, outage of Ghent 1, replacing with import from MISO (XEL).
s_GH3_1_PJM_2U	Two unit outage - Start up of Ghent 3, outage of Ghent 1, replacing with import from PJM (AEP).
s_GH3_1_TC_BR_MISO_2U	Two unit outage - Start up of Ghent 3, outage of Ghent 1, replace with Trimble Co CTs, Brown CTs, and import remaining from MISO (XEL).
s_GH3_1_TC_BR_TVA_2U	Two unit outage - Start up of Ghent 3, outage of Ghent 1, replace with Trimble Co CTs, Brown CTs, and import remaining from TVA.
s_GH3_1_TVA_2U	Two unit outage - Start up of Ghent 3, outage of Ghent 1, replacing with import from TVA.
s_GH3_4_MISO_2U	Two unit outage - Start up of Ghent 3, outage of Ghent 4, replacing with import from MISO (XEL).
s_GH3_4_PJM_2U	Two unit outage - Start up of Ghent 3, outage of Ghent 4, replacing with import from PJM (AEP).
s_GH3_4_TC_BR_MISO_2U	Two unit outage - Start up of Ghent 3, outage of Ghent 4, replace with Trimble Co CTs, Brown CTs, and import remaining from MISO (XEL).
s_GH3_4_TC_BR_TVA_2U	Two unit outage - Start up of Ghent 3, outage of Ghent 4, replace with Trimble Co CTs, Brown CTs, and import remaining from TVA.
s_GH3_4_TVA_2U	Two unit outage - Start up of Ghent 3, outage of Ghent 4, replacing with import from TVA.
s_GH3_BR3_MISO_2U	Two unit outage - Start up of Ghent 3, outage of Brown 3, replacing with import from MISO (XEL).
s_GH3_BR3_PJM_2U	Two unit outage - Start up of Ghent 3, outage of Brown 3, replacing with import from PJM (AEP).

Dispatch Code	Description
s_GH3_BR3_TC_MISO_2U	Two unit outage - Start up of Ghent 3, outage of Brown 3, replace with Trimble Co CTs, and import remaining from MISO (XEL).
s_GH3_BR3_TC_TVA_2U	Two unit outage - Start up of Ghent 3, outage of Brown 3, replace with Trimble Co CTs, and import remaining from TVA.
s_GH3_BR3_TVA_2U	Two unit outage, during start up of Ghent 3, plus outage of Brown 3, import from TVA.
s_GH3_TC2_BR_MISO_2U	Two unit outage - Start up of Ghent 3, outage of Trimble Co 2, replace with Brown CTs, and import remaining from MISO (XEL).
s_GH3_TC2_BR_TVA_2U	Two unit outage - Start up of Ghent 3, outage of Trimble Co 2, replace with Brown CTs, and import remaining from TVA.
s_GH3_TC2_MISO_2U	Two unit outage - Start up of Ghent 3, outage of Trimble Co 2, replacing with import from MISO (XEL).
s_GH3_TC2_PJM_2U	Two unit outage - Start up of Ghent 3, outage of Trimble Co 2, replacing with import from PJM (AEP).
s_GH3_TC2_TVA_2U	Two unit outage - Start up of Ghent 3, outage of Trimble Co 2, replacing with import from TVA.
s_MC4_BG12_MISO_2U	Two unit outage - Start up of Mill Creek 4, outage of Bluegrass 1&2, replacing with import from MISO (XEL).
s_MC4_BG12_PJM_2U	Two unit outage - Start up of Mill Creek 4, outage of Bluegrass 1&2, replacing with import from PJM (AEP).
s_MC4_BG12_TVA_2U	Two unit outage - Start up of Mill Creek 4, outage of Bluegrass 1&2, replacing with import from TVA.
s_MC4_CR7_MISO_2U	Two unit outage - Start up of Mill Creek 4, outage of Cane Run 7, replacing with import from MISO (XEL).
s_MC4_CR7_PJM_2U	Two unit outage - Start up of Mill Creek 4, outage of Cane Run 7, replacing with import from PJM (AEP).
s_MC4_CR7_TVA_2U	Two unit outage - Start up of Mill Creek 4, outage of Cane Run 7, replacing with import from TVA.
s_MC4_MC3_MC3_TC_BR_TVA_2U	Two unit outage - Start up of Mill Creek 4, outage of Mill Creek 3, replace with Trimble Co CTs, Brown CTs, and import remaining from TVA.
s_MC4_MC3_MISO_2U	Two unit outage - Start up of Mill Creek 4, outage of Mill Creek 3, replacing with import from MISO (XEL).
s_MC4_MC3_PJM_2U	Two unit outage - Start up of Mill Creek 4, outage of Mill Creek 3, replacing with import from PJM (AEP).
s_MC4_MC3_TC_BR_MISO_2U	Two unit outage - Start up of Mill Creek 4, outage of Mill Creek 3, replace with Trimble Co CTs, Brown CTs, and import remaining from MISO (XEL).
s_MC4_MC3_TVA_2U	Two unit outage - Start up of Mill Creek 4, outage of Mill Creek 3, replacing with import from TVA.
s_MC4_TC2_BR_MISO_2U	Two unit outage - Start up of Mill Creek 4, outage of Trimble 2, replace with Brown CTs, and import remaining from MISO (XEL).
s_MC4_TC2_BR_TVA_2U	Two unit outage - Start up of Mill Creek 4, outage of Trimble 2, replace with Brown CTs, and import remaining from TVA.
s_MC4_TC2_MISO_2U	Two unit outage - Start up of Mill Creek 4, outage of Trimble 2, replacing with import from MISO (XEL).
s_MC4_TC2_PJM_2U	Two unit outage - Start up of Mill Creek 4, outage of Trimble 2, replacing with import from PJM (AEP).
s_MC4_TC2_TVA_2U	Two unit outage - Start up of Mill Creek 4, outage of Trimble 2, replacing with import from TVA.
TC2_BG12_MISO_2U	Two unit outage - Trimble Co 2 and Bluegrass 1&2, replacing with import from MISO (XEL).
TC2_BG12_PJM_2U	Two unit outage - Trimble Co 2 and Bluegrass 1&2, replacing with import from PJM (AEP).

