



# Impact Evaluation of FY2016 Unit Energy Savings Measures & Investigation of PTCS HVAC Measures

May 2018



# Why Evaluation?



What do  
we all  
want?

Energy  
efficiency  
programs that  
save customers  
money and  
energy.

To be  
trustworthy  
stewards of  
their money.

# Evaluation

What did we achieve?

&

How do we improve?



# Impact Evaluation

Savings reliability  
with independent  
verification



Program  
improvement  
opportunities

# Evaluation Background

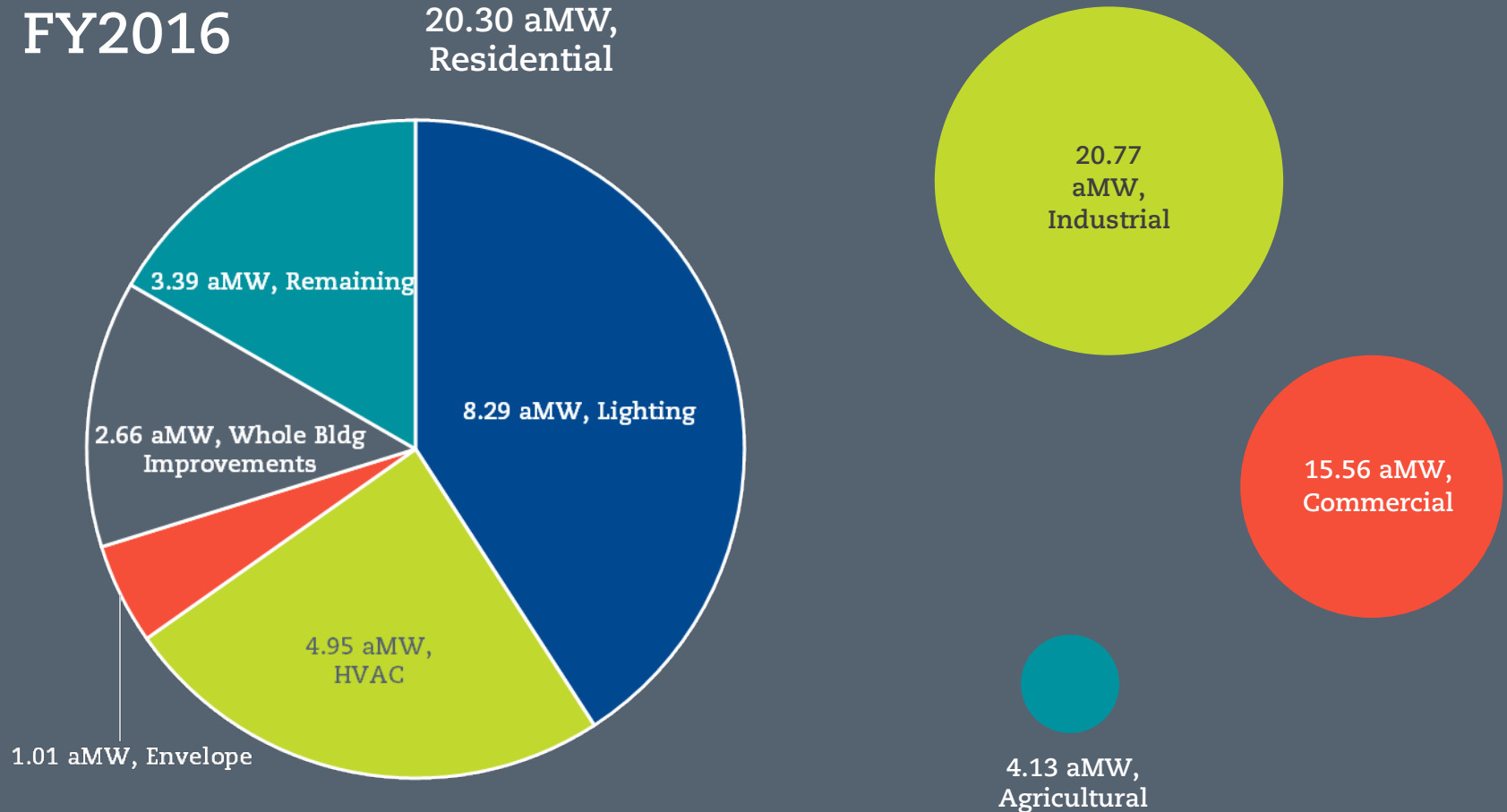
Provide  
feedback to  
enhance  
programs

