CITY OF ST. LOUIS

ELECTRIC DISTRIBUTION SYSTEM STUDY

& FIVE-YEAR PLAN

FINAL REPORT
OCTOBER 7, 2024

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CITY OF ST. LOUIS
St. Louis, Michigan

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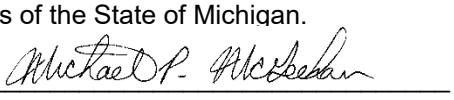
I hereby certify that this plan, specification or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Michigan.

Signature: 

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CITY OF ST. LOUIS
ELECTRIC DISTRIBUTION SYSTEM STUDY & FIVE-YEAR PLAN
EXECUTIVE SUMMARY

The scope of this electric distribution system study was to review the City of St. Louis' substations and distribution systems for equipment & conductor capacity issues, customer reliability, circuit backup ties, and voltage issues under several system scenarios. The electric system review was performed for normal system conditions plus first contingency (N-1) substation and distribution circuit critical equipment outages.

The City of St. Louis electrical system is served by a looped 46kV transmission line from Consumers Energy (CE). The City has two substations and nine circuits with three distribution voltages of 12.47kV, 4.16kV, & 2.4kV. The Gibson Substation (12.5kV) is in the northeast corner of the distribution system near the three correctional facilities. The St. Louis Main Substation (2.4kV & 4.16kV) is located in the north-central portion of the service territory adjacent to the hydro dam and diesel generation plant. Consumers Energy owns the power transformers and voltage regulators at the Main Substation the City of St. Louis owns the 5kV main busses and reclosers at this substation. The City pays over $63,000 annually to Consumers Energy for Capital and O&M Charges on the St. Louis Main Substation

The existing computer model of the primary (5kV & 15kV) electrical system was updated for the existing system and upgrades completed prior to June 1, 2023 through field mapping the primary facilities. Additionally, substation circuit reads from July 27, 2023 and customer billing load for the month of August 2023 were imported into the model and utilized for circuit load analysis.

A system operating philosophy including maximum conductor and equipment loading limits plus voltage limits was established. Conductors, reclosers, and distribution switches will be allowed to operate at 50% of their thermal rating for normal system conditions under peak loading conditions and 90% for first contingency operations. Substation transformers, voltage regulators, and high side (46kV) equipment will be allowed to operate at 40% of full forced-air nameplate rating for normal operation and 80% for first contingency operations.

The substation and distribution system were analyzed for capacity and voltage issues under peak load conditions based on 2023 system peak loading and anticipated large load additions, plus a small 0.3% load growth for 5 and 10 years. Analysis included conductor and equipment capacity and voltage drop for normal circuit configurations plus utilizing all full capacity circuit ties. A field assessment of the substation and each distribution circuit was completed. The top load and critical customers were assessed for reliability and robustness of service.

The City of St. Louis owned substation power transformer and equipment are all operating within the established limits set by this report under peak 2023 loading conditions, with the system in its normal configuration. The CE owned 2.4kV substation transformer is operating at 67% of its nameplate rating at peak conditions. There are eleven sections of mainline conductor located on five of the distribution circuits that are operating above the established loading limits. A majority of the circuits are radial with no backup tie to many of the critical and top load customers on the system.

An assessment of the substations revealed concerns with aged, oil-filled reclosers, underrated fuse holders, contaminated insulators, plus bare jumper wires and exposed bushings at wildlife contact points. Key physical concerns on the distribution system include aged construction, exposed primary bushings and bare jumper wires which are points of contact for wildlife, sections of direct buried, unjacketed underground cable, and transclosure installations.

The most critical issue in the system is the inability to sustain loss of a substation transformer without loss of service to any customers. Loss of any one of the three substation power transformers will result in an indefinite outage until repairs can be made or a replacement installed. Lead times on substation transformers currently range from 1.5 to 3.5 years once an order has been placed. Although Consumers Energy has not provided information on the availability of a spare for the two transformers under their ownership, the time to install a replacement will still be lengthy. The solution to this issue is the construction of a second 12.5kV substation along with distribution circuit voltage conversion and installation of normally open tie switches.

A total of twenty-five substation and distribution system upgrades projects were targeted for completion over the next five years. The projects initially focus on upgrades to portions of the system that impact the highest number of customers and the most critical customers. Next are distribution projects that shift load off the 2.4kV substation to the more reliable 12.5kV system. The proposed new 46kV:12.5kV substation is next on the priority list. Interspersed with these large capital projects are smaller projects including installation of capacitor banks to reduce system losses and investments in non-capital projects including implementation of a GIS system.

Completion of the recommended projects listed in this report will allow the City of St. Louis to more reliably serve their electric system customers by performing preventative maintenance at and upgrading Gibson Substation, constructing a new Main Substation that operates at 12.5kV, converting the distribution system to a single operating voltage of 12.47kV, removing single-points of failure, and increasing circuit backfeed capabilities to the majority of its customers including the top load and critical customers. System Circuit Maps, Proposed Project Maps designating the proposed capital projects, Proposed Circuit Maps are attached to this report.

CITY OF ST. LOUIS
ELECTRIC DISTRIBUTION SYSTEM STUDY & FIVE-YEAR PLAN
BACKGROUND & FINDINGS

The scope of this electric system study was to review the 12.47kV, 4.16kV, and 2.4kV distribution systems from the substation transformers through the distribution transformer level for equipment and conductor capacity issues, plus voltage issues under several system scenarios for both current system loads and projected 5 and 10-year load growth. Assessments were completed for normal system conditions plus first contingency (N-1) substation and distribution circuit critical equipment outages. Substation equipment was assessed for age and potential reliability issues. Additionally, the distribution system was assessed for aging construction including copper overhead conductors, unjacketed underground cable (where known), failing equipment, and areas with high outage rates. Implementation of the recommendations included in this report will maintain conductor and equipment within specified ratings, will balance circuit loads, will increase capacity of distribution circuits and improve customer reliability.

Study process included:

- Obtained documented history of electrical distribution system operational issues, outages, and potential growth areas.
- Retrieved summer peak circuit loads and hourly system demand data.
- Developed the City of St. Louis electric system operating philosophy including maximum conductor and equipment loading limits and voltage limits.
- Analyzed and reviewed distribution systems for capacity issues and voltage issues including conductor, substation equipment, and distribution transformer loading levels, voltage drop, capacitor placement, and load balancing.
- Analyzed system capacity and voltage drop with the use of all mainline circuit ties.
- Performed system load growth scenario for 5 & 10 years. Completed capacity and voltage drop analysis for each load growth case plus contingency cases with loss of each substation transformer and use of all mainline circuit ties.
- Assessed substation equipment for age and potential reliability issues.
- Assessed system for aged construction including copper conductors, unjacketed underground cable, and failing equipment.
- Analyzed system for ability to shift either substation load for maintenance and unplanned outages without utilizing any equipment inside the substation that is de-energized.
- Analyzed system reliability for both ten highest load customers and most critical customers.
- Prepared a list of recommended system improvement projects including substation equipment upgrades, distribution circuit rebuilds, underground conductor replacement, and GIS implementation.

System Background Information

The City of St. Louis electrical system is comprised of the following:

- One 12.47kV distribution substation (Gibson)
- One 2.4kV & 4.16kV distribution substation (Main)
- Three 12.47kV distribution circuits
- Three 4.16kV distribution circuits
- Three 2.4kV distribution circuits
- 26.8 Miles of overhead distribution line
- 6.2 Miles of underground distribution line
- 5,700kW of aggregated Generation (Hydro/Diesel/Natural Gas)
- 2023 Peak demand 7.03MW (7.68MVA)
- Approximately 1900 Customers

The City of St. Louis electrical system is served by a looped 46kV transmission line from Consumers Energy (CE). This 46kV transmission line feeds into and out of Main Substation, taps radially to Gibson Substation, and has a normally open point on Union Street north of the tap. The City of St. Louis system is comprised of two substations and nine circuits with distribution voltages of 12.47kV, 4.16kV, & 2.4kV. The Gibson Substation is in the northeast corner of the distribution system near the two correctional facilities. The Main Substation is located in the north-central portion of the service territory adjacent to the hydro dam and diesel generation plant.

Gibson Substation is the newest and most up to date substation on St. Louis' system, it was constructed in 2004. The substation is comprised of one 46kV:12.47kV 10/12.5MVA power transformer, low side voltage regulators, main bus and three vacuum reclosers. The power transformer is protected by high side fusing for each individual phase. Each recloser protects one of the three circuits with underground cable exits. This substation does not have a transfer bus or an adjacent power transformer, should the power transformer or main bus become out of service, there is no backup for this substation's distribution circuits. To perform maintenance on this station an outage to customers served by the substation is required.

Main Substation is the older of the two substations and serves two separate distribution systems. There are two power transformers at the Main Substation, one 46kV:2.4kV 2500kVA delta configured and one 46kV:4.16kV 10MVA wye configured. The power transformers and voltage regulators are owned by Consumers Energy (CE) and the City of St. Louis owns the 5kV main busses and reclosers at this substation. As is the case with the Gibson Substation, this substation also does not have an adjacent backup transformer or transfer bus. If the power transformer, voltage regulators, or main bus are out of service, there is no backup for any of this substation's distribution circuits. To perform maintenance on this station an outage to customers served by the substation is required.

Electrical Distribution System Loading

Michigan Public Power Agency (MPPA) provided historical peak system loads and circuit loads for the years 2015 – 2023. St. Louis' load has fluctuated by nearly 3MVA over the last nine years as shown in the attached Historical System Load graph which is attributed to the remediation system at the Velsicol site. Since this is a system capacity and planning study, peak summer load data from July 2023 was utilized in the analysis. Peak system load data provided by MPPA shows

the most recent system peak occurred on September 5, 2023 at hour ending 13:00. Using the billing data from July 2023 and recorded substation circuit amps over the same interval, load was applied to the electric system model.

The City of St. Louis is not required to maintain power factor within established limits and is not billed for power factor correction by CE. Total system power factor and kVAR loading were taken into account in this study as it is a capacity and load flow study. Average power factor from monthly energy bills and the power factor at the time of annual peaks were provided for use in this study. The total system average power factor is approximately 91.0% and the power factor at the time of peak has averaged 90.5% over the last nine years.

The electrical system is currently loaded to 25.0% of total substation transformer capacity at the 12.47kV voltage level, 31.0% at the 4.16kV voltage level, and 67.0% at the 2.4kV voltage level. The City of St. Louis is a summer peaking utility but occasionally has high load days during the shoulder seasons.

System Model Update

The St. Louis' electric distribution system model was created in Milsoft's WindMil Engineering Analysis software by GRP Engineering in 2014 to complete an arc-flash study and updated in 2023 to complete this study. The model was created through field mapping the St. Louis system and building a model based on these maps. The model is comprised of transmission source impedances, substation equipment, plus primary distribution line sections, equipment, and consumers (meters). The model does not contain secondaries or services which is acceptable for this study due to the excessive computational time added to system analysis routines. Revisions were made to the model for system upgrades completed up to June 1, 2023.

System Load Allocation

Proper load allocation on the system within the computer model is key to accurate analysis results. Importing individual customer billing data provides the most accurate results. The City of St. Louis provided distribution circuit load for the system peak on July 27, 2023, listed by circuit and individual phase. A billing file from the month of July 2023 was provided by the AMI system and contained the monthly loads & demands of the customers. Current transformers & potential transformer ratios were included in the provided billing file for the primary metered customers.

The electrical distribution system model contains 1,836 consumers of which load was applied to. Primary metered customer load was provided in a separate billing file containing kW demand and was manually entered into the model. All loads in the billing file provided was able to be applied to the system model.

Load was allocated in the model using Windmil's top-down method. This method places customer usage data from the billing file into the consumers within the model and load control points (LCP) are created. Each of the nine circuit's reclosers at the three distribution substations were utilized as LCP's and no additional control points were created. The peak circuit demands were input into the LCP's by phase or total kW and then the Windmil Load Allocation tool was used for calculation and applying load. This tool applies load to the model based on the LCP's and calculated load from the provided billing file through an iterative process until the results converge.

Load Growth & Additions

MPPA's load forecast projection for the City of St. Louis anticipates a small decrease in total system load demand of 0.5% between year 2024 and 2030, followed by annual small increases in load thereafter. For this study a slight increase in demand at a growth rate of 0.3% was utilized due to potential load increases from electrification. There are currently no known areas of the City of St. Louis system where load is expected to grow. Peak demand load projections (MW & MVA) are listed below.

Load Projections

Year	MW Demand	MVA Demand
2023	7.0	7.7
2024	7.1	7.7
2025	7.1	7.7
2026	7.1	7.8
2027	7.1	7.8
2028	7.1	7.8
2029	7.2	7.8
2030	7.2	7.9
2031	7.2	7.9
2032	7.2	7.9
2033	7.2	7.9

[1]Annual escalation factor of 0.3% plus projected load additions.
[2]MVA calculated based on 90.5% power factor

The addition of plugin electric vehicle (PEV) charging could bring substantial growth in 5-10 years' time. Current industry standards for modeling PEV loading forecasts are widely varying and depend on the makeup of the utility's customer base. The City of St. Louis should annually review circuit loading to ensure system capacity remains available.

Reliability

The following criteria will be used to determine if St. Louis' most critical and largest load customers (based on kWh & kW demand) have reliable and robust electric service.

- Historical outage reports
- Available backup circuit tie.
- Field circuit ties to an alternate substation transformer.

The City of St. Louis provided a list of the top ten load and most critical customers on their system. These included medical facilities, governmental and public safety buildings, large commercial and

industrial customers, plus domestic water wells. A combined list of Critical and Top Load Customers is provided below. Separated top load and critical customer tables are attached to this report.

Critical & Top Load Customers

Customer	Top Load Ranking[1]	Critical
Michigan Department of Corrections	1	Yes
Plasti-Paint	2	
Jer-Den Plastics	3	
Alpha Custom Extrusions	4	
Apex Marine	5	
Schnepp Nursing Home	6	Yes
Bear Truss	7	
St. Louis High School	8	Yes
TSN Middle School	9	Yes
WWTP	10	Yes
St. Louis City Hall	11	Yes

[1]Load ranking based on total kW demand from 2023 billing.

Conductor & Equipment Ratings

In order to evaluate substation transformer and distribution circuit capacity, not only must system load be determined, but maximum equipment and conductor ratings must be established. Ratings utilized in this study were established for three system conditions:

1. Normal – All substation transformers and distribution circuits in service, and circuit tie switches open.
2. First Contingency – One substation transformer, distribution circuit breaker or recloser out of service, bus tie switch/circuit tie switch closed. Loss of customers is not acceptable.
3. Second Contingency – Two substation transformers or distribution circuit breakers out of service with field circuit tie switch closed. Loss of customers will be acceptable.

Substation equipment including high-side (46kV) power transformers, circuit switchers, transformer secondary breakers, voltage regulators and their associated switches, will be allowed to operate at 40% of maximum nameplate rating for normal conditions, 80% for 1st contingency outages, and 100% for 2nd contingency outages. Low-side (12.47kV, 4.16kV, & 2.4kV) substation equipment and distribution circuit conductor, regardless if overhead or underground, will be allowed to operate at 50% of maximum nameplate or thermal rating for normal system conditions, 90% for 1st contingency outages, and 100% for 2nd contingency outages. The equipment and conductor ratings established in this study are goals for the City of St. Louis to achieve and are the basis for the analysis and recommendations. These ratings only apply to substation equipment owned by the City of St. Louis as the City has no control over CE-owned equipment. Refer to the Equipment & Conductor Loading table attached to this report.

Maximum ratings for substation equipment are provided by the manufacturers and are listed on equipment nameplates. Due to the expense and lead time associated with substation transformers and equipment, maximum continuous loading should not exceed nameplate ratings unless in an emergency situation. Short term overloads in emergency situations can be handled by transformers with little or no damage based on the percentage of overload and duration.

Overhead conductor ratings are more difficult to establish than equipment ratings since the calculations include thirteen variables including selecting maximum temperature often based on unknown design conditions. The ampacity (thermal) ratings of overhead conductors on the City of St. Louis system were determined by the following variables:

- 90°F (32°C) Ambient Temperature
- 167°F (75°C) Conductor Temperature *(Normal, 1st Contingency & Emergency)*
- 2ft/sec wind speed (utility standard)
- Additional eleven variables using a conservative approach.

Standard ACSR is not a high-temperature conductor and is not designed for use above 212°F. It is rated for 167°F continuous operation and 212°F emergency operation for a total of 1,500 hours over the conductor's life. Additionally, system design (sag & clearances) must reflect this rating. Conductor sag at 212°F is often not factored into overhead distribution circuit design therefore a more conservative rating (167°F) is prudent to be used for normal system conditions. Under emergency conditions, conductors will be allowed to operate at 130% of their normal rating for up to four hours.

Underground conductor ratings were determined based on cable characteristics and installation method based on conductor size.

- 90°C Conductor Temperature *(Normal & 1st Contingency)*
- 105°C Conductor Temperature *(Emergency Rating)*
- 20°C Earth Ambient Temperature
- 75% Load Factor
- Conductors up to #4/0 AL 15kV 1/3rd Concentric Neutral – direct buried, one circuit.
- Large conductors above #4/0 in size including tape-shield power cable – direct buried (non-concrete encasement) conduit, one circuit.
- 133%, EPR conductor insulation.

Conductor characteristics for the City of St. Louis' overhead and underground conductors were defined in the WindMil equipment database (EQDB) prior to running any analysis. This included ampacity ratings for normal system conditions, overhead construction design, and all underground cable characteristics, including cable and insulation diameters, concentric neutral cable characteristics, resistances, and dielectric constants.

Overhead and underground conductor ampacities utilized in the study are provided in the table in the attachments section of this report. This ampacity table should be utilized by City of St. Louis electrical system personnel for future system review and operation.

Voltage Limits

Primary system voltage limits were established based on published ANSI and MPSC voltage ranges. These allowable ranges of voltage at the customer / point of common connection (PCC) were the basis for this study. The range of service utilization voltage under normal system conditions is ±5% of 120V (114V – 126V). Since the secondaries and service wires were not included in the model, voltage drop was calculated on the primary system only. Case studies of both rural and municipal systems show that >99% of customers have ≤4.0V drop due to secondaries, services, and transformers. Therefore, a lower limit of 118V was used to account for voltage drop across the transformer and secondaries up to the customer's service entrance. This allows for 4.0V drop on secondaries and services not included in the current system model.

System Assessment

A field review of the electric distribution system and substations was completed. The 2.4kV, 4.16kV, & 12.47kV distribution systems, substations, and City of St. Louis owned facilities were visually assessed by experienced utility engineers for a number of issues including aged construction, equipment, and copper conductors, plus failing hardware, unjacketed underground cable, and vegetation issues. The field review did not include opening of padmount cabinets, transclosures, or transformers.

Substation Transformer Loading

Considering under 1st contingency outage conditions that no loss of service to customers will be allowed, substation transformer capacity must be sufficient enough to support the loss of one transformer in the system under peak load conditions. Substation transformer loading will be limited to 40% of the full forced air (FFA) nameplate rating of the unit under normal operating conditions. Limiting the loading of substation transformers under normal conditions, ensures the distribution system has sufficient capacity allowing for the loss of any substation transformer. Under a 1st contingency outage condition, substation transformers will be allowed to operate at 80% of their maximum rating. This provides capacity for short-term spikes in load, unplanned load growth, and additional load transfer in the event of a 2nd contingency condition. Refer to the Substation Equipment Loading Spreadsheet found in the Substation Loading attachments at the end of the report.

2023

Under 2023 peak loading conditions, the 2.5MVA Main Substation transformer was the only substation unit operating above the established 40% threshold for normal operating conditions. This power transformer is operating at 67% of its nameplate rating. Main Substation's 4.16kV 10MVA transformer is operating at 31%. These two substation transformers are owned by Consumers Energy, therefore loading levels are established by CE. Data and graphs provided in this report are presented for information purposes only. Gibson Substation's 10/12.5MVA power transformer is operating at 25% of the nameplate rating under peak load conditions. The established rating for all power transformers was based on allowing for a 55°C rise in the unit's temperature. This is the allowable rise in the transformer's temperature compared to the ambient temperature. Refer to the Substation Transformer Loading 2023 chart found in the Substation Loading attachments at the end of the report:

The City of St. Louis electric distribution system operates at three different voltages. Each of the three voltage systems has a single point of failure, the power transformers at the Gibson or Main Substations. Loss of any one of the three substation power transformers will result in an indefinite outage until repairs can be made or a replacement installed. Lead times on substation transformers currently range from 1.5 to 3.5 years once an order has been placed. Consumers Energy has not provided information on the availability of a spare replacement for the two transformers under their ownership nor the substation voltage regulators.

2028-2033

Under calculated 2028 & 2033 peak loading conditions including load growth, transformers are projected to maintain the loading and slightly increase. Under 2033 peak loading conditions, the 2.5MVA Main Substation transformer remains operating above the established 40% threshold for normal operating conditions. This power transformer is projected to be operating at 69% of its nameplate rating. Main Substation's 4.16kV 10MVA transformer is projected to be operating at 32%. Gibson Substation's 10/12.5MVA power transformer is projected to be operating at 26% of the nameplate rating under peak load conditions. While the loading on the 2.5MVA Main Substation remains an issue, the ability to backup the circuits served at each of the voltages if a

transformer fails is a greater concern. Refer to the Substation Transformer Loading 2028 & 2033 charts found in the Substation Loading attachments at the end of the report:

Substation Equipment

As established under the System Operating Philosophy, under a 1st contingency outage condition, no loss of service to customers will be allowed. Loading on high side substation equipment (46kV) will be limited to 40% of the devices' nameplate rating under normal operating conditions. Loading on low side substation equipment (12.47kV, 4.16kV, or 2.4kV) will be limited to 50% of the devices' nameplate rating under normal operating conditions. Limiting the loading of substation equipment under normal conditions ensures the electric system has sufficient capacity allowing for the loss of any single substation device. Under a 1st contingency outage condition, 46kV high side substation equipment including transformer secondary voltage regulators and their associated switches will be allowed to operate at 80% of maximum nameplate rating. Low side substation equipment operating at 12.47kV, 4.16kV and 2.4kV will be allowed to operate at 90% of maximum nameplate rating. This provides capacity for short-term spikes in load, unplanned load growth, and additional load transfer in the event of a 2nd contingency condition. Refer to the System Equipment Loading Spreadsheet. This spreadsheet is found in the Substation Loading attachments at the end of the report.

2023

Analysis was completed on all substation equipment including voltage regulators, fuses, reclosers, and switches for the normal state and first contingency conditions under peak 2023 loading conditions. Results of this analysis determined all pieces of substation equipment are operating below their established loading limits.

2028-2033

Analysis was completed on all substation equipment including voltage regulators, fuses, reclosers, and switches for the same normal state and first contingency conditions with five and ten years of load growth, plus all large load additions. Results of this analysis determined no additional pieces of substation equipment are anticipated to be operating above their established loading limits.

Distribution Circuit Loading

Consistent with the substation transformer outage conditions, no loss of service to customers will be allowed under 1st contingency distribution circuit breaker or main circuit outage conditions. This requirement will apply to mainline sections of distribution circuits. Limiting distribution circuit loading to 50% of conductor ampacity allows for one distribution circuit to be out of service and a backup circuit to carry all of the load under peak system conditions. Under this 1st contingency outage condition the conductor will be allowed to operate at 90% of its thermal rating. Short-term spikes in load will be covered by utilizing the reserve 10% or emergency conductor ratings. Although a majority of the distribution circuits in the system are radial with no backup, the analysis was completed the same for the entire system. Refer to the Distribution Circuit Loading Limit Diagram attached to this report.

2023

Mainline, three-phase circuit conductor loading was analyzed under 2023 peak load using the WindMil electric distribution system model. Following the conductor rating discussion provided in the Background & Findings section of this report, under normal system operating conditions,

conductors operating at or above 50% of their rated ampacity should be increased in size or have load shifted to other circuits. Analysis in Windmil determined several sections of mainline conductor or cable operating above the established 50% loading limit. Refer to the chart titled City of St. Louis Circuit Loading 2023 attached to this report.

The table below details the line sections that were determined to be operating above their allowable loading based on 2023 peak loading conditions and normal system configuration.

Overloaded Primary Conductors – System Normal

Substation	Circuit	Voltage	Area Description	Conductor	Capacity Rate
Main	1-6 Michigan Ave.	2.4kV	3Ø mainline circuit from substation exit to the first 3Ø tap at North St. and Mill St.	#1/0 ACSR	61.6%
Main	3-6 Prospect	2.4kV	3Ø mainline circuit from substation exit to river crossing.	#1/0 ACSR	83.7%
Main	3-6 Prospect	2.4kV	3Ø mainline circuit underground section along Main St. near the dam.	#1/0 AL	88.3%
Main	3-6 Prospect	2.4kV	3Ø mainline circuit from river crossing to 3Ø tap for WWTP.	#3/0 ACSR	77.0%
Main	3-6 Prospect	2.4kV	3Ø tap on Gratiot St. east of Union St. Tap feeds the WWTP.	#2 ACSR	93.9%
Main	#1 Old Industrial Park	2.4/4.16kV	3Ø underground cable exit from substation to river crossing.	#4/0 AL	53.3%
Main	#1 Old Industrial Park	2.4/4.16kV	3Ø mainline circuit from river crossing south along Main Street to Washington Street.	#3/0 ACSR	54.1%
Main	#2 Bear Truss	2.4/4.16kV	3Ø mainline underground cable located at the school pedestrian bridge across the Pine River.	#1/0 AL	55.2%
Main	#3 Michigan Ave.	2.4/4.16kV	3Ø underground cable exit from substation to overhead circuit riser pole.	#4/0 AL	63.6%
Main	#3 Michigan Ave.	2.4/4.16kV	3Ø mainline overhead from circuit riser pole to North Street.	#3/0 ACSR	65.2%
Main	#3 Michigan Ave.	2.4/4.16kV	3Ø mainline overhead from North Street south along Pine St to tap at Saginaw St.	#3/0 ACSR	62.1%

2028-2033

System load was grown at the projected 0.3% per year rate and conductor loading was analyzed with 5 and 10 years of growth utilizing the WindMil model. Based on the 2028 & 2033 anticipated peak load conditions, no additional sections of line were found to be above their established 50% rating. Sections of line that were already above their established ratings, increased by approximately 3.0%. The underground mainline section of #1/0 AL cable on circuit 3-6 Prospect noted above, was determined to be operating at 91.3% capacity after 10 years of load growth. Refer to the St. Louis' Circuit Loading 2028 & 2033 charts. Following the conductor rating discussion provided in the Background & Findings section of this report, under normal system operating conditions, conductors operating at or above 50% of their rated ampacity should be increased in size or load shifted to other circuits. For circuits operating at 2.4kV or 4.16kV, an increase circuit voltage will decrease the ampacity solving the loading issue.

Mainline Circuit Ties Loading

Conductor and equipment loading levels under a first contingency tie were evaluated for all three distribution circuit voltages. The Circuit Backup Review tables attached to this report list the ties for the distribution circuits on the City of St. Louis system. Highlighted values represent substation reclosers and distribution conductors operating above 90% when carrying the load of an adjacent circuit.

The City of St. Louis' 12.47kV distribution circuits all have normally open tie points to other circuits. The 4.16kV circuits #1 Old Industrial Park and #2 Bear Truss have a single tie point between each other. The tie is limited to 200A through a fused pole mounted cutout. All other circuits, four in total, do not have a field tie to another circuit. Lack of field ties and no transfer bus at the substations greatly limit the contingency options and result in several single points of failure on the system.

