Raquel J. Webster
Senior Counsel

December 12, 2016

BY HAND DELIVERY AND ELECTRONIC MAIL

Luly E. Massaro, Commission Clerk
Rhode Island Public Utilities Commission
89 Jefferson Boulevard
Warwick, RI 02888

RE: Docket 4592 - FY 2017 Electric Infrastructure, Safety, and Reliability Plan
Volt Var Optimization Pilot

Dear Ms. Massaro:

I have enclosed the following documents regarding National Grid's[1] Volt Var Optimization (VVO) Pilot:

1. July 25, 2016 Power Point regarding the progress and initial results of the VVO Pilot (Attachment 1);

2. December 2, 2016 PowerPoint regarding the progress of the VVO Pilot, including final measurement and verification (M&V) results for two feeders in the pilot, and the cost and benefit estimates for expanding the VVO Pilot to additional substations (Attachment 2); and

3. Utilidata Measurement and Verification Results for the VVO Pilot (Attachment 3).

Thank you for your attention to this transmittal. If you have any questions, please contact me at 781-907-2121.

Very truly yours,

Raquel J. Webster

Enclosures

cc: Steve Scialabba, Division
Greg Booth, Division
Leo Wold, Esq.
Al Contente, Division

[1] The Narragansett Electric Company d/b/a National Grid (National Grid or the Company).

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T: 781-907-2121 ■ raquel.webster@nationalgrid.com ■ www.nationalgrid.com

Certificate of Service

I hereby certify that a copy of the cover letter and any materials accompanying this certificate was electronically transmitted to the individuals listed below.

The paper copies of this filing are being hand delivered to the Rhode Island Public Utilities Commission and to the Rhode Island Division of Public Utilities and Carriers.

Joanne M. Scanlon

December 12, 2016
Date

Docket No. 4592 National Grid's Electric Infrastructure, Safety and Reliability Plan FY 2017 - Service List as of 10/5/16

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File an original & nine copies w/: Luly E. Massaro, Commission Clerk Public Utilities Commission 89 Jefferson Blvd. Warwick, RI 02888	Luly.massaro@puc.ri.gov; Cynthia.WilsonFrias@puc.ri.gov; Alan.nault@puc.ri.gov; Todd.bianco@puc.ri.gov;	401-780-2107
Seth Handy, Esq.	seth@handylawllc.com;	401-626-4839

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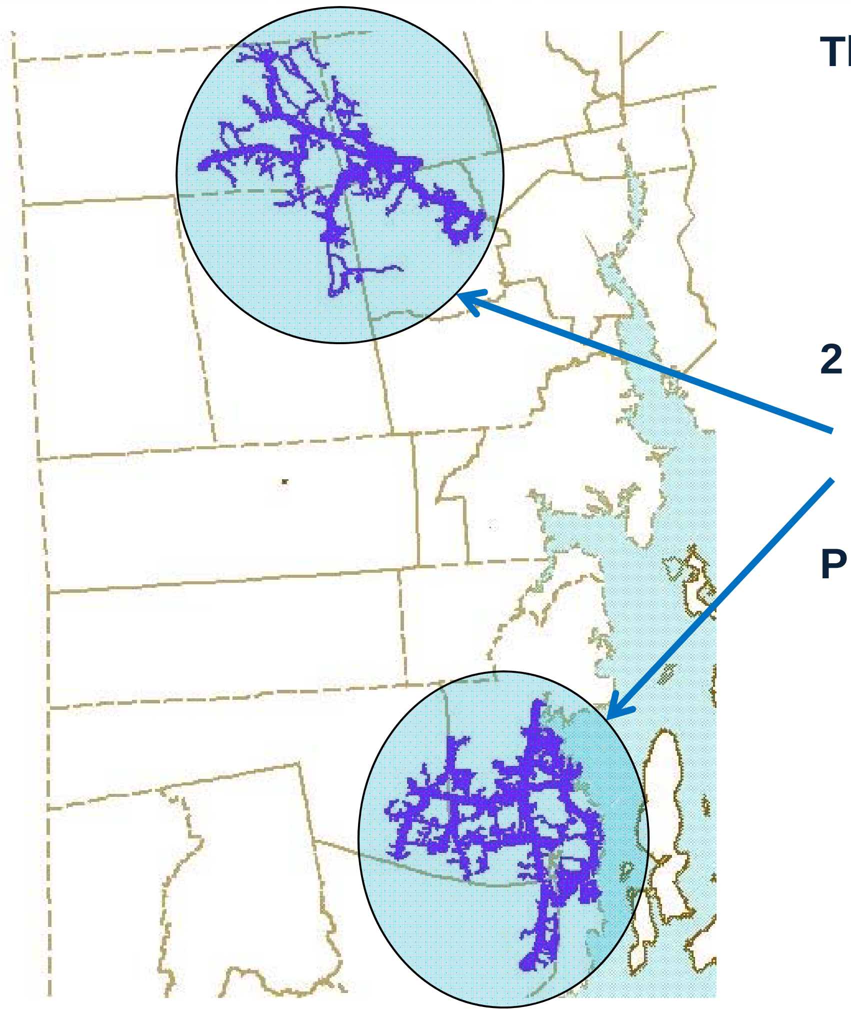
Rhode Island Volt VAR Optimization & Conservation Voltage Reduction (VVO/CVR)

Progress and Initial Results

July 25th 2016 – Jim Perkinson

RI VVO/CVR Project Scope



The project investigates two new technologies being investigated by the company:

- **Centralized VVO/CVR**
- **Mesh based field communications**

2 Substations/areas:

- **3 Feeders in Putnam Pike**
- **4 Feeders in Tower Hill**

Project includes:

- **IS/IT Backoffice Infrastructure**
- **Field Area Network**
- **Central Controller Installed at Lincoln**
- **Operational Integration to the company Energy Management System (EMS)**
- **40 Controllable field capacitors**
- **30 controllable field regulators**
- **~16k customers affected**

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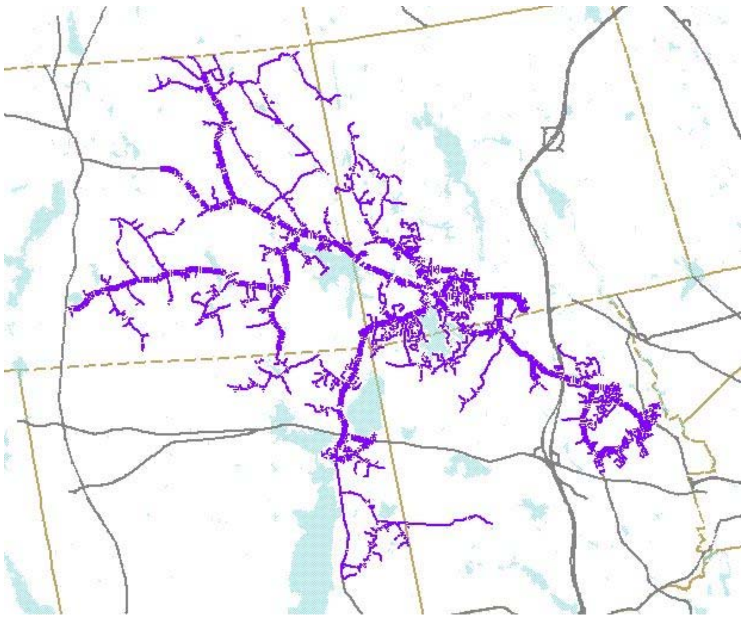
Active Devices



Putnam Pike Area:

- All Field Devices Installed
- Communications established to 93% of installed devices
- 2/3 feeders 100% operational in EMS and active in the VVO application (38F3 and 38F5)
- Measurement and Verification Process began on April 1st 2016
- Preliminary results from April 1st 2016 to June 30th 2016 are presented

All the significant challenges to date have been related to the wireless mesh for the field area network:

- 'Hop' Limitation leading to extra 3rd party towers
- Poor Line of sight performance requiring additional repeaters
- Taller utility Poles
- 5Ghz Interference issues

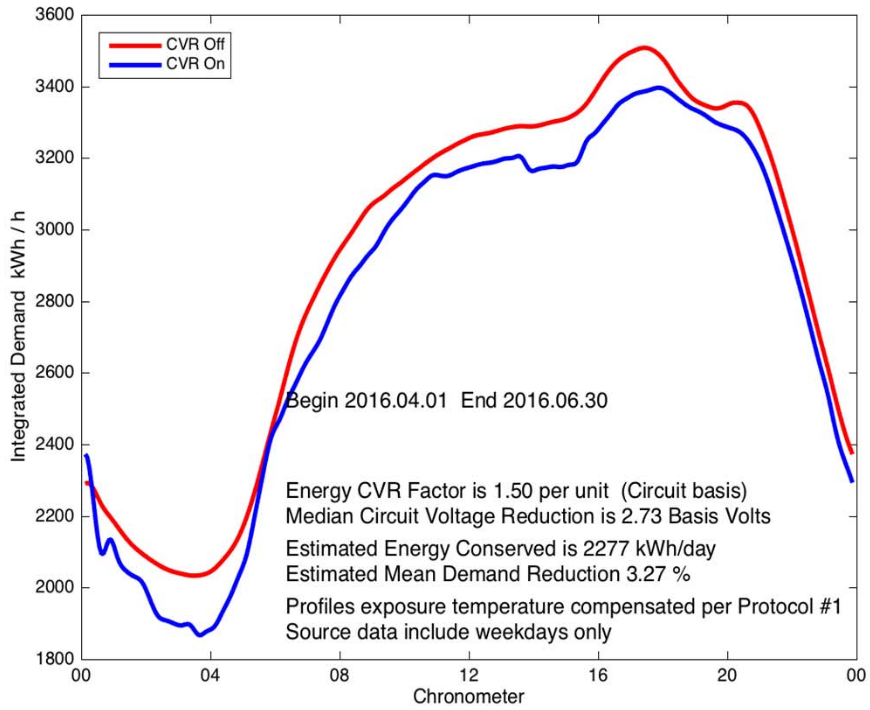
M&V Summary

Metric	Feeder 38F3	Feeder 38F5
VVO Mode days	18	21
Non-VVO Mode days	27	19
Estimated CVR Factor (per unit)	1.50	1.40
Demand Reduction (%)	**3.27**	**3.39**
Voltage Reduction, spatial avg %	2.28	2.46
Voltage Leveling improvement (volts)	0.72	0.68

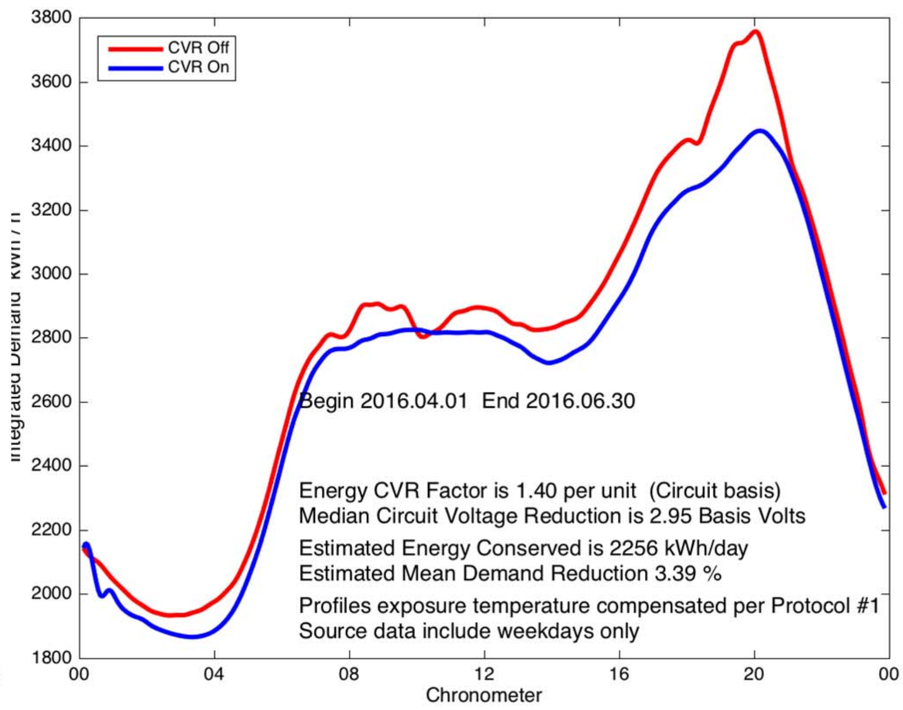
Measurement and Verification was performed utilizing filtered time series temperature compensated weekday date, following Automated CVR protocol #1.

Robust, Estimated Demand Profiles, over 24 hrs

38F3

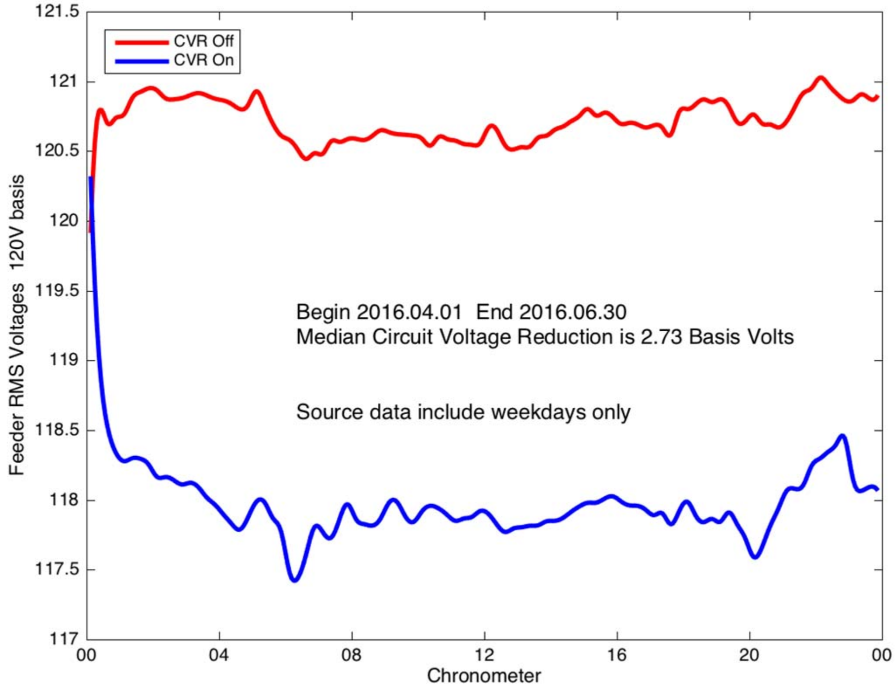


38F5



Median Circuit Voltage Profiles, Over 24hrs

38F3



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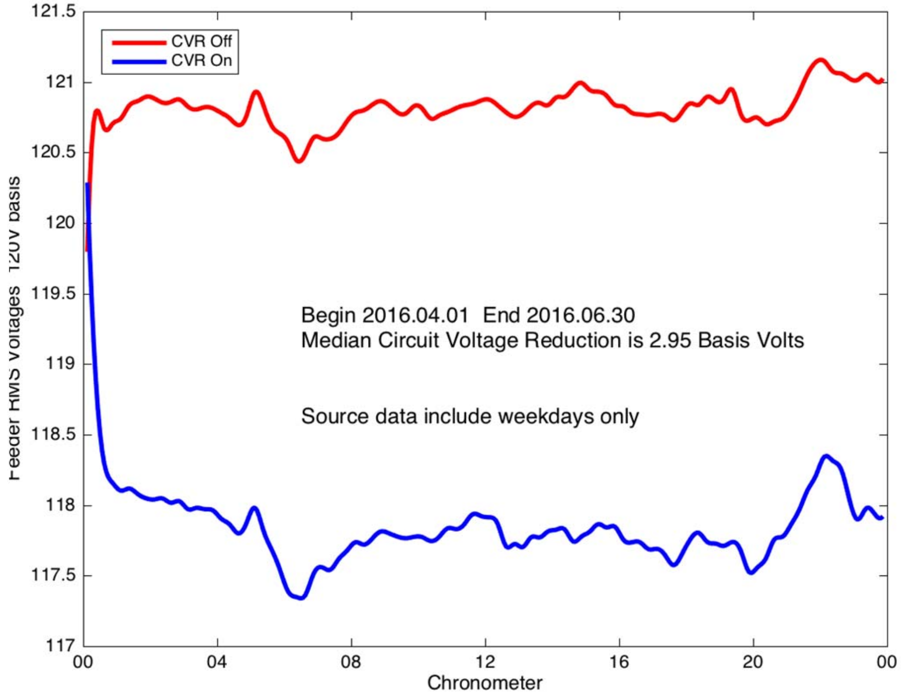