Dispatch Code	Description
TC2_BG12_TVA_2U	Two unit outage - Trimble Co 2 and Bluegrass 1&2, replacing with import from TVA.
TC2_GH3_br_MISO_2U	Two unit outage - Trimble Co 2 and Ghent 3, replace with Brown CTs, and import remaining from MISO (XEL).
TC2_GH3_br_TVA_2U	Two unit outage - Trimble Co 2 and Ghent 3, replace with Brown CTs, and import remaining from TVA.
TC2_GH3_MISO_2U	Two unit outage - Trimble Co 2 and Ghent 3, replacing with import from MISO (XEL).
TC2_GH3_PJM_2U	Two unit outage - Trimble Co 2 and Ghent 3, replacing with import from PJM (AEP).
TC2_GH3_TVA_2U	Two unit outage - Trimble Co 2 and Ghent 3, replacing with import from TVA.
TC2_TC1_br_MISO_2U	Two unit outage - Trimble Co 1 and Trimble Co 2, replace with Brown CTs, and import remaining from MISO (XEL).
TC2_TC1_br_TVA_2U	Two unit outage - Trimble Co 1 and Trimble Co 2, replace with Brown CTs, and import remaining from TVA.
TC2_TC1_MISO_2U	Two unit outage - Trimble Co 1 and Trimble Co 2, replacing with import from MISO (XEL).
TC2_TC1_PJM_2U	Two unit outage - Trimble Co 1 and Trimble Co 2, replacing with import from PJM (AEP).
TC2_TC1_TVA_2U	Two unit outage - Trimble Co 1 and Trimble Co 2, replacing with import from TVA.
BULLRUN1_S	Outage of TVA's Bull Run F 1 L, replacing with import from SOCO.
CANNELTON_W	Outage of SIGE's Cannelton Hydro units, replacing with import from MISO.
CLIFTY_N	Outage of OVEC's Clifty 7, replacing with import from AP.
COLEMAN3_W	Outage of BREC's Coleman 3, replacing with import from MISO (XEL).
CPR2_N	Outage of EKPC's Cooper 2, replacing with import from AP.
CRG2H_N	Outage of AEP's Clinch River 2 (H&L), replacing with import from AP.
EBND2_N	Outage of DEO&K's East Bend 2, replacing with import from AP.
GALL2_W	Outage of DEL's Gallagher 2, replacing with import from AP.
GALL4_W	Outage of DEL's Gallagher 4, replacing with import from AP.
GALLATIN1_S	Outage of TVA's Gallatin 1, replacing with import from SOCO.
GIB2_W	Outage of DEI's Gibson 2, replacing with import from MISO (XEL).
GREEN1_W	Outage of BREC's Green 1, replacing with import from MISO (XEL).
INDDRV_N	Outage of AEP's Industrial Drive, replacing with import from AP.
JKCT3_N	Outage of EKPC's JK Smith 3, replacing with import from AP.
JKCT9_N	Outage of EKPC's JK Smith 9, replacing with import from AP.
JOPPA2_W	Outage of EEI's Joppa 2, replacing with import from MISO (XEL).
JOPPA4_W	Outage of EEI's Joppa 4, replacing with import from MISO (XEL).

