Guidehouse

ComEd Voltage Optimization Impact Evaluation Report

Energy Efficiency / Demand Response Plan: Program Year 2019 (CY2019) (1/1/2019-12/31/2019)

Presented to
ComEd

FINAL

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ComEd Voltage Optimization Impact Evaluation Report

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1. Introduction

This report presents the results of the impact evaluation of ComEd's CY2019 Voltage Optimization (VO) Program. It includes a summary of the energy and demand impacts for the total program broken out by relevant measure and program structure details. The appendix provides the impact analysis methodology and details of the Total Resource Cost inputs. CY2019 covers January 1, 2019 through December 31, 2019.

2. Program Description

The VO Program comprises ComEd's plan to install hardware and software systems on a significant fraction of its electric power distribution grid to achieve voltage and reactive power optimization (volt-var optimization, or VVO) over the 2018-2025 time frame. VVO is a smart grid technology that uses distributed sensors, two-way communications infrastructure, remote controls on substation transformer load-tap changers and line capacitor banks, and integrating/optimizing software to flatten voltage profiles and lower average voltage levels on an electric power distribution grid. ComEd is working with an automation-optimization hardware and software vendor[1] to implement the VO program on selected parts of its distribution grid over the 2018-2025 period.

Unlike energy efficiency programs that achieve savings by providing financial incentives to encourage customers to adopt energy-efficient equipment or behavioral suggestions to encourage them to adopt no-cost energy-saving behaviors, the VO Program involves no direct customer engagement. Instead, savings is achieved by operating the voltage and reactive power controls on VO-enabled feeders and substations in a manner designed to maintain the voltages delivered to affected customers in the lower part of the allowable voltage range.[2]

The program installed and commissioned VO systems on a total of 382 feeders at 65 substations in CY2019, as shown in Table 2-1.[3]

Table 2-1. CY2019 Volumetric Findings Detail

Participation	Count
VO-Enabled Substations	65
VO-Enabled Feeders	382

Source: ComEd tracking data and evaluation team analysis

3. Program Savings Detail

Table 3-1 summarizes the incremental energy and demand savings the VO Program achieved in CY2019. As VO is not a customer facing program there is no free ridership and no spillover and as such

[1] Open Systems International (OSI) of Medina, Minnesota.
[2] The bulk of the energy savings that occurs is thus expected to occur on the customer side of the meter, although additional savings is expected from reduced current flows along the full length of the affected circuits.
[3] CY2019 VO installations occurred throughout the program year. Table 2-1 shows only those substations and feeders on which installation, commissioning and system testing were completed by December 31, 2019. This excludes four feeders that were expected to be claimed in CY2019 but which will be claimed in CY2020 instead (see finding 9 and recommendation 6 in Section 6.2 for details).

the net-to-gross (NTG) ratio is 1 and net and gross savings are identical. The program did not claim, and the evaluation did not examine, gas savings.

It should be noted that Guidehouse calculated the gross realization rate (RR)[4] shown in Table 3-1 using estimates for ex ante savings that ComEd derived from a 2014 VO potential study[5] that did not follow the methodology specified by the 2019 Stipulation Agreement[6] between ComEd, the Illinois Commerce Commission (ICC), and other parties. Thus, there is no presumption that the expected RR for the CY2019 VO Program should equal 1.0.

Table 3-1. CY2019 Total Annual Incremental Electric Savings

Savings Category	Energy Savings (kWh)	Non-Coincident Demand Savings (kW)	Summer Peak* Demand Savings (kW)
Electricity			
Ex Ante Gross Savings	196,300,500	NR	NR
Program Gross Realization Rate	0.94	NR	NR
Verified Gross Savings	184,041,503	NR	31,983
Program Net-to-Gross Ratio (NTG)	1.00	NR	1.00
Verified Net Savings	184,041,503	NR	31,983
Converted from Gas†			
Ex Ante Gross Savings	NA	NA	NA
Program Gross Realization Rate	NA	NA	NA
Verified Gross Savings	NA	NA	NA
Program Net-to-Gross Ratio (NTG)	NA	NA	NA
Verified Net Savings	NA	NA	NA
Total Electric Plus Gas			
Ex Ante Gross Savings	196,300,500	NR	NR
Program Gross Realization Rate	0.94	NR	NR
Verified Gross Savings	184,041,503	NR	31,983
Program Net-to-Gross Ratio (NTG)	1.00	NR	1.00
Verified Net Savings	184,041,503	NR	31,983

NR = Not reported (refers to a piece of data that was not reported, i.e., non-coincident demand savings)
NA = Not applicable (refers to a piece of data that cannot be produced or does not apply)
* The coincident summer peak period is defined as 1:00-5:00 p.m. Central Prevailing Time on non-holiday weekdays, June through August.
† The evaluation did not estimate gas savings for this program.
Source: ComEd tracking data and evaluation team analysis

[4] The gross RR is defined as the ratio of verified gross savings to ex ante gross savings.
[5] AEG, Voltage Optimization (VO) Feasibility Study, Final Report, March 9, 2015.
[6] Joint Ex. 1.0, Stipulation Agreement, Docket No. 19-0580, between Commonwealth Edison, the Staff of the ICC, the Citizens Utility Board, Environmental Defense Fund, the Natural Resources Defense Council, and the People of the State of Illinois (AG), hereinafter referenced as "Stipulation Agreement." <https://icc.illinois.gov/docket/files.aspx?no=P2019-0580&docId=291954>

4. Cumulative Persisting Annual Savings

Table 4-1 and Figure 4-1 show the measure-specific and total verified gross savings for the VO Program and the cumulative persisting annual savings (CPAS) for the measures installed in CY2019. The electric CPAS across all measures installed in 2019 is 184,041,503 kWh (Table 4-1). Guidehouse did not evaluate gas savings for this program and as such electric CPAS is equivalent to total CPAS. The "historic" rows in the table are the CPAS contribution back to CY2018. The "Program Total Electric CPAS" is the sum of the CY2019 contribution and the historic contribution.

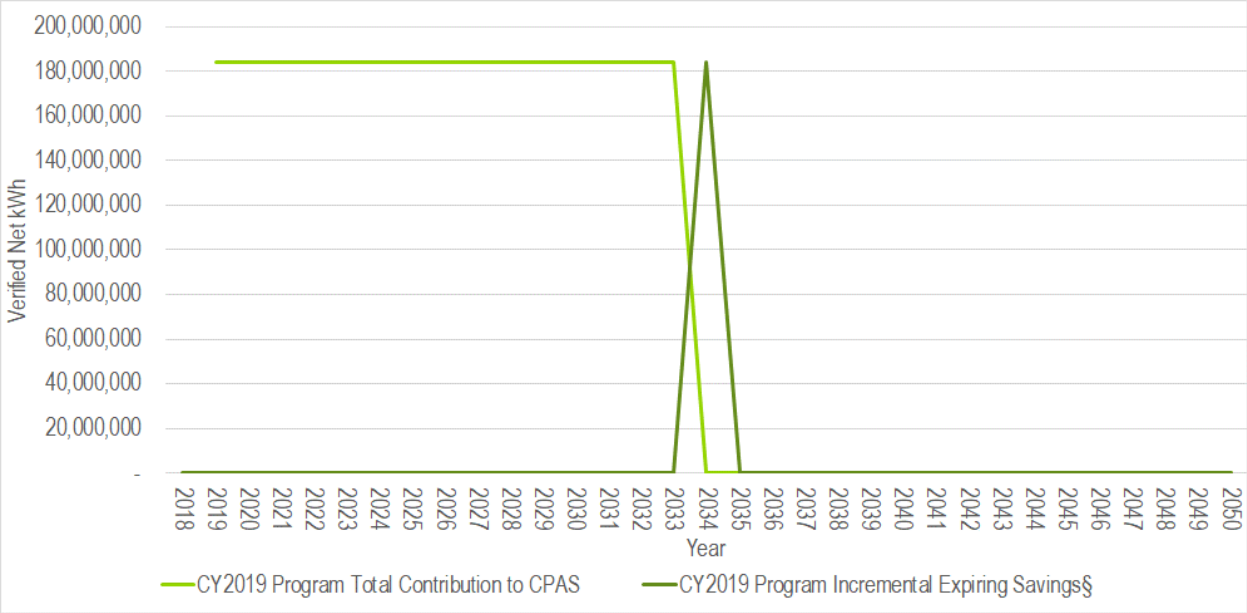
Table 4-1. Cumulative Persisting Annual Savings (CPAS) – Electric

End Use Type	Research Category	EUL	CY2019 Verified Gross Savings (kWh)	NTG*	Lifetime Net Savings (kWh)†	Verified Net kWh Savings 2018	2019	2020	2021	2022	2023	2024	2025	2026
All	VO	15.0	184,041,503	1.00	2,760,622,546		184,041,503	184,041,503	184,041,503	184,041,503	184,041,503	184,041,503	184,041,503	184,041,503
CY2019 Program Total Electric Contribution to CPAS			**184,041,503**		**2,760,622,546**		**184,041,503**	**184,041,503**	**184,041,503**	**184,041,503**	**184,041,503**	**184,041,503**	**184,041,503**	**184,041,503**
Historic Program Total Electric Contribution to CPAS‡						**66,014,049**	**66,014,049**	**66,014,049**	**66,014,049**	**66,014,049**	**66,014,049**	**66,014,049**	**66,014,049**	**66,014,049**
Program Total Electric CPAS						**66,014,049**	**250,055,552**	**250,055,552**	**250,055,552**	**250,055,552**	**250,055,552**	**250,055,552**	**250,055,552**	**250,055,552**
CY2019 Program Incremental Expiring Electric Savings§								-	-	-	-	-	-	-
Historic Program Incremental Expiring Electric Savings‡§							-	-	-	-	-	-	-	-
Program Total Incremental Expiring Electric Savings§							-	-	-	-	-	-	-	-

End Use Type	Research Category	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
All	VO	184,041,503	184,041,503	184,041,503	184,041,503	184,041,503	184,041,503	184,041,503					
CY2019 Program Total Electric Contribution to CPAS		**184,041,503**	**184,041,503**	**184,041,503**	**184,041,503**	**184,041,503**	**184,041,503**	**184,041,503**	-	-	-	-	-
Historic Program Total Electric Contribution to CPAS‡		**66,014,049**	**66,014,049**	**66,014,049**	**66,014,049**	**66,014,049**	**66,014,049**						
Program Total Electric CPAS		**250,055,552**	**250,055,552**	**250,055,552**	**250,055,552**	**250,055,552**	**250,055,552**	**184,041,503**	-	-	-	-	-
CY2019 Program Incremental Expiring Electric Savings		-	-	-	-	-	-	-	**184,041,503**	-	-	-	-
Historic Program Incremental Expiring Electric Savings		-	-	-	-	-	-	**66,014,049**	-	-	-	-	-
Program Total Incremental Expiring Electric Savings§		-	-	-	-	-	-	**66,014,049**	**184,041,503**	-	-	-	-

Note: The green highlighted cell shows program total first year electric savings. The gray cells are blank, indicating values irrelevant to the CY2019 contribution to CPAS.
* A deemed value. Source: is to be found on the Illinois SAG web site here: https://www.ilsag.info/ntg_2019.
† Lifetime savings are the sum of CPAS savings through the EUL.
‡ Historical savings go back to CY2018
§ Incremental expiring savings are equal to CPAS Y_{n-1} - CPAS Y_n
Source: Evaluation team analysis

Figure 4-1. Cumulative Persisting Annual Savings



* Expiring savings are equal to CPAS Y_{n-1} - CPAS Y_n.
Source: Evaluation team analysis

5. Program Savings by Measure

There is only one measure in this program and so measure-level results are the same as the program-level results discussed in the previous section. See Section 8 below for detailed savings results.

