



# Annual Report to the Pennsylvania Public Utility Commission Demand Response Performance Report Only

**Phase III of Act 129**

**Program Year 9**

(June 1, 2017 - May 31, 2018)

This is an amended version of the PECO PY9 Demand Response Report previously filed in January 2018 covering the performance period June 1, 2017 – September 30, 2017. The Demand Response performance is updated to reflect the verified impact results. The energy efficiency performance will be documented through the final annual report filing on November 15, 2018.

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## ACRONYMS

AMI	Advanced Metering Infrastructure
BDR	Behavioral Demand Response
C&I	Commercial and Industrial
CFL	Compact Fluorescent Lamp
CHP	Combined Heat and Power
CSP	Conservation Service Provider or Curtailment Service Provider
CV	Coefficient of Variation
DLC	Direct Load Control
DR	Demand Response
DRA	Demand Response Aggregator
EDC	Electric Distribution Company
EDT	Eastern Daylight Time
EE	Energy Efficiency
EE&C	Energy Efficiency and Conservation
EM&V	Evaluation, Measurement, and Verification
EUL	Effective Useful Life
G/E/NP	Government, Educational, and Non-Profit
GNI	Government, Non-Profit, Institutional
HER	Home Energy Report
HIM	High Impact Measure
HVAC	Heating, Ventilating, and Air Conditioning
ICSP	Implementation Conservation Service Provider
kW	Kilowatt
kWh	Kilowatt-hour
LED	Light-Emitting Diode
LIURP	Low-Income Usage Reduction Program
M&V	Measurement and Verification
MW	Megawatt
MWh	Megawatt-hour
NPV	Net Present Value
NOAA	National Oceanic and Atmospheric Administration
NTG	Net-to-Gross
P3TD	Phase III to Date
PA PUC	Pennsylvania Public Utility Commission
PSA	Phase III to Date Preliminary Savings Achieved; equal to VTD + PYRTD
PSA+CO	PSA savings plus Carryover from Phase II
PY	Program Year: e.g., PY8, from June 1, 2016 to May 31, 2017
PYRTD	Program Year Reported to Date

PYVTD	Program Year Verified to Date
RCT	Randomized Control Trial
RR	Realization Rate
RTD	Phase III to Date Reported Gross Savings
RTO	Regional Transmission Organization
SWE	Statewide Evaluator
T&D	Transmission and Distribution
TRC	Total Resource Cost
TRM	Technical Reference Manual
VTD	Phase III to Date Verified Gross Savings

## TYPES OF SAVINGS

**Gross Savings:** The change in energy consumption and/or peak demand that results directly from program-related actions taken by participants in an EE&C program, regardless of why they participated.

**Net Savings:** The total change in energy consumption and/or peak demand that is attributable to an EE&C program. Depending on the program delivery model and evaluation methodology, the net savings estimates may differ from the gross savings estimate due to adjustments for the effects of free riders, changes in codes and standards, market effects, participant and nonparticipant spillover, and other causes of changes in energy consumption or demand not directly attributable to the EE&C program.

**Reported Gross:** Also referred to as *ex ante* (Latin for “beforehand”) savings. The energy and peak demand savings values calculated by the EDC or its program Implementation Conservation Service Providers (ICSP), and stored in the program tracking system.

**Unverified Reported Gross:** The Phase III Evaluation Framework allows EDCs and the evaluation contractors the flexibility to not evaluate each program every year. If an EE&C program is being evaluated over a multiyear cycle, the reported savings for a program year where evaluated results are not available are characterized as unverified reported gross until the impact evaluation is completed and verified savings can be calculated and reported.

**Verified Gross:** Also referred to as *ex post* (Latin for “from something done afterward”) gross savings. The energy and peak demand savings estimates reported by the independent evaluation contractor after the gross impact evaluation and associated M&V efforts have been completed.

**Verified Net:** Also referred to as *ex post* net savings. The energy and peak demand savings estimates reported by the independent evaluation contractor after application of the results of the net impact evaluation. Typically calculated by multiplying the verified gross savings by a net-to-gross (NTG) ratio.

**Annual Savings:** Energy and demand savings expressed on an annual basis, or the amount of energy and/or peak demand an EE&C measure or program can be expected to save over the course of a typical year. Annualized savings are noted as MWh/year or MW/year. The Pennsylvania TRM provides algorithms and assumptions to calculate annual savings, and Act 129 compliance targets for consumption

reduction are based on the sum of the annual savings estimates of installed measures or behavior change.

**Lifetime Savings:** Energy and demand savings expressed in terms of the total expected savings over the useful life of the measure. Typically calculated by multiplying the annual savings of a measure by its effective useful life. The TRC Test uses savings from the full lifetime of a measure to calculate the cost-effectiveness of EE&C programs.

**Program Year Reported to Date (PYRTD):** The reported gross energy and peak demand savings achieved by an EE&C program or portfolio within the current program year. PYTD values for energy efficiency will always be reported gross savings in a semiannual or preliminary annual report.

**Program Year Verified to Date (PYVTD):** The verified gross energy and peak demand savings achieved by an EE&C program or portfolio within the current program year as determined by the impact evaluation findings of the independent evaluation contractor.

**Phase III to Date (P3TD):** The energy and peak demand savings achieved by an EE&C program or portfolio within Phase III of Act 129. Reported in several permutations described below.

- **Phase III to Date Reported (RTD):** The sum of the reported gross savings recorded to date in Phase III of Act 129 for an EE&C program or portfolio.
- **Phase III to Date Verified (VTD):** The sum of the verified gross savings recorded to date in Phase III of Act 129 for an EE&C program or portfolio, as determined by the impact evaluation finding of the independent evaluation contractor.
- **Phase III to Date Preliminary Savings Achieved (PSA):** The sum of the verified gross savings (VTD) from previous program years in Phase III where the impact evaluation is complete plus the reported gross savings from the current program year (PYTD). For PY8, the PSA savings will always equal the PYTD savings because PY8 is the first program year of the phase (no savings will be verified until the PY8 final annual report).
- **Phase III to Date Preliminary Savings Achieved + Carryover (PSA+CO):** The sum of the verified gross savings from previous program years in Phase III plus the reported gross savings from the current program year plus any verified gross carryover savings from Phase II of Act 129. This is the best estimate of an EDC's progress toward the Phase III compliance targets.
- **Phase III to Date Verified + Carryover (VTD + CO):** The sum of the verified gross savings recorded to date in Phase III plus any verified gross carryover savings from Phase II of Act 129.

## 1. INTRODUCTION

*Note: This is an amended version of the PECO PY9 Demand Response Report previously filed in January 2018 covering the performance period June 1, 2017 – September 30, 2017. The Demand Response performance is updated to reflect the verified impact results. The energy efficiency performance will be documented through the final annual report filing on November 15, 2018.*

Pennsylvania Act 129 of 2008, signed on October 15, 2008, mandated energy savings and demand reduction goals for the largest electric distribution companies (EDCs) in Pennsylvania for Phase I (2008 through 2013). Phase II of Act 129 began in 2013 and concluded in 2016. In late 2015, each EDC filed a new energy efficiency and conservation (EE&C) plan with the Pennsylvania Public Utilities Commission (PA PUC) detailing the proposed design of its portfolio for Phase III. These plans were updated based on stakeholder input and subsequently approved by the PUC in 2016. Phase III of Act 129 includes a demand response (DR) goal for PECO.

Implementation of Phase III of the Act 129 programs began on June 1, 2016. DR events are limited to the months of June through September, which are the first 4 months of the Act 129 program year. Because the DR season is completed early in the program year, it is possible to complete the independent evaluation of verified gross savings for DR sooner than is possible for EE programs.

PECO has retained Navigant Consulting, Inc. (Navigant) as an independent evaluation contractor for Phase III of Act 129. Navigant is responsible for the measurement and verification (M&V) of the savings and calculation of gross verified and net verified savings. This report documents the progress and effectiveness of the Phase III DR accomplishments for PECO in PY9 and the cumulative accomplishments of the Phase III DR programs since inception. This report also documents the energy savings carried over from Phase II. The Phase II carryover savings count toward EDC savings compliance targets for Phase III.

This report details the participation, spending, reported gross, verified gross, and verified net impacts of the DR programs in PY9. Compliance with Act 129 savings goals are ultimately based on verified gross savings. This report also includes estimates of cost-effectiveness accorded to the Total Resource Cost (TRC) test.<sup>1</sup>

Navigant also performed a process evaluation to examine the design, administration, implementation, and market response to the EE&C DR programs. This report presents the key findings and recommendations identified by the process evaluation and documents any changes to EE&C DR program delivery considered based on the recommendations.

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<sup>1</sup> The Pennsylvania TRC Test for Phase I was adopted by PUC order at Docket No. M-2009-2108601 on June 23, 2009 (2009 PA TRC Test Order). The TRC Test Order for Phase I later was refined in the same docket on August 2, 2011 (2011 PA TRC Test Order). The 2013 TRC Order for Phase II of Act 129 was issued on August 30, 2012. The 2016 TRC Test Order for Phase III of Act 129 was adopted by PUC order at Docket No. M-2015-2468992 on June 11, 2015.



## 2. SUMMARY OF ACHIEVEMENTS

### 2.1 Phase III DR Achievements to Date

The Phase III DR performance target for PECO is 161 MW. Compliance targets for DR programs are based on average performance across events and were established at the system level. This means the load reductions measured at the customer meter must be escalated to reflect transmission and distribution (T&D) losses.

Act 129 DR events are triggered by PJM's day-ahead load forecast. When the day-ahead forecast is above 96% of the peak load forecast for the year, a DR event is initiated for the following day. In PY9, there were three DR events called. Table 2-1 lists the days that DR events were called along with the verified gross demand reductions achieved by each event. Table 2-1 also lists the average DR performance for PY9 and for Phase III to date. PECO's average DR performance to date is 149.4 MW, which is below the Phase III compliance reduction target of 161 MW by 7% (93% of target achieved).

**Table 2-1. PY9 DR PYVTD Performance by Event**

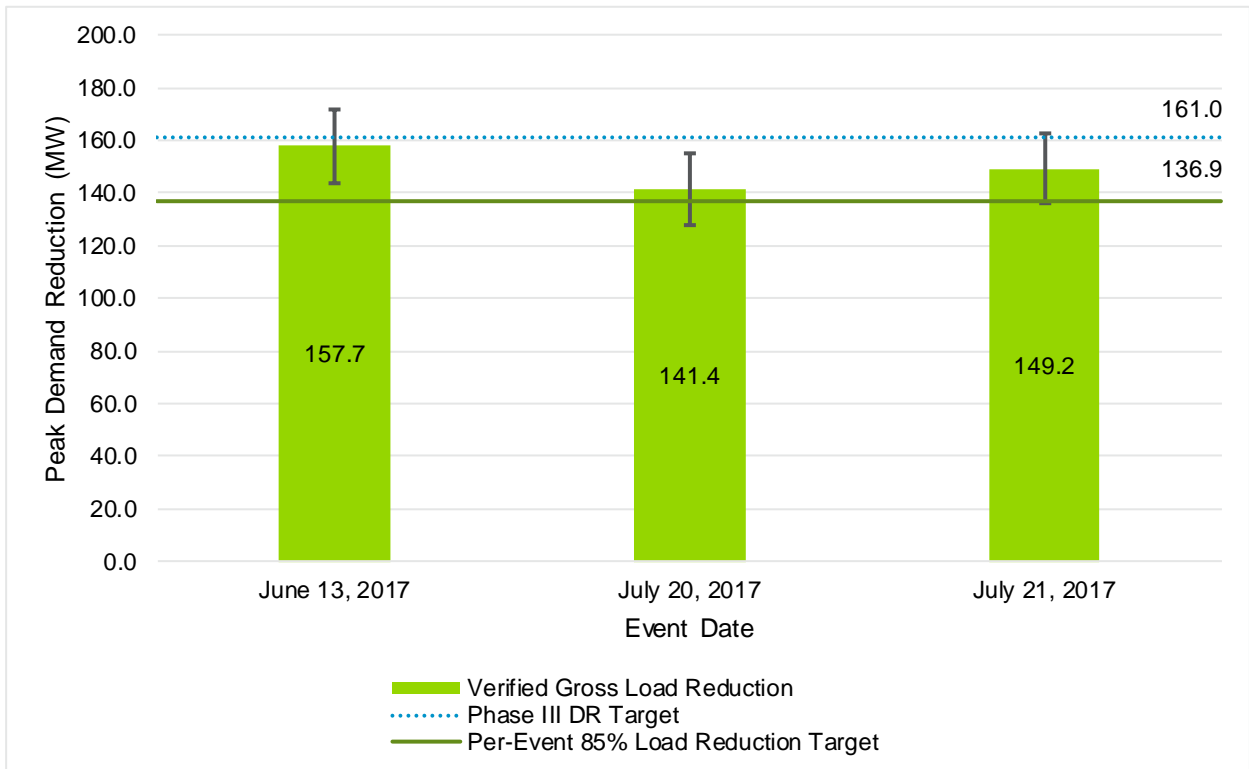
Event Date	Event Start Time	Event End Time	Program Name			
			Residential DR (MW)	Small C&I DR (MW)	Large C&I DR (MW)	Portfolio (MW)
June 13, 2017	2:00 p.m.	6:00 p.m.	39.5	0.0	118.2	157.7
July 20, 2017	2:00 p.m.	6:00 p.m.	33.5	0.0	107.9	141.4
July 21, 2017	1:00 p.m.	5:00 p.m.	23.3	0.0	125.8	149.2
<b>PYVTD - Average PY9 DR Event Performance</b>			<b>32.1</b>	<b>0.0</b>	<b>117.3</b>	<b>149.4</b>
<b>VTD - Average Phase III DR Event Performance</b>			<b>32.1</b>	<b>0.0</b>	<b>117.3</b>	<b>149.4</b>

Source: Navigant analysis

The Commission's Phase III Implementation Order also established a requirement that EDCs achieve at least 85% of the Phase III compliance reduction target in each DR event. For PECO, this translates to a 137 MW minimum for each DR event. Figure 2-1 compares the performance of each of the DR events in PY9 to the event-specific minimum and average targets. The error bars in this figure represent the margin of error for the verified gross load reduction, calculated in accordance with the protocols specified in the evaluation framework.<sup>2</sup> PECO achieved at least 85% of the reduction target in events 1, 2, and 3.