Dispatch Code	Description
JOPPAG45_W	Outage of EEI's Joppa G 4&5, replacing with import from MISO (XEL).
KILLEN_N	Outage of Dayton PL Killen 2, replacing with import from AP.
KYGER_N	Outage of OVEC's Kyger 6, replacing with import from AP.
LAUREL_N	Outage of EKPC's Laurel Lake, replacing with import from AP.
LAWBG1_N	Outage of AEP's Lawrenceburg 1A/B/C, replacing with import from AP.
MERMOM_W	Outage of HE's Merom 2, replacing with import from MISO (XEL).
MFRT6_N	Outage of DEO&K's Miami Fort 6, replacing with import from AP.
MFRT8_N	Outage of DEO&K's Miami Fort 8, replacing with import from AP.
MRKLND_W	Outage of DEI's Markland Dam, replacing with import from AP.
NORRIS1_S	Outage of TVA's Norris, replacing with import from SOCO.
NTEGEN_N	Outage of DEO&K's NTE Energy 1, replacing with import from AP.
PARADISCT3S1_S	Outage of TVA's Paradise CT 3, replacing with import from SOCO.
RKG2_N	Outage of AEP's Rockport 1, replacing with import from AP.
SEQ2_S	Outage of TVA's Sequoila 2, replacing with import from SOCO.
SHAWNEE2_S	Outage of TVA's Shawnee 2, replacing with import from SOCO.
SHAWNEE9_S	Outage of TVA's Shawnee 9, replacing with import from SOCO.
SPLK1_N	Outage of EKPC's Spurlock 1, replacing with import from AP.
SPLK2_N	Outage of EKPC's Spurlock 2, replacing with import from AP.
STUART_N	Outage of Dayton P&L Stuart, replacing with import from AP.
VACITY_SE	Outage of AEP's Virginia City, replacing with import from DVP.
WBNP1_S	Outage of TVA's Watts Bar 1, replacing with import from SOCO.
WILSON_W	Outage of BREC's Wilson, replacing with import from MISO.
WOLFCR1_S	Outage of TVA's Wolf Creek, replacing with import from SOCO.

Appendix C: Divergent Contingencies

There were numerous contingency and dispatch conditions for which a convergent solution could not be obtained with switched shunts enabled. For these contingencies, a solution was attempted with switched shunts locked. If constraints were found to exist for any of these contingencies using the locked switched shunts solution method, further analysis was performed.

Appendix D: Powerflow Model Detailed Analysis

Network Analysis

No thermal constraints due to the subject request were found. No voltage constraints due to the subject request were found.

Flowgate Analysis

Table D-1
NRIS Flowgate Detailed Analysis Results

Year/ Season	Constrained Interface					Pre Project	Post Project
	NERC Id	NERC Name	Owner	Type	Rating	MW	MW
2022OP	2047	GIBPETGIBBDF	MISO	OTDF	912.1	834.8	839.3
2022OP	1024	VOLPHBCONMOS	TVA	OTDF	1768.4	1207.3	1209.8
2022OP	1023	VOLPHBJEFROC	TVA	OTDF	1770.2	1134.4	1136.9
2022OP	1613	VOLPHB__PTDF	TVA	PTDF	1733.2	1049.8	1052.3
2022OP	17884	VOLPHBCULWYO	TVA	OTDF	1772	1071.6	1073.9
2022OP	2614	BULVOLWBNVOL	TVA	OTDF	2446.5	1457.2	1459.6
2022OP	23687	VOLPHIGAVIN2	TVA	OTDF	1773.6	1044.8	1047.2
2022OP	17564	VOLPHIMOUNTA	TVA	OTDF	1773.6	1044.4	1046.8
2022OP	24583	VOLPHIANTJAC	TVA	OTDF	1897	1090.4	1093
2022OP	1644	BLLVOL__PTDF	TVA	PTDF	2413.5	1001.5	1003.6
2022OP	2837	WILGRVMATWIL	MISO	OTDF	497.4	178.7	177.6
2022OP	3322	4CL4NH4CL4HA	MISO	OTDF	187.2	52.6	41.5
2022OP	2244	PDRSSHBAKBRO	TVA	OTDF	194.5	18.4	18.1
2022OP	1095	SMIXFRWILDAV	OMU	OTDF	308	-22.1	-24.2
2022OP	19146	SMTXFRGRSCLV	OMU	OTDF	308	-39.9	-40.1
2022OP	20603	SMTXFRCOLNEW	OMU	OTDF	308	-45.2	-42.5
2022OP	2973	SMIXFMHBGHCO	OMU	OTDF	308	-57.5	-54.7
2022S	2047	GIBPETGIBBDF	MISO	OTDF	970.4	792.7	796.1
2022S	1024	VOLPHBCONMOS	TVA	OTDF	1768.4	1191.3	1192.7
2022S	1023	VOLPHBJEFROC	TVA	OTDF	1770.2	1119.8	1121.3
2022S	17564	VOLPHIMOUNTA	TVA	OTDF	1773.6	1106.5	1107.9
2022S	1613	VOLPHB__PTDF	TVA	PTDF	1733.2	1036.6	1038.2
2022S	17884	VOLPHBCULWYO	TVA	OTDF	1772	1059.3	1060.6
2022S	2614	BULVOLWBNVOL	TVA	OTDF	2446.5	1453.7	1455
2022S	23687	VOLPHIGAVIN2	TVA	OTDF	1773.6	1031.4	1032.8
2022S	24583	VOLPHIANTJAC	TVA	OTDF	1897	1074.4	1076
2022S	2837	WILGRVMATWIL	MISO	OTDF	495.8	261.1	259.9
2022S	1644	BLLVOL__PTDF	TVA	PTDF	2413.5	994.6	995.9
2022S	3322	4CL4NH4CL4HA	MISO	OTDF	187.3	44.6	34.7
2022S	2244	PDRSSHBAKBRO	TVA	OTDF	180.9	33.1	32.1
2022S	1095	SMIXFRWILDAV	OMU	OTDF	308	39.5	38.1
2022S	20603	SMTXFRCOLNEW	OMU	OTDF	308	-100.8	-98.7
2022S	2973	SMIXFMHBGHCO	OMU	OTDF	308	-113.9	-111.8
2022S	19146	SMTXFRGRSCLV	OMU	OTDF	308	-114.6	-114.9