6. Impact Analysis Findings and Recommendations

6.1 Impact Parameter Estimates

The VO Program does not have relevant impact parameters.

6.2 Other Impact Findings and Recommendations

The evaluation team developed several recommendations based on findings from the CY2019 evaluation. Note that the Stipulation Agreement prescribed a data reconstruction process, which filled in data that was missing or removed by data cleaning. Guidehouse followed the Stipulation Agreement and guidance provided by ComEd in implementing said reconstruction process.[7] The data cleaning and reconstruction processes are described in Section 7.1.

Finding 1. Following the methodology outlined in the Stipulation Agreement, Guidehouse found energy savings of 184,041,503 kWh for the CY2019 VO feeders, resulting in a RR of 0.94. However, the ex ante savings ComEd reported for the CY2019 VO feeders were derived from

[7] ComEd's guidance was provided in a PowerPoint titled *2019 VO Measurement & Verification Methodology* dated November 6th, 2019.

a 2014 VO potential study that did not follow the methodology specified by the Stipulation Agreement. Thus, there is no presumption that the expected RR for the CY2019 VO Program should equal 1.0.

Recommendation 1. Guidehouse recommends that in the future ComEd provide ex ante savings values that align with the evaluation methodology being utilized so that the RR reflects an apples-to-apples comparison.

Finding 2. Feeder data provided by ComEd appears to include some feeders with time stamps in Central Prevailing Time and some feeders with time stamps in Central Standard Time. Guidehouse was unable to reliably distinguish between the two. As the majority of feeders appear to be in Central Standard Time, Guidehouse assumed Central Standard Time for all feeders.

Recommendation 2. Guidehouse recommends that ComEd include time zones with their time stamped data in the future or provide Guidehouse with a list of which feeders record time in Central Standard Time and which in Central Prevailing Time. ComEd and Guidehouse will work together to resolve this in the data for the CY2020 evaluation.

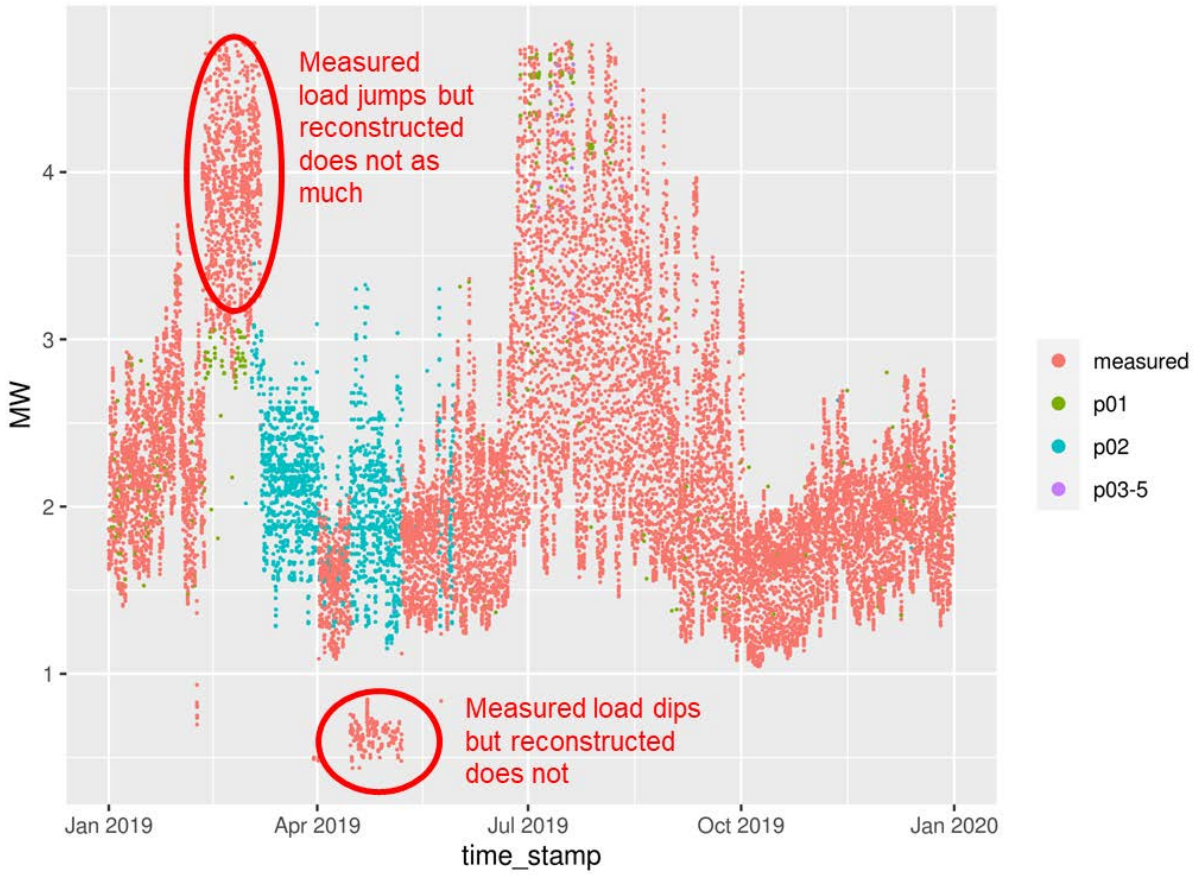
Finding 3. Guidehouse found that the data received for this program included many different values indicating bad or missing data. These included but were not limited to: “Bad Quality”, “bad quality”, “No Data”, “Historical data not extracted”, “missing”, “NA”, and “#N/A”.

Recommendation 3. Guidehouse recommends that ComEd standardize their values to indicate bad or missing data. We understand that ComEd intends to use “Bad Quality” to indicate bad or missing data going forward.

Finding 4. Many feeders have jumps or dips in load when load shifting occurs across feeders. These changes are observed in the actual data but are sometimes obscured by the data reconstruction process Guidehouse had to use to estimate missing data.[8] Figure 6-1 shows an example of this for feeder C057 on substation TDC205, where the red dots are showing actual, measured data and the other colors show reconstructed data.[9]

[8] The data cleaning and reconstruction process are discussed in detail in Section 7.
[9] The colors of the reconstructed data refer to the priority bins shown in Table 7-1.

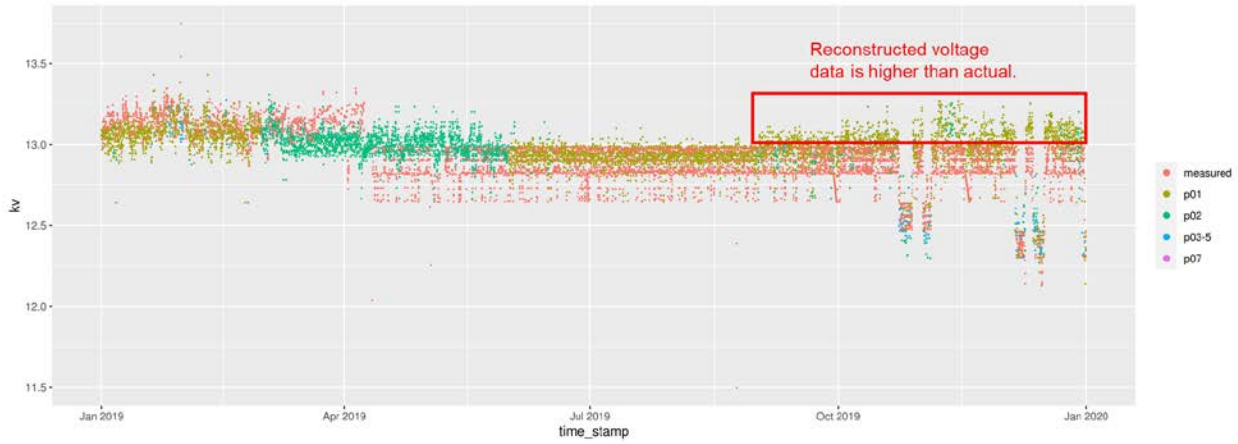
Figure 6-1. Load Data for Feeder C057 on Substation TDC205



Source: Evaluation team analysis.

Finding 5. For feeder W4101 on substation DCW41, Guidehouse found that much of the reconstructed voltage data is high compared to the actual voltage data starting in September 2019. This appears to be driven by a drop in the actual voltage in April 2019; the high values from before April 2019 pull up the reconstructed values after September 2019. Figure 6-2 shows the issue, where the red dots show actual, measured data and the other colors show reconstructed data.

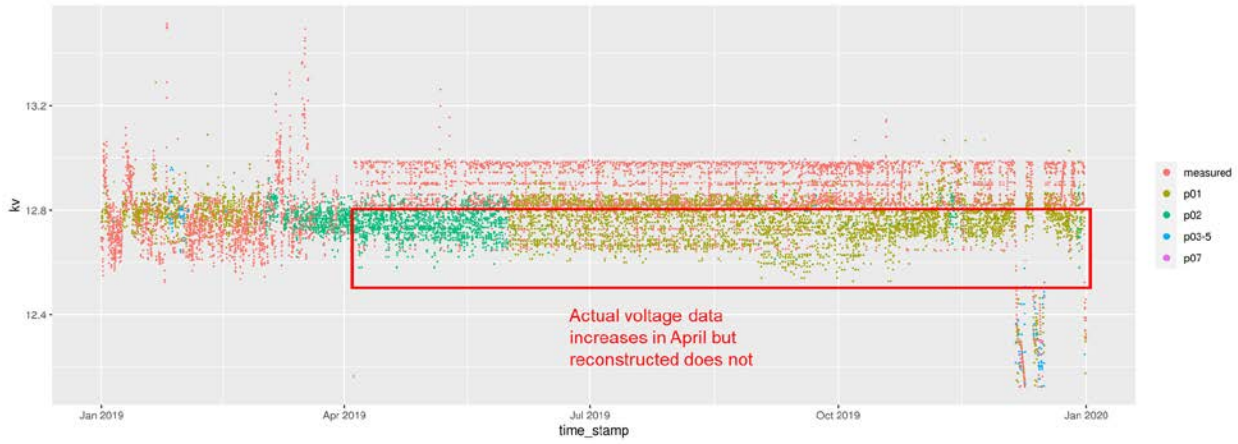
Figure 6-2. Voltage Data for Feeder W4101 on Substation DCW41



Source: Evaluation team analysis.

