LGE-GIS-2020-001
Generation Interconnection Request

System Impact Study Report
Executive Summary

Version 1.0

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1. Executive Summary

TranServ International, Inc. (TranServ), as an Independent Transmission Organization (ITO) of Louisville Gas & Electric/Kentucky Utilities (LG&E and KU), has received the following 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 GI Request listed in Table E-1. This report contains the System Impact Study (SIS) results for GI Request LGE-GIS-2020-001.

Table E-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-2020-001	10/02/2020	Madison County	KY	50	Lake Reba Tap – West Irvine Tap161 kV line	12/31/2024	NRIS/ERIS	Solar

As shown in Table E-1, the LGE-GIS-2020-001 request seeks to interconnect a 50 MW generator by tapping the Lake Reba Tap – West Irvine Tap161 kV line. If the LGE-GIS-2020-001 request is granted, the new generation will have interconnection rights for 50 MW net at the POI. The requested in-service date of the LGE-GIS-2020-001 request is December 31, 2024. A one-line diagram of the proposed interconnection is given in Appendix A of the full report. This GI SIS analyzed the impact of this addition, located in Madison County, Kentucky, in accordance with the LG&E and KU Large Generator Interconnection Study Criteria and LG&E and KU Planning Guidelines. Both of these documents are posted on the LG&E and KU Open Access Same-Time Information System (OASIS).

An Ad Hoc Study Group was involved in the study process. Tables E-2 and E-3 document 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 E-2
Ad Hoc Study Group Independent Study Comments

Ad Hoc Group Member	Date Received	Ad Hoc Group Member Comment provided within the 07/08/2021 Deadline
No Ad Hoc Member chose to provide independent testing results for this request by the 07/08/2021 deadline.		

In addition to the Table E-2 Ad Hoc Study Group responses received prior to the 07/08/2021 deadline, Table E-3 documents additional responses received.

Table E-3
Additional Ad Hoc Study Group Comments

Ad Hoc Group Member	Date Received	Ad Hoc Group Member Comment provided after the 07/08/2021 Deadline
No Ad Hoc Member chose to provide a response between 07/08/2021 and issuance of this report.		

The GI request, LGE-GIS-2020-001, is a NRIS and ERIS request and thus was studied as sourcing from the new solar generation interconnected by connecting to the Lake Reba Tap – West Irvine Tap161 kV 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 four directions (North, South, East, and West) (ERIS). TranServ performed this SIS to determine the impact of this GI on the transmission network. The simulations performed considered steady-state contingencies in Categories P0, P1, P2 EHV, P3, and P4 EHV and stability disturbances in Categories P0 - P7 of the current effective versions of North American Electric Reliability Corporation (NERC) TPL-004 standards and the LG&E and KU Planning Guidelines.

The subject request was evaluated using a 2025 Off Peak, 2025 Summer Peak and 2030 Summer Peak steady state powerflow model with roots in the LG&E and KU 2021 Transmission Expansion Plan (TEP) Base Case Study (BCS) models. The GI-2020-001 stability and short circuit models were rooted in LG&E and KU 2020 TEP models. All models used included the 2020 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). Since a prior queued request is contingent upon construction of network upgrades, a contingent facility analysis was performed as detailed in Section 1.3. 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.

1.1 Steady-State Analysis Results

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

1.2 Flowgate Analysis Results

No flowgate constraints due to the subject request were found.

1.3 Contingent Facility Analysis Results

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). Since a prior queued GI request is contingent upon construction of network upgrades, a contingent facility analysis was performed. The results of that analysis are shown in Tables E-4 and E-5 for NRIS and ERIS respectively.

As can be seen from Tables E-4 and E-5, none of the potential contingent facilities were shown to overload in the GI-2020-001 Contingent Facility Analysis and the GI-2020-001 DF on the potential contingent facilities was less than the 20% threshold for determining contingent facilities. Thus there are no GI-2020-001 contingent facilities.

Table E-4
Contingent Facility Analysis Results for NRIS

Request	Model	Facility	Rating	Pre Project	Post Project	DF
				MW	MW	
GI-2019-015	2025OP	2CLARKSON 69.000 TO 2M-V CLARK T69.000 1	65	23.23	23.27	0.08%
GI-2019-015	2025OP	2CLARKSON 69.000 TO 2WARREN TIE 69.000 1	67	42.70	42.64	-0.12%
GI-2019-015	2025OP	2EASTVIEW 69.000 TO 2M-V CLARK T69.000 1	62	21.99	22.03	0.08%
GI-2019-015	2025OP	2LEITCHF CIT69.000 TO 2LEITCHF E 69.000 1	79	46.83	46.77	-0.12%
GI-2019-015	2025OP	2LEITCHF E 69.000 TO 2WARREN TIE 69.000 1	67	43.67	43.61	-0.12%
GI-2019-015	2025S	2CLARKSON 69.000 TO 2M-V CLARK T69.000 1	47	24.35	24.30	-0.11%
GI-2019-015	2025S	2CLARKSON 69.000 TO 2WARREN TIE 69.000 1	50	28.13	28.07	-0.11%
GI-2019-015	2025S	2EASTVIEW 69.000 TO 2M-V CLARK T69.000 1	42	22.06	22.00	-0.11%
GI-2019-015	2025S	2EASTVIEW 69.000 TO 2STEPHENSBRG69.000 1	45	17.41	17.35	-0.10%
GI-2019-015	2025S	2LEITCHF E 69.000 TO 2WARREN TIE 69.000 1	50	28.16	28.11	-0.11%
GI-2019-015	2025S	4BONNIEVILLE138.00 TO 4LEBANON WES138.00 1	83	30.81	30.41	-0.80%
GI-2019-015	2025S	4BONNIEVILLE138.00 TO 4MERE TVA 138.00 1	121	69.97	69.73	-0.48%
GI-2019-015	2025S	4LEBANON WES138.00 TO 4LEBANON 138.00 1	83	23.49	23.10	-0.78%