<sup>2</sup> Evaluation Framework for Pennsylvania Act 129 EE&C Programs. [http://www.puc.state.pa.us/Electric/pdf/Act129/SWE\\_PhaseIII-Evaluation\\_Framework102616.pdf](http://www.puc.state.pa.us/Electric/pdf/Act129/SWE_PhaseIII-Evaluation_Framework102616.pdf)

**Figure 2-1. Event Performance Compared to 85% Per-Event Target**



Source: Navigant analysis

## 2.2 Phase III DR Performance by Customer Segment

The following tables present the DR program participation, savings, and spending results by customer sector for PY9.

Table 2-2 summarizes the participation and spending for the DR program for the three sectors.

Table 2-2. Summary Statistics for DR Programs by Customer Segment

Parameter	Customer Segment	Program Year					Phase III to Date
		PY8	PY9	PY10	PY11	PY12	
<b>Participation</b>	Residential	61,440	60,846				61,440 <sup>a</sup>
	Small C&I	1,586	1,564				1,586 <sup>a</sup>
	Large C&I	-	261				261 <sup>a</sup>
	<b>Total</b>	<b>63,026</b>	<b>62,671</b>				<b>63,287</b>
<b>Incentive Spending (\$1,000)</b>	Residential	3,005	2,838				5,843
	Small C&I	122	115				237
	Large C&I		0 <sup>b</sup>				0 <sup>b</sup>
	<b>Total</b>	<b>3,127</b>	<b>2,953</b>				<b>6,080</b>

<sup>a</sup> DR participation is not additive like other programs because the same participants tend to remain in the program with only small attrition. Therefore, total participation in the DR programs for Phase III is equal to the highest program year participation count for each of the three programs.

<sup>b</sup> PECO contracts with the program curtailment service providers (CSPs) to obtain the DR resources for the program and does not provide direct participant incentives. Each CSP controls its participant incentives independently; thus, the PECO customer incentive amount is zero.

Note: Values in tables may not reconcile exactly with the sum of more detailed level results or previously reported results due to rounding.

Source: Navigant analysis

Table 2-3 provides a summary of reported and verified demand (MW) savings for the DR program across the three sectors.

Table 2-3. Summary of Demand Savings for DR Programs by Customer Segment

Parameter	Customer Segment	Program Year					Phase III to Date
		PY8	PY9	PY10	PY11	PY12	
<b>Reported Gross Demand Savings (MW)</b>	Residential	N/A	N/A				N/A
	Small C&I	N/A	N/A				N/A
	Large C&I	N/A	104.8				104.8
	<b>Total</b>	<b>N/A</b>	<b>104.8</b>				<b>104.8</b>
<b>Verified Gross Demand Savings (MW)</b>	Residential	N/A	32.1				32.1
	Small C&I	N/A	0.0				0.0
	Large C&I	N/A	117.3				117.3
	<b>Total</b>	<b>N/A</b>	<b>149.4</b>				<b>149.4</b>
<b>Demand Savings Realization Rate</b>	Residential	N/A	N/A				N/A
	Small C&I	N/A	N/A				N/A
	Large C&I	N/A	112%				112%
	<b>Total</b>	<b>N/A</b>	<b>N/A</b>				<b>N/A</b>

Note: Values in tables may not reconcile exactly with the sum of more detailed level results or previously reported results due to rounding.

Source: Navigant analysis

## 2.3 Summary of DR Participation by Program

Participation is defined differently for certain programs depending on the program delivery channel and data tracking practices. Table 2-4 provides the current participation totals for PY9 and Phase III.

**Table 2-4. EE&C Portfolio DR Participation by Program**

Parameter	Program Name	Program Year					Phase III to Date
		PY8	PY9	PY10	PY11	PY12	
Participation	Residential DR	61,440	60,846				61,440 <sup>a</sup>
	Small C&I DR	1,586	1,564				1,586 <sup>a</sup>
	Large C&I DR	-	261				261 <sup>a</sup>
	<b>Portfolio Total</b>	<b>63,026</b>	<b>62,671</b>				<b>63,287</b>

<sup>a</sup> DR participation is not additive like other programs because the same participants tend to remain in the program with only small attrition. Therefore, total participation in the DR programs for Phase III is equal to the highest program year participation count for each of the three programs.

Note: Values in tables may not reconcile exactly with the sum of more detailed level results or previously reported results due to rounding.

Source: Navigant analysis

The nuances of the participant definition vary by program or solution and are below.

### Residential DR Program

Three solutions make up the Residential DR Program; however, only the Direct Load Control (DLC) Solution is currently active. PECO defined participation counts in the solution as follows:

- For Residential DLC, a participant is defined as a unique account number where device status is “install” or “swap” and the measure code is CACS (central air conditioner switch). One participant may have more than one DLC device installed at the home. The categories not included in the participant count include “disconnect”, “opt-out”, and “removal”.

### Small C&I DR Program

The Small C&I DR Program consists of the Small C&I DLC Solution. PECO defined participation counts in the solution as follows:

- For Small C&I DLC, a participant is defined as a unique account number where device status is install or swap and the measure code is PCT (programmable communicating thermostat). One participant may have more than one DLC device installed on the premise. The categories not included in the participant count include disconnect, opt-out, and removal.

### Large C&I DR Program

The Large C&I DR Program consists of the Demand Response Aggregator (DRA) Solution. PECO defined participation counts in the solution as follows:

- For DRA, a participant is defined as a Large C&I customer (defined by PECO account number) enrolled with a DR program CSP for at least 1 hour of at least one event occurring in any given program year.

## 2.4 Summary of Impact Evaluation Results

During PY9, Navigant completed impact evaluations for many of the EE programs in the portfolio. Table 2-5 summarizes the realization rates (RRs) and net-to-gross (NTG) ratios by program or evaluation initiative.

EE program information for this section will be included in the annual report filed in November 2018.

**Table 2-5. DR Impact Evaluation Results Summary**

Program Name	Parameter	Program Year					Phase III to Date
		PY8	PY9	PY10	PY11	PY12	
Residential DR	Energy RR	N/A	N/A				N/A
	Demand RR	N/A	N/A				N/A
	NTG Ratio	1	1				1
Small C&I DR	Energy RR	N/A	N/A				N/A
	Demand RR	N/A	N/A				N/A
	NTG Ratio	1	1				1
Large C&I DR	Energy RR	N/A	N/A				N/A
	Demand RR	N/A	1.12				1.12
	NTG Ratio	1	1				1

Note: Values in tables may not reconcile exactly with the sum of more detailed level results or previously reported results due to rounding.

Source: Navigant analysis

## 2.5 Summary of Demand Impacts by Program

PECO's Phase III EE&C programs achieve peak demand reductions in two primary ways. The first is through coincident reductions from EE measures and the second is through dedicated DR offerings that exclusively target temporary demand reductions on peak days. EE reductions coincident with system peak hours are reported and used in the calculation of benefits in the TRC test but do not contribute to Phase III peak demand reduction compliance goals. Phase III peak demand reduction targets are exclusive to DR programs.

The two types of peak demand reduction savings are also treated differently for reporting purposes. Peak demand reductions from EE are generally additive across program years, meaning that the P3TD savings reflect the sum of the first-year savings in each program year. Conversely, DR goals are based on average portfolio impacts across all events, so cumulative DR performance is expressed as the *average* performance of each of the DR events called in P3TD. Because of these differences, demand impacts from EE and DR are reported separately in the following sub-sections.

### 2.5.1 Energy Efficiency

EE program information for this section will be included in the annual report filed in November 2018.

### 2.5.2 Demand Response

Act 129 defines peak demand savings from DR as the average reduction in electric demand during the hours when a DR event is initiated. Phase III DR events are initiated according to the following guidelines:

- Curtailment events shall be limited to the months of June through September.
- Curtailment events shall be called for the first 6 days of each program year (starting in PY9) in which the peak hour of PJM's day-ahead forecast for the PJM regional transmission organization (RTO) is greater than 96% of the PJM RTO summer peak demand forecast for the months of June through September.
- Each curtailment event shall last 4 hours.
- Each curtailment event shall be called such that it will occur during the day's forecast peak hour(s) above 96% of the PJM RTO summer peak demand forecast.
- Once six curtailment events have been called in a program year, the peak demand reduction program shall be suspended for that program year.

The peak demand impacts from DR in this report are presented at the system level and reflect adjustments to account for T&D losses. PECO uses the following line loss percentages/multipliers by sector.<sup>3</sup>

- Residential = 107.99% or 1.0799
- Small C&I = 107.99% or 1.0799
- Large C&I = 107.99% or 1.0799

Table 2-6 summarizes the PYVTD and VTD demand reductions for each of the DR programs in the EE&C plan and for the DR portfolio as a whole. VTD demand reductions are the average performance across all Phase III DR events independent of how many events occurred in a given program year. The relative precision columns in Table 2-6 indicate the margin of error (at the 90% confidence interval) around the PYVTD and VTD demand reductions.

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<sup>3</sup> Pennsylvania Public Utility Commission, *Technical Reference Manual; State of Pennsylvania Act 129 Energy Efficiency and Conservation Program & Act 213 Alternative Energy Portfolio Standards*, dated June 2016, errata update February 2017. Section 1.14 Transmission and Distribution System Losses.

Table 2-6. Summary of Demand Savings by DR Program

Parameter	DR Program Name	Program Year					Phase III to Date
		PY8	PY9	PY10	PY11	PY12	
<b>Reported Gross Demand Savings (MW)</b>	Residential DR	N/A	N/A				N/A
	Small C&I DR	N/A	N/A				N/A
	Large C&I DR	N/A	104.8				104.8
	<b>Portfolio Total</b>	<b>N/A</b>	<b>104.8</b>				<b>104.8</b>
<b>Verified Gross Demand Savings (MW)</b>	Residential DR	N/A	32.1				32.1
	Small C&I DR	N/A	0.0				0.0
	Large C&I DR	N/A	117.3				117.3
	<b>Portfolio Total</b>	<b>N/A</b>	<b>149.4</b>				<b>149.4</b>
<b>Relative Precision of Verified Gross Demand Savings at 90% Confidence Interval</b>	Residential DR	N/A	6%				6%
	Small C&I DR	N/A	NA				NA
	Large C&I DR	N/A	12%				12%
	<b>Portfolio Total</b>	<b>N/A</b>	<b>9%</b>				<b>9%</b>

Note: Values in tables may not reconcile exactly with the sum of more detailed level results or previously reported results due to rounding.

Source: Navigant analysis

## 2.6 Summary of Cost-Effectiveness Results

Information for this section will be included in the annual report filed in November 2018.

## 2.7 Comparison of Performance to Approved EE&C Plan

Table 2-7 presents P3TD expenditures, by program, compared to the budget estimates set forth in the EE&C plan through PY9. All dollars in Table 2-7 are presented in 2016 dollars.