A total of eight circuit ties within the system were evaluated for capacity violations. 75% of these ties have 600A gang-operated switches on poles or in switchgear. The exception is the single tie point between 4.16kV circuits #1 Old Industrial Park and #2 Bear Truss, the maximum loading allowed is limited to the largest fuse.

2023

Under Peak 2023 loading conditions two (2) of the eight (8) distribution circuit ties are operating above the established 100% criteria. Under a first contingency condition with 2023 peak loading, the highest loaded backup conductors were determined to be the mainline #4/0 AL underground cable exit from the Main Substation on circuit #1 Old Industrial Park at 106% capacity and mainline #3/0 ACSR at the cable exit riser pole on circuit #2 Bear Truss at 109% capacity. All backup circuit reclosers were determined to be at or below 90% of their nameplate rating for a first contingency condition. All backup substation power transformers, high side fuses and transformer secondary voltage regulators were determined to be at or below 80% of their nameplate rating for a first contingency condition.

Analysis of the existing distribution circuit field ties shows the following deficiencies:

- No existing backup ties between 2.4kV circuits.
- All field ties between 4.16kV circuits are operating above 100% of their established rating.
- 4.16kV circuit #3 Michigan Ave does not have any existing field ties.
- Existing field ties have the same substation power transformer as a source.

The table below details the line sections that were determined to be operating above their allowable loading based on 2023 peak loading conditions and in first contingency configuration.

Overloaded Primary Conductors – First Contingency

Circuit Out of Service	Backup Circuit	Field Tie Location	Area Description	Conductor (Within Area)	Capacity Rate
#1 Old Industrial Park	#2 Bear Truss	Fused 3Ø overhead tap located at Washington and Harbor.	Mainline overhead circuit. Overloaded conductor from cable exit riser pole to voltage regulators on Hubbard St.	#3/0 ACSR	109.7%
#1 Old Industrial Park	#2 Bear Truss	Fused 3Ø overhead tap located at Washington and Harbor.	Mainline overhead circuit along Clinton St. Overloaded conductor from RR track to Hazel St.	#2 ACSR	90.9%
#2 Bear Truss	#1 Old Industrial Park	Fused 3Ø overhead tap located at Washington and Harbor.	Mainline underground circuit cable exit from substation to riser pole.	#4/0 AL	113.0%
#2 Bear Truss	#1 Old Industrial Park	Fused 3Ø overhead tap located at Washington and Harbor.	Mainline overhead circuit from cable exit riser to corner of Clinton St. and Hazel St.	#3/0 ACSR	105.8%
#2 Bear Truss	#1 Old Industrial Park	Fused 3Ø overhead tap located at Washington and Harbor.	Mainline overhead circuit along Clinton St. Overloaded conductor from RR track to Hazel St.	#2 ACSR	126.1%

*Conductors loaded above 90% of their thermal rating

For a full list of the eight (8) field circuit ties with equipment capacity loading for all voltages, refer to the chart titled City of St. Louis - Circuit Backup Review 2023 attached to this report.

2028-2033

Following five years of load growth and large load additions, it was determined two (2) of the eight (8) distribution circuit ties are still operating above the established 90% criteria for peak 2033 loading. These two field ties not only are loaded above 90%, but both are loaded above 100% and one of the ties is loaded above 110%. All backup substation power transformers, high side fuses, and transformer secondary voltage regulators were determined to be at or below 80% of their nameplate rating for a first contingency condition.

For a full list of the eight field circuit ties with backup transformer & recloser capacity loading, refer to the chart titled City of St. Louis Circuit Backup Review 2028 & 2033 attached to this report.

Voltage Drop Analysis – Circuits Normal

Voltages were calculated on the system under peak 2023 loading conditions, plus 5 and 10-year load growth with the system in the following conditions:

- All circuit switches in normal state.
- Distribution system capacitors bank off
- All substation transformer secondary voltage regulators allowed to operate to maximum step limit 16 raise.
- All available generation off.

Analysis was completed in the WindMil model for the 2023 peak loading plus 5 and 10-year load growth with capacitors both on and off. Primary line sections showing an operating voltage below the 118V limit are noted for each circuit below.

2023

Modeling resulted in calculation of voltages below 118VAC on several sections of three different circuits. The circuits where low voltage on the primary system was calculated included 2.4kV circuit 3-6 Prospect, 2.4/4.16kV #1 Old Industrial Park, and 2.4/4.16kV #3 Michigan Avenue. Low voltage conditions were not found on the other six circuits not listed. The lowest calculated voltage on the system was on circuit 3-6 Prospect. The voltage at the end of line on N. Union Road had a calculated primary voltage of 114.1VAC (2.282kV). Voltage drop was also completed with all the distribution capacitors on. Distribution capacitors were not located on circuits with a calculated low voltage and thus did not improve the sections of circuits that were identified in the analysis.

The table on the following page details the areas of the distribution circuits primary line sections that were determined to be operating below their allowable 118V voltage level based on 2023 peak loading conditions and normal system configuration.

Voltage Drop Violations – System Normal

Substation	Circuit	Voltage	Area Description	End of Line Voltage
Main	3-6 Prospect	2.4kV	Voltage issues begin on BØ near the intersection of Gratiot St. and Union St. Voltage drops when moving downline, eventually effecting all three phases and continues to be an issue throughout downline elements.	114.1V
Main	3-6 Prospect	2.4kV	Voltage issues begin on BØ near the intersection of Prospect St. and Sharon St. Voltage drops when moving downline, eventually effecting AØ and continues to be an issue throughout downline elements.	117.7V
Main	#1 Old Industrial Park	2.4/4.16kV	Voltage issues on 1Ø section of overhead line along State St. before East St. and continue to end of line.	117.9V
Main	#3 Michigan Ave.	2.4/4.16kV	Voltage issues on CØ section of underground cable within Evergreen Village.	117.9V

2028 – 2033

After ten years of load growth, modeling resulted in no additional sections of the distribution systems having calculated voltages below 118V under 2028 or 2033 proposed peak loading conditions. Results were determined using the peak loading data and all capacitor banks off. The system overall does not have a significant voltage drop at the primary connections of the distribution transformers. The only area of the system that was identified as having a major voltage quality issue was on circuit 3-6 Prospect. The voltage at the end of line under 2033 loading was determined to be 113.8VAC (2.276kV).

Voltage Drop Analysis – Circuits 1st Contingency

Voltage conditions for eight (8) mainline circuit ties under a first contingency condition of one circuit utilized as a backup were analyzed. Voltage drop analysis was performed on these eight (8) circuits tie points regardless of if either mainline conductor overloading or mainline voltage drop conditions were found during capacity or voltage drop analysis using Windmil.

Voltages for a first contingency loss of equipment were calculated on the system under peak 2023 loading conditions, plus 5 and 10-year load growth with the system in the following conditions:

- All circuit switches in normal state.
- Recloser at substation opened (for circuit out of service).
- Circuit field tie switch is closed (Normally Open).
- Distribution system capacitors bank permanently off.
- All substation transformer voltage regulators allowed to operate to maximum step limit of 16 raise.
- All available generation off.

2023

Analysis completed in WindMil shows that with all distribution capacitor banks offline, none of the 12.47kV circuit ties resulted in a calculated voltage on a mainline primary line section less than 118V under 2023 peak loading conditions with the three capacitor banks off and without voltage support from any generation. Voltage drop analysis on circuits #1 Old Industrial Park and #2 Bear Truss when using a field tie resulted in widespread voltage issues across the circuits. This tie cannot be used on the peak loading day due to low voltage conditions.

2028 – 2033

No additional sections of the distribution circuits fall below the 118V threshold after the 0.3% load increase for 5 and 10 years of growth under the 1st contingency analysis. Voltage issues at the ends of lines on the 2.4/4.16kV contingency ties continue to incur the largest voltage drops and end of line sections were found to have a calculated voltage of 111.2VAC on the primary system.

Reliability

The distribution system's ability to provide reliable service to its customers via outage information and key performance indices was not reviewed as outage information is not fully documented. It is recommended to maintain outage records to assist with determining areas in the system that require maintenance, replacement, or vegetation clearing. The City of St. Louis noted that their crews are called out for outages infrequently and outages are not limited to any geographic area. The City of St. Louis noted no specific areas of the system have a higher number of outages.

Key reliability indices can now be tracked since the customers have been added into the system model. Reducing the geographic footprint and/or number of customers connected to each circuit would improve overall reliability. Installation of additional fuses will reduce the number of customers affected for a fault and automatic protective devices such as line reclosers can reduce the outage time by providing fault data and indication. Reducing the customers affected, the duration of the outage, and the number of outages will improve the system KPIs.

The City of St. Louis' list of top load customers includes a mix of governmental (State correctional facilities, industrial, medical, and educational customers. The most critical customers are the correctional facilities, the WWTP, a senior care facility, and the public school buildings. Maintaining service to both the top load customers and more importantly the critical customers must be a priority in the design, construction, and operation of the electric utility system.

Reliability to the highest load and most critical customers was reviewed based on availability of a backup circuit and connection to a separate substation transformer through a distribution circuit tie. Critical customer and highest load customer lists based on demand and energy use (kW and kWh) are attached to this report. The ranking of critical customers was based on the standard utility evaluation practices and does not include analysis of on-site backup generation assets.

Key Performance Indices (KPI) – Outage Reports

KPIs and outage reports are currently not recorded or calculated by the City of St. Louis. The City of St. Louis should record the following data for each outage incident on the system:

- Customer Address
- Time of Outage
- Duration of Outage
- Number of Customers Affected
- Name of Circuit
- Cause of Outage

Documenting the number of customers affected and the circuit name allows for KPIs to be calculated. Tracking the cause of the outage will help determine any preventative measures that should be implemented to reduce the number of outages. Preventative measures would include animal guards, conductor cover-up, vegetation management, and installation of line reclosers & sectionalizing devices.

Available Backup Circuit Ties

The City of St. Louis does not have backup ties to each of its critical and top load customers. This analysis only included distribution circuit ties outside of the substation. The ties were reviewed under the 2023 peak loading case, plus 2028, and 2033 load growth.

Customers served by the Gibson Substation all have an available backup tie that can be used on the peak day without causing low voltage conditions on the circuit, although the Woodside Industrial Park customers are at the far end of this radial distribution circuit. Customers served by circuits #1 Old Industrial Park and #2 Bear Truss have a single backup tie that is limited by both capacity and voltage loss. This tie point cannot be utilized on the peak day. The other circuits serving critical and top load customers are #3 Michigan Avenue and 3-6 Prospect. Both circuits do not have backup circuit ties, leaving no contingency plan via field tie points. Of the sixteen critical and top load customers, twelve customers have backup ties to alternate substation reclosers, however only eight of the twelve ties can be used on the peak day.

Alternate Substation Ties

Extreme weather, loss of transmission source, or equipment failure can render a customer's primary feed unavailable. Should an event happen that causes the primary substation feed to a customer to become unavailable, a tie to an alternate substation is needed to limit the service interruption. The City of St. Louis does not have direct backup ties from an alternate substation to any of its top load and critical customers.

Summary

Under peak 2023 loading, eight of the sixteen (50%) City of St. Louis critical and top load customers have a reliable distribution service with multiple contingency switching options and are not prone to outages above an acceptable occurrence or length, as determined by industry standards. Four of the customers served at the 2.4kV or 2.4/4.16kV voltage level have a single tie point to #1 Old Industrial Park through a fuse, but this tie is limited in ampacity to 215A due to the cable exit of #1/0AL. Furthermore, none of the customers have a tie to an alternate substation transformer, leaving the status of service up to several electrical devices with no alternate feeds. The loss of any substation high side fusing, power transformer, or voltage regulator will cause sustained outages until replacement devices can be installed or repairs can be made.

Tables have been prepared listing the customers and the criteria utilized in the evaluation for reliable service to the critical and top load customers. Reliability tables state the criteria violation in the note's column. Refer to the Critical Customer and Top Load Customer tables attached to this report.

Load Balancing

A balanced distribution system has lower losses than the unbalanced case. Although completely balanced circuits are ideal, it is not always possible to achieve. All distribution circuits were analyzed for unbalanced loading conditions through evaluation of phase loading from historical substation loading data and calculated load place throughout the distribution system model.

To determine if the circuit has a load imbalance that needs to be addressed, a formula was used. This formula takes the difference between the highest and lowest phases and divides that value by the minimum phase amps. If this calculated value is greater than 49%, the circuit is deemed unbalanced. The tables below summarize the circuit loading findings under the 2023 peak loading. If the highest phase is 1.5 times or greater than the lowest phase, the circuit is considered unbalanced.

Circuit Loading – 2023 Peak Substation Reads

Circuit	AØ	BØ	CØ	Imbalance
GB-1	97A	100A	111A	14.4%
GB-2	41A	41A	41A	0.0%
GB-4	0A	0A	0A	---
#1 Old Ind. Park	83A	143A	142A	72.3%
#2 Bear Truss	120A	130A	121A	8.3%
#3 Mi Ave.	141A	157A	117A	34.2%
1-6 Mi Ave.	130A	118A	38A	242.1
3-6 Prospect	210A	185A	140A	50.0%
5-6 Business	80A	90A	50A	80%

Note: Load Unbalanced if % imbalance (Max Phase Amps – Min Phase Amps)/Min Phase Amps > 49%

Circuit loading per phase under 2023 peak loading for City of St. Louis system shows that four of the eight (50%) distribution circuits with load have a load imbalance of 49% or greater. The City of St. Louis will need to rephase the following circuits to improve efficiency, lower the voltage drop, and lower the amp reading on the highest loaded phase. Imbalanced circuits were limited to the 2.4kV and 2.4/4.16kV distribution systems.

- #1 Old Industrial Park 72.3% unbalanced
- 1-6 Michigan Avenue 242.1% unbalanced
- 3-6 Prospect 50.0% unbalanced
- 5-6 Business 80.0% unbalanced

Balancing the phases on a circuit will reduce the current on the highest loaded phase for any circuit that balancing is completed. Lowering the highest loaded phase will improve circuit tie conditions for voltage drops and capacity violations. Improving the strength of the field circuit ties will improve the overall reliability of the distribution system. See the Recommendations section of the report for greater details on balancing the circuit per phase loading.

System Assessment

The electric utility system substation and distribution facilities were assessed via field review as part of this study. The 2.4kV, 2.4/4.16kV, & 7.2/12.5kV distribution systems, and substations were visually assessed by experienced utility engineers for a number of issues including aged construction, equipment, copper conductors, failing hardware, unjacketed underground cable, and vegetation issues.

Substations

The two distribution substations, St. Louis Main Substation and Gibson Substation, were assessed as part of this study. The substation sites were visited and assessed for aged equipment, over-dutied equipment, under-maintained equipment, vegetation issues, animal guarding, potential failure points and unsafe conditions.

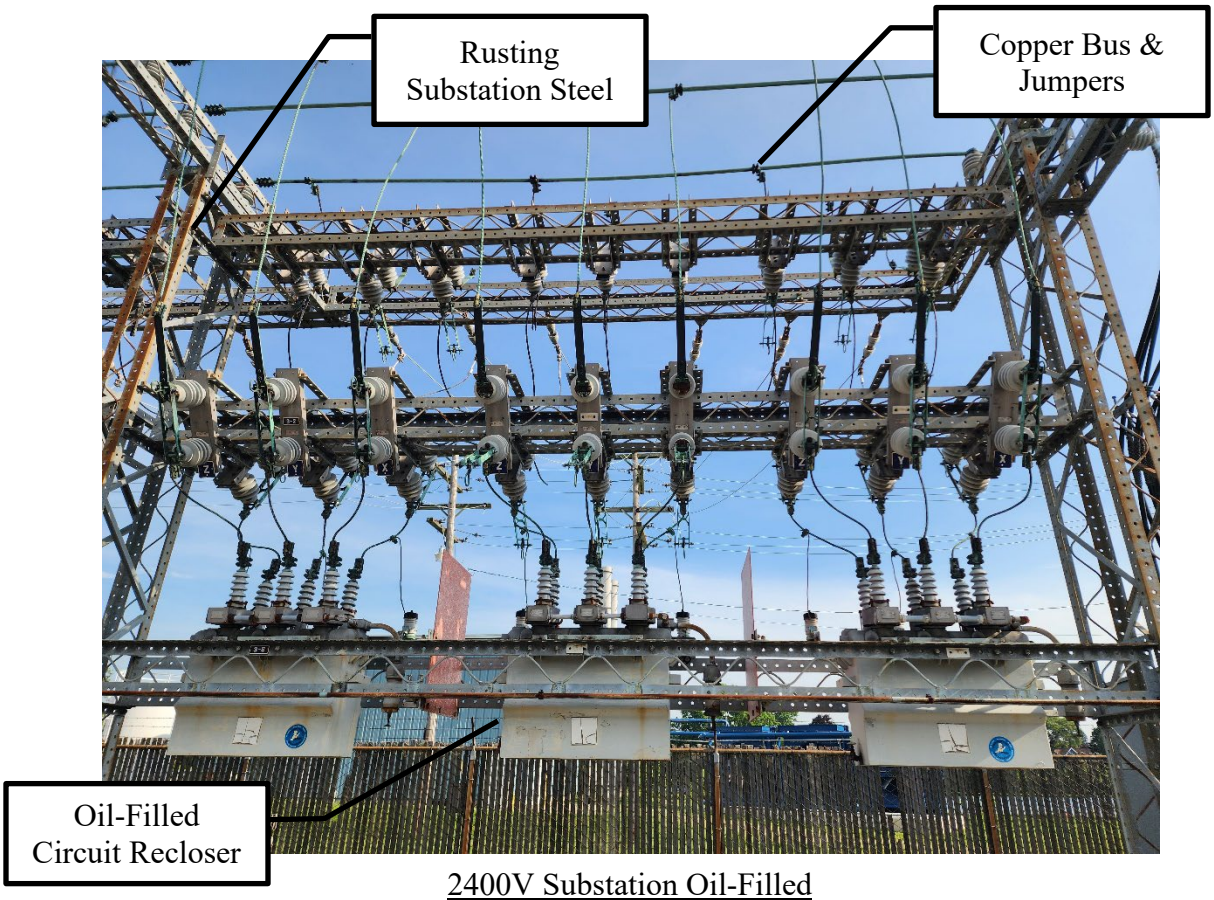
St. Louis Main Substation (2.4kV & 4.16kV) is the oldest substation on the City's system with no known upgrades. The 46kV section plus power transformers and voltage regulators are owned and operated by Consumers Energy. The City pays over $63,000 annually to CE in Capital and Operation & Maintenance Charges on the St. Louis Main substation. The City of St. Louis owns the 2.4kV & 2.4/4.16kV sections of the substation. Although no recent operational issues have been documented, the equipment in these substations is showing significant signs of its age.

Structural steel, power transformer, and the three-phase voltage regulator are rusting significantly. Fused cutouts utilized for revenue metering are very aged and underrated for substation use. The 2.4kV reclosers are oil-filled and do not have separate electronic controllers. The 2.4/4.16kV reclosers are a mix of oil-filled and vacuum, but all electronics are well over 30 years in age. Insulators in the substation are highly contaminated along with the stone surfacing which provides worker safety during fault conditions.

St. Louis / Main Substation
Consumer Energy Owned 46kV Facilities

St. Louis / Main Substation
City of St. Louis Owned 5kV Facilities

The distribution circuit reclosers in the 2400V substation and most in the 4.16kV substation are original Cooper VWE reclosers which have surpassed their useful life. These oil-filled reclosers should be replaced with maintenance free vacuum style reclosers. Two additional areas of concern with aged equipment and points of failure were noted. The 4.16kV bus metering PT fuse cutouts are standard distribution style (5kV porcelain) that do not have the fault withstand capability required in a substation. Additionally, the energized jumper wires for both the bus PT's and station service transformer are bare copper which is a point of wildlife contact. Pictures of the substation equipment are provided below and on the following pages.

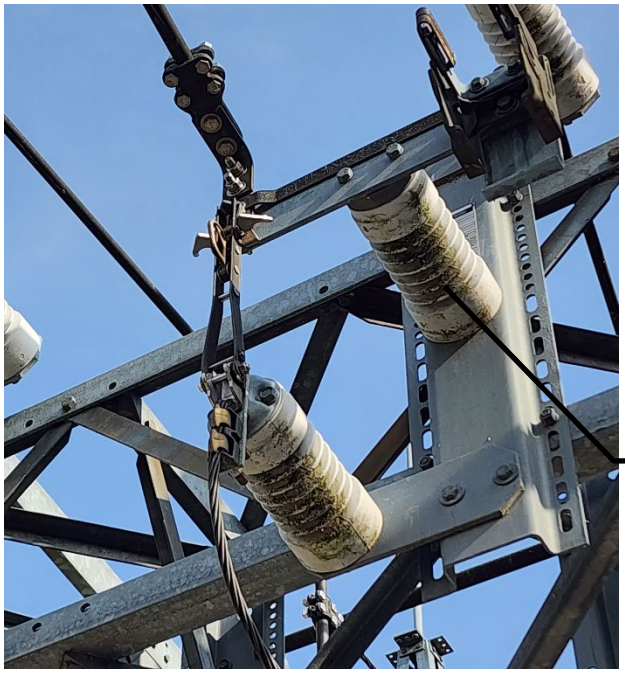


2400V Substation Oil-Filled
Distribution Circuit Reclosers

4.16kV Substation
Distribution Circuit Recloser

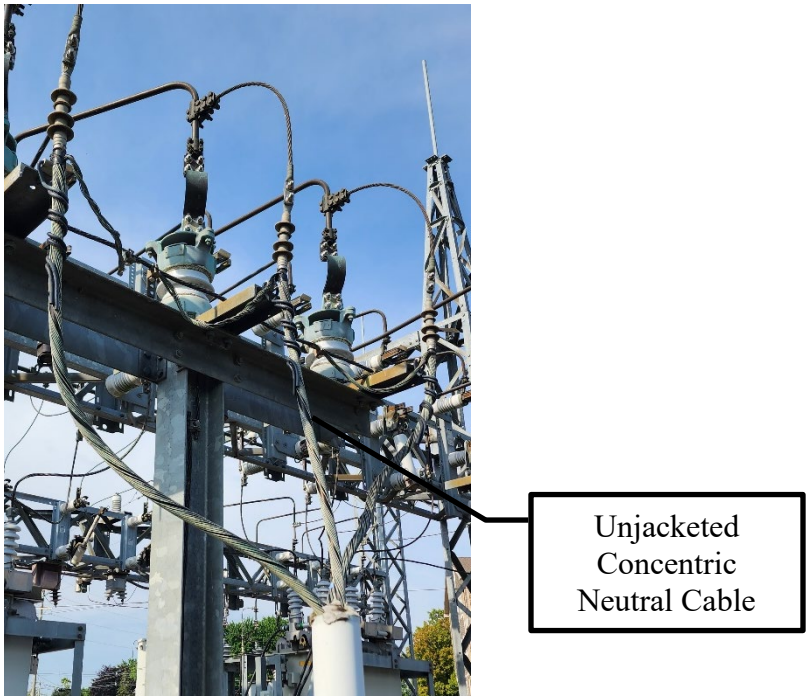
Bare Copper Jumpers
& No Bushing
Wildlife Guards

Station Service Transformer



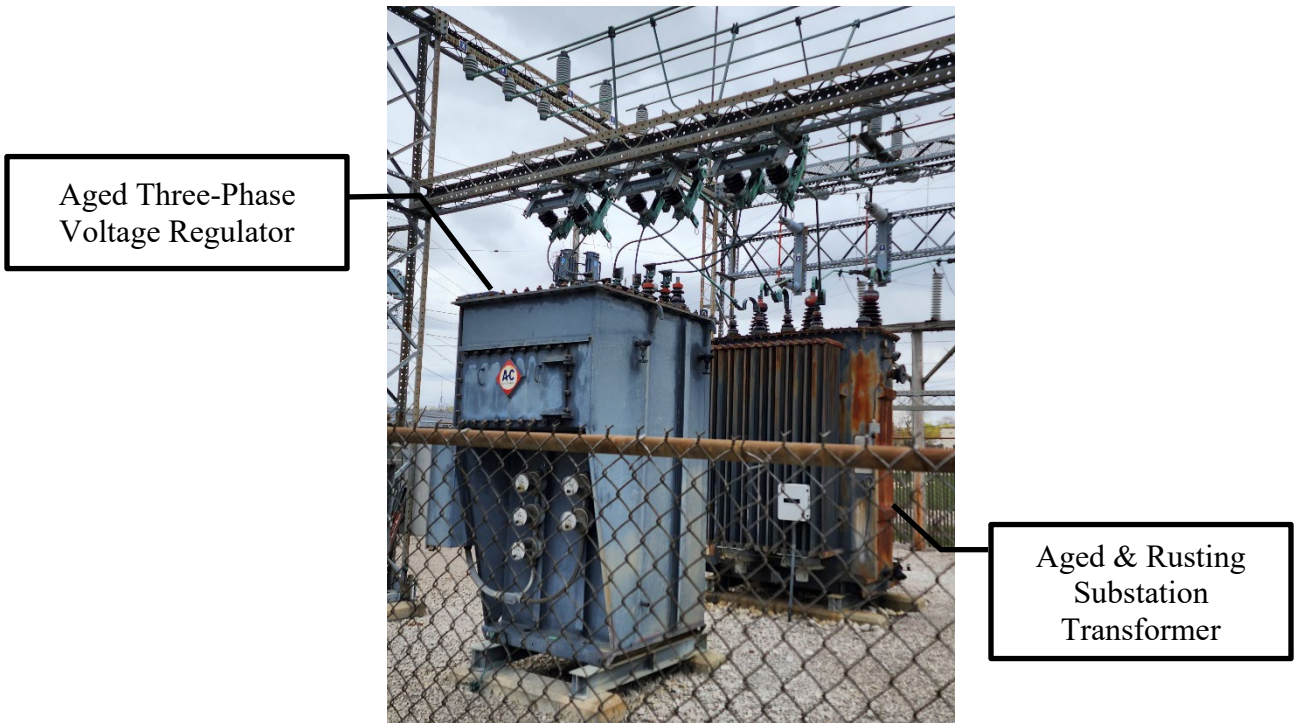
Contaminated /
Dirty Insulators

4.16kV Substation
Contaminated Insulators



4.16kV Substation Circuit Exit
Aged Underground Cable

4.16kV Substation Metering



2400V Transformer & Voltage Regulator
Consumer Energy Owned Equipment

Summary of 2400V & 4.16kV Substation Issues

- Oil-filled circuit reclosers
- Aged substation equipment
- Station service transformer & circuit reclosers bare jumper wire plus no bushing guards
- Insulator contamination
- Unjacketed concentric neutral underground circuit exit cable

Gibson Substation, constructed in 2004, is the newest and most up to date substation on the City of St. Louis' system. The substation is comprised of one 46kV:12.47kV 10/12.5MVA power transformer, low side voltage regulators, main bus and three vacuum reclosers. Two of the electronic recloser controllers are twenty years old and should be updated. The energized jumper wires for the station service transformer are bare copper which is a point of wildlife contact. This jumper should be replaced along with installation of transformer bushing covers. Pictures of the substation equipment are provided and on the following pages.