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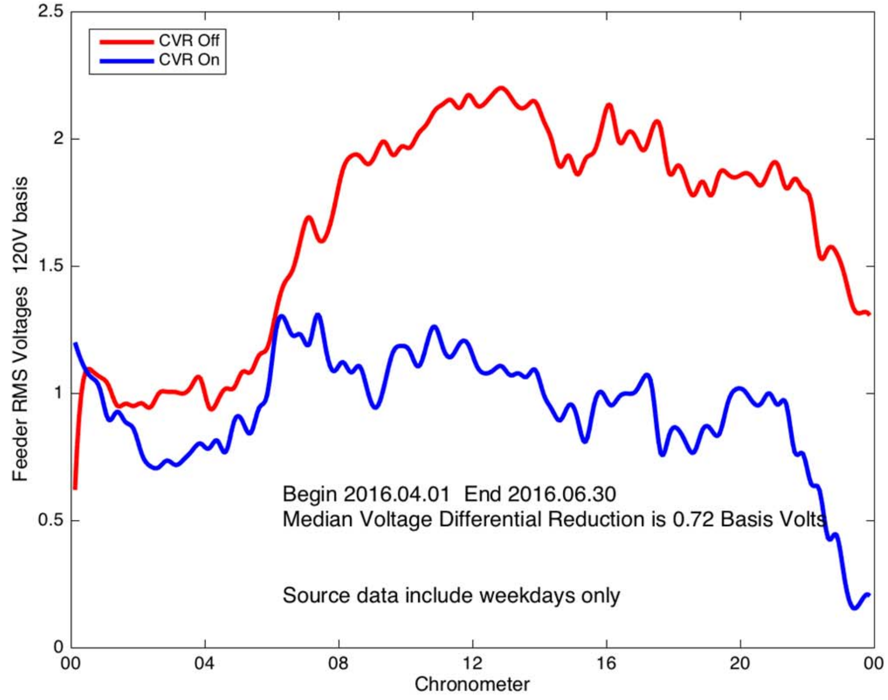
Median Voltage Differential Profiles

38F3



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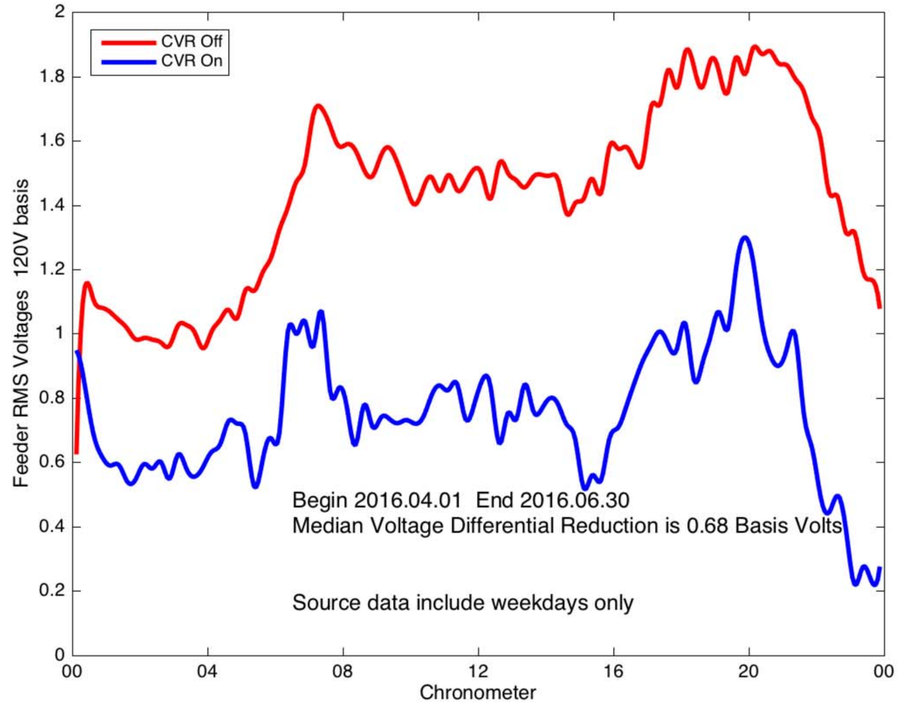

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Preliminary Conclusions and Next Steps

Conclusions:

- Preliminary M&V shows greater than 3% reduction in demand when using CVR Protocol #1.
- CVR factor for these circuits is in the 1.4-1.5 range.

Next Steps:

- Continue M&V over the summer peak demand periods
- Complete the Putnam Pike and Tower Hill areas, utilizing cellular communications to resolve FAN challenges (to be completed FY17)
- Leverage IS/IT/OT infrastructure, and evaluate expanding VVO to future target areas in FY18 and beyond

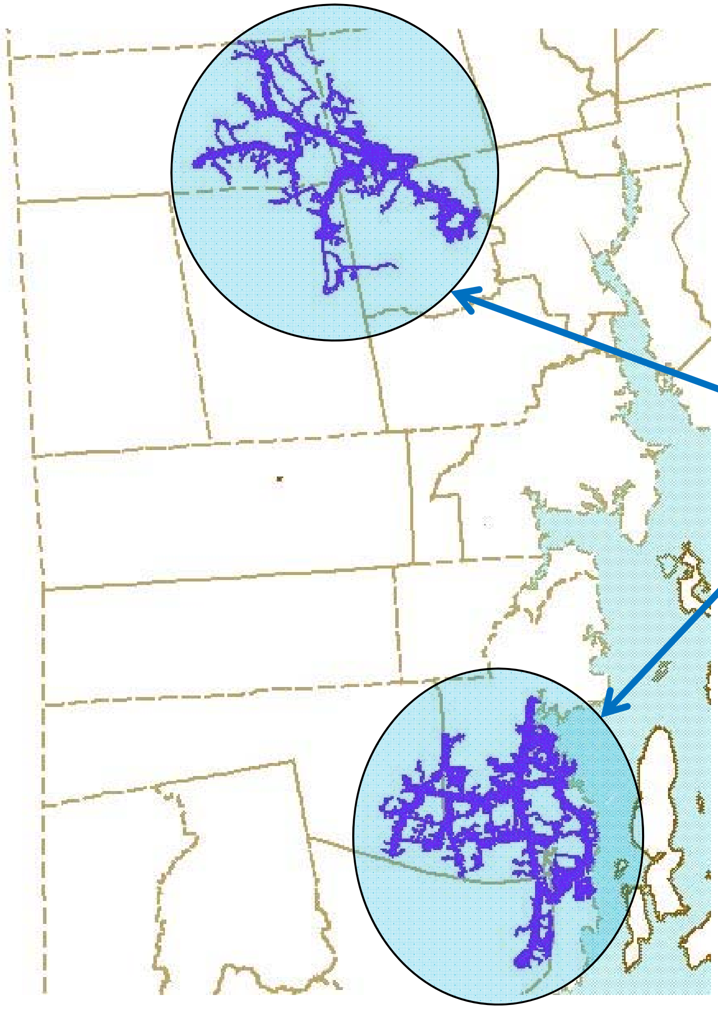
Rhode Island Volt VAR Optimization & Conservation Voltage Reduction (VVO/CVR)

December Update, 38F3 and 39F5 final M&V results, Cost and Benefit Estimates

Updates From July presentation in Red (slides 1-8), C/B information from slide 9 - end

Dec 2nd 2016 – Jim Perkinson

RI VVO/CVR Pilot Project Scope



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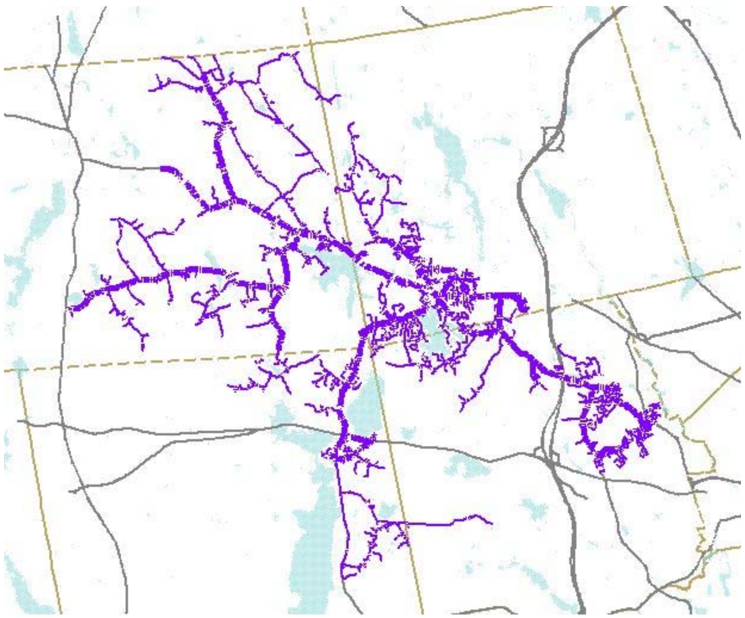

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Non- Regulator Tap operations, phase mean (daily)	16.3	14.0

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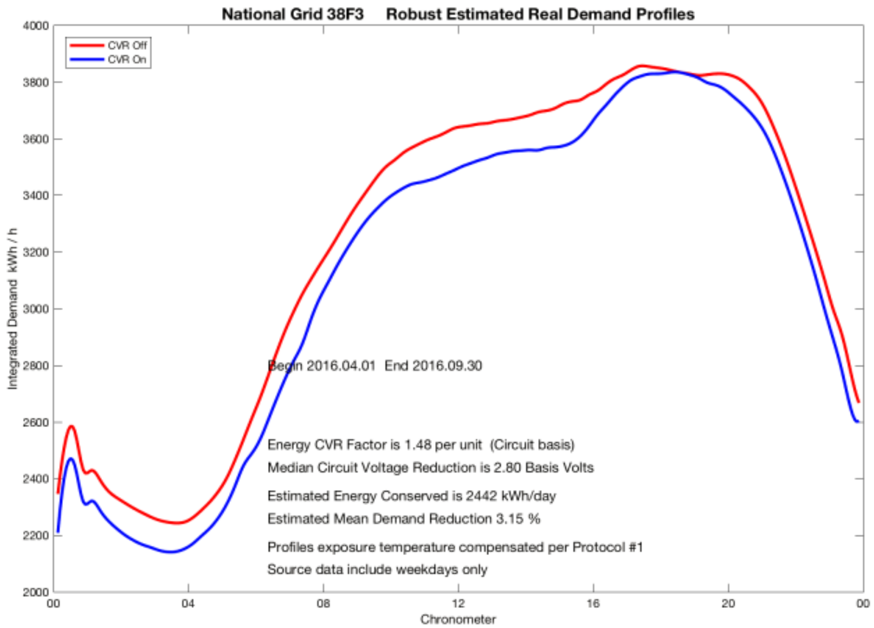
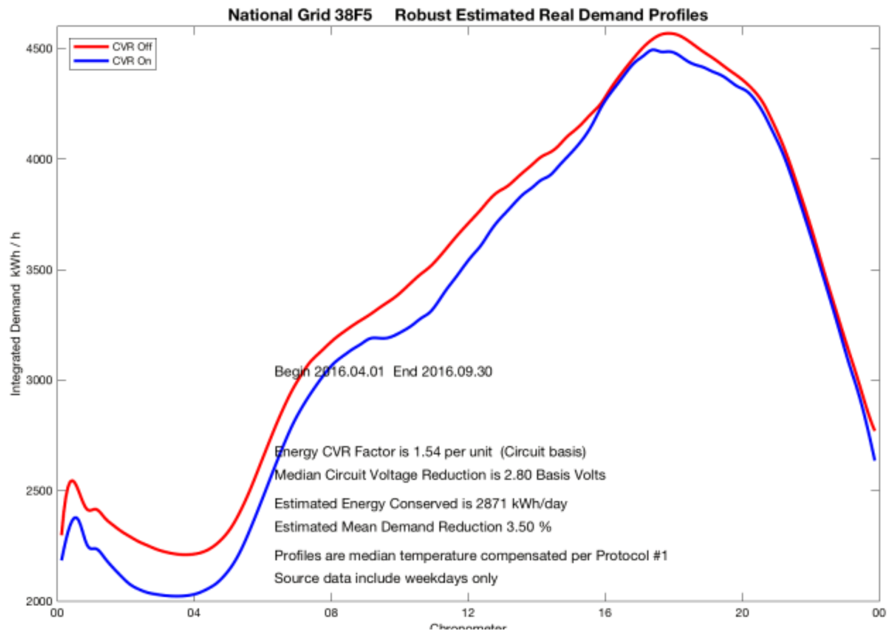


38F5



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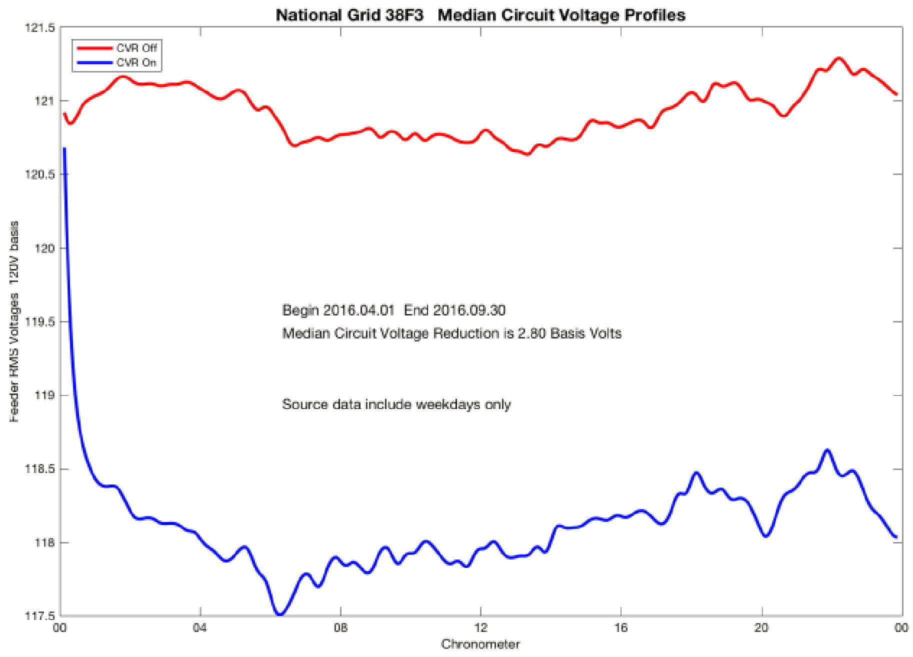
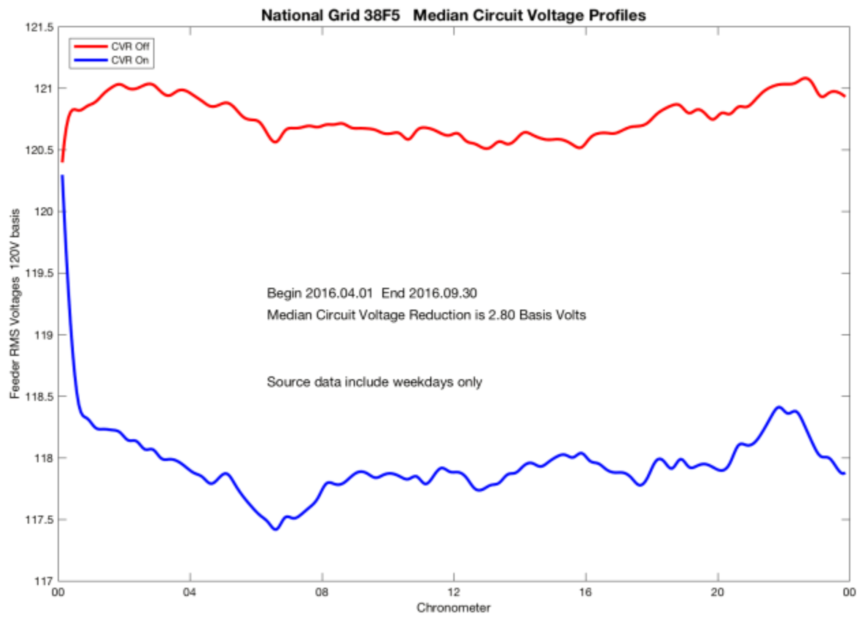


38F5



Median Voltage Differential Profiles

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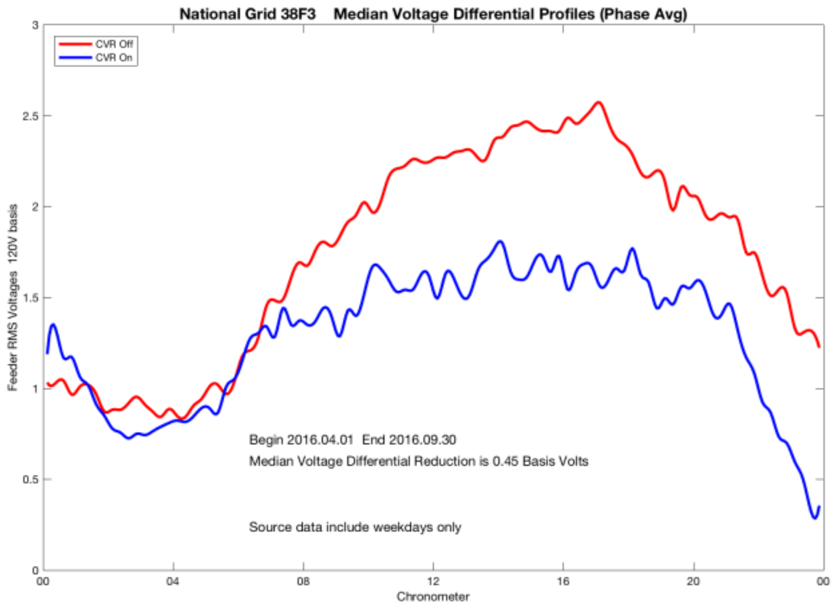

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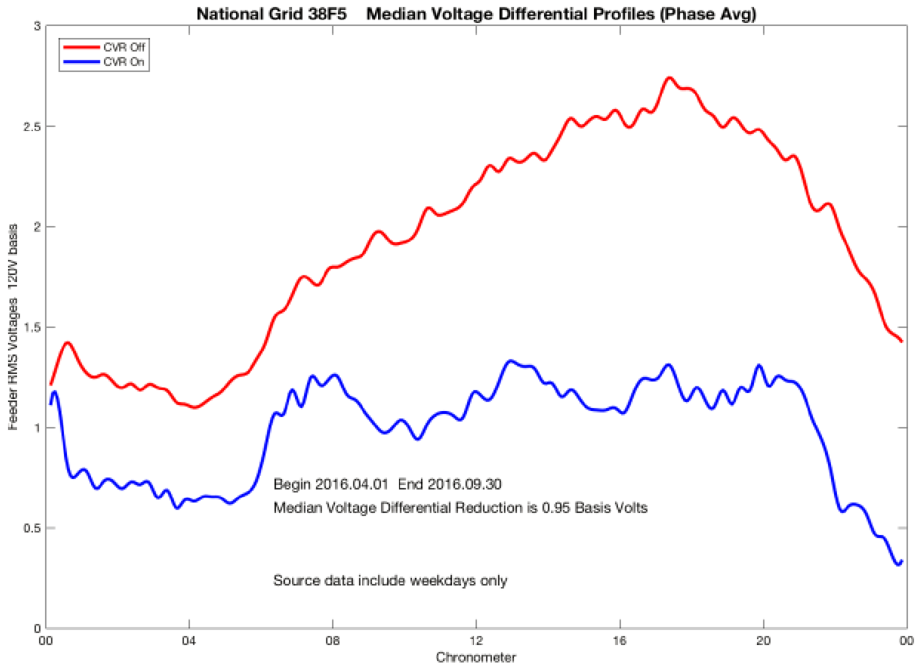

Preliminary Conclusions and Next Steps

Conclusions:

- Final M&V shows greater than 3% reduction in demand when using CVR Protocol #1.
- CVR factor for these circuits is in the 1.4-1.5 range.