Table 2-7. Comparison of Expenditures to Phase III EE&C Plan by DR Program

Parameter	Program Name	Program Year					Phase III to Date
		PY8	PY9	PY10	PY11	PY12	
<b>EE&amp;C Plan Budget (\$1,000)</b>	Residential DR	2,310	2,734	2,799	2,884	2,990	13,717
	Small C&I DR	186	187	188	190	192	943
	Large C&I DR	165	6,771	6,752	6,733	6,715	27,137
	<b>Portfolio Total</b>	<b>2,661</b>	<b>9,692</b>	<b>9,740</b>	<b>9,807</b>	<b>9,896</b>	<b>41,796</b>
<b>Actual Expenditures (\$1,000)</b>	Residential DR	3,953	3,440				7,393
	Small C&I DR	106	133				239
	Large C&I DR	1,742	574				2,316
	<b>Portfolio Total</b>	<b>5,801</b>	<b>4,147</b>				<b>9,948</b>
<b>Ratio (Actual/Planned Spending)</b>	Residential DR	172%	127%				54%
	Small C&I DR	53%	66%				26%
	Large C&I DR	871%	8%				8%
	<b>Portfolio Total</b>	<b>215%</b>	<b>43%</b>				<b>24%</b>

Note: Values in tables may not reconcile exactly with the sum of more detailed level results or previously reported results due to rounding.

Source: Navigant analysis

Table 2-8 compares the verified gross program savings to the demand savings projections filed in the EE&C plan.

Table 2-8. Comparison of DR Savings to Phase III EE&C Plan by Program

Parameter	Program Name	Program Year					Phase III to Date
		PY8	PY9	PY10	PY11	PY12	
<b>EE&amp;C Plan Verified Gross Demand Savings (MW)</b>	Residential DR		44				44
	Small C&I DR		1				1
	Large C&I DR		125				125
	<b>Portfolio Total</b>		<b>170</b>				<b>170</b>
<b>Actual Verified Gross Demand Savings (MW)</b>	Residential DR		32.1				32.1
	Small C&I DR		0.0				0.0
	Large C&I DR		117.3				117.3
	<b>Portfolio Total</b>		<b>149.4</b>				<b>149.4</b>
<b>Ratio (Actual/Planned Savings)</b>	Residential DR		73%				<b>73%</b>
	Small C&I DR		0%				<b>0%</b>
	Large C&I DR		94%				94%
	<b>Portfolio Total</b>		<b>88%</b>				<b>88%</b>

Note: Values in tables may not reconcile exactly with the sum of more detailed level results or previously reported results due to rounding.

Source: Navigant analysis



The list below briefly discusses several key reasons why programs exceeded or fell short of projected gross demand savings in PY9.

- The Residential and Small C&I DR Programs fell short of projected savings due to lower than expected per-unit impacts.
- The Large C&I DR Program fell slightly short of projected savings due to under performance by several participants and other non-Act 129 and non-PJM Emergency DR load management activities. PECO has identified that some large C&I customers participate in active demand management including peak load shaving for the top five coincident peak (5CP) hours and the PJM Economic Program. PECO could provide PJM Economic DR participation data only for a single customer, meaning that Navigant could not explicitly control for non-Act 129 DR, potentially biasing impacts downward. Large power users contributed 15 MWh of curtailment to PJM in June and 61 MWh in July, so there are likely other PJM-enrolled customers that were not accounted for in Navigant's analysis.<sup>4</sup>

As mentioned, Navigant and PECO are working through continuous process evaluation discussions to identify potential changes to the Phase III programs. There are no official, significant changes to report at this time; however, Navigant has made program-specific recommendations that will be discussed in subsequent sections of this report. See Table 2-9 for a summary of these recommendations.

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<sup>4</sup> McAnany, James, *2017 Demand Response Operations Markets Activity Report: April 2018.*, PJM Demand Side Response Operations, April 10, 2018, <http://www.pjm.com/-/media/markets-ops/dsr/2017-demand-response-activity-report.ashx>.

## 2.8 Findings and Recommendations

The PY9 impact and process evaluation activities completed by Navigant led to a variety of recommendations for program improvement. Table 2-9 lists the overarching recommendations that affect more than one program, the evaluation activity(s) that uncovered the finding, and Navigant’s recommendation(s) to PECO to address the finding. Detailed findings and recommendations for each program and solution are discussed in subsequent sections of this report.

**Table 2-9. Summary of Evaluation Recommendations**

Program(s)	Finding	Recommendation
Residential and Small Commercial DR	Event performance was lower than projected	Investigate program DR event signal reception and DLC switch and PCT operability
Large C&I	Event performance was slightly lower than projected	Consider reviewing available resources vs. PY9 achieved and review shortfalls with CSPs toward developing a plan for ensuring better target achievement for PY10
Residential and Small Commercial DR	Advanced metering infrastructure (AMI) meter data contained a large percentage of integers	Investigate data quality and data query procedures
Residential DR	Some customers reported that they would like more information about the program	Consider increasing communication with customers so that they feel more engaged with the program: a. Invite customers to opt in to event notification emails b. Send an end-of-season report to customers that explains the event dates that were called and the system impacts of the program
Residential and Small Commercial DR	Customers are interested in saving energy but have low awareness of other program offerings	Market additional EE opportunities to encourage program channeling

Source: Navigant analysis

### 3. EVALUATION RESULTS BY PROGRAM

This section documents the gross impact, net impact, and process evaluation activities conducted in PY9 along with the outcomes of those activities. Not every program receives an evaluation every program year. Table 3-1 shows a breakdown of the evaluation activity plan, with a check mark indicating the type of evaluation Navigant will conduct for each program over each year.

**Table 3-1. Evaluation Activity Matrix**

Program	Solution	PY8			PY9			PY10			PY11			PY12		
		Gross	Net	Process	Gross	Net	Process	Gross	Net	Process	Gross	Net	Process	Gross	Net	Process
DR	Residential DR	√			√		√	√				√		√		√
	Small C&I DR	√			√		√	√				√				√
	Large C&I DR				√		√	√				√		√		√

Source: Navigant analysis

### 3.1 Residential DR Program

The PECO Residential DR Program encompasses opportunities designed to engage customers in demand reduction. The eligible population and target markets for the PECO Residential DR Program are all PECO residential electric customers. The program encompasses three solutions: Residential DLC, Smart Thermostat for DR Savings, and Behavioral DR Savings. Only the Residential DLC Solution is currently active.

The Residential DLC Program is implemented by Itron (previously Comverge). It has been designed to shift participant loads from peak to off-peak hours by cycling their air conditioner during DR event days. For Residential DLC, a participant is defined as a unique account number where device status is install or swap and the measure code is CACS (central air conditioner switch). One participant may have more than one DLC device installed at the home. The categories not included in the participant count include disconnect, opt-out, and removal. The summer DR events had over 61,000 residential participants. This year and for the remainder of Phase III, the incentive is \$40 per DLC unit per year.

For Phase III, event days are called when the PJM day-ahead peak load forecast reaches 96%. Based on the day-ahead forecasts, PECO called three events during the summer of 2017: June 13 (2:00 p.m.-6:00 p.m.), July 20 (2:00 p.m.-6:00 p.m.), and July 21 (1:00 p.m.-5:00 p.m.).

Compliance targets for DR programs were established at the system level, which means the load reductions measured at the customer meter must be escalated to reflect T&D losses. The peak demand impacts presented in this section have been adjusted for line losses.

#### ***3.1.1 Participation and Reported Savings by Customer Segment***

This section provides the total Residential DR Program results for PY9, including participation, demand savings, and incentive costs. Table 3-2 presents the participation counts and incentive payments for the Residential DR Program in PY9 by customer segment.

**Table 3-2. Summary Statistics for Residential DR Program by Customer Segment**

Parameter	Customer Segment	Program Year					Phase III to Date
		PY8	PY9	PY10	PY11	PY12	
<b>Participation</b>	Residential	61,440	60,846	-	-	-	61,440 <sup>a</sup>
	Small C&I	-	-	-	-	-	-
	Large C&I	-	-	-	-	-	-
	<b>Total</b>	<b>61,440</b>	<b>60,846</b>	-	-	-	<b>61,440</b>
<b>Incentive Spending (\$1,000)</b>	Residential	3,005	2,838	-	-	-	5,843
	Small C&I	-	-	-	-	-	-
	Large C&I	-	-	-	-	-	-
	<b>Total</b>	<b>3,005</b>	<b>2,838</b>	-	-	-	<b>5,843</b>

<sup>a</sup> DR participation is not additive like other programs because the same participants tend to remain in the program with only small attrition. Therefore, total participation in the DR programs for Phase III is equal to the highest program year participation count.

Note: Values in tables may not reconcile exactly with the sum of more detailed level results or previously reported results due to rounding.

Source: Navigant analysis

Table 3-3 provides the reported and verified demand savings results for the Residential DR Program for PY9.

**Table 3-3. Summary of Demand Savings for Residential DR Program by Customer Segment**

Parameter	Customer Segment	Program Year					Phase III to Date
		PY8	PY9	PY10	PY11	PY12	
<b>Reported Gross Demand Savings (MW)</b>	Residential	-	N/A	-	-	-	N/A
	Small C&I	-	-	-	-	-	-
	Large C&I	-	-	-	-	-	-
	<b>Total</b>	-	<b>N/A</b>	-	-	-	<b>N/A</b>
<b>Verified Gross Demand Savings (MW)</b>	Residential	-	32.1	-	-	-	32.1
	Small C&I	-	-	-	-	-	-
	Large C&I	-	-	-	-	-	-
	<b>Total</b>	-	<b>32.1</b>	-	-	-	<b>32.1</b>
<b>Demand Savings RR</b>	Residential	-	N/A	-	-	-	N/A
	Small C&I	-	-	-	-	-	-
	Large C&I	-	-	-	-	-	-
	<b>Total</b>	-	<b>N/A</b>	-	-	-	<b>N/A</b>

Note: Values in tables may not reconcile exactly with the sum of more detailed level results or previously reported results due to rounding.

Source: Navigant analysis

### 3.1.2 Gross Impact Evaluation

For the Residential DR Program, the evaluation plan identified two methods to estimate demand savings. Navigant selected the method described below based on the metering and data management systems in place at PECO.

Billing analysis employs econometric regression methods to estimate the net demand savings from the program by utilizing AMI data at hourly or sub-hourly intervals. The 2016 Technical Reference Manual (TRM) suggests that billing analysis be based on experimental design (e.g., randomized control trials, or RCTs) as the first and preferred method for evaluating impacts from such programs. However, this method is not feasible for the Residential DLC Program during Phase III because it was created in Phase I, and all participants in that program were enrolled without randomization or the creation of a control group. Thus, Navigant chose one of the secondary approaches described below to verify achievement of the Phase III demand reduction targets as outlined in the 2016 PA TRM:

1. **Comparison group analysis:** Uses loads from a group of non-participating customers and matches them to similar participating customers with respect to observable characteristics—e.g., non-event weekday consumption.
2. **Within-subject regression:** Uses loads of participating customers on non-event days to estimate the reference load. Demand is specified as a function of temperature and other variables that influence usage in the regression equation.

While the preferred approach above is a comparison group analysis, this approach was not possible for PY9. This was due to the low precision data available from PECO to conduct the analyses. A significant number of integer values were present in the data, leading to low data resolution. This reduced precision would not deliver a robust matched control group.<sup>5</sup>

#### Within-Subjects Regression

When the development of the counterfactual (baseline) from a separate population in a program is not possible, a within-subjects approach using an individual's usage on non-event weekdays can estimate the counterfactual. Navigant selected a subset of available AMI data to create a sample of non-event weekdays and customers that best represent usage on event days. Specifically, Navigant selected the three non-event days with the highest average daily temperature, not including July 13, which had a rapid temperature drop off during the window of time in which the events occurred on event days. The dates included in the regressions were June 12, July 12, and July 19 (non-event days), as well as June 13, July 20, and July 21 (event days). Navigant excluded 0.4% out of 60,400 customers in the sample: 10 customers that were missing weather data and 247 that were not representative of residential customers. The latter customers included those with missing demand data and those who exhibited demand greater than 20 kW, considered outliers.

Equation 3-1 shows the within-subjects regression equation. This model estimates customer load as a function of the event hours, cooling degree hours, normalized heat buildup, and snapback effect in post-event hours. Variables included in the within-subjects regression were demeaned by hour and account, effectively making the model in Equation 3-1 a fixed effects specification. Navigant estimated a separate

<sup>5</sup> To find a customer's best match, it is imperative to have data that is beyond one decimal place. A read of zero may in fact be a positive usage value, but that value could have been rounded or truncated, no longer representing the customer's true usage value. Therefore, when conducting a comparison group exercise, the group selected may not be the most accurate group for comparison.

regression for each hour of the day between 9 a.m. and 10 p.m., Eastern prevailing time (hours ending 10 through 22).