Gibson Substation

Gibson Substation
Distribution Circuit Reclosers

Summary of Gibson Substation Issues

- Aging distribution circuit reclosers & controllers
- Station service transformer bare jumper wire and lack of bushing guards

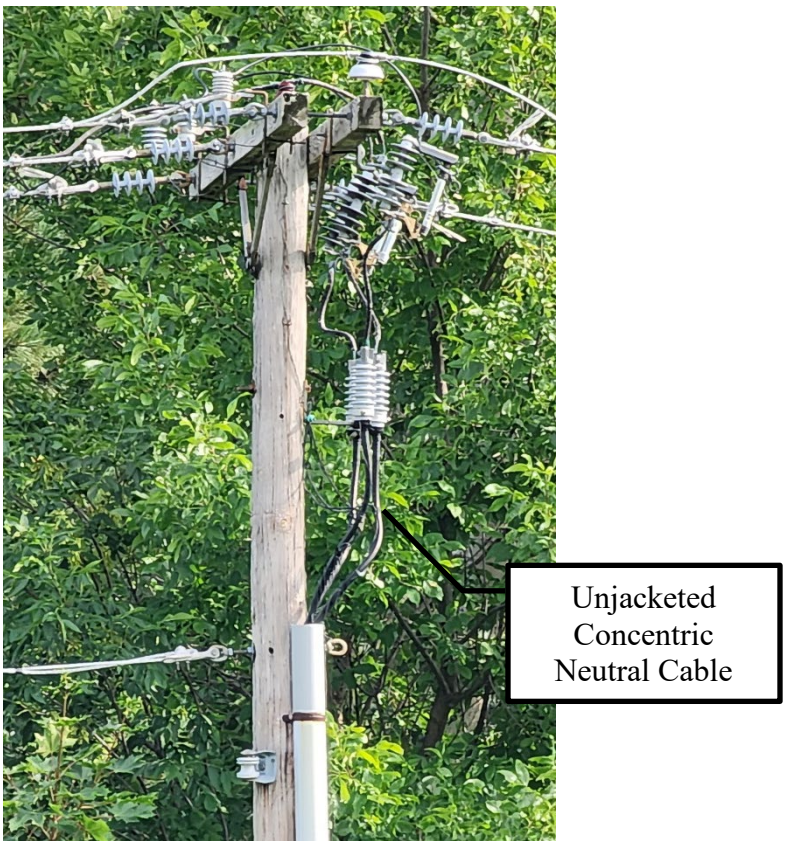
12.47kV, 4.16kV & 2.4kV Distribution Systems

The City of St. Louis overhead distribution system condition does vary based on the circuit and geographic area as seen through a visual assessment completed for this study. Overall, the overhead portion of the distribution systems are in good condition and only a few spans of aged copper conductors were identified. The core city areas of the system which are the oldest are showing the highlest levels of deteriorating poles and crossarms plus rusting hardware. Circuits that are operating at the higher 12.5kV voltage originating from Gibson Substation are on the outer edges of the system and are generally of newer construction utilizing ACSR conductors.

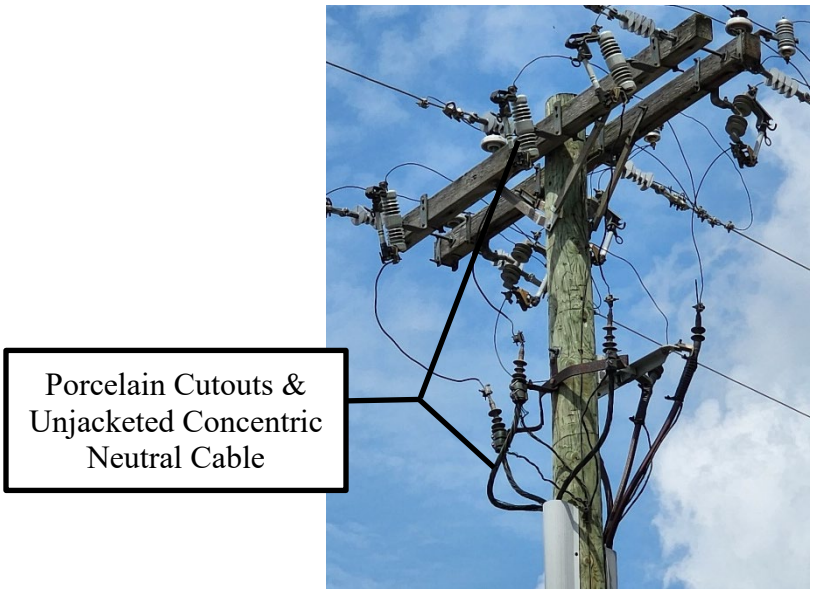
Highlighted items of note in the aged construction include deteriorating wood poles and crossarms, porcelain cutouts and surge arresters, metal equipment standoff brackets, and rusting equipment. As noted in the substation assessment section, bare copper jumpers and uncovered equipment primary bushings are points of wildlife contact that often create nuisance outages. Porcelain cutouts and arresters are increasing in failure rates therefore many utilities are working to replace this hardware with polymer equivalents. Samples of this aged construction are shown in the pictures on the following pages.

Underground cable with XLPE insulation manufactured in the 1970's and 1980's has high failure rates in the utility industry. These rates are even higher for unjacketed (exposed concentric neutral wires) installed as direct buried cables. Although not all sections of underground cable were inventoried as part of this system study, a field review and discussions with City staff did document sections of direct buried, unjacketed concentric neutral, XLPE cable. Locations include the WWTP, Evergreen Village, and Shepley Apartments. Replacement of these aged cables prior to failure should be a priority as repair time following a failure can often be lengthy and difficult depending on the time of year. Pictures of unjacketed concentric neutral cable are provided on the following pages.

An additional item of concern are transclosure installations mainly located in Evergreen Village. A transclosure is a pole mount transformer installed on a concrete pad inside a metal enclosure. These transformer installation are less safe than padmount style transformers as transclosures have exposed energized conductors and connections at ground level inside the metal cabinet. Pictures of transclosures at both Evergreen Village and the Housing Commission building are shown in the following pages.



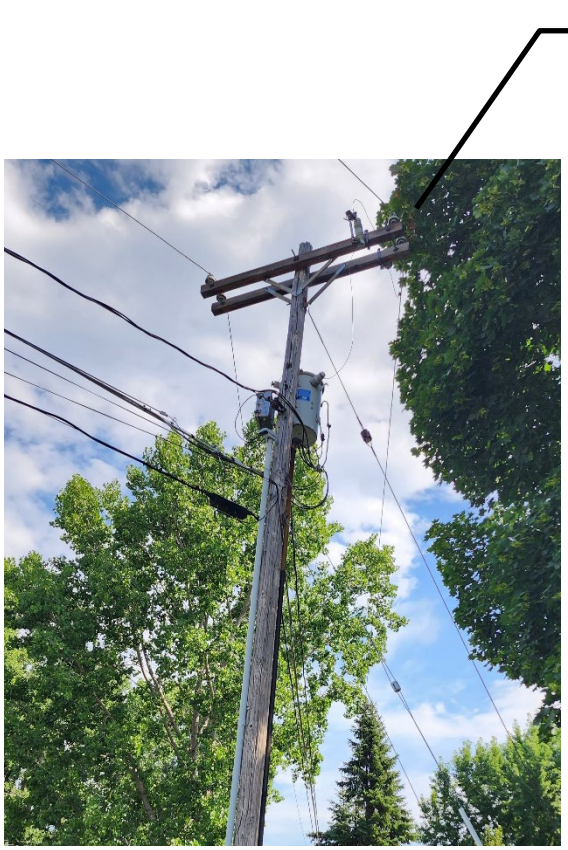
WWTP Riser
Unjacketed Concentric Neutral Cable



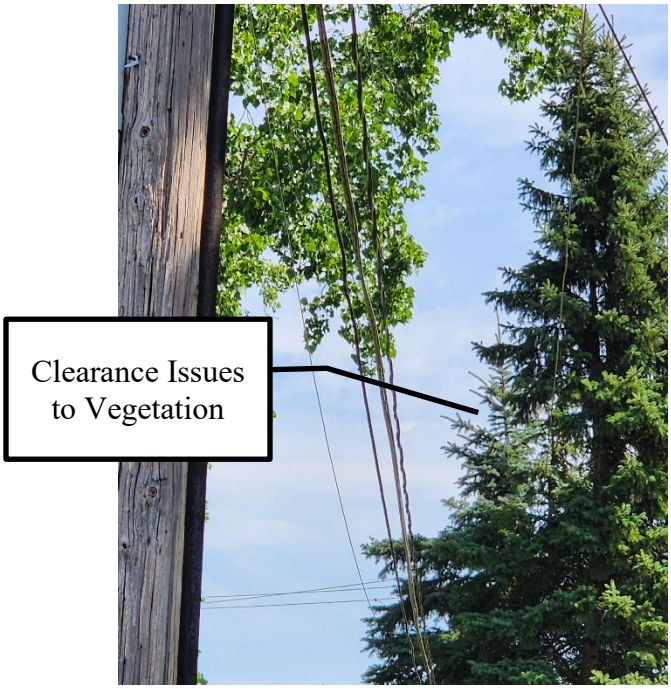
Unjacketed Concentric Neutral Cable

Circuit #3-6 Prospect Street
Aged Construction & Low Clearance

Shepley Apartments
Riser Pole



Circuit #3-6 Prospect Street
Tight Clearances



Tight Clearances

Aged Transclosure
(Polemount Transformer in Cabinet)

Evergreen Village
Unjacketed Concentric Neutral Cable

Evergreen Village
Aged Transclosure
(Polemount Transformer in Cabinet)

Summary of Distribution Circuit Issues

- Aged hardware & equipment
- Unjacketed concentric neutral underground cable
- Transclosure installations

Plug-In Electric Vehicle Growth

A review of current industry standards for modeling plug-in electric vehicle (PEV) load growth for utilities found greatly varying figures in both energy and power demands. Growth rates for PEVs are not solidly established at this time and, in fact, vastly differ even in studies prepared for the same entities. Growth rates are being determined through use of State target goals or the US Energy Information Administration's Annual Energy Outlook. Both of the above methods are determining PEV growth over a large geographical area and not a small footprint such as a municipal electric system.

Utilities and Regional Transmission Organizations (RTO) including MISO and PJM are anticipating growth anywhere between 0.1% to 33% increase in load by 2030. A recent study completed for MISO stated a possible 50% increase in electric demand from PEVs by 2040. A separate study listed varying projections including a minor 3% increase in demand from PEVs and heating loads over the next 20 years, yet the same study also stated load could grow by up to 70%.

An additional study for a separate RTO indicated a 15-20% market penetration of PEVs will result in a demand increase on the electric system of 25-33%. Furthermore, depending on the charging device, each PEV could account for an increase of 0.8 to 1.5kW of load and require $1,700 to $5,800 in infrastructure investment. PEVs are also anticipated to have peak charging beginning between 4pm and 6pm, which coincides with the normal system peak of people arriving home after a typical school or work day. Thus, PEVs electric demand must be added into utilities current growth rate. For utilities that have no information on future PEV demand, they can use their established growth rate as a best case. Industry experts do agree that PEV demand is going to be larger than utility's current growth rate.

The City of St. Louis electric distribution system's substation power transformers are currently loaded to 25% for the 12.47kV unit, 31% for the 4.16kV CE-owned unit, and 67% for the 2.4kV CE-owned unit under peak summer loading 2023. Mainline circuit conductors are loaded, on average, to 17% for 12.47kV, 60% for 4.16kV, and 68% for 2.4kV under peak summer loading 2023. With the average loading of 2.4kV circuits being 68% and 4.16kV circuits at 60%, there is not sufficient capacity to add electric vehicle chargers at these distribution voltages. There is sufficient capacity on the 12.47kV circuits for the addition of several electric charging stations.

Voltage drop on the line will still need to be considered when adding PEV charging stations to the system. Considering the length of time required to upgrade electric utility transmission, substations and distribution systems, The City of St. Louis should work to closely monitor load growth from electrification and plan for these potential increases based on more solid and local data.

The City of St. Louis will need to continue investing in reconductoring their distribution system and completing voltage conversion projects to prepare the utility for this potential growth from electrification.

CITY OF ST. LOUIS
ELECTRIC DISTRIBUTION SYSTEM STUDY & FIVE-YEAR PLAN
RECOMMENDATIONS

The following recommendations are based on the findings and analysis stated above including conductor and equipment loading at normal and first contingency operations (one circuit or substation transformer out of service), established acceptable service voltages, balanced circuit loads, and equipment condition. Implementation of these recommendations will bring the electrical distribution system within the required parameters established herein.

With the exception of Main Substation's 2.5MVA 2.4kV delta power transformer (CE-owned), the City of St. Louis substation transformers, fusing, isolation switches, circuit reclosers, and distribution circuits are all operating below their established loading limits. Distribution circuit loading is an issue and would be of greater concern if there were additional circuit tie points that were relied on for contingency conditions. Mainline rebuild projects will correct the loading issues by increasing the circuits maximum capacity and will also reduce voltage losses. Reducing voltage drop losses on the circuits creates more viable field ties for the peak loading days.

The City of St. Louis electric system has three distribution circuit voltages including 2.4kV, 4.16kV & 12.5kV. Circuits operating at different voltages cannot be tied together without a transformer to convert the voltage. Placing step-down transformers at each circuit potential tie of different voltages is possible, but at a relatively high cost. The City of St. Louis should convert the two lower voltages, 2.4kV & 4.16kV up to 12.5kV and replace the existing 2.4kV delta power transformer at their Main Substation with one that matches voltage at Gibson Substation. Installation of a second 12.5kV substation transformer will provide full backup to the Gibson Substation.

Steps to complete this voltage conversion include shifting all of the 2,400V load off the 2.4kV delta bus at Main Substation and removing the 2.4kV portion of Main Substation. Once completed, a new substation will be constructed in its place with a 10/13.3/16.7MVA 46kV:12.5kV power transformer with LTC, four distribution circuit, and associated facilities. The next phase in voltage conversion will be to move the 4.16kV load to the new 12.5kV power transformer and Gibson Substation. Step-down transformers at the new substation circuit exits and small step-down transformers at some taps will be utilized in the voltage conversion from 4.16kV to 12.47kV.

The 46kV equipment, metering, transformers, bus, and protective devices at St. Louis' Main Substation are all owned by Consumers Energy. Preliminary discussions with CE produced three options for moving forward with the voltage conversion of the Main Substation:

- CE makes all substation upgrades and adjusts rates accordingly.
- CE retires the substation and the City of St. Louis constructs a new station independently.
- CE sells the Main Substation to City of St. Louis.

During informal discussions regarding the future of the St. Louis Main Substation, Consumers Energy has stated that any upgrades to the substation should be made by the City of St. Louis and

that CE is not interested in investing into substations for municipal clients. CE noted that the preference is one of the two latter alternate options listed above.

Retirement of the substation while constructing a new one in its place would be costly and agitating as parts of the station would need to remain energized throughout the several year process and there would be several substation outages while CE removes different sections of the yard and equipment. Retirement of the station by CE has abandonment costs associated with it and would not be a case of simply walking away.

The sale of the existing substation to the City of St. Louis from CE is the most reasonable option for converting the voltage at the St. Louis Main Substation. Purchasing the substation and its equipment will allow the City of St. Louis to convert the voltage at their pace while utilizing the existing equipment to maintain electric service to their customers. Consumers Energy estimates the sale of the existing substation assets at $450k-$500k. This is not a firm cost as it was obtained through informal discussions and CE stated they also need to calculate the depreciated value of the substation.

The City of St. Louis does pay annual fees to the Consumers Energy for the substation along with demand charges associated with CE owning the substation assets. The City pays $63,252 annually to CE for the Capital and O&M Charges on the existing St. Louis Main Substation. These charges will be eliminated with the City owning the substation along with reducing demand charges by approximately $14,000 annually. At an estimated sale price of $500k, the purchase price of the substation assets could be paid off in 6-7 years or even sooner based on potential future Wholesale Distribution Service (WDS) demand rates increases by CE.

The following recommended projects cover both substation and distribution system upgrades. The projects initially focus on upgrades to portions of the system that impact the highest number of customers and the most critical customers. Next are distribution projects that shift load off the 2.4kV substation to the more reliable 12.5kV system. The proposed new 46kV:12.5kV substation is next in the priority list. Interspersed with these large capital projects are smaller projects including installation of capacitor banks to reduce system losses and implementation of a GIS system.

Substation Projects

Substation projects over the next five years will focus on replacement of Gibson Substation circuit reclosers & controllers, replacement of Gibson Substation voltage regulator controllers, preventative maintenance at Gibson Substation, jumper and bushing cover-up at the Main Substation, purchasing or retiring the Consumers Energy portion of the Main Substation, and retiring the 2.4kV delta bus & 4.16kV wye bus at Main Substation while installing a new 12.5kV transformer and bus with bays for four (4) 600A circuits. Completion of these substation projects will allow for a majority of the existing system to move to an operating voltage of 12,470V which will lower the circuits mainline amp loading, reduce voltage drop, allow for the creation of several new field tie points. These ties can be utilized on the peak loading day without loss to any customer's service and improve the reliability and robustness of the electrical distribution system. Upon completion, the generation owned by the City of St. Louis will be connected to the new Main Substation 12,470V bus.

2025

Project #	Substation	Description
#201	Gibson	Replacement of two Cooper VSA reclosers and Form 5 recloser controllers at Gibson Substation with new G&W Viper ST Vacuum Reclosers, new SEL-651R controllers, power & control cables, conduit modifications, covered wire jumpers, and wildlife guards. Estimated cost: $104,000 Priority: High

Project #	Substation	Description
#202	Gibson	Replacement of three GE-2011 voltage regulator controllers with new SEL-2431 controllers at Gibson Substation. Estimated cost: $10,000 Priority: Medium

Project #	Substation	Description
#203	Gibson	Maintenance and testing for substation power transformer, voltage regulators, 46kV gang-operated switch, and 15kV single-phase disconnect switches. Work to be completed during overnight/premium time hours. Estimated cost: $40,000 Priority: High

2026

Project #	Substation	Description
#204	4.16kV	Replacement of bus PT fuse cutouts and jumpers to/from the bus PT's, station service transformer, and reclosers at the 4.16kV Substation. Includes new substation rated fuse holders, coated jumpers, and wildlife guards. Work to be completed during overnight/premium time hours. Estimated cost: $23,000 Priority: High

2027

Project #	Substation	Description
#205	Main	Construction of a new main substation located at the generating plant with a 46kV:12.5kV 10/13.3/16.7MVA transformer with LTC and four underground circuit exits. Includes purchase of 2.4kV & 4.16kV substation assets from Consumers Energy ad 46kV transmission line modifications outside the substation. Estimated cost: $5,800,000 Priority: High

2028

Project #	Substation	Description
#206	4.16kV	Demolition & removal of old Consumers Energy 4.16kV Substation. Estimated cost: $150,000 Priority: High

Distribution Line Projects

The primary concerns with the distribution circuits are lower operating voltage, undersized mainline conductor, lack of circuit tie points due to differing voltages, and direct buried unjacketed concentric neutral underground cable. Proposed distribution projects are organized based on voltage conversion projects which will allow for removal of the 2.4kV substation, increasing circuit capacity, providing additional circuit backup ties, replacement of aging system construction, and implementation of a GIS system.

2025

Project #	Circuit	Description
#301	GB-1	Purchase of a rebuilt spare 2500kVA 12.5kV:4.16kV step-down transformer. Transformer will be maintained as a spare for the existing 4.16kV Correctional Facility on Gibson Substation 12.5kV circuit GB-1 as well as future step-downs installed during the voltage conversion process. Install transformer on Enterprize Drive to create a circuit tie point between GB-2 and #3 Michigan Ave. Completion of this project solves the single-contingency point of failure for this top load and critical customer plus creates a circuit backup for Woodside Industrial Park. Estimated cost: $175,000 Priority: High
#302	#1-6	Conversion of 2400V Circuit #1-6 to 2.4/4.16kV along North Street plus lines south to M-46 and Hazel Street. Shift load to #3 Michigan Ave Circuit and remove duplicate lines on Pine Street. Completion of this project eliminates the first of three remaining 2400V circuits. Estimated cost: $142,000 Priority: High
#303	#5-6	Conversion of 2400V Circuit #5-6 to 2.4/4.16kV along River Court and Tyrell St east of Main Street. Shift load to #1 Old Industrial Park Circuit. Completion of this project eliminates the second of three remaining 2400V circuits. Estimated cost: $100,000 Priority: High
#304	GB-1	Installation of a 900kVAR switched capacitor bank on GB-1 prior to the Woodside Industrial Park tap poles. Estimated cost: $18,000 Priority: Medium
#305	N/A	Implementation of the initial phase of a GIS database and mapping for the electric system through purchase of WindMilMap and associated ESRI software licensing, iPads for field use, plus required staff training. Completion of this first phase will create the main GIS database and mapping for the electric system through exporting of the current system computer model which included primary features (i.e. conductors, transformers, capacitor banks, cabinets, and switches) plus the customer meters. Data and maps to be available on desktop and mobile devices.

Estimated cost: $100,000
Priority: Low

2026

Project #	Circuit	Description
#306	#3-6	Conversion of 2400V Circuit #3-6 to 7.2/12.5kV along Prospect Street west to the Hidden Oaks Golf Course plus lines on Main Street & Gratiot Street. Replace aged underground cable to the WWTP and Shepley Apartments, rebuild circuit through backlot west of Clinton Street to #336.4 Hendrix, plus rebuild to three-phase along I&K Street and Olive Street then shift load to 12.5kV circuit GB-4. Completion of this project eliminates last remaining 2400V circuit along with alleviating the four overloaded line sections during peak conditions. Estimated cost: $750,000 Priority: High
#307	N/A	Installation of a 3,750kVA 2400V:12.5kV step-up transformer and recloser. Transformer will be utilized to temporarily connect the Hydro generators plus units #1 & 7 to Gibson GB-4 12.5kV circuit until the new substation is constructed. Completion of this project is the final step allowing for the removal of the 2.4kV Substation. Estimated cost: $254,000 Priority: High
#308	GB-1	Upgrade of the existing capacitor bank on circuit GB-1 along Croswell Road to a 900kVAR switched capacitor bank and relocation to a pole north of the main circuit riser pole. Estimated cost: $18,000 Priority: Medium
#309	GB-2	Upgrade of the existing capacitor bank on circuit GB-2 east of Union Street to a 900kVAR switched capacitor bank and relocation to a pole west of the Central Michigan Correctional Facility west riser pole. Estimated cost: $18,000 Priority: Medium
#310	N/A	Implementation of the second phase of a GIS database and mapping for the electric system. Completion of this second phase will add secondaries, services, and street lights to the WindMilMap GIS database. Estimated cost: $100,000 Priority: Low

2027

Project #	Circuit	Description
#311	#2	Conversion of 2.4/4.16kV Circuit #2 Bear Truss to 7.2/12.5kV along N. Union Road and M-46 east to Croswell Road. Shift load to 12.5kV circuit MS-1. Installation of an underground tie on W. Saginaw Street from Main Street. Completion of this project moves this large load customer to the more reliable 12.5kV system and alleviates the overloaded line section during peak conditions. Estimated cost: $296,000 Priority: Medium
#312	N/A	Completion of the third phase of a GIS database and mapping for the electric system including inventorying all poles, construction assemblies, and joint-use attachments. Estimated cost: $80,000 Priority: Low

2028

Project #	Circuit	Description
#313	#1 & #3	Installation of a 1500kVA 12.5kV:4.16kV step-down transformer for Circuit #1 Old Industrial Park and a 2500kVA 12.5kV:4.16kV step-down transformer for Circuit #3 Michigan Ave at the new Main Substation. Connect transformers to new 12.5kV circuits MS-2 & MS-3, respectively. Completion of this project moves these two circuits to the more reliable 12.5kV system and prepares them for future voltage conversion. Estimated cost: $246,000 Priority: Medium
#314	#3	Reconstruction of 1.25 miles of three-phase overhead to #336.4 ACSR along Pine Street & Michigan Avenue from the new Main Substation to Woodside Industrial Park. Installation of step-down transformer for Mobile Home Park and conversion of taps to 7.2/12.5kV. Completion of this project moves the remaining Woodside Industrial Park customers to the more reliable 12.5kV system, alleviates the four overloaded line sections during peak conditions, and provides for backup from another circuit. Estimated cost: $680,000 Priority: Medium
#315	GB-1/MS-3	Installation of 600A three-phase gang operated switch between circuits GB-1 and MS-3. Switch will be located at Woodside & Enterprize Drive. Completion of this project creates a tie between the two distribution circuits providing full backup for both circuits. Estimated cost: $10,000

Priority: Medium

2029

Project #	Circuit	Description
#316	#1	Reconstruction of 1.15 miles of three-phase overhead to #336.4 ACSR along Main Street from the new Main Substation to Woodside Industrial Park. Conversion of taps to 7.2/12.5kV. Completion of this project moves this circuit to the more reliable 12.5kV system, alleviates the overloaded line sections during peak conditions, and provides for backup from another circuit. Estimated cost: $800,750 Priority: Medium
#317	GB-1/MS-2	Installation of 600A three-phase gang operated switch between circuits GB-1 and MS-2. Switch will be located on Main Street north of Woodside Drive. Completion of this project creates a tie between the two distribution circuits providing full backup for both circuits. Estimated cost: $10,000 Priority: Medium
#318	MS-3	Installation of new #1/0 AL 15kV underground cable in pipe via directional boring, plus replacement of transformers at Evergreen Village. Completion of this project replaces the unreliable direct buried unjacketed cable and removes the unsafe transclosure installations. Estimated cost: $250,000 Priority: Medium
#319	MS-3/MS-4	Installation of 600A three-phase gang operated switch between circuits MS-3 and MS-4. Switch will be located on M-46 east of Watson Street. Completion of this project creates a tie between the two distribution circuits providing full backup for both circuits. Estimated cost: $10,000 Priority: Medium

Potential Future Projects

Potential projects that are beyond the five-year range of this system study include continuation of circuit voltage conversion to 7.2/12.5kV, underground cable upgrades, and additional capacitor banks:

Circuit #3 Michigan Ave – Voltage Conversion Phase 2
Devon Drive & Essex Drive Subdivision – Conversion to Underground
Underground Cable Upgrade – Evergreen Village Phase 2
Circuit #2 Bear Truss – Underground Cable Upgrade
Circuit MS-3 - Capacitor Bank

Phase Balancing

Distribution circuits operating at 2.4kV and 4.16kV circuit #1 Old Industrial Park all have poor balancing. These circuits need their loading per phase balanced to improve efficiency, reduce line losses, and reduce total loading per circuit. Balancing the phases will improve the City of St. Louis' ability to tie circuits together, as the highest loaded phase is the limiting factor when making distribution ties. The City of St. Louis should take specific spot load measurements on peak load days to verify which areas of the system are responsible for the unbalanced conditions.

The following circuits should be re-phased to improve load balance on the distribution circuits. Rephasing can be completed in conjunction with circuit rebuild and voltage conversion projects.