Finding 6. For feeder W4401 on substation DCW44, Guidehouse found that actual voltage increased starting in April 2019 but the reconstructed data did not. Figure 6-3 shows the issue, where the red dots show actual, measured data and the other colors show reconstructed data.

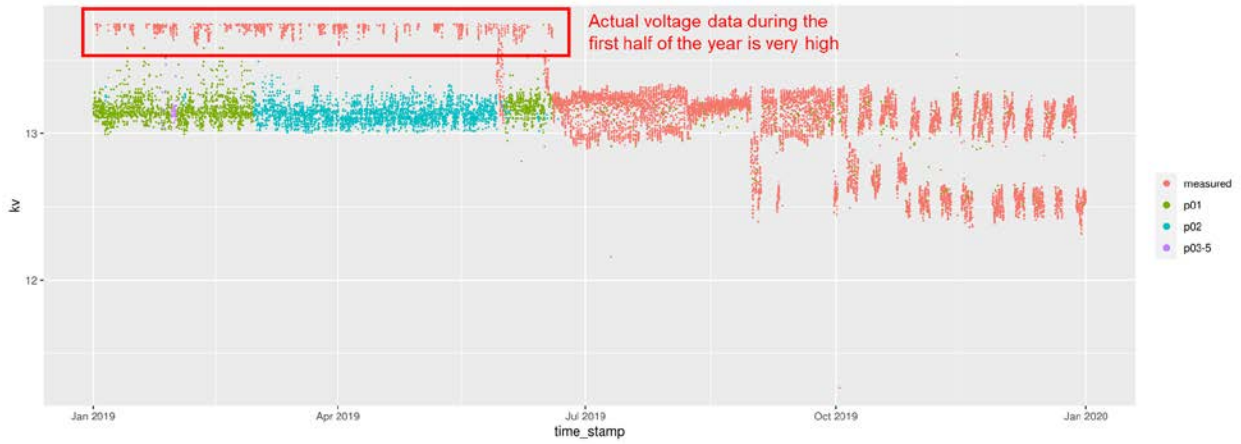
Figure 6-3. Voltage Data for Feeder W4401 on Substation DCW44



Source: Evaluation team analysis.

Finding 7. For many of the feeders on substation TDC469, Guidehouse found that much of the data in the first half of the year is missing or removed by the data cleaning process. The reconstructed load data appear to match the actual data fairly well. However, the actual voltage data during this time frame is very high compared to the reconstructed data and the rest of the year. Figure 6-4 shows an example of this for feeder G6971, where the red dots show actual, measured data and the other colors show reconstructed data.

Figure 6-4. Voltage Data for Feeder G6971 on Substation TDC469

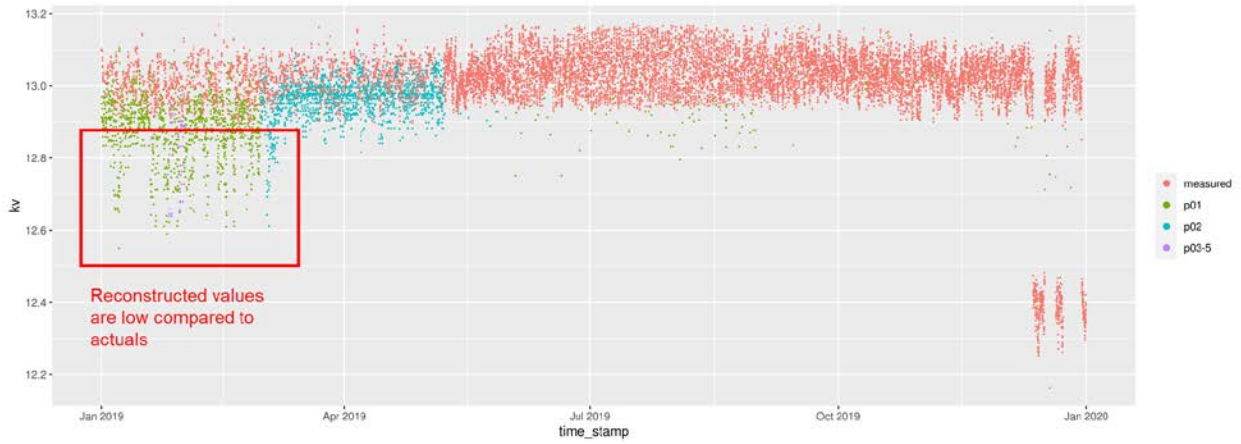


Source: Evaluation team analysis.

Recommendation 4. Guidehouse recommends ComEd investigate why actual voltage was anomalously high during the first half of 2019 for feeders on substation TDC469. ComEd has stated, "Prior to upgrading the regulating devices on transformer 71, part of the station was operating at a higher voltage than the standardized operational limit across ComEd feeders. During June 2019, relay upgrades were completed and new standardized voltage settings were applied across the substation's transformers."

Finding 8. For feeders on substation DCH78, reconstructed voltage data for January through March is low compared to contemporaneous actual values and to the rest of 2019. This appears to be caused by a sharp increase in actual measured voltage in August 2018 (ComEd has indicated these changes in operating voltage occurred due to the upgrade in the relay); the low values from the first half of 2018 pull down the reconstructed values for 2019. Figure 6-5 shows feeder H787 as an example of this where the red dots show actual, measured data and the other colors show reconstructed data.

Figure 6-5. Voltage Data for Feeder H787 on Substation DCH78



Source: Evaluation team analysis.

Recommendation 5. Guidehouse recommends ComEd and Guidehouse work together to revisit and potentially refine the data cleaning and reconstruction process for future evaluation

years, and in consideration of the final methodology for version 9 of the TRM, to better deal with the types of situations raised in findings 4 through 8.

Finding 9. Guidehouse identified four feeders with extreme deviations from the expected VO on/off testing schedule. These included:

- Feeder C211 on substation DCC21 had VO enabled in March but had fewer than 10 days with VO turned on for the rest of the year.
- Feeder C858 on substation DCC85 had VO enabled in January but had VO off from early July through the end of 2019.
- Feeder G091 on substation DCG909 had VO enabled in March but had sustained off periods from March 26 to April 30 and July 9 to July 29. This feeder also had only 3 days with any VO on from September 2 through the end of the year.
- Feeder W513 on substation DCW51 went live on June 26, 2019 but had only 8 days with any VO on from July 1 to December 31. In particular, VO was marked off from October 8 to the end of 2019.

Recommendation 6. Guidehouse, in conjunction with ComEd and ICC Staff, has decided to leave these four feeders out of the CY2019 evaluation. ComEd will be able to claim savings for these feeders in CY2020 assuming the VO on/off testing occurs as expected.

Finding 10. Considering the magnitude of the system being implemented, despite best efforts, ComEd did not always adhere to the agreed-upon 4 days on/4 days off testing protocol on all of its CY2019 VO-enabled feeders. Adherence to this experimental design is important because it permits the evaluation team to produce an unbiased estimate of the true impact of VO on energy consumption. This is especially true when regression is used to estimate savings, for example to update the TRM.

Recommendation 7. While we understand that sometimes deviations from the testing schedule are necessary for a variety of reasons, Guidehouse recommends that ComEd should try to follow the agreed-upon testing schedule as closely as possible.

7. Appendix 1. Impact Analysis Methodology

The Stipulation Agreement specifies how the evaluator will calculate savings for the CY2019 VO program.[10] The relevant text of the Stipulation Agreement (Section II.7) is included as Appendix 4. Guidehouse followed that stipulated approach and guidance provided by ComEd[11] in estimating CY2019 savings. The following sections describe how we estimated CY2019 energy and summer peak demand savings from the VO Program.

7.1 Energy Savings Methodology

The stipulation methodology relies on a conservation voltage reduction factor (CVRf), which is deemed at 0.8, and utilizes Equation 7-1 to estimate energy savings.

Equation 7-1. Stipulation Energy Savings Calculation

$$Energy\ Savings = Energy\ Baseline * CVRf * voltage\ reduction\ percentage$$

Appendix 4 reproduces the relevant sections of the stipulation; this section does not reproduce the stipulation but provides relevant details that supplement the information in the stipulation.

[10] See footnote 6.
[11] See footnote 7.

Regarding Section c of the stipulation on the energy baseline.

1. In regard to Section c.i of the stipulation, in cases where power (MW) data was not available, Guidehouse converted the corresponding current (amps) value to MW using Equation 7-2 through Equation 7-4. This conversion was applied to at least some of the data used for reconstruction (data from January 1, 2018 to January 31, 2020) for 178 feeders.

Equation 7-2. Amps to MW Conversion (3-Phase with Line-to-Line Voltage)

$$P_t = \sqrt{3} * V_t * I_t * p_f$$

Equation 7-3. Amps-to-MW Conversion (3-Phase with Line-to-Neutral Voltage)

$$P_t = 3 * V_t * I_t * p_f$$

Equation 7-4. Amps-to-MW Conversion (Single Phase)

$$P_t = V_t * I_t * p_f$$

where:

P_t	Calculated MW data at time *t*
V_t	Average measured voltage at time *t*
I_t	Average measured amps at time *t*
p_f	Power factor assumed to be 0.9[12]

2. In regard to Section c.ii of the stipulation, Guidehouse created a lookup table to reconstruct load (MW) and voltage data that was missing or eliminated by the data cleaning process (see bullet 3) based on the priority sequence shown in Table 7-1. Guidehouse used data from January 1, 2018 through January 31, 2020 to reconstruct data for CY2019. Guidehouse chose not to reconstruct data for feeders with fewer than 1000 measured data points after cleaning; this resulted in feeder C162Y being dropped and assigned savings based on the average of all the other feeders.

[12] Guidehouse's empirical review of the CY2019 time-series data from VO Program feeders shows the actual measured power factor ranges from 0.1 to 1, with the majority falling in the 0.80 to 1 range. Guidehouse used 0.9 to align with ComEd's assumed power factor.