Appendix E: Powerflow Model Documentation

Table E-1
Selected Generation Modeling in the Pre GI-2019-029
ERIS Summer/Off Peak Models

Bus Number	Bus Name	ID	2022OP PGen (MW)	2022OP PMax (MW)	2022S PGen (MW)	2022S PMax (MW)
324000	1BROWN 1 13.800	1	0	0	0	0
324001	1BROWN 2 18.000	2	0	0	0	0
324002	1BROWN 3 24.000	3	0	455.5	459	459
324003	1BROWN 5 13.800	5	0	121	0	131
324004	1BROWN 6 18.000	6	0	158	0	155
324005	1BROWN 7 18.000	7	0	158	0	154
324006	1BROWN 8 13.800	8	0	119	0	122
324007	1BROWN 9 13.800	9	0	119	0	122
324008	1BROWN 10 13.800	10	0	119	0	122
324009	1BROWN 11 13.800	11	0	119	0	122
324013	1CANE RN 11 14.000	11	0	14	0	14
324014	1DIX DAM 1 13.200	1	11.3	11.3	10.5	10.5
324015	1DIX DAM 2 13.200	2	11.3	11.3	10.5	10.5
324016	1DIX DAM 3 13.200	3	11.3	11.3	10.5	10.5
324017	1GHENT 1 18.000	1	0	520	526	526
324018	1GHENT 2 22.000	2	372.0835	520	530	530
324019	1GHENT 3 22.000	3	0	527.5	538	538
324020	1GHENT 4 22.000	4	262	525	538	538
324023	1HAEFLING 13.800	1	0	14	0	12
324023	1HAEFLING 13.800	2	0	14	0	12
324024	1MILL CRK 1 22.000	1	330	330	333	333
324025	1MILL CRK 2 22.000	2	330	330	336	336
324026	1MILL CRK 3 22.000	3	422.5	422.5	425	425
324027	1MILL CRK 4 22.000	4	521	521	526	526
324031	1PADDY RN 1316.000	13	0	162	0	152
324034	1TRIM CO 1 22.000	1	552	552	530	530
324035	1TRIM CO 2 24.000	2	817	817	781	781
324036	1TRIM CO 5 18.000	5	0	170	160.4	160.437
324037	1TRIM CO 6 18.000	6	0	170	171.3	171.255
324038	1TRIM CO 7 18.000	7	0	170	89.07	163.175
324039	1TRIM CO 8 18.000	8	0	170	81	160
324040	1TRIM CO 9 18.000	9	0	170	81	165.988
324041	1TRIM CO 10 18.000	10	0	170	81	163.753
324043	2ZORN 69.000	1	0	15	0	14
324044	1BLUEGRASS 118.000	1	0	166	166	166

324045	1BLUEGRASS 218.000	2	0	166	166	166
324046	1BLUEGRASS 318.000	3	0	166	166	166
324052	1LOCK 7 2.4000	1	2	2	2	2
324234	1OHIO FALL 114.000	1	12.625	12.625	8	8
324234	1OHIO FALL 114.000	2	12.625	12.625	8	8
324234	1OHIO FALL 114.000	3	12.625	12.625	8	8
324234	1OHIO FALL 114.000	4	12.625	12.625	8	8
324235	1OHIO FALL 214.000	5	12.625	12.625	8	8
324235	1OHIO FALL 214.000	6	12.625	12.625	8	8
324235	1OHIO FALL 214.000	7	12.625	12.625	8	8
324235	1OHIO FALL 214.000	8	12.625	12.625	8	8
324677	2PARIS 12 69.000	1	0	11.27	0	11.27
324697	1KMPA PAD2 13.800	2	0	61	47.85	54
324699	2RICE STA TP69.000	1	2.64	2.64	2.64	2.64
324933	1KMPA PAD1 13.800	1	0	61	47.85	54
325012	1BROWN SOLAR13.200	S1	10	10	8	8
325093	1CANERUN7CT118.000	71	234.5	234.5	231.5	231.5
325094	1CANERUN7CT218.000	72	234.5	234.5	231.5	231.5
325095	1CANERUN7ST 18.000	7S	235	235	241	241
326514	1PADDY RN 1114.000	11	0	12.5	0	12
326515	1PADDY RN 1214.000	12	0	25.5	0	23
326541	2EKPC OFFICE69.000	P1	5	5	8.5	8.5
990060	GI006 GEN 0.6000	1	100.58	100.58	80.46	100.58
999003	GI-003 GEN 34.500	1	35	35	28	35