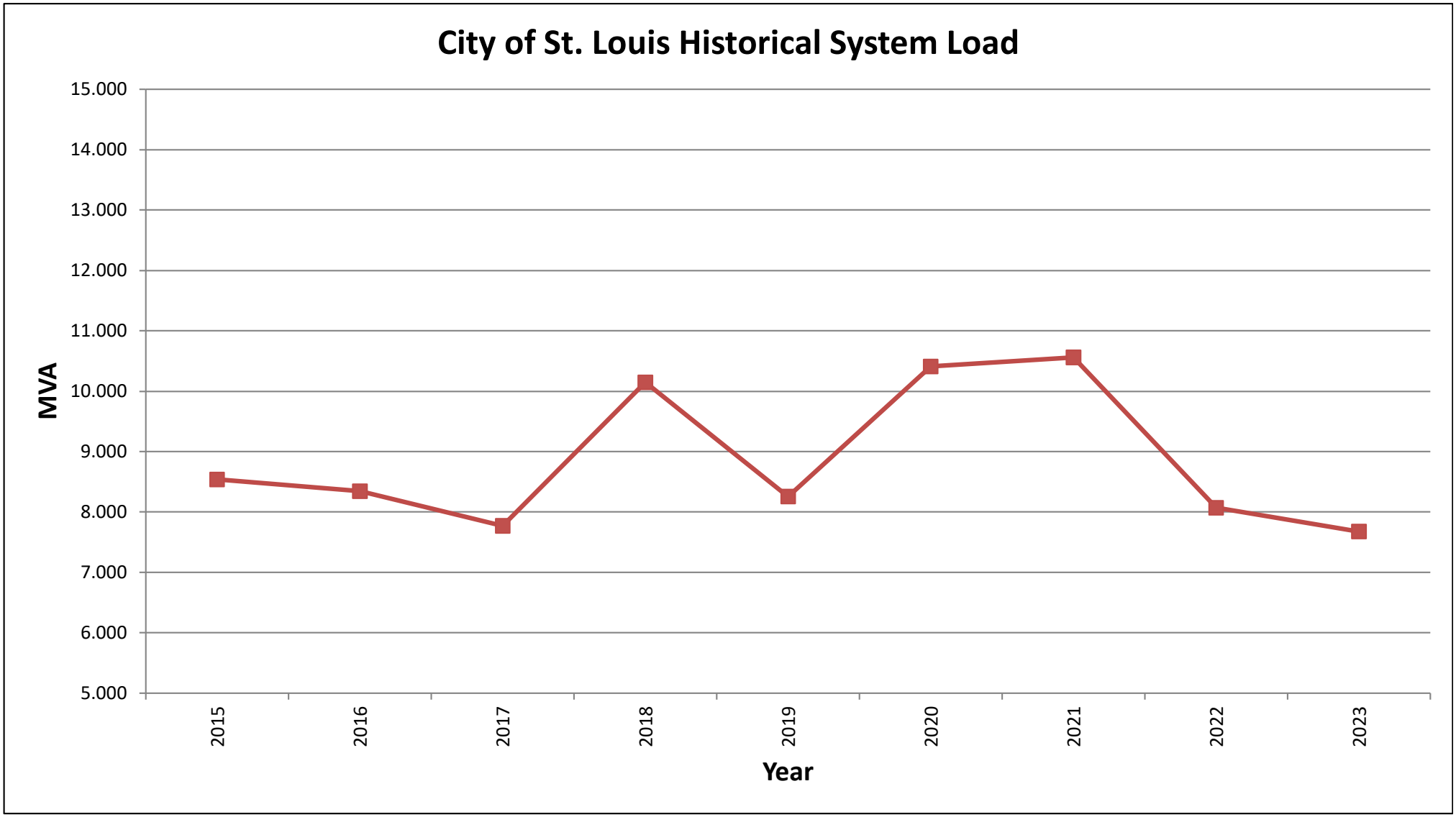
1-6 Michigan Avenue – move 35A of load from AØ to CØ and 20A of load from BØ to CØ.
3-6 Prospect – move 30A of load from AØ to CØ.
5-6 Buisiness – move 20A of load from BØ to CØ.
#1 Old Industrial Park – move 20A of load from BØ to AØ and 20A of load from CØ to AØ.

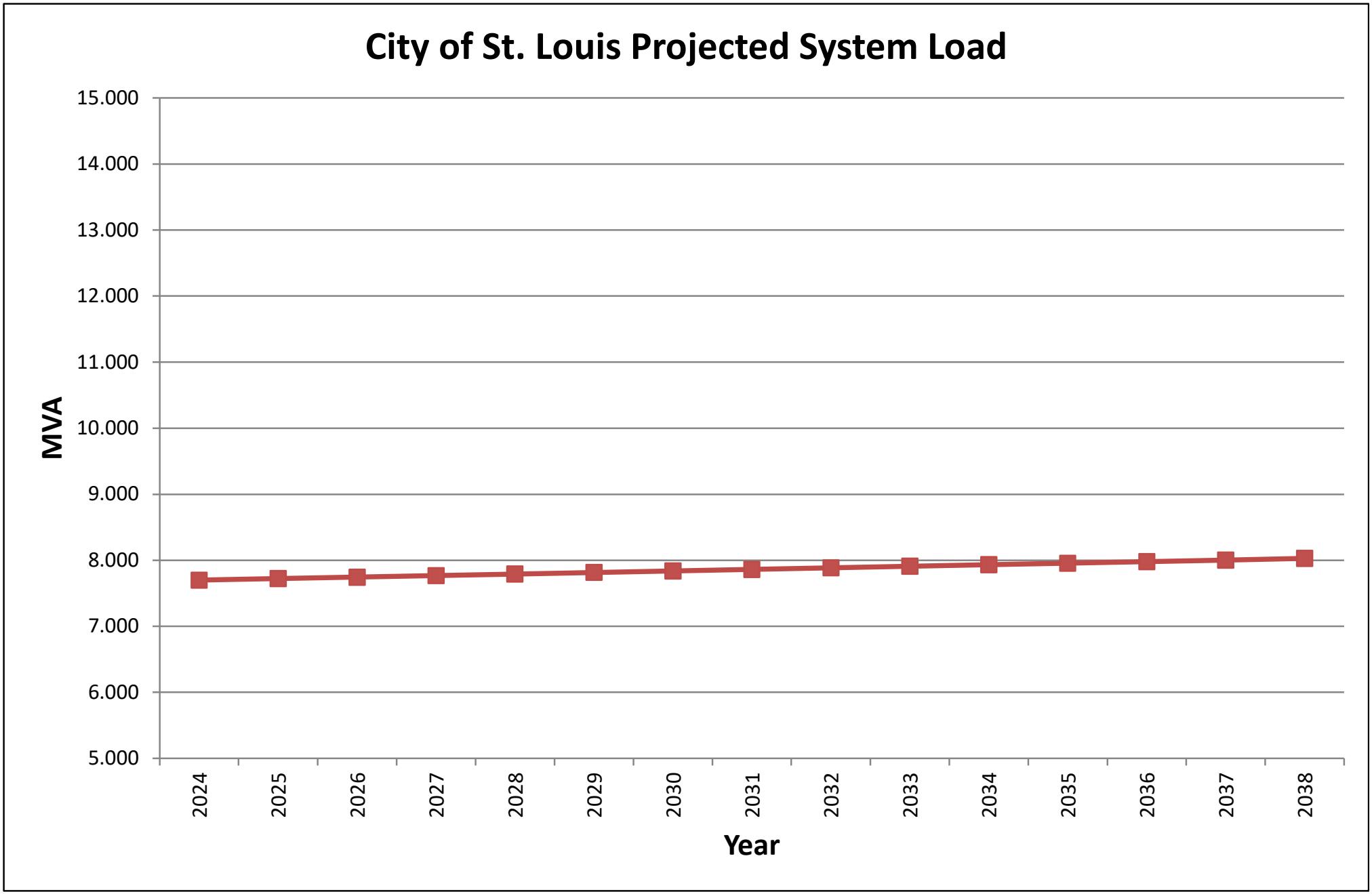
Additionally, the re-phasing of some taps may not be possible due to phase orientation on the poles. Should this be the case, similarly loaded taps should be located that can be re-phased. Some phase imbalance may also be on the customer side of the system and may not be able to be balanced.

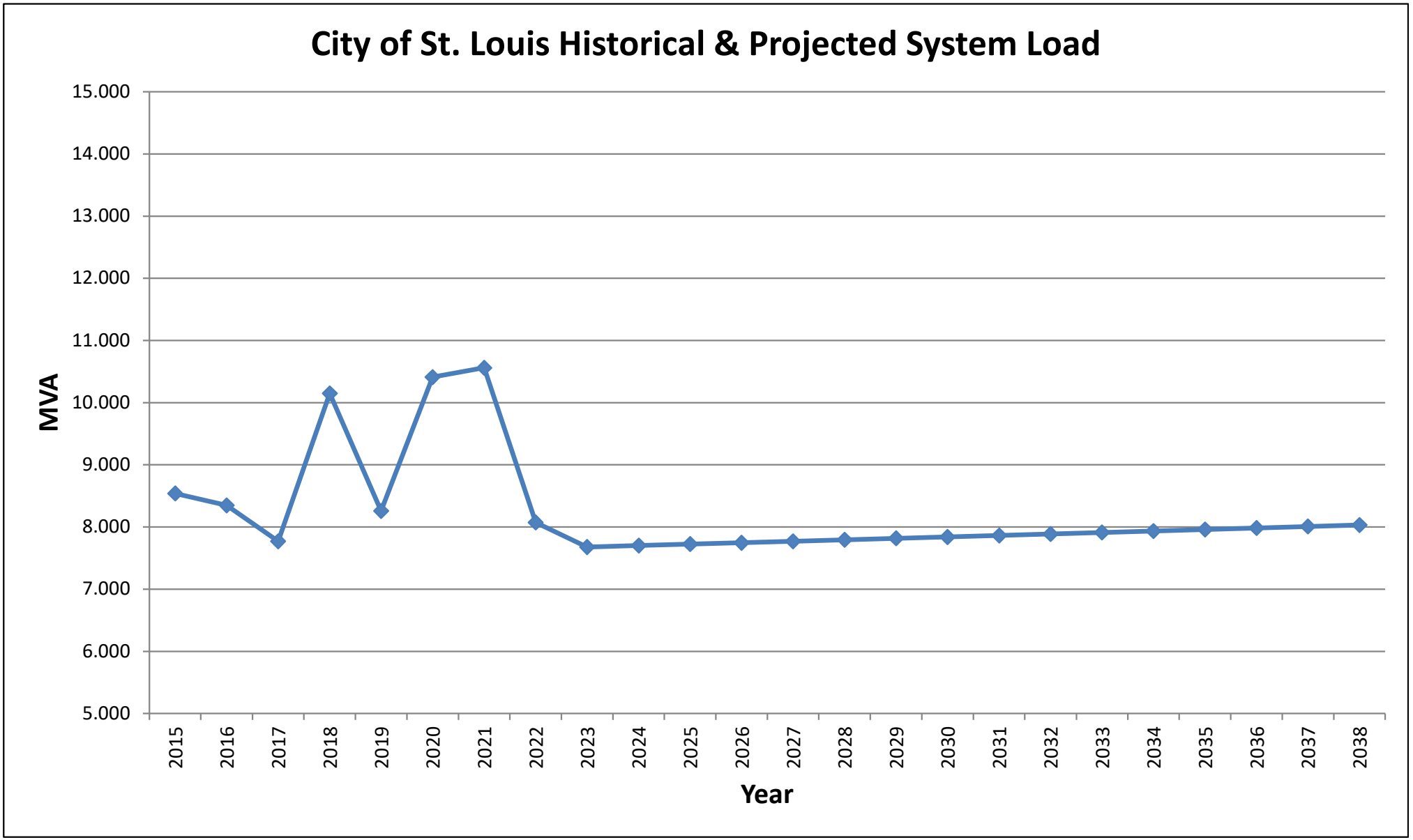
Conclusions

Completion of the recommended projects listed in this report will allow the City of St. Louis to more reliably serve their electric system customers by performing preventative maintenance at and upgrading Gibson Substation, constructing a new Main Substation that operates at 12.5kV, converting the distribution system to a single operating voltage of 12.47kV, removing single-points of failure, and increasing circuit backfeed capabilities to the majority of its customers including the top load and critical customers. System Circuit Maps, Proposed Project Maps designating the proposed capital projects, Proposed Circuit Maps are attached to this report.

SYSTEM LOAD & EQUIPMENT RATING


City of St. Louis Historical System Load
15.000
14.000
13.000
12.000
11.000
10.000
9.000
8.000
7.000
6.000
5.000
MVA
2015
2016
2017
2018
2019
2020
2021
2022
2023
Year


City of St. Louis Projected System Load
15.000
14.000
13.000
12.000
11.000
10.000
9.000
8.000
7.000
6.000
5.000
MVA
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
Year


City of St. Louis Historical & Projected System Load
MVA
15.000
14.000
13.000
12.000
11.000
10.000
9.000
8.000
7.000
6.000
5.000
2015
2016
2017
2018
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2020
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2035
2036
2037
2038
Year

City of St. Louis
Electrical System Study
Substation Loading Peak Conditions

Gibson Substation

			2023		2024		2028		2033		
Item	Device	Rating[1]	Amps	Capacity	Amps	Capacity	Amps	Capacity	Amps	Capacity	Notes
GB-199	600A V-Switch	600	40	7%	40	7%	40	7%	41	7%	
Fuse #199 (T1 Pri)	200E	482	40	8%	40	8%	40	8%	41	8%	
GB_T1	10/12.5 MVA Xfmr	579	146	25%	146	25%	148	26%	150	26%	
GB_REG #1	416kVA V-Regulator	578	146	25%	146	25%	148	26%	150	26%	
GB-1 (Mid/Pine River)	800A VSA Recloser	800	111	14%	111	14%	113	14%	114	14%	
GB-2 (Industrial Park)	800A VSA Recloser	800	35	4%	35	4%	36	4%	36	5%	
GB-3 (Spare)	Future	800	0	0%	0	0%	0	0%	0	0%	
GB-4 (Velsicol)	800A Viper	800	0	0%	0	0%	0	0%	0	0%	

4.16kV Substation

			2023		2024		2028		2033		
Item	Device	Rating[1]	Amps	Capacity	Amps	Capacity	Amps	Capacity	Amps	Capacity	Notes
5kV_T1	10/12.5 MVA Xfmr	1,390	430	31%	431	31%	436	31%	443	32%	CE Owned Equipment
REG #1	416kVA V-Regulator	1,733	430	25%	431	25%	436	25%	443	26%	CE Owned Equipment
#1 (Old Industrial Park)	800A VSA Recloser	800	143	18%	143	18%	145	18%	147	18%	
#2 (Bear Truss)	800A VSA Recloser	800	130	16%	130	16%	132	16%	134	17%	
#3 (Michigan Ave.)	800A VSA Recloser	800	157	20%	157	20%	159	20%	162	20%	
#4 (Spare)	800A VSA Recloser	800	0	0%	0	0%	0	0%	0	0%	

2.4kV Substation

			2023		2024		2028		2033		
Item	Device	Rating[1]	Amps	Capacity	Amps	Capacity	Amps	Capacity	Amps	Capacity	Notes
2.4kV_T1	2.5 MVA Xfmr	602	405	67%	406	67%	411	68%	417	69%	CE Owned Equipment
REG #1	250kVA V-Regulator	1,041	405	39%	406	39%	411	39%	417	40%	CE Owned Equipment
1-6 (Michigan Ave.)	560A VWE Recloser	560	130	23%	130	23%	132	24%	134	24%	
3-6 (Prospect)	560A VWE Recloser	560	185	33%	186	33%	188	34%	191	34%	
5-6 (Buisiness)	560A VWE Recloser	560	90	16%	90	16%	91	16%	93	17%	

[1] Transformer ratings are given for FFA rating on the secondary side of the transformers. Secondary voltage is either 12.5kV, 4.16kV, or 2.4kV.
[2] Bus tie breaker/switch amps are calculated from the sum of adjacent bus breakers/switches.
[3] Cells highlighted in red represent transformers and their primary side equipment which are operating at or above 40% of nameplate rating OR secondary side (2.4/4.16/12.5kV) equipment which is operating at or above 50% of nameplate rating under normal peak load conditions.

CITY OF ST. LOUIS
ELECTRIC DISTRIBUTION SYSTEM STUDY
TOP CRITICAL CUSTOMER LIST

				Primary		Backup		
Number	Name	Address	Type	Circuit / Construction		Circuit / Construction		Notes
1	St. Louis Correctional Facility	8505 N. Croswell Rd.	Governmental	GB-1 Central Mich	UG	GB-2 Level 4/Ind Park	OH	No backup substation transformer
2	Central Michigan Correctional Facility (West Campus)	320 N. Hubbard St.	Governmental	GB-2 Level 4/Ind Park	OH	GB-1 Central Mich	UG	West Service, No backup substation transformer
3	Central Michigan Correctional Facility (East Campus)	8201 N. Croswell Rd.	Governmental	GB-2 Level 4/Ind Park	UG	GB-1 Central Mich	UG	East Service, No backup substation transformer
4	St. Louis City Hall	300 N. Mill St.	Governmental	#3 Michigan Ave	OH	No Backup	NA	No backup substation transformer or field tie
5	WWTP	404 E. Prospect St.	Utility	3-6 Prospect	OH	No Backup	NA	No backup substation transformer or field tie
6	Schnepp Senior Care	427 E. Washington St.	Medical	#2 Bear Truss	OH	#1 Old Industrial Park	OH	No backup substation transformer, field tie overloaded on peak day
7	St. Louis High School	113 E. Sagniaw St.	Educational	#2 Bear Truss	OH	#1 Old Industrial Park	OH	No backup substation transformer, field tie overloaded on peak day
8	TSN Middle School	312 Union St.	Educational	#2 Bear Truss	OH	#1 Old Industrial Park	OH	(5) Meters. Includes bus garage, etc., No backup substation transformer, field tie overloaded on peak day
9	Carrie Knause Elementary School	121 I&K St.	Educational	3-6 Prospect	OH	No Backup	NA	No backup substation transformer or field tie
10	Nikkari Elementary School	301 W. State St.	Educational	GB-1 Central Mich	OH	GB-2 Level 4/Ind Park	OH	No backup substation transformer
11	Westgate School	840 Cheesman Rd.	Educational	#3 Michigan Ave	OH	No Backup	NA	No backup substation transformer or field tie

Notes:

1. Construction types: OH - overhead, UG - underground
2. Circuit construction type based on majority of line from the substation to the customer.
3. Primary circuits may have multiple backup circuits. Selected circuit has 3-phase switching capabilities and/or remains under equipment ratings.
4. Reliability criteria deficiency is shown in the Notes column.

CITY OF ST. LOUIS
ELECTRIC DISTRIBUTION SYSTEM STUDY
TOP LOAD CUSTOMER LIST (KW - Demand)

			Primary		Backup		
Number	Name	Address	Circuit / Construction		Circuit / Construction		Notes
1	St. Louis Correctional Facility	8505 N. Croswell Rd.	GB-1 Central Mich	OH	GB-2 Level 4/Ind Park	OH	
2	Central Michigan Correctional Facility	320 N. Hubbard St.	GB-2 Level 4/Ind Park	OH	GB-1 Central Mich	OH	West Service
3	Central Michigan Correctional Facility	8201 N. Croswell Rd.	GB-2 Level 4/Ind Park	OH	GB-1 Central Mich	OH	East Service
4	Plasti-Paint	801 Woodside Dr.	GB-1 Central Mich	OH	GB-1 Central Mich	OH	(3) Meters. All load is at 801 Woodside Dr.
5	Jer-Den Plastics	750 Woodside Dr.	GB-1 Central Mich	OH	GB-2 Level 4/Ind Park	OH	No backup substation transformer
6	Alpha Custom Extrusions, Inc.	800 Woodside Dr.	GB-1 Central Mich	OH	GB-2 Level 4/Ind Park	OH	No backup substation transformer
7	Apex Marine	300 Woodside Dr.	GB-1 Central Mich	OH	GB-2 Level 4/Ind Park	OH	No backup substation transformer
8	Schnepp Senior Care	427 E. Washington St.	#2 Bear Truss	OH	#1 Old Industrial Park	OH	No backup substation transformer, field tie overloaded on peak day
9	Bear Truss	721 E. Washington St.	#2 Bear Truss	OH	#1 Old Industrial Park	OH	(4) Meters, No backup substation transformer, field tie overloaded on peak day
10	St. Louis High School	113 E. Sagniaw St.	#2 Bear Truss	OH	#1 Old Industrial Park	OH	No backup substation transformer, field tie overloaded on peak day
11	TSN Middle School	312 Union St.	#2 Bear Truss	OH	#1 Old Industrial Park	OH	(5) Meters. Includes bus garage. No backup substation transformer, field tie overloaded on peak day
12	WWTP	404 E. Prospect St.	3-6 Prospect	OH	No Backup	NA	No backup substation transformer or field tie
13	St. Louis City Hall	300 N. Mill St.	#3 Michigan Ave	OH	No Backup	NA	No backup substation transformer or field tie
14	Westgate School	840 Cheesman Rd.	#3 Michigan Ave	OH	No Backup	NA	No backup substation transformer or field tie
15	Carrie Knause Elementary School	121 I&K St.	3-6 Prospect	OH	No Backup	NA	No backup substation transformer or field tie
16	Nikkari Elementary School	301 W. State St.	GB-1 Central Mich	OH	GB-2 Level 4/Ind Park	OH	No backup substation transformer

Notes:

1. Construction types: OH - Overhead, UG - Underground
2. Circuit construction type based on majority of line from the substation to the customer.
3. Primary circuits may have multiple backup circuits. Selected circuit has 3-phase switching capabilities and/or remains under equipment ratings.
4. Reliability criteria deficiency is shown in the Notes column.

CITY OF ST. LOUIS
ELECTRIC DISTRIBUTION SYSTEM STUDY
TOP LOAD CUSTOMER LIST (kWh - Energy)

			Primary		Backup		
Number	Name	Address	Circuit / Construction		Circuit / Construction		Notes
1	St. Louis Correctional Facility	8505 N. Croswell Rd.	GB-1 Central Mich	OH	GB-2 Level 4/Ind Park	OH	No backup substation transformer
2	Central Michigan Correctional Facility	320 N. Hubbard St.	GB-2 Level 4/Ind Park	OH	GB-1 Central Mich	OH	West Service, No backup substation transformer
3	Central Michigan Correctional Facility	8201 N. Croswell Rd.	GB-2 Level 4/Ind Park	OH	GB-1 Central Mich	OH	East Service, No backup substation transformer
4	Plasti-Paint	801 Woodside Dr.	GB-1 Central Mich	OH	GB-1 Central Mich	OH	(3) Meters. All load is at 801 Woodside Dr., No backup substation transformer
5	WWTP	404 E. Prospect St.	3-6 Prospect	OH	No Backup	NA	No backup substation transformer or field tie
6	Jer-Den Plastics	750 Woodside Dr.	GB-1 Central Mich	OH	GB-2 Level 4/Ind Park	OH	No backup substation transformer
7	Alpha Custom Extrusions, Inc.	800 Woodside Dr.	GB-1 Central Mich	OH	GB-2 Level 4/Ind Park	OH	No backup substation transformer
8	Apex Marine	300 Woodside Dr.	GB-1 Central Mich	OH	GB-2 Level 4/Ind Park	OH	No backup substation transformer
9	Schnepp Senior Care	427 E. Washington St.	#2 Bear Truss	OH	#1 Old Industrial Park	OH	No backup substation transformer, field tie overloaded on peak day
10	Bear Truss	721 E. Washington St.	#2 Bear Truss	OH	#1 Old Industrial Park	OH	(4) Meters, No backup substation transformer, field tie overloaded on peak day
11	St. Louis High School	113 E. Sagniaw St.	#2 Bear Truss	OH	#1 Old Industrial Park	OH	No backup substation transformer, field tie overloaded on peak day
12	TSN Middle School	312 Union St.	#2 Bear Truss	OH	#1 Old Industrial Park	OH	(5) Meters. Includes bus garage. No backup substation transformer, field tie overloaded on peak day
13	Westgate School	840 Cheesman Rd.	#3 Michigan Ave	OH	No Backup	NA	No backup substation transformer or field tie
14	Carrie Knause Elementary School	121 I&K St.	3-6 Prospect	OH	No Backup	NA	No backup substation transformer or field tie
15	Nikkari Elementary School	301 W. State St.	GB-1 Central Mich	OH	GB-2 Level 4/Ind Park	OH	No backup substation transformer
16	St. Louis City Hall	300 N. Mill St.	#3 Michigan Ave	OH	No Backup	NA	No backup substation transformer or field tie

Notes:

1. Construction types: OH - Overhead, UG - Underground
2. Circuit construction type based on majority of line from the substation to the customer.
3. Primary circuits may have multiple backup circuits. Selected circuit has 3-phase switching capabilities and/or remains under equipment ratings.
4. Reliability criteria deficiency is shown in the Notes column.

