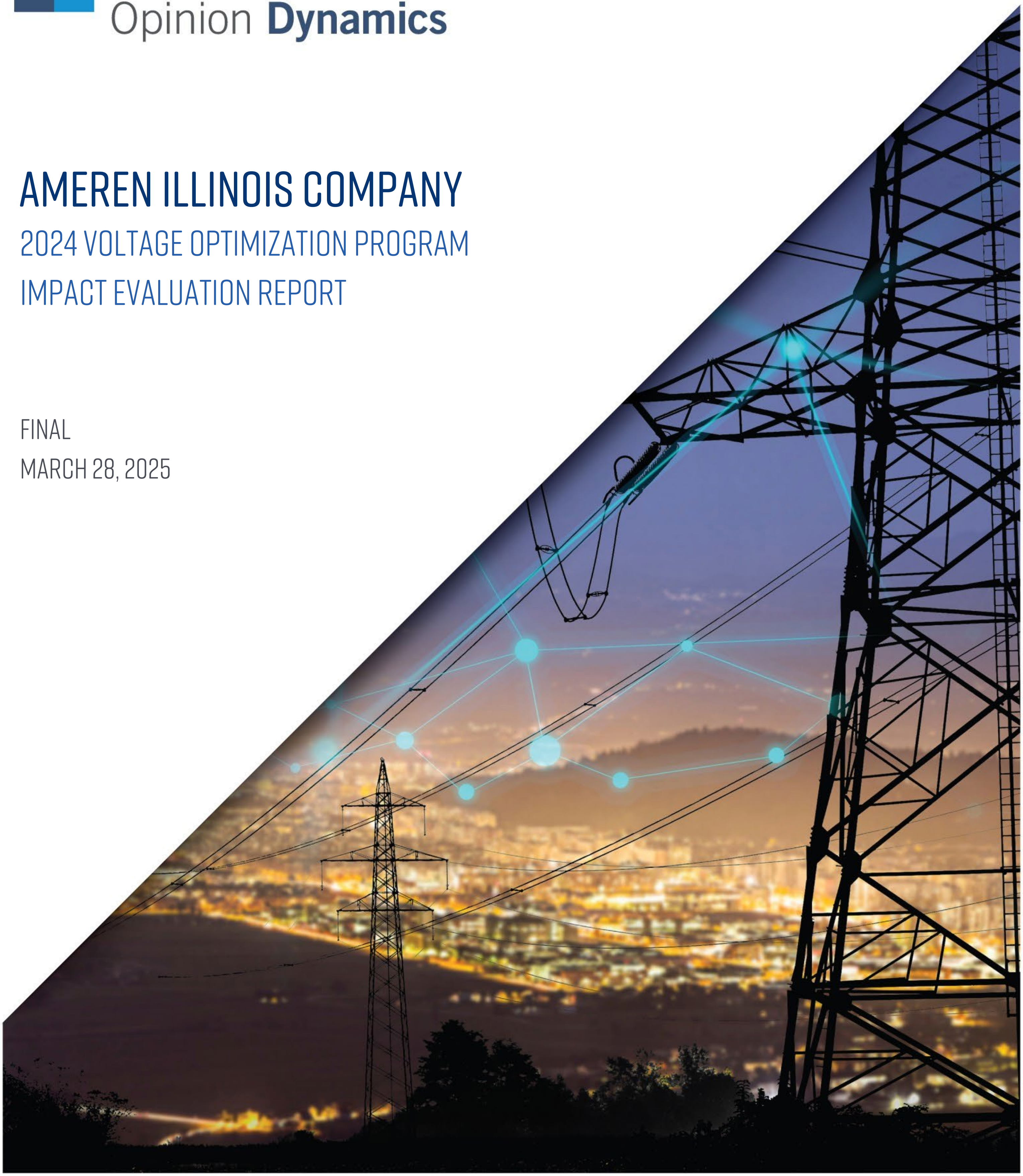
AMEREN ILLINOIS COMPANY

2024 VOLTAGE OPTIMIZATION PROGRAM IMPACT EVALUATION REPORT

FINAL

MARCH 28, 2025



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I. EXECUTIVE SUMMARY

This report presents the impact evaluation results from Ameren Illinois Company's (AIC) Voltage Optimization (VO) Program implemented in 2024. The objective of the 2024 impact evaluation was to determine energy and peak demand savings associated with the VO Program and verify the continued operation of voltage optimization for a sample of previously evaluated circuits.

I.I BACKGROUND

VO is an energy efficiency that technology electric utilities implement at the distribution substation or circuit level. This technology optimizes voltage levels along distribution circuits to reduce electricity usage. AIC's VO Program employs a combination of hardware, software, and communications solutions that leverage VO technologies. The two primary VO technologies used are Volt-VAR Optimization (VVO) and Conservation Voltage Reduction (CVR). VVO improves the power factor to reduce line losses, and CVR reduces customer energy consumption by reducing line voltage. Once implemented, VO technologies are intended to operate 24 hours a day, every day of the year. This report discusses the investigation and analysis of circuits integrated with VO technology, and these will herein be referred to as "circuits."

Prior to the program launch, AIC identified multiple technology upgrades required to successfully deploy the VO Program successfully and selected a pool of potential candidate circuits for VO deployment.[1] In 2017, AIC began installing VO hardware, software, and communications components on a subset of the selected circuits on a phased basis. As outlined in the AIC Voltage Optimization Plan,[2] AIC is only allowed to claim savings for circuits that are operational during a full calendar year. Program Year 2024 is the sixth full calendar year in which AIC is claiming energy savings.

The 2024 evaluation activities included estimating energy and peak demand savings for all 214 circuits that became operational in 2024 and verifying the continued operation of a sample of circuits previously evaluated in 2019, 2020, 2021, 2022, and 2023 (2, 13, 18, 19, and 20 sampled circuits, respectively).

[1] AIC staff used voltage level as the primary criteria for establishing the initial pool of potential candidate circuits and excluded circuits served by voltage levels > 20 kilovolts (kV) or that only serve customers exempt at the time of this determination (a customer whose highest 15-minute demand is ≥ 10 MW). In addition, only circuits that were estimated to be cost-effective based on a TRC test were deemed eligible.

[2] Ameren Illinois Voltage Optimization Plan, filed in ICC Docket 18-0211 on January 25, 2018. Accessed at: https://www.icc.illinois.gov/downloads/public/edocket/463457.pdf.

1.2 2024 VOLTAGE OPTIMIZATION PROGRAM SAVINGS

1.2.1 ANNUAL SAVINGS

We estimated energy and peak demand savings for all 214 circuits that became operational in 2024. Overall, the 2024 VO Program achieved 77,169 MWh of verified net energy savings and 13.66 MW of verified net peak demand savings (Table 1).

Table 1. 2024 VO Program Annual Energy and Peak Demand Savings

Metric	Energy Savings (MWh)	Peak Demand Savings (MW)	Gas Savings (Therms)
Ex Ante Gross Savings [a]	70,743	N/A	N/A
Gross Realization Rate	109%	N/A	N/A
Verified Gross Savings	77,169	13.66	N/A
NTGR	N/A	N/A	N/A
Verified Net Savings	77,169	13.66	N/A

[a] Ex ante energy savings sourced from AIC. Ex ante gross savings assume a 0.80 CVR factor and 3.2% voltage reduction across the 214 measured circuits. There are no ex ante demand savings estimates for this program.

1.2.2 CUMULATIVE PERSISTING ANNUAL SAVINGS

Table 2 summarizes cumulative persisting annual savings (CPAS) and the weighted average measure life (WAML) for the 2024 VO Program. The overall WAML for the VO Program is 15 years. For additional details about CPAS and WAML, please see Appendix C of this report.

Table 2. 2024 VO Program CPAS and WAML

Measure	Measure Life	Annual Verified Gross Savings (MWh)	NTGR	CPAS – Verified Net Savings (MWh)							Lifetime Savings (MWh)
				2024	2025	2026	2027	...	2030	...	
Voltage Optimization – 2024 Cohort	15.0	77,169	N/A	77,169	77,169	77,169	77,169	...	77,169	...	1,157,529
2024 CPAS		**77,169**	**N/A**	**77,169**	**77,169**	**77,169**	**77,169**	**...**	**77,169**	**...**	**1,157,529**
Expiring 2024 CPAS				**0**	**0**	**0**	**0**	**...**	**0**	**...**	
Expired 2024 CPAS				**0**	**0**	**0**	**0**	**...**	**0**	**...**	
WAML	**15.0**										

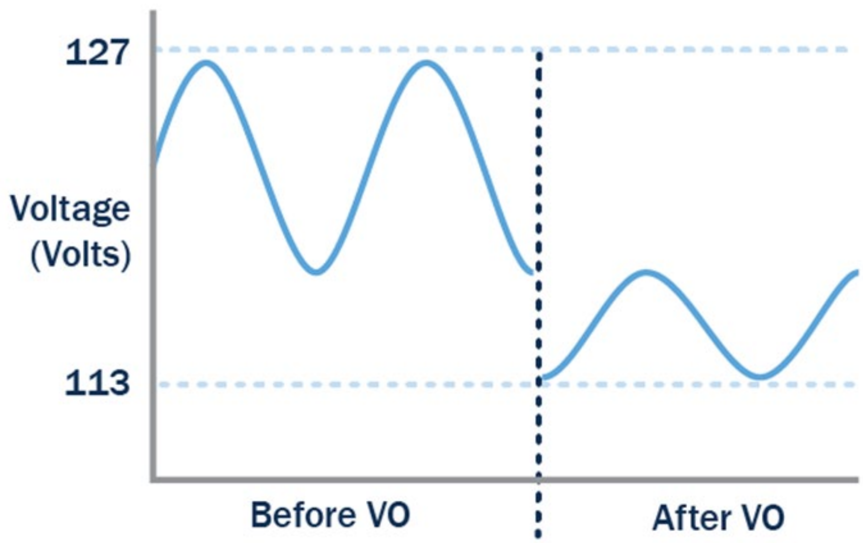
2. OVERVIEW OF VOLTAGE OPTIMIZATION PROGRAM

Illinois state law defines voltage optimization as an energy efficiency measure and allows AIC to make cost-effective voltage optimization investments as part of its energy efficiency portfolio.[3]

2.1 BACKGROUND

AIC defines VO as a combination of VVO and CVR, which are implemented first to reduce the reactive power flows on a circuit and then to lower the voltage in order to reduce end-use customer energy consumption and utility distribution system losses.[4] VVO optimizes capacitor bank[5] operations to improve power factor and reduce system losses.[6] CVR utilizes voltage regulators, transformer load tap changers and capacitors to control and reduce end-user voltages, which, in turn, lowers customers' energy consumption. In other words, VVO and CVR technologies work together to reduce distribution line voltage by regulating voltage in the lower portion of the allowable range. Historically, utilities have regulated voltage in the upper portion of the range to avoid low voltage violations. However, AIC regulates voltage in the lower portion of the range, which does not compromise power quality. Most end uses use less energy at lower voltage, due to VO technologies. (Figure 1).

Figure 1. Illustration of VO Effect on Voltage



VO technologies can operate 24 hours a day, every day of the year. Energy savings are predominantly driven through end-use load reduction and, to a lesser extent, distribution line loss reductions. While AIC's VO Program was developed to provide energy savings, not peak demand savings, some associated demand reduction on some circuits is to be expected during the hours of operation of the system.

[3] Specifically, 220 ILCS 5/8-103B(b-20).

[4] Reactive power is measured in Volt-Amperes Reactive (VAR).

[5] Capacitor banks are groupings of several capacitors and are used to store or condition electricity (e.g., by correcting power factor).

[6] Power factor is the ratio of working power (kW) to apparent power (kVA). Higher power factors indicate higher efficiency.

2.2 PROGRAM DESCRIPTION

AIC developed the VO Program, described in the Ameren Illinois Voltage Optimization Plan (referred to as the Plan hereafter), to comply with Illinois state law and achieve energy savings supporting its energy efficiency portfolio goals.[7] Per the Plan, AIC anticipates deploying VO on all circuits, which is estimated to be cost-effective by 2024. AIC initially planned to deploy VO on a total of 1,047 circuits by 2024.[8] The program team has indicated that they now expect to deploy VO to more than 1,200 circuits by the end of 2024.[9]

Before the program launch, AIC identified multiple technology upgrades required to deploy VO. In 2017, AIC began installing VO hardware, software, and communications components on a phased basis on a subset of the eligible circuits using four different VO vendor solutions: Utilidata, DVI, OSI, and ABB Group.[10] AIC staff used voltage level as the primary criteria for establishing the initial pool of candidate circuits and excluded circuits served by voltage levels >20 kilovolts (kV) and circuits that at the time served only customers exempt under Illinois state law (customers whose highest 15-minute demand is greater than or equal to 10 MW).[11]

Table 3 provides AIC's original implementation plan and savings estimates for the VO Program.