Request	Model	Facility	Rating	Pre Project	Post Project	DF
				MW	MW	
GI-2019-015	2025S	4LEITCHFIELD138.00 TO 2LEITCHFIELD69.000 1	82	47.73	47.69	-0.06%
GI-2019-015	2025S	4SHREWSBURY 138.00 TO GI-2019-015P138.00 1	210	150.51	150.31	-0.40%
GI-2019-015	2030S	2CLARKSON 69.000 TO 2M-V CLARK T69.000 1	47	23.70	23.65	-0.10%
GI-2019-015	2030S	2CLARKSON 69.000 TO 2WARREN TIE 69.000 1	50	27.43	27.38	-0.10%
GI-2019-015	2030S	2EASTVIEW 69.000 TO 2M-V CLARK T69.000 1	42	21.46	21.41	-0.10%
GI-2019-015	2030S	2EASTVIEW 69.000 TO 2STEPHENSBRG69.000 1	45	16.89	16.86	-0.06%
GI-2019-015	2030S	2LEITCHF CIT69.000 TO 2LEITCHF E 69.000 1	66	32.94	32.89	-0.10%
GI-2019-015	2030S	2LEITCHF E 69.000 TO 2WARREN TIE 69.000 1	50	27.46	27.41	-0.10%
GI-2019-015	2030S	4BONNIEVILLE138.00 TO 4LEBANON WES138.00 1	83	26.91	26.52	-0.77%
GI-2019-015	2030S	4BONNIEVILLE138.00 TO 4MERE TVA 138.00 1	121	70.97	70.72	-0.50%
GI-2019-015	2030S	4LEBANON WES138.00 TO 4LEBANON 138.00 1	83	19.72	19.34	-0.75%
GI-2019-015	2030S	4LEITCHFIELD138.00 TO 2LEITCHFIELD69.000 1	82	45.93	45.90	-0.06%
GI-2019-015	2030S	4SHREWSBURY 138.00 TO GI-2019-015P138.00 1	210	150.62	150.40	-0.45%
GI-2019-029	2025OP	2CENT HARDIN69.000 TO 2KARGLE 69.000 1	98	79.99	80.06	0.15%
GI-2019-029	2025OP	2ETOWN KU 69.000 TO 2KARGLE 69.000 1	98	60.97	61.05	0.14%
GI-2019-029	2025OP	4HARDINSBURG138.00 TO 4N.HARD 138.00 1	191	160.74	160.64	-0.20%
GI-2019-029	2025S	2CENT HARDIN69.000 TO 2KARGLE 69.000 1	98	67.05	67.21	0.32%
GI-2019-029	2025S	2ETOWN KU 69.000 TO 2KARGLE 69.000 1	86	48.37	48.53	0.32%
GI-2019-029	2025S	4BLACKBRANCH138.00 TO 4CENT HARDIN138.00 1	227	125.82	125.53	-0.57%
GI-2019-029	2025S	4BLACKBRANCH138.00 TO GI2019029P 138.00 1	208	140.37	140.08	-0.57%
GI-2019-029	2025S	4BLACKBRANCH138.00 TO GI2019029P 138.00 1	208	136.48	136.27	-0.42%
GI-2019-029	2025S	4HARDINSBURG138.00 TO 4N.HARD 138.00 1	191	138.49	138.55	0.12%
GI-2019-029	2030S	2CENT HARDIN69.000 TO 2KARGLE 69.000 1	98	65.85	66.01	0.31%
GI-2019-029	2030S	2ETOWN KU 69.000 TO 2KARGLE 69.000 1	86	47.16	47.31	0.31%
GI-2019-029	2030S	4BLACKBRANCH138.00 TO GI2019029P 138.00 1	208	140.49	140.21	-0.57%
GI-2019-029	2030S	4BLACKBRANCH138.00 TO GI2019029P 138.00 1	208	136.61	136.39	-0.44%
GI-2019-029	2030S	4HARDINSBURG138.00 TO 4N.HARD 138.00 1	191	138.61	138.67	0.12%

Table E-5
Contingent Facility Analysis Results for ERIS

Request	Model	Facility	Rating	Pre Project	Post Project	DF
				MW	MW	
GI-2019-015	2025OP	2CLARKSON 69.000 TO 2M-V CLARK T69.000 1	65	35.25	35.00	-0.49%
GI-2019-015	2025OP	2CLARKSON 69.000 TO 2WARREN TIE 69.000 1	67	37.55	37.30	-0.50%
GI-2019-015	2025OP	2EASTVIEW 69.000 TO 2M-V CLARK T69.000 1	62	33.98	33.74	-0.49%
GI-2019-015	2025OP	2LEITCHF E 69.000 TO 2WARREN TIE 69.000 1	67	37.61	37.36	-0.50%
GI-2019-015	2025S	2CLARKSON 69.000 TO 2M-V CLARK T69.000 1	47	21.81	21.58	-0.46%
GI-2019-015	2025S	2CLARKSON 69.000 TO 2WARREN TIE 69.000 1	50	25.56	25.32	-0.47%
GI-2019-015	2025S	2EASTVIEW 69.000 TO 2M-V CLARK T69.000 1	42	19.53	19.29	-0.46%
GI-2019-015	2025S	2LEITCHF E 69.000 TO 2WARREN TIE 69.000 1	50	25.58	25.35	-0.47%
GI-2019-015	2025S	4BONNIEVILLE138.00 TO 4LEBANON WES138.00 1	83	28.15	27.55	-1.20%

Request	Model	Facility	Rating	Pre Project	Post Project	DF
				MW	MW	
GI-2019-015	2025S	4BONNIEVILLE138.00 TO 4MERE TVA 138.00 1	121	66.90	66.42	-0.97%
GI-2019-015	2025S	4LEBANON WES138.00 TO 4LEBANON 138.00 1	83	20.89	20.30	-1.18%
GI-2019-015	2025S	4LEITCHFIELD138.00 TO 2LEITCHFIELD69.000 1	82	45.89	45.73	-0.32%
GI-2019-015	2025S	4SHREWSBURY 138.00 TO GI-2019-015P138.00 1	210	146.32	145.77	-1.10%
GI-2019-015	2030S	2CLARKSON 69.000 TO 2M-V CLARK T69.000 1	47	21.27	21.04	-0.45%
GI-2019-015	2030S	2CLARKSON 69.000 TO 2WARREN TIE 69.000 1	50	24.96	24.73	-0.46%
GI-2019-015	2030S	2EASTVIEW 69.000 TO 2M-V CLARK T69.000 1	42	19.03	18.80	-0.45%
GI-2019-015	2030S	2EASTVIEW 69.000 TO 2STEPHENSBRG69.000 1	45	15.49	15.30	-0.38%
GI-2019-015	2030S	2LEITCHF E 69.000 TO 2WARREN TIE 69.000 1	50	24.99	24.76	-0.46%
GI-2019-015	2030S	4BONNIEVILLE138.00 TO 4LEBANON WES138.00 1	83	27.57	26.97	-1.20%
GI-2019-015	2030S	4BONNIEVILLE138.00 TO 4MERE TVA 138.00 1	121	68.74	68.25	-0.97%
GI-2019-015	2030S	4LEBANON WES138.00 TO 4LEBANON 138.00 1	83	20.36	19.77	-1.18%
GI-2019-015	2030S	4SHREWSBURY 138.00 TO GI-2019-015P138.00 1	210	146.13	145.55	-1.17%
GI-2019-029	2025OP	2CENT HARDIN69.000 TO 2KARGLE 69.000 1	98	74.88	74.55	-0.66%
GI-2019-029	2025OP	4HARDINSBURG138.00 TO 4N.HARD 138.00 1	191	162.39	162.41	0.06%
GI-2019-029	2025S	2CENT HARDIN69.000 TO 2KARGLE 69.000 1	98	62.66	62.36	-0.60%
GI-2019-029	2025S	2ETOWN KU 69.000 TO 2KARGLE 69.000 1	86	43.98	43.69	-0.60%
GI-2019-029	2025S	4BLACKBRANCH138.00 TO GI2019029P 138.00 1	208	136.54	136.05	-0.99%
GI-2019-029	2025S	4BLACKBRANCH138.00 TO GI2019029P 138.00 1	208	132.94	132.45	-0.98%
GI-2019-029	2025S	4HARDINSBURG138.00 TO 4N.HARD 138.00 1	191	137.87	137.81	-0.11%
GI-2019-029	2030S	2CENT HARDIN69.000 TO 2KARGLE 69.000 1	98	61.58	61.29	-0.58%
GI-2019-029	2030S	2ETOWN KU 69.000 TO 2KARGLE 69.000 1	86	42.90	42.61	-0.58%
GI-2019-029	2030S	4BLACKBRANCH138.00 TO GI2019029P 138.00 1	208	136.62	136.12	-0.99%
GI-2019-029	2030S	4BLACKBRANCH138.00 TO GI2019029P 138.00 1	208	133.01	132.52	-0.98%
GI-2019-029	2030S	4HARDINSBURG138.00 TO 4N.HARD 138.00 1	191	138.02	137.96	-0.11%

1.4 Short Circuit Analysis Results

The Short Circuit Analysis results indicate that the transmission system has adequate interrupting capabilities to accommodate the addition of the new solar generator.

1.5 Stability Analysis Results

In initially testing the P1 disturbances it was found that with the addition of GI-2020-001 and its provided protection settings, the GI-2020-001 generation would trip due to the provided voltage settings. Table E-6 suggest the modified voltage settings for the GI-2020-001 solar generation.