Table 7-1. Data Reconstruction Priority Sequence

Priority	Components and Commonalities of Table
1	Season*, Temperature†, Day Type‡, Hour§, VO Status
2	Temperature, Day Type, Hour, VO Status
3-5	Temperature +/-5‖, Day Type, Hour, VO Status
6	Season, Day Type, Hour, VO Status
7	Temperature, Day Type, VO Status
8	Season, Day Type, VO Status
9	Temperature, VO Status
10	Season, VO Status
11	VO Status, Day Type, Hour
12	VO Status, Day Type
13	VO Status

* Seasons are: Spring (March to May), Summer (June to August), Fall (September to November), and Winter (December to February)
† Temperature was binned to the ceiling of the nearest 5°F interval. Guidehouse sourced temperature data from the National Oceanic and Atmospheric Administration (NOAA) Quality Controlled Local Climatological Data (QCLCD) weather station geographically closest to each feeder. Guidehouse filled in missing data via linear interpolation (for gaps of 4 or fewer hours) or from the next closest weather station (for gaps longer than 4 hours).
‡ Day types are weekdays (Monday to Friday) and weekends (Saturday and Sunday).
§ Hour refers to the same hour of the day.
‖ Temperature +/-5 refers to temperatures one 5°F bin above or below the temperature of the observation being reconstructed. This occurred in three stages where we first looked across the bin above and below and then in just one or the other if there were no data points in one of them.
Source: ComEd

3. In regard to Section c.iii of the stipulation, Guidehouse cleaned the MW data by removing anomalous values of the following types:
    a. Negative values
    b. Non-numeric values
    c. Zero values
    d. Missing values
    e. Repetitive values[13]
    f. Interpolated values[14]
    g. Outlier values
        i. Defined as values above 110% or below 10% of the feeder peak load for feeders without distributed energy resources (DER)
        ii. Defined as values above 110% of the feeder peak load or below the expected reverse power for feeders with DER[15]

[13] Repetitive values are cases where three values in a row match up to six decimal places.
[14] Interpolated values are detected when the difference between values is the same (up to three decimal places) for at least two values in a row.
[15] The expected reverse power flow (P_{rev}) is calculated based on the total installed DER capacity on the feeder (P_{DER}) and the expected feeder demand during DER peak time (P_{Demand} = 50% of feeder peak load):

$$P_{rev} = P_{Demand} - P_{DER}$$

4. In regard to Section c.v of the stipulation, Guidehouse accounted for line losses of 3.67%.[16]

Regarding Section d of the stipulation on the voltage reduction percentage:

1. In regard to Section d.i and d.v of the stipulation, Guidehouse constructed the counterfactual voltage profile based on the same priority sequence as shown in Table 7-1.

2. In regard to Section d.iii and d.iv of the stipulation, Guidehouse cleaned the voltage data by removing anomalous values of the same types as for the MW data (see bullet 3 regarding Section c), except outlier values are defined as values above 1.10 per unit (p.u.) and below 0.90 p.u. of the nominal line-to-line voltage level for regular transformers, and the line-to-neutral voltage for DC-in-a-box (DCIAB) transformers. Guidehouse reconstructed missing and eliminated voltage data using the same priority sequence as shown in Table 7-1.

Load and voltage data were cleaned separately and Table 7-2 shows how much of the reconstructed data for each unit came from each priority bin in Table 7-1.

Table 7-2. Data Reconstruction

Priority Bin	Percentage Voltage Data (kV)	Percentage Load Data (MW)
Actual Measured	84.73%	80.54%
1	8.74%	11.01%
2	5.63%	7.27%
3-5	0.83%	1.04%
6	0.00%	0.00%
7	0.06%	0.10%
8	<0.01%	0.02%
9	0.01%	0.01%
10	0.00%	0.00%
11	<0.01%	<0.01%
12	<0.01%	<0.01%
13	0.00%	0.00%

Source: ComEd tracking data and evaluation team analysis

Per agreement with ComEd, ICC staff, and the other stipulating parties, Guidehouse applied a de-rating factor of 1.11% to the final energy savings. This factor accounts for times when VO is expected to be off for reasons that are within ComEd's control for each year of the 15 year measure life. The calculation of the de-rating factor is discussed in Appendix 5.

[16] Distribution system energy losses are assumed to be 3.67%, based on ComEd's filed 2019 ComEd Distribution System Loss Study.
ComEd. 2020. *2019 ComEd Distribution System Loss Study*. Docket No. 20. ComEd Ex. 6.01. Available at: https://www.icc.illinois.gov/downloads/public/edocket/520735.PDF

7.2 Peak Demand Savings Methodology

Summer peak demand savings are not mentioned in the Stipulation Agreement. Guidehouse's method utilized a regression model that takes advantage of the VO on/off testing to estimate summer peak period savings. We felt this was more accurate than modifying the Stipulation methodology as it does not rely on using a deemed CVR factor of 0.8, which may not be correct for the summer peak period.[17] Additionally, the regression analysis utilizes the experimental design, wherein VO was meant to be turned on and off on a set schedule independent of any other factors, which is the gold standard for evaluation.

Guidehouse only utilized CY2019 feeders which had VO enabled by August 1, 2019 in order to have sufficient peak period on/off testing data for the regression; we applied the average savings from these 148 feeders[18] to all 382 CY2019 feeders to get total summer peak demand savings.

For the summer peak demand savings estimation, Guidehouse utilized the cleaned data, before reconstruction, from the energy savings methodology described above. We subsetted the data to contain only summer peak period days: non-holiday weekdays from June 1 through August 31. We then ran the pooled regression models shown in Equation 7-5 across all feeders to estimate VO's impact on load and voltage. We utilized this pooled approach rather than feeder-by-feeder estimation because it achieved a higher level of statistical significance, and the summer peak savings averaged across all feeders provides sufficient information for cost-effectiveness modelling.

Equation 7-5. Summer Peak Demand Load and Voltage Regression Models

$$MW_{it} = \eta_i + \tau_h + \alpha VO_{it} + \beta VO_{it} \cdot offpeak_t + \gamma CHD_{it} + \omega CDH_{it}^2 + e_{it}$$

$$kV_{it} = \eta_i + \tau_h + \alpha VO_{it} + \beta VO_{it} \cdot offpeak_t + \gamma CHD_{it} + \omega CDH_{it}^2 + e_{it}$$

where:

MW_{it}	Load (MW) on feeder *i* at half-hour *t*
kV_{it}	Voltage (kV) on feeder *i* at half-hour *t*
η_i	A feeder fixed effect for feeder *i*, controlling for fixed feeder characteristics that may affect VO
τ_h	An hourly fixed effect for each hour of the day *h*
VO_{it}	An indicator equal to 1 when VO is on for feeder *i* during half-hour *t*
$offpeak_t$	An off-peak indicator equal to 1 when half-hour *t* is between 12:00 AM through 12:59 PM and 5:00 PM through 11:59 PM in Central Prevailing Time
CDH_{it} and CDH_{it}^2	Cooling degree-hours, base 65 degrees Fahrenheit, for feeder *i* during half-hour *t* and its square to capture nonlinear impacts of temperature on cooling load
e_{it}	The cluster-robust error term for feeder *i* during half-hour *t*[19]

The coefficient α in Equation 7-5 represents the impact of VO during the summer peak period.

[17] Assuming that 0.8 is the correct CVR factor for the entire year (all seasons, all day types, all hours of the day), it would be unlikely to also be the correct CVR factor for the summer peak period.
[18] Although 149 of the feeders being claimed in CY2019 had VO enabled prior to August 1, feeder C162Y did not have sufficient data after cleaning to be used in the analysis.
[19] Cluster-robust errors account for heteroskedasticity and autocorrelation at the feeder level.

8. Appendix 2. Impact Analysis Detail

Table 8-1 presents the verified CY2019 VO Program energy impacts by feeder, and Table 8-2 presents the RR by substation.

Table 8-1. CY2019 Verified VO Energy Savings and Voltage Reductions by Feeder

Substation	Feeder	VO Go-Live Date	CVRf	Energy Baseline (MWh)	Average Voltage Reduction (%)	Verified Energy Savings (MWh)
dca37	a372	10/31/2019	0.8	16,224.904	4.56%	571.439
dcb96	b961	5/24/2019	0.8	26,505.381	3.77%	755.080
dcc25	c253	7/5/2019	0.8	18,473.419	3.22%	416.334
dcc61	c615	2/28/2019	0.8	25,870.018	4.79%	952.821
dcc66	c661	5/8/2019	0.8	24,603.356	3.82%	709.211
dcd20	d2002	1/18/2019	0.8	15,433.536	3.76%	438.798
dcd351	d5111	2/9/2019	0.8	25,906.219	4.33%	854.010
dcd40	d4020	4/30/2019	0.8	24,145.812	4.57%	839.206
dcd40	d4021	4/30/2019	0.8	21,086.308	4.74%	763.825
dcd46	d4602	1/8/2019	0.8	23,246.529	4.25%	744.940
dce16	e134	7/29/2019	0.8	21,083.905	4.78%	774.701
dce16	e135	7/29/2019	0.8	17,624.428	3.96%	524.149
dce17	e175	3/8/2019	0.8	13,357.282	4.06%	418.969
dce29	e295	6/26/2019	0.8	16,335.736	3.87%	483.019
dce29	e296	6/26/2019	0.8	20,195.173	4.19%	651.031
dce35	e355	10/23/2019	0.8	9,593.868	5.13%	378.247
dce35	e356	10/23/2019	0.8	19,918.461	4.56%	690.152
dce46	e465	6/26/2019	0.8	15,556.075	4.07%	487.398
dce79	e792	8/1/2019	0.8	18,048.963	3.21%	434.365
dce8	e81	7/31/2019	0.8	15,568.910	4.83%	577.201
dce8	e82	9/9/2019	0.8	16,353.132	4.88%	613.684
dcf45	f457	6/4/2019	0.8	25,187.651	4.33%	834.847
dcf45	f458	6/4/2019	0.8	24,823.213	3.96%	754.968
dcg121	g211	2/28/2019	0.8	18,000.612	4.34%	601.550
dcg42	g429	9/13/2019	0.8	27,006.495	3.96%	813.734
dcg88	g881	2/9/2019	0.8	21,843.145	3.88%	643.838
dch27	h275	10/31/2019	0.8	23,163.860	4.27%	759.155
dch56	h565	10/31/2019	0.8	6,431.630	4.16%	208.344
dch56	h566	10/31/2019	0.8	3,021.247	4.17%	99.543
dch65	h652	8/23/2019	0.8	16,429.426	2.65%	343.534

Substation	Feeder	VO Go-Live Date	CVRf	Energy Baseline (MWh)	Average Voltage Reduction (%)	Verified Energy Savings (MWh)
dch76	h761	10/5/2019	0.8	29,629.276	1.19%	277.116
dch78	h786	12/12/2019	0.8	22,435.272	4.74%	816.781
dch78	h787	12/12/2019	0.8	21,999.753	4.69%	786.728
dcj19	j195	7/29/2019	0.8	20,882.831	3.97%	638.242
dcj19	j196	7/29/2019	0.8	17,725.185	4.36%	596.194
dcj87	j875	3/1/2019	0.8	22,174.870	3.76%	624.800
dcs67	s675	9/30/2019	0.8	14,728.279	2.93%	331.496
dcw115	w152	4/30/2019	0.8	22,944.430	3.40%	580.029
dcw115	w175	4/30/2019	0.8	15,770.431	4.41%	535.003
dcw119	w190	9/27/2019	0.8	23,795.116	3.64%	655.526
dcw119	w191	9/27/2019	0.8	11,296.913	4.73%	411.917
dcw148	w140	11/27/2019	0.8	21,408.422	4.76%	785.701
dcw148	w142	11/27/2019	0.8	20,320.803	4.49%	702.341
dcw25	w258	4/30/2019	0.8	24,140.339	4.46%	832.799
dcw304	w041	10/23/2019	0.8	20,672.036	3.57%	574.417
dcw41	w4101	10/23/2019	0.8	26,751.022	3.70%	746.869
dcw44	w4401	12/5/2019	0.8	22,207.327	3.83%	655.250
dcw46	w467	12/6/2019	0.8	17,390.600	4.27%	571.948
dcw50	w500	4/30/2019	0.8	18,908.977	4.37%	632.367
dcw50	w501	4/30/2019	0.8	18,928.159	3.78%	547.658
dcw50	w502	4/30/2019	0.8	23,862.816	4.36%	807.771
dcw51	w511	2/1/2019	0.8	18,868.909	4.64%	667.406
ss311	h113	3/30/2019	0.8	19,443.396	3.75%	547.367
ss459	f595	4/30/2019	0.8	12,261.526	4.28%	399.959
ss459	f596	4/30/2019	0.8	17,217.906	4.00%	527.891
ss513	w1310	11/1/2019	0.8	24,134.929	3.05%	563.803
ss513	w1311	11/1/2019	0.8	23,504.222	3.94%	717.252
ss513	w1312	11/1/2019	0.8	24,625.756	3.59%	662.369
ss513	w1313	11/1/2019	0.8	21,118.581	3.96%	647.453
ss553	w530	8/14/2019	0.8	15,580.171	4.78%	569.573
ss553	w531	8/14/2019	0.8	14,215.331	3.40%	346.930
tdc205	c050	4/30/2019	0.8	17,093.746	4.83%	634.392
tdc205	c051	4/30/2019	0.8	30,588.350	4.26%	998.551
tdc205	c0510	4/30/2019	0.8	21,214.303	4.83%	785.314