**Equation 3-1. Residential Within-Subjects Regression**

$$Q_{ki} = \beta_0 + \sum_{\varphi}^N \beta_{1\varphi} Treat_{kij} + \beta_{2i} CDH_i + \beta_{3i} NHB U_{ij} + \sum_f^2 \beta_{4f} SB_{ki} + \varepsilon_{ki}$$

Where:

- $k$  = customer
- $i$  = hour ending
- $Q_{ki}$  = Hourly demand for customer  $k$  during hour ending  $i$ .
- $Treat_{kij}$  = A set of indicator variables, one for each event hour, taking value of 1 if customer  $k$  during hour ending  $i$  is in an event period for event  $j$  and takes value 0 if otherwise. A separate dummy variable exists for each event hour in the summer of 2017.
- $CDH_{ij}$  = is the number of cooling degree hours in during hour ending  $i$ . The base for this calculation is 65°F.
- $NHB U_{ij}$  = is the normalized heat buildup term during hour ending  $i$ . Normalized heat buildup is calculated as follows:

$$HeatBuildup = \frac{\sum_1^{72} (0.96)^t * (HeatIndex \ t \ hours \ prior)}{1,000}$$

Heat index is calculated according to the National Oceanic and Atmospheric Administration (NOAA) formula with no adjustment<sup>6</sup> as:

$$Heat \ Index = -42.379 + 2.04901523 * T + 10.14333127 * RH - .22475541 * T * RH - .00683783 * T * T - .05481717 * RH * RH + .00122874 * T * T * RH + .00085282 * T * RH * RH - .00000199 * T * T * RH * RH$$

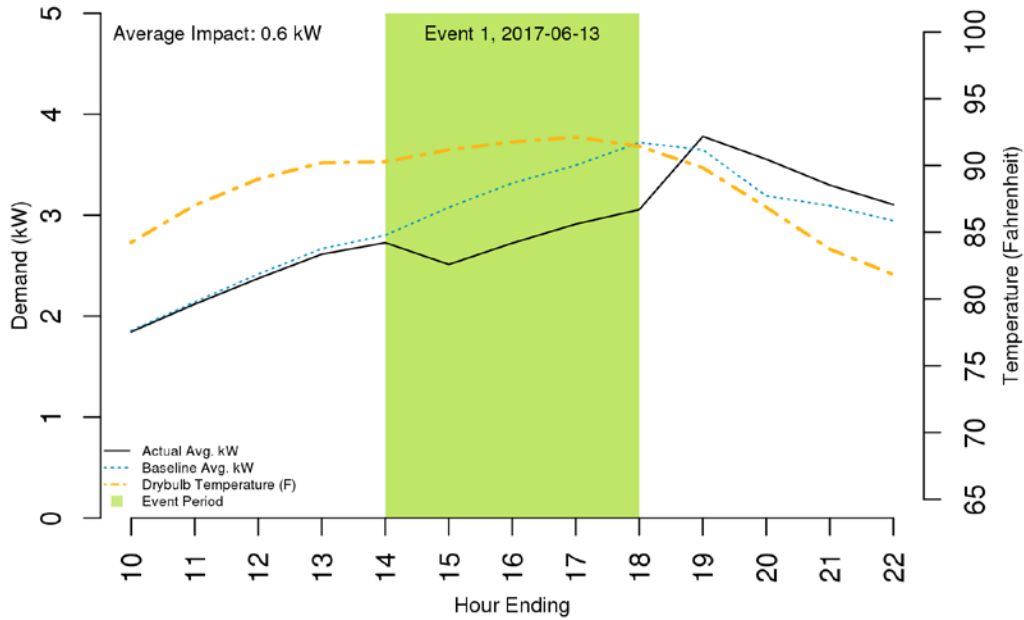
Where  $T$  is the dry-bulb temperature in degrees Fahrenheit and  $RH$  is relative humidity in percent.

- $SB_{kijt}$  = is a dummy variable taking the value 1 where hour of sample  $t$  is the  $f^{th}$  hour following the end of an event. The 2 hours following each event were considered snapback hours.
- $\beta_0 - \beta_4$  = Parameter estimates. These values are the estimated relationship between demand and the variable for which the beta represents.  $\beta_0$  is the intercept.

Figure 3-1, 3-2, and 3-3 compare the average estimated baseline (blue dashed) and actual (solid black) loads for all customers, and illustrate the reduction in load in each hour of the event period.

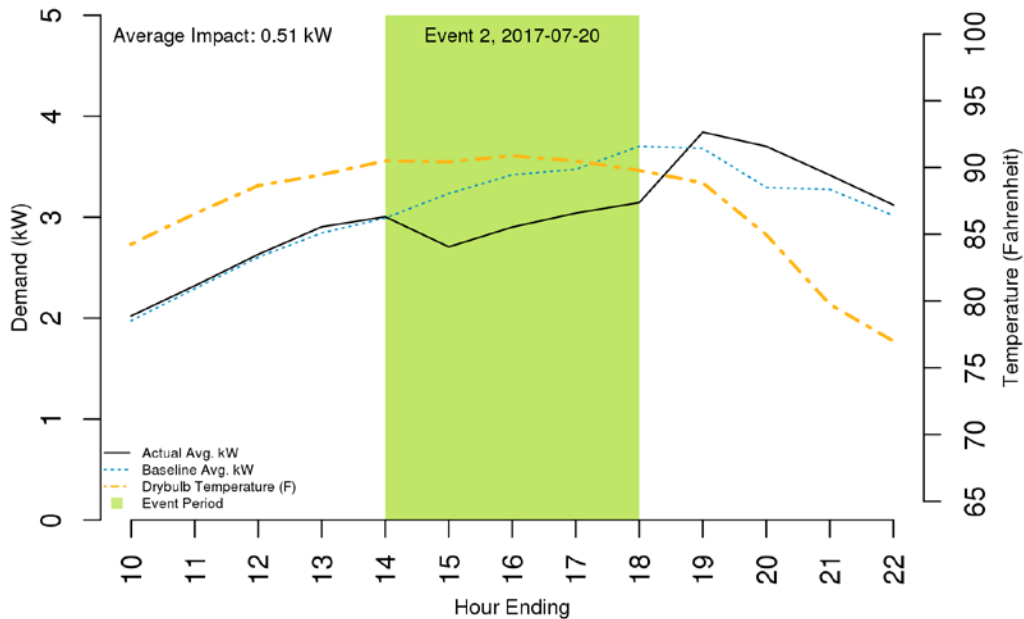
<sup>6</sup> The Heat Index Equation. National Oceanic and Atmospheric Administration. "The Heat Index Equation." [http://www.wpc.ncep.noaa.gov/html/heatindex\\_equation.shtml](http://www.wpc.ncep.noaa.gov/html/heatindex_equation.shtml).

**Figure 3-1. Event 1 Residential Average Actual Load, Estimated Baseline Load, and Temperature**



Source: Navigant analysis

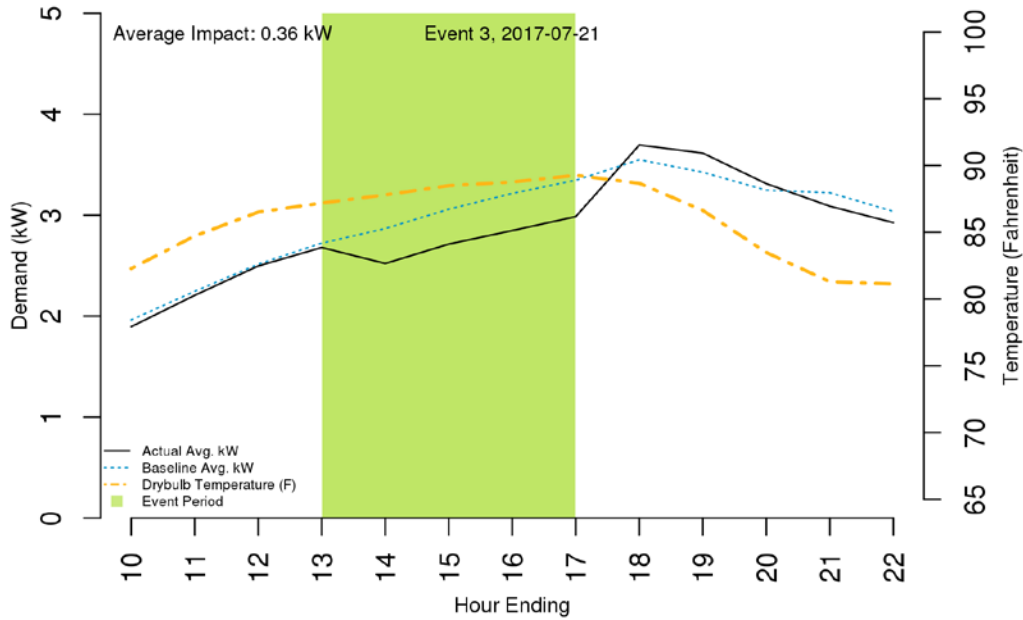
**Figure 3-2. Event 2 Residential Average Actual Load, Estimated Baseline Load, and Temperature**



Source: Navigant analysis



Figure 3-3. Event 3 Residential Average Actual Load, Estimated Baseline Load, and Temperature



Source: Navigant analysis

Table 3-4 provides the sampling frame for the gross impact evaluation of the Residential DR Program in PY9.

Table 3-4. Residential DR Program Gross Impact Sample Design for PY9

Stratum Solution	Stratum Name	Percentage of Program Reported Savings	Population Size	Achieved Sample Size	Verification Method
<b>Total Program</b>	Residential	100%	60,846	60,143	Within-Subjects Regression

Note: Values in tables may not reconcile exactly with the sum of more detailed level results or previously reported results due to rounding.

Source: Navigant analysis

Table 3-5 provides a summary of reported and verified demand (MW) savings results, along with the relative precision for each stratum sampled for the Residential DR Program in PY9. The relative precision was calculated in accordance with the protocols specified in the evaluation framework.<sup>7</sup>

<sup>7</sup> Evaluation Framework For Pennsylvania Act 129 EE&C Programs. [http://www.puc.state.pa.us/Electric/pdf/Act129/SWE\\_PhaseIII-Evaluation\\_Framework102616.pdf](http://www.puc.state.pa.us/Electric/pdf/Act129/SWE_PhaseIII-Evaluation_Framework102616.pdf)

**Table 3-5. Residential DR Program Gross Demand Savings Impact Evaluation Results for PY9**

Stratum Solution	Stratum Name	Reported Gross Demand Savings (MW)	Verified Gross Demand Savings (MW)	Demand RR	Relative Precision at 90% Confidence Interval
<b>Total Program</b>	Residential	N/A	32.1	N/A	6%

Note: Values in tables may not reconcile exactly with the sum of more detailed level results or previously reported results due to rounding.

Source: Navigant analysis

The verified gross demand savings of 32.1 MW represents 86% of the expected savings of the 37.5 MW anticipated for the residential Direct Load Control solution in PECO’s Phase III EE&C Plan. The following are possible factors that led to the lower than expected verified savings:

- Some residential air conditioners may have been replaced and the DLC switch not reconnected to the new appliance.
- Some switches may be malfunctioning, reducing the overall average impact per customer.
- Some percentage of customers may have turned off or uninstalled their switch to avoid being curtailed altogether.

### 3.1.3 Process Evaluation

Navigant conducted in-depth interviews with the program managers at PECO and the CSP, Itron. The interviews provided a detailed picture of the program implementation, the goals of the program managers, and the customer experience with the program. These interviews also informed the content of the customer surveys.

Navigant fielded a post-event survey for residential customers. The survey was designed to:

- Assess customer understanding, satisfaction, and attitudes about the program
- Assess customer awareness and comfort during DR events
- Measure success and identify potential areas for program design improvement

The survey was fielded by telephone directly following the first and third DR events of the 2017 season, as well as one placebo day—a day when the weather was hot but no DR event was called. When possible, fielding was completed within 48 hours of the end of the event. The residential survey targeted 90 completes per fielding based on a sample designed to achieve 90/10 confidence and precision. Table 3-6 displays the total number of completes achieved.

**Table 3-6. Residential DR Post-Event Survey Completes**

Stratum Name	Event 1: June 13	Event 3: July 21	Placebo: August 2
<b>Residential</b>	109	92	91

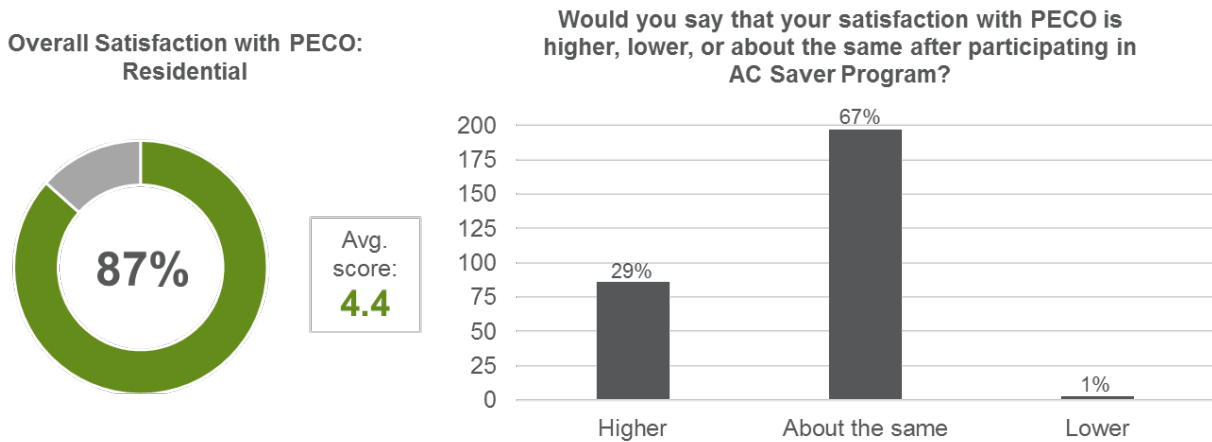
Source: Navigant analysis

The survey assessed whether participants were aware of the DR event and found that only 18% of customers reported awareness. Of those customers, 57% reported receiving a pre-event notification from

PECO. Customers are able to opt in to event notification emails, but only approximately 3,000 customers are enrolled.