Table E-6
Modified Voltage Settings for GI-2020-001 Tripping

Relay Identifier Number	Protection module	Upper Voltage Limit	Lower Voltage Limit	ITO Suggested Upper Voltage Limit	Customer Provided Relay pick up Time (sec)	Breaker Delay Time
9991592	VTGDCAT	1.2000	-1.0000	1.2300	0.16	0
9991593	VTGDCAT	1.1000	-1.0000	1.2200	10.00	0

It should be noted that the modified upper voltage limit setting mitigation must be verified with the manufacture by the customer for any technical limitation or generator protection issues. The customer provided voltage relay settings would result in unacceptable tripping of the GI-2020-001 generation and must be modified.

The GI-2020-001 stability analysis was performed with the ITO suggested settings in Table E-6.

The study relied on the following; all of which are discussed in detail in Section 5 of the full report:

- Modifications to relay settings for the GI-2020-001 generation as provided in Table E-6. If the suggested Table E-6 relay settings are not achievable for any reason, additional study, in the Facilities Study, will be required to determine an alternative mitigation.
- 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 5.8.1.

With the ITO suggested modifications to the GI-2020-001 generation relay settings, all tested disturbances passed the stability criterion. If the suggested Table E-6 relay settings are not achievable for any reason, additional study, in the Facilities Study, will be required to determine an alternative mitigation.

1.6 Stiffness Verification due to Inverter Based Resource Interconnection

The GI-2020-001 Short circuit ratio (SCR) was found to exceed the minimum requirement of 2.0. Due to the location of the GI-2020-001 POI, the Weighted SCR (WSCR) did not apply. There are no Grid Stiffness constraints to granting the GI-2020-001 GI request.

1.7 Conclusion

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.

No LG&E and KU thermal, voltage, short circuit, or stability constraints due to the subject request were identified.

However the customer must work with the TO and ITO during the Facilities Study (FS) to determine mutually agreeable relay settings. If the Table E-6 modified settings cannot be used, additional study maybe required.

No third party constraints were identified in this study, and no Ad Hoc Study Group member has indicated a need to perform an Affected System Study as shown in Tables E-2 and E-3.

In order to obtain 50 MW injection at the POI, the study determined that the gross generation at the plant inverter bus would need to be 51 MW. The solar plant gross generation of 51 MW was modeled for this SIS. The data provided by the customer supports the 51 MW gross generation level.

The study determined that the inverters' +/- 17.163 MVAR reactive capability plus the customer provided 8 MVAR capacitor did meet the +/- 0.95 power factor at the high side of the customer main transformer requirement.

Since no LG&E and KU constraints were identified, LG&E and KU has not provided an estimate upgrade costs. LG&E and KU has however provided a good faith estimate of the interconnection costs. The Interconnection costs are the same for both the NRIS and ERIS.

- Generator Owner Facilities: Customer to Determine.
- Transmission Interconnection Facilities: **$1,142,753 USD**.
- Network Interconnection Facilities: **$9,607,305 USD.**
- NRIS Network Upgrade Facilities: **$0 USD.**
- Distribution Facilities: **$0 USD.**

LG&E and KU's NRIS good faith estimate of the total cost for facilities is **$10,750,058 USD.**

LG&E and KU has indicated that the interconnection facilities can be completed within 24 months after the GIA is signed and the customer provides a construction-ready site. The full report is available on the LG&E and KU Critical Energy Infrastructure Information (CEII) File Transfer Protocol (FTP) site. See study report title posting on OASIS for instructions for accessing LG&E

and KU CEII FTP site. The LG&E and KU secure CEII FTP site URL is: https://eftws.lge-ku.com/EFTClient/Account/Login.htm.

PPL companies

LGE-GIS-2020-001
Facilities Study Report

January 18, 2022

Study & Preliminary Report Completed By:
LG&E/KU Transmission

Report Prepared By:
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1. Executive Summary

A Facilities Study was performed by LG&E/KU for the following request:

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-2020-001	10/02/2020	Madison County	KY	50	Lake Reba Tap – West Irvine Tap 161 kV line	11/30/2024 *	NRIS/ERIS	Solar

*Commercial Operation data updated from 12/31/2024 to 11/30/2024 in Facilities study agreement

TranServ as Independent Transmission Organization (ITO) completed a Generator Interconnection (GI) System Impact Study (SIS). The GI SIS analyzed the impact of this Generator Interconnection, located near Louisville, Kentucky, in accordance with the LG&E and KU Large GI Study Criteria document as posted on the LG&E and KU Open Access Same-Time Information System (OASIS). Customer executed a Facility Study Agreement with the ITO and LG&E and KU to complete a Facilities Study. LG&E and KU Services Company (LG&E-KU) contracted Black & Veatch (BV) to complete a +/-20% cost estimate study for the Generation Interconnect Request GI-2020-001 facility study. The request requires interconnecting to the existing Lake Reba Tap – West Irvine Tap161 kV line in Madison County, Kentucky.

The LG&E/KU Open Access Transmission Tariff (OATT) states that the Facilities Study will include a good faith estimate of (i) the cost of Direct Assignment Facilities to be charged to the Eligible Customer, (ii) the Eligible Customer's appropriate share of the cost of any Network Upgrades, and (iii) the time required to complete such construction and initiate the requested service.

TranServ has reviewed the Facilities Study results from LG&E and KU and prepared this report in accordance with the LG&E and KU OATT.

2. Constraint Identified in the SIS

2.1 Steady State Constraints

No constraints were found in the SIS report.

2.2 Contingent Facility Analysis Results

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). Since a prior queued GI request is contingent upon construction of network upgrades, a contingent facility analysis was performed. The results of that analysis are shown in Tables E-1 and E-2 for NRIS and ERIS respectively.

As can be seen from Tables E-1 and E-2, none of the potential contingent facilities were shown to overload in the GI-2020-001 Contingent Facility Analysis and the GI-2020-001 DF on the potential contingent facilities was less than the 20% threshold for determining contingent facilities. Thus there are no GI-2020-001 contingent facilities.

Table E-1
Contingent Facility Analysis Results for NRIS

Request	Model	Dispatch	Facility	Rating	Pre Project	Post Project	DF
					MW	MW	
GI-2019-015	2025OP	mbr_nits	2CLARKSON 69.000 TO 2M-V CLARK T69.000 1	65	23.23	23.27	0.08%
GI-2019-015	2025OP	bullrun1_s	2CLARKSON 69.000 TO 2WARREN TIE 69.000 1	67	42.70	42.64	-0.12%
GI-2019-015	2025OP	mbr_nits	2EASTVIEW 69.000 TO 2M-V CLARK T69.000 1	62	21.99	22.03	0.08%
GI-2019-015	2025OP	wbnp1_s	2LEITCHF CIT69.000 TO 2LEITCHF E 69.000 1	79	46.83	46.77	-0.12%
GI-2019-015	2025OP	wbnp1_s	2LEITCHF E 69.000 TO 2WARREN TIE 69.000 1	67	43.67	43.61	-0.12%
GI-2019-015	2025S	wbnp1_s	2CLARKSON 69.000 TO 2M-V CLARK T69.000 1	47	24.35	24.30	-0.11%
GI-2019-015	2025S	wbnp1_s	2CLARKSON 69.000 TO 2WARREN TIE 69.000 1	50	28.13	28.07	-0.11%
GI-2019-015	2025S	wbnp1_s	2EASTVIEW 69.000 TO 2M-V CLARK T69.000 1	42	22.06	22.00	-0.11%
GI-2019-015	2025S	wbnp1_s	2EASTVIEW 69.000 TO 2STEPHENSBRG69.000 1	45	17.41	17.35	-0.10%
GI-2019-015	2025S	wbnp1_s	2LEITCHF E 69.000 TO 2WARREN TIE 69.000 1	50	28.16	28.11	-0.11%
GI-2019-015	2025S	br3_merit_miso	4BONNIEVILLE138.00 TO 4LEBANON WES138.00 1	83	30.81	30.41	-0.80%