Table 3. AIC's Original VO Implementation Plan and Savings Estimates

Year Ending	2018	2019	2020	2021	2022	2023	2024	2025
Estimated Cumulative Persisting Annual Savings (MWh)	0	7,650	59,994	128,433	201,725	275,006	348,287	421,568
% Annual Cumulative Persisting Savings	0%	0.03%	0.21%	0.46%	0.72%	0.98%	1.25%	1.50%
Estimated Incremental # of Circuits Deployed	19	130	170	182	182	182	182	0
Estimated Incremental Construction Cost (Capital Cost)	$2M	$14M	$18M	$19M	$19M	$19M	$19M	$0
Estimated Incremental Total Investment Cost (Construction Capital, Construction O&M, Upfront Capital)	$5M	$17M	$20M	$20M	$20M	$20M	$20M	$0

Source: Ameren Illinois Voltage Optimization Plan

VO is a major part of AIC's 2022–2025 energy efficiency plan. Per AIC's most recent filing, VO was expected to yield 73,281 MWh in energy savings in 2024, about 17% of AIC's total estimated 2024 portfolio energy savings goal.[12] In 2024, AIC completed the deployment of VO technology to 214 new circuits, which were then evaluated as part of the 2024 program year.

[7] Ameren Illinois Voltage Optimization Plan, filed in ICC Docket 18-0211 on January 25, 2018. Accessed at: https://www.icc.illinois.gov/downloads/public/edocket/463457.pdf

[8] The number of circuits planned for VO deployment was determined based on a cost-effectiveness study using calculated assumptions, industry results, and past AIC VO pilot results. The actual number of circuits with VO could fluctuate based on deployment results. See Ameren Illinois Voltage Optimization Plan for details.

[9] Interview with VO implementation staff of AIC on July 7, 2023.

[10] AIC has now selected a primary vendor, and remaining circuit construction is proceeding with only one solution.

[11] Note that as a result of the Climate and Equitable Jobs Act, customers with >10MW demand are no longer automatically exempt.

[12] Appendix F to AIC's 2022–2025 EE Plan. Accessed at: https://www.icc.illinois.gov/docket/P2021-0158/documents/322771/files/561827.pdf

3. VOLTAGE OPTIMIZATION EVALUATION APPROACH

The 2024 VO evaluation approach was primarily governed by the Illinois Technical Reference Manual for Energy Efficiency (IL-TRM) Version 12.0, which prescribes the use of an algorithmic approach to estimating electric energy and peak demand savings from VO activities.[13] In addition to the IL-TRM, we leveraged a previously agreed-upon methodology and approach to verifying the continued operation of previously installed circuits during 2024.[14]

In this report, we address the following key research questions:

- What are the estimated energy savings from VO?
- What are the estimated peak demand savings from VO?
- Did the 2, 13, 18, 19, and 20 sampled circuits from 2019, 2020, 2021, 2022, and 2023 deployment operate for over 90% of non-excludable hours in 2024?[15]

3.1 EVALUATION RESEARCH OBJECTIVES

The 2024 VO evaluation estimated annual energy savings and peak demand savings for the 214 operational circuits as of January 1, 2024.

3.2 VERIFIED IMPACT ANALYSIS APPROACH

3.2.1 ENERGY SAVINGS METHODOLOGY

The IL-TRM requires the use of an algorithmic approach to evaluate VO energy savings. The algorithmic approach combines deemed parameter values with measured reductions in voltage to calculate energy savings. The algorithm used for AIC's VO Program energy savings evaluation is shown in Equation 1.

Equation 1. AIC VO Energy Savings Algorithm

$$Annual\ Energy\ Savings_i = \ Annual\ Energy\ Use_{2014-2016,i} * \ CVR_f * \%\ \Delta V_i$$

Where:

- $Annual\ Energy\ Use_{2014-2016,i}$= the average annual customer energy use for circuit *i* over the 2014–2016 timeframe, excluding exempt customers;
- CVR_f= conservation voltage reduction factor, defined as the percent change in energy usage divided by the percent change in voltage (deemed at 0.80 by the IL-TRM V12.0); and,

[13] Illinois Statewide Technical Reference Manual for Energy Efficiency Version 12.0, Volume 4, Cross-Cutting Measures and Attachments, Measure 6.2.1. Accessed at: https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_4_X-Cutting_Measures_and_Attach_09222023_FINAL.pdf

[14] Ameren Illinois Company Voltage Optimization Verification and Exclusion Approach Memo, accessed at: https://www.ilsag.info/wp-content/uploads/AIC-2019-Voltage-Optimization-Operation-Verification-Memo-FINAL-2020-04-17.pdf

[15] Roughly 10 percent of the evaluated circuits, chosen randomly.

- $\% \Delta V_i$= the percent change in voltage for circuit *i* resulting from VO implementation relative to the pre-period, estimated using a regression model to control for exogenous factors that may contribute to changes in voltage (e.g., weather).

3.2.2 PEAK DEMAND SAVINGS METHODOLOGY

Peak demand savings were also estimated using an algorithmic approach. The peak period is defined as 1:00 p.m.–5:00 p.m. (CDT) on non-holiday weekdays from June 1 to August 31.[16] The algorithm used for AIC's VO peak demand savings program evaluation is shown in Equation 2.

Equation 2. AIC VO Peak Demand Savings Algorithm

$$Peak\ Demand\ Savings_i = Avg\ Peak\ Demand_{2014-2016,i} * CVR_{f,PEAK} * \%\ \Delta V_{i,PEAK}$$

Where:

- $Avg\ Peak\ Demand_{2014-2016,i}$ = the average demand in the peak hour for circuit *i* over the 2014–2016 timeframe during the peak period adjusted by a calibration factor that captures the relationship between peak demand and average demand in the peak period, excluding >10 MW customers;
- $CVR_{f,PEAK}$ = the estimate of the peak conservation voltage reduction factor, defined as the percent change in energy usage divided by the percent change in voltage during the peak period (deemed at 0.68 by the IL-TRM V12.0); and,
- $\%\ \Delta V_{i,PEAK}$= the percent change in voltage for circuit *i* resulting from VO implementation relative to the peak hours of the pre-period, using a regression model to control for exogenous factors that may contribute to changes in voltage (e.g., weather). Per the guidance in the IL-TRM, this is to be calculated in the same manner as energy savings but with the intention of measuring peak demand savings rather than total energy savings.

3.2.3 VERIFICATION OF CONTINUED OPERATION

The IL-TRM V12.0 deems VO savings for 15 years after completion of the initial evaluation of a circuit.[17] Retroactive changes to deemed savings are not permitted.[18] Therefore, in the Illinois evaluation framework, impact evaluation for VO does not require retroactive or ongoing verification.

Nevertheless, in 2020, Opinion Dynamics, AIC, and ICC staff agreed that ongoing verification of VO should be conducted for process purposes to provide information to all stakeholders as to the level of continued VO operation and, if needed, to provide context as to why VO may not have operated continuously. All parties agreed that Opinion Dynamics would conduct verification activities to assess the degree to which VO continued to operate in a sample of circuits deployed

[16] Illinois Statewide Technical Reference Manual for Energy Efficiency Version 12.0, Volume 4, Cross-Cutting Measures and Attachments, Measure 6.2.1. Accessed at: https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_4_X-Cutting_Measures_and_Attach_09222023_FINAL.pdf

[17] Note that the IL-TRM V12.0 outlines a process through which the measure life for VO, including circuits that have already been evaluated and had savings claimed, can be "extended." AIC and its evaluator will revisit past circuits at the expiration of their existing measure life, beginning in the 2034 program year.

[18] Illinois Energy Efficiency Policy Manual Version 3.0, Section 11.2. Accessed at: https://www.ilsag.info/wp-content/uploads/IL_EE_Policy_Manual_Version_3.0_Final_11-3-2023.pdf

and evaluated prior to the current evaluation period. An acceptable uptime threshold of operation was set to ensure that circuits operated over 90% of the time, barring non-operation due to excludable events.[19]

As part of the 2024 evaluation, Opinion Dynamics verified ongoing operation in circuits evaluated in 2019, 2020, 2021, 2022, and 2023. To determine whether these circuits operated at or over the target 90% uptime threshold during 2024, we conducted the following analytical activities:

- Selected a random sample of 2 of the 19 circuits evaluated in 2019, 13 of the 125 circuits evaluated in 2020, 18 of the 180 circuits evaluated in 2021, 19 of the 181 circuits evaluated in 2022, and 20 of the 194 circuits evaluated in 2023;
- Requested operation log summaries for the sample of circuits. Our variable of interest for this effort included the VO status (e.g., "On/Off") at a circuit level for all hours throughout 2024;
- Removed excludable events;[20] and,
- Divided the total number of hours the status logs indicated that VO was 'On' by the total number of non-excludable hours in the year.

3.2.4 CONSIDERATION OF VOLTAGE OPTIMIZATION NET EFFECTS

Because AIC is the sole operator and "participant" in the VO Program, no adjustments to savings were made to reflect net effects (free ridership and spillover) that are often present for other, more traditional energy efficiency programs.

3.3 SOURCES AND MITIGATION OF ERROR

Because the evaluation team relied on regression models to estimate the change in voltage and peak demand, some uncertainty is to be expected in the model-produced estimates. Therefore, the team designed analyses to address the following types of errors:

- **Model Specification Error:** The most difficult type of modeling error in terms of bias and the ability to mitigate it is specification error. In this type of error, variables that determine model outcomes are excluded when they should not be, potentially producing biased estimates. We addressed this type of error by carefully examining the model diagnostics and goodness-of-fit statistics of the data variables.
- **Measurement Errors:** Specifying an incorrect time period (either VO "On" or VO "Off") can lead to measurement error. We worked extensively with AIC to ensure that operations log data anomalies were discussed and addressed where possible. Measurement error can also come from variables such as weather data, which are commonly included in consumption analysis models. If an inefficient base temperature is chosen for calculating degree days or an incorrect climate zone weather station is chosen, the model results could be subject to measurement error. We mitigated this type of error by meticulously choosing the closest weather station for each circuit in the model to ensure the most accurate weather data were used in the model.
- **Multi-collinearity:** This type of modeling error can both bias and produce substantial variances in the results. We dealt with this type of error by using evaluation model diagnostics, though the models used in the impact analysis are unlikely to have problems with multi-collinearity.

[19] Ameren Illinois Company Voltage Optimization Verification and Exclusion Approach Memo, accessed at: https://www.ilsag.info/wp-content/uploads/AIC-2019-Voltage-Optimization-Operation-Verification-Memo-FINAL-2020-04-17.pdf

[20] For the rationale behind and definition of excludable events, please see the IL-TRM Voltage Optimization measure: Illinois Statewide Technical Reference Manual for Energy Efficiency Version 12.0, Volume 4 Cross-Cutting Measures and Attachments, Measure 6.2.1. Accessed at: https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010124_v12.0_Vol_4_X-Cutting_Measures_and_Attach_09222023_FINAL.pdf

- **Heteroskedasticity:** This type of modeling error can result in imprecise statistical inference due to variance changing across circuits with different consumption levels. We addressed this type of error by using robust standard errors. Most statistical packages offer a robust standard error option and make conservative assumptions when calculating errors, which also makes the model’s significance tests conservative.

4. 2024 VOLTAGE OPTIMIZATION PROGRAM VERIFIED SAVINGS

In this section, we present the results of the impact evaluation of the 2024 VO Program. Additional details on the impact analysis methodology used for this evaluation are presented in Appendix B.

4.1 ANNUAL SAVINGS SUMMARY

The 2024 VO Program deployed the VO technology to 214 circuits, achieving 77,169 MWh of verified net energy savings and 13.66 MW of verified net peak demand savings. The year-end verified savings are within 0.3% of the interim report’s forecasted savings of 76,940 MWh. Table 4 presents the 2024 VO Program annual energy and peak demand savings. Detailed results by circuit are available in Appendix B.