Table E-2
Selected Generation Modeling in the Post GI-2019-029
ERIS Summer/Off-Peak Models

Bus Number	Bus Name	ID	2022OP PGen (MW)	2022OP PMax (MW)	2022S PGen (MW)	2022S PMax (MW)
324000	1BROWN 1 13.800	1	0	0	0	0
324001	1BROWN 2 18.000	2	0	0	0	0
324002	1BROWN 3 24.000	3	0	455.5	459	459
324003	1BROWN 5 13.800	5	0	121	0	131
324004	1BROWN 6 18.000	6	0	158	0	155
324005	1BROWN 7 18.000	7	0	158	0	154
324006	1BROWN 8 13.800	8	0	119	0	122
324007	1BROWN 9 13.800	9	0	119	0	122
324008	1BROWN 10 13.800	10	0	119	0	122
324009	1BROWN 11 13.800	11	0	119	0	122
324013	1CANE RN 11 14.000	11	0	14	0	14

324014	1DIX DAM 1 13.200	1	11.3	11.3	10.5	10.5
324015	1DIX DAM 2 13.200	2	11.3	11.3	10.5	10.5
324016	1DIX DAM 3 13.200	3	11.3	11.3	10.5	10.5
324017	1GHENT 1 18.000	1	0	520	526	526
324018	1GHENT 2 22.000	2	371.403	520	530	530
324019	1GHENT 3 22.000	3	0	527.5	538	538
324020	1GHENT 4 22.000	4	262	525	538	538
324023	1HAEFLING 13.800	1	0	14	0	12
324023	1HAEFLING 13.800	2	0	14	0	12
324024	1MILL CRK 1 22.000	1	330	330	333	333
324025	1MILL CRK 2 22.000	2	330	330	336	336
324026	1MILL CRK 3 22.000	3	422.5	422.5	425	425
324027	1MILL CRK 4 22.000	4	521	521	526	526
324031	1PADDY RN 1316.000	13	0	162	0	152
324034	1TRIM CO 1 22.000	1	552	552	530	530
324035	1TRIM CO 2 24.000	2	817	817	781	781
324036	1TRIM CO 5 18.000	5	0	170	160.44	160.44
324037	1TRIM CO 6 18.000	6	0	170	171.25	171.25
324038	1TRIM CO 7 18.000	7	0	170	88.009	163.18
324039	1TRIM CO 8 18.000	8	0	170	81	160
324040	1TRIM CO 9 18.000	9	0	170	81	165.99
324041	1TRIM CO 10 18.000	10	0	170	81	163.75
324043	2ZORN 69.000	1	0	15	0	14
324044	1BLUEGRASS 118.000	1	0	166	166	166
324045	1BLUEGRASS 218.000	2	0	166	166	166
324046	1BLUEGRASS 318.000	3	0	166	166	166
324052	1LOCK 7 2.4000	1	2	2	2	2
324234	1OHIO FALL 114.000	1	12.625	12.625	8	8
324234	1OHIO FALL 114.000	2	12.625	12.625	8	8
324234	1OHIO FALL 114.000	3	12.625	12.625	8	8
324234	1OHIO FALL 114.000	4	12.625	12.625	8	8
324235	1OHIO FALL 214.000	5	12.625	12.625	8	8
324235	1OHIO FALL 214.000	6	12.625	12.625	8	8
324235	1OHIO FALL 214.000	7	12.625	12.625	8	8
324235	1OHIO FALL 214.000	8	12.625	12.625	8	8
324677	2PARIS 12 69.000	1	0	11.27	0	11.27
324697	1KMPA PAD2 13.800	2	0	61	47.85	54
324699	2RICE STA TP69.000	1	2.64	2.64	2.64	2.64
324933	1KMPA PAD1 13.800	1	0	61	47.85	54
325012	1BROWN SOLAR13.200	S1	10	10	8	8
325093	1CANERUN7CT118.000	71	234.5	234.5	231.5	231.5
325094	1CANERUN7CT218.000	72	234.5	234.5	231.5	231.5