Request	Model	Dispatch	Facility	Rating	Pre Project	Post Project	DF
					MW	MW	
GI-2019-015	2025S	br3_merit_miso	4BONNIEVILLE138.00 TO 4MERE TVA 138.00 1	121	69.97	69.73	-0.48%
GI-2019-015	2025S	br3_merit_miso	4LEBANON WES138.00 TO 4LEBANON 138.00 1	83	23.49	23.10	-0.78%
GI-2019-015	2025S	wbnp1_s	4LEITCHFIELD138.00 TO 2LEITCHFIELD69.000 1	82	47.73	47.69	-0.06%
GI-2019-015	2025S	wbnp1_s	4SHREWSBURY 138.00 TO GI-2019-015P138.00 1	210	150.51	150.31	-0.40%
GI-2019-015	2030S	wbnp1_s	2CLARKSON 69.000 TO 2M-V CLARK T69.000 1	47	23.70	23.65	-0.10%
GI-2019-015	2030S	wbnp1_s	2CLARKSON 69.000 TO 2WARREN TIE 69.000 1	50	27.43	27.38	-0.10%
GI-2019-015	2030S	wbnp1_s	2EASTVIEW 69.000 TO 2M-V CLARK T69.000 1	42	21.46	21.41	-0.10%
GI-2019-015	2030S	br3_merit_miso	2EASTVIEW 69.000 TO 2STEPHENSBRG69.000 1	45	16.89	16.86	-0.06%
GI-2019-015	2030S	wbnp1_s	2LEITCHF CIT69.000 TO 2LEITCHF E 69.000 1	66	32.94	32.89	-0.10%
GI-2019-015	2030S	wbnp1_s	2LEITCHF E 69.000 TO 2WARREN TIE 69.000 1	50	27.46	27.41	-0.10%
GI-2019-015	2030S	cpr2_n	4BONNIEVILLE138.00 TO 4LEBANON WES138.00 1	83	26.91	26.52	-0.77%
GI-2019-015	2030S	cpr2_n	4BONNIEVILLE138.00 TO 4MERE TVA 138.00 1	121	70.97	70.72	-0.50%
GI-2019-015	2030S	cpr2_n	4LEBANON WES138.00 TO 4LEBANON 138.00 1	83	19.72	19.34	-0.75%
GI-2019-015	2030S	wbnp1_s	4LEITCHFIELD138.00 TO 2LEITCHFIELD69.000 1	82	45.93	45.90	-0.06%
GI-2019-015	2030S	wbnp1_s	4SHREWSBURY 138.00 TO GI-2019-015P138.00 1	210	150.62	150.40	-0.45%
GI-2019-029	2025OP	mtc_nits	2CENT HARDIN69.000 TO 2KARGLE 69.000 1	98	79.99	80.06	0.15%
GI-2019-029	2025OP	mgh_nits	2ETOWN KU 69.000 TO 2KARGLE 69.000 1	98	60.97	61.05	0.14%
GI-2019-029	2025OP	paradisct3s1_s	4HARDINSBURG138.00 TO 4N.HARD 138.00 1	191	160.74	160.64	-0.20%
GI-2019-029	2025S	wbnp1_s	2CENT HARDIN69.000 TO 2KARGLE 69.000 1	98	67.05	67.21	0.32%
GI-2019-029	2025S	wbnp1_s	2ETOWN KU 69.000 TO 2KARGLE 69.000 1	86	48.37	48.53	0.32%

Request	Model	Dispatch	Facility	Rating	Pre Project	Post Project	DF
					MW	MW	
GI-2019-029	2025S	mtc_nits	4BLACKBRANCH138.00 TO 4CENT HARDIN138.00 1	227	125.82	125.53	-0.57%
GI-2019-029	2025S	mtc_nits	4BLACKBRANCH138.00 TO GI2019029P 138.00 1	208	140.37	140.08	-0.57%
GI-2019-029	2025S	Base Dispatch	4BLACKBRANCH138.00 TO GI2019029P 138.00 1	208	136.48	136.27	-0.42%
GI-2019-029	2025S	wilson_w	4HARDINSBURG138.00 TO 4N.HARD 138.00 1	191	138.49	138.55	0.12%
GI-2019-029	2030S	wbnp1_s	2CENT HARDIN69.000 TO 2KARGLE 69.000 1	98	65.85	66.01	0.31%
GI-2019-029	2030S	wbnp1_s	2ETOWN KU 69.000 TO 2KARGLE 69.000 1	86	47.16	47.31	0.31%
GI-2019-029	2030S	mtc_nits	4BLACKBRANCH138.00 TO GI2019029P 138.00 1	208	140.49	140.21	-0.57%
GI-2019-029	2030S	Base Dispatch	4BLACKBRANCH138.00 TO GI2019029P 138.00 1	208	136.61	136.39	-0.44%
GI-2019-029	2030S	wilson_w	4HARDINSBURG138.00 TO 4N.HARD 138.00 1	191	138.61	138.67	0.12%

Table E-2
Contingent Facility Analysis Results for ERIS

Request	Model	Dispatch	Facility	Rating	Pre Project	Post Project	DF
					MW	MW	
GI-2019-015	2025OP	gib2_w	2CLARKSON 69.000 TO 2M-V CLARK T69.000 1	65	35.25	35.00	-0.49%
GI-2019-015	2025OP	gib2_w	2CLARKSON 69.000 TO 2WARREN TIE 69.000 1	67	37.55	37.30	-0.50%
GI-2019-015	2025OP	gib2_w	2EASTVIEW 69.000 TO 2M-V CLARK T69.000 1	62	33.98	33.74	-0.49%
GI-2019-015	2025OP	gib2_w	2LEITCHF E 69.000 TO 2WARREN TIE 69.000 1	67	37.61	37.36	-0.50%
GI-2019-015	2025S	wbnp1_s	2CLARKSON 69.000 TO 2M-V CLARK T69.000 1	47	21.81	21.58	-0.46%
GI-2019-015	2025S	wbnp1_s	2CLARKSON 69.000 TO 2WARREN TIE 69.000 1	50	25.56	25.32	-0.47%
GI-2019-015	2025S	wbnp1_s	2EASTVIEW 69.000 TO 2M-V CLARK T69.000 1	42	19.53	19.29	-0.46%
GI-2019-015	2025S	wbnp1_s	2LEITCHF E 69.000 TO 2WARREN TIE 69.000 1	50	25.58	25.35	-0.47%
GI-2019-015	2025S	br3_merit_miso	4BONNIEVILLE138.00 TO 4LEBANON WES138.00 1	83	28.15	27.55	-1.20%
GI-2019-015	2025S	br3_merit_miso	4BONNIEVILLE138.00 TO 4MERE TVA 138.00 1	121	66.90	66.42	-0.97%
GI-2019-015	2025S	br3_merit_miso	4LEBANON WES138.00 TO 4LEBANON 138.00 1	83	20.89	20.30	-1.18%