The survey also investigated satisfaction. Satisfaction is assessed using a scale of 1 to 5, with 1 being very unsatisfied and 5 being very satisfied. Navigant qualifies customer satisfaction as a rating of 4 or 5. The team found that most participants were satisfied with PECO as a company and the DLC Program participation had a positive or neutral effect, as shown in Figure 3-4.

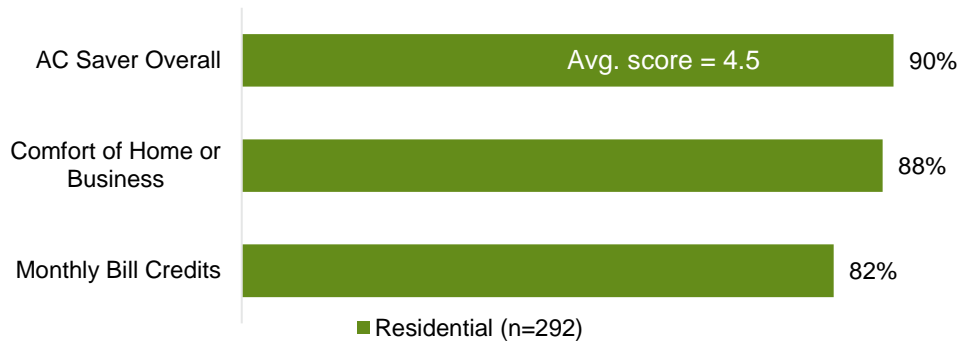
**Figure 3-4. Residential DR Satisfaction with PECO (n=286)**



Source: Navigant analysis

Most Residential DR participants were also satisfied with the AC Saver Program, their home comfort during events, and the bill credits they receive, as shown in Figure 3-5.

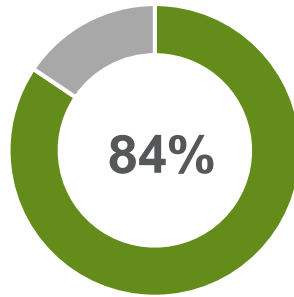
**Figure 3-5. Residential DR Satisfaction with Program Components**



Source: Navigant analysis

Survey respondents were also asked to rate the likelihood they would recommend the DR program to friends or family. Of residential respondents, 84% were likely to recommend the program, as shown in Figure 3-6.

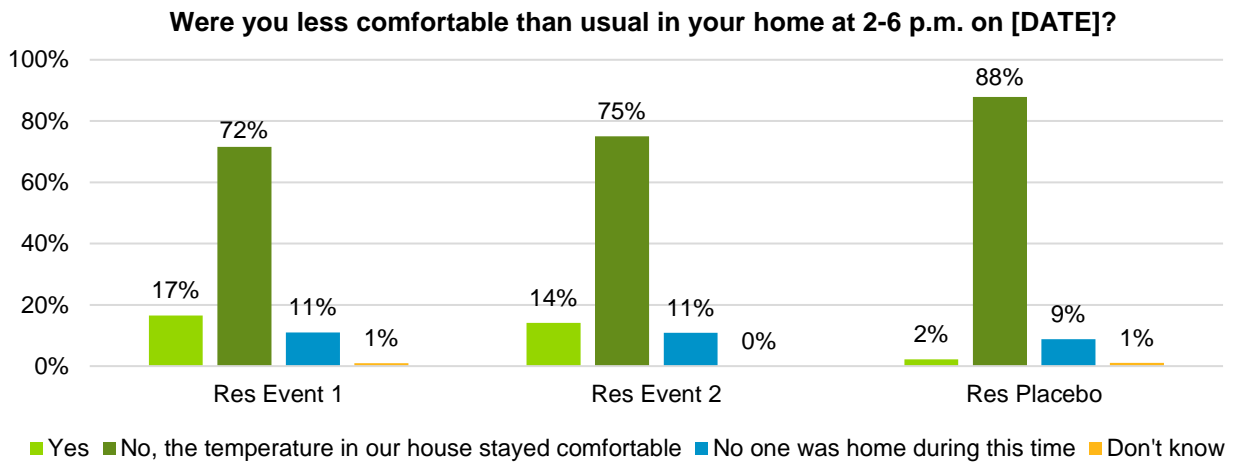
Figure 3-6. Likelihood to Recommend AC Saver Program: Residential (n=288)



Source: Navigant analysis

As shown in Figure 3-7, the majority of residential customers did not report any discomfort during event hours.

Figure 3-7. Residential DR Reported Home Comfort During Events (n=292)



Source: Navigant analysis

### 3.1.4 Cost-Effectiveness Reporting

A detailed breakdown of program finances and cost-effectiveness will be presented in the Annual PY9 Report filed in November 2018, once full program year expenditures are complete.

### 3.1.5 Status of Recommendations

The impact and process evaluation activities in PY9 led to the following findings and recommendations from Navigant to PECO, along with a summary of how PECO plans to address the recommendation in program delivery.

**Table 3-7. Summary of Findings and Recommendations for Residential DR Program**

Solution	Finding	Recommendation	EDC Status
DLC	Event performance was lower than projected	Investigate switch operability	Switch Operability Study Planned
DLC	AMI meter data contained a large percentage of integers	Investigate data quality and data query procedures	Completed (Spring 2018)
DLC	Some customers reported that they would like more information about the program	Consider increasing communication with customers so that they feel more engaged with the program: a. Invite customers to opt in to event notification emails b. Send an end-of-season report to customers that explains the event dates that were called and the system impacts of the program	Under consideration
DLC	Customers are interested in saving energy but have low awareness of other program offerings	Market additional EE opportunities to encourage program channeling	Under consideration

Source: Navigant analysis

### 3.2 Small C&I DR Program

PECO designed the its Small C&I DR Program to engage customers in demand reduction through DLC of major electrical end-use equipment during designated peak load hours. The eligible population and target markets for the Small C&I DR Program are all PECO small C&I customers; this includes customers in the government, educational, and non-profit (G/E/NP) sector. The program encompasses a single solution: the DLC Solution.

The Small C&I DLC Solution is implemented by Itron (previously Converge). The program shifts load off peak hours by cycling participant air conditioners during DR event days. A participant is defined as a unique account number where device status is install or swap and the measure code is PCT (program controlled thermostat). One participant may have more than one DLC device installed on the premise. The categories not included in the participant count include disconnect, opt-out, and removal. The summer DR events had over 1,500 small C&I participants. This year and for the remainder of Phase III, the incentive is \$40 per DLC unit per year.

For Phase III, these event days are called when the PJM day-ahead peak load forecast reaches 96%. Based on the day-ahead forecasts, PECO called three events during the summer of 2017: June 13 (2:00 p.m.-6:00 p.m.), July 20 (2:00 p.m.-6:00 p.m.), and July 21 (1:00 p.m.-5:00 p.m.).

Compliance targets for DR programs were established at the system level, which means the load reductions measured at the customer meter must be escalated to reflect T&D losses. The peak demand impacts presented in this section are adjusted for line losses.

### 3.2.1 Participation and Reported Savings by Customer Segment

This section provides the total Small C&I DR Program results for PY9, including participation, demand savings, and incentive costs. Table 3-8 presents the participation counts and incentive payments for the Small C&I DR Program in PY9 by customer segment.

**Table 3-8. Summary Statistics for Small C&I DR Program by Customer Segment**

Parameter	Customer Segment	Program Year					Phase III to Date
		PY8	PY9	PY10	PY11	PY12	
<b>Participation</b>	Residential	-	-	-	-	-	-
	Small C&I	1,586	1,564	-	-	-	1,586 <sup>a</sup>
	Large C&I	-	-	-	-	-	-
	<b>Total</b>	<b>1,586</b>	<b>1,564</b>	-	-	-	<b>1,586</b>
<b>Incentive Spending (\$1,000)</b>	Residential	-	-	-	-	-	-
	Small C&I	122	115	-	-	-	237
	Large C&I	-	-	-	-	-	-
	<b>Total</b>	<b>122</b>	<b>115</b>	-	-	-	<b>237</b>

<sup>a</sup> DR participation is not additive like other programs because the same participants tend to remain in the program with only small attrition. Therefore, total participation in the DR programs for Phase III is equal to the highest program year participation count.

Note: Values in tables may not reconcile exactly with the sum of more detailed level results or previously reported results due to rounding.

Source: Navigant analysis

Table 3-9 provides the reported and verified demand savings results for the Small C&I DR Program for PY9.

**Table 3-9. Summary of Demand Savings for Small C&I DR Program by Customer Segment**

Parameter	Customer Segment	Program Year					Phase III to Date
		PY8	PY9	PY10	PY11	PY12	
<b>Reported Gross Demand Savings (MW)</b>	Residential	-	-	-	-	-	-
	Small C&I	-	N/A	-	-	-	N/A
	Large C&I	-	-	-	-	-	-
	<b>Total</b>	-	<b>N/A</b>	-	-	-	<b>N/A</b>
<b>Verified Gross Demand Savings (MW)</b>	Residential	-	-	-	-	-	-
	Small C&I	-	0	-	-	-	0
	Large C&I	-	-	-	-	-	-
	<b>Total</b>	-	<b>0</b>	-	-	-	<b>0</b>
<b>Demand Savings RR</b>	Residential	-	-	-	-	-	-
	Small C&I	-	N/A	-	-	-	N/A
	Large C&I	-	-	-	-	-	-
	<b>Total</b>	-	<b>N/A</b>	-	-	-	<b>N/A</b>

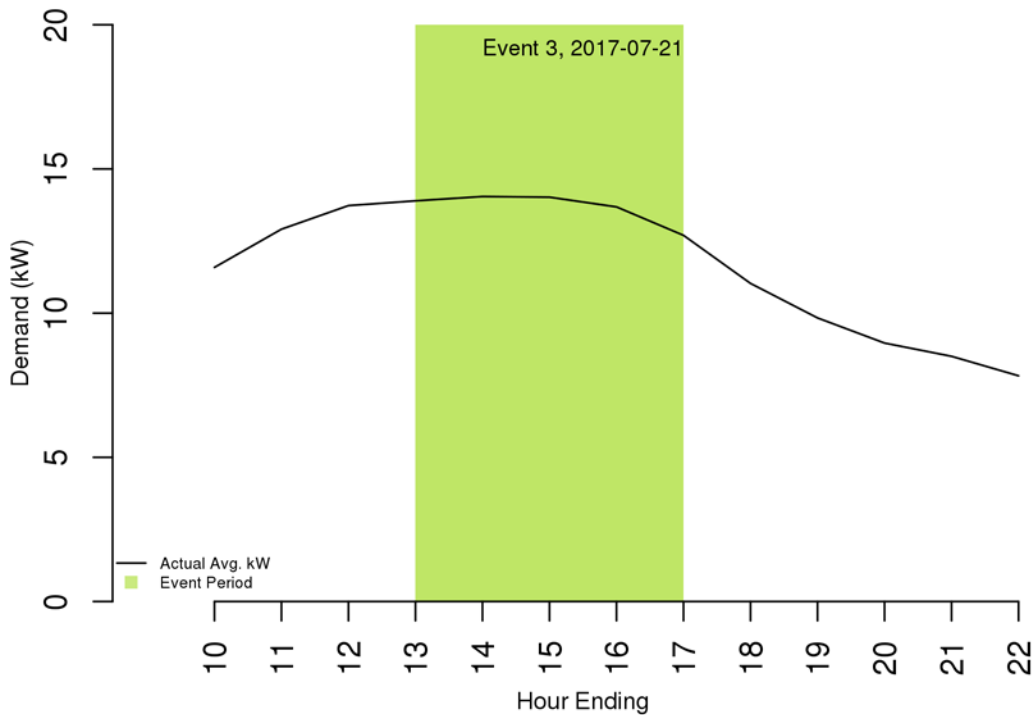
Note: Values in tables may not reconcile exactly with the sum of more detailed level results or previously reported results due to rounding.