325095	1CANERUN7ST 18.000	7S	235	235	241	241
326514	1PADDY RN 1114.000	11	0	12.5	0	12
326515	1PADDY RN 1214.000	12	0	25.5	0	23
326541	2EKPC OFFICE69.000	P1	5	5	8.5	8.5
990060	GI006 GEN 0.6000	1	100.58	100.58	80.46	100.58
999003	GI-003 GEN 34.500	1	35	35	28	35
999129	GI-2019-029 0.5500	1	101.3	107.5	101.3	107.5

Table E-3
Selected Generation Modeling in the Pre GI-2019-030
NRIS Summer/Off Peak Models

Bus Number	Bus Name	ID	2022OP PGen (MW)	2022OP PMax (MW)	2022S PGen (MW)	2022S PMax (MW)
324000	1BROWN 1 13.800	1	0	0	0	0
324001	1BROWN 2 18.000	2	0	0	0	0
324002	1BROWN 3 24.000	3	0	455.5	459	459
324003	1BROWN 5 13.800	5	0	121	0	131
324004	1BROWN 6 18.000	6	0	158	0	155
324005	1BROWN 7 18.000	7	0	158	0	154
324006	1BROWN 8 13.800	8	0	119	0	122
324007	1BROWN 9 13.800	9	0	119	0	122
324008	1BROWN 10 13.800	10	0	119	0	122
324009	1BROWN 11 13.800	11	0	119	0	122
324013	1CANE RN 11 14.000	11	0	14	0	14
324014	1DIX DAM 1 13.200	1	11.3	11.3	10.5	10.5
324015	1DIX DAM 2 13.200	2	11.3	11.3	10.5	10.5
324016	1DIX DAM 3 13.200	3	11.3	11.3	10.5	10.5
324017	1GHENT 1 18.000	1	0	520	526	526
324018	1GHENT 2 22.000	2	372.0835	520	530	530
324019	1GHENT 3 22.000	3	0	527.5	538	538
324020	1GHENT 4 22.000	4	262	525	538	538
324023	1HAEFLING 13.800	1	0	14	0	12
324023	1HAEFLING 13.800	2	0	14	0	12
324024	1MILL CRK 1 22.000	1	330	330	333	333
324025	1MILL CRK 2 22.000	2	330	330	336	336
324026	1MILL CRK 3 22.000	3	422.5	422.5	425	425
324027	1MILL CRK 4 22.000	4	521	521	526	526
324031	1PADDY RN 1316.000	13	0	162	0	152
324034	1TRIM CO 1 22.000	1	552	552	530	530
324035	1TRIM CO 2 24.000	2	817	817	781	781
324036	1TRIM CO 5 18.000	5	0	170	160.4	160.437

324037	1TRIM CO 6 18.000	6	0	170	171.3	171.255
324038	1TRIM CO 7 18.000	7	0	170	89.07	163.175
324039	1TRIM CO 8 18.000	8	0	170	81	160
324040	1TRIM CO 9 18.000	9	0	170	81	165.988
324041	1TRIM CO 10 18.000	10	0	170	81	163.753
324043	2ZORN 69.000	1	0	15	0	14
324044	1BLUEGRASS 118.000	1	0	166	166	166
324045	1BLUEGRASS 218.000	2	0	166	166	166
324046	1BLUEGRASS 318.000	3	0	166	166	166
324052	1LOCK 7 2.4000	1	2	2	2	2
324234	1OHIO FALL 114.000	1	12.625	12.625	8	8
324234	1OHIO FALL 114.000	2	12.625	12.625	8	8
324234	1OHIO FALL 114.000	3	12.625	12.625	8	8
324234	1OHIO FALL 114.000	4	12.625	12.625	8	8
324235	1OHIO FALL 214.000	5	12.625	12.625	8	8
324235	1OHIO FALL 214.000	6	12.625	12.625	8	8
324235	1OHIO FALL 214.000	7	12.625	12.625	8	8
324235	1OHIO FALL 214.000	8	12.625	12.625	8	8
324677	2PARIS 12 69.000	1	0	11.27	0	11.27
324697	1KMPA PAD2 13.800	2	0	61	47.85	54
324699	2RICE STA TP69.000	1	2.64	2.64	2.64	2.64
324933	1KMPA PAD1 13.800	1	0	61	47.85	54
325012	1BROWN SOLAR13.200	S1	10	10	8	8
325093	1CANERUN7CT118.000	71	234.5	234.5	231.5	231.5
325094	1CANERUN7CT218.000	72	234.5	234.5	231.5	231.5
325095	1CANERUN7ST 18.000	7S	235	235	241	241
326514	1PADDY RN 1114.000	11	0	12.5	0	12
326515	1PADDY RN 1214.000	12	0	25.5	0	23
326541	2EKPC OFFICE69.000	P1	5	5	8.5	8.5
990060	GI006 GEN 0.6000	1	100.58	100.58	80.46	100.58
999003	GI-003 GEN 34.500	1	35	35	28	35

Table E-4
Selected Generation Modeling in the Post GI-2019-029
NRIS Summer/Off Peak Models