Request	Model	Dispatch	Facility	Rating	Pre Project	Post Project	DF
					MW	MW	
GI-2019-015	2025S	wbnp1_s	4LEITCHFIELD138.00 TO 2LEITCHFIELD69.000 1	82	45.89	45.73	-0.32%
GI-2019-015	2025S	wbnp1_s	4SHREWSBURY 138.00 TO GI-2019-015P138.00 1	210	146.32	145.77	-1.10%
GI-2019-015	2030S	wbnp1_s	2CLARKSON 69.000 TO 2M-V CLARK T69.000 1	47	21.27	21.04	-0.45%
GI-2019-015	2030S	wbnp1_s	2CLARKSON 69.000 TO 2WARREN TIE 69.000 1	50	24.96	24.73	-0.46%
GI-2019-015	2030S	wbnp1_s	2EASTVIEW 69.000 TO 2M-V CLARK T69.000 1	42	19.03	18.80	-0.45%
GI-2019-015	2030S	wbnp1_s	2EASTVIEW 69.000 TO 2STEPHENSBRG69.000 1	45	15.49	15.30	-0.38%
GI-2019-015	2030S	wbnp1_s	2LEITCHF E 69.000 TO 2WARREN TIE 69.000 1	50	24.99	24.76	-0.46%
GI-2019-015	2030S	br3_merit_miso	4BONNIEVILLE138.00 TO 4LEBANON WES138.00 1	83	27.57	26.97	-1.20%
GI-2019-015	2030S	br3_merit_miso	4BONNIEVILLE138.00 TO 4MERE TVA 138.00 1	121	68.74	68.25	-0.97%
GI-2019-015	2030S	br3_merit_miso	4LEBANON WES138.00 TO 4LEBANON 138.00 1	83	20.36	19.77	-1.18%
GI-2019-015	2030S	br3_merit_miso	4SHREWSBURY 138.00 TO GI-2019-015P138.00 1	210	146.13	145.55	-1.17%
GI-2019-029	2025OP	wbnp1_s	2CENT HARDIN69.000 TO 2KARGLE 69.000 1	98	74.88	74.55	-0.66%
GI-2019-029	2025OP	paradisct3s1_s	4HARDINSBURG138.00 TO 4N.HARD 138.00 1	191	162.39	162.41	0.06%
GI-2019-029	2025S	wbnp1_s	2CENT HARDIN69.000 TO 2KARGLE 69.000 1	98	62.66	62.36	-0.60%
GI-2019-029	2025S	wbnp1_s	2ETOWN KU 69.000 TO 2KARGLE 69.000 1	86	43.98	43.69	-0.60%
GI-2019-029	2025S	mtc_nits	4BLACKBRANCH138.00 TO GI2019029P 138.00 1	208	136.54	136.05	-0.99%
GI-2019-029	2025S	Base Dispatch	4BLACKBRANCH138.00 TO GI2019029P 138.00 1	208	132.94	132.45	-0.98%
GI-2019-029	2025S	wilson_w	4HARDINSBURG138.00 TO 4N.HARD 138.00 1	191	137.87	137.81	-0.11%
GI-2019-029	2030S	wbnp1_s	2CENT HARDIN69.000 TO 2KARGLE 69.000 1	98	61.58	61.29	-0.58%
GI-2019-029	2030S	wbnp1_s	2ETOWN KU 69.000 TO 2KARGLE 69.000 1	86	42.90	42.61	-0.58%

Request	Model	Dispatch	Facility	Rating	Pre Project	Post Project	DF
					MW	MW	
GI-2019-029	2030S	mtc_nits	4BLACKBRANCH138.00 TO GI2019029P 138.00 1	208	136.62	136.12	-0.99%
GI-2019-029	2030S	Base Dispatch	4BLACKBRANCH138.00 TO GI2019029P 138.00 1	208	133.01	132.52	-0.98%
GI-2019-029	2030S	wilson_w	4HARDINSBURG138.00 TO 4N.HARD 138.00 1	191	138.02	137.96	-0.11%

2.3 Short Circuit Analysis Results

The Short Circuit Analysis results indicate that the transmission system has adequate interrupting capabilities to accommodate the addition of the new solar generator.

2.4 Stability Analysis Results in the SIS

In initially testing the P1 disturbances it was found that with the addition of GI-2020-001 and its provided protection settings, the GI-2020-001 generation would trip due to the provided voltage settings. Table E-3 suggest the modified voltage settings for the GI-2020-001 solar generation.

Table E-3
Modified Voltage Settings for GI-2020-001 Tripping

Relay Identifier Number	Protection module	Upper Voltage Limit	Lower Voltage Limit	ITO Suggested Upper Voltage Limit	Customer Provided Relay pick up Time (sec)	Breaker Delay Time
9991592	VTGDCAT	1.2000	-1.0000	1.2300	0.16	0
9991593	VTGDCAT	1.1000	-1.0000	1.2200	10.00	0

It should be noted that the modified upper voltage limit setting mitigation must be verified with the manufacture by the customer for any technical limitation or generator protection issues. The customer provided voltage relay settings would result in unacceptable tripping of the GI-2020-001 generation and must be modified.

The GI-2020-001 stability analysis was performed with the ITO suggested settings in Table E-3. The study relied on the following; all of which are discussed in detail in Section 5 of the full SIS report:

- Modifications to relay settings for the GI-2020-001 generation as provided in Table E-3. If the suggested Table E-6 relay settings are not achievable for any reason, additional study, in the Facilities Study, will be required to determine an alternative mitigation.
- 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 5.8.1of the SIS full report.

With the ITO suggested modifications to the GI-2020-001 generation relay settings, all tested disturbances passed the stability criterion. If the suggested Table E-3 relay settings are not achievable for any reason, additional study, in the Facilities Study, will be required to determine an alternative mitigation.

2.5 Stiffness Verification due to Inverter Based Resource Interconnection

The GI-2020-001 Short circuit ratio (SCR) was found to exceed the minimum requirement of 2.0. Due to the location of the GI-2020-001 POI, the Weighted SCR (WSCR) did not apply. There are no Grid Stiffness constraints to granting the GI-2020-001 GI request.

3. Affected System Impacts from SIS

An Ad Hoc Study Group was involved in the study process. Tables E-4 and E-5 document 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 E-4
Ad Hoc Study Group Independent Study Comments

Ad Hoc Group Member	Date Received	Ad Hoc Group Member Comment provided within the 07/08/2021 Deadline
No Ad Hoc Member chose to provide independent testing results for this request by the 07/08/2021 deadline.		

In addition to the Table E-4 Ad Hoc Study Group responses received prior to the 07/08/2021 deadline, Table E-5 documents additional responses received.

Table E-5
Additional Ad Hoc Study Group Comments

Ad Hoc Group Member	Date Received	Ad Hoc Group Member Comment provided after the 07/08/2021 Deadline
No Ad Hoc Member chose to provide a response between 07/08/2021 and issuance of this report.		

4. Facilities Study Results from LG&E and KU

4.1 Methodology

The following terms are defined in this facilities study report

- **New Network Facilities (NNF)** - additions, modifications, and upgrades to the Transmission Owner's system required at or beyond the Point of Interconnection (POI) to accommodate the interconnection of the Generating Facility to the Transmission System. It is possible for system network power to flow through NNF equipment, along with generation facility power.
- **Transmission Interconnection Facilities (TIF)** - all facilities and equipment owned by the Transmission Owner from the Point of Interconnection (POI) to the Point of Change of Ownership (PCO); including any modifications, additions, or upgrades to such facilities and equipment. Transmission Interconnection Facilities are sole use facilities and shall not include Distribution Upgrades, Generator Upgrades, Stand Alone Network Upgrades, or Network Upgrades. Only generation facility power can flow through TIF equipment.
- **Generation Owner Facilities –** all facilities and equipment owned by the Interconnection Customer starting at the Point of Change of Ownership (PCO).
- **Point of Interconnection (POI) –** the point where the transmission interconnection facilities connect to the new network upgrades.
- **Point of Change of Ownership (PCO) –** the point where the Interconnection Customer's facilities connect to the transmission interconnection facilities.
- **Distribution Upgrades (Distribution Facilities)**
- **Interconnection Customer (IC) -** The Generator Owner.