Source: Navigant analysis

### 3.2.2 Gross Impact Evaluation

Navigant applied the identical regression specification described for the Residential DLC Program and did not find statistically significant savings for the June 13, July 20, or July 21 events. As shown in Figure 3-8 the average demand for all participants during Event 3 does not show a substantial impact. The results suggest that PECO cannot claim any savings for this program for PY9. Accordingly, savings are set equal to zero for PY9.

Figure 3-8. Actual Average Demand for All Small C&I Participants on Event 3



Source: Navigant analysis

### 3.2.3 Process Evaluation

Navigant conducted in-depth interviews with the program managers at PECO and the CSP, Itron. The interviews provided a detailed picture of the program implementation, the goals of the program managers, and the customer experience with the program. These interviews also informed the content of the customer surveys.

Navigant fielded a post-event survey for commercial customers. The survey was designed to:

- Assess customer understanding, satisfaction, and attitudes about the program
- Assess customer awareness and comfort during DR events
- Measure success and identify potential areas for program design improvement

The survey was fielded by telephone directly following the third DR event of the 2017 season, as well as one placebo day—a day when the weather was hot but no DR event was called. When possible, fielding was completed within 5 days of the end of the event. The commercial survey targeted 50 completes per fielding based on a sample designed to achieve 90/10 confidence and precision. As shown in Table 3-10, the total number of completes achieved was below the target sample. The team, therefore, caveats the results presented below and only shows results aggregated from the two survey fielding efforts (51



completes total). Navigant is considering alternative survey methods to reach the Small C&I group in future program years, including online surveys.

**Table 3-10. Small C&I DR Post-Event Survey Completes**

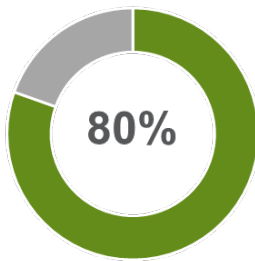
Stratum Name	Event 1: June 13	Event 3: July 21	Placebo: August 2
<b>Commercial</b>	0	8	43

Source: Navigant analysis

The survey primarily examined satisfaction. Satisfaction is assessed using a scale of 1 to 5, with 1 being very unsatisfied and 5 being very satisfied. Navigant qualifies customer satisfaction as a rating of 4 or 5. The team found that most commercial participants were satisfied with PECO as a company and the AC Saver participation had a positive or neutral effect, as shown in Figure 3-9.

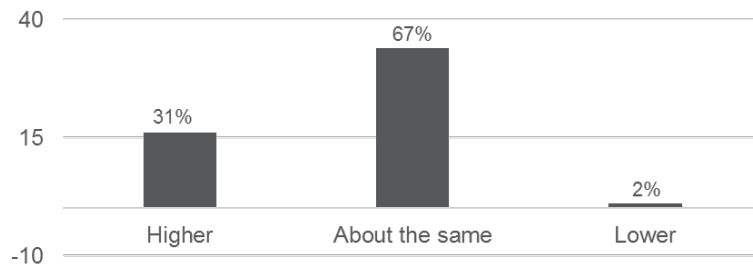
**Figure 3-9. Small C&I DR Satisfaction with PECO (n=51)**

Overall Satisfaction with PECO:  
Commercial



Avg. score:  
**4.2**

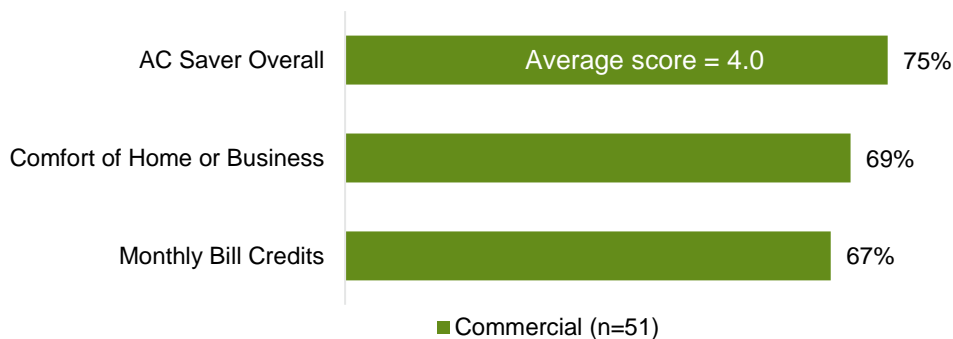
Would you say that your satisfaction with PECO is higher, lower, or about the same after participating in AC Saver Program?



Source: Navigant analysis

Most commercial DR participants were also satisfied with the AC Saver Program, the comfort of their place of business during events, and the bill credits they receive, as shown in Figure 3-10.

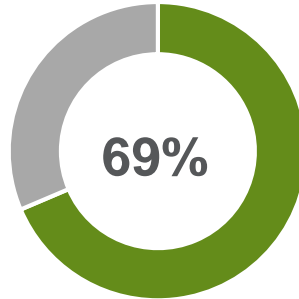
**Figure 3-10. Small C&I DR Satisfaction with Program Components**



Source: Navigant analysis

Survey respondents were also asked to rate the likelihood they would recommend the DR program to friends or family. Of commercial respondents, 96% were likely to recommend the program, as shown in Figure 3-11.

**Figure 3-11. Likelihood to Recommend DR Program: Small C&I (n=51)**



Source: Navigant analysis

**3.2.4 Cost-Effectiveness Reporting**

A detailed breakdown of program finances and cost-effectiveness will be presented in the Annual PY9 Report filed in November 2018, once full program year expenditures are complete.

**3.2.5 Status of Recommendations**

The impact and process evaluation activities in PY9 led to the following findings and recommendations from Navigant to PECO, along with a summary of how PECO plans to address the recommendation in program delivery.

**Table 3-11. Summary of Findings and Recommendations for Small C&I DR Program**

Solution	Finding	Recommendation	EDC Status
DLC	Event performance was lower than projected	Investigate PCT signal reception and operability	Switch Operability Study Planned
DLC	AMI meter data contained a large percentage of integers	Investigate data quality and data query procedures	Completed (Spring 2018)
DLC	Some customers reported that they would like more information about the program	Consider increasing communication with customers so that they feel more engaged with the program: a. Invite customers to opt in to event notification emails b. Send an end-of-season report to customers that explains the event dates that were called and the system impacts of the program	Under consideration
DLC	Customers are interested in saving energy but have low awareness of other program offerings	Market additional EE opportunities to encourage program channeling	Under consideration

Source: Navigant analysis

### 3.3 Large C&I DR Program

PECO designed the Large C&I DR Program to engage customers in demand reduction through DRA across multiple customers. The eligible population and target markets for the PECO Large C&I DR Program are all PECO large C&I electric customers, including those in the G/E/NP sector. The program encompasses a single solution: the DRA Solution. The program is implemented by two CSPs: EnerNOC and CPower.

Compliance targets for DR programs were established at the system level, which means the load reductions measured at the customer meter must be escalated to reflect T&D losses. The peak demand impacts presented in this section have been adjusted for line losses.

#### 3.3.1 Participation and Reported Savings by Customer Segment

This section provides the total Large C&I DR Program results for PY9, including participation, demand savings, and incentive costs. Table 3-12 presents the participation counts and incentive payments for the Large C&I DR Program in PY9 by customer segment. In PY9, 261 Large C&I customers participated in the program.

**Table 3-12. Summary Statistics for Large C&I DR Program by Customer Segment**

Parameter	Customer Segment	Program Year					Phase III to Date
		PY8	PY9	PY10	PY11	PY12	
<b>Participation</b>	Residential	-	-	-	-	-	-
	Small C&I	-	-	-	-	-	-
	Large C&I	N/A	261	-	-	-	261 <sup>a</sup>
	<b>Total</b>	<b>N/A</b>	<b>261</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>261</b>
<b>Incentive Spending (\$1,000)</b>	Residential	-	-	-	-	-	-
	Small C&I	-	-	-	-	-	-
	Large C&I	0	0 <sup>b</sup>	-	-	-	0 <sup>b</sup>
	<b>Total</b>	<b>0</b>	<b>0</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>0</b>

<sup>a</sup> DR participation is not additive like other programs because the same participants tend to remain in the program with only small attrition. Therefore, total participation in the DR programs for Phase III is equal to the highest program year participation count.

<sup>b</sup> PECO contracts with the program CSPs to obtain the DR resources for the program and does not provide direct participant incentives. Each CSP controls its participant incentives independently; thus, the PECO customer incentive amount is zero.

Note: Values in tables may not reconcile exactly with the sum of more detailed level results or previously reported results due to rounding.

Source: Navigant analysis

Table 3-13 provides the reported and verified demand savings results for the Large C&I DR Program for PY9. Reported savings for PY9 are equal to 104.8 MW, while verified gross savings are equal to 117.3 MW. This is equal to an 112% RR for the Large C&I segment of the PY9 DR program.

**Table 3-13. Summary of Demand Savings for Large C&I DR Program by Customer Segment**

Parameter	Customer Segment	Program Year					Phase III to Date
		PY8	PY9	PY10	PY11	PY12	
<b>Reported Gross Demand Savings (MW)</b>	Residential	-	-	-	-	-	-
	Small C&I	-	-	-	-	-	-
	Large C&I	N/A	104.8	-	-	-	104.8
	<b>Total</b>	<b>N/A</b>	<b>104.8</b>	-	-	-	<b>104.8</b>
<b>Verified Gross Demand Savings (MW)</b>	Residential	-	-	-	-	-	-
	Small C&I	-	-	-	-	-	-
	Large C&I	N/A	117.3	-	-	-	117.3
	<b>Total</b>	<b>N/A</b>	<b>117.3</b>	-	-	-	<b>117.3</b>
<b>Demand Savings RR</b>	Residential	-	-	-	-	-	-
	Small C&I	-	-	-	-	-	-
	Large C&I	N/A	112%	-	-	-	112%
	<b>Total</b>	<b>N/A</b>	<b>112%</b>	-	-	-	<b>112%</b>

Note: Values in tables may not reconcile exactly with the sum of more detailed level results or previously reported results due to rounding.

Source: Navigant analysis

### 3.3.2 Gross Impact Evaluation

Navigant implemented a combination approach for estimating gross demand impacts for the Large C&I Program: within-subjects regression (individual customer regressions) and day averaging (customer baselines, or CBLs). Although the accuracy of a variety of different CBLs was tested, the final verified impacts reported by Navigant are all derived from regression models (the preferred approach for Large C&I DR evaluation cited in the Evaluation Framework’s hierarchy of approaches). The reasons for this are discussed in this section.

Navigant’s approach tests several baseline methods for each customer and chooses the baseline that most accurately predicts actual baseline in an out-of-sample non-event period. Table 3-14 summarizes the baseline methods tested in this analysis. These methods are further described in the paragraphs that follow.

Table 3-14. Summary of Baselines for Large C&I Impact Evaluation

Baseline	Description
<b>Within-Subjects Regression</b>	Uses loads of participating customers on non-event days to estimate the reference load. Demand is specified as a function of temperature and other variables that influence usage in the regression equation. The regression dataset includes all non-event, non-holiday weekdays, with some exclusions described in this section. This dataset is the base dataset.
<b>Within-Subjects Regression – Decile Method</b>	The regression dataset excludes 10% of non-event days from the base set. Two alternative metrics were tested for selecting exclusions: days with the lowest customer demand and days with the lowest customer demand from 12 p.m. to 9 p.m. are excluded.
<b>Within-Subjects Regression – Quintile Method</b>	The regression dataset excludes 20% of non-event days from the base set. Two alternative metrics were tested for selecting exclusions: days with the lowest customer demand and days with the lowest customer demand from 12 p.m. to 9 p.m. are excluded.
<b>Customer Baseline (CBL) – X-of-Y</b>	Reference load calculation, which is the simple arithmetic mean of loads from the same hour on non-event days. X out of the previous Y days before the event are used for this calculation, not including event days, weekends/holidays, notification days (June 12, July 19) and special exclusions in the lookback window. Navigant tested seven different CBLs: 2-of-2, 2-of-3, 3-of-3, 4-of-4, 3-of-5, 4-of-5, and 5-of-5.

Source: Navigant analysis

### 1. Within-Subjects Regression

The within-subjects regression model predicts customer load as a function of the event hours, day of the week, hour of the day, and cooling degree hours. The within-subjects regression equation is illustrated in Equation 3-2.