Assess  
cost-  
effective-  
ness

## Objectives

Evaluate energy  
savings for  
consistency with  
savings claimed

# Contributors to Energy Savings



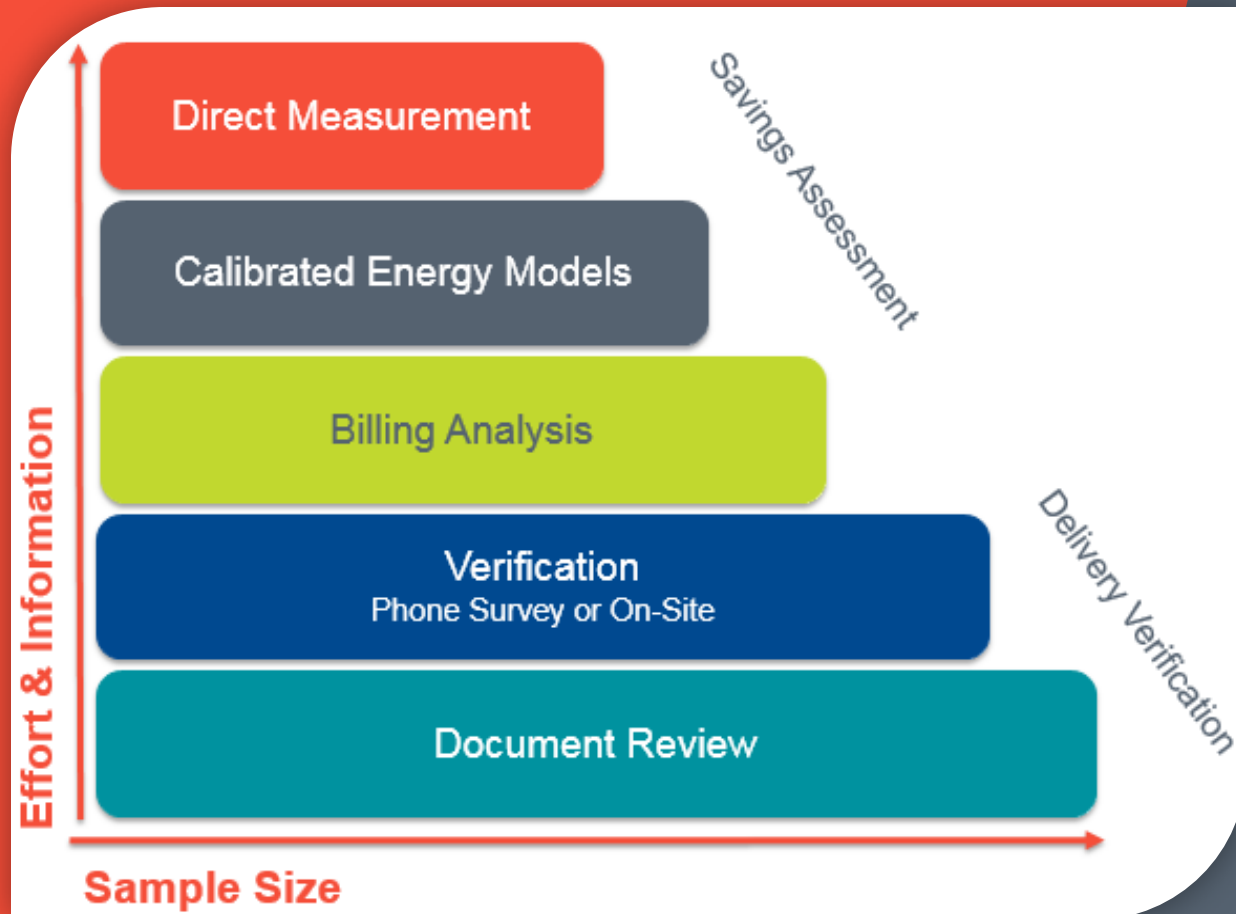
Source: Summarized from BPA's IS2.0 database, accessed Dec 2017