Article 11 of the LGIA specifies which party (Transmission or Generator Owner) has a construction obligation and who bears the expense of that obligation. Based on the requirements within the LGIA:

- **Generator Owner Facilities:** The Generator Owner is responsible for building, owning, and maintaining the assets. The Generator Owner bears the expense for these assets.
- **Transmission Interconnection Facilities (TIF):** LG&E and KU Transmission is responsible for building, owning, and maintaining the assets. The Generator Owner bears the non-refundable expense for these assets (Generation contribution to Transmission).
- **Network Facilities (NF) (include NNF):** LG&E and KU Transmission is responsible for building, owning, and maintaining the assets. However, the Generator Owner funds the initial expense for the Network Facilities unless LG&E and KU Transmission chooses to fund

them. Any funds received from the Generator will be refunded to the Generator, plus interest, as the Generator takes transmission service, or repayment can be set up over a defined period. The Terms of payment for the Network Facilities will be determined in the negotiation period (identified in the LG&E and KU OATT: Attachment M Section 11) of the LGIA.

- **Distribution Facilities:** LG&E and KU Transmission does not own any Distribution Assets. So, Distribution Asset Costs identified would be reviewed and determined with the local distribution utility.

The LGE-GIS-2020-001 Solar Transmission Estimate was created following the below steps:

- Engineering and Project Management costs were estimated. LG&E and KU project Management & Engineering labor were estimated at 20% of the contracted project Management & Engineering labor cost.
- Construction Management labor costs were estimated. LG&E and KU Construction Management were estimated at 50% of the contracted Construction Management labor costs.
- The Generator Owner facilities are not included in the estimates.
- The Transmission Owner's Telecommunications Department provided an estimate for telecom facilities.
- Cost estimates were broken down between Company labor, contracted labor, materials, and contingency.
- Pricing provided by the vendor was combined with Transmission Owner's burdens and contingency cost
- Pricing provided by the Transmission Owner's Telecommunications Department was aggregated in the cost summary table.
- The responsibility for costs was determined per the Transmission Owner's Allocation of Costs for Generator Interconnections document, effective January 1, 2018, for connecting to a new substation ring bus configuration. As such, costs associated with this estimate are categorized as Transmission Interconnect Facilities (TIF) and New Network Facilities (NNF). All costs associated with Transmission Interconnect Facilities (TIF) will be the sole responsibility of the Interconnection Customer. Transmission Interconnect Facilities (TIF) cost estimate and summary are shown on Section 4.5.2. New Network Facilities (NNF) cost estimate and summary are shown on Section 4.5.4.

4.2 Major Project Assumptions, Constraints, and Risks

4.2.1 Assumptions and Clarifications

The cost estimates prepared for this interconnect request are based on the following assumptions.

- The IC's interconnection circuit construction and the IC's generation facilities are not included in this study.
- Substation Engineering & Project Management costs are assumed to be split between Network and Interconnect Facilities based on the ratio of zones of protection for the ultimate station configuration. For this estimate, these costs were split 67% Network, 33% Interconnection.
- Construction Management costs are assumed to be split between Network and Interconnect Facilities based on the ratio of zones of protection for the ultimate station configuration. For this estimate, these costs were split 67% Network (60% Substation, 7% Lines), 33% Interconnection.
- Estimate accuracy is +/- 20%.
- Internal LG&E-KU costs for Project Management & Engineering labor were estimated at 20% of the contracted Project Management & Engineering labor costs.
- Internal LG&E-KU costs for Construction Management were estimated at 50% of the contracted Construction Management labor costs.
- Telecom labor and material costs were provided by LG&E-KU and are assumed to be 100% LG&E-KU costs.
- LG&E-KU burdens and contingency were estimated internally by LG&E-KU.
- All contracted costs presented within this report include 6% escalation on cost, contractor burdens, and markups.
- Union Labor rates were utilized for construction labor.
- Materials are assumed to be tax exempt. No sales taxes are included in the estimate.
- Insurance is included for contracted costs.

4.2.1.1 Construction

- Temporary construction power is assumed to be provided by LG&E-KU.
- Costs for subcontracted site security are included for non-work hours, holidays, and weekends for the duration of construction.
- Costs are included for a part-time onsite Construction Safety manger.
- Temporary laydown, matting, or other improvements are not included.
- Overhead Line construction is assumed to be concurrent with construction of the interconnection facility station.
- No costs are included for crop damage.
- Costs for demolition of the existing control house at Lake Reba Tap substation is included in this estimate. It is assumed that LG&E-KU will be responsible for disposal of demolition waste from the control house.

4.2.1.2 Civil-Site Development

- Site development for the access road, substation pad, and transmission cut-in will be by the IC and is not included in the cost of this estimate. It is assumed that all property purchase, site clearing/grubbing, grading, landscaping, drainage, stormwater, and/or erosion control design, permitting, and construction will be provided by the IC. The IC will provide a rough graded and fenced pad with a 20’ swing gate per LG&E-KU standards.
- Boundary, topographic, and/or environmental surveys are not included and are assumed to be by the IC.
- Site Planning, Zoning, Easement and/or Real Estate negotiations or approvals are not included and are assumed to be by the IC.
- All environmental and other necessary permits to complete the site development construction will be secured and paid for by the IC.
- Final surfacing stone for the station is included.

4.2.1.3 Civil-Structural

- H-Frame and lightning mast structures will be comprised of bent plate and will be detail-designed by a steel fabricator, with loads provided by the substation engineer.
- All remaining steel will consist of standard AISC shapes to be detail-designed by the substation engineer.

- Geotechnical soil information was not available at the time of the estimate completion. Black & Veatch completed a geotechnical desktop review of the site location to generate foundation design assumptions for the estimate. Costs for procurement of soil borings, soil resistivity testing, and completion of a geotechnical report are included in the estimate.
- Based on the proposed location of the site, it is expected that the site will fall under Seismic Design Category C. Liquefaction was not considered for foundation design estimates.
- Based on Kentucky Geological Survey maps, there is a low risk of Karst. No costs for additional studies for sinkhole/void investigation are included in this estimate.
- The soil conditions are assumed to be conducive for the installation of drilled pier foundations. It is assumed that temporary and/or permanent casing will not be required.
- Based on the geotechnical desktop review, it was assumed that the site will consist of clay soil over rock. Rock depth is expected to vary but could be as shallow as 5' below grade. Drilled pier foundations are assumed to have a rock socket of up to 5 feet, varying based on the magnitude of the applied loads and length of foundation. Final rock embedment will be dependent on actual depth of rock.
- The control house at both the GI Station and the Lake Reba Tap are assumed to be constructed at approximately grade elevation on drilled pier foundations. They will not be elevated for flood considerations. No stairs are assumed to be required

4.2.1.4 Relaying & Communications

- The IC will supply the fiber communication (OPGW) channel between the IC collector substation and the LG&E-KU station.
- The estimate includes costs for the fiber connection from the new LG&E-KU Control House to the dead end structure.
- The IC will supply a line protection relay panel in the IC-owned collector substation to interface with the LG&E-KU-owned line protection relay panel in the interconnection station for coordinated protection of the IC line segment.

4.2.1.5 Transmission Lines

- Analysis of existing structures within PLS-CADD was not completed
- It was assumed the criteria, line tensions, and structure configurations within PLS-CADD model, lake reba – delvinta (612015). BAK, are accurate.
- An additional 200 FT for pulling/tensioning adder and 2% sag adder was utilized for shield wire.