Table 4. 2024 VO Program Annual Energy and Peak Demand Savings

Metric	Energy Savings (MWh)	Peak Demand Savings (MW)	Gas Savings (Therms)
Ex Ante Gross Savings [a]	70,743	N/A	N/A
Gross Realization Rate	109%	N/A	N/A
Verified Gross Savings	77,169	13.66	N/A
NTGR	N/A	N/A	N/A
Verified Net Savings	77,169	13.66	N/A

[a] Ex ante energy savings sourced from AIC. Ex ante gross savings assume 0.80 CVR factor and 3.2% voltage reduction across the 214 measured circuits. There are no ex ante demand savings estimates for this program.

Factors driving program performance include the following:

- The 2024 VO Program exceeded its ex ante gross energy savings due to larger estimated percent changes in voltage than assumed values (3.20% ex ante compared to 3.43% verified weighted average).
- Greater changes in voltage resulted in greater than expected energy savings, and the program achieved a gross realization rate of 109%.

4.1.1 DETAILED ENERGY SAVINGS

Savings were calculated using the annual energy savings algorithm, which uses the CVR factor (CVRf), the percent change in voltage resulting from VO implementation relative to the baseline, and average annual customer energy use over the 2014–2016 timeframe, excluding exempt customers. We used regression models to estimate the percent change in voltage for each circuit, applied that to the CVRf, and assumed the baseline of each circuit. Table 5 summarizes the energy savings results across all 214 circuits (see Appendix B for circuit-level percent change in voltage results).

Table 5. Ex Ante and Verified Algorithmic Inputs and Associated Energy Savings

Metric	Annual Gross Energy Use (MWh)	CVRf	Average Percent Change in Voltage	Annual Gross Energy Savings (MWh)
Ex Ante[a]	2,763,403	0.80	3.20%	70,743
Verified	2,763,403	0.80	3.49% [a]	77,169 [b]
Realization Rate	100%	100%	109%	109%

[a] Weighted average percent change in voltage is obtained after weighing circuit-level voltage reductions in percentage terms by their 2014–2016 average yearly energy usage in MWh.
[b] Application of Equation 1 to values in Table 5 does not produce 77,169 MWh savings due to the rounding of the Average Percent Change in Voltage value.

4.1.2 DETAILED PEAK DEMAND SAVINGS

Given the variability of load across circuits, we estimated peak demand savings using an individual regression analysis approach for each circuit. The percentage voltage reduction for each circuit was multiplied by the peak period CVRf of 0.68 (deemed) and the annual peak demand baseline value (measured in MW). The resulting peak demand savings were summed across circuits to determine the total peak demand reduction of 13.66 MW. The weighted average percent change in voltage during peak demand periods was 2.95%, as shown in Table 6. AIC does not report ex ante demand savings; therefore, no ex ante savings or realization rates are reported.

Table 6. Verified Algorithmic Inputs and Associated Demand Savings

Metric	Peak Demand (MW)	CVRf	Average Percent Change in Peak Voltage	Peak Demand Savings (MW)
Verified	680.21	0.68	2.95% [a]	13.66

[a] Weighted average percent change in peak voltage is obtained after weighing feeder level voltage reductions in percentage terms by their 2014-2016 average yearly energy usage in MWh.

4.2 CUMULATIVE PERSISTING ANNUAL SAVINGS

Table 7 presents CPAS and WAML for the 2024 VO Program. The total verified gross savings for the Program are summarized, and CPAS in 2024–2027 and 2030 are presented. The WAML for the Program is 15 years.

Table 7 2024 VO Program CPAS and WAML

Measure	Measure Life	Annual Verified Gross Savings (MWh)	NTGR	CPAS – Verified Net Savings (MWh)							Lifetime Savings (MWh)
				2024	2025	2026	2027	…	2030	…	
Voltage Optimization – 2024 Cohort	15.0	77,169	N/A	77,169	77,169	77,169	77,169	…	77,169	…	1,157,529
2024 CPAS		**77,169**	**N/A**	**77,169**	**77,169**	**77,169**	**77,169**	**…**	**77,169**	**…**	**1,157,529**
Expiring 2024 CPAS				**0**	**0**	**0**	**0**	**…**	**0**	**…**	
Expired 2024 CPAS				**0**	**0**	**0**	**0**	**…**	**0**	**…**	
WAML	**15.0**										

4.3 VERIFICATION OF CONTINUED OPERATIONS

As discussed in Section 3.2.3, we analyzed status logs for a randomly selected sample of previously implemented circuits to verify continued VO operation. In 2024, we sampled 2 of the 19 circuits evaluated in 2019, 13 of the 125 circuits evaluated in 2020, 18 of the 180 circuits evaluated in 2021, 19 of the 181 circuits evaluated in 2022, and 20 of the 194 circuits evaluated in 2023. Per the terms of the verification agreement, detailed further in Section 3.2.2, we set a threshold of operation of 90% of non-excludable hours. Our analysis found that all sampled circuits were “On” for more than 90% of non-excludable hours in 2024.

More information on the verification approach can be found in Appendix D.

5. CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this evaluation, we offer the following key findings and recommendations for AIC's VO Program moving forward:

- **Key Finding #1:** The VO Program continues to provide substantial energy savings to the AIC portfolio and exceeds AIC's initial expectations for savings achieved.
- **Key Finding #2:** The average percent change in voltage due to VO was 3.49%, higher than the planning value of 3.20%. There is substantial variation across circuits in percent change in voltage (0.08%–5.41%). For 154 of the 214 evaluated circuits, the percent change in voltage was estimated to be larger than the planning value of 3.20%.
  - Recommendation: Consider further updates to planning values to reflect the percent change in voltage derived from evaluated values. AIC updated the planning value from 3% to 3.20% in 2022, which better aligns with evaluation findings to date, but the planning value continues to significantly understate verified results. Updating the planning value could also support a more accurate assessment of the ex ante cost-effectiveness for each circuit screened for inclusion in the program.
- **Key Finding #3:** The evaluation team found that all of the 72 circuits sampled from the 2019-2023 evaluation cohorts were "On" for more than the 90% threshold of non-excludable hours in 2024. Specially, the uptime ranges from 93.20% to 99.80% of non-excludable hours, with an average of 99.45%. This indicates that VO is being appropriately maintained and operated and continues to suggest that the approach of prospectively deeming VO savings is likely to closely represent actual achieved energy savings over time.
- **Key Finding #4:** The evaluation team developed and presented forecasts of year-end savings with its first and second interim impact analysis of 2024. The year-end verified savings are within 0.3% of the interim report forecasted savings of 76,940 MWh.

APPENDIX A. 2024 VOLTAGE OPTIMIZATION CIRCUIT SUMMARY

Table 8 presents detailed characteristics for VO circuits evaluated in 2024. It includes the circuit name and substation for each circuit, as well as various circuit characteristics that may affect voltage reductions. Since AIC prioritized low-income customers as part of its VO deployment, we also note the number of low-income customers estimated to be served by each circuit evaluated in 2024 when data are available.

Table 8. 2024 Evaluated VO Circuits

Circuit	Substation	Line Length (Miles)	% Res.	% Com.	% Large C&I	Voltage Level	Low-Income Customers
301051	MITCHELL-12	6.1	79%	20%	0%	7.20	3
301052	MITCHELL-12	8.6	93%	6%	0%	7.20	7
301053	MITCHELL-12	12.3	26%	46%	29%	7.20	1
326168	SPRING 1	4.4	73%	25%	2%	4.16	6
326169	SPRING 1	2.2	48%	52%	0%	4.16	1
326170	SPRING 1	2.9	0%	83%	17%	4.00	N/A
350103	ARROW WOOD 1	14.2	94%	6%	0%	4.16	1
350104	ARROW WOOD 1	10.4	98%	3%	0%	4.00	N/A
A32001	WALLACE 1	3.2	0%	100%	0%	13.20	N/A
A32002	WALLACE 1	5.1	0%	91%	9%	13.20	N/A
A32003	WALLACE 1	7.0	90%	9%	1%	7.62	13
A49001	FARMDALE 1	14.0	87%	13%	0%	7.62	12
A49002	FARMDALE 1	12.9	90%	10%	0%	7.62	3
A49003	FARMDALE 1	32.2	98%	2%	0%	7.62	11
A50001	FLINT 1	19.9	85%	15%	0%	7.20	20
A50002	FLINT 1	14.8	40%	58%	2%	12.00	N/A
A73002	WHEELER 1	57.7	83%	17%	0%	7.62	1
A85001	SAND PRAIRIE 1	101.6	79%	21%	0%	7.62	25
A91001	ALLEN 1	37.1	95%	5%	0%	7.62	2
A91002	ALLEN 1	48.4	90%	9%	0%	7.62	1
B08002	JUNCTION 1	3.8	81%	18%	1%	7.62	11
B08003	JUNCTION 2	8.8	87%	13%	0%	13.20	N/A
B08004	JUNCTION 2	8.4	81%	19%	0%	7.62	5
B62001	METAMORA 1	79.1	88%	11%	0%	7.62	10
B62002	METAMORA 2	29.2	95%	5%	0%	7.62	3
B62004	METAMORA 1	42.7	91%	9%	1%	7.62	9
B84001	BUSH 2	4.2	33%	65%	1%	12.00	N/A
B84002	BUSH 2	32.6	95%	5%	0%	7.20	23
B84003	BUSH 1	11.1	89%	11%	0%	12.00	N/A
B84004	BUSH 1	3.8	72%	27%	1%	7.20	5
B84005	BUSH 1	19.0	89%	11%	0%	12.00	N/A
B84006	BUSH 1	20.2	88%	12%	0%	7.20	5
C10002	ATLANTA 1	34.7	82%	18%	0%	7.20	6
C15002	RIVERTON 1	33.3	94%	6%	0%	12.00	N/A

Circuit	Substation	Line Length (Miles)	% Res.	% Com.	% Large C&I	Voltage Level	Low-Income Customers
C50001	HEYWORTH 1	56.6	91%	8%	0%	7.20	5
C50002	HEYWORTH 1	6.9	84%	16%	0%	12.00	1
C50003	HEYWORTH 1	37.9	74%	26%	0%	12.00	1
C65001	WILLIAMSVILLE 1	33.6	88%	12%	0%	7.20	2
D35002	HENRY 1	23.0	87%	13%	0%	7.20	10
D41001	ALTA 1	32.9	99%	1%	0%	7.62	2
D41002	ALTA 1	23.1	93%	7%	0%	7.62	2
D41003	ALTA 1	53.0	95%	5%	0%	13.20	N/A
D41004	ALTA 1	2.7	59%	41%	0%	13.20	N/A
D69001	RADNOR 1	14.3	50%	47%	3%	7.62	2
D69002	RADNOR 1	12.2	77%	23%	0%	13.20	N/A
D69003	RADNOR 1	12.8	98%	2%	0%	7.62	3
D69004	RADNOR 1	18.2	91%	8%	0%	7.62	4
D69005	RADNOR 1	15.8	89%	10%	0%	7.62	6
D69006	RADNOR 2	67.9	84%	15%	1%	7.62	4
D69007	RADNOR 2	6.2	81%	19%	0%	13.20	1
D69008	RADNOR 2	38.4	97%	3%	0%	7.62	40
D69009	RADNOR 2	32.7	87%	13%	0%	13.20	N/A
F03003	ROCHESTER OAK ST 1	87.3	89%	11%	1%	7.20	3
F03004	ROCHESTER OAK ST 2	20.9	93%	7%	0%	7.20	2
H01190	WEST ILLIOPOLIS 2	67.1	83%	17%	0%	12.00	6
H01192	WEST ILLIOPOLIS 1	43.5	84%	16%	0%	12.00	N/A
H01194	WEST ILLIOPOLIS 1	45.9	88%	12%	0%	7.20	9
HE3303	SHILOH TAMARACK 1	11.5	96%	4%	0%	7.20	3
HE3304	SHILOH TAMARACK 1	7.4	94%	5%	0%	7.20	4
HE3305	SHILOH TAMARACK 1	5.8	0%	100%	0%	12.00	N/A
J05138	ALEDO 2	15.8	92%	8%	0%	12.00	4
J05139	ALEDO 3	17.9	60%	35%	5%	7.20	1
J07135	ALPHA 1	131.8	81%	19%	1%	7.20	2
J12166	ARGENTA 1	42.0	92%	7%	0%	7.20	3
J13108	ARPEE JUNCTION 1	65.2	83%	16%	0%	7.20	17
J18267	AVISTON 1	45.5	89%	11%	0%	7.20	10
J18268	AVISTON 1	52.3	90%	10%	0%	7.20	3
J47175	BLOOMINGTON EMPIRE ST 2	3.1	85%	15%	0%	12.00	4
J47176	BLOOMINGTON EMPIRE ST 2	8.0	93%	6%	0%	7.20	2
J47178	BLOOMINGTON EMPIRE ST 1	13.8	86%	14%	0%	7.20	24
J47179	BLOOMINGTON EMPIRE ST 1	2.7	0%	100%	0%	12.00	N/A
J68401	BLOOMINGTON WASHINGTON ST 1	10.6	77%	22%	1%	7.20	8
J68402	BLOOMINGTON WASHINGTON ST 1	12.6	53%	44%	3%	7.20	2
J82116	BELLEVILLE 17TH ST 3	3.5	89%	11%	0%	4.00	5
J83137	BELLEVILLE 44TH ST 1	10.0	93%	7%	0%	12.00	12
J83139	BELLEVILLE 44TH ST 1	4.8	81%	19%	0%	12.00	13