\* Savings from Energy Smart Grocers deemed measures are not included in this summary.

\*\* Ag/Industrial value does not include savings achieved through the Scientific Irrigation Scheduling measure.

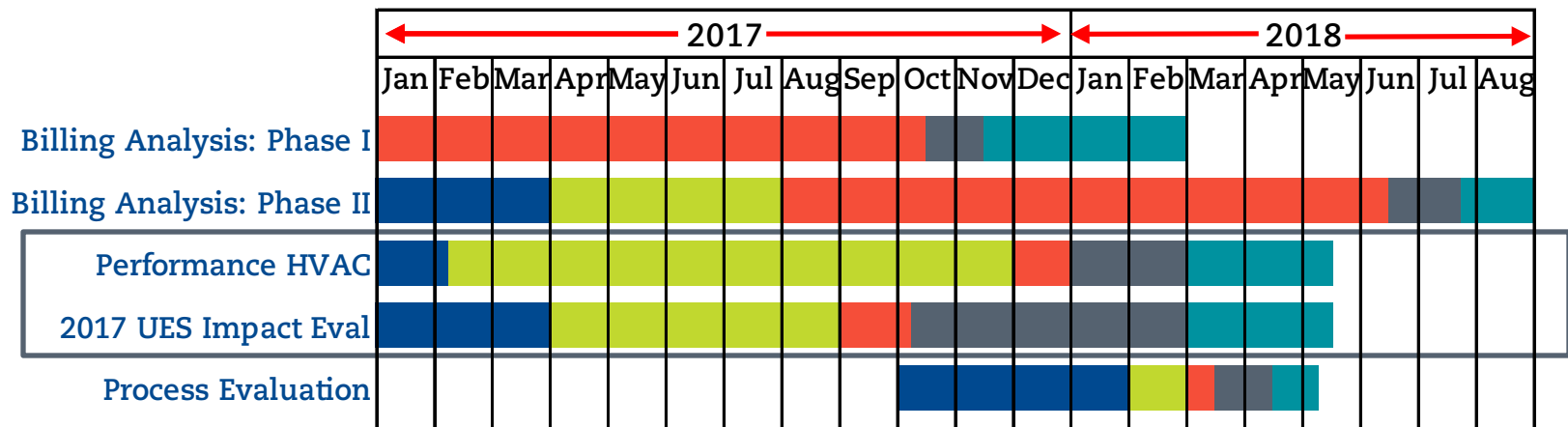


# Delivery Verification (DV) via Document Review: A Resource-Efficient Approach



# Research Timeline

The studies covered in this presentation are part of a multi-year impact evaluation effort.



# Delivery Verification for Unit Energy Savings (UES) Measures: Impact Evaluation Approach

# Delivery Verification Requirements

1. Established by the RTF
2. For evaluation purposes, all DV requirements must be met to verify savings for a project

Efficiency Tier

Install  
Location

HVAC Type

Heating  
Climate Zone

Example DV requirements for  
Heat Pump Water Heaters

Source: RTF

# Verifying Project Energy Savings

## Verified

No discrepancies between the project documentation and the reported savings: Team assigned reported savings

## Revised

Project documentation included all data but indicated a different unit energy savings (UES) than reported: Team revised UES value and recalculated savings