City of St. Louis
Electrical System Study
System Equipment Loading

High Side Substation Equipment (46kV)

Breakers, Circuit Switchers, and Disconnect Switches

Example 1200A Switch

		Amps	MVA (46kV)
Normal	40%	480	4
1st Contigency	80%	960	8
2nd Contigency	100%	1,200	10

Transformers (Maximum Nameplate Rating - 1st Stage Cooling)

Substation Power Transformers

Example 46kV 10/12/16MVA Power Transformer

		OA (MVA)	FA (MVA)	FFA (MVA)
Normal	40%	4.0	4.8	6.4
1st Contigency	80%	8.0	9.6	12.8
2nd Contigency	100%	10.0	12.0	16.0

Low Side Distribution Equipment (12.47kV, 4.16kV, & 2.4kV)

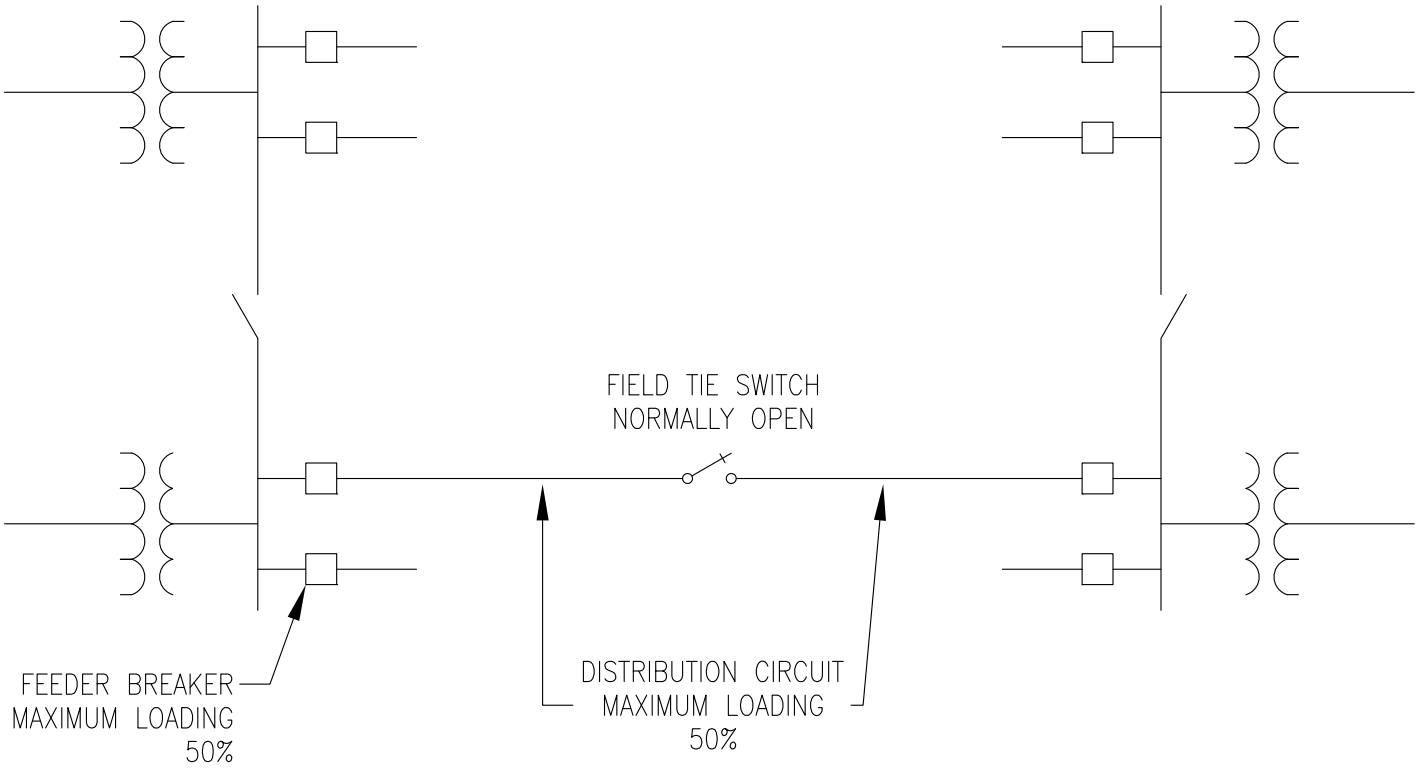
Feeder Breakers, Reclosers, and Disconnect Switches

Example 560A Breaker with 500CU UG Exit and #336.4 ACSR OH

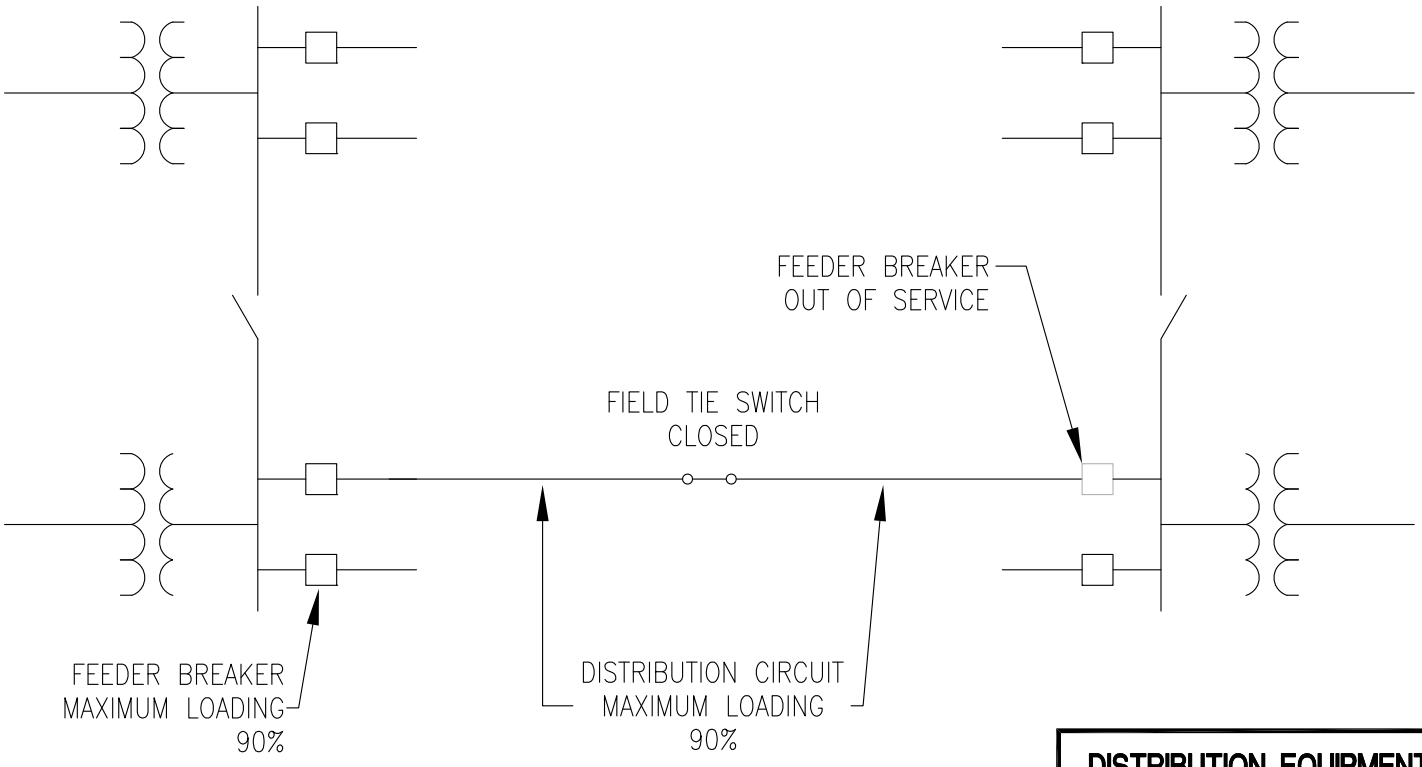
		Recloser Amps	500kCM 15kV CU	#336.4 ACSR
Normal	50%	400	215	235
1st Contigency	90%	720	387	423
2nd Contigency	100%	800	430	470

Cable and conductor ratings provided for reference.

SYSTEM NORMAL
PEAK CONDITIONS



DISTRIBUTION CIRCUIT BREAKER
OUT OF SERVICE



DISTRIBUTION EQUIPMENT LOADING LIMIT DIAGRAM

City of St. Louis
Conductor Ampacity

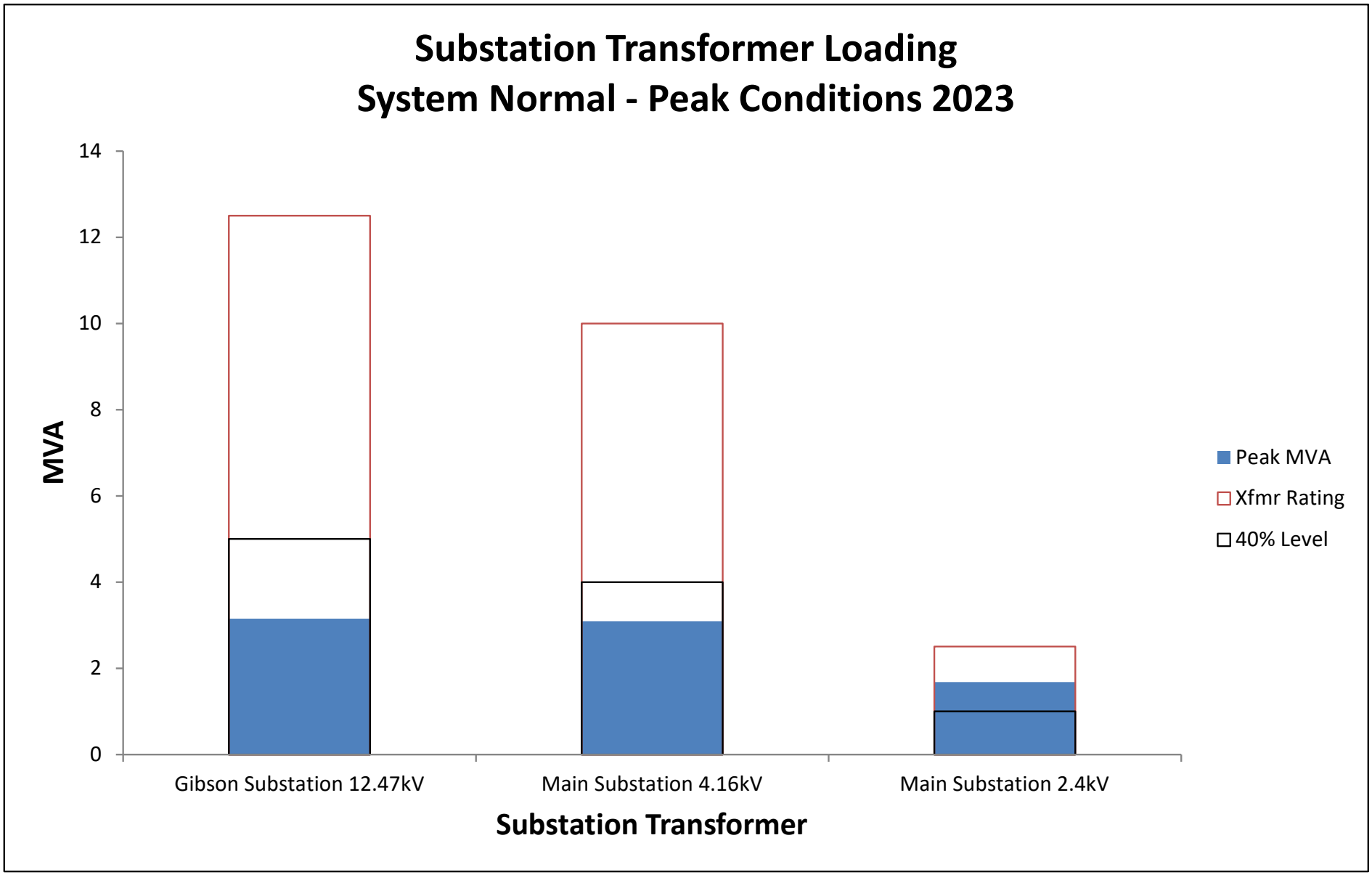
	Rated Ampacity			50% Rated Ampacity		
Conductor	120°F	167°F	212°F	120°F	167°F	212°F
#4 ACSR 7/1 "Swannate"	46	115	149	23	58	75
#2 ACSR 7/1 "Sparate"	59	153	197	30	77	99
#1/0 ACSR 6/1 "Raven"	73	198	256	37	99	128
#2/0 ACSR 6/1 "Quail"	80	226	292	40	113	146
#3/0 ACSR 6/1 "Pigeon"	88	257	331	44	129	166
#4/0 ACSR 6/1 "Penguin"	96	295	381	48	148	191
#336.4 ACSR 18/1 "Merlin"	119	421	562	60	211	281
#477 ACSR 26/7 "Hawk"	126	533	715	63	267	358
#715.5 AAC "Violet"	113	660	892	57	330	446
#795 ACSR 26/7 "Drake"	117	732	992	59	366	496
#1/0 HDCU - 3 Str		257			129	
#4/0 HDCU - 7 Str		397			199	
#1/0 Hendrix Black		201	235		101	118
#3/0 Hendrix Black		241	347		121	174
#4/0 Hendrix Black		306	357		153	179
#336 Hendrix Black		447	521		224	261
#336 Hendrix Grey		478	548		239	274
#477 Hendrix Black		556	647		278	324
#477 Hendrix Grey		596	683		298	342

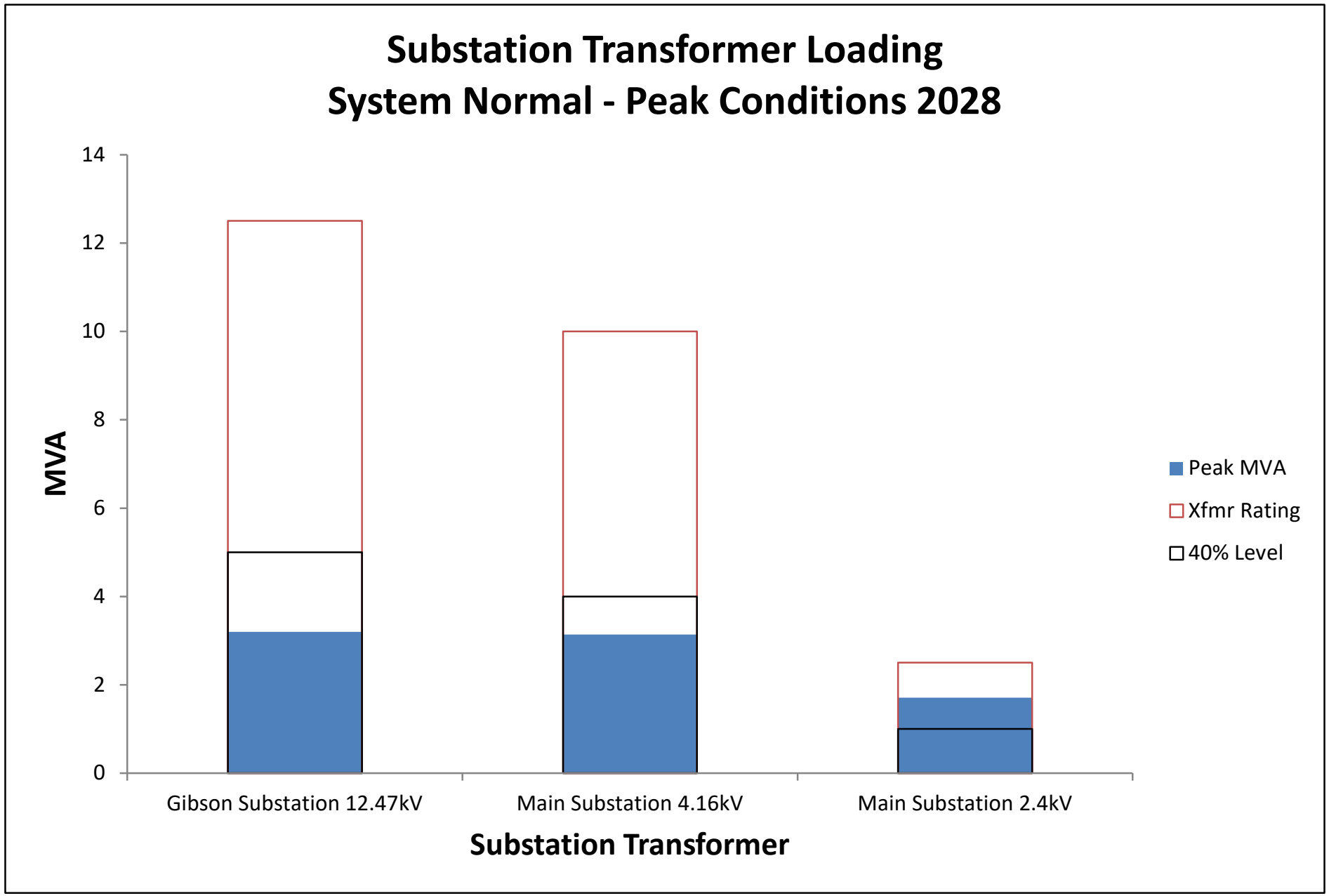
*Ampacities based on 104°F (40°C) Ambient Temperature, 2 ft/sec Wind Speed, Full Sun.

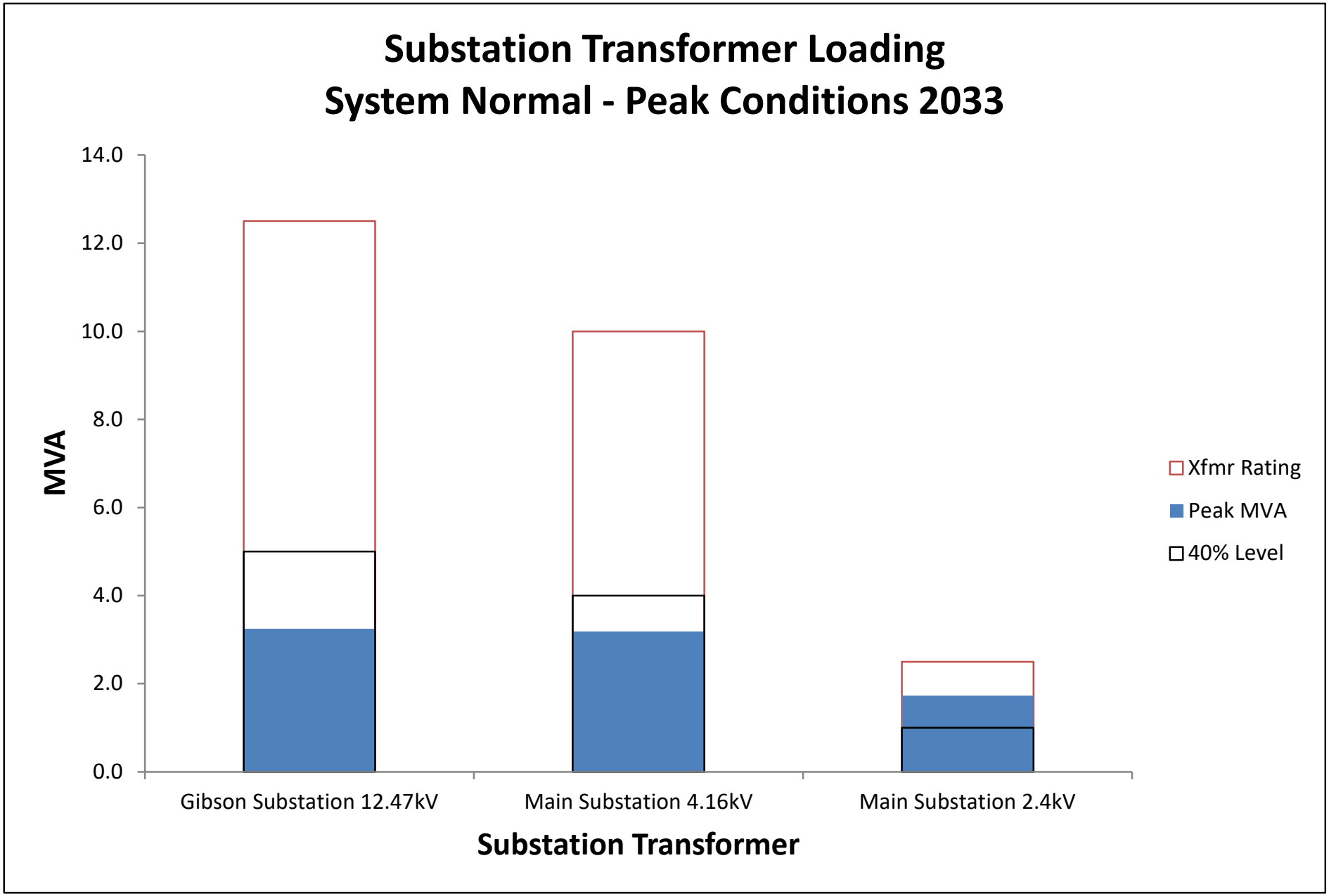
	AL Rated Ampacity		CU Rated Ampacity	
Underground Cable	Direct Buried	Buried Ductbank (2-way)	Direct Buried	Buried Ductbank (2-way)
#2 15kV Full Neutral	165	125	215	
#1/0 15kV Full Neutral	218		275	
#2/0 15kV Full Neutral	240		293	
#4/0 15kV 1/3rd Neutral	318	244	404	309
#4/0 15kV Power Cable		275		350
#350 15kV Power Cable		292		375
#500 15kV 1/3rd Neutral	502	356	609	476
#500 15kV Power Cable		378		456
#750 15kV 1/3rd Neutral		427		490
#750 15kV Power Cable		480		547

*Ampacities based on 90°C (194°F) conductor temperature, 75% load factor, 20°C (68°F) ambient earth temperature & 90rho soil.

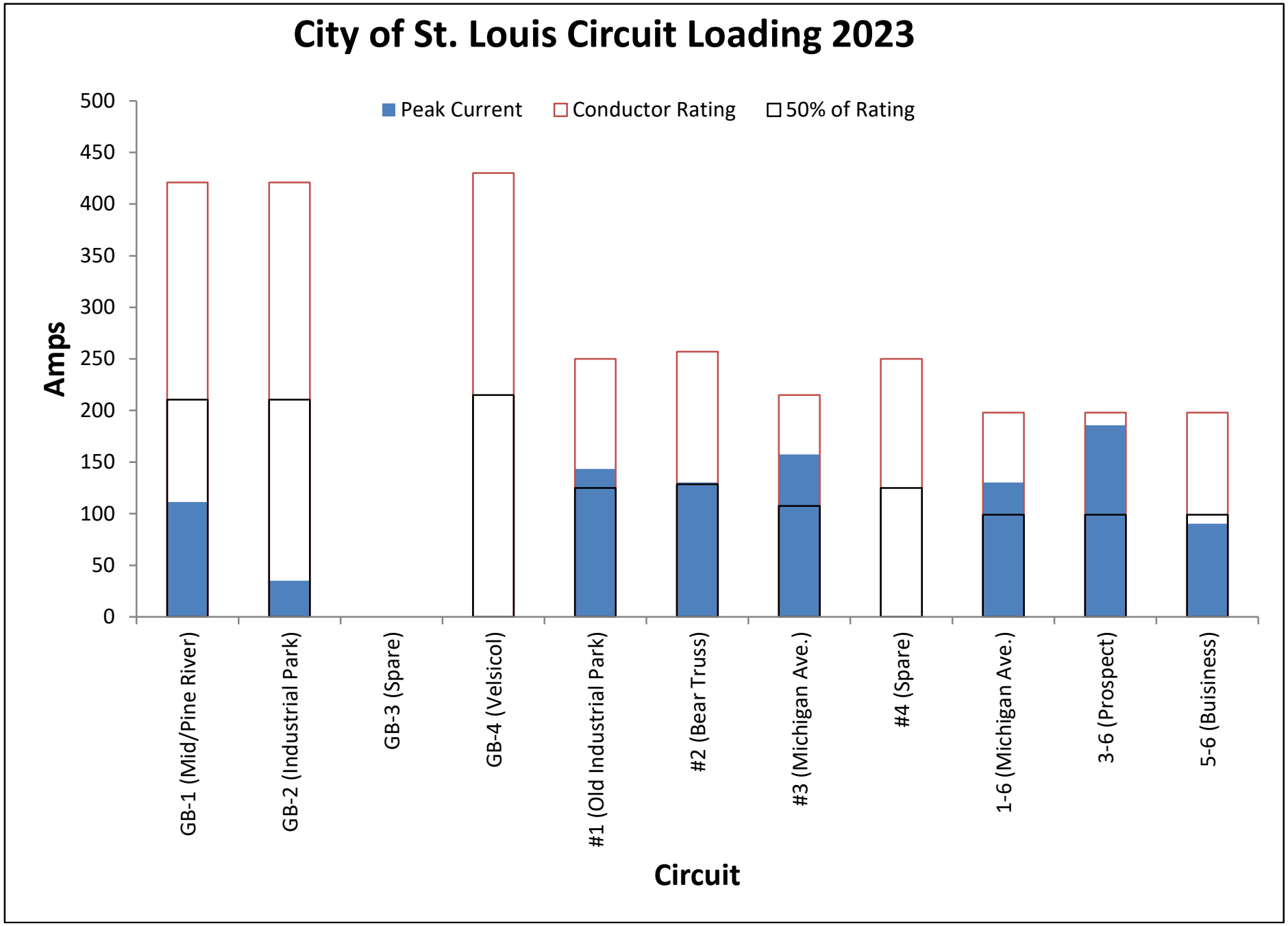
TRANSFORMER
LOADING CHARTS

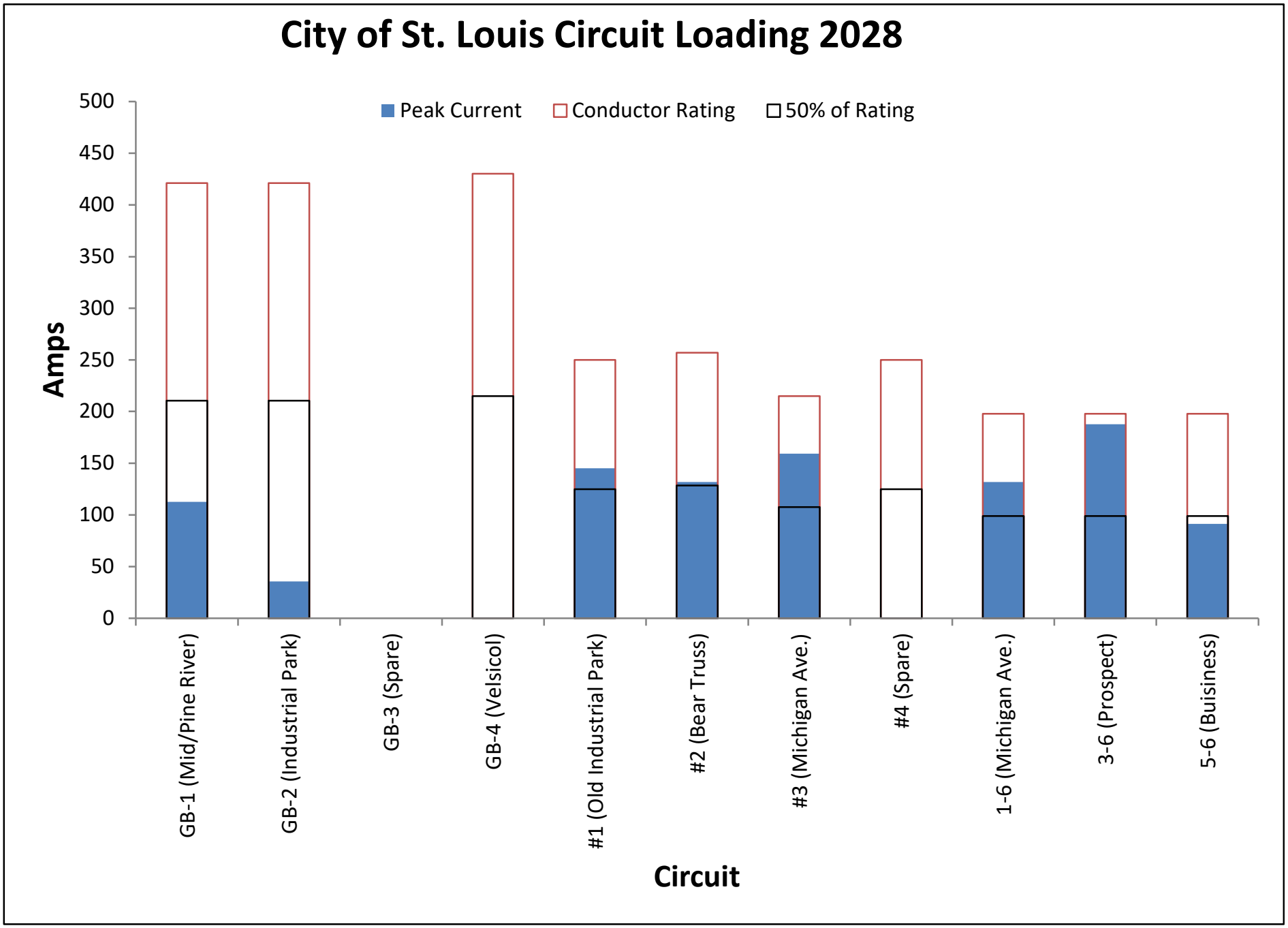

Substation Transformer Loading
System Normal - Peak Conditions 2023
MVA
14
12
10
8
6
4
2
0
Gibson Substation 12.47kV
Main Substation 4.16kV
Main Substation 2.4kV
Substation Transformer
Peak MVA
Xfmr Rating
40% Level


Substation Transformer Loading
System Normal - Peak Conditions 2028
MVA
14
12
10
8
6
4
2
0
Gibson Substation 12.47kV
Main Substation 4.16kV
Main Substation 2.4kV
Substation Transformer
Peak MVA
Xfmr Rating
40% Level


Substation Transformer Loading
System Normal - Peak Conditions 2033
MVA
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Xfmr Rating
Peak MVA
40% Level
Gibson Substation 12.47kV
Main Substation 4.16kV
Main Substation 2.4kV
Substation Transformer