Circuit	Substation	Line Length (Miles)	% Res.	% Com.	% Large C&I	Voltage Level	Low-Income Customers
J86108	BELLEVILLE 88TH ST 1	13.0	96%	4%	0%	7.20	12
J86118	BELLEVILLE 88TH ST 1	9.3	90%	10%	0%	12.00	12
K36151	CLINTON MONROE ST 2	32.6	83%	16%	1%	7.20	6
K36252	CLINTON MONROE ST 1	0.7	61%	39%	0%	4.00	1
K57211	COLUMBIA 2	23.3	94%	6%	0%	7.20	1
K57212	COLUMBIA 2	14.0	83%	16%	0%	7.20	6
K58210	COLUMBIA PALMER CREEK 1	23.8	85%	14%	1%	7.20	2
K58213	COLUMBIA PALMER CREEK 1	40.0	90%	10%	0%	12.00	N/A
K71810	CHAMPAIGN KIRBY AVE 1	10.0	99%	1%	0%	7.20	3
K71811	CHAMPAIGN KIRBY AVE 1	11.0	97%	3%	0%	7.20	15
K71812	CHAMPAIGN KIRBY AVE 1	35.6	94%	6%	0%	7.20	19
K71822	CHAMPAIGN KIRBY AVE 2	10.7	99%	1%	0%	7.20	17
K78351	CHAMPAIGN SOUTHWEST CAMPUS 2	5.3	2%	98%	0%	12.00	N/A
K78352	CHAMPAIGN SOUTHWEST CAMPUS 2	9.4	89%	11%	0%	7.20	4
K82202	DANVERS 1	39.9	88%	11%	0%	7.20	7
L08225	DECATUR LEAFLAND AVE 1	7.5	91%	9%	0%	4.00	16
L11241	DECATUR MICHIGAN AVE 1	4.9	91%	8%	0%	4.16	6
L11244	DECATUR MICHIGAN AVE 2	5.3	96%	4%	0%	4.00	13
L14231	DECATUR NORTH 21ST ST 1	7.2	59%	40%	1%	4.16	1
L50217	DUPO 1	7.5	87%	13%	0%	7.20	2
L71170	DANVILLE EASTGATE 1	6.6	0%	96%	4%	12.00	N/A
L73154	DANVILLE FRANKLIN ST 1	4.3	76%	24%	0%	4.00	10
L73155	DANVILLE FRANKLIN ST 2	3.5	64%	36%	0%	4.00	9
L73156	DANVILLE FRANKLIN ST 1	2.1	82%	18%	0%	4.00	8
L73184	DANVILLE FRANKLIN ST 2	3.2	63%	37%	0%	4.00	1
L73185	DANVILLE FRANKLIN ST 3	3.6	66%	34%	0%	12.00	5
M05360	EDWARDSVILLE SECOND STREET 2	46.4	93%	7%	0%	7.20	10
M05361	EDWARDSVILLE SECOND STREET 2	19.8	92%	8%	0%	7.20	6
M05362	EDWARDSVILLE SECOND STREET 3	8.3	73%	26%	1%	7.20	4
M54314	GRANITE CITY 22ND STREET 1	5.9	93%	7%	0%	4.00	20
M54316	GRANITE CITY 22ND STREET 2	4.4	94%	6%	0%	4.00	22
M54317	GRANITE CITY 22ND STREET 2	2.5	89%	11%	0%	4.00	6
M73329	GRANITE CITY KATE STREET 1	3.1	95%	5%	0%	4.00	8
M73330	GRANITE CITY KATE STREET 1	3.1	97%	3%	0%	4.00	17
N14879	GREENVILLE ROUTE 40 1	13.1	73%	26%	2%	7.20	3
N14880	GREENVILLE ROUTE 40 1	16.2	74%	26%	0%	12.00	9
N73121	LAKEVIEW-DANVILLE 1	6.1	93%	7%	0%	4.00	16
P53341	MONTICELLO ROUTE 105 1	28.5	89%	11%	0%	7.20	4
P77235	NEW ATHENS 1	13.1	92%	8%	0%	7.20	4
P77237	NEW ATHENS 2	41.4	82%	18%	0%	12.00	N/A
Q10702	NORTH GRANITE CITY 1	11.6	38%	54%	7%	7.20	1

Circuit	Substation	Line Length (Miles)	% Res.	% Com.	% Large C&I	Voltage Level	Low-Income Customers
Q18243	O FALLON 1	4.8	76%	23%	0%	7.20	1
Q18244	O FALLON 2	8.8	90%	10%	0%	7.20	2
Q18245	O FALLON 1	12.4	92%	7%	0%	7.20	6
Q21292	O FALLON PORTER ROAD 4	7.9	71%	27%	1%	7.20	4
Q21293	O FALLON PORTER ROAD 4	27.1	96%	4%	0%	12.00	N/A
Q21294	O FALLON PORTER ROAD 3	16.6	79%	21%	0%	12.00	N/A
Q21321	O FALLON PORTER ROAD 3	24.3	89%	11%	0%	7.20	8
Q21322	O FALLON PORTER ROAD 4	7.7	86%	13%	1%	7.20	1
Q21423	O FALLON PORTER ROAD 3	27.7	90%	10%	0%	7.20	3
Q24310	OFALLON TROY ROAD 1	23.6	99%	1%	0%	12.00	N/A
Q24311	OFALLON TROY ROAD 1	31.3	97%	3%	0%	12.00	N/A
Q24312	OFALLON TROY ROAD 2	31.4	98%	2%	0%	7.20	1
Q67948	PINCKNEYVILLE ROUTE 154 1	37.8	90%	9%	0%	7.20	3
R01152	SOUTH BLOOMINGTON 4	17.7	90%	10%	1%	7.20	11
R10941	SPARTA 2	3.7	88%	12%	0%	12.00	N/A
R10943	SPARTA 1	21.0	90%	10%	0%	7.20	10
R50910	TROY GROVE 1	78.7	86%	13%	1%	7.20	3
R58921	URBANA FIVE POINTS 2	5.3	80%	20%	0%	4.16	7
R66472	URBANA WASHINGTON ST 1	8.2	96%	4%	0%	12.00	45
R71286	VALMEYER RT. 156 1	52.0	94%	5%	0%	7.20	2
R93350	WANDA 2	29.6	82%	16%	2%	7.20	10
R93351	WANDA 2	22.0	92%	8%	0%	7.20	4
R95520	WEDRON 1	94.8	89%	11%	0%	7.20	5
S01511	ANNA 2	6.7	92%	7%	1%	7.20	5
S01521	ANNA 2	11.4	75%	25%	0%	12.00	5
S01558	ANNA 1	2.0	76%	24%	0%	4.00	2
S13548	CARBONDALE,ILL ST 1	1.5	90%	8%	2%	4.16	3
S13550	CARBONDALE,ILL ST 1	1.3	30%	69%	1%	4.00	N/A
S20554	CARRIER MILLS 1	12.8	83%	17%	0%	12.00	12
S47537	HERRIN 1	10.5	98%	2%	0%	7.20	7
S47575	HERRIN 3	12.0	87%	12%	1%	7.20	10
S47576	HERRIN 1	29.8	88%	12%	0%	7.20	8
S47586	HERRIN 2	2.1	68%	32%	1%	4.16	1
U07001	AUBURN	4.5	84%	16%	0%	4.00	3
U07002	AUBURN	4.4	87%	13%	0%	4.00	3
U09540	AUBURN,W 2	5.3	29%	71%	0%	12.00	N/A
U09557	AUBURN,W 3	14.8	90%	10%	0%	7.20	3
U09569	AUBURN,W 3	10.9	96%	4%	0%	12.00	2
U57560	GIRARD 1	9.6	87%	12%	1%	7.20	13
U57561	GIRARD 1	9.9	89%	11%	0%	12.00	11
U60518	GRAFTON JCT 1	35.2	78%	21%	1%	7.20	5
U64518	GRIGGSVILLE, N 1	10.5	83%	17%	0%	12.00	1

Circuit	Substation	Line Length (Miles)	% Res.	% Com.	% Large C&I	Voltage Level	Low-Income Customers
U64521	GRIGGSVILLE, N 1	26.4	81%	18%	1%	7.20	13
U80003	JERSEYVILLE 3	3.1	79%	21%	0%	4.00	9
U80564	JERSEYVILLE 2	21.7	65%	35%	1%	7.20	20
V04537	MEREDOSIA-SWITCHYARD 1	2.5	0%	64%	36%	12.00	N/A
V21500	PETERSBURG 1	32.3	92%	8%	0%	7.20	10
V21548	PETERSBURG 1	38.0	81%	19%	0%	12.00	1
V38001	QUINCY,21&BDWY 1	1.9	93%	6%	0%	4.00	1
V38003	QUINCY,21&BDWY 1	1.5	85%	15%	0%	4.00	3
V40549	QUINCY,24&CHERRY 1	11.8	95%	5%	0%	12.00	1
V41527	QUINCY,28&ADAMS 1	7.3	97%	3%	0%	12.00	11
V43543	QUINCY,30&TURNER 1	1.5	0%	91%	9%	12.00	N/A
V43565	QUINCY,30&TURNER 1	1.2	17%	67%	17%	12.00	N/A
V47001	QUINCY,BLESS HOSP 1	1.9	75%	23%	2%	4.16	1
V55524	QUINCY,SOYBEAN 1	4.5	50%	50%	0%	12.00	N/A
V89523	MT. STERLING,SOUTH 1	0.9	67%	33%	0%	12.00	N/A
V92542	HAMILTON 12KV 2	32.4	87%	12%	0%	7.20	10
V92543	HAMILTON 12KV 1	14.0	89%	10%	0%	7.20	6
V92555	HAMILTON 12KV 1	12.3	89%	11%	0%	7.20	9
X19561	BISMARCK 1	51.0	89%	11%	0%	7.20	8
X35500	CHARLESTON,S (EIU) 1	2.5	89%	11%	0%	12.00	2
X35564	CHARLESTON,S (EIU) 1	2.3	94%	6%	0%	12.00	1
X64002	FAIRBURY 2	2.1	75%	25%	0%	4.00	3
X64003	FAIRBURY 2	4.0	82%	18%	0%	4.00	3
X64503	FAIRBURY 1	11.1	84%	16%	0%	7.20	3
X66581	FARINA 1	5.7	76%	24%	0%	12.00	3
X82576	HOOPESTON 2	12.5	87%	13%	0%	12.00	11
X82585	HOOPESTON 2	6.2	96%	4%	0%	12.00	4
X83533	HOOPESTON,S 1	14.7	91%	9%	0%	12.00	6
X96001	LAWRENCEVILLE,S 4	3.2	85%	15%	0%	4.00	8
X96002	LAWRENCEVILLE,S 4	1.9	86%	14%	0%	4.00	3
X96523	LAWRENCEVILLE,S 3	11.2	91%	9%	0%	12.00	24
Y11555	MATTOON,NW 1	13.2	90%	10%	0%	12.00	19
Y11557	MATTOON,NW 2	1.3	33%	0%	67%	12.00	N/A
Y31589	NOBLE 1	17.6	80%	20%	0%	7.20	14
Y31591	NOBLE 1	13.5	71%	28%	1%	12.00	N/A
Y32571	NOKOMIS 1	6.9	93%	7%	0%	12.00	9
Y32572	NOKOMIS 1	5.9	72%	28%	0%	12.00	3
Y36541	OLNEY,N 3	28.9	84%	15%	0%	7.20	17
Y54001	PARIS,W 2	2.0	85%	15%	0%	4.00	3
Y54560	PARIS,W 1	17.0	55%	43%	1%	12.00	N/A
Y54587	PARIS,W 1	8.3	86%	13%	1%	7.20	10
Y54591	PARIS,W 1	8.4	92%	8%	0%	12.00	17

Circuit	Substation	Line Length (Miles)	% Res.	% Com.	% Large C&I	Voltage Level	Low-Income Customers
Y66556	ROBINSON,W 1	7.5	78%	21%	0%	7.20	6
Y69553	ST ELMO 1	10.4	78%	22%	0%	12.00	5
Y69565	ST ELMO 1	8.1	83%	17%	0%	12.00	5
Y86593	STOY 1	11.3	79%	19%	2%	7.20	1
Y86595	STOY 1	17.0	83%	17%	0%	7.20	4
Y98518	TUSCOLA,E 2	13.3	45%	53%	2%	7.20	1
Y98561	TUSCOLA,E 2	11.5	93%	6%	0%	7.20	3
Z06538	WATSEKA,E 2	7.9	79%	20%	2%	7.20	4
Z08509	WENONAH 1	34.2	85%	15%	0%	7.20	13
Z11536	WINDSOR 1	18.0	87%	13%	0%	7.20	11
Z19532	ROBINSON COR CTR 1	1.9	45%	55%	0%	12.00	N/A
Z33511	ASSUMPTION,EAST 1	0.2	0%	0%	100%	12.00	N/A
Z51556	LAWRENCEVILLE, EAST 1	0.8	0%	0%	100%	12.00	N/A

Note: N/A indicates that low-income data were not available.