- An additional 300 FT for pulling/tensioning adder and 2% sag adder was utilized for the conductor.
- It is assumed no permitting will be required for the transmission line efforts.
- The estimate does not include costs associated with distribution work. It is assumed no work will be required.
- Foundations are excluded from the estimate at this time, pending a geotechnical investigation. The estimate will be updated with foundation costs upon completion of the geotechnical investigation and conceptual foundation design

4.2.2 Project Risks and Constraints

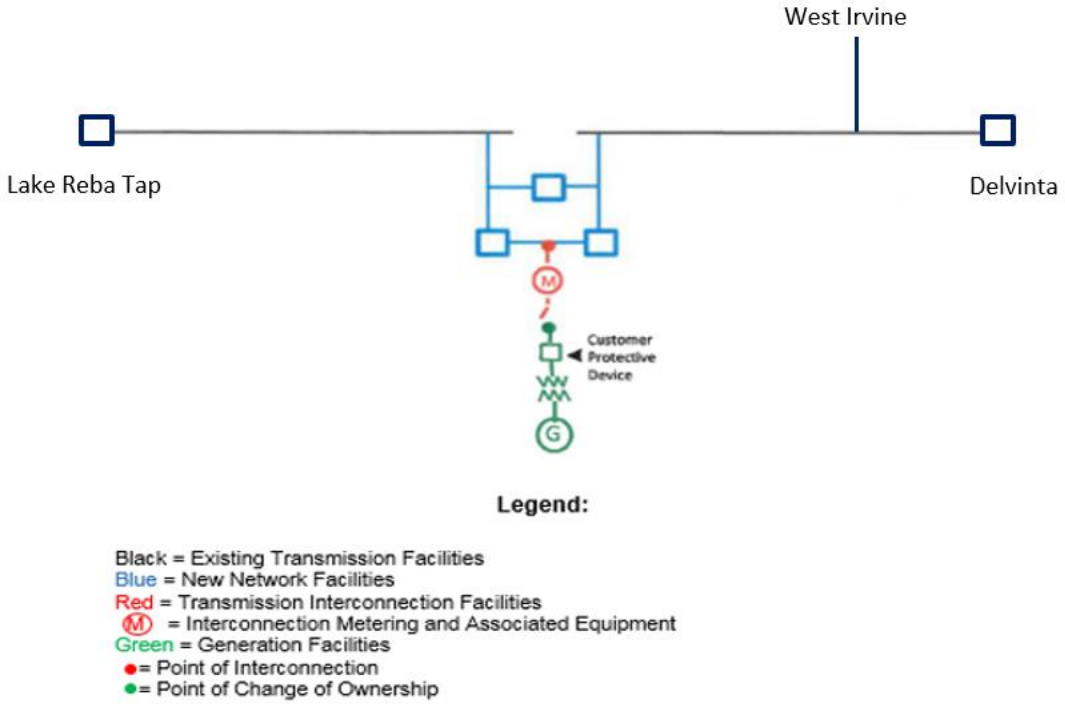
- Geotechnical soil information was not available at the time of the estimate completion. Black & Veatch completed a geotechnical desktop review of the site location to generate foundation design assumptions for the estimate. Costs for procurement of soil borings and completion of a geotechnical report are included in the estimate. Site soil conditions that differ from anticipated conditions could have significant impact on foundation design and below grade construction.
- No property survey information was available at the time of the conceptual substation design and cost estimate. The locations of the network and interconnection facilities were identified based on aerial imagery and partial property parcel information. Changes to the physical location of the facilities could impact costs.
- Material and labor availability at the time of project execution could have significant cost impacts.

4.3 Interconnection Facilities Needs

Figure 1 shows the division of responsibility for a new substation ring bus configuration, per the Transmission Owner's *Allocation of Costs for Generator Interconnections* document, effective 01/01/2018.

The IC will be responsible for the design, construction, and permitting of the transmission line from their facilities to the Point of Change of Ownership (PCO) at the existing Lake Reba Tap – West Irvine Tap161 kV line.

Figure 1: Point of Interconnection



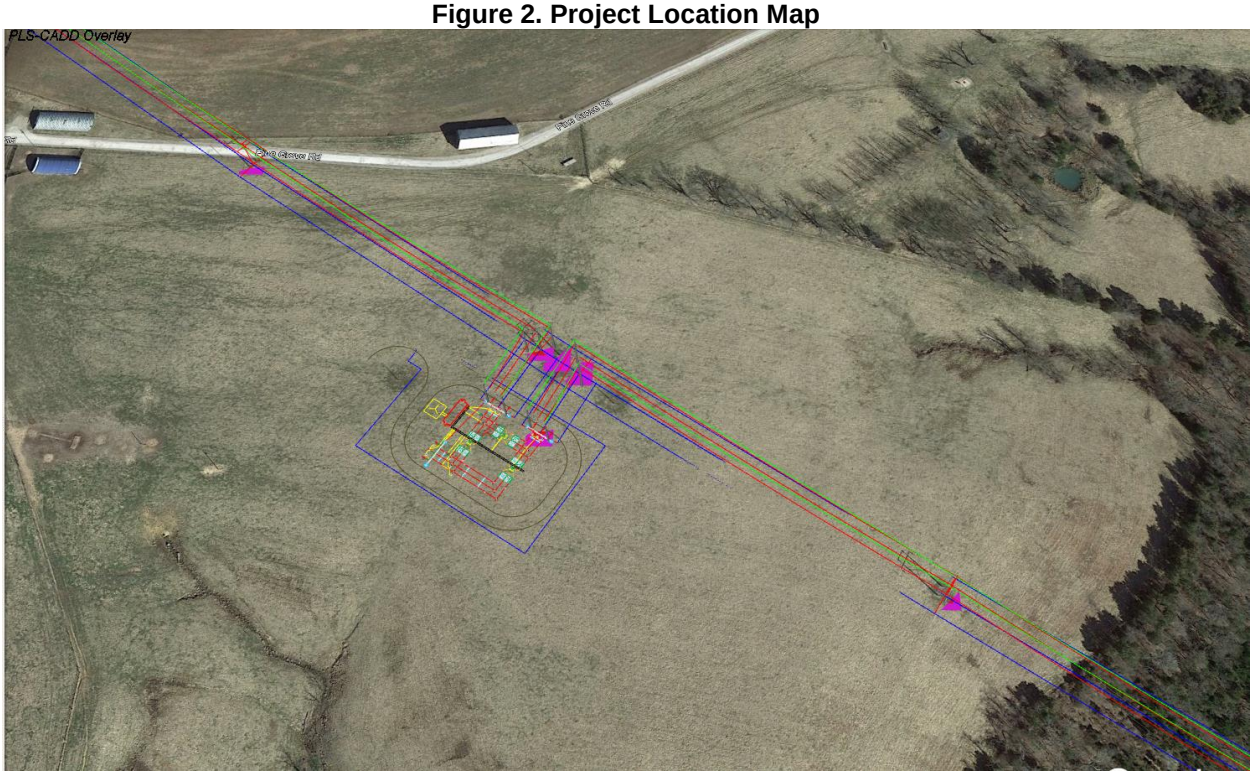
Details of the Transmission Interconnection Facilities and New Network Facilities required for the generation interconnection are provided in Section 4.5.

4.4 Description of Upgrades

The next section describes facilities identified to be installed, replaced, and/or upgraded by LG&E-KU to accommodate the project. During detailed design other components may be identified for installation or replacement due to this interconnection.

The conceptual station arrangement developed for this estimate is included as Appendix A. The station and transmission line structure locations are shown below in Figure 2. The approximate latitude and longitude of the POI is (37.709542°, - 84.111944°).

Figure 2. Project Location Map



4.5 Total Conceptual Cost Estimate: (Total Estimated Cost $13,332,904 USD)

The cost estimates are based on existing substation ring bus interconnection configuration as shown in Figure 1 of Section 4.3 and the assumptions provided in the Section 4.2. The estimated total project cost is estimated with +/- 20% accuracy.

4.5.1 Generator Owner Facilities

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

4.5.2 Transmission Interconnection Facilities: (Total Estimated Cost $1,995,044)

The transmission interconnection facilities will include all equipment and materials at the interconnection facility between the Point of Ownership Change and the Point of Interconnection. The required equipment and materials are identified below, and a summary of the interconnection facilities costs are provided in Table 4-1.