DISTRIBUTION CIRCUIT LOADING CHARTS


City of St. Louis Circuit Loading 2023
Peak Current
Conductor Rating
50% of Rating
Amps
500
450
400
350
300
250
200
150
100
50
0
GB-1 (Mid/Pine River)
GB-2 (Industrial Park)
GB-3 (Spare)
GB-4 (Velsicol)
#1 (Old Industrial Park)
#2 (Bear Truss)
#3 (Michigan Ave.)
#4 (Spare)
1-6 (Michigan Ave.)
3-6 (Prospect)
5-6 (Buisiness)
Circuit


City of St. Louis Circuit Loading 2028
Peak Current
Conductor Rating
50% of Rating
Amps
500
450
400
350
300
250
200
150
100
50
0
GB-1 (Mid/Pine River)
GB-2 (Industrial Park)
GB-3 (Spare)
GB-4 (Velsicol)
#1 (Old Industrial Park)
#2 (Bear Truss)
#3 (Michigan Ave.)
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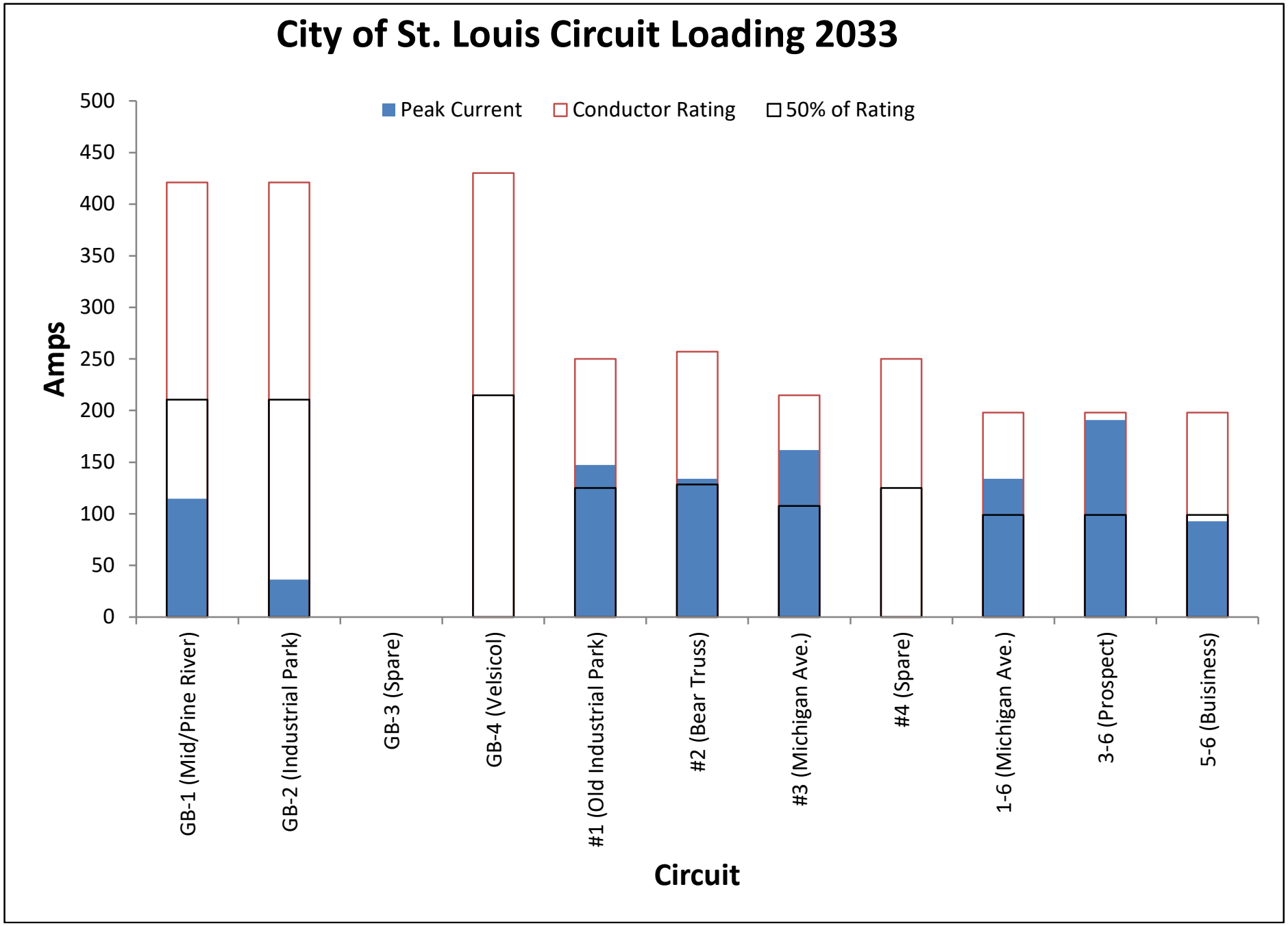
1-6 (Michigan Ave.)
3-6 (Prospect)
5-6 (Buisiness)
Circuit


City of St. Louis Circuit Loading 2033
Peak Current
Conductor Rating
50% of Rating
Amps
500
450
400
350
300
250
200
150
100
50
0
GB-1 (Mid/Pine River)
GB-2 (Industrial Park)
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#4 (Spare)
1-6 (Michigan Ave.)
3-6 (Prospect)
5-6 (Buisiness)
Circuit

DISTRIBUTION CIRCUIT
BACKUP REVIEW

City of St. Louis
Electrical System Study
Circuit Backup Review

Circuit Out-of-Service	Backup Circuit	Load Year 2023 Total Load	Recloser/ Breaker Capacity	Backup Circuit Conductor Capacity	Backup Circuit Sub Xfmr Capacity	Tie Point
GB-1 (Mid/Pine River)	GB-2 (Industrial Park)	146	18%	35%	25%	Central Michigan Correctional Facility Drive
GB-1 (Mid/Pine River)	GB-2 (Industrial Park)	146	18%	35%	25%	PMH-11 - Gibson Substation
GB-2 (Industrial Park)	GB-4 (Velsicol)	35	4%	8%	25%	North Union Road
GB-2 (Industrial Park)	GB-1 (Mid/Pine River)	146	18%	35%	25%	Central Michigan Correctional Facility Drive
GB-2 (Industrial Park)	GB-1 (Mid/Pine River)	146	18%	35%	25%	PMH-11 - Gibson Substation
GB-4 (Velsicol)	GB-2 (Industrial Park)	35	4%	8%	25%	North Union Road
#1 (Old Industrial Park)	#2 (Bear Truss)	273	34%	106%	31%	East Washington Street & Hubbard Street
#2 (Bear Truss)	#1 (Old Industrial Park)	273	34%	109%	31%	East Washington Street & Hubbard Street

[1] Ratings for transformers are given as FFA rating on the secondary side of the transformers. Recloser ratings are nameplate. Conductor ratings are based on maximum thermal conductor operating temperature.

[2] Cells highlighted in red represent high-side (46kV) equipment and transformers which would be operating at or above 80% of nameplate rating OR low-side (2.4kV, 4.16kV, & 12.5kV) equipment and conductors which would be operating at or above 90% of nameplate rating for these 1st contigency conditions.

City of St. Louis
Electrical System Study
Circuit Backup Review

Circuit Out-of-Service	Backup Circuit	Load Year: Total Load	2028: Recloser/ Breaker Capacity	Backup Circuit Conductor Capacity	Backup Circuit Sub Xfmr Capacity	Tie Point
GB-1 (Mid/Pine River)	GB-2 (Industrial Park)	148	19%	35%	26%	Central Michigan Correctional Facility Drive
GB-1 (Mid/Pine River)	GB-2 (Industrial Park)	148	19%	35%	26%	PMH-11 - Gibson Substation
GB-2 (Industrial Park)	GB-4 (Velsicol)	36	4%	8%	26%	North Union Road
GB-2 (Industrial Park)	GB-1 (Mid/Pine River)	148	19%	35%	26%	Central Michigan Correctional Facility Drive
GB-2 (Industrial Park)	GB-1 (Mid/Pine River)	148	19%	35%	26%	PMH-11 - Gibson Substation
GB-4 (Velsicol)	GB-2 (Industrial Park)	36	4%	8%	26%	North Union Road
#1 (Old Industrial Park)	#2 (Bear Truss)	277	35%	108%	31%	East Washington Street & Hubbard Street
#2 (Bear Truss)	#1 (Old Industrial Park)	277	35%	111%	31%	East Washington Street & Hubbard Street

[1] Ratings for transformers are given as FFA rating on the secondary side of the transformers. Recloser ratings are nameplate. Conductor ratings are based on maximum thermal conductor operating temperature.

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City of St. Louis
Electrical System Study
Circuit Backup Review

Circuit Out-of-Service	Backup Circuit	Load Year 2033 Total Load	Recloser/ Breaker Capacity	Backup Circuit Conductor Capacity	Backup Circuit Sub Xfmr Capacity	Tie Point
GB-1 (Mid/Pine River)	GB-2 (Industrial Park)	150	19%	36%	26%	Central Michigan Correctional Facility Drive
GB-1 (Mid/Pine River)	GB-2 (Industrial Park)	150	19%	36%	26%	PMH-11 - Gibson Substation
GB-2 (Industrial Park)	GB-4 (Velsicol)	36	5%	8%	26%	North Union Road
GB-2 (Industrial Park)	GB-1 (Mid/Pine River)	150	19%	36%	26%	Central Michigan Correctional Facility Drive
GB-2 (Industrial Park)	GB-1 (Mid/Pine River)	150	19%	36%	26%	PMH-11 - Gibson Substation
GB-4 (Velsicol)	GB-2 (Industrial Park)	36	5%	9%	26%	North Union Road
#1 (Old Industrial Park)	#2 (Bear Truss)	281	35%	109%	32%	East Washington Street & Hubbard Street
#2 (Bear Truss)	#1 (Old Industrial Park)	281	35%	113%	32%	East Washington Street & Hubbard Street

[1] Ratings for transformers are given as FFA rating on the secondary side of the transformers. Recloser ratings are nameplate. Conductor ratings are based on maximum thermal conductor operating temperature.

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City of St. Louis
2023 Distribution Transformer Loading

Transformer (Object ID)	Transformer Impedance	Rated kVA	Peak kVA	Percentage Loading	Location	Comments
XFMR645	1 ph 25 kva	25	112.84	451%		
XFMR643	1 ph 25 kva	25	91.662	367%		
XFMR829	1 ph 10 kva	10	26.267	263%		
XFMR1228	1 ph 25 kva	25	58.831	235%		
XFMR979	1 ph 10 kva	10	23.425	234%		
XFMR652	1 ph 37.5 kva	37.5	72.833	194%		
XFMR1492	1 ph 10 kva	10	17.678	177%		
XFMR1845	1 ph 25 kva	50	77.528	155%		
XFMR632	1 ph 37.5 kva	37.5	55.611	148%		
XFMR486	1 ph 25 kva	25	34.556	138%		
XFMR1110	1 ph 25 kva	25	34.063	136%		
XFMR1068	1 ph 25 kva	25	31.447	126%		
XFMR1660	1 ph 10 kva	10	12.478	125%		
XFMR1836	3 ph 75 kva	75	93.577	125%		
XFMR1195	1 ph 10 kva	10	12.376	124%		
XFMR1529	1 ph 25 kva	25	28.282	113%		
XFMR1481	1 ph 37.5 kva	37.5	41.35	110%		
XFMR658	1 ph 10 kva	10	10.931	109%		
XFMR1884	1 ph 25 kva	25	27.164	109%		
XFMR648	1 ph 25 kva	25	27.044	108%		
XFMR1022	1 ph 37.5 kva	37.5	39.827	106%		
XFMR1460	1 ph 25 kva	25	25.364	101%		
XFMR1882	1 ph 25 kva	25	25.33	101%		
XFMR1087	1 ph 10 kva	10	10.087	101%		
XFMR1828	1 ph 25 kva	25	24.555	98%		
XFMR1470	1 ph 37.5 kva	37.5	35.964	96%		
XFMR1225	1 ph 25 kva	25	23.815	95%		
XFMR1500	1 ph 37.5 kva	37.5	35.206	94%		
XFMR1488	1 ph 25 kva	25	23.066	92%		
XFMR1508	1 ph 37.5 kva	37.5	33.657	90%		
XFMR1476	1 ph 50 kva	50	42.247	84%		
XFMR1113	1 ph 25 kva	25	20.78	83%		
XFMR813	1 ph 37.5 kva	37.5	31.071	83%		
XFMR1016	1 ph 75 kva	75	60.916	81%		
XFMR1463	1 ph 25 kva	25	18.726	75%		
XFMR1557	1 ph 25 kva	25	18.472	74%		
XFMR1900	1 ph 100 kva	100	73.787	74%		
XFMR1881	1 ph 15 kva	15	11.051	74%		
XFMR855	1 ph 37.5 kva	37.5	26.83	72%		
XFMR1659	1 ph 50 kVA Pad	50	35.701	71%		
XFMR809	1 ph 50 kva	50	34.571	69%		
XFMR487	1 ph 50 kva	150	103.205	69%		
XFMR852	1 ph 37.5 kva	37.5	25.735	69%		
XFMR1503	1 ph 50 kva	50	34.227	68%		
XFMR798	1 ph 37.5 kva	37.5	25.332	68%		
XFMR1115	1 ph 10 kva	10	6.747	67%		
XFMR1515	3 ph 75 kva	75	49.88	67%		
XFMR914	1 ph 10 kva	10	6.494	65%		
XFMR1705	1 ph 37.5 kVA Pad	37.5	23.985	64%		
XFMR1552	1 ph 25 kva	25	15.786	63%		
XFMR1194	1 ph 25 kva	25	15.756	63%		
XFMR1542	1 ph 25 kva	25	15.732	63%		
XFMR1241	1 ph 37.5 kva	37.5	23.592	63%		
XFMR1890	1 ph 37.5 kVA Pad	37.5	23.572	63%		
XFMR7500	1 ph 37.5 kva	37.5	23.537	63%		
XFMR1827	1 ph 37.5 kVA Pad	37.5	23.052	61%		
XFMR1601	1 ph 25 kva	25	15.259	61%		
XFMR1455	1 ph 25 kva	25	14.878	60%		
XFMR1036	1 ph 15 kva	15	8.837	59%		
XFMR1539	1 ph 37.5 kva	37.5	22.078	59%		
XFMR1883	1 ph 37.5 kva	37.5	21.75	58%		
XFMR1102	1 ph 25 kva	25	14.418	58%		
XFMR449	1 ph 37.5 kva	37.5	20.735	55%		
XFMR1525	1 ph 15 kva	15	8.246	55%		
XFMR1209	1 ph 50 kva	50	25.957	52%		

City of St. Louis
2023 Distribution Transformer Loading

Transformer (Object ID)	Transformer Impedance	Rated kVA	Peak kVA	Percentage Loading	Location	Comments
XFMR1207	3 ph 300 kva	300	153.333	51%		
XFMR995	1 ph 37.5 kva	37.5	18.695	50%		
XFMR1616	1 ph 37.5 kVA Pad	37.5	18.409	49%		
XFMR1232	3 ph 300 kva	300	146.995	49%		
XFMR1104	1 ph 25 kva	25	12.17	49%		
XFMR908	1 ph 10 kva	10	4.83	48%		
XFMR729	1 ph 10 kva	10	4.681	47%		
XFMR1604	1 ph 50 kva	50	23.153	46%		
XFMR1006	1 ph 25 kva	25	11.104	44%		
XFMR7494	1 ph 25 kva	25	10.603	42%		
XFMR1880	1 ph 37.5 kva	37.5	15.863	42%		
XFMR1714	1 ph 75 kVA Pad	75	31.055	41%		
XFMR767	1 ph 15 kva	15	6.065	40%		
XFMR1120	1 ph 10 kva	10	4.038	40%		
XFMR1728	1 ph 100 kva	100	39.77	40%		
XFMR1484	1 ph 37.5 kva	37.5	14.035	37%		
XFMR811	1 ph 50 kva	50	18.712	37%		
XFMR1841	3 ph 1500 kva	1500	556.667	37%		
XFMR1071	1 ph 75 kva	75	27.791	37%		
XFMR966	1 ph 10 kva	10	3.616	36%		
XFMR1607	1 ph 37.5 kva	37.5	13.466	36%		
XFMR485	1 ph 50 kva	150	53.052	35%		
XFMR1652	1 ph 37.5 kVA Pad	37.5	13.018	35%		
XFMR1024	1 ph 15 kva	45	15.574	35%		
XFMR1717	1 ph 100 kVA Pad	100	34.555	35%		
XFMR1535	1 ph 25 kva	25	8.38	34%		
XFMR1731	1 ph 100 kva	100	33.389	33%		
XFMR1519	1 ph 37.5 kva	37.5	12.333	33%		
XFMR1637	1 ph 37.5 kVA Pad	37.5	11.913	32%		
XFMR1566	1 ph 10 kva	10	3.157	32%		
XFMR775	1 ph 37.5 kVA Pad	37.5	11.8	31%		
XFMR1235	1 ph 75 kva	75	23.306	31%		
XFMR1522	1 ph 37.5 kva	37.5	11.446	31%		
XFMR1014	1 ph 37.5 kva	112.5	34.156	30%		
XFMR962	1 ph 10 kva	10	2.953	30%		
XFMR1750	3 ph 500 kva	500	147.556	30%		
XFMR484	1 ph 50 kva	50	14.458	29%		
XFMR1727	1 ph 100 kva	100	28.872	29%		
XFMR1004	1 ph 37.5 kVA Pad	37.5	10.494	28%		
XFMR1000	1 ph 25 kva	25	6.896	28%		
XFMR7497	1 ph 37.5 kVA Pad	37.5	10.274	27%		
XFMR850	1 ph 37.5 kva	37.5	10.265	27%		
XFMR7520	1 ph 37.5 kva	37.5	10.215	27%		
XFMR802	1 ph 25 kva	25	6.627	27%		
XFMR709	1 ph 15 kva	15	3.862	26%		
XFMR674	1 ph 37.5 kva	37.5	9.564	26%		
XFMR1647	1 ph 37.5 kva	37.5	9.456	25%		
XFMR1838	1 ph 167 kVA Pad	167	41.402	25%		
XFMR1177	1 ph 25 kva	25	6.098	24%		
XFMR7503	1 ph 37.5 kva	37.5	8.931	24%		
XFMR7523	1 ph 37.5 kVA Pad	37.5	8.902	24%		
XFMR903	1 ph 10 kva	10	2.326	23%		
XFMR1170	1 ph 25 kva	25	5.807	23%		
XFMR7509	1 ph 37.5 kva	37.5	8.558	23%		
XFMR936	1 ph 10 kva	10	2.22	22%		
XFMR1039	1 ph 25 kva	87.5	19.376	22%		
XFMR1527	1 ph 37.5 kva	37.5	8.301	22%		
XFMR1157	1 ph 25 kva	25	5.447	22%		
XFMR1624	1 ph 50 kVA Pad	50	10.713	21%		
XFMR1679	1 ph 10 kVA Pad	10	2.114	21%		
XFMR750	1 ph 10 kva	10	2.103	21%		
XFMR7513	1 ph 37.5 kva	37.5	7.846	21%		
XFMR1735	1 ph 100 kva	100	20.544	21%		
XFMR7519	1 ph 50 kva	50	9.833	20%		
XFMR1582	1 ph 37.5 kva	37.5	7.326	20%		

City of St. Louis
2023 Distribution Transformer Loading

Transformer (Object ID)	Transformer Impedance	Rated kVA	Peak kVA	Percentage Loading	Location	Comments
XFMR1630	1 ph 37.5 kVA Pad	37.5	7.049	19%		
XFMR706	1 ph 25 kva	25	4.693	19%		
XFMR1168	1 ph 37.5 kva	37.5	6.876	18%		
XFMR1610	1 ph 50 kva	50	8.692	17%		
XFMR984	1 ph 10 kva	10	1.727	17%		
XFMR752	1 ph 37.5 kva	37.5	6.456	17%		
XFMR746	1 ph 37.5 kva	37.5	6.432	17%		
XFMR1573	1 ph 15 kva	15	2.554	17%		
XFMR1147	1 ph 25 kva	25	4.22	17%		
XFMR1143	1 ph 37.5 kva	37.5	6.322	17%		
XFMR1020	1 ph 25 kva	125	20.907	17%		
XFMR666	1 ph 25 kva	25	4.173	17%		
XFMR1523	1 ph 25 kva	25	4.165	17%		
XFMR990	1 ph 37.5 kva	37.5	6.185	16%		
XFMR727	1 ph 15 kva	15	2.462	16%		
XFMR973	1 ph 10 kva	10	1.63	16%		
XFMR7510	1 ph 37.5 kva	37.5	6.057	16%		
XFMR847	1 ph 50 kVA Pad	50	7.984	16%		
XFMR1844	1 ph 15 kva	15	2.374	16%		
XFMR7559	1 ph 37.5 kva	37.5	5.805	15%		
XFMR1661	1 ph 15 kVA Pad	15	2.233	15%		
XFMR1666	1 ph 10 kVA Pad	10	1.45	15%		
XFMR1656	1 ph 100 kva	100	14.16	14%		
XFMR1834	3 ph 112.5 kva	112.5	15.111	13%		
XFMR1243	1 ph 25 kva	75	9.818	13%		
XFMR1064	3 PH 150 KVA	150	19.198	13%		
XFMR1150	1 ph 37.5 kva	37.5	4.763	13%		
XFMR7801	1 ph 50 kVA Pad	50	6.209	12%		
XFMR1172	1 ph 37.5 kva	37.5	4.444	12%		
XFMR1053	1 ph 50 kva	150	17.685	12%		
XFMR765	1 ph 37.5 kVA Pad	37.5	4.328	12%		
XFMR1159	1 ph 37.5 kva	37.5	4.257	11%		
XFMR817	1 ph 50 kva	50	5.658	11%		
XFMR1592	1 ph 50 kVA Pad	50	5.595	11%		
XFMR1174	1 ph 37.5 kva	37.5	4.161	11%		
XFMR1613	1 ph 25 kva	25	2.712	11%		
XFMR1117	1 ph 10 kva	10	1.076	11%		
XFMR1790	3 ph 300 kva	300	30.717	10%		
XFMR1560	1 ph 15 kva	15	1.526	10%		
XFMR1635	1 ph 37.5 kVA Pad	37.5	3.629	10%		
XFMR731	1 ph 25 kva	25	2.418	10%		
XFMR1223	1 ph 37.5 kva	112.5	10.846	10%		
XFMR815	1 ph 50 kva	50	4.696	9%		
XFMR1266	1 ph 37.5 kva	37.5	3.459	9%		
XFMR918	1 ph 15 kva	15	1.329	9%		
XFMR1672	1 ph 10 kVA Pad	10	0.875	9%		
XFMR1154	1 ph 25 kva	25	2.174	9%		
XFMR1163	1 ph 37.5 kva	37.5	3.22	9%		
XFMR1544	1 ph 10 kva	10	0.853	9%		
XFMR905	1 ph 15 kva	45	3.822	8%		
XFMR1055	1 ph 37.5 kva	75	6.143	8%		
XFMR874	1 ph 37.5 kva	37.5	3.052	8%		
XFMR1180	1 ph 25 kva	25	2.029	8%		
XFMR7518	3 ph 225 kva	225	17.784	8%		
XFMR7472	1 ph 167 kva	167	12.847	8%		
XFMR1868	1 ph 37.5 kVA Pad	37.5	2.798	7%		
XFMR1166	1 ph 37.5 kVA Pad	37.5	2.792	7%		
XFMR923	3 ph 45 kva	45	3.343	7%		
XFMR741	1 ph 15 kva	15	1.073	7%		
XFMR939	1 ph 50 kva	50	3.502	7%		
XFMR7514	1 ph 10 kva	10	0.697	7%		
XFMR1906	1 ph 25 kva	75	5.227	7%		
XFMR688	1 ph 15 kva	15	1.028	7%		
XFMR1182	1 ph 15 kva	15	0.975	7%		
XFMR916	1 ph 10 kva	30	1.895	6%		

City of St. Louis
2023 Distribution Transformer Loading

Transformer (Object ID)	Transformer Impedance	Rated kVA	Peak kVA	Percentage Loading	Location	Comments
XFMR7492	1 ph 37.5 kva	112.5	6.653	6%		
XFMR877	1 ph 10 kva	30	1.714	6%		
XFMR1060	3 ph 112.5 kva	112.5	6.337	6%		
XFMR1256	1 ph 37.5 kva	112.5	6.299	6%		
XFMR1139	1 ph 25 kva	25	1.377	6%		
XFMR1085	3 ph 112.5 kva	112.5	5.842	5%		
XFMR1189	1 ph 37.5 kva	37.5	1.917	5%		
XFMR671	1 ph 50 kva	50	2.516	5%		
XFMR716	1 ph 25 kva	25	1.242	5%		
XFMR1589	1 ph 100 kVA Pad	100	4.877	5%		
XFMR1264	1 ph 37.5 kva	112.5	4.724	4%		
XFMR931	1 ph 10 kva	45	1.856	4%		
XFMR755	1 ph 37.5 kva	37.5	1.535	4%		
XFMR885	3 ph 75 kva	75	2.997	4%		
XFMR720	1 ph 25 kva	25	0.825	3%		
XFMR712	1 ph 37.5 kva	37.5	1.227	3%		
XFMR895	3 ph 112.5 kva	112.5	3.51	3%		
XFMR724	3 ph 300 kva	300	8.356	3%		
XFMR1145	1 ph 25 kva	25	0.694	3%		
XFMR1049	1 ph 37.5 kva	112.5	3.12	3%		
XFMR690	1 ph 15 kva	15	0.404	3%		
XFMR1152	1 ph 37.5 kva	37.5	0.973	3%		
XFMR1018	1 ph 25 kva	75	1.907	3%		
XFMR1855	3 ph 500 kva	500	10.666	2%		
XFMR7491	1 ph 37.5 kva	37.5	0.507	1%		
XFMR942	1 ph 37.5 kva	112.5	1.259	1%		
XFMR7568	1 ph 37.5 kVA Pad	37.5	0.404	1%		
XFMR1449	3 ph 75 kva	75	0.677	1%		
XFMR1646	1 ph 37.5 kVA Pad	37.5	0.327	1%		
XFMR7468	1 ph 37.5 kVA Pad	75	0.651	1%		
XFMR7555	3 ph 500 kva	500	3.532	1%		
XFMR1904	1 ph 15 kva	15	0.096	1%		
XFMR950	1 ph 100 kva	300	1.87	1%		
XFMR1045	1 ph 75 kva	225	1.213	1%		
XFMR1248	1 ph 25 kva	25	0.131	1%		
XFMR7567	1 ph 37.5 kVA Pad	37.5	0.189	1%		
XFMR7470	3 PH 150 KVA	150	0.689	0%		
XFMR1751	1 ph 25 kva	25	0.022	0%		
XFMR1027	1 ph 10 kva	10	0	0%		
XFMR1043	3 ph 300 kva	300	0	0%		
XFMR1047	3 ph 112.5 kva	112.5	0	0%		
XFMR1122	1 ph 10 kva	10	0	0%		
XFMR1201	1 ph 37.5 kva	112.5	0	0%		
XFMR1203	1 ph 25 kva	75	0	0%		
XFMR1212	3 ph 500 kva	500	0	0%		
XFMR1252	1 ph 37.5 kva	112.5	0	0%		
XFMR1254	1 ph 37.5 kva	37.5	0	0%		
XFMR1261	3 ph 500 kva	500	0	0%		
XFMR1270	1 ph 15 kva	45	0	0%		
XFMR1289	3 ph 2500 kva	2500	0	0%		
XFMR1546	1 ph 10 kva	10	0	0%		
XFMR1683	1 ph 10 kVA Pad	10	0	0%		
XFMR1697	1 ph 75 kVA Pad	75	0	0%		
XFMR1707	1 ph 37.5 kVA Pad	37.5	0	0%		
XFMR1757	3 ph 300 kva	300	0	0%		
XFMR1771	1 ph 50 kva	150	0	0%		
XFMR1772	1 ph 50 kva	150	0	0%		
XFMR1856	1 ph 50 kva	150	0	0%		
XFMR1857	1 ph 10 kva	10	0	0%		
XFMR1893	1 ph 37.5 kVA Pad	37.5	0	0%		
XFMR1910	1 ph 15 kva	45	0	0%		
XFMR1913	1 ph 37.5 kva	37.5	0	0%		
XFMR1920	3 ph 225 kva	225	0	0%		
XFMR522	3 ph 45 kva	45	0	0%		
XFMR603	3 PH 150 KVA	150	0	0%		