APPENDIX B. DETAILED IMPACT ANALYSIS METHODOLOGY

DATA INGESTION AND REVIEW

Opinion Dynamics used the following data to perform the energy and peak demand savings evaluation: (1) advanced metering infrastructure (AMI) data extracts; (2) VO status and operations logs; (3) circuit characteristics; and (4) hourly weather data.

- **AMI data extracts.** AIC provided Opinion Dynamics with AMI data containing hourly demand (kWh), instantaneous voltage, and average instantaneous voltage at four different base voltages. AMI data are preferred for all evaluations in Illinois, and consumption is measured at the customer meter rather than the circuit level. Because there may be over 1,000 AMI meters on a given circuit, AIC provided average normalized voltage and kWh data. For a given circuit, the AMI data reflects normalized voltage based on the voltage class (e.g., 120V, 240V, 480V) where each AMI meter was located on the circuit.
- **System operations log.** This log contains the VO "On" and "Off" schedules, as well as information on critical system operation events that could cause data anomalies, such as outages. AIC provided this log with a summary tab containing VO status events (VO "On" and VO "Off"), timestamps for the events, and notes on the cause of the event. Within the system operations log, the evaluation team flagged certain time frames as excludable, adhering to guidance in the IL-TRM V12.0.
- **Circuit characteristics.** AIC provided Opinion Dynamics with a number of datasets with descriptive circuit characteristic information, including data presented in Appendix A, as well as baseline usage information.
- **Hourly weather data.** The evaluation team sourced weather data from the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information, which were mapped to circuits using GPS coordinates. We then calculated the cooling and heating degree hours, using base temperatures of 75ºF and 65ºF, respectively, to generate the weather parameters used in modeling.

ENERGY SAVINGS

DATA CLEANING

To support the 2024 impact evaluation, we cleaned the provided data to meet analytical needs. 2024 VO data were provided by AIC incrementally throughout the year to support interim impact analyses. As such, we incrementally aggregated the VO data provided before we took further data-cleaning steps. During this aggregation, we took two steps to prepare data:

- **Remove perfectly duplicated observations:** Observations with perfectly duplicated values across all variables (e.g., perfect overlaps between data files) were flagged and removed from the analysis.
- **Aggregate remaining duplicate observations:** After removing perfect duplicates, a small number of observations remained with duplicate timestamps by circuit but different voltage data. In this case, we averaged observations to arrive at a dataset with a unique set of timestamps by circuit. This affected 0.02% of records.

Once the data were aggregated, we conducted the following data-cleaning steps prior to modeling:

- **Remove time periods without weather data:** As previously noted, we downloaded weather data from NOAA. We used circuit longitude and latitude to find the weather station closest to each circuit's location. We removed the corresponding time periods from the analysis for instances where weather data for a particular weather station was not recorded.

- **Remove negative and zero values:** Negative and zero values in kV and MW data were flagged and removed from use in the analysis.
- **Examine outliers:** Outliers were screened on a circuit-by-circuit basis. Exploration of the outliers showed that all outliers were within a reasonable range to be included in the analysis.
- **Flag excludable time periods:** In some circumstances, it is best practice or required to disable VO to support system changes, growth, outages, and maintenance, both planned and unplanned. AIC has indicated that a subset of VO events should be excluded in this analysis. In 2020, Opinion Dynamics, ICC Staff, and stakeholders agreed on specific VO events that could be considered excludable and memorialized them in a memo.[21] VO events that were approved for exclusion were those for which (1) there was a circuit outage for any reason; (2) the circuit was under repair or maintenance, causing VO to be disabled; (3) VO was disabled due to any necessary switching event; (4) the circuit had experienced a failure in information or communication technology; and (5) any event was flagged for the worldwide pandemic or outages ordered by civil authorities. This information has now been memorialized in IL-TRM V12.0.
- **Remove "On" events in pre-period:** To construct a pre-period, "On" events were flagged and removed from the 2023 dataset.

Table 9 provides a summary of the second stage of data cleaning for this analysis. Results include all 214 circuits within the analysis. The primary driver for removing observations were occurrences when VO was turned "Off" for an excludable event (1.4% of total observations), followed by time periods without weather data (1.3% of total observations). Overall, after data cleaning activity, 2.7% of observations were dropped. It should be noted that no circuits were removed from the energy savings analysis due to data insufficiency.

Table 9. Summary of Data Cleaning Results for 2024 VO Energy Savings Impacts

Cleaning Steps	Circuits	Remaining Observations	# Dropped Observations	% Remaining
Initial Count	214	3,722,688	N/A	100.0%
Aggregate Duplicates	214	3,722,088	600	100.0%
Time Periods Without Weather Data	214	3,674,369	47,719	98.7%
kV Less Than or Equal to 0	214	3,674,369	0	98.7%
On in Pre-Period	214	3,674,369	0	98.7%
Excludable Time Periods	214	3,620,717	53,652	97.3%
Final	**214**	**3,620,717**	**101,971**	**97.3%**

MODELING PERCENT CHANGE IN VOLTAGE FOR DEMAND SAVINGS

The evaluation team removed VO "On" periods in 2023 to develop a pre-period baseline for this evaluation. As a result, the baseline includes VO "Off" periods only. The post-period of interest is 2024 when all circuits are active. The post-period consists of largely "On" periods and non-excludable "Off" periods. The evaluation team used this structure to fit individual models on each circuit.

[21] Ameren Illinois Company Voltage Optimization Verification and Exclusion Approach Memo, accessed at: https://www.ilsag.info/wp-content/uploads/AIC-2019-Voltage-Optimization-Operation-Verification-Memo-FINAL-2020-04-17.pdf

To estimate changes in voltage, we used a regression model described in Equation 3.

Equation 3. Voltage Reduction Model

$$kV_{it} = a_i + \beta_{1i}Post_{it} + \beta_{2i}CDH_{it} + \beta_{3i}HDH_{it} + \beta_{4i}Weekend_t + \beta_{5i}Post_{it} * CDH_{it} + \beta_{6i}Post_{it} * HDH_{it} + \beta_{7i}Post_{it} * Weekend_t + \varepsilon_{it}$$

Where:

- kV_{it} = Kilovolts for circuit *i* at time *t*
- a_i = Model intercept of circuit *i*
- β_x = Regression coefficients for circuit i
- $Post_{it}$= Indicator variable for circuit *i* at time *t* for the time relative to VO deployment where the circuit is in the post-period ($Post_{it}$ = 1) or in the pre-period ($Post_{it}$ = 0)
- CDH_{it}= The number of cooling degree-hours at time *t* corresponding to circuit *i*
- HDH_{it} = The number of heating degree-hours at time *t* corresponding to circuit *i*
- $Weekend_t$ = Indicator variable for weekend ($Weekend_t$= 1) or weekday ($Weekend_t$ = 0)
- ε_{it} = Error term

CALCULATING ANNUAL ENERGY SAVINGS

The IL-TRM V12.0 prescribes an algorithmic approach to evaluating VO energy savings. The algorithmic approach combines deemed parameter values with measured savings in voltage to calculate energy savings using Equation 4. Since we apply the estimated change in voltage to the circuit-level annual usage, the results are effectively annualized for the entire year.

Equation 4. AIC VO Energy Savings Algorithm

$$Annual\ Energy\ Savings_i = Annual\ Energy\ Use_{2014-2016,i} * CVR_f * \%\ \Delta V_i$$

Where:

- $Annual\ Energy\ Use_{2014-2016,i}$= the average annual customer energy use for circuit *i* over the 2014–2016 timeframe, excluding exempt customers;
- CVR_f= conservation voltage reduction factor, defined as the percent change in energy usage divided by the percent change in voltage (deemed at 0.80 by the IL-TRM V12.0); and,
- $\%\ \Delta V_i$= the percent change in voltage for circuit *i* resulting from VO implementation relative to the pre-period, estimated using a regression model to control for exogenous factors that may contribute to changes in voltage (e.g., weather).

DETAILED CIRCUIT RESULTS: ANNUAL ENERGY SAVINGS

Table 10 provides each algorithmic input by circuit as well as the total estimated savings per circuit that can be attributed to the VO Program. For 154 of the 214 circuits, the percent change in voltage was estimated to be larger than the planned value of 3.2%. The overall average percent change in voltage was 3.49%.

Table 10. Verified Algorithmic Inputs and Associated Energy Savings by Circuit

Circuit	Annual Gross Energy Use 2014–2016 (MWh)	CVRf	Average Percent Change in Voltage	Annual Gross Energy Savings (MWh)
301051	6,524	0.80	2.78%	145
301052	10,288	0.80	2.79%	230
301053	40,449	0.80	2.83%	916
326168	15,909	0.80	0.63%	80
326169	7,131	0.80	1.50%	86
326170	17,542	0.80	1.85%	259
350103	11,186	0.80	1.21%	109
350104	10,270	0.80	1.36%	112
A32001	8,814	0.80	2.64%	186
A32002	24,750	0.80	2.64%	523
A32003	10,900	0.80	2.92%	255
A49001	19,555	0.80	3.43%	536
A49002	10,439	0.80	2.97%	248
A49003	21,234	0.80	4.58%	778
A50001	22,706	0.80	0.80%	146
A50002	22,219	0.80	1.29%	230
A73002	21,448	0.80	3.62%	621
A85001	22,391	0.80	2.51%	449
A91001	19,005	0.80	4.58%	696
A91002	17,826	0.80	4.18%	597
B08002	24,983	0.80	4.25%	849
B08003	6,988	0.80	4.52%	253
B08004	12,639	0.80	3.95%	400
B62001	30,333	0.80	3.71%	900
B62002	12,516	0.80	3.22%	322
B62004	16,252	0.80	4.52%	587
B84001	12,032	0.80	3.70%	356
B84002	24,967	0.80	2.60%	519
B84003	9,416	0.80	3.52%	265
B84004	33,263	0.80	1.73%	459
B84005	17,974	0.80	1.96%	281
B84006	14,822	0.80	0.90%	106
C10002	10,611	0.80	2.39%	203
C15002	11,493	0.80	3.62%	333
C50001	18,729	0.80	3.22%	482