Equation 3-2. Large C&I Within-Subjects Regression Equation

$$Q_{kijt} = \beta_0 + \sum_{\varphi}^N \beta_{1\varphi} Treat_{kijt} + \sum_{i=1}^{48} \beta_{2i} \cdot h_{ijt} + \sum_{i=1}^{48} \beta_{3i} \cdot h_{ijt} \cdot CDH_{ijt} + \varepsilon_{kijt}$$

Where

- $k$  = customer,  $i$  = half hour ending,  $j$  = day,  $t$  = month.
- $Q_{kijt}$  = Half hour demand for customer  $k$  during hour ending  $i$  on day  $j$  in month  $t$ .
- $Treat_{kijt}$  = A set of 24 indicator variables (one for each half hour period in which an event takes place—i.e., three events times 4 hours, times two observations per hour) taking value of

	1 if customer $k$ at half hour ending $i$ on day $j$ and month $t$ is an event and takes value 0 if otherwise.
$h_{ijt}$	= 48 indicator variables, each taking a value of 1 if half hour ending $i$ of the day $j$ on month $t$ and 0 otherwise.
$CDH_{ijt}$	= is the number of cooling degree hours during half hour ending $i$ day $j$ and month $t$ . The base for this calculation is 65°F.
$\beta_0 - \beta_3$	= Parameter estimates. These values are the estimated relationship between demand and the variable for which the beta represents. $\beta_0$ is the intercept.

## 2. Day Averaging (CBL Baseline)

The CBL approach employed by Navigant is a standard X-of-Y CBL. CBLs were estimated for a number of different values of X and Y. Navigant tested seven different CBLs: 2-of-2, 2-of-3, 3-of-3, 4-of-4, 3-of-5, 4-of-5, and 5-of-5. The baseline was estimated in the following manner:

- 1. Remove non-qualifying days:** In this step, weekends, public holidays, and any other exclusions are removed from the dataset.
- 2. Identify lookback window:** Next, a Y-day window of qualifying days preceding the event is identified.
- 3. Keep X highest demand days:** The X days with the highest average demand during the event window are kept and other days are dropped.
- 4. Calculate CBL:** The event-specific CBL values are estimated by calculating the average demand, by half hour of day, in the X non-event days kept from within the lookback window.

### Baseline Selection

To determine which baseline to compare actual usage to during the event windows, Navigant used a method selection process for each customer as follows:

- 1. Select test days:** Select three days with which to test the performance of each baseline method.
- 2. Estimate all baselines:** Calculate baselines on test days using all methods.
- 3. Test and select best method:** Determine which method performed best on test days and use it to calculate the baseline on event days.

### Select Test Days

For each customer, Navigant selected the three days with the highest daily average load as forecast by PJM from the time period after the last event (July 21) through July 31, the last day for which data was available for the majority of participants. This window was selected to maximize the number of days available for CBL calculations. For 250 customers, the selected test days were July 24, 27, and 31. The remainder of customers (11) did not have interval data available during this window. For these customers test days were selected from dates where all such customers had available interval data. The selected test days were July 13, 14, and 18.

### Estimate All Baselines

To estimate baselines for each customer, Navigant created a base dataset using interval data for June and July 2017, which excluded certain dates from the interval data. The dates excluded were:

- Test days (specific to each customer), excluded only for selecting the best method, and otherwise included in estimating impacts
- Event days
- Weekends/holidays
- June 12 and July 19 (notification days)
- Special exclusions (i.e., days where sites participated in economic events, such as for a large education sector customer<sup>8</sup>)

Navigant used the base dataset to estimate the following CBLs for each customer: 2-of-2, 2-of-3, 3-of-3, 4-of-4, 3-of-5, 4-of-5, and 5-of-5.

Navigant estimated impacts for each customer using one of five regression models, based on four variations of the base dataset for each customer, employing the decile and quintile methods.

Each “model” uses the same model specification, but four of these approaches exclude some non-event days from the estimation set. The fifth approach includes all non-missing data not otherwise excluded per the above (e.g., holidays, etc.) The details of the exclusions for the four variations are provided below.<sup>9</sup>

1. **Decile, All Hours:** The bottom **decile** demand days are dropped. For this dataset, each customer’s lowest decile of demand days is removed. This is determined by taking average demand per day over all hours in the day.
2. **Decile, Prime Hours:** The bottom **decile** demand days are dropped. For this dataset, each customer’s lowest decile of demand days is removed. This is determined by taking average demand per day over the period 12:00 p.m. to 9:00 p.m.
3. **Quintile, All Hours:** The bottom **quintile** demand days are dropped. For this dataset, each customer’s lowest quintile of demand days is removed. This is determined by taking average demand per day over all hours in the day.
4. **Quintile, Prime Hours:** The bottom **quintile** demand days are dropped. For this dataset, each customer’s lowest quintile of demand days is removed. This is determined by taking average demand per day over the period 12:00 p.m. to 9:00 p.m. This time period was selected because this is the dispatch period.

### ***Test and Select Best Method***

<sup>8</sup> To date, non-Act 129 DR participation information has been provided only for this customer.

<sup>9</sup> For the four set of exclusionary data sets below, Navigant applied an additional, pre-processing step, to avoid (for example) excluding days with complete data in favor of days with very few non-missing observations. For the four exclusionary sets below, the pre-processing step eliminates any days in which more than 25% of observations in the period of interest (all hours of the day for the “All Hours” sets, and from noon to 9pm for the “Prime Hours” sets) are missing, prior to applying the decile or quintile matching..

The predicted demand from all methods was compared with actual demand on test days during the event window, 1 p.m. to 6 p.m.. For each customer, Navigant selected the best method to estimate baseline demand on event days based on the following criteria:

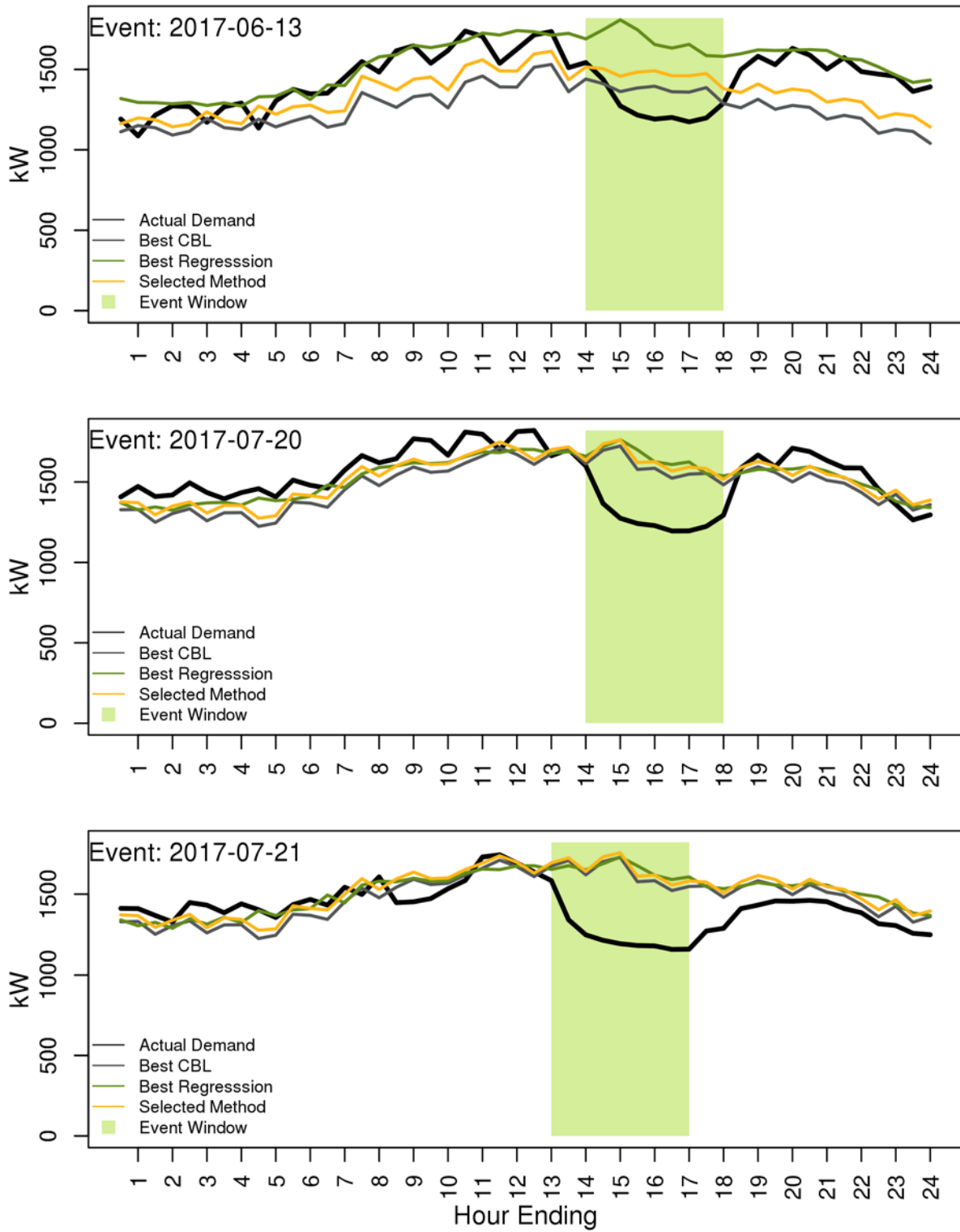
- Most accurately predicts demand during the event window on test days, defined as the lowest mean squared error over all test days.
- Can be computed for all three event days. For example, some CBLs could not be calculated for certain event days due to missing interval data for previous non-event, non-holiday weekdays. In this case, any method that could not be computed for all three events was not selected.

An analysis of the estimated impacts delivered by this approach showed that CBLs substantially underestimated impacts (in aggregate) for Event 1.

In aggregate, regressions and CBLs delivered similar impacts for Events 2 and 3. This is illustrated in Figure 3-12, which compares the actual average demand (black line) for all customers with the averages of the best CBL (grey line), best regression (green line), and the best selected method for each customer (a mixture of CBLs and regressions, yellow line). A comparison of the grey and yellow lines (that all include CBLs) with actual event day demand (black line) shows that the CBL-derived baselines are biased downward, underestimating both baseline demand and, consequently, impacts.



Figure 3-12. Average Demand and Predictions for Aggregated Large C&I Customers by Event

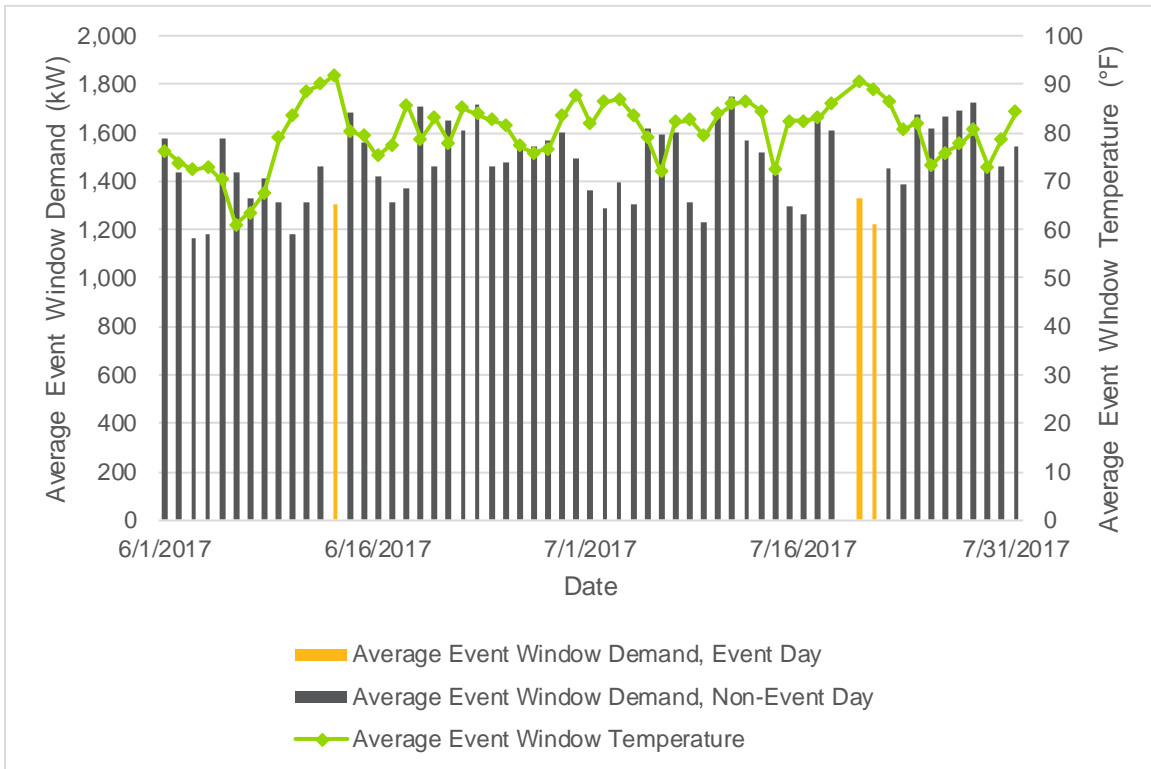
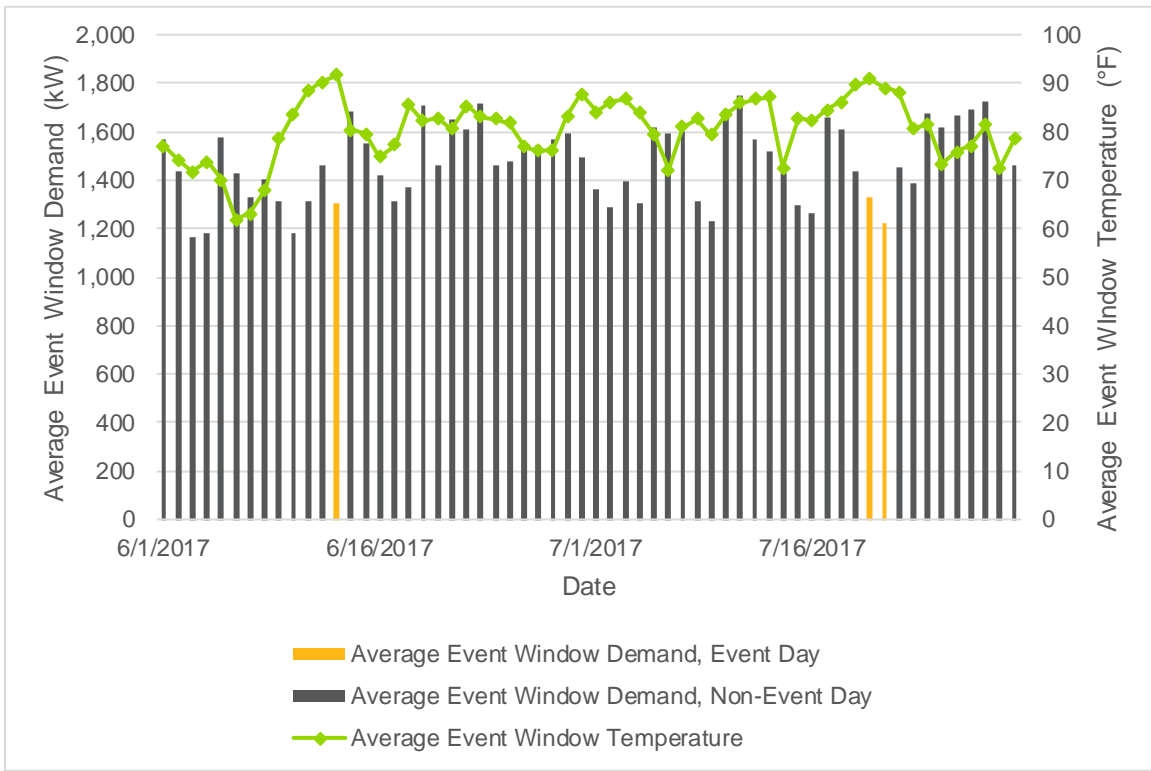