City of St. Louis
2023 Distribution Transformer Loading

Transformer (Object ID)	Transformer Impedance	Rated kVA	Peak kVA	Percentage Loading	Location	Comments
XFMR622	3 ph 112.5 kva	112.5	0	0%		
XFMR627	3 PH 150 KVA	150	0	0%		
XFMR640	3 ph 300 kva	300	0	0%		
XFMR656	3 ph 300 kva	300	0	0%		
XFMR686	1 ph 167 kVA Pad	501	0	0%		
XFMR7484	1 ph 37.5 kva	112.5	0	0%		
XFMR7487	3 ph 112.5 kva	112.5	0	0%		
XFMR7537	3 ph 112.5 kva	112.5	0	0%		
XFMR7546	3 ph 500 kva	500	0	0%		
XFMR7551	3 ph 1500 kva	1500	0	0%		
XFMR7649	3 ph 1250 kva	1250	0	0%		
XFMR7656	3 ph 100 kva	100	0	0%		
XFMR7705	3 ph 100 kva	100	0	0%		
XFMR777	1 ph 10 kva	10	0	0%		
XFMR842	1 ph 10 kva	10	0	0%		
XFMR910	1 ph 15 kva	67.5	0	0%		
XFMR927	3 ph 225 kva	225	0	0%		
XFMR952	1 ph 10 kva	10	0	0%		

TRANSFORMER
LOADING CHARTS
PROPOSED SYSTEM

City of St. Louis
Electrical System Study
Proposed Substation Loading Peak Conditions

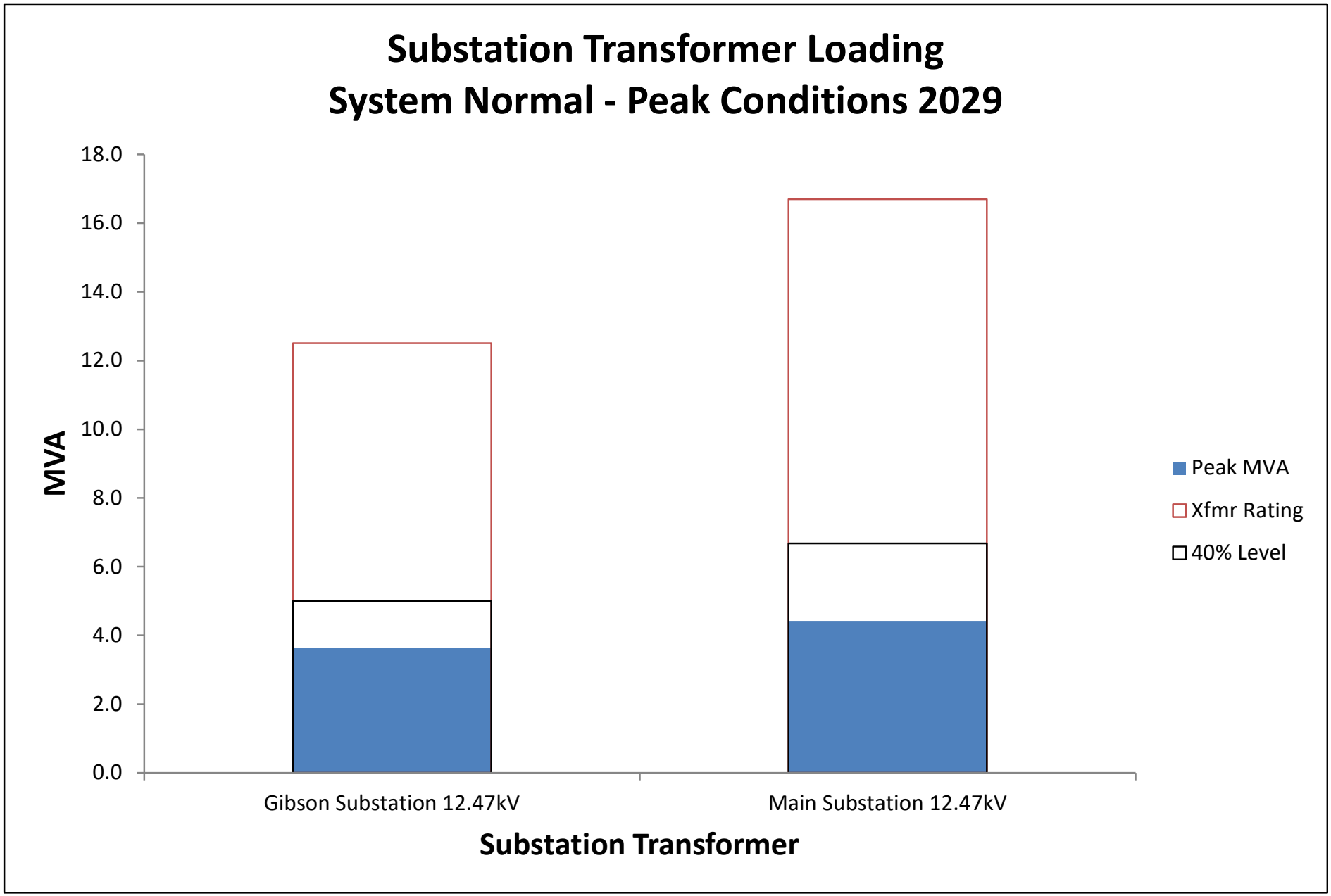
Gibson Substation

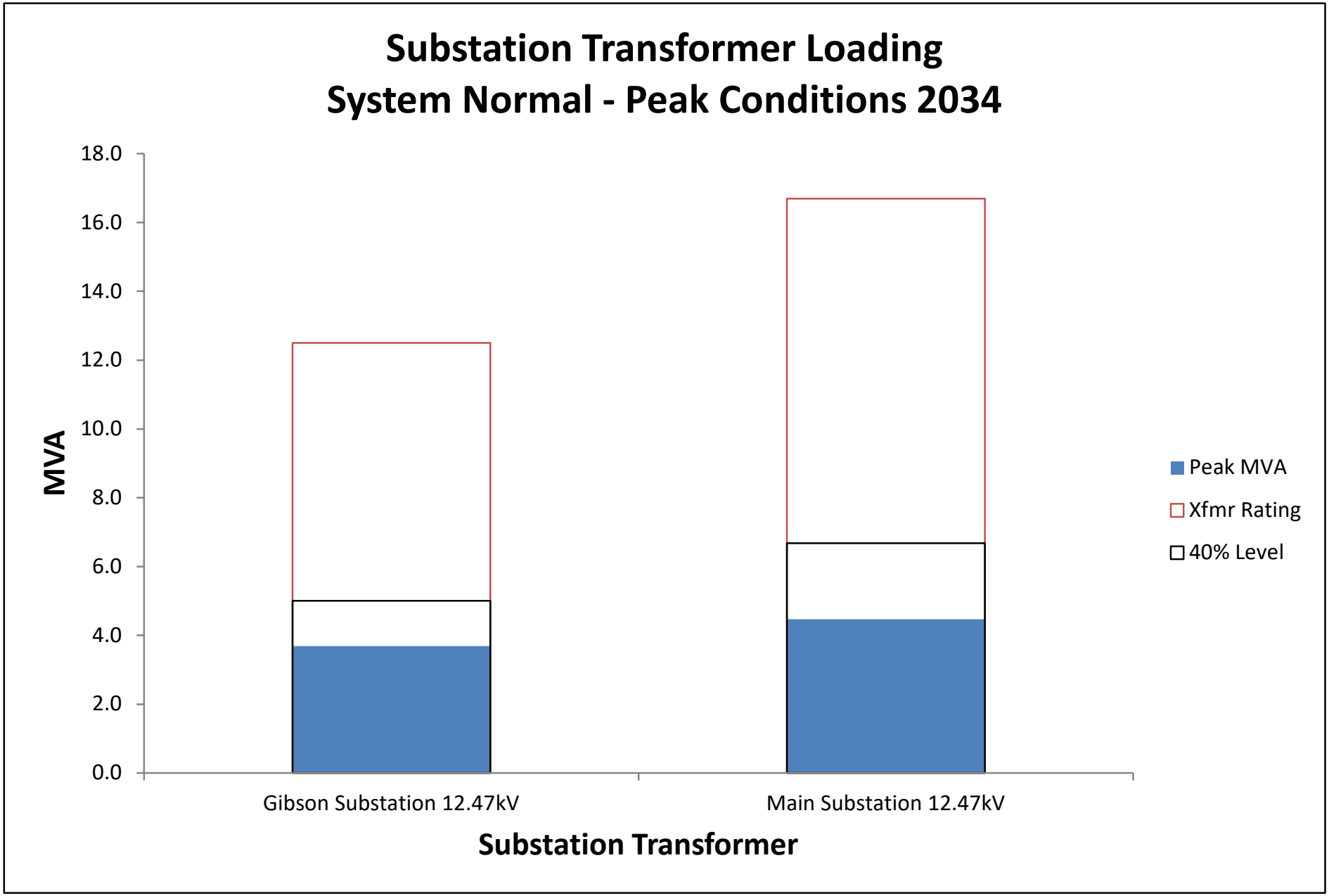
			2029		2034		
Item	Device	Rating[1]	Amps	Capacity	Amps	Capacity	Notes
GB-199	600A V-Switch	600	46	8%	46	8%	
Fuse #199 (T1 Pri)	200E	482	46	9%	46	10%	
GB_T1	10/12.5 MVA Xfmr	579	169	29%	171	30%	
GB_REG #1	416kVA V-Regulator	578	169	29%	171	30%	
GB-1 (Mid/Pine River)	800A VSA Recloser	800	113	14%	115	14%	
GB-2 (Industrial Park)	800A VSA Recloser	800	36	4%	36	5%	
GB-3 (Spare)	Future	---	0	0%	0	0%	
GB-4 (Velsicol)	800A Viper	800	20	3%	20	3%	

New Main Substation

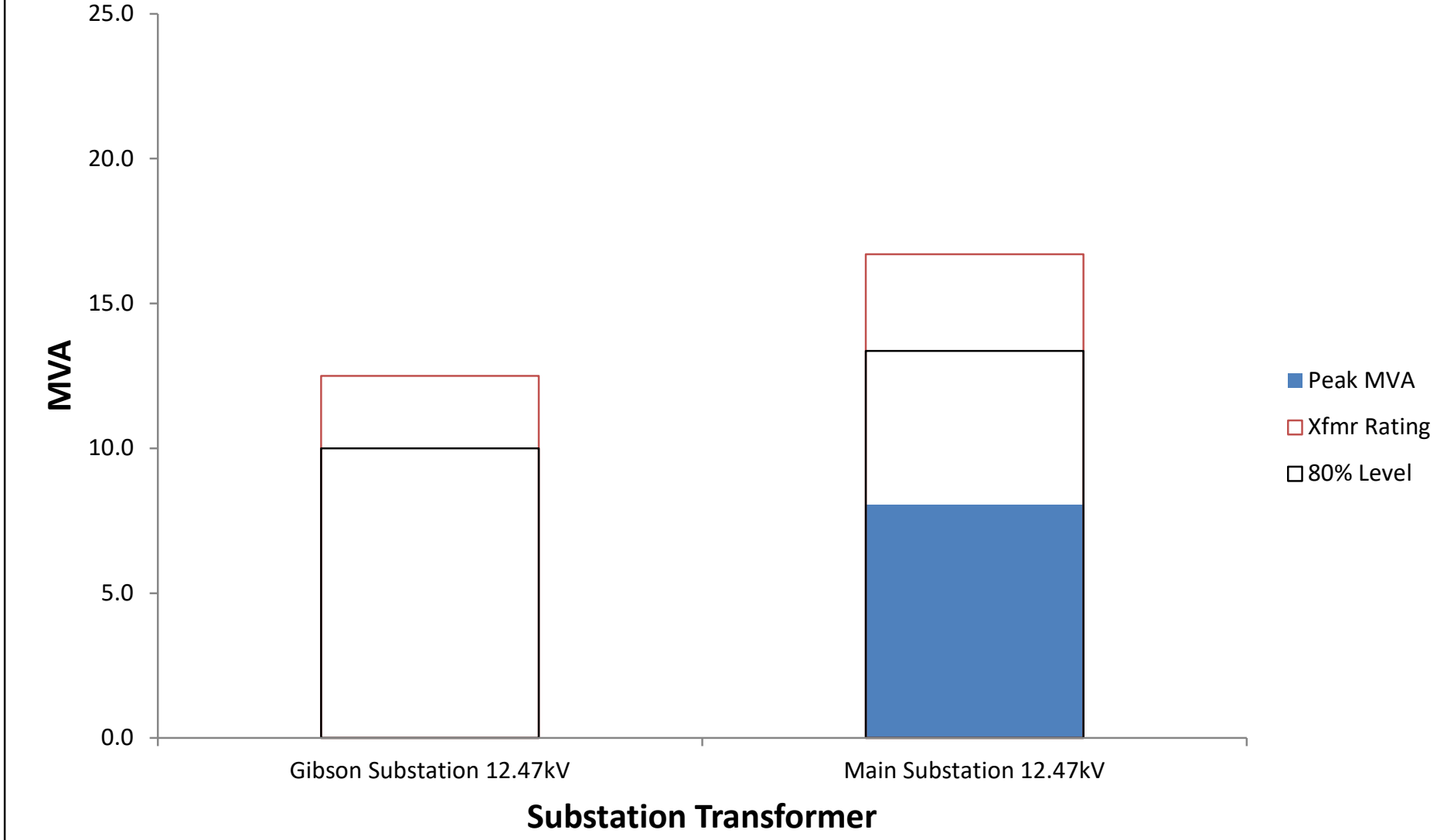
			2029		2034		
Item	Device	Rating[1]	Amps	Capacity	Amps	Capacity	Notes
SW-199	600A V-Switch	600	11	2%	11	2%	
Fuse #199 (T1 Pri)	200E	482	11	2%	11	2%	
MS_T1	10/13.3/16.7 MVA Xfmr	774	204	26%	207	27%	
MS-1 (Bear Truss)	800A Viper	800	44	6%	45	6%	
MS-2 (Main St)	800A Viper	800	83	10%	84	11%	
MS-3 (Michigan Ave)	800A Viper	800	44	6%	45	6%	
MS-4 (M-46 West)	800A Viper	800	33	4%	33	4%	

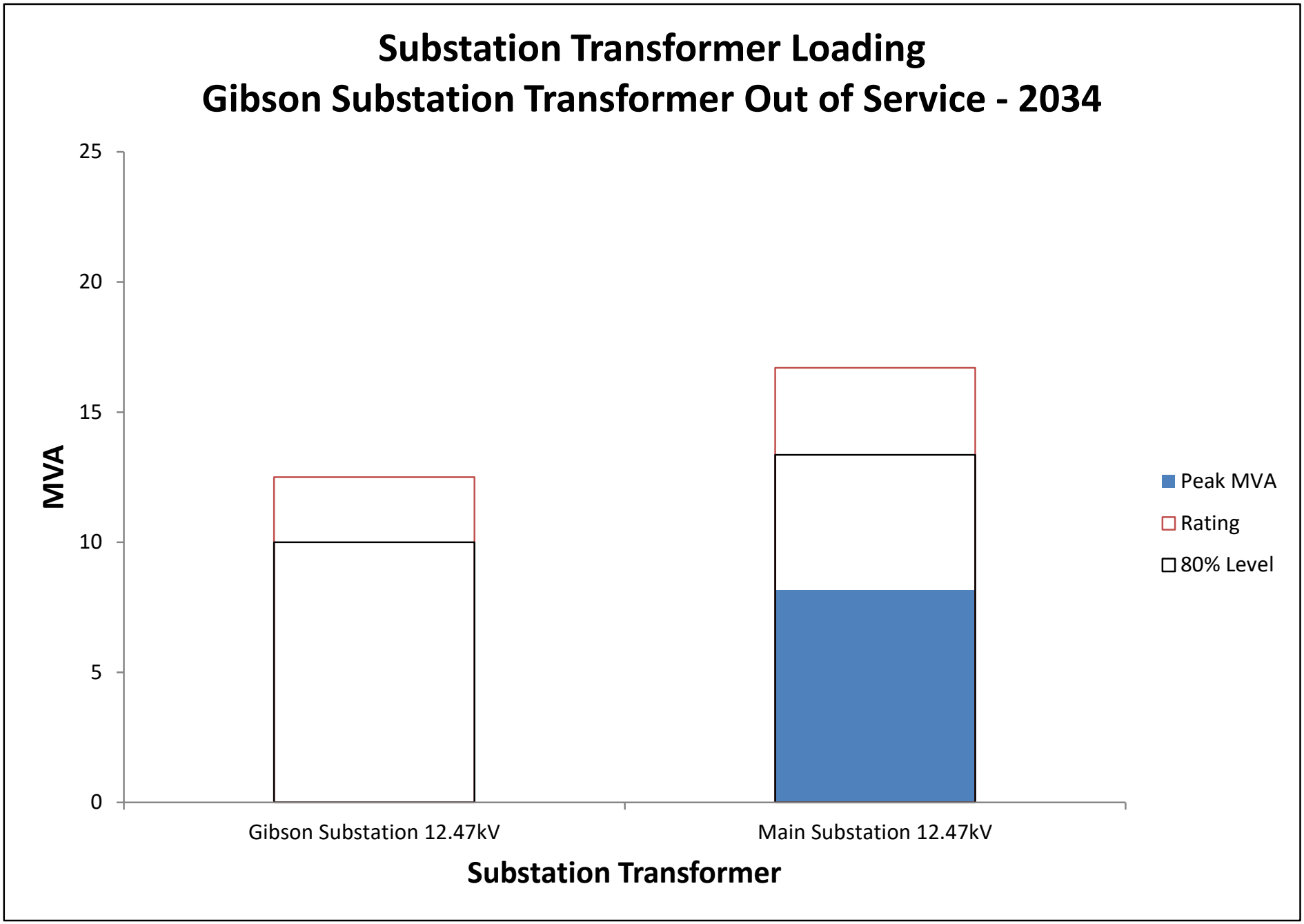
[1] Transformer ratings are given for FFA rating on the secondary side of the transformers. Secondary voltage is either 12.5kV, 4.16kV, or 2.4kV.
[2] Bus tie breaker/switch amps are calculated from the sum of adjacent bus breakers/switches.
[3] Cells highlighted in red represent transformers and their primary side equipment which are operating at or above 40% of nameplate rating OR secondary side (2.4/4.16/12.5kV) equipment which is operating at or above 50% of nameplate rating under normal peak load conditions.

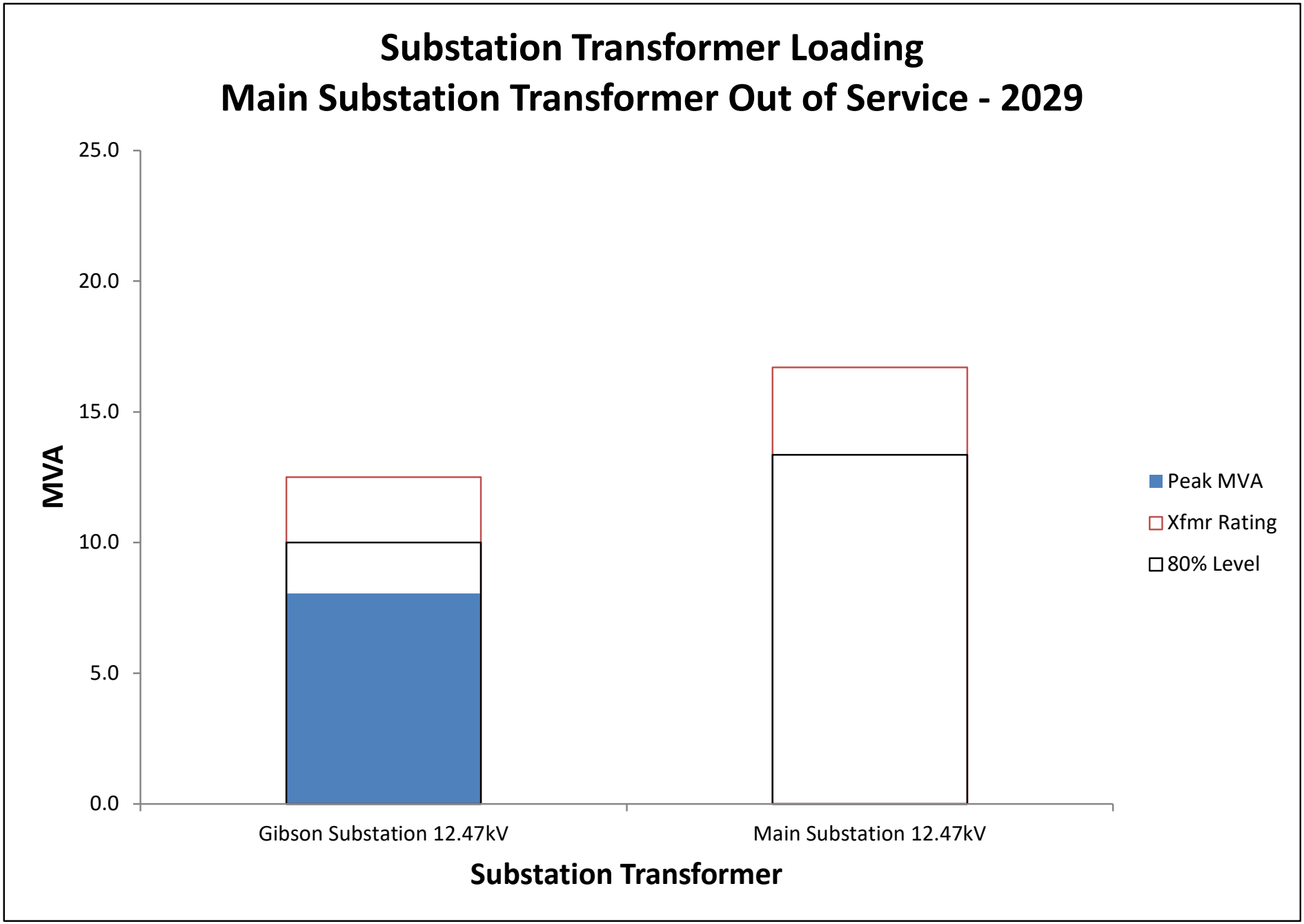

Substation Transformer Loading
System Normal - Peak Conditions 2029
MVA
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Gibson Substation 12.47kV
Main Substation 12.47kV
Substation Transformer
Peak MVA
Xfmr Rating
40% Level

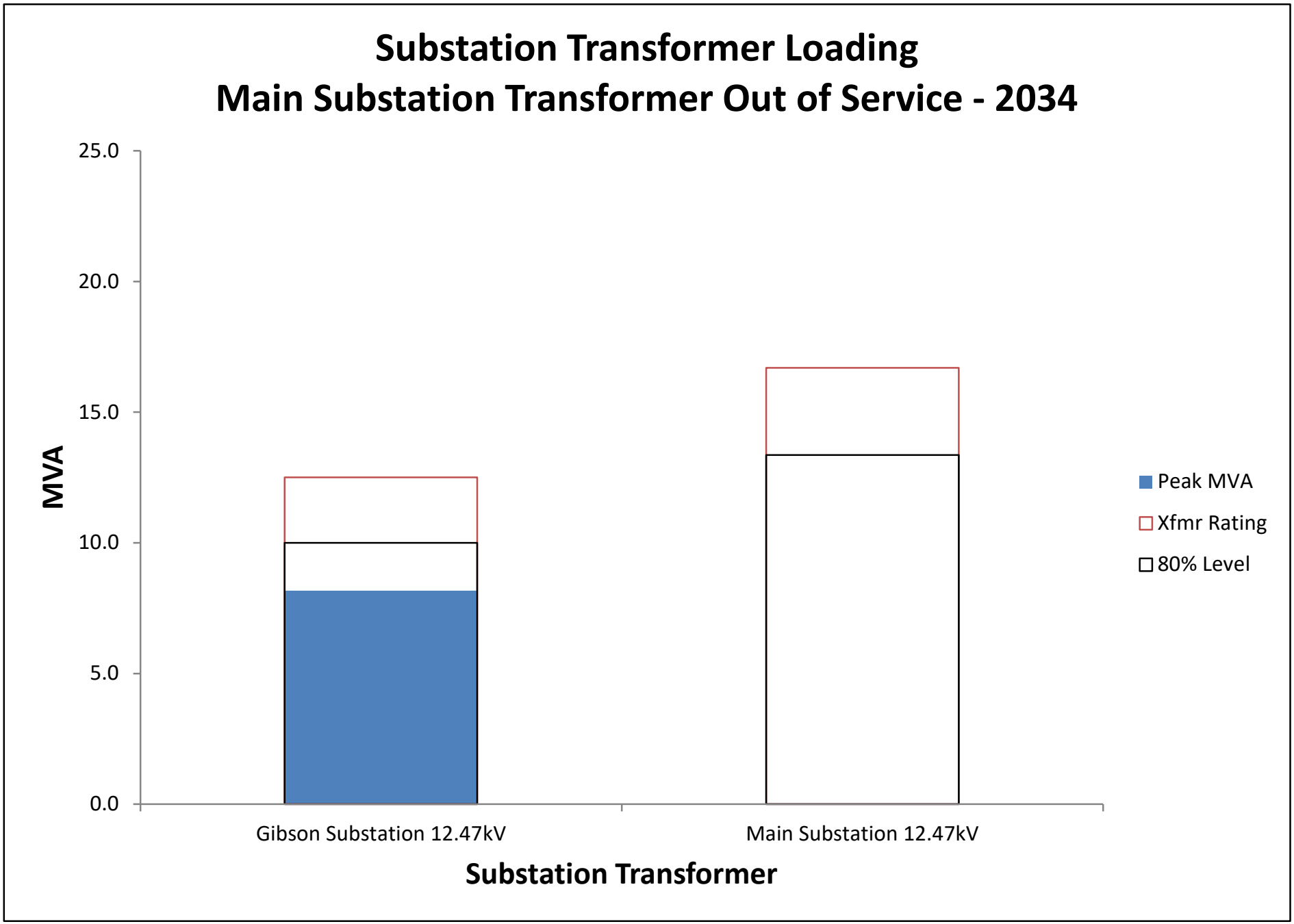

Substation Transformer Loading
System Normal - Peak Conditions 2034
MVA
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Gibson Substation 12.47kV
Main Substation 12.47kV
Substation Transformer
Peak MVA
Xfmr Rating
40% Level