Bus Number	Bus Name	ID	2022OP PGen (MW)	2022OP PMax (MW)	2022S PGen (MW)	2022S PMax (MW)
324000	1BROWN 1 13.800	1	0	0	0	0
324001	1BROWN 2 18.000	2	0	0	0	0
324002	1BROWN 3 24.000	3	0	455.5	459	459
324003	1BROWN 5 13.800	5	0	121	0	131
324004	1BROWN 6 18.000	6	0	158	0	155
324005	1BROWN 7 18.000	7	0	158	0	154
324006	1BROWN 8 13.800	8	0	119	0	122
324007	1BROWN 9 13.800	9	0	119	0	122
324008	1BROWN 10 13.800	10	0	119	0	122
324009	1BROWN 11 13.800	11	0	119	0	122
324013	1CANE RN 11 14.000	11	0	14	0	122
324014	1DIX DAM 1 13.200	1	11.3	11.3	10.5	0
324015	1DIX DAM 2 13.200	2	11.3	11.3	10.5	0
324016	1DIX DAM 3 13.200	3	11.3	11.3	10.5	459
324017	1GHENT 1 18.000	1	0	520	526	0
324018	1GHENT 2 22.000	2	272.9895	520	530	0
324019	1GHENT 3 22.000	3	0	527.5	538	459
324020	1GHENT 4 22.000	4	262	525	538	538
324023	1HAEFLING 13.800	1	0	14	0	0
324023	1HAEFLING 13.800	2	0	14	0	0
324024	1MILL CRK 1 22.000	1	330	330	333	0
324025	1MILL CRK 2 22.000	2	330	330	336	0
324026	1MILL CRK 3 22.000	3	422.5	422.5	425	459
324027	1MILL CRK 4 22.000	4	521	521	526	538
324031	1PADDY RN 1316.000	13	0	162	0	152
324034	1TRIM CO 1 22.000	1	552	552	530	0
324035	1TRIM CO 2 24.000	2	817	817	781	0
324036	1TRIM CO 5 18.000	5	0	170	157.7	131
324037	1TRIM CO 6 18.000	6	0	170	81	155
324038	1TRIM CO 7 18.000	7	0	170	81	154
324039	1TRIM CO 8 18.000	8	0	170	81	122
324040	1TRIM CO 9 18.000	9	0	170	81	122
324041	1TRIM CO 10 18.000	10	0	170	81	122
324043	2ZORN 69.000	1	0	15	0	0
324044	1BLUEGRASS 118.000	1	0	166	166	0
324045	1BLUEGRASS 218.000	2	0	166	166	0
324046	1BLUEGRASS 318.000	3	0	166	166	459

324052	1LOCK 7 2.4000	1	2	2	2	0
324234	1OHIO FALL 114.000	1	12.625	12.625	8	0
324234	1OHIO FALL 114.000	2	12.625	12.625	8	0
324234	1OHIO FALL 114.000	3	12.625	12.625	8	459
324234	1OHIO FALL 114.000	4	12.625	12.625	8	538
324235	1OHIO FALL 214.000	5	12.625	12.625	8	131
324235	1OHIO FALL 214.000	6	12.625	12.625	8	155
324235	1OHIO FALL 214.000	7	12.625	12.625	8	154
324235	1OHIO FALL 214.000	8	12.625	12.625	8	122
324677	2PARIS 12 69.000	1	0	11.27	0	0
324697	1KMPA PAD2 13.800	2	0	61	47.85	0
324699	2RICE STA TP69.000	1	2.64	2.64	2.64	0
324933	1KMPA PAD1 13.800	1	0	61	47.85	0
325012	1BROWN SOLAR13.200	S1	10	10	8	8
325093	1CANERUN7CT118.000	71	234.5	234.5	231.5	231.5
325094	1CANERUN7CT218.000	72	234.5	234.5	231.5	231.5
325095	1CANERUN7ST 18.000	7S	235	235	241	241
326514	1PADDY RN 1114.000	11	0	12.5	0	122
326515	1PADDY RN 1214.000	12	0	25.5	0	23
326541	2EKPC OFFICE69.000	P1	5	5	8.5	8.5
990060	GI006 GEN 0.6000	1	100.58	100.58	80.46	0
999003	GI-003 GEN 34.500	1	35	35	28	0
999129	GI-2019-029 0.5500	1	101.3	107.5	101.3	0