Next Steps:

- Complete the Putnam Pike and Tower Hill areas, utilizing cellular communications to resolve communications challenges (to be completed FY17)
  - ~80% of devices ready for installation, remaining 20% to be finished in Dec.
  - ~30% of devices installed in Tower Hill. Remaining devices to be installed Dec-Feb
  - Remaining Putnam Pike devices to be commissioned by Jan
- Leverage IS/IT/OT infrastructure, and evaluate expanding VVO to future target areas in FY18 and beyond

Expansion Scope

The expansion proposed an additional 40 feeders

The Company anticipates spending **$8.6M of CAPEX (PV $10.4M)** to apply the technology to approximately 61,000 distribution customers over the next 4 years. When fully deployed, the program will have an annual O&M run the business cost of approximately **$0.300M**

The expected benefits include an estimated reduction in peak demand of 11.5 MW, and an annual energy reduction of 41 GWh. The equipment is expected to be in service for at least 15 years, and over that time horizon, this savings could yield a cumulative financial savings of **$24.7M** (PV) in avoided energy costs, as well as an estimated **$17.7M** (PV) in avoided capacity costs.

The expansion leverages the IS/OT infrastructure deployed during the pilot.

Expansion Scope

Over the next 4 years:

- 40 additional feeders will be brought online
- Each year, a grouping of substations and feeders will be selected for deployment within the following FY. This will ensure the company selects best value feeders to deploy the technology.
  - Feeders with high-benefit to cost ratios
  - Feeders that have recently gone through short and long term planning studies, and are unlikely to undergo major changes in the near term.
- FY18 substation and feeders have already been selected, and proposed in the proposed ISR.
  - Langworthy Corner #86, Tiogue Ave #100, Lincoln Ave #72 – (8 feeders total)
- FY19-FY21 Highest benefit-cost ratio substations were used to inform costs, refinement will be made before each FY to factor in recent system state.

Project Expansion Costs

	CAPEX	OPEX	COR	Total	Cumulative Feeders per year	Cumulative Customers Affected
FY17	$2,000,000	$0	$0	$2,000,000	0	0
FY18	$1,395,404	$265,870	$70,309	$1,731,583	8	20109
FY19	$1,267,572	$239,580	$75,011	$1,582,163	19	37300
FY20	$767,087	$148,673	$49,941	$965,701	27	46565
FY21	$1,594,411	$357,906	$83,166	$2,035,483	39	61324

- Costs include a $2M payment to Utilidata in FY17 to purchase licenses for the expansion at a discounted bulk price. These license will be applied to the projects from FY18-FY21
- Cost estimates are based on actual averages from installation of pilot devices.
- Pilot costs and benefits are not included in the benefit and cost analysis presented here.

Expansion Benefits

Benefits Monetized over a 15 year horizon:

- **Avoided Energy Costs**
  - **Utilized a conservative 3% energy reduction, realized starting the year following a feeder installation**
  - **Total of around 41 GWh (Based on 2015 loading)**
- **Avoided Capacity Costs**
  - **Utilized a conservative 3% demand reduction, benefit realized starting in 2021**
  - **Total of 11.5 MW of peak reduction (Based on 2015 loading)**
- **Benefits not Monetized:**
  - **Improved situational awareness of target feeders to better inform Operations**
  - **Improved interval data to better inform distribution planning and asset management**
  - **Direct Custom Bill Impacts are not considered as part of this analysis**

Avoided Energy Costs Calculation

Assumptions		Forecasted LMP AESC 2015 Appendix B: RI file pp. 320-321 Columns v-y 2015$/kWh	RI Wholesale Avoided Unit Cost of Electricity (grossed up for losses and WRP)	Constant 2015$/kWh: Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak	All Hours Weighted Average	All Hours Weighted Average Nominal$/GWh	Annual Energy Savings from VVO GWh	Annual Avoided Energy Cost from VVO Nominal$
Losses	7.2%	2015	lookup index>	1	2	3	4			nput Annual GWl	(Result)
Wholesale Risk Premium (WRP)	9.0%	0.0732	2015	0.0855	0.0758	0.0460	0.0353	0.0671	$67,104.14	0	$0.00
		0.0649	2016	0.0777	0.0721	0.0549	0.0356	0.0648	$66,001.81	0	$0.00
Winter months/year	8	0.0394	2017	0.0743	0.0689	0.0568	0.0422	0.0640	$66,476.44	0.00	$0.00
Summer months/year	4	0.0302	2018	0.0630	0.0576	0.0556	0.0458	0.0569	$60,208.47	7.43	$447,572.77
Hrs/wk	168	2016	2019	0.0620	0.0568	0.0553	0.0453	0.0562	$60,565.10	10.10	$611,632.86
Peak hrs/wk	80	0.0665	2020	0.0605	0.0548	0.0556	0.0434	0.0547	$60,093.44	21.90	$1,316,293.41
Off-peak hrs/wk	88	0.0617	2021	0.0630	0.0575	0.0589	0.0467	0.0576	$64,386.09	33.87	$2,180,628.63
		0.047	2022	0.0667	0.0606	0.0620	0.0493	0.0608	$69,285.87	40.94	$2,836,730.17
Inflation	1.88%	0.0305	2023	0.0684	0.0627	0.0665	0.0522	0.0633	$73,453.75	40.94	$3,007,373.01
		2017	2024	0.0708	0.0652	0.0666	0.0549	0.0654	$77,345.91	40.94	$3,166,727.45
Constant$ to Nominal$ Conversion Index		0.0636	2025	0.0754	0.0675	0.0727	0.0569	0.0690	$83,105.79	40.94	$3,402,550.89
2015	1	0.059	2026	0.0770	0.0701	0.0778	0.0601	0.0718	$88,085.14	40.94	$3,606,417.34
2016	1.02	0.0486	2027	0.0785	0.0723	0.0751	0.0620	0.0729	$91,213.87	40.94	$3,734,514.90
2017	1.04	0.0361	2028	0.0804	0.0748	0.0804	0.0650	0.0757	$96,489.51	40.94	$3,950,512.35
2018	1.06	2018	2029	0.0849	0.0795	0.0839	0.0680	0.0799	$103,710.25	40.94	$4,246,146.96
2019	1.08	0.0539	2030	0.0930	0.0832	0.1024	0.0737	0.0877	$115,968.00	40.94	$4,748,008.57
2020	1.10	0.0493	2031	0.0964	0.0865	0.1071	0.0769	0.0912	$122,903.11	40.94	$5,031,948.66

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Avoided Capacity Costs Calculation

Assumptions	
Incorporated Losses	8.0%
Wholesale Risk Premium (WRP)	9.0%
Reserve Margin	17.0%
Capacity Multiplier	1.38
Inflation	1.88%
Constant$ to Nominal$ Conversion Index	
2015	1
2016	1.02
2017	1.04
2018	1.06
2019	1.08
2020	1.10
2021	1.12
2022	1.14
2023	1.16

	Unit Cost of Electric Capacity (FCA price grossed up for RM, losses, a				
	Constant 2015$/kW-yr		Avoided Capacity Cost Nominal $/GW-yr	Annual Capacity Savings from VVO (Input GW-yr)	Annual Avoided Capacity Cost from VVO Nominal $
	FCA Price				
	(AESC 2015 App. B: RI file pp. 320-321 Column ab)	FCA Price grossed up for RM, losses, and WRP			
2015	$39.67	$54.64	$54,638,443.08	-	$ -
2016	$38.16	$52.56	$53,546,787.10	-	$ -
2017	$114.53	$157.74	$163,731,879.99	-	$ -
2018	$132.93	$183.09	$193,609,172.52	0.0027	$ -
2019	$123.29	$169.81	$182,944,649.72	0.0034	$ -
2020	$135.75	$186.97	$205,220,449.67	0.0065	$ -
2021	$138.60	$190.90	$213,468,089.48	0.0097	$ 2,072,942.01
2022	$139.90	$192.69	$219,521,157.35	0.0115	$ 2,529,761.40
2023	$137.73	$189.70	$220,179,130.83	0.0115	$ 2,537,343.89
2024	$140.57	$193.61	$228,943,957.98	0.0115	$ 2,638,349.74
2025	$143.50	$197.65	$238,109,859.72	0.0115	$ 2,743,977.57
2026	$144.08	$198.44	$243,566,813.36	0.0115	$ 2,806,863.50
2027	$142.75	$196.61	$245,855,239.20	0.0115	$ 2,833,235.31
2028	$146.18	$201.34	$256,495,791.95	0.0115	$ 2,955,857.02
2029	$151.86	$209.16	$271,471,735.15	0.0115	$ 3,128,439.76
2030	$153.53	$211.46	$279,616,895.44	0.0115	$ 3,222,304.57
2031	$147.00	$202.47	$272,757,330.04	0.0115	$ 3,143,254.96

For an efficiency program that produces reductions starting in 2016, there is no benefit of a reduction in peak demand until 2020, at which point the annual benefit is calculated as follows:
kW reduction at the meter during system peak in a given year × summer peak-hour losses from the ISO delivery points to the end use × the Avoided Unit Cost of Capacity for that year, which is the FCA price for that year adjusted upward by the reserve margin that ISO-NE requires for that year, distribution losses (user defined), by the PTF losses, and the wholesale risk premium (AESC 2015 p. A-8).

Benefit-Cost Ratios

Costs:

PV Project Installation Costs (Capex/Opex/CoR), FY17-FY21:

- **$7.3M**

PV Run The Business costs: FY17-FY31:

- **$3.1M**

- **PV Total Cost: $10.4M**

Benefits:

PV Avoided Energy Costs FY17-FY31:

- **$24.7M**

PV Avoided Capacity Costs : FY17-FY31:

- **$17.7M**

- **PV Total Benefit: $42.5M**

B:C ratio – 4.11

Measurement & Verification Results

National Grid – Putnam Pike April 2016 to September 2016

November 2016

This document contains Utilidata's measurement and verification analysis of National Grid's 38F3 and 38F5 feeders served by the Putnam Pike substation.

Contents

Executive Summary

Utilidata is pleased to provide results of the measurement and verification analysis for National Grid's 38F3 and 38F5 feeders served by the Putnam Pike substation. The following table summarizes the results of the study, which took place from April 1, 2016 to September 30, 2016.

Putnam Pike substation – Feeder analysis

Metric	Feeder 38F3	Feeder 38F5
VVO Mode days	29	36
Non-VVO Mode days	59	52
Real CVR Factor (per unit)	1.48	1.54
Demand Reduction (%)	3.15	3.50
Voltage Reduction, Spatial Avg %	2.33	2.33
Voltage Leveling Improvement (basis volts)	0.45	0.95
VVO Regulator tap ops, phase mean (daily)	14.6	13.1
Non-VVO Regulator tap ops, phase mean (daily)	16.3	14.0

These results are consistent with loads generally comprising significant air conditioning and refrigeration. As expected, favorable summer season CVR factors consistent with such loads are confirmed by this analysis. Although the sample size is small given the limited number of qualified experimental time series records, the residual variances estimated in this analysis are consistent with those typically observed in distribution circuit loads. The tap operations rate remained basically flat; that is, the differences in tap rate are not statistically significant.

The following sections contain more information on the experiment and individual graphs for tap operations and voltage profiles on each feeder.

We will continue to collect data and provide additional updates as requested.

General Observations

The following are general observations about the test results.

(1) The CVR factors estimated for the subject circuits are consistent with those expected for circuits serving mixed residential and light commercial loads in a temperate season; the demand response to reduced voltage clearly indicates the presence of air conditioning and mechanical refrigeration in the served load.

(2) The availability of integral signal records is marginal to average, because system operations were subject to some interruptions due to telemetry failures; energy conservation is optimized when such interruptions are rare.

(3) The residual variance in the stated estimates is typical for distribution circuits.

(4) There is no evidence of distinct demand processes in this experiment.

(5) The dependence of demand on ambient temperature for the subject circuits manifested minimal temperature dependence in the heating demand regime. The demand process, instead, behaved almost as expected for the neutral regime. This effect does not degrade the analysis in any way, since the procedure naturally accommodates such variations.

(6) Loads for which the estimated CVR factors exceed unity will generally manifest further efficiency improvements with additional voltage reductions; Utilidata anticipates that this is the case for the loads served by the subject circuits.

(7) Realized voltage reductions, and the consequent demand reductions, are not uniform across phases in either of the circuits under study. Circuit voltage uniformity was improved by AdaptiVolt; refer to the per-phase voltage graphics for details.

(8) Estimated demand profiles for circuit 38F3 were summed post-regression, since demand metering by phase was reported. Estimated demand profiles for circuit 38F5 were computed using three-phase aggregate demand signals as reported.

Analyst Notes

The following are notes about the test prepared by the Utilidata analyst.

(1) The conservation performance results are calculated using the analysis method outlined Automated CVR Protocol # 1. This method implements the MCD robust regression procedure across ensembles of time series of demand measurements and, in its present formulation, requires that each member record of an ensemble comprise a full 24-hour operational record. Any record in which either the CVR operation was interrupted or the data recordings were defective for any reason are excluded from these analyses. Regime voltages are estimated by minimizing the mutual summation of the Euclidean distances between all the voltage observations in each regime. This estimate is known as the L1 median.

(2) Time series records were smoothed prior to ensemble selection and regression. The smoothing procedure preserves the signal mean over the smoothing interval such that the signal of interest is not biased. (*Smoothing and differentiation by simplified least squares procedures,* Abraham Savitzky and M. J. E. Golay, Analytical Chemistry, Vol. 36, No. 8 [July 1964], pp. 1627–1639))

(3) All reported demand profiles (real, reactive, current) are compensated for ambient temperature as specified in Protocol # 1. These profiles therefore represent the expected demands, not to be confused with the demands recorded for any individual day during the experiment.

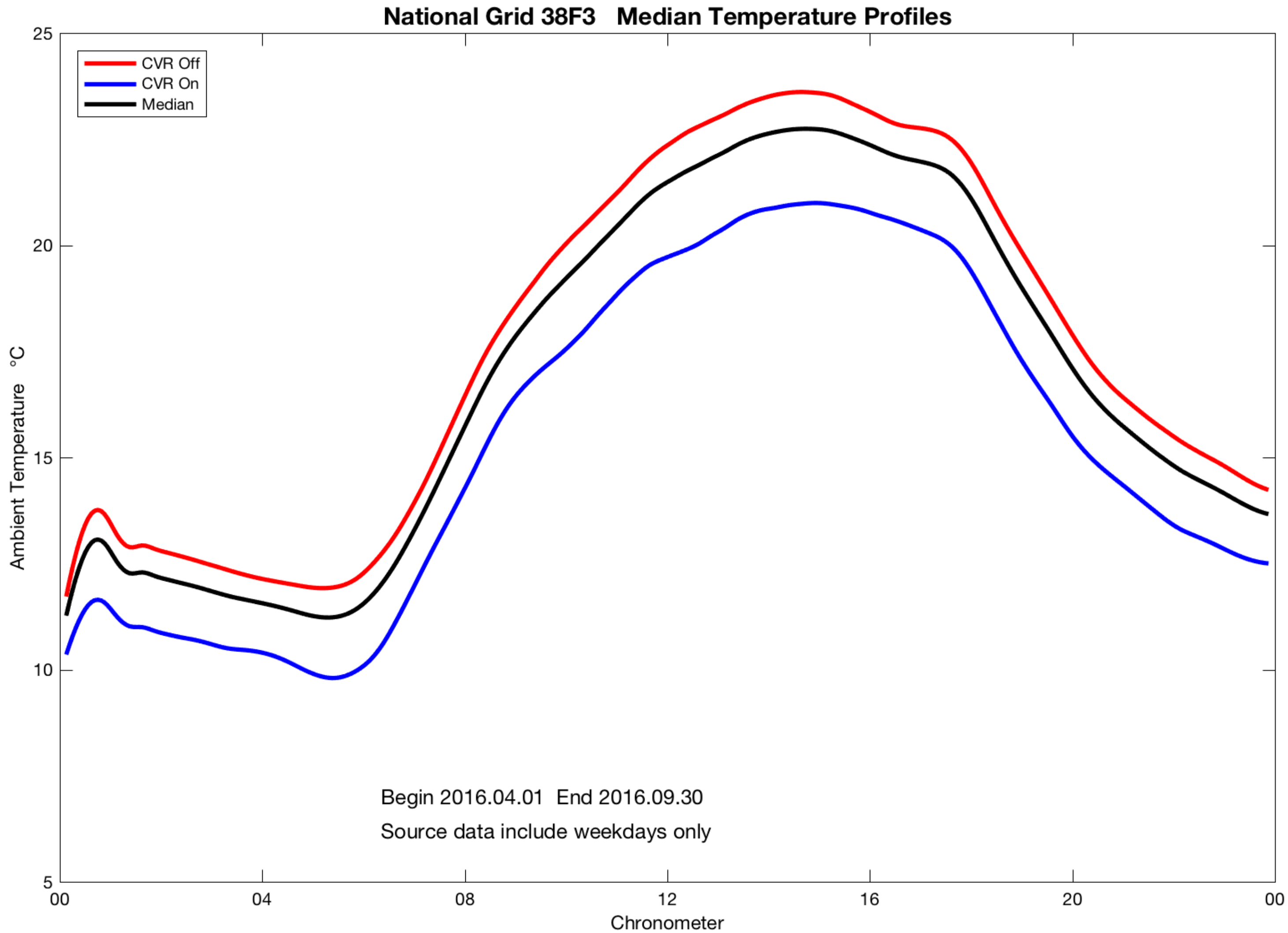
(4) Weekend demands are excluded from the present analysis; the distinctly different consumer weekend behavior results in an identifiably different demand process, which must be excluded in accordance with the requirements of Protocol #1.