Circuit	Annual Gross Energy Use 2014–2016 (MWh)	CVRf	Average Percent Change in Voltage	Annual Gross Energy Savings (MWh)
C50002	6,468	0.80	4.08%	211
C50003	4,392	0.80	3.39%	119
C65001	13,562	0.80	0.08%	9
D35002	14,186	0.80	3.01%	341
D41001	16,864	0.80	4.79%	646
D41002	15,380	0.80	3.92%	483
D41003	8,119	0.80	4.03%	262
D41004	6,351	0.80	3.51%	178
D69001	33,222	0.80	2.74%	729
D69002	28,640	0.80	2.38%	545
D69003	11,328	0.80	3.10%	281
D69004	25,025	0.80	3.30%	660
D69005	20,494	0.80	3.31%	543
D69006	26,408	0.80	1.70%	359
D69007	3,919	0.80	1.68%	53
D69008	24,298	0.80	1.43%	278
D69009	24,582	0.80	1.60%	316
F03003	29,761	0.80	3.44%	819
F03004	9,983	0.80	1.88%	151
H01190	12,901	0.80	3.86%	398
H01192	6,089	0.80	0.55%	27
H01194	13,824	0.80	4.54%	502
HE3303	9,081	0.80	3.72%	270
HE3304	9,415	0.80	5.20%	392
HE3305	4,907	0.80	2.09%	82
J05138	7,044	0.80	4.06%	229
J05139	18,120	0.80	3.08%	446
J07135	21,766	0.80	3.15%	548
J12166	15,246	0.80	4.44%	541
J13108	13,871	0.80	3.77%	419
J18267	19,546	0.80	3.85%	602
J18268	17,978	0.80	3.05%	438
J47175	6,945	0.80	1.75%	97
J47176	10,022	0.80	4.57%	366
J47178	26,152	0.80	2.83%	592
J47179	14,910	0.80	4.88%	582
J68401	30,377	0.80	2.72%	660
J68402	12,838	0.80	4.41%	453
J82116	5,029	0.80	5.12%	206
J83137	9,892	0.80	4.23%	335
J83139	9,797	0.80	4.78%	374
J86108	12,076	0.80	4.55%	439
J86118	9,415	0.80	4.28%	322

Circuit	Annual Gross Energy Use 2014–2016 (MWh)	CVRf	Average Percent Change in Voltage	Annual Gross Energy Savings (MWh)
K36151	22,531	0.80	2.76%	497
K36252	2,828	0.80	4.10%	93
K57211	18,741	0.80	4.99%	748
K57212	17,856	0.80	4.52%	646
K58210	27,937	0.80	4.25%	950
K58213	13,577	0.80	4.37%	475
K71810	7,094	0.80	4.95%	281
K71811	13,084	0.80	4.88%	510
K71812	31,077	0.80	4.60%	1,144
K71822	9,937	0.80	5.05%	401
K78351	26,787	0.80	3.94%	844
K78352	16,292	0.80	4.72%	615
K82202	13,814	0.80	1.79%	198
L08225	6,896	0.80	3.92%	216
L11241	19,617	0.80	4.77%	749
L11244	6,239	0.80	4.45%	222
L14231	15,694	0.80	3.24%	407
L50217	9,942	0.80	4.02%	319
L71170	16,642	0.80	3.48%	463
L73154	7,159	0.80	3.66%	209
L73155	6,196	0.80	4.22%	209
L73156	6,262	0.80	4.72%	236
L73184	2,832	0.80	4.38%	99
L73185	7,384	0.80	3.15%	186
M05360	19,413	0.80	4.15%	645
M05361	17,765	0.80	4.17%	592
M05362	23,619	0.80	3.45%	652
M54314	5,667	0.80	4.71%	213
M54316	4,864	0.80	4.33%	169
M54317	6,717	0.80	4.11%	221
M73329	6,755	0.80	4.13%	223
M73330	5,656	0.80	4.56%	206
N14879	11,928	0.80	4.50%	430
N14880	8,793	0.80	3.69%	260
N73121	5,847	0.80	3.52%	165
P53341	13,860	0.80	2.89%	320
P77235	10,242	0.80	4.27%	349
P77237	8,448	0.80	4.66%	315
Q10702	23,931	0.80	4.57%	875
Q18243	10,522	0.80	3.27%	276
Q18244	15,060	0.80	4.77%	574
Q18245	15,395	0.80	4.73%	582
Q21292	24,022	0.80	4.44%	852

Circuit	Annual Gross Energy Use 2014–2016 (MWh)	CVRf	Average Percent Change in Voltage	Annual Gross Energy Savings (MWh)
Q21293	16,032	0.80	4.77%	612
Q21294	25,478	0.80	4.44%	905
Q21321	17,868	0.80	4.33%	619
Q21322	18,234	0.80	2.69%	392
Q21423	18,684	0.80	4.70%	703
Q24310	13,225	0.80	5.27%	558
Q24311	12,660	0.80	5.12%	518
Q24312	12,890	0.80	4.95%	510
Q67948	13,951	0.80	4.81%	537
R01152	13,960	0.80	3.99%	446
R10941	2,323	0.80	4.50%	84
R10943	9,361	0.80	4.25%	318
R50910	19,573	0.80	3.28%	513
R58921	8,414	0.80	3.47%	234
R66472	9,054	0.80	4.84%	351
R71286	11,014	0.80	4.44%	391
R93350	21,677	0.80	4.02%	697
R93351	12,498	0.80	4.82%	482
R95520	11,357	0.80	3.23%	293
S01511	8,797	0.80	4.21%	297
S01521	4,495	0.80	3.76%	135
S01558	2,844	0.80	5.01%	114
S13548	12,453	0.80	3.03%	302
S13550	5,433	0.80	5.41%	235
S20554	8,353	0.80	3.66%	244
S47537	9,425	0.80	4.09%	309
S47575	14,792	0.80	3.97%	470
S47576	12,520	0.80	2.11%	211
S47586	10,189	0.80	4.45%	363
U07001	4,766	0.80	4.34%	165
U07002	5,734	0.80	3.94%	181
U09540	11,399	0.80	4.86%	443
U09557	14,636	0.80	4.05%	474
U09569	6,006	0.80	4.23%	203
U57560	11,868	0.80	3.56%	338
U57561	6,954	0.80	3.86%	215
U60518	14,373	0.80	2.74%	314
U64518	3,474	0.80	4.57%	127
U64521	13,453	0.80	4.97%	535
U80003	5,355	0.80	3.73%	160
U80564	17,379	0.80	4.27%	594
V04537	11,219	0.80	3.27%	293
V21500	13,028	0.80	3.51%	366

Circuit	Annual Gross Energy Use 2014–2016 (MWh)	CVRf	Average Percent Change in Voltage	Annual Gross Energy Savings (MWh)
V21548	5,345	0.80	5.02%	215
V38001	5,757	0.80	4.95%	228
V38003	2,923	0.80	4.36%	102
V40549	6,884	0.80	3.08%	170
V41527	8,250	0.80	4.58%	302
V43543	8,273	0.80	1.75%	116
V43565	20,282	0.80	0.71%	116
V47001	11,914	0.80	4.31%	411
V55524	7,107	0.80	4.06%	231
V89523	8,363	0.80	3.52%	235
V92542	11,735	0.80	2.78%	261
V92543	13,921	0.80	3.56%	397
V92555	13,484	0.80	3.23%	348
X19561	15,584	0.80	3.26%	407
X35500	3,703	0.80	4.10%	121
X35564	5,356	0.80	3.97%	170
X64002	3,105	0.80	3.57%	89
X64003	4,717	0.80	4.81%	181
X64503	9,684	0.80	3.89%	301
X66581	5,725	0.80	4.60%	211
X82576	5,829	0.80	3.99%	186
X82585	6,329	0.80	4.02%	204
X83533	8,587	0.80	4.82%	331
X96001	5,755	0.80	3.37%	155
X96002	3,270	0.80	4.58%	120
X96523	6,577	0.80	3.20%	168
Y11555	9,467	0.80	3.67%	278
Y11557	18,784	0.80	3.36%	505
Y31589	11,243	0.80	1.31%	118
Y31591	3,343	0.80	3.93%	105
Y32571	5,285	0.80	2.74%	116
Y32572	4,460	0.80	2.74%	98
Y36541	12,020	0.80	4.46%	429
Y54001	2,936	0.80	3.82%	90
Y54560	17,735	0.80	4.29%	608
Y54587	18,145	0.80	3.74%	543
Y54591	6,460	0.80	3.38%	175
Y66556	9,559	0.80	3.69%	282
Y69553	4,761	0.80	3.93%	150
Y69565	6,048	0.80	2.99%	145
Y86593	12,977	0.80	2.26%	235
Y86595	13,957	0.80	1.58%	176
Y98518	13,718	0.80	4.38%	480

Circuit	Annual Gross Energy Use 2014–2016 (MWh)	CVRf	Average Percent Change in Voltage	Annual Gross Energy Savings (MWh)
Y98561	9,047	0.80	4.13%	299
Z06538	13,455	0.80	3.56%	383
Z08509	12,565	0.80	2.07%	208
Z11536	8,829	0.80	2.44%	172
Z19532	10,476	0.80	3.86%	323
Z33511	18,053	0.80	2.88%	415
Z51556	11,684	0.80	3.77%	352

PEAK DEMAND ENERGY SAVINGS

DATA CLEANING

Data cleaning for the peak demand analysis included all steps undertaken for the energy savings model, plus the following additional cleaning steps:

- **Peak Period Data Only:** The VO peak demand model includes only observations during the peak period, defined as the hours of 1:00 p.m.–5:00 p.m. on non-holiday weekdays between June and August.
- **Less than 20 Days in Peak Period:** Circuits with less than 20 days in the peak period were removed from the analysis. No feeders were affected by this step.
- **Missing Peak Period:** Circuits missing the 2023 or 2024 peak period were removed from the analysis. No feeders were affected by this step.

Table 11 provides a summary of the data cleaning results for this analysis. Interim impact analysis 2 dataset, covering January through August, contains the entirety of the VO peak period as defined above. Starting with the January to August dataset, we removed all non-peak days. This step resulted in the removal of 78.5% of the data. The remainder of the data cleaning steps outlined below reduced the total number of observations by about 18 percentage points.

Table 11. Summary of Data Cleaning Results for Peak Demand Savings

Cleaning Step	Circuits	Remaining Observations	# Dropped Observations	% Remaining
Initial Count	214	3,037,680 [a]	0	N/A
Remove Non-Peak Days	214	654,589	2,383,091	21.5%
Less than 20 Days in Peak Period	214	654,589	0	21.5%
Missing Peak Period	214	654,589	0	21.5%
Peak Hours	214	109,296	545,293	3.6%
Final	**214**	**109,296**	**2,928,384**	**3.6%**

[a] Interim impact analysis 2 dataset, covering January through August, contains the entirety of the VO peak period. We start peak period demand savings analysis using the January to August dataset. As such, the initial count in this table is less than the initial count in Table 9 that starts with the full year dataset.

MODELING PERCENT CHANGE IN VOLTAGE FOR DEMAND SAVINGS

To develop a baseline, the evaluation team used the 2023 and 2024 peak period subsets of the cleaned data. The peak period is defined as 1:00 p.m.–5:00 p.m. on non-holiday weekdays from June 1 to August 31. As with the energy savings model, the demand savings model uses 2023 as the pre-period and 2024 as the post-period. To estimate changes in voltage, we used a regression model described in Equation 5.

Equation 5. Voltage Reduction Model

$$kV_{it} = \alpha_i + \beta_{1i}Post_{it} + \beta_{2i}CDH_{it} + \beta_{3i}Post_{it} * CDH_{it} + \varepsilon_{it}$$

Where:

- kV_{it} = Kilovolts for circuit *i* at time *t*
- α_i= Model intercept for circuit *i*
- β_{xi} = Regression coefficients for circuit *i*
- $Post_{it}$= Indicator variable for circuit *i* at time *t* for the time relative to VO deployment where the circuit is in the post-period ($Post_{it}$ = 1) or in the pre-period ($Post_{it}$ = 0)
- CDH_{it}= The number of cooling degree-hours at time *t* corresponding to circuit *i*
- ε_{it} = Error term

CALCULATING PEAK DEMAND ENERGY SAVINGS

VO peak demand savings are also estimated with an algorithmic approach using Equation 6.

Equation 6. AIC VO Peak Demand Savings Algorithm

$$Peak\ Demand\ Savings_i = Avg\ Peak\ Demand_{2014-2016,i} * CVR_{f,PEAK} * \%\ \Delta V_{i,PEAK}$$

Where:

- $Avg\ Peak\ Demand_{2014-2016,i}$ = the average demand in the peak hour for circuit *i* over the 2014–2016 timeframe during the peak period adjusted by a calibration factor that captures the relationship between peak demand and average demand in the peak period, excluding >10 MW customers;
- $CVR_{f,PEAK}$ = the estimate of the peak conservation voltage reduction factor, defined as the percent change in energy usage divided by the percent change in voltage during the peak period (deemed at 0.68 by the IL-TRM V12.0); and,
- $\%\ \Delta V_{i,PEAK}$= the percent change in voltage for circuit *i* resulting from VO implementation relative to the peak hours of the pre-period, using a regression model to control for exogenous factors that may contribute to changes in voltage (e.g., weather). Per the guidance in the IL-TRM, this is to be calculated in the same manner as energy savings but to measure peak demand savings rather than total energy savings.