*Source: Navigant analysis*

This bias in CBLs for Event 1 appears to be because Event 1 (June 13) was preceded by much cooler weather, shown in Figure 3-13. Specifically, the average event period temperature on June 13 (Event 1) was 90°F. Although the day immediately preceding this event was also hot (average temperature 88°F), it was a Monday, meaning that there is a 2-day gap between that day and the next eligible CBL baseline day. The average event period temperature was only 78°F on June 9 (Friday), 67°F on June 8 (Thursday), and 63°F and 61°F, respectively, on June 7 and 6. This means that the CBL is making use of days in which the average temperature could be as much as 30°F lower than the event day to predict event day demand (since a CBL only uses prior days for estimation). The effect of this cool (relative to the event day) baseline period is to deliver an inappropriately low CBL baseline for Event 1. Regressions, in contrast, are not limited only to pre-event days and leverage estimated demand/temperature relationships throughout the entire summer to predict a baseline.

Based on this analysis and its findings, Navigant decided (in consultation with the Statewide Evaluator, or SWE) that it was inappropriate to apply the CBLs for event day impact estimation. The exclusive use of regression analysis is consistent with the SWE's hierarchy of methods described in the Evaluation Framework, which favors regressions over CBLs.

**Figure 3-13. Average Demand and Temperature during Event Window (1 p.m.-6 p.m.) by Day**



Source: Navigant analysis

Table 3-15 summarizes the number customers for which each regression method was selected.

**Table 3-15. Summary of Large C&I Regression Methods Selected**

Regression Method Selected	Number of Customers	Percent of Total
Base Dataset	101	39%
Quintile, All Hours	71	27%
Quintile, Prime Hours	59	23%
Decile, All Hours	23	9%
Decile, Prime Hours	7	3%

Source: Navigant analysis

Table 3-16 provides the sampling frame for the gross impact evaluation of the Large C&I DR Program in PY9.

**Table 3-16. Large C&I DR Program Gross Impact Sample Design for PY9**

Stratum Solution	Stratum Name	Percentage of Program Reported Savings	Population Size	Achieved Sample Size	Verification Method
<b>Total Program</b>	Large C&I DR	100%	261	261	Regression

Source: Navigant analysis

Table 3-17 provides a summary of reported and verified demand (MW) savings results, along with the relative precision for each stratum sampled for the Large C&I DR Program in PY9. The relative precision was calculated in accordance with the protocols specified in the evaluation framework.<sup>10</sup>

**Table 3-17. Large C&I DR Program Gross Demand Savings Impact Evaluation Results for PY9**

Stratum Solution	Stratum Name	Reported Gross Demand Savings (MW)	Verified Gross Demand Savings (MW)	Demand RR	Relative Precision at 90% Confidence Interval
<b>Total Program</b>	Large C&I DR	104.8	117.3	112%	12%

Note: Values in tables may not reconcile exactly with the sum of more detailed level results or previously reported results due to rounding.

Source: Navigant analysis

The following are possible factors that led to the variation between the reported and verified savings and the resulting observed RRs:

- To calculate reported savings, CSPs rely on the CBL approach; however, CBLs were excluded from verification (per discussion above) entirely. The higher verified savings are consistent with CBLs underestimating impacts for Event 1.

<sup>10</sup> Evaluation Framework For Pennsylvania Act 129 EE&C Programs. [http://www.puc.state.pa.us/Electric/pdf/Act129/SWE\\_PhaseIII-Evaluation\\_Framework102616.pdf](http://www.puc.state.pa.us/Electric/pdf/Act129/SWE_PhaseIII-Evaluation_Framework102616.pdf)

The following are possible factors that led to lower than expected verified savings:

- PECO has identified that some large C&I customers conduct active demand management activities, including peak load shaving for 5CP hours and the PJM Economic Program. PECO could provide DR participation data only for a single customer, meaning that Navigant could not explicitly control for non-Act 129 DR, potentially biasing impacts downward. Large power users contributed 15 MWh of curtailment in June and 61 MWh in July.<sup>11</sup>

### 3.3.3 Process Evaluation

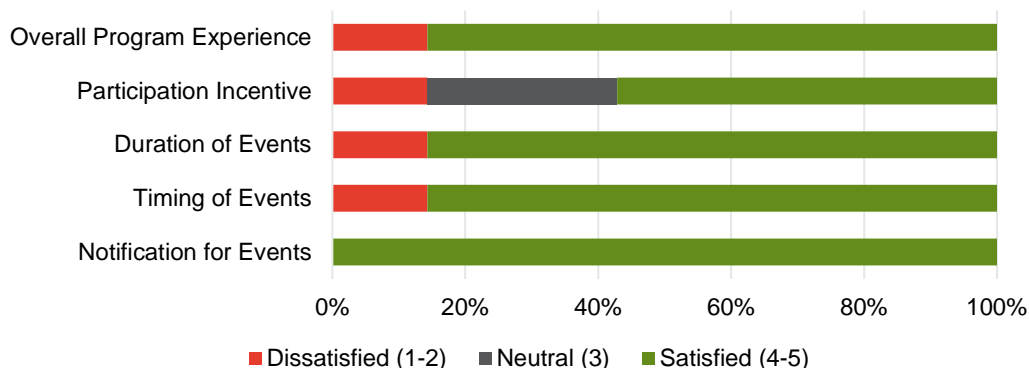
Navigant conducted in-depth interviews with the program managers at PECO and the CSPs, EnerNOC and CPower. The interviews provided a detailed picture of the program implementation, the goals of the program managers, and the customers' experience with the program. These interviews also informed the content of the customer surveys.

Navigant fielded a post-season survey for commercial customers. The survey was designed to assess customer understanding, satisfaction, and attitudes about the program. The survey was fielded online via email in October 2017, after the summer DR season concluded. The Navigant team received contact information for 44 customers, seven of whom completed the survey. The respondents represented 63 participating sites.

Survey respondents reported their reasons for participating in the PECO Large C&I DR program. The most common reasons cited were the ability to earn money and that it was not difficult to participate in the program.

The survey also investigated satisfaction. Satisfaction is assessed using a scale of 1 to 5, with 1 being very unsatisfied and 5 being very satisfied. Navigant qualifies customer satisfaction as a rating of 4 or 5. The team found that most participants were satisfied with the DR program in general. Note that one respondent did report dissatisfaction (shown in red in Figure 3-14), but that respondent represented one site that signified a small proportion of savings.

**Figure 3-14. Large C&I DR Satisfaction with Program (n=7)**



Source: Navigant analysis

<sup>11</sup> McAnany, James, 2017 Demand Response Operations Markets Activity Report: April 2018., PJM Demand Side Response Operations, April 10, 2018, <http://www.pjm.com/-/media/markets-ops/dsr/2017-demand-response-activity-report.ashx>.

### 3.3.4 Cost-Effectiveness Reporting

A detailed breakdown of program finances and cost-effectiveness will be presented in the Annual PY9 Report filed in November 2018, once full program year expenditures are complete.

### 3.3.5 Status of Recommendations

The impact and process evaluation activities in PY9 led to the following findings and recommendations from Navigant to PECO, along with a summary of how PECO plans to address the recommendation in program delivery.

**Table 3-18. Summary of Findings and Recommendations for Large C&I DR Program**

Solution	Finding	Recommendation	EDC Status
DRA	Navigant was unable to gather data to document which days participants had settlements in the PJM economic market	Set up a process to determine which days program participants have settlements in PJM economic market, to identify such days as exclusions from the participant's baseline	In process
DRA	The program under performed as compared to projected demand reductions	Consider reviewing available resources vs. PY9 achieved and review shortfalls with CSPs toward developing a plan for ensuring better target achievement for PY10	Under consideration
DRA	Customers reported lower satisfaction with incentive payments	Encourage CSPs to provide fast feedback on event performance and to communicate flexibility on incentive payments to increase customer satisfaction	Under consideration

Source: Navigant analysis

## APPENDIX A. DEMAND RESPONSE PROGRAMS

Table A-1 presents the event and hour impacts for the DR programs (Residential, Small C&I, and Large C&I).

Table A-1. Hourly Results by DR Event Summary Table

Event	Hour Ending (HE)	Residential DR Program (Verified MW)	Small C&I DR Program (Verified MW)	Large C&I DR Program (Verified MW)	Average Portfolio (Verified MW)
<b>Event 1</b> 13-Jun-17	HE15	37.2	0.0	116.6	153.8
	HE16	39.0	0.0	136.6	175.6
	HE17	38.3	0.0	125.6	163.9
	HE18	43.6	0.0	94.1	137.7
	<b>Average Event Impact by Program</b>	<b>39.5</b>	<b>0.0</b>	<b>118.2</b>	<b>157.7</b>
	<b>Error Margin at 90% CI</b>	<b>±1.8</b>	<b>±0.0</b>	<b>±13.8</b>	<b>±13.9</b>
<b>Event 2</b> 20-Jul-17	HE15	34.7	0.0	116.3	151.1
	HE16	34.1	0.0	118.7	152.8
	HE17	28.5	0.0	116.8	145.2
	HE18	36.6	0.0	79.7	116.4
	<b>Average Event Impact by Program</b>	<b>33.5</b>	<b>0.0</b>	<b>107.9</b>	<b>141.4</b>
	<b>Error Margin at 90% CI</b>	<b>±2.5</b>	<b>±0.0</b>	<b>±13.5</b>	<b>±13.8</b>
<b>Event 3</b> 21-Jul-17	HE14	22.8	0.0	104.0	126.8
	HE15	22.7	0.0	143.0	165.8
	HE16	24.2	0.0	132.0	156.2
	HE17	23.7	0.0	124.5	148.2
	<b>Average Event Impact by Program</b>	<b>23.3</b>	<b>0.0</b>	<b>125.8</b>	<b>149.2</b>
	<b>Error Margin at 90% CI</b>	<b>±1.8</b>	<b>±0.0</b>	<b>±13.3</b>	<b>±13.4</b>
<b>Average Program Year Impact (PYVTD)</b>		<b>32.1</b>	<b>0.0</b>	<b>117.3</b>	<b>149.4</b>
<b>Average Phase III Impact (VTD)*</b>					<b>149.4</b>

Source: Navigant analysis