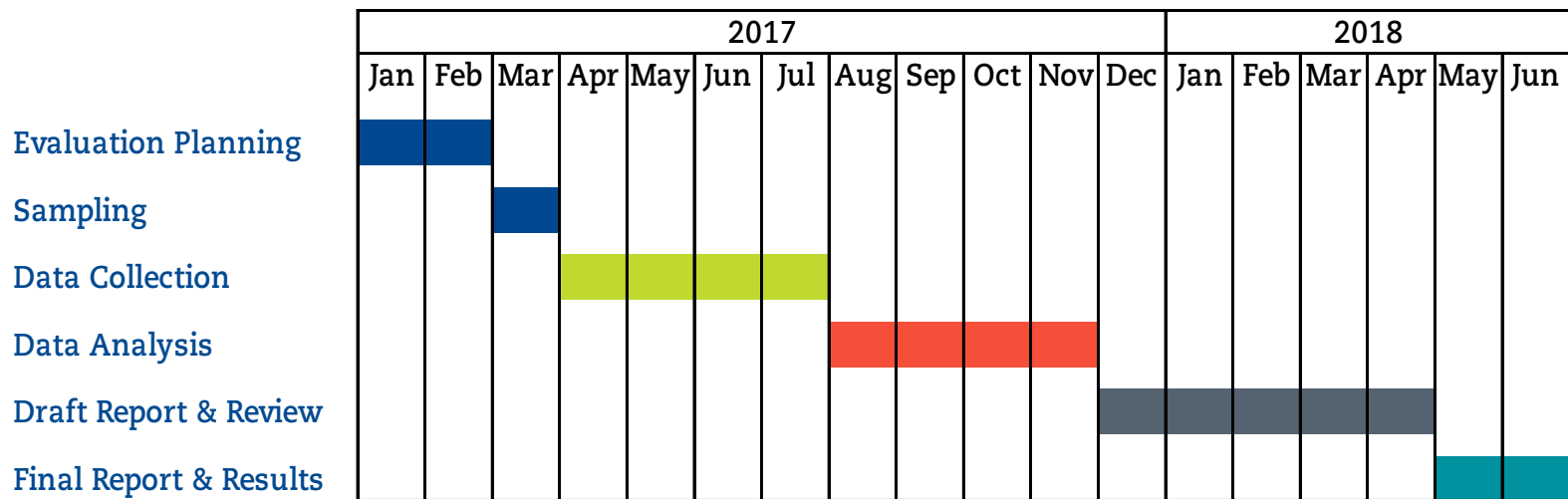
## No Savings

Required data was missing in the project documentation: Team assigned zero savings

$$\frac{\text{Evaluated Savings}}{\text{Reported Savings}} = \text{Realization Rate}$$



# DV for UES Measures: Impact Evaluation Timeline



# DV for UES Measures: Covered Measure Groups

Measure Group	RTF Measure Status in FY2016*	Current RTF Measure Status	Fraction of Total Savings from Evaluated Measure Groups
Ductless Heat Pump (DHP) Replacing Zonal Heat	Proven	Proven	42%
Advanced Power Strips (APS)	Planning	Planning	28%
Showerheads	Proven	Planning	18%
Heat Pump Water Heaters (HPWH)	Provisional	Proven, Planning†	5%
Agricultural Transformer De-Energization	Small Saver**	Small Saver	4%
Ag and Industrial Green Motors	Small Saver**	Small Saver	2%

\* The RTF allows DV to be used as impact evaluation for Proven measures only. While not all sampled measure groups were proven in FY2016, BPA and stakeholders felt that conducting document reviews of these measure groups provides BPA with insight and may ultimately flag areas of additional research.

\*\* Small Saver measures are measures that comprise a small percentage of the portfolio and thus are not held to the same evaluation standards as other measures. BPA chose to take this opportunity to evaluate these measures.

† Measure is “Planning” for split systems and new construction only.