Feeder 38F3 Results

This section contains graphs illustrating the results of the measurement and verification analysis for the 38F3 feeder served by the Putnam Pike substation.

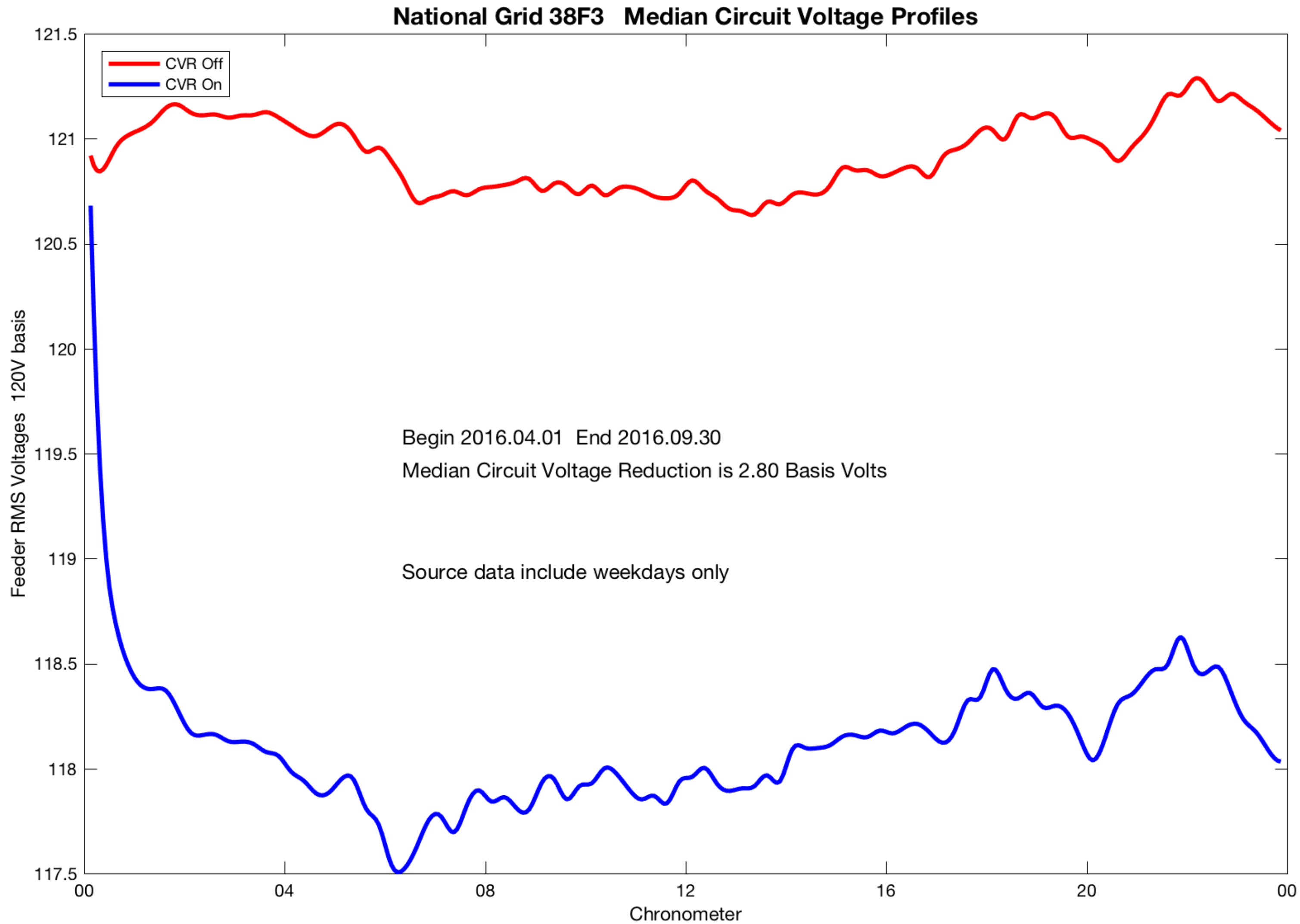
Feedder 38F3: Median Temperature Profiles

Graph 1



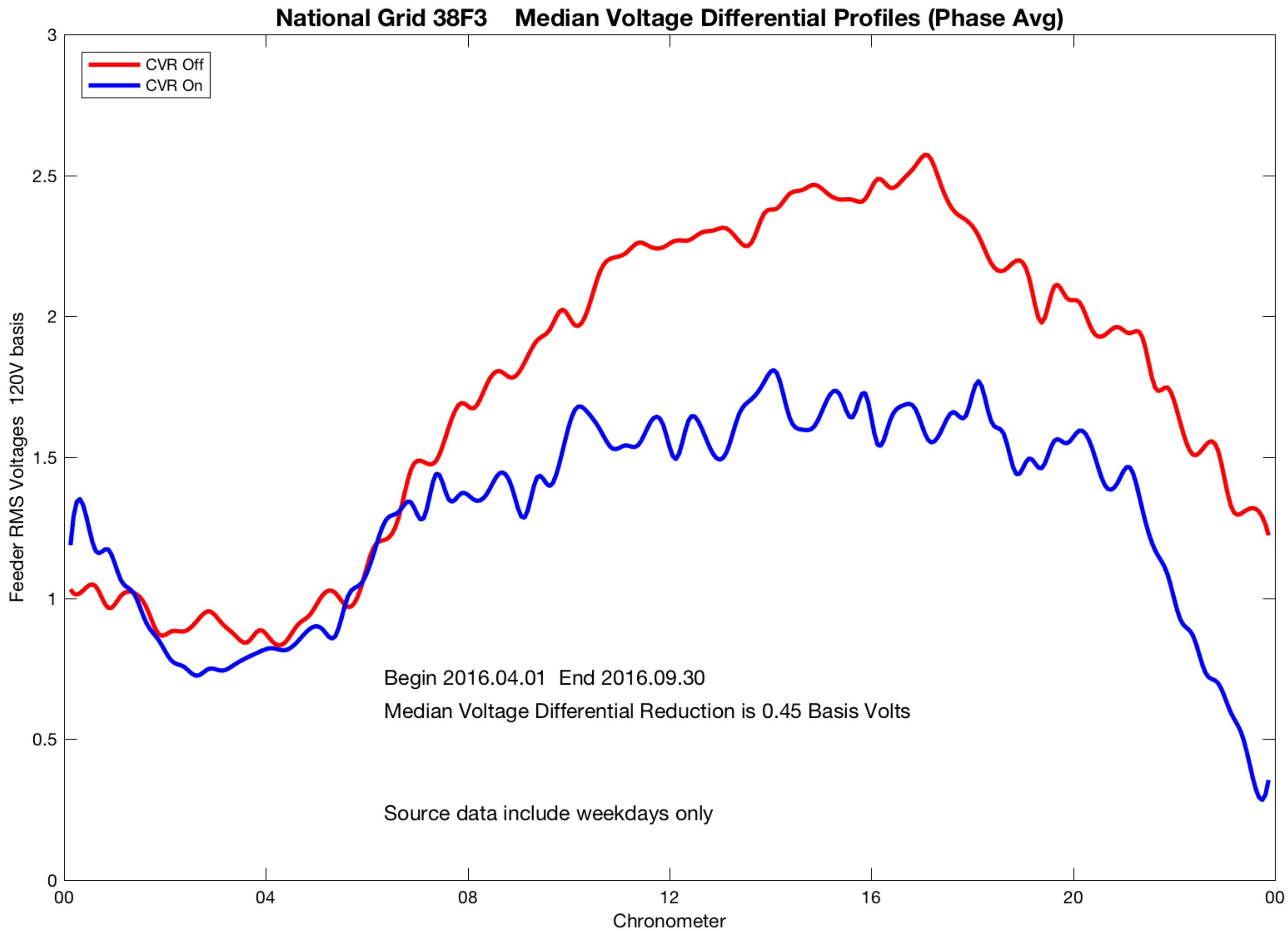
Feedester 38F3: Median Circuit Voltage Profiles

<u>Graph 2</u>



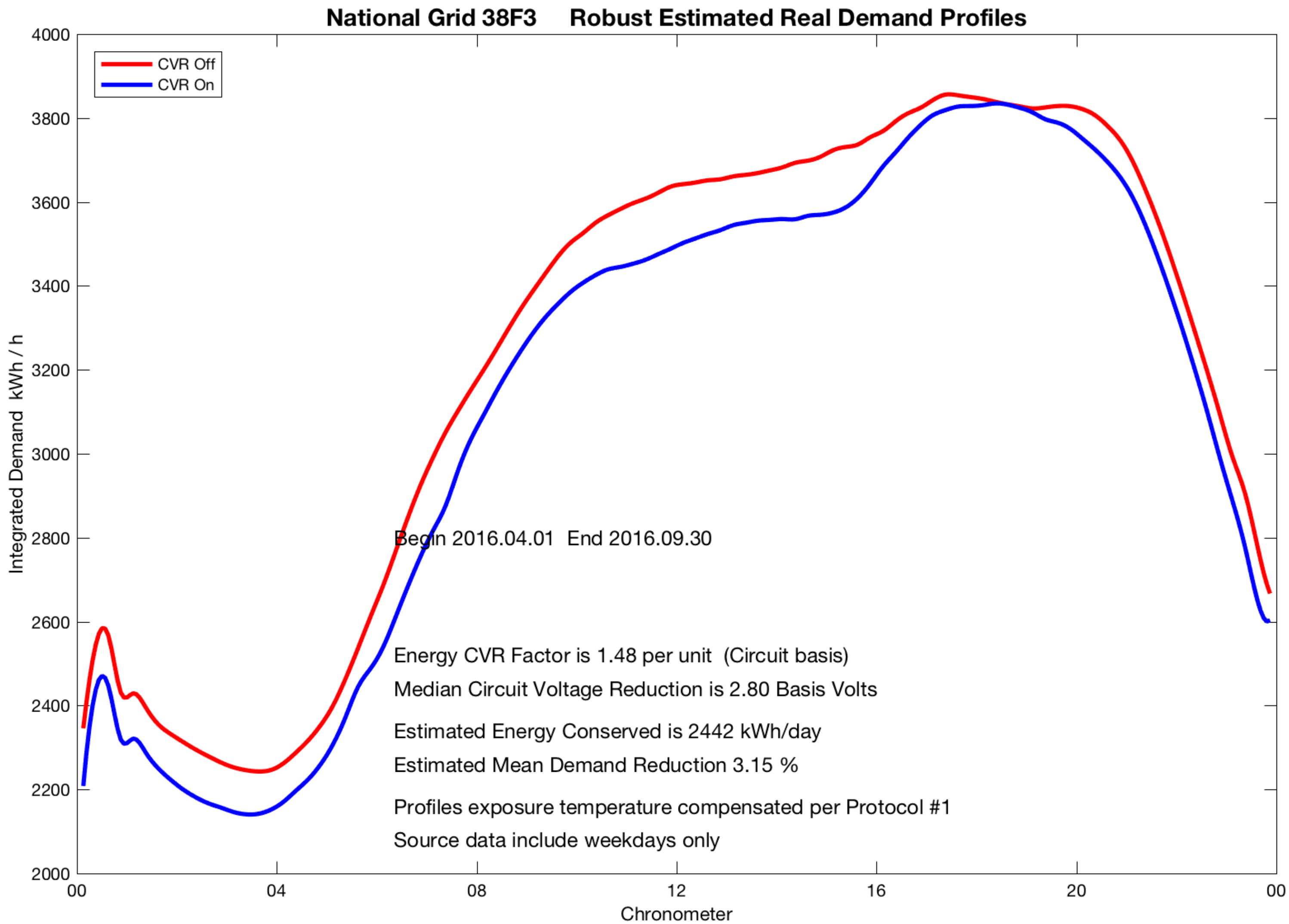
Feeder 38F3: Median Voltage Differential Profiles (Phase Avg)

Graph 3



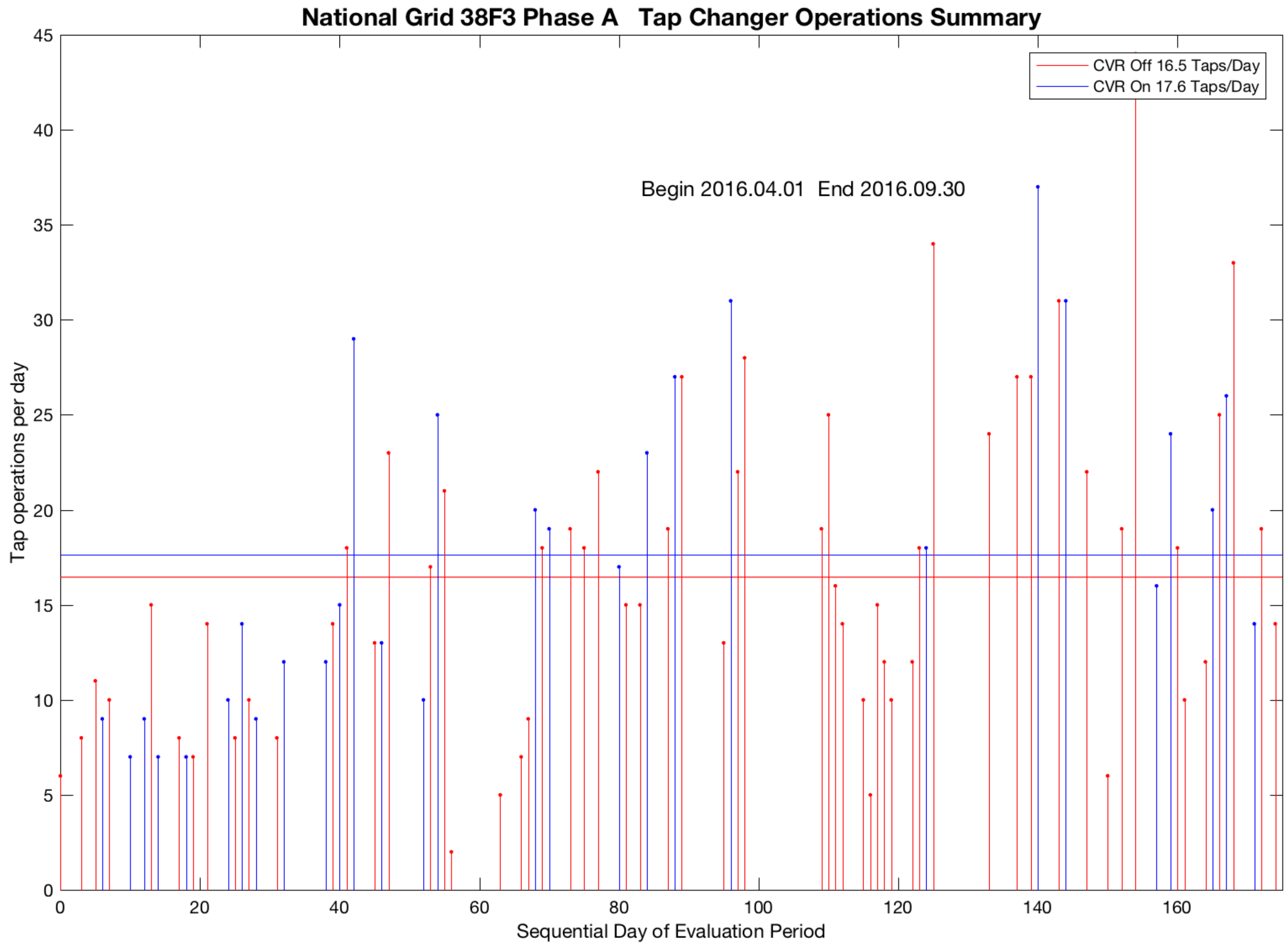
Feeder 38F3: Robust Estimated Real Demand Profiles