Substation Transformer Loading
Gibson Substation Transformer Out of Service - 2029

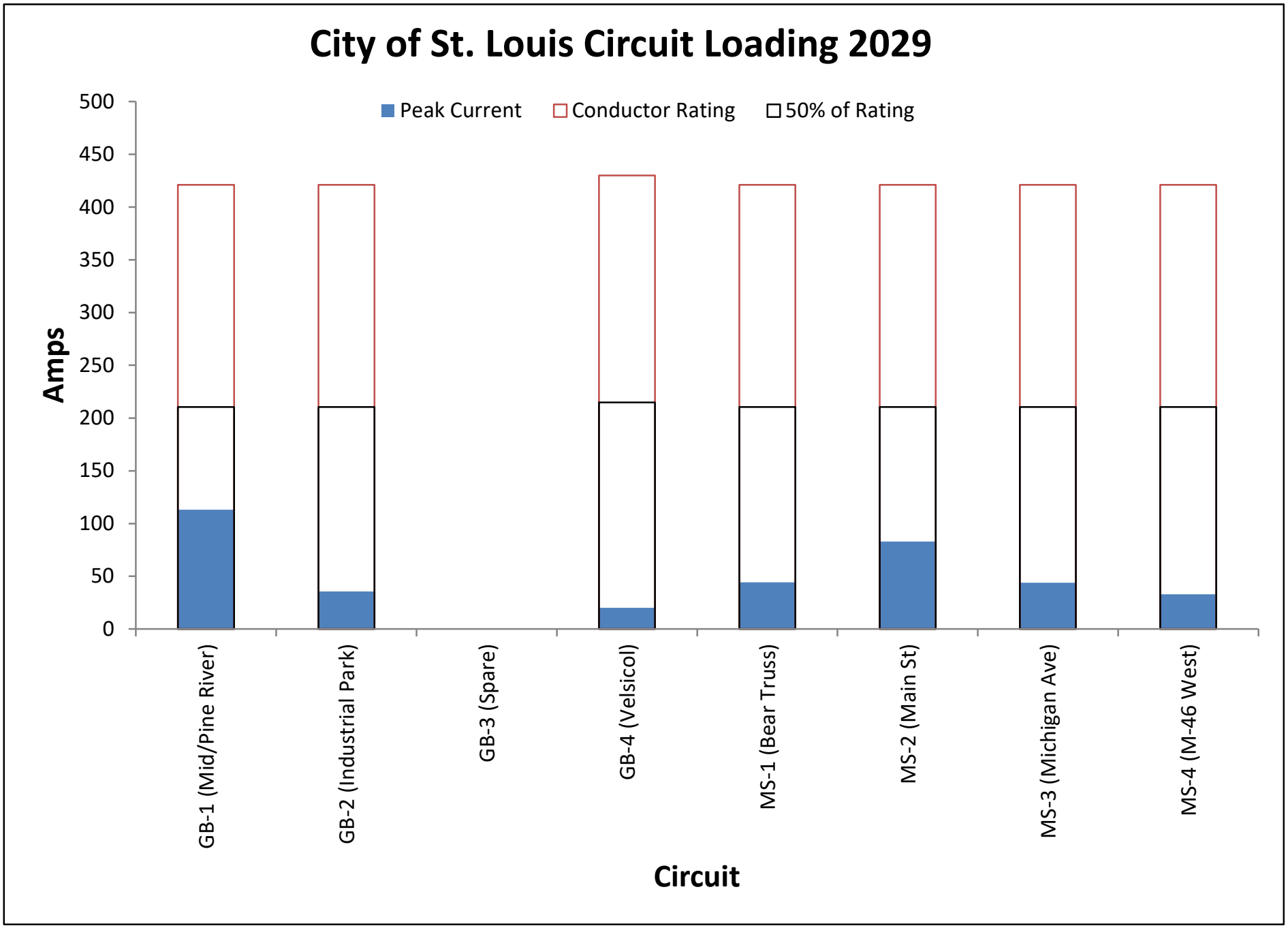


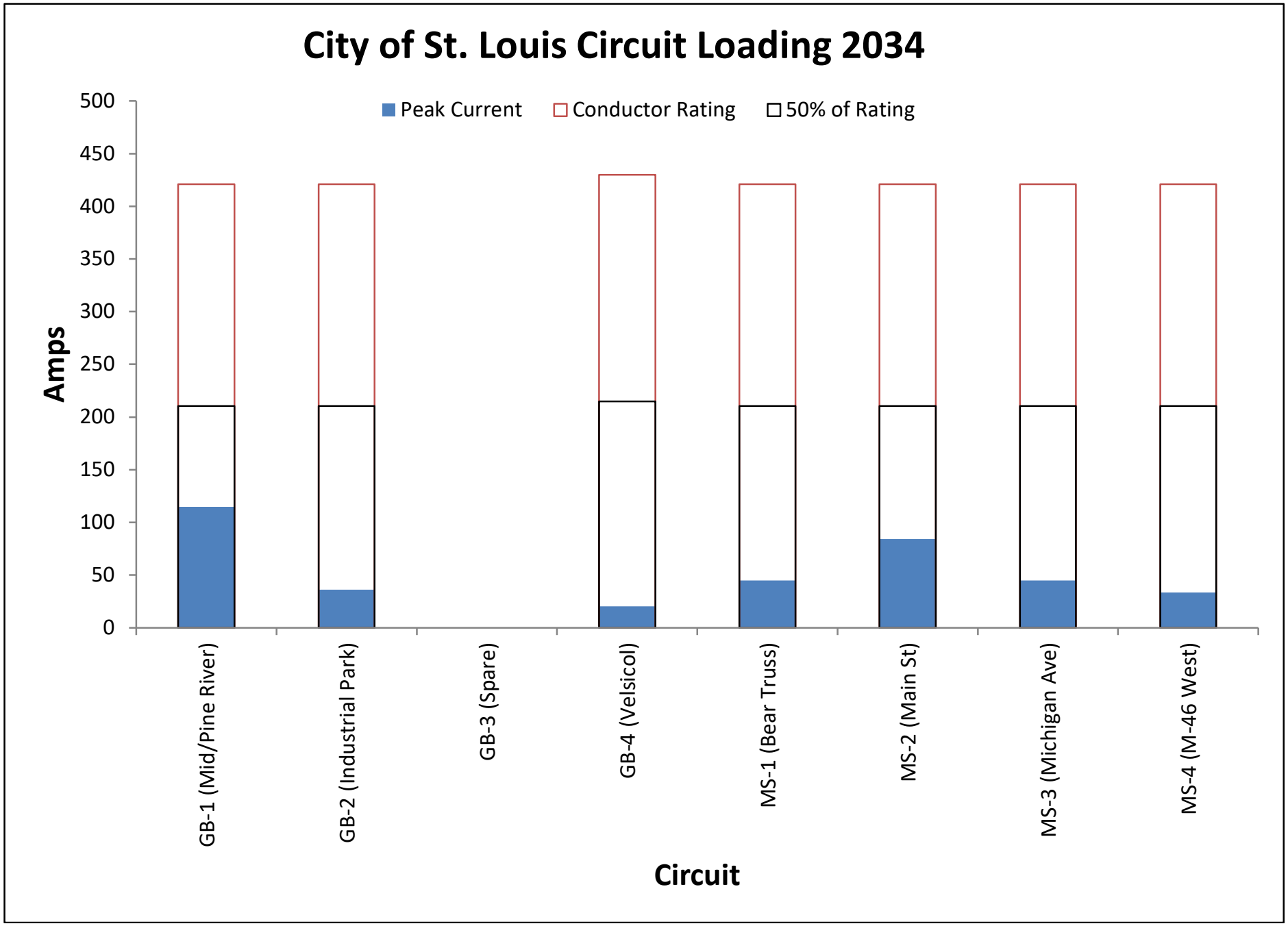

Substation Transformer Loading
Gibson Substation Transformer Out of Service - 2034
25
20
15
10
5
0
MVA
Peak MVA
Rating
80% Level
Gibson Substation 12.47kV
Main Substation 12.47kV
Substation Transformer


Substation Transformer Loading
Main Substation Transformer Out of Service - 2029
25.0
20.0
15.0
10.0
5.0
0.0
MVA
Peak MVA
Xfmr Rating
80% Level
Gibson Substation 12.47kV
Main Substation 12.47kV
Substation Transformer


Substation Transformer Loading
Main Substation Transformer Out of Service - 2034
25.0
20.0
15.0
10.0
5.0
0.0
MVA
Peak MVA
Xfmr Rating
80% Level
Gibson Substation 12.47kV
Main Substation 12.47kV
Substation Transformer

DISTRIBUTION CIRCUIT
LOADING CHARTS
PROPOSED SYSTEM


City of St. Louis Circuit Loading 2029
Peak Current
Conductor Rating
50% of Rating
Amps
500
450
400
350
300
250
200
150
100
50
0
GB-1 (Mid/Pine River)
GB-2 (Industrial Park)
GB-3 (Spare)
GB-4 (Velsicol)
MS-1 (Bear Truss)
MS-2 (Main St)
MS-3 (Michigan Ave)
MS-4 (M-46 West)
Circuit


City of St. Louis Circuit Loading 2034
Peak Current
Conductor Rating
50% of Rating
Amps
500
450
400
350
300
250
200
150
100
50
0
GB-1 (Mid/Pine River)
GB-2 (Industrial Park)
GB-3 (Spare)
GB-4 (Velsicol)
MS-1 (Bear Truss)
MS-2 (Main St)
MS-3 (Michigan Ave)
MS-4 (M-46 West)
Circuit

DISTRIBUTION CIRCUIT
BACKUP REVIEW
PROPOSED SYSTEM

City of St. Louis
Electrical System Study
Proposed Circuit Backup Review

Circuit Out-of-Service	Backup Circuit	Load Year 2029 Total Load	Recloser/ Breaker Capacity	Backup Circuit Conductor Capacity	Backup Circuit Sub Xfmr Capacity	Tie Point
GB-1 (Mid/Pine River)	GB-2 (Industrial Park)	149	19%	35%	29%	Central Michigan Correctional Facility Drive (Existing)
GB-1 (Mid/Pine River)	GB-2 (Industrial Park)	149	19%	35%	29%	PMH-11 - Gibson Substation (Existing)
GB-1 (Mid/Pine River)	MS-2 (Main St)	196	25%	47%	41%	South Main Street & Woodside Drive (New)
GB-1 (Mid/Pine River)	MS-3 (Michigan Ave)	44	6%	10%	26%	Woodside Drive & Michigan Avenue (New)
GB-2 (Industrial Park)	GB-1 (Mid/Pine River)	149	19%	35%	29%	Central Michigan Correctional Facility Drive (Existing)
GB-2 (Industrial Park)	GB-1 (Mid/Pine River)	149	19%	35%	29%	PMH-11 - Gibson Substation (Existing)
GB-2 (Industrial Park)	GB-4 (Velsicol)	56	7%	13%	29%	North Union Road (Existing)
GB-4 (Velsicol)	GB-2 (Industrial Park)	56	7%	13%	29%	North Union Road (Existing)
GB-4 (Velsicol)	MS-1 (Bear Truss)	44	6%	10%	26%	South of WWTP near River Crossing (New)
GB-4 (Velsicol)	MS-2 (Main St)	83	10%	20%	26%	North Main Street & River Court (New)
MS-1 (Bear Truss)	GB-4 (Velsicol)	64	8%	15%	37%	South of WWTP near River Crossing (New)
MS-1 (Bear Truss)	MS-2 (Main St)	127	16%	30%	26%	East Washington Street & Hubbard Street (Existing)
MS-2 (Main St)	GB-1 (Mid/Pine River)	196	25%	47%	43%	South Main Street & Woodside Drive (New)
MS-2 (Main St)	MS-1 (Bear Truss)	127	16%	30%	26%	East Washington Street & Hubbard Street (Existing)
MS-3 (Michigan Ave)	MS-4 (M-46 West)	33	4%	8%	26%	West Washington Street, east of North Watson Street (New)
MS-4 (M-46 West)	MS-3 (Michigan Ave)	44	6%	10%	26%	West Washington Street, east of North Watson Street (New)

[1] Ratings for transformers are given as FFA rating on the secondary side of the transformers. Recloser ratings are nameplate.
Conductor ratings are based on maximum thermal conductor operating temperature.

[2] Cells highlighted in red represent high-side (46kV) equipment and transformers which would be operating at or above 80% of nameplate rating OR low-side (12.5kV) equipment and conductors which would be operating at or above 90% of nameplate rating for these 1st contigency conditions.

City of St. Louis
Electrical System Study
Proposed Circuit Backup Review

Circuit Out-of-Service	Backup Circuit	Load Year 2034 Total Load	Recloser/ Breaker Capacity	Backup Circuit Conductor Capacity	Backup Circuit Sub Xfmr Capacity	Tie Point
GB-1 (Mid/Pine River)	GB-2 (Industrial Park)	151	19%	36%	30%	Central Michigan Correctional Facility Drive (Existing)
GB-1 (Mid/Pine River)	GB-2 (Industrial Park)	151	19%	36%	30%	PMH-11 - Gibson Substation (Existing)
GB-1 (Mid/Pine River)	MS-2 (Main St)	199	25%	47%	31%	South Main Street & Woodside Drive (New)
GB-1 (Mid/Pine River)	MS-3 (Michigan Ave)	45	6%	11%	17%	Woodside Drive & Michigan Avenue (New)
GB-2 (Industrial Park)	GB-1 (Mid/Pine River)	151	19%	36%	30%	Central Michigan Correctional Facility Drive (Existing)
GB-2 (Industrial Park)	GB-1 (Mid/Pine River)	151	19%	36%	30%	PMH-11 - Gibson Substation (Existing)
GB-2 (Industrial Park)	GB-4 (Velsicol)	57	7%	13%	30%	North Union Road (Existing)
GB-4 (Velsicol)	GB-2 (Industrial Park)	57	7%	13%	30%	North Union Road (Existing)
GB-4 (Velsicol)	MS-1 (Bear Truss)	45	6%	11%	17%	South of WWTP near River Crossing (New)
GB-4 (Velsicol)	MS-2 (Main St)	84	11%	20%	17%	North Main Street & River Court (New)
MS-1 (Bear Truss)	GB-4 (Velsicol)	65	8%	15%	37%	South of WWTP near River Crossing (New)
MS-1 (Bear Truss)	MS-2 (Main St)	129	16%	31%	17%	East Washington Street & Hubbard Street (Existing)
MS-2 (Main St)	GB-1 (Mid/Pine River)	199	25%	47%	44%	South Main Street & Woodside Drive (New)
MS-2 (Main St)	MS-1 (Bear Truss)	129	16%	31%	17%	East Washington Street & Hubbard Street (Existing)
MS-3 (Michigan Ave)	MS-4 (M-46 West)	33	4%	8%	17%	West Washington Street, east of North Watson Street (New)
MS-4 (M-46 West)	MS-3 (Michigan Ave)	45	6%	11%	17%	West Washington Street, east of North Watson Street (New)

[1] Ratings for transformers are given as FFA rating on the secondary side of the transformers. Recloser ratings are nameplate.
Conductor ratings are based on maximum thermal conductor operating temperature.

[2] Cells highlighted in red represent high-side (46kV) equipment and transformers which would be operating at or above 80% of nameplate rating OR low-side (12.5kV) equipment and conductors which would be operating at or above 90% of nameplate rating for these 1st contigency conditions.

ELECTRIC SYSTEM PROJECTS AND COST ESTIMATES

City of St. Louis
2025 - 2029 Electric System Projects

Year	Project #	Priority	Ranking	Project Description	Risks If Delayed / Not Completed	Estimated Cost
2025	201	High	1	**Gibson Substation Recloser Replacement** Replacement of two Cooper VSA reclosers and Form 5 recloser controllers at Gibson Substation with new G&W Viper ST Vacuum Reclosers, new SEL-651RA controllers, power & control cables, conduit modifications, covered wire jumpers, and wildlife guards.	Loss of service to Gibson Substation customers including correctional facilities and industries for a downline distribution circuit fault. The existing reclosers and electronic reclosers have been in service for over 20 years with no routine testing or maintenance. Should a recloser not operate, the substation transformer fuse(s) will open causing outages to all downline customers.	$104,000
2025	202	Medium	2	**Gibson Substation Voltage Regulator Controller Replacement** Replacement of three GE-2011 voltage regulator controllers with new SEL-2431 controllers at Gibson Substation.	Loss of voltage regulation at Gibson Substation due to aged electronics. The existing electronic regulator controllers have been in service for over 20 years with no routine testing. Should a controller fail to work correctly, voltage on the distribution circuits could be out of ANSI/utility standards.	$10,000
2025	203	High	3	**Gibson Substation Maintenance** Maintenance and testing for substation power transformer, voltage regulators, and switches.	Loss of service to Gibson Substation customers including correctional facilities and industries. The substation transformer, voltage regulators, and switches have been in service for over 20 years with minimal to no testing or maintenance. Should the power transformer need to be taken out of service, there is no backup to maintain service to the customers.	$40,000
2025	301	High	4	**Spare Step-Down Transformer** Purchase of a rebuilt spare 2500kVA 12.5kV:4.16kV step-down transformerand install on Enterprize Drive. Transformer will be maintained as a spare for the existing 4.16kV Correctional Facility on Gibson Substation 12.5kV circuit GB-1 as well as future step-downs installed during the voltage conversion process plus create a circuit tie between GB-2 and #3 Michigan Ave.	Loss of ability to provide service to the primary metered Correctional Facility operating at 4.16kV voltage on the Gibson Substation 12.5kV circuit. Loss of service to Woodside Industrial Park customers as there is no circuit tie.	$175,000
2025	302	High	5	**Circuit #1-6 Michigan Ave Conversion** Conversion of 2400V Circuit #1-6 to 2.4/4.16kV along North Street plus lines south to M-46 and Hazel Street. Shift load to #3 Michigan Ave Circuit and remove duplicate lines on Pine Street.	Loss of service to customers on Circuit #1-6 Michigan Ave as this is a radial circuit with no ties. Delays ability to shutdown the aged 2400V substation and construct a new 12.5kV substation.	$142,000
2025	303	High	6	**Circuit #5-6 Business Conversion** Conversion of 2400V Circuit #5-6 to 2.4/4.16kV along River Court and Tyrell St east of Main Street. Shift load to #1 Old Industrial Park Circuit.	Loss of service to customers on Circuit #5-6 Business as this is a radial circuit with no ties. Delays ability to shutdown the aged 2400V substation and construct a new 12.5kV substation.	$100,000
2025	304	Medium	7	**Circuit GB-1 Capacitor Bank** Installation of a 900kVAR switched capacitor bank on GB-1 prior to the Woodside Industrial Park tap poles.	Higher system losses and power purchase costs that are not recoverable. Lower system voltage at extreme end of distribution circuit serving industrial customers.	$18,000
2025	305	Low	9	**Electric System GIS Phase 1** Implementation of the initial phase of a GIS database and mapping for the electric system through purchase of WindMilMap and associated ESRI software licensing, iPads for field use, plus required staff training. Completion of this first phase will create the main GIS database and mapping for the electric system through exporting of the current system computer model which included primary features (i.e. conductors, transformers, capacitor banks, cabinets, and switches) plus the customer meters. Data and maps to be available on desktop and mobile devices.	Continued use of paper maps, lengthier time completing underground system locates, manual updates to historical paper files, difficulty in sharing system information with staff.	$100,000
					2025 Project Total	$689,000

City of St. Louis
2025 - 2029 Electric System Projects

Year	Project #	Priority	Ranking	Project Description	Risks If Delayed / Not Completed	Estimated Cost
2026	204	High	1	**4.16kV Substation Jumper & Bushing Coverup** Replacement of bus PT fuse cutouts and jumpers to/from the bus PT's, station service transformer, and reclosers at the 4.16kV Substation. Includes new substation rated fuse holders, coated jumpers, and wildlife guards.	Possible catastrophic failure of the fuse and holder should a fault occur at the bus potential transformers (PT's), plus potential full substation outage due to wildlife contact with energized parts.	$23,000
2026	306	High	2	**Circuit #3-6 Prospect Street Conversion** Conversion of 2400V Circuit #3-6 to 7.2/12.5kV along Prospect Street west to the Hidden Oaks Golf Course plus lines on Main Street & Gratiot Street. Replace aged underground cable to the WWTP and Shepley Apartments, rebuild circuit through backlot west of Clinton Street to #336.4 Hendrix, plus rebuild to three-phase along I&K Street and Olive Street then shift load to 12.5kV circuit GB-4.	Loss of service to customers on Circuit #3-6 Prospect Street as this is a radial circuit with no ties. Delays ability to shutdown the aged 2400V substation and construct a new 12.5kV substation.	$750,000
2026	307	High	3	**Generator Temporary 12.5kV Connections** Installation of a 3,750kVA 2400V:12.5kV step-up transformer and recloser. Transformer will be utilized to temporarily connect the Hydro generators plus units #1 & 7 to Gibson GB-4 12.5kV circuit until the new substation is constructed.	Delays ability to shutdown the aged 2400V substation and construct a new 12.5kV substation.	$254,000
2026	308	Medium	4	**Circuit GB-1 Capacitor Bank Upgrade** Upgrade of the existing capacitor bank on circuit GB-1 along Croswell Road to a 900kVAR switched capacitor bank and relocation to a pole north of the main circuit riser pole.	Higher system losses and power purchase costs that are not recoverable.	$18,000
2026	309	Medium	5	**Circuit GB-2 Capacitor Bank Upgrade** Upgrade of the existing capacitor bank on circuit GB-2 east of Union Street to a 900kVAR switched capacitor bank and relocation to a pole west of the Central Michigan Correctional Facility west riser pole.	Higher system losses and power purchase costs that are not recoverable.	$18,000
2026	310	Low	6	**Electric System GIS Phase 2** Implementation of the second phase of a GIS database and mapping for the electric system. Completion of this second phase will add secondaries, services, and street lights to the WindMilMap GIS database.	GIS mapping will be limited to primary lines equipment and meters only.	$100,000
					2026 Project Total	$1,163,000

City of St. Louis
2025 - 2029 Electric System Projects

Year	Project #	Priority	Ranking	Project Description	Risks If Delayed / Not Completed	Estimated Cost
2027	205	High	1	**New Substation Construction** Construction of a new main substation located at the generating plant with a 46kV:12.5kV 10/13.3/16.7MVA transformer with LTC and four underground circuit exits. CE to remove existing 2400V substation and install demarcation fence to 4.16kV substation.	Potential for extended customer outages upon loss of any of the three existing substation transformers, higher system losses, low voltage conditions, and inability to backup distribution circuits due to differing primary voltages.	$5,800,000
2027	311	Medium	2	**Circuit #2 Bear Truss Conversion** Conversion of 2.4/4.16kV Circuit #2 Bear Truss to 7.2/12.5kV along N. Union Road and M-46 east to Croswell Road. Shift load to 12.5kV circuit MS-1. Installation of an underground tie on W. Saginaw Street from Main Street.	Loss of service to customers on Circuit #2 Bear Truss if 4.16kV substation is out of service as there is no backup 4.16kV substation transformer.	$296,000
2027	312	Low	3	**Electric System GIS Phase 3** Completion of the third phase of a GIS database and mapping for the electric system including inventorying all poles, construction assemblies, and joint-use attachments.	Pole, construction, and joint-use data will not be documented and GIS mapping will be limited to primary, secondary, and service lines.	$80,000
					2027 Project Total	$6,176,000

City of St. Louis
2025 - 2029 Electric System Projects

Year	Project #	Priority	Ranking	Project Description	Risks If Delayed / Not Completed	Estimated Cost
2028	313	Medium	1	**Main Sub Step-Down Transformers** Installation of a 1500kVA 12.5kV:4.16kV step-down transformer for Circuit #1 Old Industrial Park and a 2500kVA 12.5kV:4.16kV step-down transformer for Circuit #3 Michigan Ave at the new Main Substation. Connect transformers to new 12.5kV circuits MS-2 & MS-3, respectively.	Delays ability to shutdown the aged 2.4/4.16kV substation. Loss of service to customers on Circuit #1 Old Industrial Park and Circuit #3 Michigan Ave if the 4.16kV substation is out of service as there is no backup 4.16kV substation transformer.	$246,000
2028	206	Medium	2	**Demolition of 4.16kV Substation** Demolition & removal of old Consumers Energy 4.16kV Substation.	Aged and disconnected equipment left at the generating plant/Main Substation location with continued monthly payments to Consumers Energy.	$150,000
2028	314	Medium	3	**Circuit #3 Michigan Ave - Rebuild & Phase 1 Conversion** Reconstruction of 1.25 miles of three-phase overhead to #336.4 ACSR along Pine Street & Michigan Avenue from the new Main Substation to Woodside Industrial Park. Installation of step-down transformer for Mobile Home Park. Conversion of taps to 7.2/12.5kV.	Loss of service to customers on Circuit #3 Michigan Ave until spare step-down transformer can be installed as this is a radial circuit. Inability to backup GB-1 in the Woodside Industrial Park. Leaves numerous joint-use attachment clearance violations.	$680,000
2028	315	Medium	4	**GB-1 to MS-3 Field Tie Switch** Installation of 600A three-phase gang operated switch between circuits GB-1 and MS-3. Switch will be located at Woodside & Enterprize Drive.	Loss of service to Woodside Industrial Park customers on Circuit GB-1 if Gibson 12.5kV substation is out of service as this is a radial circuit in the Industrial Park.	$10,000
					2028 Project Total	$1,086,000

City of St. Louis
2025 - 2029 Electric System Projects

Year	Project #	Priority	Ranking	Project Description	Risks If Delayed / Not Completed	Estimated Cost
2029	316	Medium	1	**Circuit #1 Old Industrial Park Conversion** Reconstruction of 1.15 miles of three-phase overhead to #336.4 ACSR along Main Street from the new Main Substation to Woodside Industrial Park. Conversion of taps to 7.2/12.5kV.	Loss of service to customers on Circuit #1 Old Industrial Park until spare step-down transformer can be installed as this is a radial circuit.	$800,750
2029	317	Medium	2	**GB-1 to MS-2 Field Tie Switch** Installation of 600A three-phase gang operated switch between circuits GB-1 and MS-2. Switch will be located on Main Street north of Woodside Drive.	Loss of service to Woodside Industrial Park customers on Circuit GB-1 if Gibson 12.5kV substation is out of service as this is a radial circuit in the Industrial Park.	$10,000
2029	318	Medium	3	**Underground Cable Upgrade - Evergreen Village Phase 1** Installation of new #1/0 AL 15kV underground cable in pipe via directional boring, plus replacement of transformers at Evergreen Village.	Potential customer outages due to aged underground cable and padmount equipment plus worker safety concerns with transclosure installations. Cable repairs would require excavations and splices added at failure points.	$250,000
2029	319	Medium	3	**MS-3 to MS-4 Field Tie Switch** Installation of 600A three-phase gang operated switch between circuits MS-3 and MS-4. Switch will be located on M-46 east of Watson Street.	Loss of service to customers west of Watson Street on proposed Circuit MS-4 if substation recloser is out of service as this is a radial circuit.	$10,000
					2029 Project Total	$1,070,750
					2025 - 2029 Total	$10,184,750

ELECTRICAL SYSTEM
PROJECT MAPS