# DV for UES Measures: Sample Design

Measure Group	Assumed Coefficient of Variation	Number of Utilities	Target Sample	# Projects Requested (including backups)	Total # Units Represented in Requested Projects
DHP-Zonal	0.3	10	98	118	118
APS*	0.3	5	5	8	18,302
Showerheads	0.3	9	9	15	11,403
HPWH	0.3	8	31	43	45
Ag De-Energization	N/A	3	3 (census)	3 (census)	5,000
Green Motors	0.3	N/A	9	13	13

*\*This measure group has comparatively smaller sample size because one of the projects represented ~9,000 units distributed and >40% of total savings for this measure group.*

Source: Navigant analysis of complete FY2016 IS2.0 data

# DV for UES Measures: Data Sources

Summary of Data Collected for Each Measure Group

Measure Group	Who Provided Data	Type of Data Provided
DHP-Zonal	Utilities	Installation form and invoice
APS	Utilities	Invoice and (for by-request and direct install) measure distribution log
Showerheads	Utilities	Invoice and (for by-request and direct install) measure distribution log
HPWH	Utilities	Installation form and invoice
De-Energization	BPA	Savings calculation file
Green Motors	BPA	Invoice

# Delivery Verification for UES Measures: Impact Evaluation Results & Conclusions

# DV for UES Measures: Detailed Results

Evaluated savings were high because most projects met all of the RTF DV requirements

Measure	# of Projects in the Sample	# of Projects Received*	# of Projects Meeting RTF DV	Ex Ante Savings - Population (aMW)	Ex Post Savings - Population (aMW)	Realization Rate
DHP-Zonal	98	117	112	2.09	1.99	95%
APS	5	8	8	1.04	1.04	100%
Showerheads	9	15	15	0.94	0.94	100%
HPWH	31	43	42	0.23	0.25	109%
De-Energization	3	3	3	0.20	0.20	100%
Green Motors	9	13	13	0.06	0.06	100%