Table E-8
Selected Generation Modeling in the Pre GI-2019-029 Stability Models

Bus Number	Bus Name	ID	2020S		2020SM		2023LL	
			PGen (MW)	PMax (MW)	PGen (MW)	PMax (MW)	PGen (MW)	PMax (MW)
324002	1BROWN 3 24.000	3	459	459	454	180	0	459
324003	1BROWN 5 13.800	5	0	131	141	50	0	127
324004	1BROWN 6 18.000	6	0	155	177	16	0	167
324005	1BROWN 7 18.000	7	0	154	177	105	0	166
324006	1BROWN 8 13.800	8	0	122	140	50	0	120
324007	1BROWN 9 13.800	9	0	122	140	50	0	120
324008	1BROWN 10 13.800	10	0	122	140	50	0	120
324009	1BROWN 11 13.800	11	0	122	140	50	0	125
324013	1CANE RN 11 14.000	11	0	14	16	2	0	14
324014	1DIX DAM 1 13.200	1	11	11	11	2	0	11
324015	1DIX DAM 2 13.200	2	11	11	11	2	0	11
324016	1DIX DAM 3 13.200	3	11	11	11	2	0	11

Bus Number	Bus Name	ID	2020S		2020SM		2023LL	
			PGen (MW)	PMax (MW)	PGen (MW)	PMax (MW)	PGen (MW)	PMax (MW)
324017	1GHENT 1 18.000	1	526	526	545	200	0	526
324018	1GHENT 2 22.000	2	530	530	543	200	0	530
324019	1GHENT 3 22.000	3	538	538	547	200	0	538
324020	1GHENT 4 22.000	4	538	538	550	200	0	538
324023	1HAEFLING 13.800	1	0	12	18	2	0	14
324023	1HAEFLING 13.800	2	0	13	18	2	0	14
324024	1MILL CRK 1 22.000	1	333	333	343	123	333	333
324025	1MILL CRK 2 22.000	2	336	336	341	134	336	336
324026	1MILL CRK 3 22.000	3	425	425	445	299	425	425
324027	1MILL CRK 4 22.000	4	526	526	541	313	526	526
324031	1PADDY RN 1316.000	13	0	152	175	100	0	172
324032	1SMITH 2 22.000	2	0	286	286	131	0	287
324033	1SMITH 1 18.000	1	0	153	153	115	0	157
324034	1TRIM CO 1 22.000	1	530	530	557	280	261	530
324035	1TRIM CO 2 24.000	2	781	781	832	432	470	795
324036	1TRIM CO 5 18.000	5	160	160	180	85	0	180
324037	1TRIM CO 6 18.000	6	171	171	180	84	0	180
324038	1TRIM CO 7 18.000	7	80	163	180	85	0	179
324039	1TRIM CO 8 18.000	8	81	160	180	90	0	174
324040	1TRIM CO 9 18.000	9	81	166	180	85	0	180
324041	1TRIM CO 10 18.000	10	81	164	180	86	0	173
324043	2ZORN 69.000	1	0	14	16	2	0	15
324044	1BLUEGRASS 118.000	1	166	166	228	116	0	166
324045	1BLUEGRASS 218.000	2	166	166	228	116	0	166
324046	1BLUEGRASS 318.000	3	166	166	228	116	0	166
324234	1OHIO FALL 114.000	1	8	8	13	2	0	9
324234	1OHIO FALL 114.000	2	8	8	13	2	0	9
324234	1OHIO FALL 114.000	3	8	8	13	2	0	9
324234	1OHIO FALL 114.000	4	8	8	13	2	0	9
324235	1OHIO FALL 214.000	5	8	8	13	2	0	9
324235	1OHIO FALL 214.000	6	8	8	13	2	0	9
324235	1OHIO FALL 214.000	7	8	8	13	2	0	9
324235	1OHIO FALL 214.000	8	8	8	13	2	0	9
324697	1KMPA PAD2 13.800	2	19	54	62	15	0	61
324933	1KMPA PAD1 13.800	1	0	54	62	15	0	61
325012	1BROWN SOLAR13.200	S1	8	8	10	0	0	0
325093	1CANERUN7CT118.000	7A	232	232	230	89	188	232
325094	1CANERUN7CT218.000	7B	232	232	230	89	135	232

Bus Number	Bus Name	ID	2020S		2020SM		2023LL	
			PGen (MW)	PMax (MW)	PGen (MW)	PMax (MW)	PGen (MW)	PMax (MW)
325095	1CANERUN7ST 18.000	7C	241	241	231	165	154	241
326514	1PADDY RN 1114.000	11	0	12	16	2	0	13
326515	1PADDY RN 1214.000	12	0	23	32	2	0	26
326541	2EKPC OFFICE69.000	P1	9	9	9	0	0	9
990001	GI2017-002G 34.500	1	69	86	86	0	86	86
990060	GI-2017-006 0.6000	1	80	101	101	0	101	101
990105	GI2019-003GS0.6450	1	130	163	163	0	163	163
990108	GI2019-003GB0.6450	2	-6	38	38	-38	-37	38
991044	GI-2019-002G0.5500	1	0	125	111	0	0	111
991160	2019-GI001 G0.6600	1	0	112	112	0	0	112
999003	GI-2017-003 34.500	1	28	35	35	0	35	35
999129	GI-2019-029S0.5500	1	101	108	108	0	101	108

Appendix F: Switching Procedures

No switching procedures were relied upon to dismiss potential constraints in this study.