Substation	Feeder	VO Go-Live Date	CVRf	Energy Baseline (MWh)	Average Voltage Reduction (%)	Verified Energy Savings (MWh)
tdc205	c052	4/30/2019	0.8	21,952.748	4.26%	718.384
tdc205	c053	4/30/2019	0.8	19,982.829	4.82%	737.105
tdc205	c054	4/30/2019	0.8	14,002.881	4.82%	517.368
tdc205	c055	4/30/2019	0.8	15,377.239	4.82%	568.478
tdc205	c056	4/30/2019	0.8	34,015.572	4.26%	1,108.841
tdc205	c057	4/30/2019	0.8	20,023.210	4.26%	657.510
tdc205	c058	4/30/2019	0.8	15,954.744	4.83%	589.516
tdc205	c059	4/30/2019	0.8	18,305.478	4.26%	594.951
tdc216	c160	7/29/2019	0.8	24,606.440	3.93%	738.013
tdc216	c161	7/29/2019	0.8	25,988.133	4.62%	895.688
tdc216	c162x	7/29/2019	0.8	31,642.796	3.95%	941.150
tdc216	c162y*	7/29/2019	NA	NA	NA	487.192
tdc216	c163	7/29/2019	0.8	15,133.408	4.63%	521.178
tdc216	c164	7/29/2019	0.8	27,492.808	3.99%	824.155
tdc216	c165x	7/29/2019	0.8	7,140.970	4.62%	245.151
tdc216	c165y	7/29/2019	0.8	13,312.618	4.63%	468.226
tdc216	c166	7/29/2019	0.8	3,872.204	3.94%	111.794
tdc216	c167	7/29/2019	0.8	17,848.335	4.62%	625.009
tdc216	c168	7/29/2019	0.8	18,720.375	3.93%	551.585
tdc216	c169	7/29/2019	0.8	10,810.818	4.62%	381.203
tdc317	h1777	11/27/2019	0.8	18,317.962	4.46%	624.184
tdc317	h1778	11/27/2019	0.8	21,633.747	4.46%	743.268
tdc317	h1781	11/27/2019	0.8	9,139.882	4.46%	309.220
tdc317	h1782	11/27/2019	0.8	26,555.939	4.46%	909.767
tdc372	h7270	9/27/2019	0.8	19,126.664	2.30%	337.836
tdc372	h7271	9/27/2019	0.8	25,025.095	2.30%	441.738
tdc372	h7274	9/27/2019	0.8	8,457.226	3.35%	213.510
tdc372	h7275	9/27/2019	0.8	26,597.260	3.21%	648.420
tdc372	h7276	9/27/2019	0.8	22,939.732	3.23%	561.176
tdc435	f3571	12/20/2019	0.8	14,396.678	2.73%	299.415
tdc435	f3572	12/20/2019	0.8	24,218.488	2.73%	506.503
tdc435	f3573	12/20/2019	0.8	16,326.607	2.68%	334.756
tdc435	f3574	12/20/2019	0.8	16,179.496	2.71%	334.467
tdc435	f3575	12/20/2019	0.8	16,329.747	2.75%	342.765

Substation	Feeder	VO Go-Live Date	CVRf	Energy Baseline (MWh)	Average Voltage Reduction (%)	Verified Energy Savings (MWh)
tdc435	f3576	12/20/2019	0.8	17,911.291	2.70%	369.731
tdc435	f3577	12/20/2019	0.8	20,212.405	2.69%	420.298
tdc435	f3578	12/20/2019	0.8	22,543.576	2.67%	459.143
tdc435	f3581	12/20/2019	0.8	19,353.165	2.60%	381.370
tdc435	f3582	12/20/2019	0.8	14,899.741	2.63%	299.388
tdc435	f3583	12/20/2019	0.8	13,552.640	2.73%	285.344
tdc435	f3584	12/20/2019	0.8	23,039.484	2.74%	484.609
tdc435	f3585	12/20/2019	0.8	25,505.137	2.13%	420.927
tdc435	f3586	12/20/2019	0.8	27,135.880	2.19%	461.323
tdc435	f3587	12/20/2019	0.8	17,191.239	2.18%	290.911
tdc435	f3588	12/20/2019	0.8	20,592.635	2.15%	344.396
tdc444	j4401	11/27/2019	0.8	19,532.907	4.78%	717.159
tdc444	j4402	11/27/2019	0.8	12,478.379	4.78%	457.867
tdc444	j4403	11/27/2019	0.8	26,264.329	4.79%	962.064
tdc444	j4405	11/27/2019	0.8	21,405.532	4.31%	702.838
tdc444	j4409	11/27/2019	0.8	23,370.775	4.32%	772.381
tdc444	j4410	11/27/2019	0.8	22,942.960	4.31%	752.858
tdc446	f461	9/9/2019	0.8	9,519.361	3.76%	269.849
tdc446	f462	9/9/2019	0.8	17,720.807	3.75%	515.616
tdc446	f463	9/9/2019	0.8	23,357.974	3.76%	674.684
tdc446	f465	9/9/2019	0.8	22,248.380	4.55%	776.884
tdc446	f466	9/9/2019	0.8	17,716.295	4.54%	618.195
tdc446	f467	9/9/2019	0.8	11,666.656	4.57%	400.423
tdc446	f4674	9/9/2019	0.8	15,943.558	3.75%	461.226
tdc446	f4675	9/9/2019	0.8	13,691.954	3.75%	401.609
tdc446	f4681	9/9/2019	0.8	20,802.987	4.57%	731.452
tdc446	f4684	9/9/2019	0.8	20,130.746	4.55%	703.066
tdc469	g6971	8/30/2019	0.8	24,823.422	4.30%	819.684
tdc469	g6972	8/30/2019	0.8	20,572.357	4.32%	692.240
tdc469	g6973	8/30/2019	0.8	23,265.497	4.34%	794.022
tdc469	g6974	8/30/2019	0.8	22,675.033	4.35%	761.620
tdc469	g6975	8/30/2019	0.8	19,597.814	4.30%	659.663
tdc469	g6976	8/30/2019	0.8	18,234.882	4.30%	609.493
tdc469	g6977	8/30/2019	0.8	5,381.202	4.01%	166.772

Substation	Feeder	VO Go-Live Date	CVRf	Energy Baseline (MWh)	Average Voltage Reduction (%)	Verified Energy Savings (MWh)
tdc469	g6979	8/30/2019	0.8	17,769.727	3.92%	537.400
tdc469	g6980	8/30/2019	0.8	15,081.712	4.08%	471.037
tdc469	g6983	8/30/2019	0.8	19,490.329	3.92%	591.118
tdc469	g6984	8/30/2019	0.8	22,314.622	3.94%	679.044
tdc499	j9901	12/5/2019	0.8	30,222.485	4.95%	1,145.031
tdc499	j9902	12/5/2019	0.8	19,187.319	4.96%	728.204
tdc499	j9903	12/5/2019	0.8	21,453.976	4.96%	813.545
tdc499	j9904	12/5/2019	0.8	26,427.713	4.99%	1,016.640
tdc499	j9905	12/5/2019	0.8	19,338.266	4.93%	734.687
tdc499	j9906	12/5/2019	0.8	11,808.062	4.93%	448.178
tdc499	j9907	12/5/2019	0.8	18,691.803	4.93%	709.546
tdc499	j9909	12/5/2019	0.8	20,295.740	4.96%	777.055
tdc499	j9910	12/5/2019	0.8	28,051.153	4.96%	1,072.358
tdc499	j9911	12/5/2019	0.8	12,461.030	4.96%	476.630
tdc510	w1031	11/8/2019	0.8	16,876.251	4.96%	641.737
tdc510	w1032	11/8/2019	0.8	22,563.790	4.96%	862.014
tdc510	w1036	11/8/2019	0.8	17,867.332	4.92%	673.215
tdc510	w1039	11/8/2019	0.8	28,224.884	4.85%	1,051.052
tdc517	d1778	10/31/2019	0.8	17,603.491	3.32%	446.173
tdc517	d1779	10/31/2019	0.8	18,005.328	3.33%	459.083
tdc517	d1781	10/31/2019	0.8	31,754.227	3.32%	812.535
tdc517	d1782	10/31/2019	0.8	14,882.845	3.32%	375.948
tdc517	d1783	10/31/2019	0.8	19,839.135	3.33%	503.408
tdc517	d1784	10/31/2019	0.8	5,976.988	3.32%	151.845
tdc517	d1786	10/31/2019	0.8	21,542.267	1.76%	274.046
tdc517	d1787	10/31/2019	0.8	20,307.820	1.76%	257.991
tdc517	d1792	10/31/2019	0.8	26,113.470	1.76%	335.430
tdc517	d1793	10/31/2019	0.8	5,757.945	1.76%	75.868
tdc550	d5001	11/27/2019	0.8	19,843.204	2.80%	421.900
tdc550	d5003	11/27/2019	0.8	17,793.367	2.87%	398.336
tdc550	d5004	11/27/2019	0.8	29,544.399	3.10%	718.340
tdc550	d5005	11/27/2019	0.8	30,796.014	2.85%	692.685
tdc550	d5006	11/27/2019	0.8	24,168.299	2.92%	550.127
tdc550	d5007	11/27/2019	0.8	11,823.579	2.88%	271.854