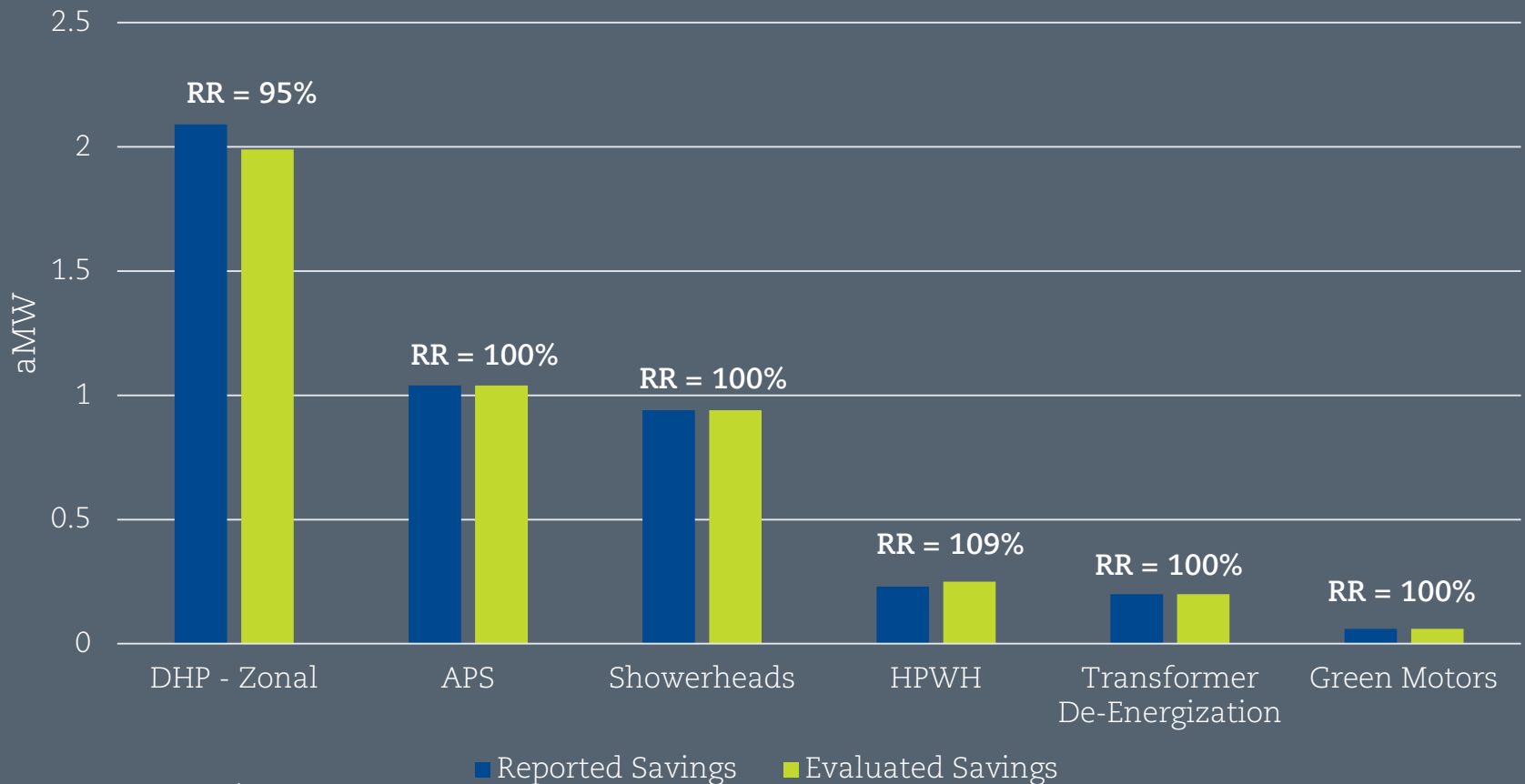
\*Includes backups

Source: Navigant

# DV for UES Measures: Evaluated Savings

All measure groups achieved savings near 100%!

Measure Group Savings



Source: Navigant

# DV for UES Measures: Cost-Effectiveness Results

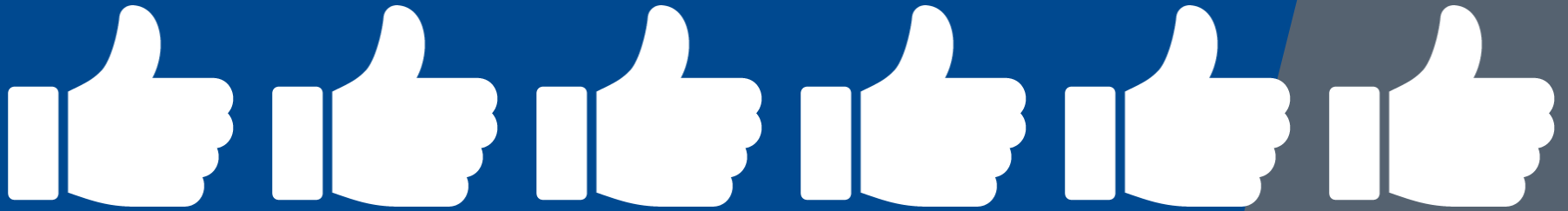
Overall, savings were cost-effective.

Measure Group	Present Value of Benefits	Present Value of Costs	Total Resource Benefit/Cost Ratio
DHP-Zonal	\$939,161	\$487,616	1.93
APS	\$8,647,293	\$4,962,371	1.74
Showerheads	\$6,658,650	\$517,474	12.87
HPWH	\$103,669	\$108,756	0.95
De-Energization	\$1,566,547	\$801,772	1.95
Green Motors	\$234,930	\$41,498	5.66

*\*Based on evaluated savings*

*Source: Navigant analysis using ProCost and 7th Plan inputs*

# DV for UES Measures: Conclusions



Delivery Verification was successfully used as an evaluation approach for the six UES measures. The measures achieved realization rates near 100%, indicating reported savings matched evaluated savings.