Graph 4



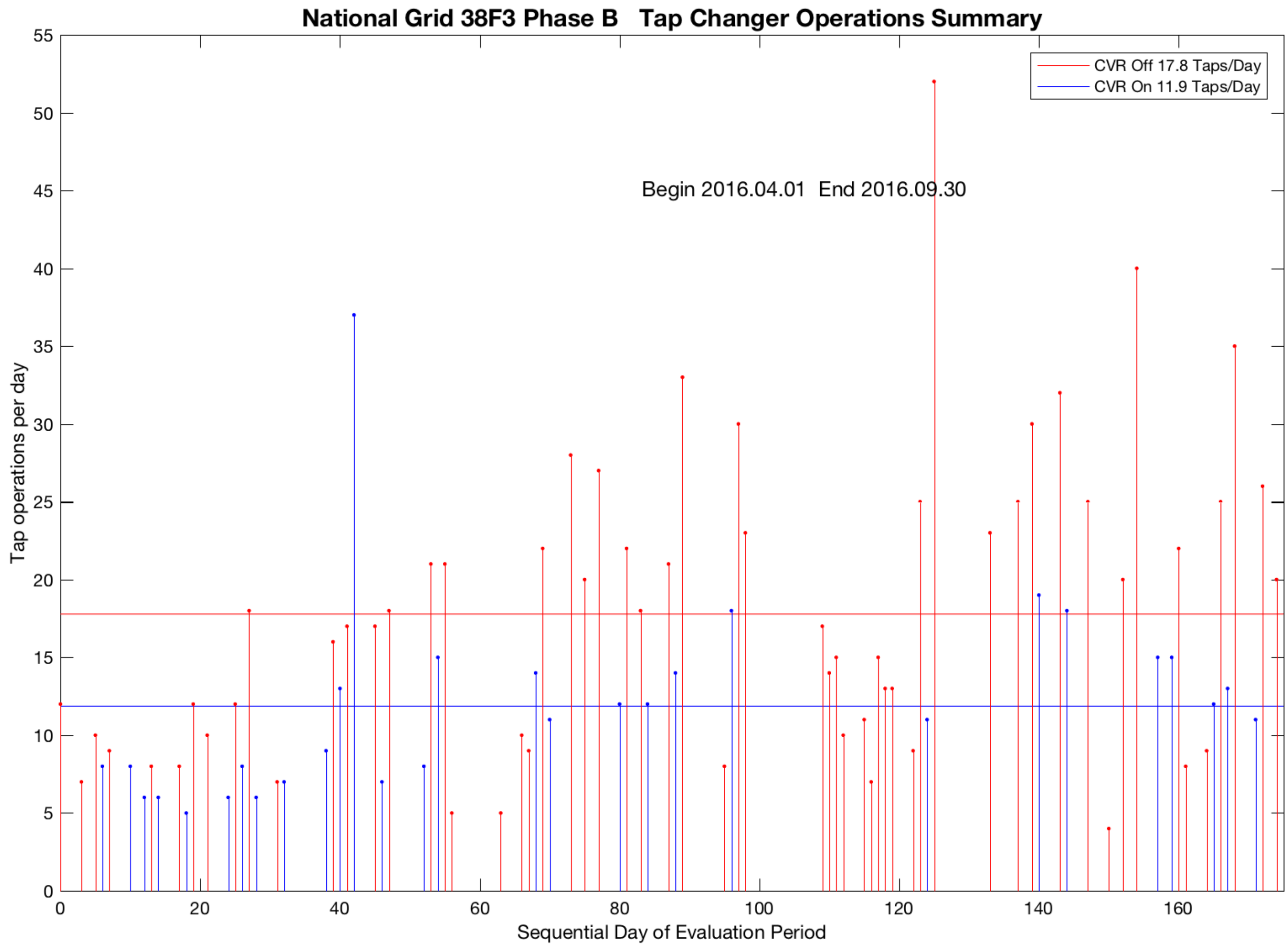
Feeder 38F3: Phase A – Tap Changer Operations Summary

Graph 5



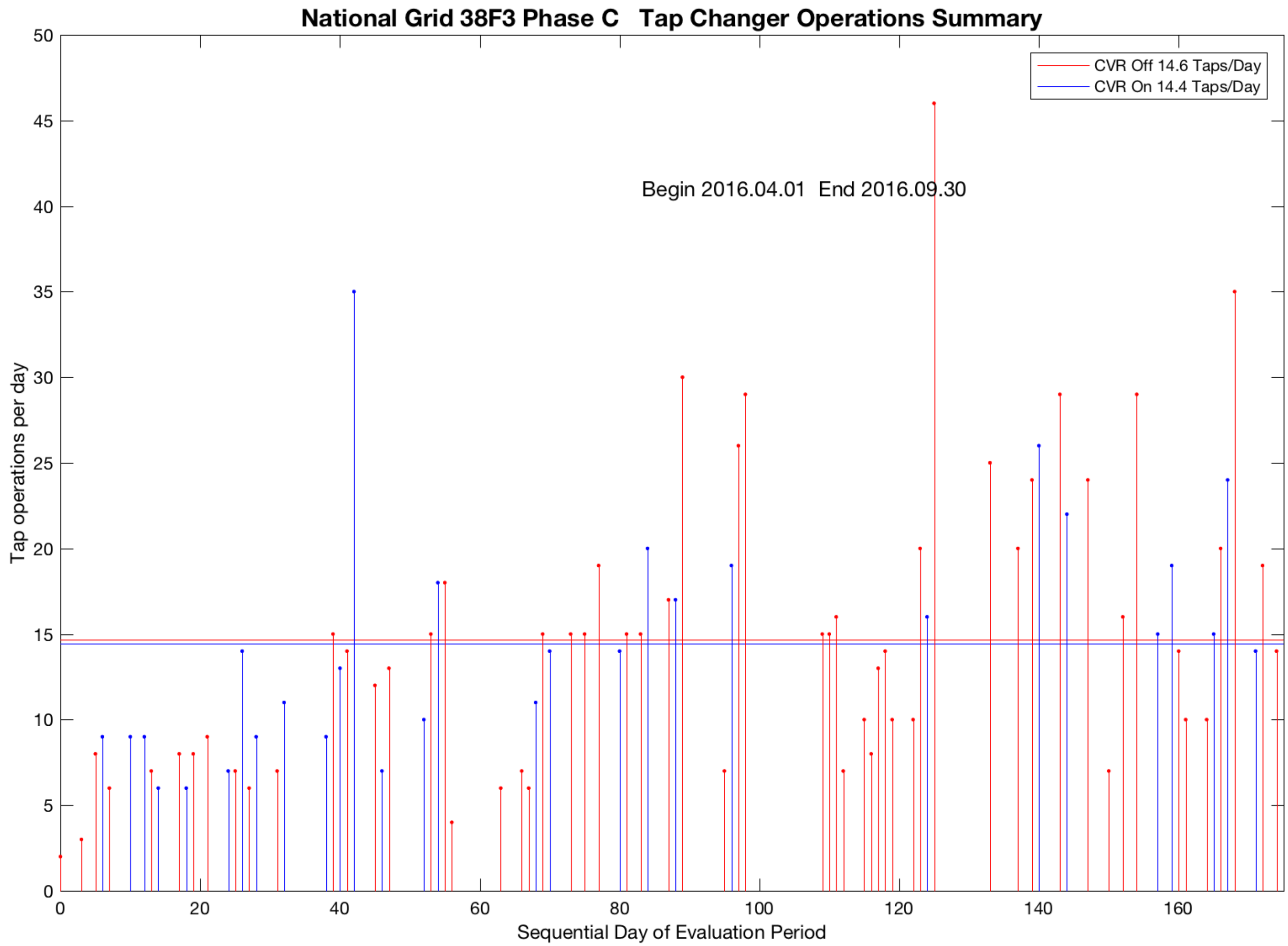
Feeder 38F3: Phase B – Tap Changer Operations Summary

Graph 6



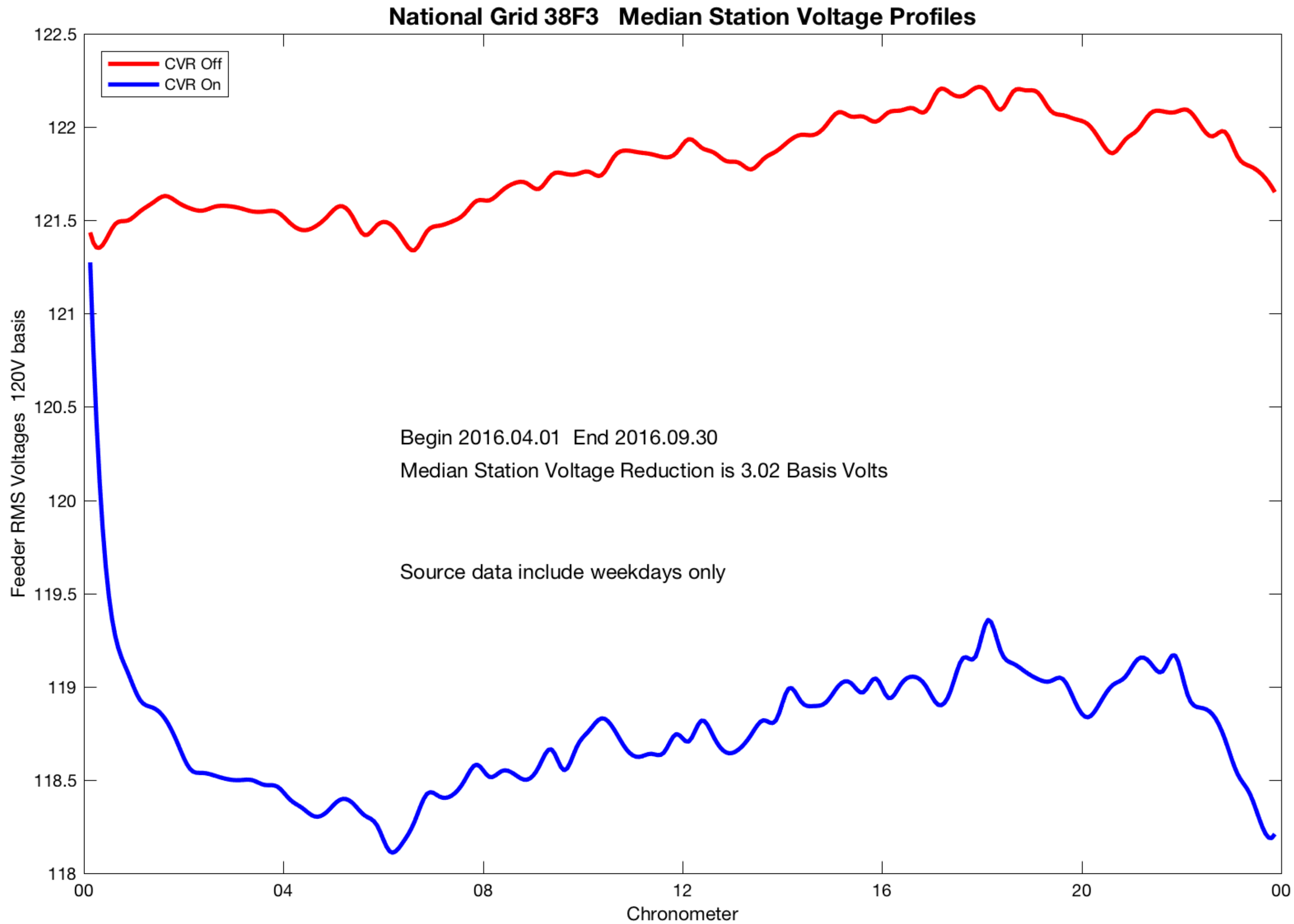
Feeder 38F3: Phase C – Tap Changer Operations Summary

Graph 7



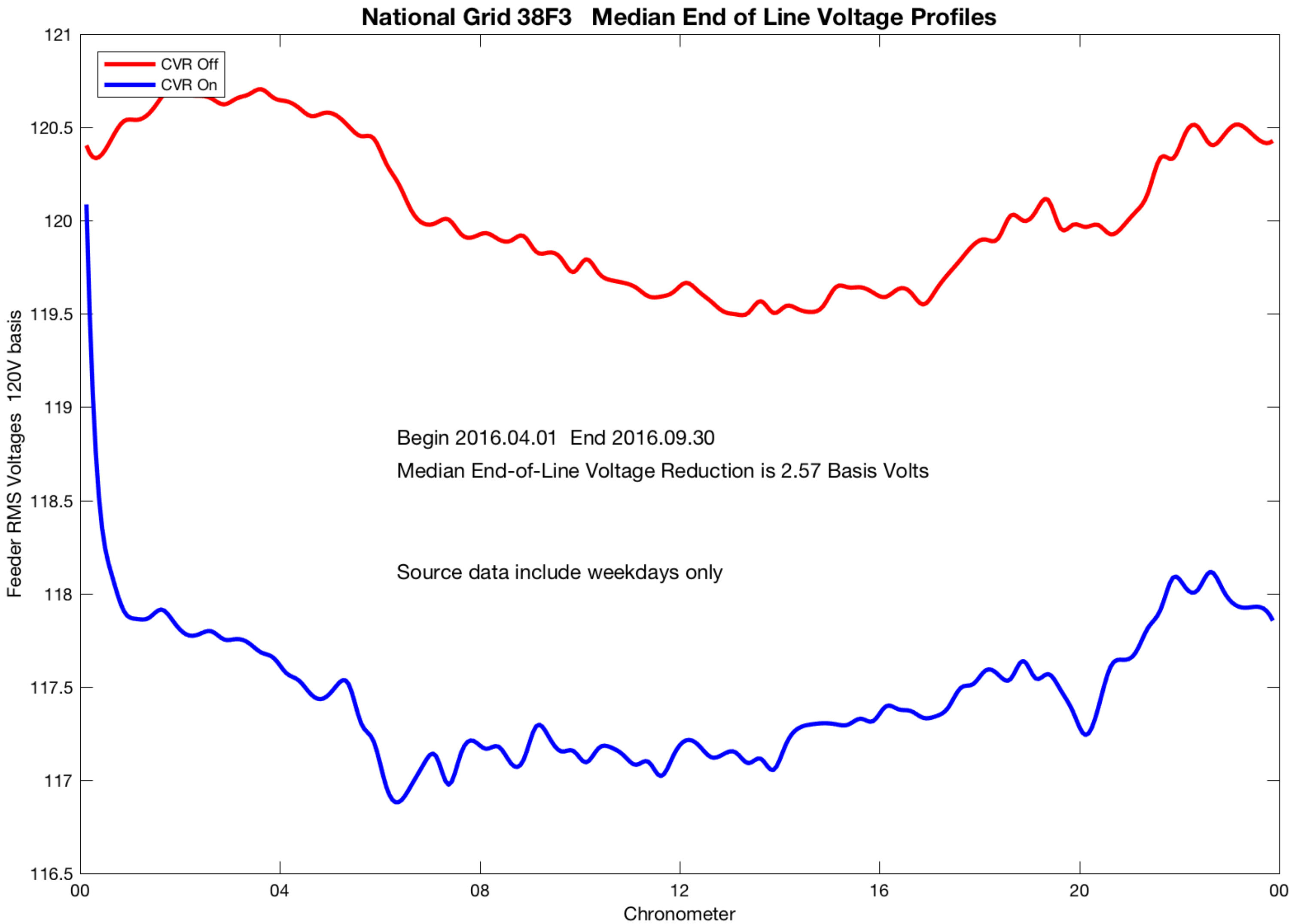
Feeder 38F3: Median Station Voltage Profiles

Graph 8



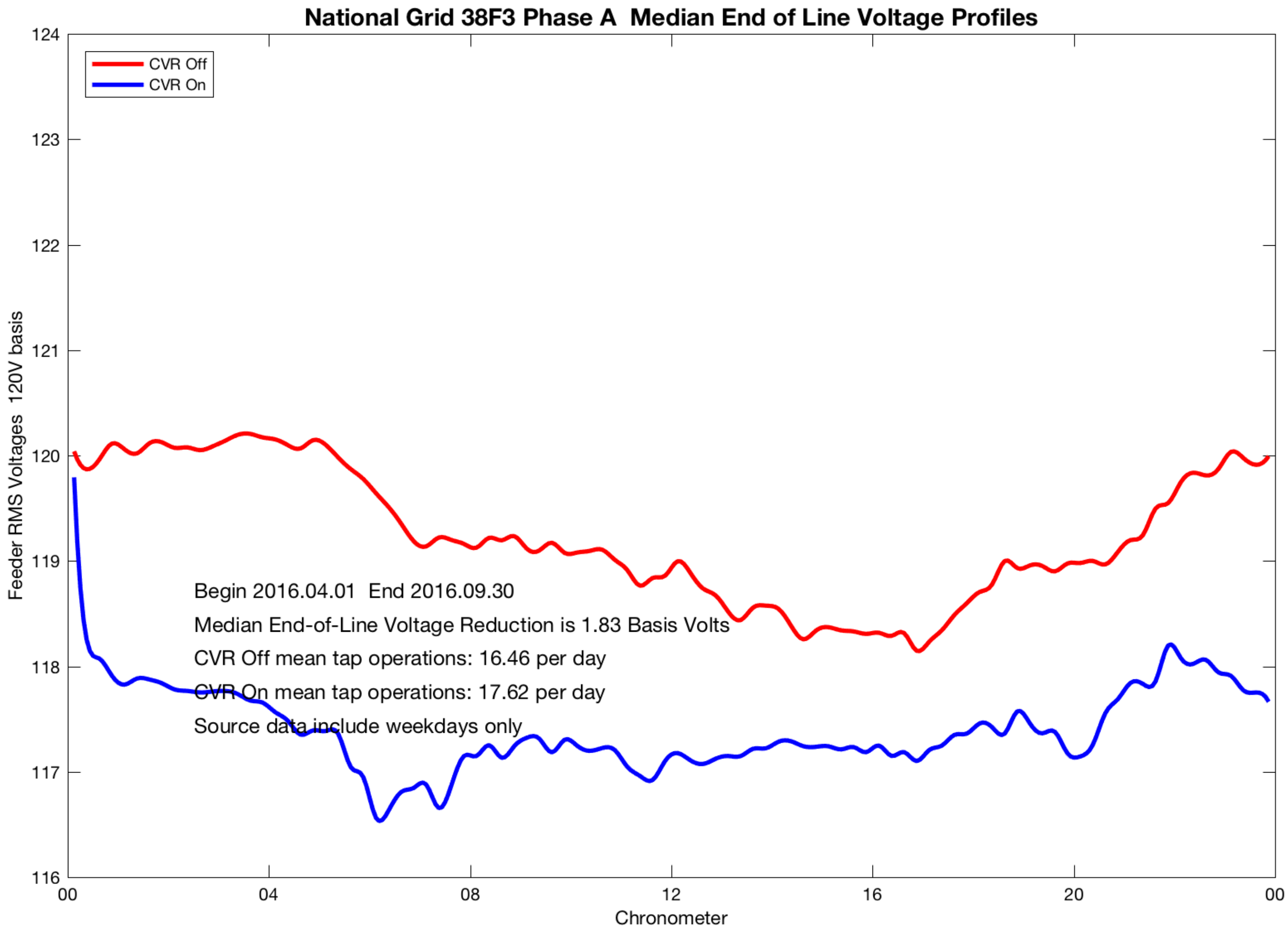
Feeder 38F3: Median End of Line Voltage Profiles (Phase Avg)