Substation	Feeder	VO Go-Live Date	CVRf	Energy Baseline (MWh)	Average Voltage Reduction (%)	Verified Energy Savings (MWh)
tdc550	d5008	11/27/2019	0.8	15,040.892	2.94%	341.540
tdc550	d5009	11/27/2019	0.8	27,881.113	2.96%	640.474
tdc550	d5010	11/27/2019	0.8	26,175.310	2.97%	621.773
tdc550	d5011	11/27/2019	0.8	17,143.608	2.97%	388.136
tdc550	d5012	11/27/2019	0.8	15,100.864	2.99%	341.573
tdc550	d5013	11/27/2019	0.8	25,481.294	4.06%	786.290
tdc550	d5014	11/27/2019	0.8	14,415.235	4.05%	437.400
tdc550	d5015	11/27/2019	0.8	29,543.516	4.08%	921.567
tdc550	d5016	11/27/2019	0.8	18,806.728	4.05%	573.837
tdc550	d5017	11/27/2019	0.8	9,597.253	4.19%	312.784
tdc550	d5018	11/27/2019	0.8	12,251.937	4.18%	387.440
tdc552	w5202	5/24/2019	0.8	23,540.838	3.27%	593.668
tdc552	w5203	5/24/2019	0.8	14,926.118	3.12%	360.976
tdc552	w5204	5/24/2019	0.8	27,039.331	3.12%	653.302
tdc552	w5205	5/24/2019	0.8	15,901.877	3.17%	384.361
tdc552	w5206	5/24/2019	0.8	14,821.275	3.32%	383.281
tdc552	w5208	5/24/2019	0.8	19,668.083	3.42%	526.752
tdc552	w5209	5/24/2019	0.8	15,351.661	3.41%	407.359
tdc552	w5210	5/24/2019	0.8	14,412.368	3.31%	372.971
tdc559	w590	10/31/2019	0.8	16,064.172	4.88%	607.471
tdc559	w591	10/31/2019	0.8	16,884.915	4.88%	639.227
tdc559	w5910	10/31/2019	0.8	10,052.454	4.20%	325.760
tdc559	w5911	10/31/2019	0.8	13,032.899	4.88%	492.490
tdc559	w592	10/31/2019	0.8	14,721.836	4.88%	556.501
tdc559	w593	10/31/2019	0.8	13,712.381	4.20%	443.472
tdc559	w594	10/31/2019	0.8	11,035.960	4.20%	357.785
tdc559	w595	10/31/2019	0.8	11,977.201	4.21%	386.586
tdc559	w596	10/31/2019	0.8	8,316.382	4.20%	275.068
tdc559	w597	10/31/2019	0.8	14,039.630	4.20%	452.650
tdc559	w598	10/31/2019	0.8	24,898.384	4.88%	935.475
tdc559	w599	10/31/2019	0.8	19,607.159	4.89%	741.647
tdc568	w680	6/26/2019	0.8	4,673.082	4.23%	152.307
tdc568	w681	6/26/2019	0.8	19,840.384	4.20%	647.109
tdc568	w682	6/26/2019	0.8	23,439.242	4.18%	755.849

Substation	Feeder	VO Go-Live Date	CVRf	Energy Baseline (MWh)	Average Voltage Reduction (%)	Verified Energy Savings (MWh)
tdc568	w683	6/26/2019	0.8	21,984.286	4.19%	709.172
tdc568	w684	6/26/2019	0.8	14,736.163	3.79%	421.465
tdc568	w685	6/26/2019	0.8	555.212	3.89%	16.237
tdc568	w686	6/26/2019	0.8	16,071.425	3.79%	459.461
tdc568	w687	6/26/2019	0.8	18,042.491	3.79%	517.502
tdc568	w688	6/26/2019	0.8	22,579.906	3.73%	639.715
tdc568	w689	6/26/2019	0.8	17,512.314	3.79%	499.620
tdc595	w9501	11/27/2019	0.8	23,596.463	3.50%	640.894
tdc595	w9502	11/27/2019	0.8	14,267.067	3.50%	388.360
tdc595	w9503	11/27/2019	0.8	17,499.547	3.50%	473.811
tdc595	w9504	11/27/2019	0.8	16,646.300	3.50%	452.768
tdc595	w9505	11/27/2019	0.8	20,767.629	3.50%	563.481
tdc595	w9506	11/27/2019	0.8	13,307.586	3.51%	363.150
tdc595	w9507	11/27/2019	0.8	15,917.308	3.32%	412.126
tdc595	w9508	11/27/2019	0.8	18,244.514	3.47%	491.034
tdc595	w9509	11/27/2019	0.8	20,986.278	3.45%	560.628
tdc595	w9510	11/27/2019	0.8	18,592.859	3.45%	497.668
tdc595	w9511	11/27/2019	0.8	15,207.198	3.45%	406.734
tdc595	w9512	11/27/2019	0.8	28,504.580	3.45%	759.566
tdc595	w9513	11/27/2019	0.8	20,668.075	3.32%	534.339
tdc595	w9514	11/27/2019	0.8	23,632.660	3.32%	608.835
tdc595	w9515	11/27/2019	0.8	14,153.126	3.32%	366.338
tdc595	w9516	11/27/2019	0.8	15,084.743	3.32%	383.228
tdc595	w9517	11/27/2019	0.8	38,670.202	3.32%	998.837
tdc595	w9518	11/27/2019	0.8	18,959.557	3.32%	489.780
tdc595	w9519	11/27/2019	0.8	11,635.801	3.28%	298.030
tdc595	w9520	11/27/2019	0.8	14,137.982	3.29%	361.031
tdc595	w9521	11/27/2019	0.8	17,094.504	3.33%	443.250
tdc595	w9522	11/27/2019	0.8	38,348.530	3.47%	1,028.789
tdc595	w9523	11/27/2019	0.8	14,623.821	3.31%	379.490
tdc595	w9524	11/27/2019	0.8	18,859.553	3.32%	485.533
tdc595	w9525	11/27/2019	0.8	26,005.994	3.51%	708.249
tss111	w1131	11/27/2019	0.8	14,308.329	4.22%	460.451
tss111	w1132	11/27/2019	0.8	29,087.255	4.21%	932.876

Substation	Feeder	VO Go-Live Date	CVRf	Energy Baseline (MWh)	Average Voltage Reduction (%)	Verified Energy Savings (MWh)
tss111	w1133	11/27/2019	0.8	19,644.289	4.33%	652.900
tss111	w1134	11/27/2019	0.8	25,358.791	4.32%	840.380
tss111	w1135	11/27/2019	0.8	28,725.710	4.22%	925.960
tss111	w1136	11/27/2019	0.8	12,822.064	4.32%	426.369
tss111	w1137	11/27/2019	0.8	16,930.170	4.22%	549.894
tss137	z13731	1/25/2019	0.8	22,826.778	3.16%	553.013
tss137	z13733	1/25/2019	0.8	17,935.344	3.16%	437.641
tss137	z13734	1/25/2019	0.8	22,648.376	3.17%	552.955
tss137	z13735	1/25/2019	0.8	24,302.361	3.16%	589.834
tss137	z13736	1/25/2019	0.8	18,686.383	3.08%	440.606
tss137	z13737	1/25/2019	0.8	17,771.276	3.15%	431.181
tss137	z13746	1/25/2019	0.8	16,508.596	3.15%	401.965
tss137	z13750	1/25/2019	0.8	21,644.706	3.15%	525.185
tss137	z13751	1/25/2019	0.8	17,975.256	3.15%	436.069
tss137	z13752	1/25/2019	0.8	19,073.084	3.15%	462.869
tss137	z13753	1/25/2019	0.8	25,597.823	3.14%	619.414
tss137	z13754	1/25/2019	0.8	25,670.324	3.15%	621.939
tss137	z13755	1/25/2019	0.8	23,622.827	3.16%	572.914
tss137	z13757	1/25/2019	0.8	27,928.802	3.15%	677.748
tss137	z13758	1/25/2019	0.8	29,030.783	3.16%	707.674
tss137	z13759	1/25/2019	0.8	18,440.590	3.17%	450.506
tss137	z13760	1/25/2019	0.8	25,662.413	3.16%	622.626
tss137	z13761	1/25/2019	0.8	30,632.504	3.15%	743.074
tss137	z13763	1/25/2019	0.8	18,100.098	2.84%	395.169
tss137	z13765	1/25/2019	0.8	22,026.642	2.88%	488.191
tss137	z13766	1/25/2019	0.8	11,050.867	2.84%	241.917
tss137	z13767	1/25/2019	0.8	20,149.534	2.86%	445.421
tss137	z13768	1/25/2019	0.8	23,090.571	2.88%	512.064
tss137	z13769	1/25/2019	0.8	18,010.351	2.85%	395.167
tss137	z13778	1/25/2019	0.8	28,491.267	2.87%	630.704
tss137	z13779	1/25/2019	0.8	16,625.453	2.89%	368.542
tss137	z13781	1/25/2019	0.8	28,684.184	2.86%	635.976
tss137	z13783	1/25/2019	0.8	11,296.967	2.95%	257.251
tss137	z13785	1/25/2019	0.8	26,255.726	2.89%	588.359

Substation	Feeder	VO Go-Live Date	CVRf	Energy Baseline (MWh)	Average Voltage Reduction (%)	Verified Energy Savings (MWh)
tss137	z13786	1/25/2019	0.8	25,363.367	2.85%	557.726
tss137	z13787	1/25/2019	0.8	18,955.916	2.87%	423.280
tss137	z13789	1/25/2019	0.8	20,278.802	2.86%	447.089
tss137	z13790	1/25/2019	0.8	18,208.079	2.88%	407.194
tss137	z13791	1/25/2019	0.8	18,976.754	2.88%	424.289
tss137	z13792	1/25/2019	0.8	20,120.694	2.86%	445.732
tss137	z13793	1/25/2019	0.8	19,869.065	2.86%	440.659
tss151	e511	5/24/2019	0.8	23,136.843	2.52%	462.113
tss151	e5112	5/24/2019	0.8	22,949.525	2.53%	459.217
tss151	e5113	5/24/2019	0.8	14,626.783	2.53%	293.283
tss151	e5116	5/24/2019	0.8	14,304.369	2.52%	284.684
tss151	e514	5/24/2019	0.8	20,792.555	2.56%	421.051
tss172	c720	9/27/2019	0.8	14,575.687	3.24%	361.494
tss172	c721	9/27/2019	0.8	12,123.363	3.24%	301.926
tss172	c7210	9/27/2019	0.8	16,697.450	3.31%	423.183
tss172	c7211	9/27/2019	0.8	24,769.635	3.09%	585.390
tss172	c7212	9/27/2019	0.8	22,917.099	3.24%	566.700
tss172	c7213	9/27/2019	0.8	15,456.094	3.30%	388.818
tss172	c7214	9/27/2019	0.8	15,667.232	3.30%	394.411
tss172	c7215	9/27/2019	0.8	17,324.405	3.24%	428.237
tss172	c7216	9/27/2019	0.8	14,110.378	3.25%	352.341
tss172	c7217x	9/27/2019	0.8	18,632.397	3.05%	442.742
tss172	c7217y	9/27/2019	0.8	16,775.891	3.05%	392.423
tss172	c7218	9/27/2019	0.8	11,482.556	3.30%	290.351
tss172	c7219	9/27/2019	0.8	13,974.985	3.05%	326.376
tss172	c722	9/27/2019	0.8	13,568.811	3.09%	321.867
tss172	c7220	9/27/2019	0.8	27,527.032	3.05%	640.792
tss172	c7221	9/27/2019	0.8	19,711.876	3.05%	462.426
tss172	c7222	9/27/2019	0.8	24,913.890	3.05%	589.246
tss172	c7223	9/27/2019	0.8	21,433.330	3.09%	511.141
tss172	c7224	9/27/2019	0.8	22,211.539	3.25%	550.590
tss172	c7225	9/27/2019	0.8	21,451.215	3.05%	503.082
tss172	c7226	9/27/2019	0.8	16,363.445	3.05%	381.795
tss172	c723	9/27/2019	0.8	13,992.546	3.24%	345.901