DETAILED CIRCUIT RESULTS: PEAK DEMAND ENERGY SAVINGS

Table 12 provides each algorithmic input by circuit and the total estimated savings per circuit that can be attributed to the VO Program. The overall average percent change in voltage was 2.95%.

Table 12. Verified Algorithmic Inputs and Associated Peak Demand Savings by Circuit

Circuit	Annual Peak Demand 2014–2016 (MW)	$CVR_{f,PEAK}$	Average Percent Change in Peak Voltage	Annual Demand Savings (MW)
301051	1.61	0.68	1.05%	0.01
301052	2.52	0.68	1.00%	0.02
301053	7.23	0.68	1.08%	0.05
326168	3.76	0.68	0.62%	0.02
326169	1.80	0.68	1.12%	0.01
326170	2.85	0.68	1.32%	0.03
350103	2.85	0.68	-0.10%	0.00
350104	2.75	0.68	0.08%	0.00
A32001	2.06	0.68	1.87%	0.03
A32002	5.52	0.68	1.92%	0.07
A32003	2.40	0.68	2.92%	0.05
A49001	5.62	0.68	2.34%	0.09
A49002	2.19	0.68	2.75%	0.04
A49003	6.89	0.68	3.89%	0.18
A50001	6.27	0.68	0.11%	0.00
A50002	5.20	0.68	0.99%	0.04
A73002	5.02	0.68	2.54%	0.09
A85001	6.67	0.68	1.13%	0.05
A91001	6.78	0.68	3.73%	0.17
A91002	5.20	0.68	3.42%	0.12
B08002	4.32	0.68	3.72%	0.11
B08003	2.79	0.68	4.13%	0.08
B08004	3.60	0.68	3.02%	0.07
B62001	1.82	0.68	3.01%	0.04
B62002	3.22	0.68	2.38%	0.05
B62004	4.24	0.68	3.61%	0.10
B84001	2.68	0.68	3.21%	0.06
B84002	7.07	0.68	0.36%	0.02
B84003	1.51	0.68	2.07%	0.02
B84004	2.90	0.68	0.08%	0.00
B84005	4.48	0.68	0.38%	0.01
B84006	3.27	0.68	-0.29%	-0.01
C10002	2.54	0.68	1.19%	0.02
C15002	3.53	0.68	3.76%	0.09
C50001	5.79	0.68	1.75%	0.07
C50002	1.38	0.68	3.08%	0.03

Circuit	Annual Peak Demand 2014–2016 (MW)	$CVR_{f,PEAK}$	Average Percent Change in Peak Voltage	Annual Demand Savings (MW)
C50003	2.00	0.68	2.37%	0.03
C65001	3.67	0.68	-0.71%	-0.02
D35002	3.17	0.68	1.35%	0.03
D41001	2.08	0.68	3.99%	0.06
D41002	4.35	0.68	2.60%	0.08
D41003	2.28	0.68	2.85%	0.04
D41004	0.99	0.68	2.25%	0.02
D69001	7.73	0.68	2.05%	0.11
D69002	7.04	0.68	2.27%	0.11
D69003	3.59	0.68	2.92%	0.07
D69004	5.98	0.68	3.10%	0.13
D69005	4.78	0.68	3.09%	0.10
D69006	6.80	0.68	0.32%	0.01
D69007	1.41	0.68	0.35%	0.00
D69008	7.03	0.68	-0.51%	-0.02
D69009	6.09	0.68	-0.03%	0.00
F03003	7.84	0.68	2.97%	0.16
F03004	3.00	0.68	1.06%	0.02
H01190	4.36	0.68	3.40%	0.10
H01192	2.55	0.68	-0.03%	0.00
H01194	3.82	0.68	3.56%	0.09
HE3303	2.63	0.68	3.52%	0.06
HE3304	1.43	0.68	5.58%	0.05
HE3305	0.53	0.68	2.38%	0.01
J05138	2.28	0.68	2.92%	0.05
J05139	4.39	0.68	2.97%	0.09
J07135	5.03	0.68	3.22%	0.11
J12166	4.54	0.68	3.90%	0.12
J13108	3.27	0.68	3.48%	0.08
J18267	5.30	0.68	3.00%	0.11
J18268	4.68	0.68	2.62%	0.08
J47175	2.14	0.68	0.07%	0.00
J47176	3.01	0.68	3.34%	0.07
J47178	5.99	0.68	2.65%	0.11
J47179	2.90	0.68	5.36%	0.11
J68401	5.92	0.68	1.98%	0.08
J68402	2.30	0.68	3.78%	0.06
J82116	1.50	0.68	4.75%	0.05
J83137	3.06	0.68	3.60%	0.07
J83139	2.53	0.68	4.19%	0.07
J86108	3.85	0.68	3.90%	0.10
J86118	4.64	0.68	3.46%	0.11
K36151	4.05	0.68	1.30%	0.04

Circuit	Annual Peak Demand 2014–2016 (MW)	$CVR_{f,PEAK}$	Average Percent Change in Peak Voltage	Annual Demand Savings (MW)
K36252	1.20	0.68	3.09%	0.03
K57211	9.55	0.68	5.24%	0.34
K57212	2.98	0.68	3.85%	0.08
K58210	6.06	0.68	3.80%	0.16
K58213	3.51	0.68	4.40%	0.11
K71810	2.48	0.68	5.08%	0.09
K71811	3.71	0.68	4.71%	0.12
K71812	8.02	0.68	4.06%	0.22
K71822	3.35	0.68	4.78%	0.11
K78351	4.93	0.68	4.48%	0.15
K78352	3.67	0.68	4.56%	0.11
K82202	4.80	0.68	1.78%	0.06
L08225	1.81	0.68	2.04%	0.03
L11241	1.79	0.68	3.92%	0.05
L11244	2.15	0.68	3.99%	0.06
L14231	2.79	0.68	2.37%	0.04
L50217	2.77	0.68	3.23%	0.06
L71170	2.82	0.68	4.34%	0.08
L73154	1.58	0.68	3.40%	0.04
L73155	1.27	0.68	3.42%	0.03
L73156	1.20	0.68	3.94%	0.03
L73184	0.78	0.68	3.63%	0.02
L73185	1.80	0.68	1.75%	0.02
M05360	5.47	0.68	3.58%	0.13
M05361	4.34	0.68	3.57%	0.11
M05362	5.62	0.68	3.48%	0.13
M54314	1.49	0.68	4.43%	0.04
M54316	1.53	0.68	4.36%	0.05
M54317	1.54	0.68	3.19%	0.03
M73329	2.07	0.68	3.07%	0.04
M73330	1.77	0.68	4.07%	0.05
N14879	2.43	0.68	4.09%	0.07
N14880	2.21	0.68	3.61%	0.05
N73121	1.57	0.68	3.34%	0.04
P53341	3.65	0.68	2.55%	0.06
P77235	3.01	0.68	3.62%	0.07
P77237	2.17	0.68	4.44%	0.07
Q10702	5.05	0.68	4.67%	0.16
Q18243	2.60	0.68	3.95%	0.07
Q18244	4.91	0.68	4.22%	0.14
Q18245	4.48	0.68	4.33%	0.13
Q21292	4.88	0.68	3.46%	0.11
Q21293	4.33	0.68	5.15%	0.15

Circuit	Annual Peak Demand 2014–2016 (MW)	$CVR_{f,PEAK}$	Average Percent Change in Peak Voltage	Annual Demand Savings (MW)
Q21294	6.10	0.68	3.84%	0.16
Q21321	4.44	0.68	3.09%	0.09
Q21322	1.95	0.68	2.72%	0.04
Q21423	8.06	0.68	3.24%	0.18
Q24310	4.77	0.68	5.28%	0.17
Q24311	4.30	0.68	5.28%	0.15
Q24312	3.57	0.68	5.32%	0.13
Q67948	1.74	0.68	4.55%	0.05
R01152	3.97	0.68	2.24%	0.06
R10941	0.50	0.68	4.72%	0.02
R10943	2.34	0.68	2.92%	0.05
R50910	5.41	0.68	2.66%	0.10
R58921	1.72	0.68	4.07%	0.05
R66472	3.02	0.68	4.10%	0.08
R71286	2.82	0.68	4.35%	0.08
R93350	3.37	0.68	3.56%	0.08
R93351	3.53	0.68	4.64%	0.11
R95520	2.43	0.68	2.84%	0.05
S01511	2.02	0.68	2.95%	0.04
S01521	2.21	0.68	2.54%	0.04
S01558	0.67	0.68	4.41%	0.02
S13548	1.60	0.68	2.37%	0.03
S13550	1.07	0.68	5.12%	0.04
S20554	0.77	0.68	1.79%	0.01
S47537	3.22	0.68	4.59%	0.10
S47575	3.55	0.68	3.74%	0.09
S47576	3.37	0.68	2.10%	0.05
S47586	2.13	0.68	3.17%	0.05
U07001	1.40	0.68	3.57%	0.03
U07002	1.39	0.68	3.39%	0.03
U09540	3.03	0.68	4.37%	0.09
U09557	6.00	0.68	3.76%	0.15
U09569	2.00	0.68	3.57%	0.05
U57560	2.89	0.68	3.49%	0.07
U57561	1.81	0.68	3.15%	0.04
U60518	3.86	0.68	1.41%	0.04
U64518	0.86	0.68	4.18%	0.02
U64521	3.08	0.68	4.23%	0.09
U80003	1.83	0.68	2.62%	0.03
U80564	3.80	0.68	2.70%	0.07
V04537	1.40	0.68	3.96%	0.04
V21500	3.88	0.68	2.50%	0.07
V21548	1.39	0.68	4.83%	0.05

Circuit	Annual Peak Demand 2014–2016 (MW)	$CVR_{f,PEAK}$	Average Percent Change in Peak Voltage	Annual Demand Savings (MW)
V38001	1.47	0.68	4.33%	0.04
V38003	0.91	0.68	3.16%	0.02
V40549	2.05	0.68	2.13%	0.03
V41527	2.86	0.68	3.83%	0.07
V43543	2.33	0.68	2.13%	0.03
V43565	3.51	0.68	0.90%	0.02
V47001	2.13	0.68	4.26%	0.06
V55524	2.11	0.68	3.67%	0.05
V89523	1.53	0.68	3.64%	0.04
V92542	2.43	0.68	3.53%	0.06
V92543	2.70	0.68	3.44%	0.06
V92555	2.76	0.68	2.63%	0.05
X19561	3.22	0.68	2.78%	0.06
X35500	0.80	0.68	4.86%	0.03
X35564	1.30	0.68	4.05%	0.04
X64002	0.89	0.68	3.44%	0.02
X64003	1.27	0.68	4.30%	0.04
X64503	2.65	0.68	2.79%	0.05
X66581	2.81	0.68	4.45%	0.09
X82576	1.48	0.68	2.92%	0.03
X82585	1.74	0.68	2.87%	0.03
X83533	2.26	0.68	3.88%	0.06
X96001	1.47	0.68	3.29%	0.03
X96002	0.93	0.68	4.16%	0.03
X96523	2.00	0.68	3.28%	0.04
Y11555	2.73	0.68	3.09%	0.06
Y11557	3.97	0.68	3.93%	0.11
Y31589	2.23	0.68	1.11%	0.02
Y31591	1.02	0.68	4.11%	0.03
Y32571	1.50	0.68	3.30%	0.03
Y32572	1.43	0.68	3.70%	0.04
Y36541	2.25	0.68	3.77%	0.06
Y54001	0.84	0.68	3.37%	0.02
Y54560	4.19	0.68	3.02%	0.09
Y54587	3.90	0.68	2.43%	0.06
Y54591	1.63	0.68	3.19%	0.04
Y66556	2.15	0.68	3.06%	0.04
Y69553	1.21	0.68	4.17%	0.03
Y69565	1.53	0.68	3.34%	0.03
Y86593	2.10	0.68	2.32%	0.03
Y86595	3.31	0.68	0.22%	0.01
Y98518	3.49	0.68	4.08%	0.10
Y98561	2.26	0.68	3.35%	0.05