4.5.2.1 Station

The transmission interconnection facilities will include the following:

4.5.2.1.1 High Voltage

- One (1) 161kV Motor-Operated Disconnect Switch mounted on H-Frame structure
- Three (3) 161kV Surge Arresters
- Three (3) 161kV Metering CCVTs
- Three (3) 161kV Metering CTs
- Two (2) 161kV SSVTs (Split Cost between Network and Transmission Interconnect as described above)

4.5.2.1.2 Civil/Structural

- One (1) Steel H-Frame Structure & Foundations
- Six (6) 1-Phase CCVT / Metering CT Supports & Foundations
- Two (2) SSVT Supports (Split Cost) & Foundations
- Drilled pier foundations for new control enclosure and associated entrance mats (Split Cost)

4.5.2.1.3 Protection & Control

- One (1) New Control House Space Allocation consisting of the following:
    - Line protection panel for GI Interconnect
    - (1) Metering panel
    - (1) RTU panel
    - AC/DC systems (Split Cost)

4.5.3 Transmission Lines

- Not applicable

4.5.3.1 Telecommunication Facilities

- Not applicable

Transmission Interconnection Facility Cost Estimate

Description	TIF Subs Cost
Company Labor	$240,745
Contract Labor	$810,958
Materials	$761,973
Contingency	$181,368
Total	$1,995,044

4.5.4 Network Facilities: (Total Estimated Cost $11,337,860 USD)

The network facilities include a new 161 kV circuit breaker and two (2) disconnect switches that will be added to the existing ring bus for the new GI line. Other Network Facility requirements include telecom infrastructure and rerouting of existing OPGW static wire on transmission structures outside of the North Princeton station to allow room for the new GI Line. The required equipment for each component of the network facilities is identified below and a summary of the network facilities costs are provided in Table 4-2.

4.5.4.1 Network Interconnection Facilities: (Total Estimated Cost $11,337,860)

LG&E/KU and the vendor combined cost estimate for network interconnection facilities is shown in Table 4-2 and includes the following:

4.5.4.1.1 High Voltage

GI Station

- Three (3) 161kV Circuit Breakers
- Six (6) 161kV Manually Operated Disconnect Switches
- Six (6) 161kV Surge Arresters
- Six (6) 161kV CCVTs
- Two (2) 161kV SSVTs (Split Cost between Network and Transmission Interconnect as described above)
- Four (4) Wave trap with Line Tuner

Lake Reba Tap

- All existing equipment will remain, but all new conduits will be installed from existing equipment to new control house.
- Two (2) wave trap and (2) line tuner for the GI station line

West Irvine Station

- Two (2) wave trap and (2) line tuner

Delvinta Station

- Two (2) wave trap and (2) line tuner

4.5.4.1.2 Civil/Structural

GI Station

- Two (2) Steel H-Frame Structures
- Five (5) 3-Phase High Bus Supports
- Sixteen (16) 1-Phase Low Bus Supports
- Two (2) 1-Phase High Bus Supports
- Four (4) Low Disconnect Switch Support Stands
- Two (2) High Disconnect Switch Support Stands
- Six (6) 1-Phase CCVT Supports
- Two (2) SSVT Supports (Split Cost)
- Drilled pier foundations for new control enclosure and associated entrance mats (Split Cost)
- One (1) Lightning Mast
- Three (3) circuit breaker slab foundations

Lake Reba Tap

- Demolition of existing control house slab foundation
- Drilled pier foundations for new control enclosure and associated entrance mats

4.5.4.1.3 Protection & Control

GI Station

- One (1) Small (14’ x 42’) control house.
- Two (2) line protection panels for Lake Reba Tap & West Irvine-Delvinta
- One (1) communication path for DCUB and DTT associated with the Lake Reba Tap line
- Dual frequency PLC communication path for DCUB and DTT associated with the West Irvine-Delvinta Line
- One (1) RTU panel
- One (1) DFR panel
- AC/DC systems (Split Cost)

Lake Reba Tap

- One (1) Small (14’ x 42’) control house to replace the existing, which does not contain sufficient space to accommodate additional panels
- One (1) communication path for DCUB and DTT associated with the GI station line
- One (1) communication path for DCUB and DTT associated with the Fawkes-EKP Fawkes line
- One (1) communication path for DCUB and DTT associated with the Bluegrass Army Depot line
- One (1) new line protection panel for the GI station line
- One (1) new line protection panel for the Fawkes-EKP Fawkes line
- One (1) new line protection panel for the Bluegrass Army Depot line
- One (1) new line protection panel for the J.K. SMITH line

West Irvine Station

- Dual frequency communication path for DCUB and DTT associated with the GI station line
- One (1) new line protection panel for the GI station line

Delvinta Station

- One (1) new line protection panel for the GI station line
- Dual frequency communication path for DCUB and DTT associated with the GI station line

4.5.4.2 Transmission Lines

The transmission line scope of work includes a 161kV tap to the existing Lake Reba – Delvinta transmission line. The scope includes the following items:

- Two (2) 161kV three (3) pole, caisson supported, steel deadend structures and foundations

- Remove one (1) 70’ h-frame tangent wood pole structure
- Hardware and Conductor for taps from existing 161kV line to the station structures

4.5.4.3 Telecommunication Facilities

Telecommunication requirements for the interconnection facility includes work at the Interconnection Facility as well as work at Richmond Service Center (Communication source location) and Lake Reba Tap station. The costs for telecom facilities are assumed to be 100% New Network Facilities. The scope includes the following items:

- Geotechnical and Field Path Surveys
- Three (3) 195’ tall Microwave tower and foundations – one at each location
- Antennae and alarm systems
- Alarm systems
- Relay Racks
- Wilmore DC-DC converters
- Dehydrators
- 11 GHz MW radios
- ICON nodes
- Data Network switches

Table 4-2
Network Interconnection Facility Cost Estimate

Description	Cost
Company Labor	$900,543
Contract Labor	$3,504,018
Contracted Materials	$5,902,599
Contingency	$1,030,699
Total	$11,337,860

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

No distribution facility upgrades have been identified.

This report does

5. Conclusion and Project Completion Timeframes

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.

In addition, the customer must work with the TO and ITO during the Facilities Study (FS) to determine mutually agreeable relay settings. If the Table E-3 modified settings cannot be used, additional study maybe required.

No third party constraints were identified in this study, and no Ad Hoc Study Group member has indicated a need to perform an Affected System Study as shown in Tables E-4 and E-5.

In order to obtain 50 MW injection at the POI, the study determined that the gross generation at the plant inverter bus would need to be 51 MW. The solar plant gross generation of 51 MW was modeled for this SIS. The data provided by the customer supports the 51 MW gross generation level. .

The study determined that the inverters' +/- 17.163 MVAR reactive capability plus the customer provided 8 MVAR capacitor did meet the +/- 0.95 power factor at the high side of the customer main transformer requirement.

The engineering, design, and construction of the interconnection facilities and network upgrades is estimated to take twenty-four (24) months from receipt of the Interconnection Customer's execution of the LGIA or notice to proceed in the event of a suspension. Additionally, this estimate assumes that the project schedule would not be impacted by storm damage and restoration, time of year limitations, permitting issues, outage scheduling, system emergencies, and contractor and equipment availability, or other unforeseen circumstances.

Interconnection to LG&E and KU system is contingent on steady state, short circuit and dynamic model, assumptions and settings used in the SIS and Facilities Study.

6. References

[1]https://www.oasis.oati.com/woa/docs/LGEE/LGEEdocs/Allocation_of_Costs_for_Generator_Interconnections_effective_1-1-2018.pdf

Appendix A. Conceptual Substation Layout

The appendix A of this report is available on the LG&E and KU Critical Energy Infrastructure Information (CEII) File Transfer Protocol (FTP) site. The LG&E and KU secure CEII FTP site URL is: https://eftws.lge-ku.com/EFTClient/Account/Login.htm.

Appendix A. Conceptual Substation Layout

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