Substation	Feeder	VO Go-Live Date	CVRf	Energy Baseline (MWh)	Average Voltage Reduction (%)	Verified Energy Savings (MWh)
tss172	c724	9/27/2019	0.8	15,136.332	3.09%	358.400
tss172	c725	9/27/2019	0.8	14,054.617	3.05%	330.414
tss172	c726x	9/27/2019	0.8	9,135.900	3.24%	225.803
tss172	c726y	9/27/2019	0.8	15,187.484	3.24%	379.274
tss172	c727	9/27/2019	0.8	23,020.439	3.24%	568.051
tss172	c728	9/27/2019	0.8	12,877.878	3.10%	307.556
tss172	c729	9/27/2019	0.8	24,234.810	3.31%	609.297
tss174	z17431	4/30/2019	0.8	19,053.204	1.33%	193.650
tss174	z17432	4/30/2019	0.8	21,688.208	1.33%	222.850
tss174	z17434	4/30/2019	0.8	19,094.413	1.33%	192.964
tss174	z17435	4/30/2019	0.8	16,653.348	1.32%	173.637
tss174	z17437	4/30/2019	0.8	26,961.001	1.33%	279.088
tss174	z17439	4/30/2019	0.8	30,407.793	1.34%	309.305
tss174	z17440	4/30/2019	0.8	18,908.849	1.33%	192.414
tss174	z17441	4/30/2019	0.8	21,291.333	1.33%	216.298
tss174	z17443	4/30/2019	0.8	17,870.292	1.38%	190.062
tss174	z17445	4/30/2019	0.8	22,485.423	1.27%	217.387
tss174	z17446	4/30/2019	0.8	17,410.968	1.39%	186.026
tss174	z17448	4/30/2019	0.8	21,303.313	1.38%	225.457
tss174	z17450	4/30/2019	0.8	27,643.955	1.39%	293.384
tss174	z17451	4/30/2019	0.8	27,497.500	1.38%	292.275
tss174	z17452	4/30/2019	0.8	19,589.783	1.38%	208.635
tss174	z17454	4/30/2019	0.8	26,294.673	1.35%	272.423
tss174	z17455	4/30/2019	0.8	14,193.121	1.32%	143.635
tss174	z17457	4/30/2019	0.8	33,352.574	1.35%	346.952
tss174	z17458	4/30/2019	0.8	20,719.458	1.35%	215.567
tss174	z17459	4/30/2019	0.8	19,690.777	1.35%	204.508
tss174	z17461	4/30/2019	0.8	22,835.606	1.33%	233.354
tss174	z17464	4/30/2019	0.8	21,884.358	1.33%	224.470
tss174	z17465	4/30/2019	0.8	20,941.978	1.34%	213.719
tss174	z17466	4/30/2019	0.8	21,875.763	1.27%	213.301
tss174	z17467	4/30/2019	0.8	18,394.342	1.27%	182.134
tss174	z17468	4/30/2019	0.8	16,191.278	1.28%	155.343
tss174	z17469	4/30/2019	0.8	26,308.159	1.27%	256.938

Substation	Feeder	VO Go-Live Date	CVRf	Energy Baseline (MWh)	Average Voltage Reduction (%)	Verified Energy Savings (MWh)
tss174	z17470	4/30/2019	0.8	15,127.698	1.27%	146.995
tss174	z17472	4/30/2019	0.8	3,192.192	1.32%	31.599
tss174	z17473	4/30/2019	0.8	20,425.952	1.30%	205.623
tss174	z17474	4/30/2019	0.8	25,791.873	1.27%	259.829
tss174	z17475	4/30/2019	0.8	15,978.588	1.34%	159.094
tss174	z17476	4/30/2019	0.8	22,916.613	1.31%	230.243
tss174	z17477	4/30/2019	0.8	18,668.816	1.38%	196.082
tss33	z3331	10/23/2019	0.8	18,985.076	2.20%	304.419
tss33	z3332	10/23/2019	0.8	21,897.061	2.21%	365.672
tss33	z3333	11/8/2019	0.8	11,859.849	1.25%	109.488
tss33	z3334	10/23/2019	0.8	18,430.448	2.12%	289.164
tss33	z3335	11/8/2019	0.8	14,474.199	1.29%	134.768
tss33	z3336	11/8/2019	0.8	26,940.467	1.60%	311.967
tss33	z3337	11/8/2019	0.8	21,508.439	1.60%	243.182
tss33	z3338	11/8/2019	0.8	27,487.434	1.61%	308.079
tss33	z3339	11/8/2019	0.8	13,403.927	1.52%	153.283
tss33	z3340	11/8/2019	0.8	24,871.543	1.62%	287.129
tss33	z3341	11/8/2019	0.8	28,480.257	1.53%	327.092
tss33	z3345	10/23/2019	0.8	5,844.536	1.92%	84.179
tss33	z3346	10/23/2019	0.8	19,211.482	1.95%	280.658
tss33	z3347	10/23/2019	0.8	18,357.991	2.18%	300.016
tss33	z3348	10/23/2019	0.8	22,766.325	2.28%	384.788
tss33	z3349	10/23/2019	0.8	22,582.563	2.13%	355.743
tss33	z3350	10/23/2019	0.8	3,702.357	2.15%	59.296
tss33	z3351	10/23/2019	0.8	37,398.060	2.20%	627.871
tss33	z3352	10/23/2019	0.8	17,035.588	2.17%	274.919
tss89	z8931	11/28/2019	0.8	24,631.314	2.06%	390.445
tss89	z8932	11/28/2019	0.8	12,317.784	2.07%	195.645
tss89	z8933x	11/28/2019	0.8	18,820.963	2.06%	298.181
tss89	z8933y	11/28/2019	0.8	19,469.549	2.06%	324.466
tss89	z8934	11/28/2019	0.8	23,059.462	2.07%	363.522
tss89	z8935	11/28/2019	0.8	20,146.455	2.07%	324.853
tss89	z8936	11/28/2019	0.8	18,440.578	2.33%	330.977
tss89	z8937	11/28/2019	0.8	18,469.366	2.22%	315.928

Substation	Feeder	VO Go-Live Date	CVRf	Energy Baseline (MWh)	Average Voltage Reduction (%)	Verified Energy Savings (MWh)
tss89	z8939	11/28/2019	0.8	24,030.999	2.32%	426.945
tss89	z8940	11/28/2019	0.8	16,444.660	2.30%	287.461
tss89	z8941	11/28/2019	0.8	23,732.882	2.32%	419.800
tss89	z8942	11/28/2019	0.8	18,676.945	2.34%	334.702
tss89	z8943	11/28/2019	0.8	12,546.375	2.34%	223.794
tss89	z8944	11/28/2019	0.8	13,432.861	2.33%	239.019
tss89	z8945	11/28/2019	0.8	13,818.112	2.34%	247.302
tss89	z8946	11/28/2019	0.8	21,284.697	2.32%	378.940
tss89	z8947	11/28/2019	0.8	22,197.744	2.32%	391.832
tss89	z8948	11/28/2019	0.8	5,548.295	1.85%	78.898
tss89	z8949	11/28/2019	0.8	18,627.882	1.85%	264.351
tss89	z8950	11/28/2019	0.8	14,688.987	1.81%	198.135
					Total	**186,107.294**

* Feeders C162Y did not have enough data for reconstruction. Guidehouse assigned this feeder the average of all other feeders.

Source: Evaluation team analysis

Table 8-2. CY2019 VO RRs by Substation

Substation	Verified Energy Savings (MWh)	Ex-Ante Energy Savings (MWh)	Realization Rate
dca37	571.439	1,042	0.55
dcb96	755.080	602	1.25
dcc25	416.334	324	1.28
dcc61	952.821	961	0.99
dcc66	709.211	459	1.55
dcd20	438.798	672	0.65
dcd351	854.010	780	1.09
dcd40	1,603.032	1,779	0.90
dcd46	744.940	784	0.95
dce16	1,298.849	1,420	0.91
dce17	418.969	683	0.61
dce29	1,134.050	1,471	0.77
dce35	1,068.399	1,658	0.64
dce46	487.398	614	0.79
dce79	434.365	467	0.93

Substation	Verified Energy Savings (MWh)	Ex-Ante Energy Savings (MWh)	Realization Rate
dce8	1,190.885	1,391	0.86
dcf45	1,589.815	965	1.65
dcg121	601.550	732	0.82
dcg42	813.734	914	0.89
dcg88	643.838	725	0.89
dch27	759.155	714	1.06
dch56	307.887	387	0.80
dch65	343.534	1,129	0.30
dch76	277.116	720	0.38
dch78	1,603.508	1,359	1.18
dcj19	1,234.435	1,406	0.88
dcj87	624.800	927	0.67
dcs67	331.496	570	0.58
dcw115	1,115.032	1,458	0.76
dcw119	1,067.442	1,045	1.02
dcw148	1,488.042	1,209	1.23
dcw25	832.799	874	0.95
dcw304	574.417	1,328	0.43
dcw41	746.869	959	0.78
dcw44	655.250	1,176	0.56
dcw46	571.948	1,260	0.45
dcw50	1,987.796	2,255	0.88
dcw51	667.406	765.5	0.87
ss311	547.367	606	0.90
ss459	927.850	1,554	0.60
ss513	2,590.876	2,214	1.17
ss553	916.503	1,297	0.71
tdc205	7,910.411	5,298	1.49
tdc216	6,790.343	7,474	0.91
tdc317	2,586.440	2,437	1.06
tdc372	2,202.680	3,145	0.70
tdc435	6,035.346	653	9.24
tdc444	4,365.167	3,473	1.26
tdc446	5,553.004	628	8.84

Substation	Verified Energy Savings (MWh)	Ex-Ante Energy Savings (MWh)	Realization Rate
tdc469	6,782.093	7,388	0.92
tdc499	7,921.872	6,894	1.15
tdc510	3,228.018	1,566	2.06
tdc517	3,692.326	5,940	0.62
tdc550	8,806.055	9,564	0.92
tdc552	3,682.669	5,427	0.68
tdc559	6,214.132	6,392	0.97
tdc568	4,818.437	5,031	0.96
tdc595	13,095.951	14,810	0.88
tss111	4,788.829	1,346	3.56
tss137	17,951.946	12,170	1.48
tss151	1,920.348	4,576	0.42
tss172	12,340.029	18,696	0.66
tss174	7,285.240	7,637	0.95
tss33	5,201.714	6,924	0.75
tss89	6,035.194	15,176	0.40
Total	**186,107.294**	**196,300.5**	**0.94**

Source: Evaluation team analysis

The savings totals in Table 8-1 and Table 8-2 (186,107,294 kWh) were multiplied by 98.89% to account for the de-rating of savings for times when VO is expected to be off for reasons that are within ComEd's control for each year of the 15 year measure life. This results in total verified savings of 184,041,503 kWh.