Graph 9



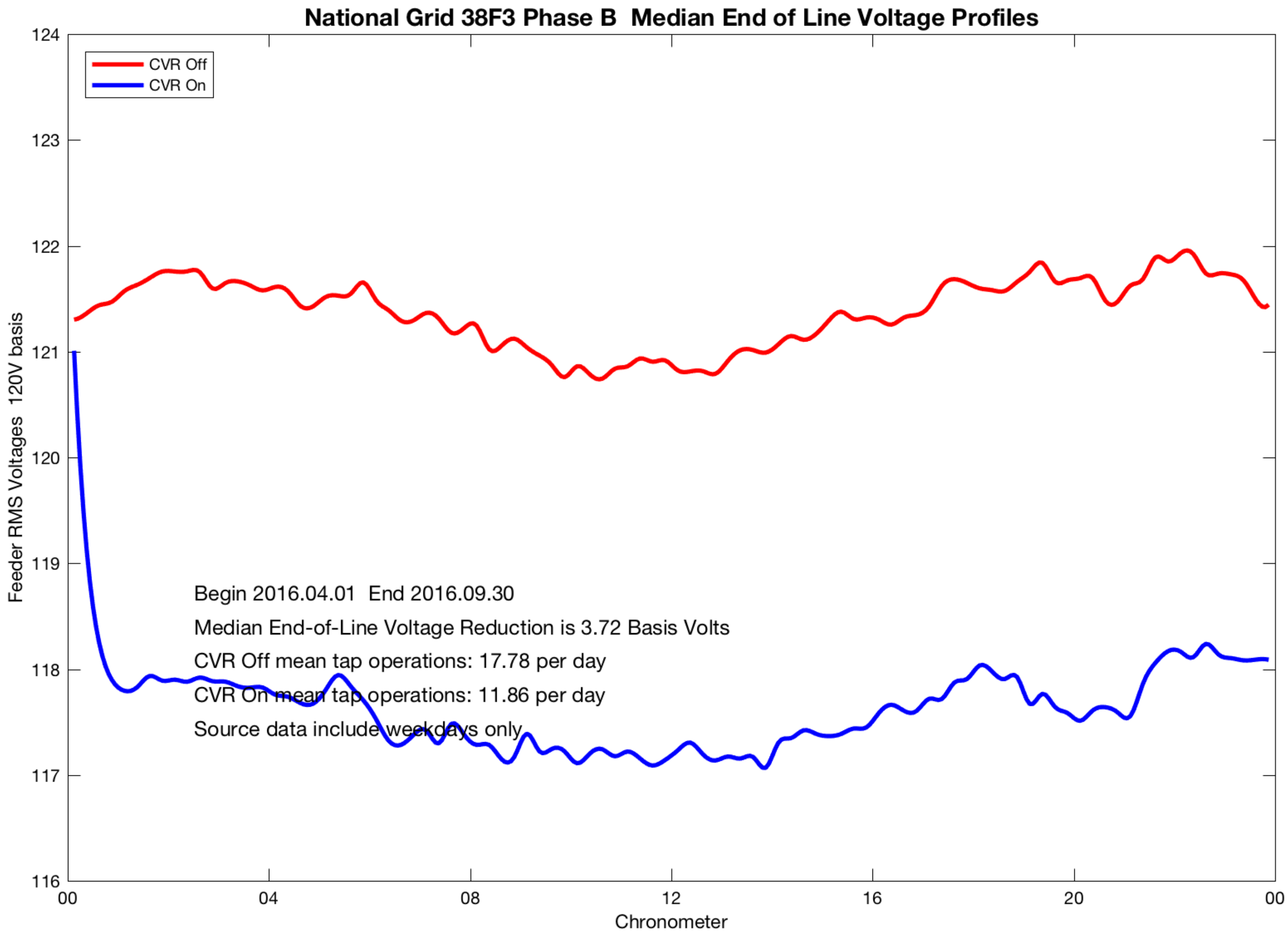
Feeder 38F3: Phase A – Median End of Line Voltage Profiles

Graph 10



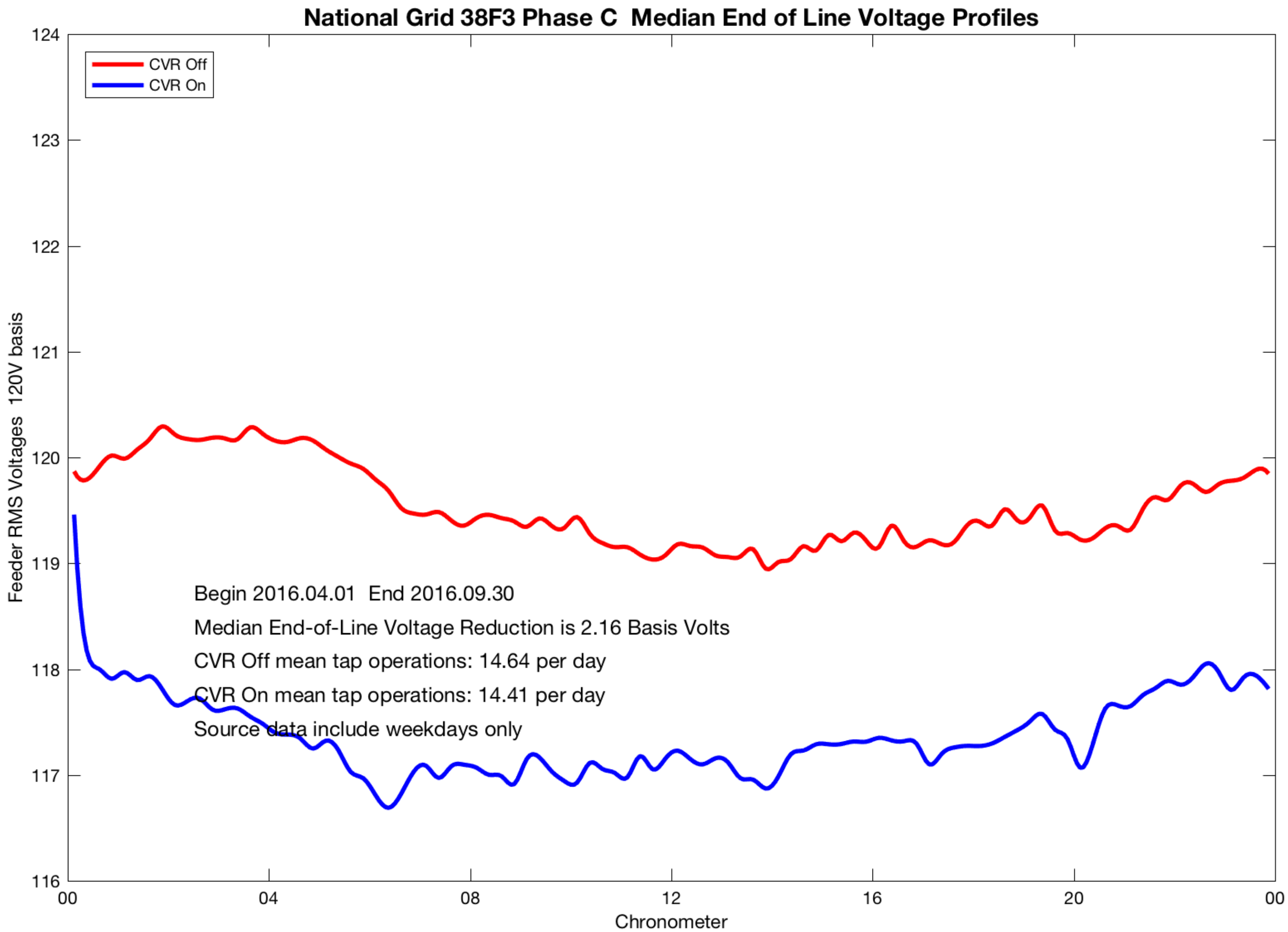
Feeder 38F3: Phase B – Median End of Line Voltage Profiles

Graph 11



Feeder 38F3: Phase C – Median End of Line Voltage Profiles

Graph 12

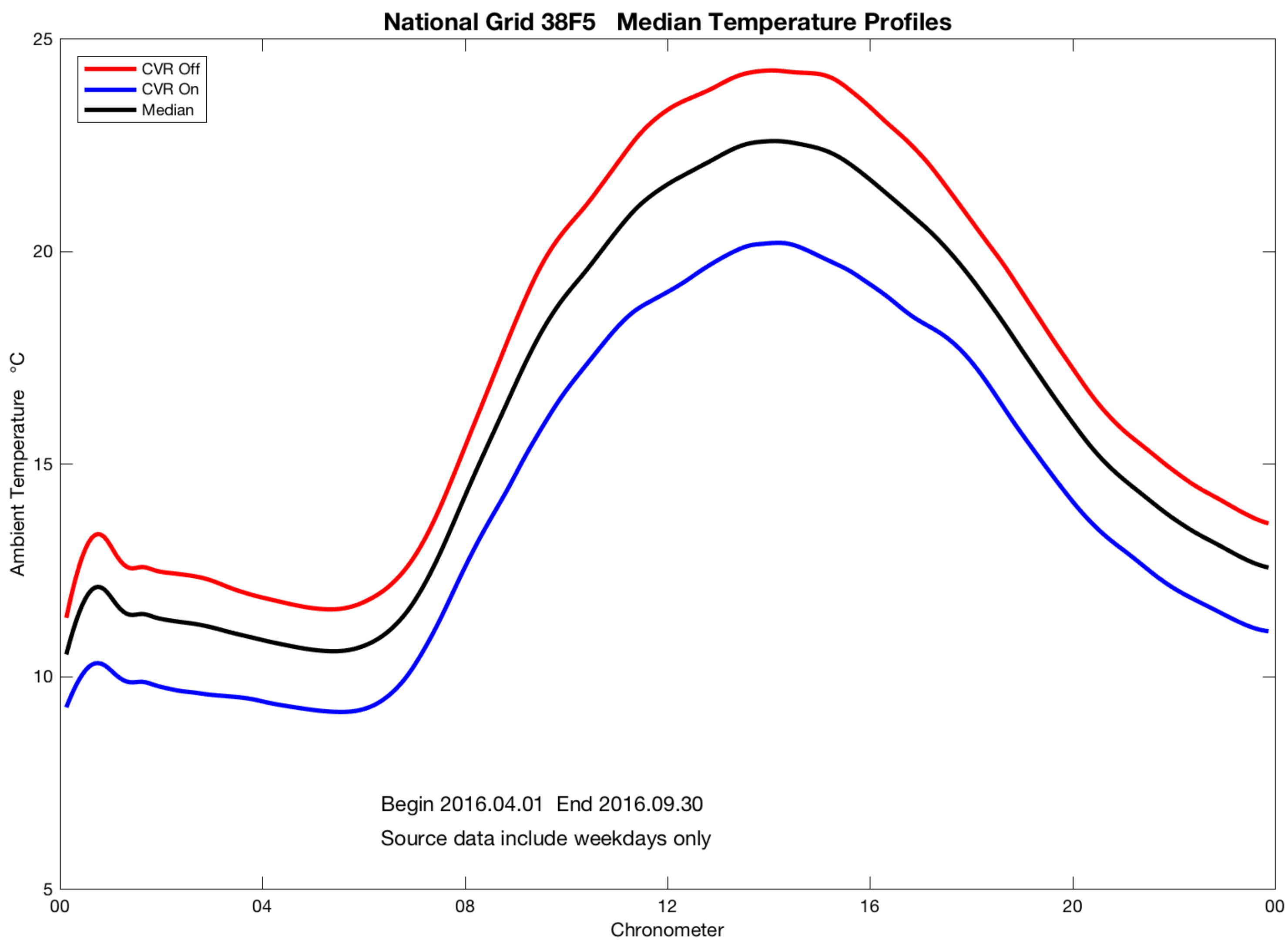


Feeder 38F5 Results

This section contains graphs illustrating the results of the measurement and verification analysis for the 38F5 feeder served by the Putnam Pike substation.

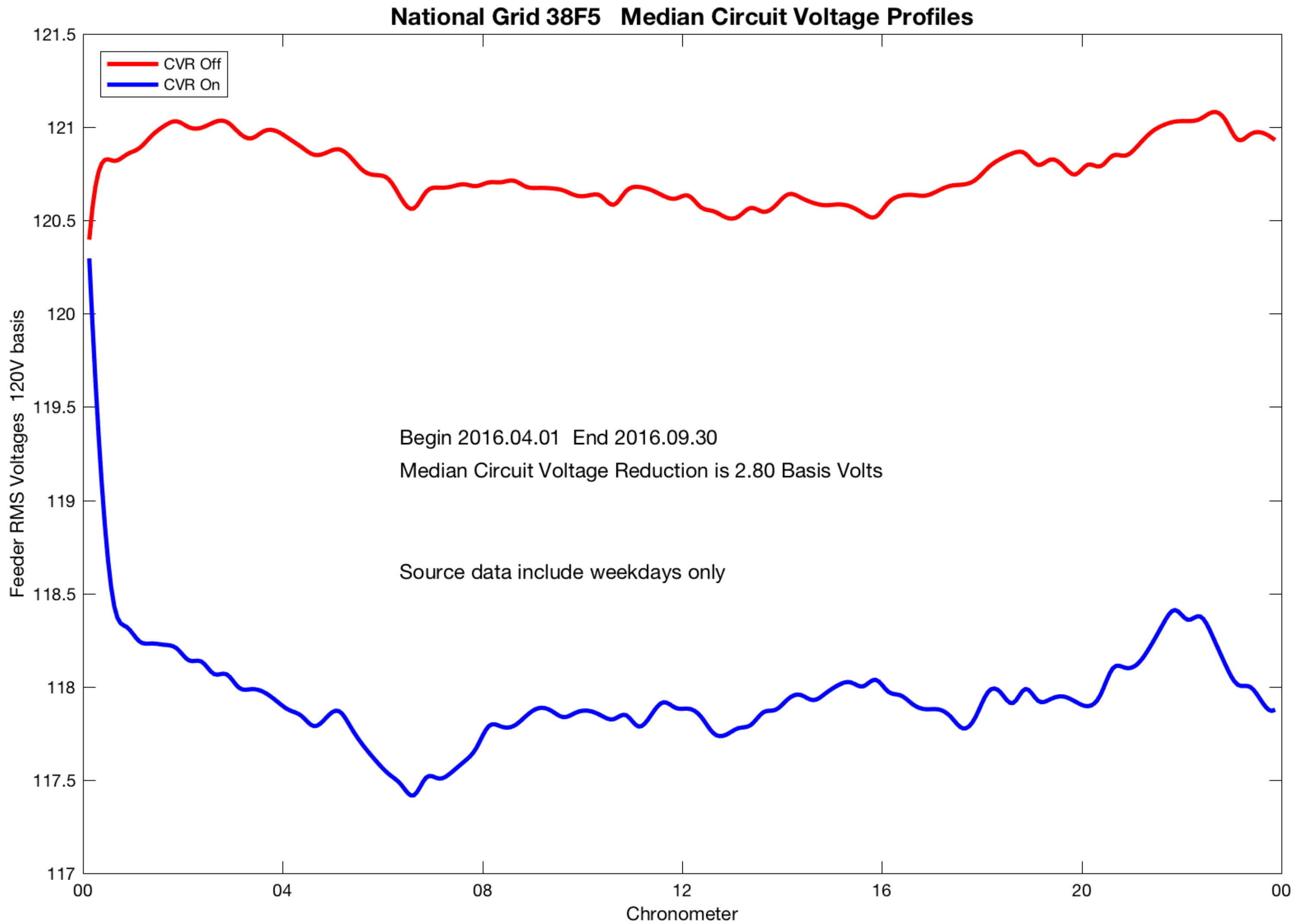
Feedeer 38F5: Median Temperature Profiles