Circuit	Annual Peak Demand 2014–2016 (MW)	$CVR_{f,PEAK}$	Average Percent Change in Peak Voltage	Annual Demand Savings (MW)
Z06538	2.98	0.68	3.45%	0.07
Z08509	3.34	0.68	2.43%	0.06
Z11536	2.44	0.68	3.11%	0.05
Z19532	2.14	0.68	5.43%	0.08
Z33511	4.80	0.68	3.07%	0.10
Z51556	2.97	0.68	4.56%	0.09
V92542	2.43	0.68	3.53%	0.06
V92543	2.70	0.68	3.44%	0.06
V92555	2.76	0.68	2.63%	0.05
X19561	3.22	0.68	2.78%	0.06
X35500	0.80	0.68	4.86%	0.03
X35564	1.30	0.68	4.05%	0.04
X64002	0.89	0.68	3.44%	0.02
X64003	1.27	0.68	4.30%	0.04
X64503	2.65	0.68	2.79%	0.05
X66581	2.81	0.68	4.45%	0.09
X82576	1.48	0.68	2.92%	0.03
X82585	1.74	0.68	2.87%	0.03
X83533	2.26	0.68	3.88%	0.06
X96001	1.47	0.68	3.29%	0.03
X96002	0.93	0.68	4.16%	0.03
X96523	2.00	0.68	3.28%	0.04
Y11555	2.73	0.68	3.09%	0.06
Y11557	3.97	0.68	3.93%	0.11
Y31589	2.23	0.68	1.11%	0.02
Y31591	1.02	0.68	4.11%	0.03
Y32571	1.50	0.68	3.30%	0.03
Y32572	1.43	0.68	3.70%	0.04
Y36541	2.25	0.68	3.77%	0.06
Y54001	0.84	0.68	3.37%	0.02
Y54560	4.19	0.68	3.02%	0.09
Y54587	3.90	0.68	2.43%	0.06
Y54591	1.63	0.68	3.19%	0.04
Y66556	2.15	0.68	3.06%	0.04
Y69553	1.21	0.68	4.17%	0.03
Y69565	1.53	0.68	3.34%	0.03
Y86593	2.10	0.68	2.32%	0.03
Y86595	3.31	0.68	0.22%	0.01
Y98518	3.49	0.68	4.08%	0.10
Y98561	2.26	0.68	3.35%	0.05
Z06538	2.98	0.68	3.45%	0.07
Z08509	3.34	0.68	2.43%	0.06
Z11536	2.44	0.68	3.11%	0.05

Circuit	Annual Peak Demand 2014–2016 (MW)	$CVR_{f,PEAK}$	Average Percent Change in Peak Voltage	Annual Demand Savings (MW)
Z19532	2.14	0.68	5.43%	0.08
Z33511	4.80	0.68	3.07%	0.10
Z51556	2.97	0.68	4.56%	0.09

APPENDIX C. CUMULATIVE PERSISTING ANNUAL SAVINGS

Table 13 provides CPAS and WAML for the 2024 VO Program through 2039. Lifetime savings for the 2024 VO Program are 1,157,529 MWh.

Table 13. 2024 VO Program CPAS and WAML through 2039

Measure Category	Measure Life	Annual Verified Gross Savings (MWh)	NTGR	CPAS - Verified Net Savings (MWh)							
				2024	2025	2026	2027	2028	2029	2030	2031
Voltage Optimization - 2024 Cohort	15.0	77,169	1.000	77,169	77,169	77,169	77,169	77,169	77,169	77,169	77,169
2024 CPAS		77,169	N/A	77,169	77,169	77,169	77,169	77,169	77,169	77,169	77,169
Expiring 2024 CPAS				0	0	0	0	0	0	0	0
Expired 2024 CPAS				0	0	0	0	0	0	0	0

Measure Category	Measure Life	Annual Verified Gross Savings (MWh)	NTGR	CPAS - Verified Net Savings (MWh)							
				2032	2033	2034	2035	2036	2037	2038	2039
Voltage Optimization - 2024 Cohort	15.0	77,169	1.000	77,169	77,169	77,169	77,169	77,169	77,169	77,169	0
2024 CPAS		77,169	N/A	77,169	77,169	77,169	77,169	77,169	77,169	77,169	0
Expiring 2024 CPAS				0	0	0	0	0	0	0	77,169
Expired 2024 CPAS				0	0	0	0	0	0	0	77,169
WAML	15.0										

Table 14 presents cumulative verified CPAS and expected CPAS per the original AIC VO plan. As of the end of program year 2024, cumulative verified CPAS exceeded the expected CPAS by 22%.

Table 14. Total CPAS vs. Expected CPAS Per AIC's Original VO Implementation Plan

Year Ending	2018	2019	2020	2021	2022	2023	2024	2025
Expected Cumulative Persisting Annual Savings (MWh) per AIC's VO Implementation Plan	0	7,650	59,994	128,433	201,725	275,006	348,287	421,568
Total Cumulative Persisting Annual Savings (MWh) [a]	0	9,175	81,843	177,275	264,167	347,583	424,751	N/A
% of Expected Savings Reached by End of Evaluation Period	N/A	120%	136%	138%	131%	126%	122%	N/A

[a] This row contains the total CPAS from all years of VO Program implementation (2019–2024) and, therefore, differs from the values presented in Table 13 above, which presents only CPAS from the 2024 VO Program.

APPENDIX D. VERIFICATION OF CONTINUED OPERATIONS

Opinion Dynamics conducted an analysis of the 2019, 2020, 2021, 2022, and 2023 cohorts of circuits to verify continued operations. Since VO savings are deemed for 15 years after completion of the initial evaluation of a circuit, and no retroactive changes are subsequently made to the savings, verification is necessary to confirm continued operation.

In 2020, Opinion Dynamics, AIC, and ICC Staff agreed that ongoing verification of VO should be conducted to provide information to all stakeholders about the level of continued VO operation and, if needed, to provide context as to why VO may not have operated continuously. After the initial evaluation of each year of circuits, all parties agreed that Opinion Dynamics would conduct verification activities to assess the degree to which VO continued to operate throughout each year. The acceptable uptime threshold of operation was set to ensure that circuits operated over a 90% threshold.[22]

The purpose of this verification is to provide information to stakeholders and other parties as to the level of continued operation of VO throughout the deemed 15-year period of savings and, if needed, to provide context as to why VO may not have operated continuously at the acceptable 90% uptime threshold throughout the period.

We conducted the following activities to determine whether these circuits operated over a 90% uptime threshold.

- **Sample Selection.** We randomly selected roughly 10% of each of the previously evaluated cohorts of circuits. This translates to 2 of the 19 circuits evaluated in 2019, 13 of the 125 circuits evaluated in 2020, 18 of the 180 circuits evaluated in 2021, 19 of the 181 circuits evaluated in 2022, and 20 of the 194 circuits. See Table 15 for the list of sampled circuits. Sample selection was performed retrospectively and provided to AIC in the second half of December of the evaluation year. This was done to ensure that the anticipated evaluation did not change the operations of the circuits subject to verification of continued operation.
- **Review operation log summaries for the sample.** The variable of interest for this effort included the VO status (i.e., VO "On" and VO "Off") for specific hours throughout the year at a circuit level. We were able to rely on the VO status log summaries for this analysis since we generally expected VO to run for nearly all hours in a year.
- **Data cleaning.** Opinion Dynamics did not perform any data cleaning prior to the verification activities except for removing excludable events. Excludable events are discussed in detail in Appendix B.
- **Calculated operation status.** We calculated the proportion of hours that each circuit's VO status was "On" for a given year. We then divided the total number of hours the status logs indicated that VO was operational by the total number of non-excludable hours in the year.

Table 15 presents the sample of the circuits evaluated as part of the 2019, 2020, 2021, 2022, and 2023 circuit verification.

Table 15. Sample of Circuits Evaluated in 2019, 2020, 2021, 2022, and 2023

Feeder	Substation	Year Previously Evaluated	Uptime (% of 2024)*
C52002	RIDGE C52002	2019	99.8%
P58155	MT VERNON 27TH ST P58155	2019	99.8%
P57103	MT VERNON 11TH ST P57LTC1	2020	99.8%
L93134	EAST BELLEVILLE L93134	2020	99.8%

[22] See Ameren Illinois Company Voltage Optimization Verification and Exclusion Approach Memorandum here: https://www.ilsag.info/wp-content/uploads/AIC-2019-Voltage-Optimization-Operation-Verification-Memo-FINAL-2020-04-17.pdf

Feeder	Substation	Year Previously Evaluated	Uptime (% of 2024)*
K52401	COLLINSVILLE REESE DR K52401	2020	99.8%
K39154	CLINTON RT 54 K39154	2020	99.8%
K76546	CHAMPAIGN OAK ST K76546	2020	99.5%
T06503	WEST FRANKFORT T06503	2020	99.8%
K52400	COLLINSVILLE REESE DR K52400	2020	99.8%
L73160	DANVILLE FRANKLIN ST L73160	2020	99.8%
L12126	DECATUR MOUND RD L12126	2020	99.8%
B80003	SHERIDAN B80LTC1	2020	99.8%
N95823	LITCHFIELD N95823	2020	95.4%
K76545	CHAMPAIGN OAK ST K76545	2020	99.8%
Y55003	PAXTON Y55003	2020	99.8%
A17021	BARTONVILLE A17021	2021	99.8%
P98190	NORMAL MAIN ST P98190	2021	99.8%
Q01282	NORMAL RTE 66 Q01282	2021	99.5%
Q28141	OLD SHAWNEETOWN Q28141	2021	99.8%
N54108	JACKSONVILLE WEST SIDE N54108	2021	99.8%
L50215	DUPO L50215	2021	99.8%
X60595	EFFINGHAM N X60595	2021	99.8%
L50214	DUPO L50214	2021	99.8%
349002	SUMMIT 349	2021	99.8%
A97004	EAST PEORIA PARALLEL A97LTC	2021	99.8%
R59417	URBANA GOODWIN R59417	2021	99.8%
R48167	TILTON ROSS LANE R48167	2021	99.8%
X77543	GILMAN S X77543	2021	99.8%
U33509	CANTON SPOON RIVER U33509	2021	99.5%
C40001	HAUK C40LTC1	2021	99.8%
P98193	NORMAL MAIN ST P98193	2021	99.8%
Q80352	ROSEWOOD HEIGHTS Q80352	2021	99.8%
J63173	BLOOMINGTON PROSPECT J63173	2021	99.8%
Q23256	OFALLON SEVEN HILLS ROAD	2022	99.8%
P20930	MARISSA P20930	2022	99.8%
M40132	GALESBURG MONMOUTH BLVD M40132	2022	99.8%
C37001	BISSELL C37001	2022	99.8%
R28870	STAUNTON SPRING STREET R28870	2022	93.2%
B45005	GRANDVIEW PARALLEL B45LTC	2022	99.8%
Z41528	TEUTOPOLIS WEST Z41528	2022	99.8%
M40117	GALESBURG MONMOUTH BLVD M40117	2022	99.8%
K73362	CHAMPAIGN LEVERETT RD K73362	2022	99.8%
S61531	MARION S61531	2022	99.8%
J50186	BLOOMINGTON GE ROAD J50186	2022	99.8%
D96001	SALEM D96001	2022	99.8%
N67309	KEWANEE NORTH MAIN ST N67309	2022	99.8%
A36002	EUREKA A36002	2022	99.8%

Feeder	Substation	Year Previously Evaluated	Uptime (% of 2024)*
R41131	TEXAS R41131	2022	99.8%
K09864	CARLINVILLE K09864	2022	99.8%
R49275	TRENTON R49275	2022	99.8%
K09863	CARLINVILLE K09863	2022	99.8%
L74194	DANVILLE HAZEL ST L74194	2022	99.8%
B21001	FONDULAC B21LTC1	2023	99.8%
B76001	KICE B76001	2023	99.8%
P85141	NORMAL P85141	2023	99.8%
S49550	HERRIN SW S49550	2023	99.8%
M49424	GLEN CARBON MAIN ST M49424	2023	99.8%
J88162	BELLEVILLE BELLE VALLEY J88162	2023	99.8%
P49183	MONMOUTH HARLEM AVE P49183	2023	99.8%
HK8115	DECATUR OLIVE STREET HK8LTC1	2023	99.8%
B28006	KOCH B28LTC1	2023	99.8%
D53001	MINDALE 69KV D53001	2023	99.5%
G50002	BEMENT G50	2023	99.8%
B27008	ADAMS B27LTC2	2023	99.8%
S43511	HARRISBURG S S43511	2023	99.8%
L80221	DANVILLE LYNCH ROAD L80221	2023	94.3%
P85146	NORMAL P85146	2023	99.8%
B93001	FULTON B93001	2023	97.1%
T23527	GOREVILLE N T23527	2023	99.8%
Y63531	ROBINSON E Y63531	2023	99.8%
S19556	CARBONDALE UNIVERSITY MALL S19556	2023	94.7%
Z18554	PARIS INDUSTRIAL PARK Z18554	2023	99.8%

[a] Excludes excludable events

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