Guidehouse estimated average summer peak demand reduction from the pooled model of 83.7 kW per feeder per hour. Multiplying by the 382 feeders claimable in CY2019 brings the aggregate summer peak demand reduction across all feeders to 31,983 kW per hour (+/- 4,415 kW at a 90 percent confidence level). Across all feeders and peak period hours, Guidehouse found total summer peak period energy savings of 8,187,677 kWh (+/- 1,130,134 kWh at a 90 percent confidence level).

Guidehouse also estimated the voltage reduction during the summer peak period. We found an average voltage reduction across all feeders of 2.87%. Converting the demand savings to a percentage gives 2.79%. Dividing these two values gives an implied summer peak period CVR factor of 0.97.

9. Appendix 3. Total Resource Cost Detail

Table 9-1 shows the Total Resource Cost (TRC) cost-effectiveness analysis inputs available at the time of finalizing this impact evaluation report. Additional required cost data (e.g., measure costs, program level incentive and non-incentive costs) are not included in this table and will be provided to the evaluation team later.

Table 9-1. Total Resource Cost Savings Summary

End Use Type	Research Category	Units	Quantity	EUL (years)*	ER Flag†	Verified Gross Electric Energy Savings (kWh)	Verified Gross Peak Demand Reduction (kW)	Verified Gross Gas Savings (Therms)	Gross Heating Penalty (kWh)	Gross Heating Penalty (Therms)	NTG (kWh)	NTG (kW)	NTG (Therms)	Verified Net Electric Energy Savings (kWh)	Verified Net Peak Demand Reduction (kW)	Verified Net Gas Savings (Therms)	Net Heating Penalty (kWh)	Net Heating Penalty (Therms)
All	VO	Feeders	382	15.0	No	184,041,503	31,983.00	NA	NA	NA	1	1	NA	184,041,503	31,983.00	NA	NA	NA
	Total			**NA**		**184,041,503**	**31,983**	**0**	**0**	**0**	**NA**	**NA**	**NA**	**184,041,503**	**31,983**	**0**	**0**	**0**

NA = Not applicable

* The total of the EUL column is the weighted average measure life (WAML), and is calculated as the sum product of EUL and measure savings divided by total program savings.

† Early Replacement (ER) measures are flagged as YES, otherwise a NO is indicated in the column.

Source: ComEd tracking data and evaluation team analysis

10. Appendix 4. Stipulation Agreement

This section shows the text of Section II.7 of the Stipulation Agreement which describes the CY2019 VO evaluation methodology.

7. **Voltage Optimization Evaluation Methodology for 2019 Evaluated Savings.** The methodology described below in subsections (a) through (d) shall be used to evaluate ComEd's 2019 VO Program and the savings achieved under the Program during 2019; the methodology below will apply to the circuits on which VO was commissioned in 2019. The record contains substantial evidence concerning the 2019 VO evaluation to support Parties' stipulation.

*Energy Savings = Energy Baseline * CVRf * voltage reduction percentage*

a. *Annualization*: Savings will be annualized in accordance with ComEd's Plan 5 Stipulation.[2]

b. *Conservation Voltage Reduction (CVR) factor*: 0.80

c. *Energy Baseline*: The Energy Baseline shall be made up from the sum of the annual energy consumption utilizing the actual energy measurement during the time when VO was OFF (this includes the actual measurements prior to VO activation during the given program year) and a calculated VO OFF value for the time when VO was ON. VO OFF Baseline Energy calculation for the periods when VO is ON shall be calculated using:

$$E_{VO\_OFF} = \frac{E_{VO\_ON}}{1 - (CVR_f * \Delta V)}$$

Where;
E_{VO_OFF} is the calculated VO OFF energy consumption when VO is ON (activated)
E_{VO_ON} is the actual measured energy consumptions during the period when VO is ON
ΔV is the voltage reduction
CVR_f denotes the CVR factor

i. Where power (MW) data has not been established yet, best available data from the feeder line measurement devices should be considered.

ii. Data are clustered into bins in accordance to temperature, seasons, day type (weekday/weekend), and time of the day based on the VO OFF and ON statuses to create a lookup table. If multiple data points are found (i.e., same temperature range, same day type, same hour of the day,

[2] *Commonwealth Edison Co.*, ICC Docket No. 17-0312, Mosenthal Dir., AG Ex. 1.2 (filed July 25, 2017).

and same VO status), the average of multiple references are placed into the lookup table.

- Weekdays are Monday thru Friday
- Weekends are Saturday and Sunday
- Seasons are defined as follows;
  - Spring: March thru May
  - Summer: June thru August
  - Fall: September thru November
  - Winter: December thru February

iii. The independent evaluator shall use best practices, including an appropriate technique that is transparent, replicable, and most accurate to address any data quality issues, with input from interested stakeholders, including ComEd

iv. Every feeder, under testing protocol, will be assessed individually to estimate the energy consumption

v. When energy consumption baseline is measured at the feeder head, an adjustment will be made to recognize line losses and loss savings

d. *Voltage Reduction Measurement*: Voltage reduction shall be calculated using the following equation and in accordance with the terms provided in subsections (1) through (6) below:

$$\Delta V = \left(\frac{V_{OFF} - V_{ON}}{V_{OFF}}\right)$$

i. When VO is "OFF", the voltage if VO was "ON" needs to be estimated and vice versa. The savings reductions during the VO On/Off testing shall not be a basis to reduce the estimated savings, the off periods shall be treated as if they were on during the evaluation period.

ii. Voltage measurements are taken from the feeder's head end primary voltage source.

iii. Data are clustered into bins in accordance to temperature, seasons, day type (weekday/weekend), and time of the day based on the VO OFF and ON statuses to create a lookup table. If multiple data points are found (i.e., same temperature range, same day type, same hour of the day, and same VO status), the average of multiple references are placed into the lookup table.

- Weekdays are Monday thru Friday
- Weekends are Saturday and Sunday
- Seasons are defined as follows;
  - Spring: March thru May

- Summer: June thru August
- Fall: September thru November
- Winter: December thru February

iv. The independent evaluator shall use best practices, including an appropriate technique that is transparent, replicable, and most accurate, to address any data quality issues, with the input from interested stakeholders, including ComEd

v. The VO ON and VO OFF profiles shall be created for the entire program year at selected substation bus voltage control zones representative of the population of VO circuits using the lookup table for:

- Alternating status (i.e., if VO is OFF, the VO ON profile shall be created and vice versa);
- Corresponding temperature (*e.g.*, 5˚ F) ranges;
- Each hour of the day;
- Each season; and
- Each weekday/weekend day type

vi. If VO is ON in a continuous basis throughout the year, previous year's voltage data along with temperature, day type, and time of the day can be correlated in accordance to present year's temperature data, day type, and time of the day to create the VO OFF profile. This correlation shall use the data created from the most representative feeder or feeders that have undergone testing.

11. Appendix 5. De-Rating Factor Calculation

To calculate a de-rating factor to account for times when VO is expected to be off for reasons that are within ComEd's control for each year of the 15 year measure life, ComEd reviewed the intended on/off VO cycling schedule versus the actual VO status logs and identified misalignments greater than a day (48 half hourly intervals). ComEd categorized each of these deviations as excludable or not-excludable based on Table 11-1.

ComEd identified misalignments between the schedule and the logs 5.65% of the time; this breaks down into 4.55% excludable and 1.11% not-excludable. Table 11-2 shows this breakdown. Guidehouse applied the not-excludable percentage (1.11%) as a derating factor to the annualized savings.

Table 11-1. ComEd's Definition of the Excludable and Not-Excludable Events

Event	Description	Reason/Explanation	Category
System Operational Requirements	OCC takes control and disables VO due to station/circuit out of configuration, major alarm, repair/maintenance or switching events.	Circuit outages are typically not predictable or planned and are outside of ComEd control. ComEd will take necessary steps to ensure the reliability and safety of the system during storms and outages, maintenance, and work to support new customer growth. These events are not certain to occur on the same circuit in subsequent years.	Excludable
Loss of communication	Any unplanned interruption to the communication network.	Natural causes or unplanned repair due to equipment failure occasionally disrupting communication network.	Excludable
VO Control System	System component failure requires vendor upgrade or revision.	The failure of the VO Software provided by the outside vendor (OSI), or a Cyber event. Events of this nature are an anomaly and are not certain to occur year after year. This event is not predictable or planned and is outside of ComEd's control.	Excludable
VO On-Off Cycling Schedule	Supervision over the transitional states from ON to OFF, and vice versa.	When adding or commissioning substations or feeders to the VO Control system.	Excludable
Customer Maintenance	VO is disabled to investigate power quality issues.	Possible VO deactivation may be required to facilitate certain investigation requirements.	Not-Excludable
Worldwide Pandemic / Orders by Civil Authorities	Repairs and maintenance may take longer due to limited crew availability or other restrictions and priorities. Example: COVID-19	Due to restrictions, repairs and maintenance may take longer. This reasonable delay is outside the control of ComEd.	Excludable
VO Control System	Anytime VO system fails to operate due to model error in VO software, or inappropriate manual settings (human error).	Events of this nature should be addressed by ComEd in a timely manner, resulting in negligible impacts to energy savings.	Not-Excludable
Loss of communication	Any planned system upgrade that interrupts communication.	Planned system patching or upgrades interfere with the communication network and disable VO. This should be addressed by ComEd in a timely manner, resulting in negligible impacts to energy savings.	Not-Excludable

Event	Description	Reason/Explanation	Category
Equipment	Equipment failure that results in VO circuits being disabled (MJ5/DCIAB).	The equipment failure should be addressed by ComEd in a timely manner. This should result in negligible impacts to energy savings.	Not-Excludable
Server patching/ issues	Anytime servers would go down or if patching took place and VO system did not come back online due to servers not rebooting correctly.	Events of this nature are unavoidable but should be addressed by ComEd in a timely manner. This should result in negligible impacts to energy savings.	Not-Excludable

Source: ComEd

Table 11-2. Percentage of ComEd's Defined Categories

Event	Category	Duration (half hourly intervals)	Percentage (%)
System Operational Requirements	Excludable	42,965	1.95
Loss of Communication	Not-Excludable	583	0.03
	Excludable	3,070	0.14
Equipment Issue	Not-Excludable	12,413	0.56
VO Control System	Not-Excludable	4,589	0.21
	Excludable	23,647	1.07
VO On-Off Cycling Schedule	Excludable	30,363	1.38
Under Investigation	Not-Excludable	208	0.01
Customer Maintenance	Excludable	6,494	0.30
Summary	**Not-Excludable**	**17,793**	**1.11%**
	Excludable	**106,539**	**4.55%**

Source: ComEd