Graph 13



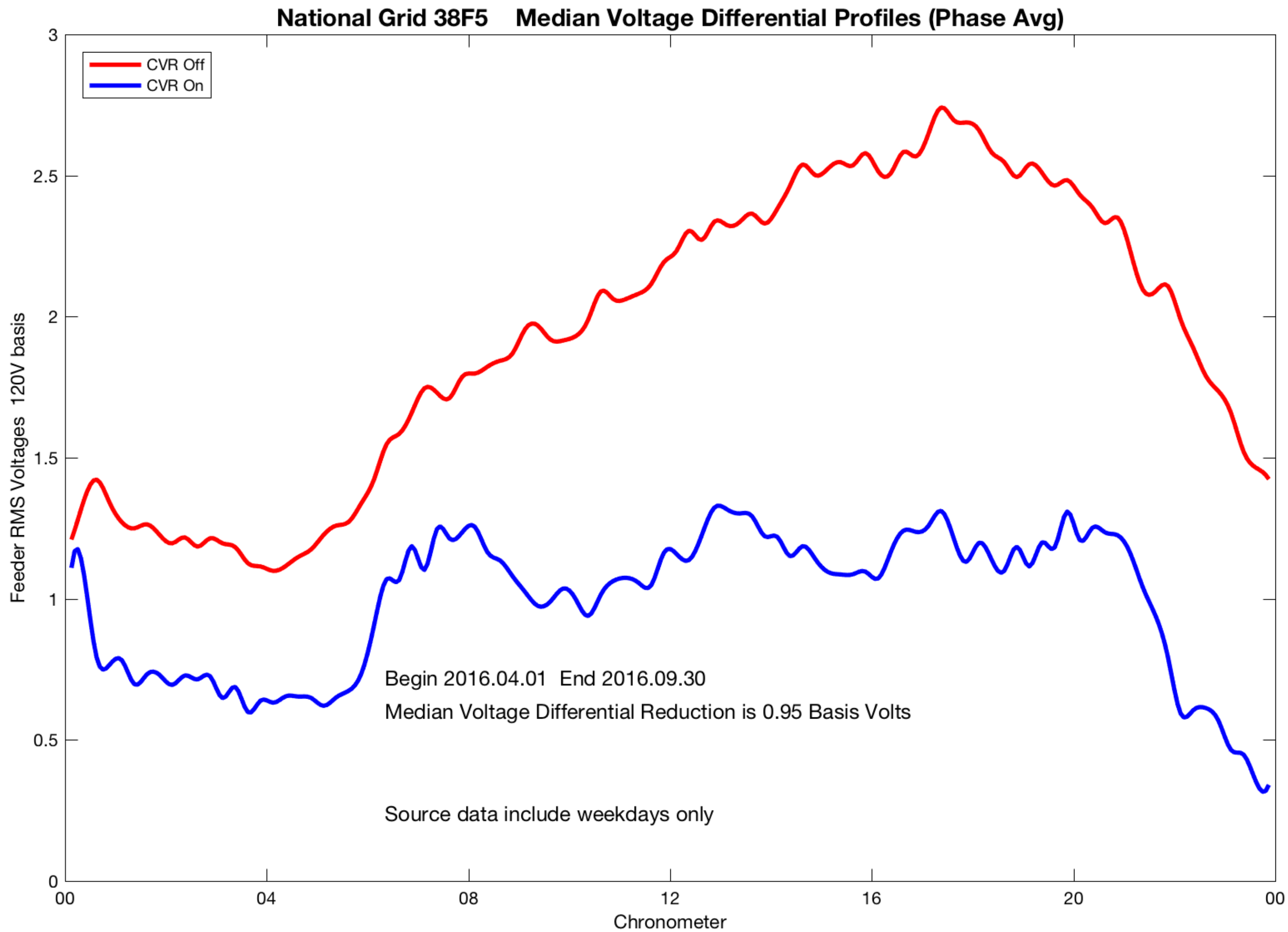
Feeder 38F5: Median Circuit Voltage Profiles

Graph 14



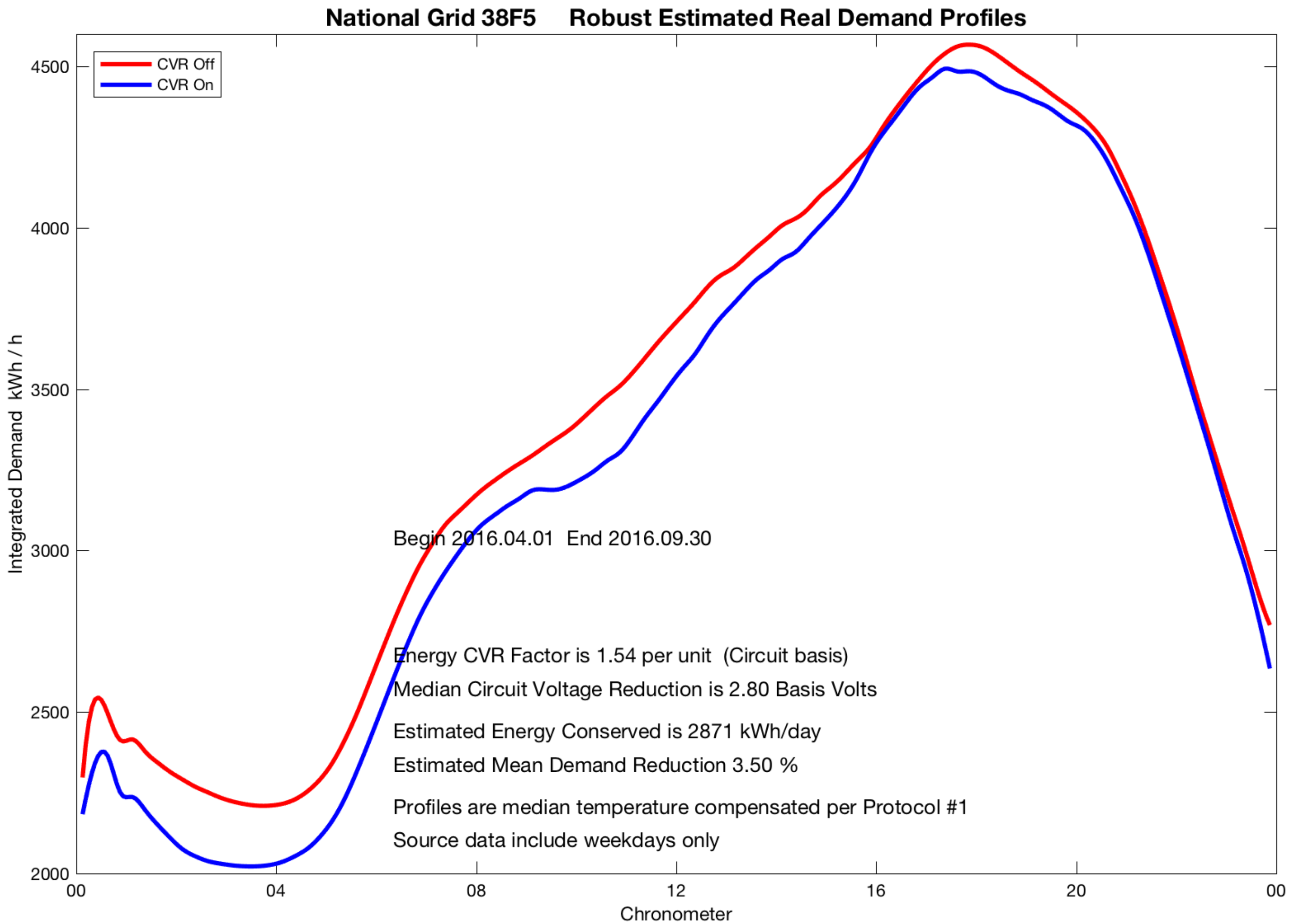
Feeder 38F5: Median Voltage Differential Profiles (Phase Avg)

Graph 15



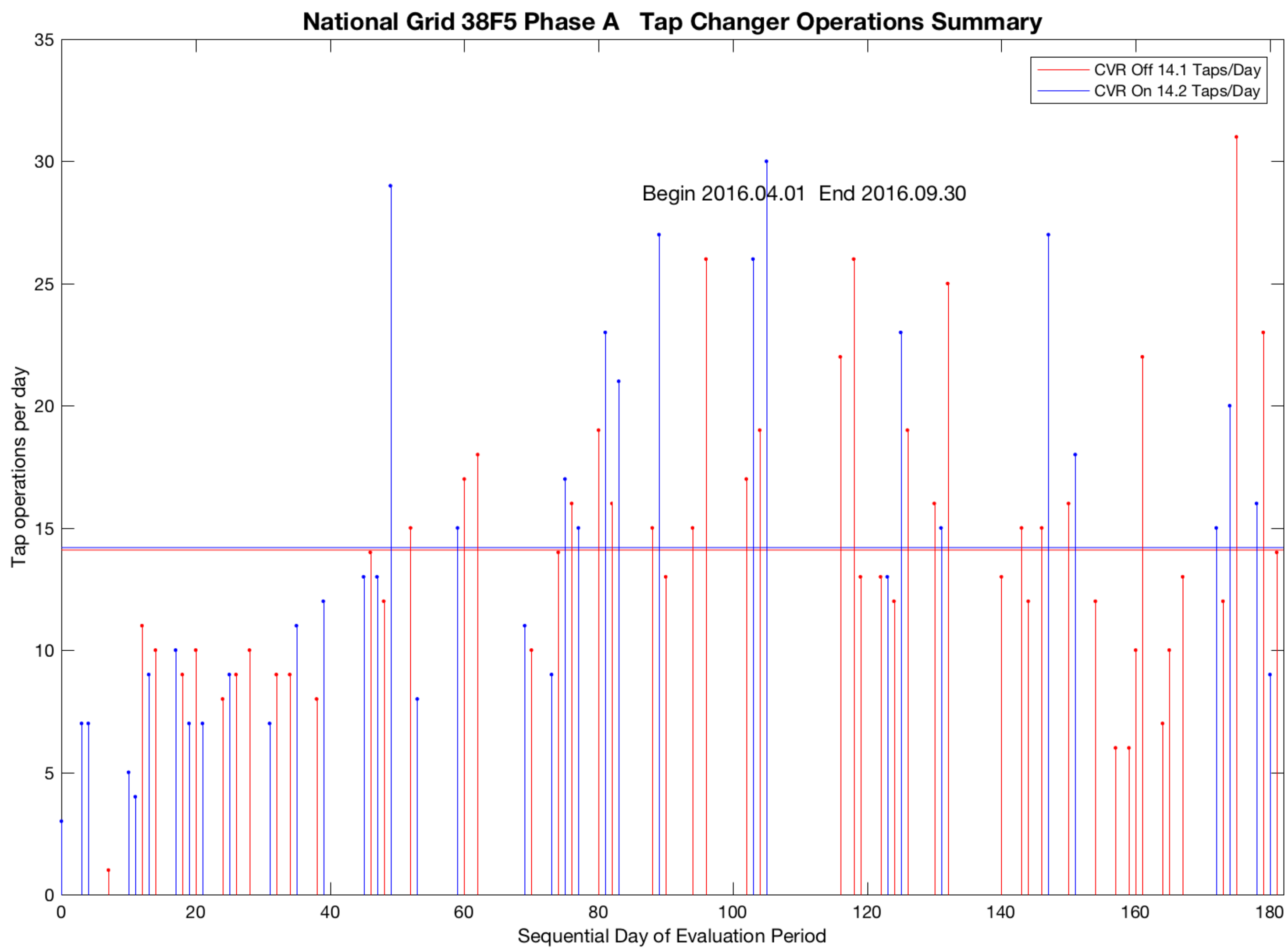
Feedeer 38F5: Robust Estimated Real Demand Profiles

Graph 16



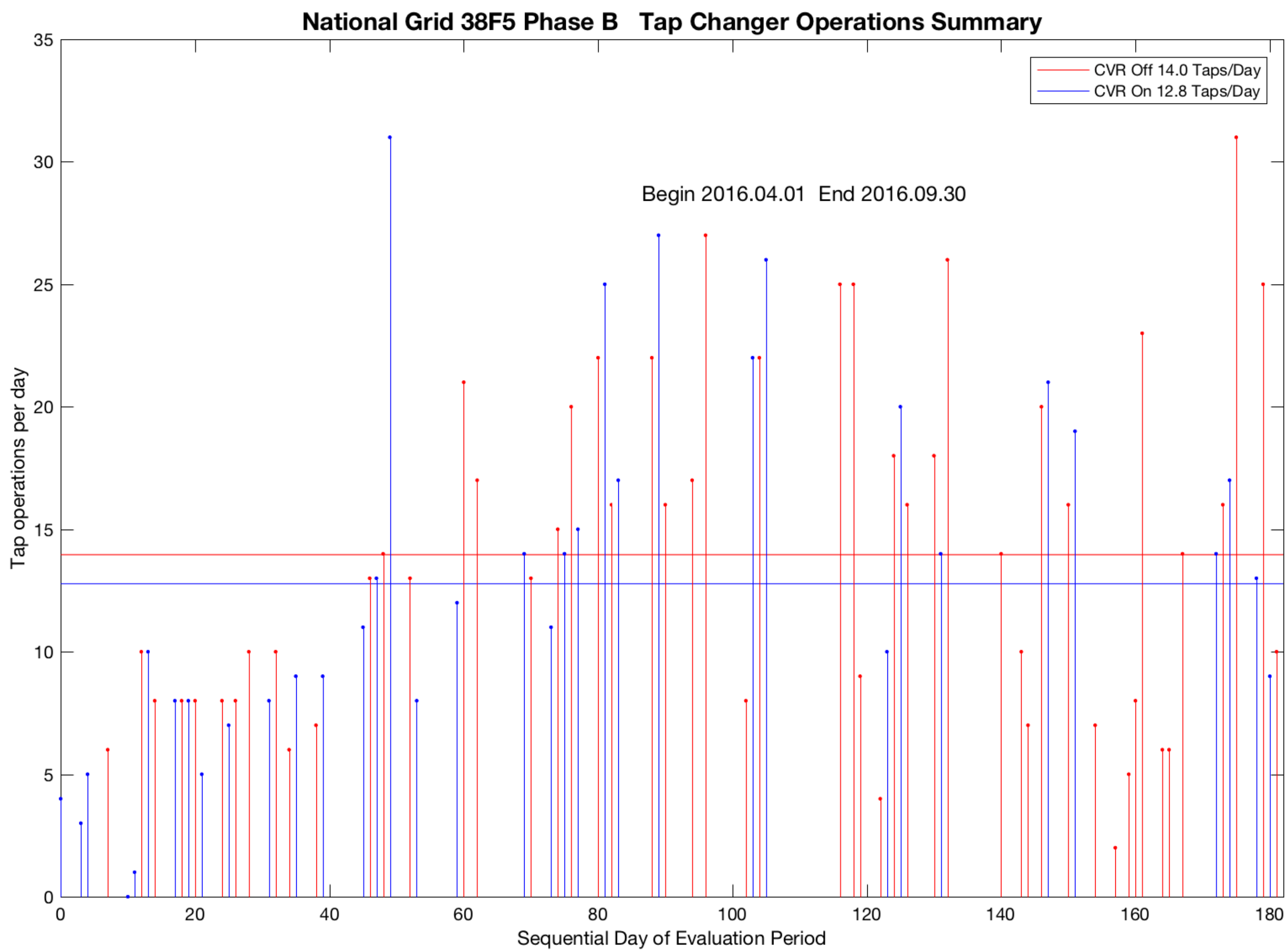
Feeder 38F5: Phase A – Tap Changer Operations Summary

Graph 17



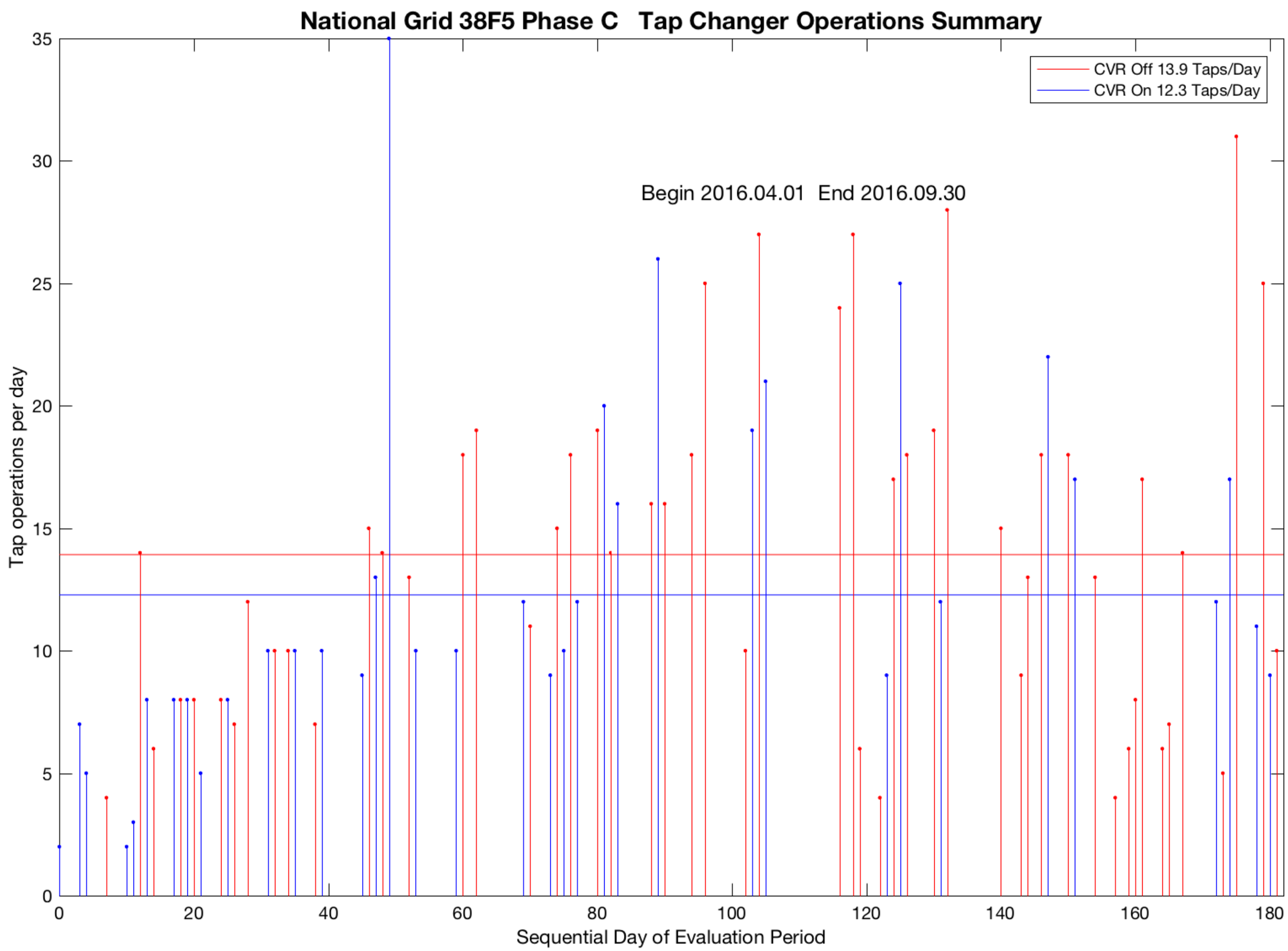
Feeder 38F5: Phase B – Tap Changer Operations Summary

Graph 18



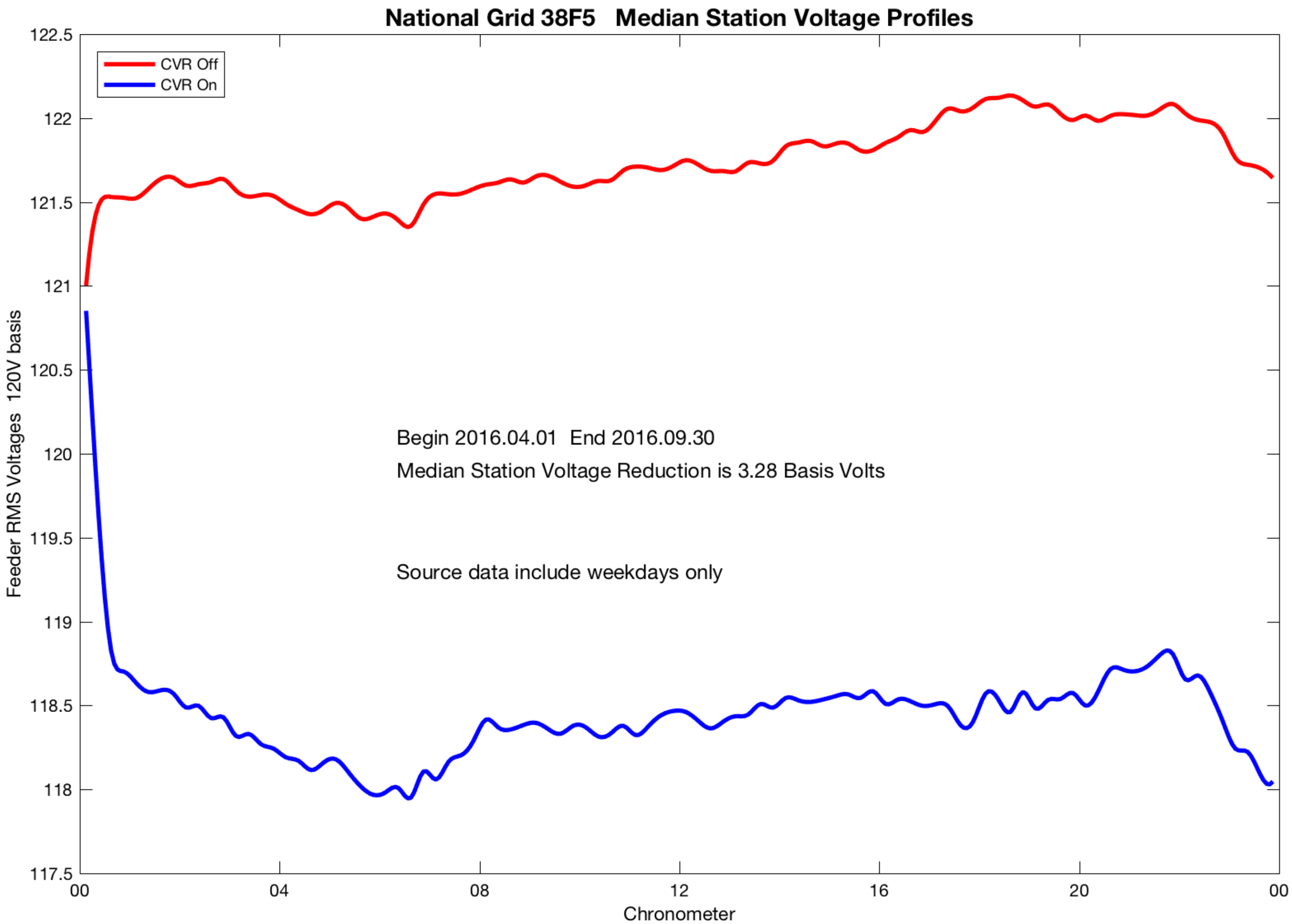
Feeder 38F5: Phase C – Tap Changer Operations Summary

Graph 19



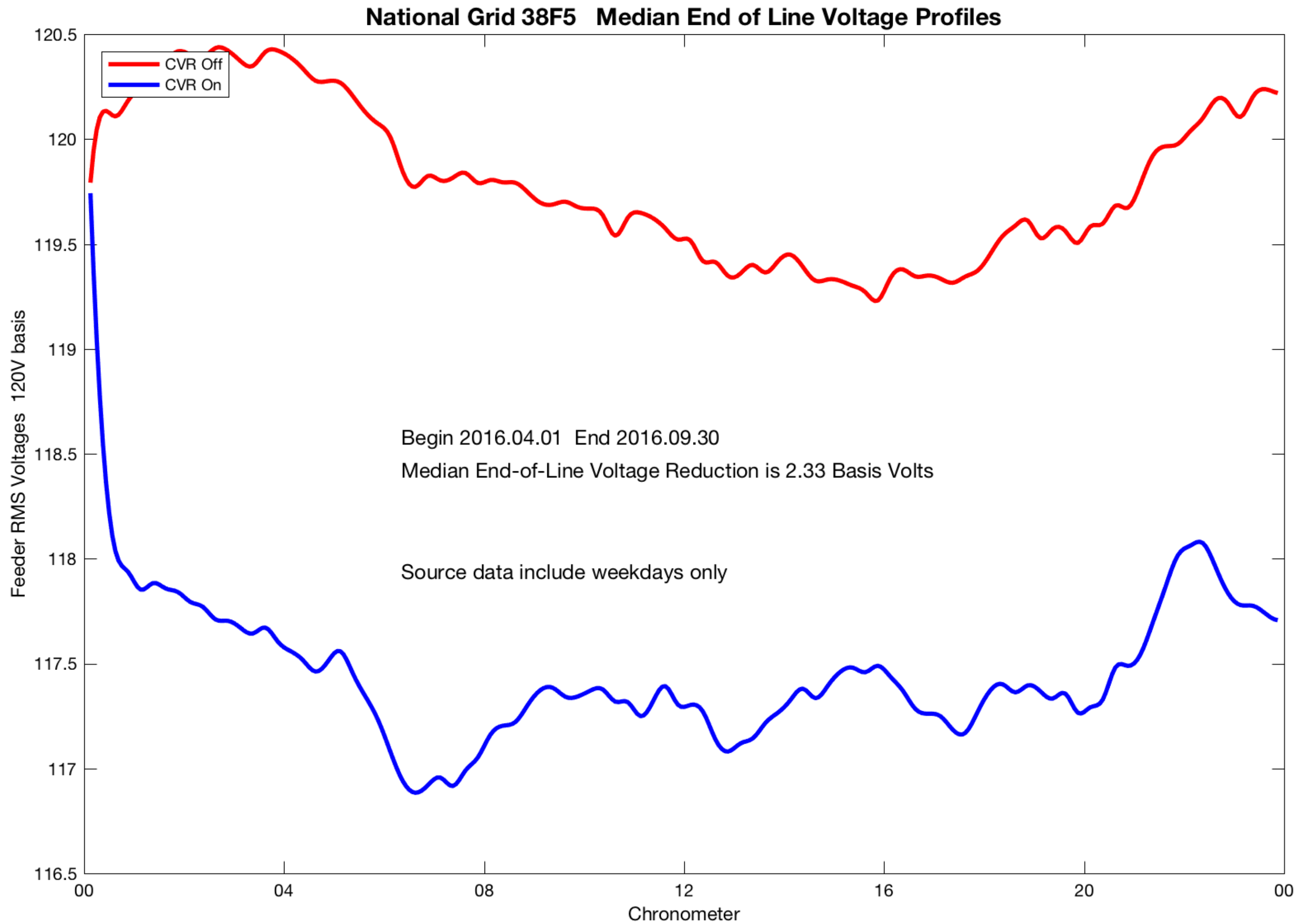
Feedder 38F5: Median Station Voltage Profiles

Graph 20



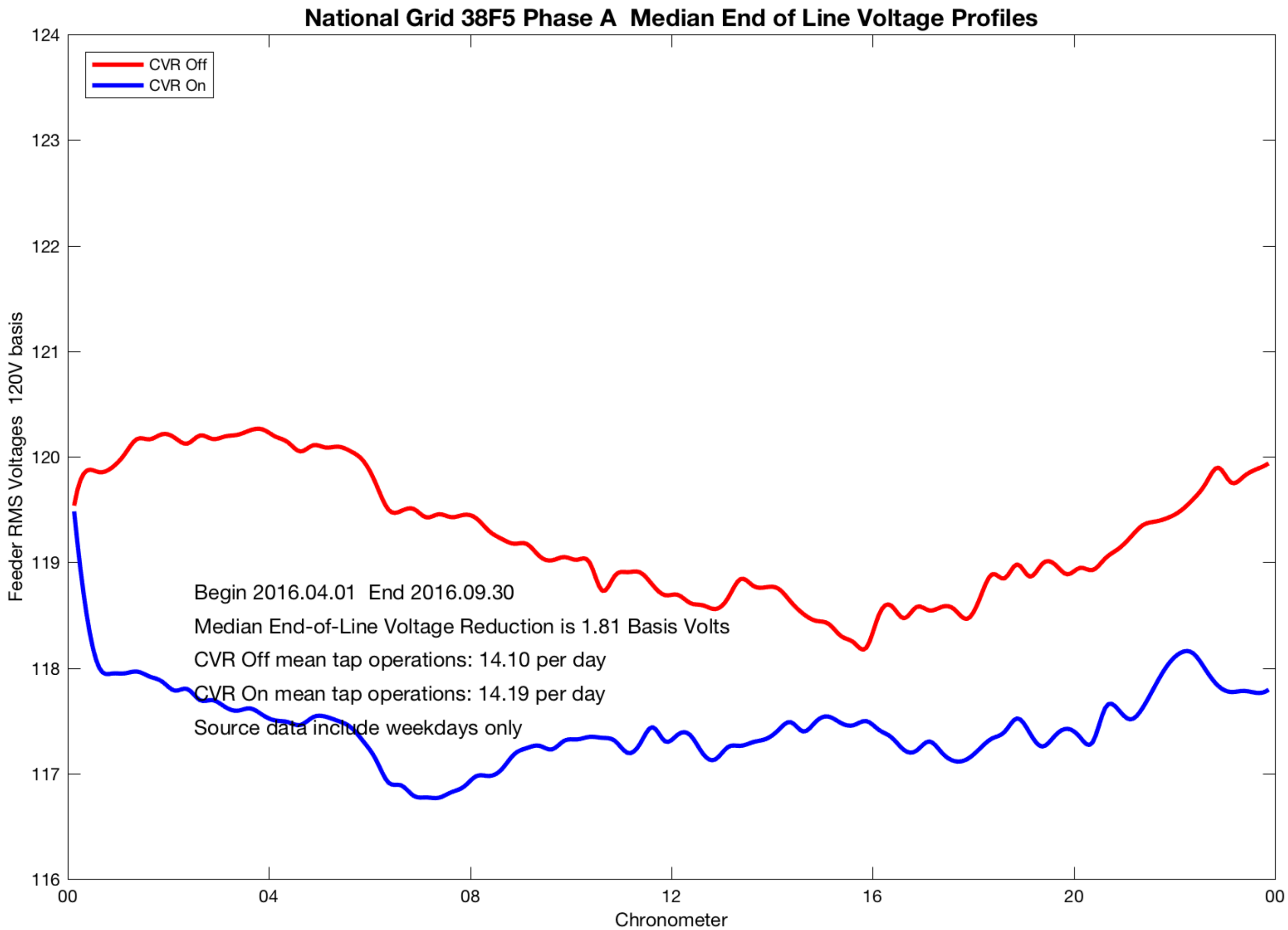
Feeder 38F5: Median End of Line Voltage Profiles (Phase Avg)

Graph 21



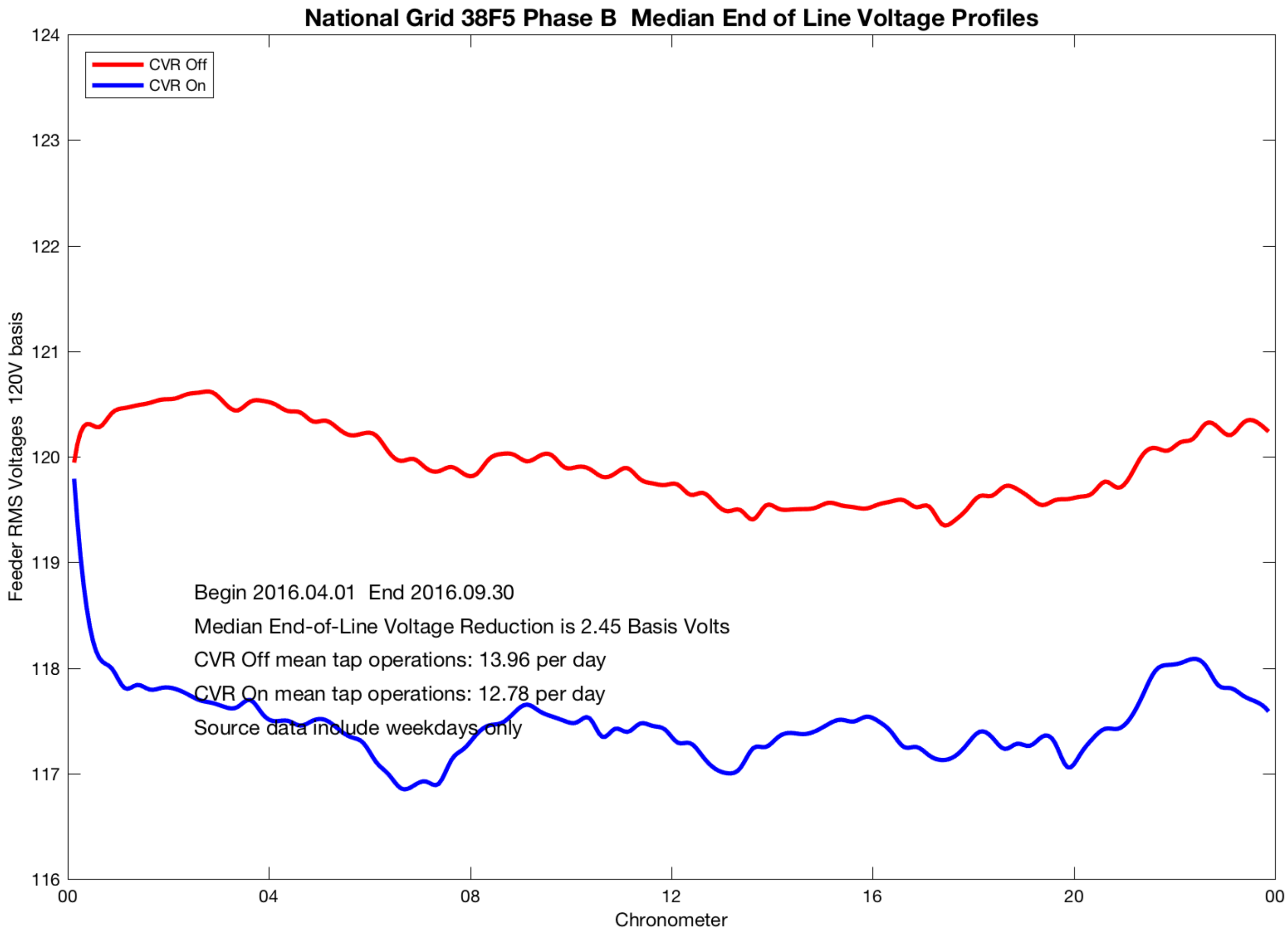
Feeder 38F5: Phase A – Median End of Line Voltage Profiles

Graph 22



Feeder 38F5: Phase B – Median End of Line Voltage Profiles

Graph 23



Feeder 38F5: Phase C – Median End of Line Voltage Profiles

Graph 24