# PTCS Measures Investigation Approach



# PTCS Measures Investigation: Study Background

BPA investigated the use of DV for certain residential HVAC measures that are included in QA inspections.

The goal was to leverage existing program QA oversight activities to develop less burdensome program evaluation methods.

This investigation was intended to function as impact evaluation, but the team determined that more research is needed.

# PTCS Measures Investigation: Study Background

Limitations of the investigation include:

Sample fulfillment  
was not achieved

More alignment is  
needed between RTF  
DV requirements and  
PTCS data  
requirements

Uncertainty in how  
to address projects  
remediated by the  
PTCS team as part of  
their oversight

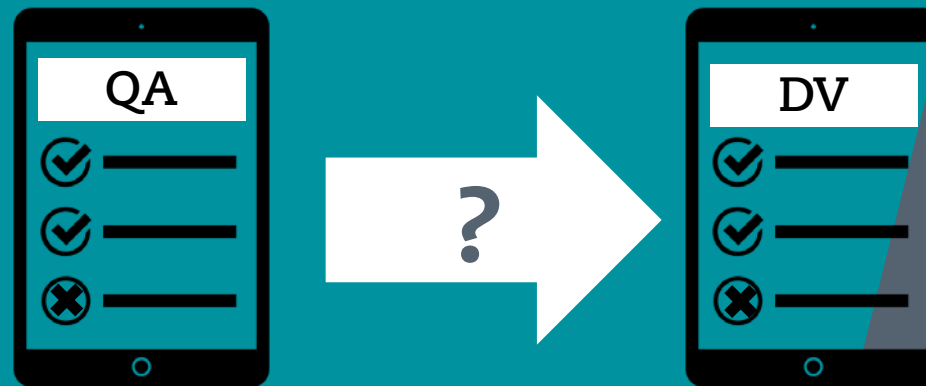
Because of these limitations, the results of the investigation are presented separately from the results of the UES impact evaluation.

# Could DV be Used as Impact Evaluation for PTCS Measures?

A portion of Performance Tested Control System (PTCS) measures receive Quality Assurance (QA) inspection as part of program oversight after installation.

QA data collection has a significant overlap with the RTF's delivery verification requirements for certain measure groups.

The PTCS team and Evaluation team worked together before 2017 data collection to revise the PTCS QA forms so that they collect all the required RTF DV requirements.



# PTCS QA versus RTF DV

A project may pass the PTCS QA inspection without meeting all the DV requirements...



...but to receive savings in an impact evaluation, a project typically **must** meet all RTF DV requirements.

# PTCS QA Data Parameters

PTCS QA data parameters contribute to a project's grade on a weighted basis.

If certain parameters are not met, it causes an "Overall Fail" of QA.

## Example: Weighting of PTCS QA Parameters for Air Source Heat Pump with CCS

Data Parameter	RTF DV Requirement?	Causes PTCS QA Overall Fail?	Weighting of Parameter in PTCS Grade*
Airflow	Yes – CCS Requirement	No	10%
External Static Pressure	Yes – CCS Requirement	No	10%
Temperature Split	Yes – CCS Requirement	No	15%
Meets HSPF and CCS	Yes – ASHP Requirement	Yes	10%
Compressor Lockout Temperature	Yes – CCS Requirement	No	15%
Strip (Backup Heat) Lockout Temperature	Yes – CCS Requirement	Yes	20%
Balance Temperature	Yes – CCS Requirement	Yes	20%
Penetrations Sealed	No	N/A	0%

\*As of April 2017, "penetrations sealed" was removed from the PTCS QA requirements and no longer contributes to the QA grade. The weightings for the other parameters were distributed accordingly.

# Investigation of PTCS QA versus RTF DV

The evaluation team collected data on a sample of projects to determine feasibility of using PTCS QA data for impact evaluation.

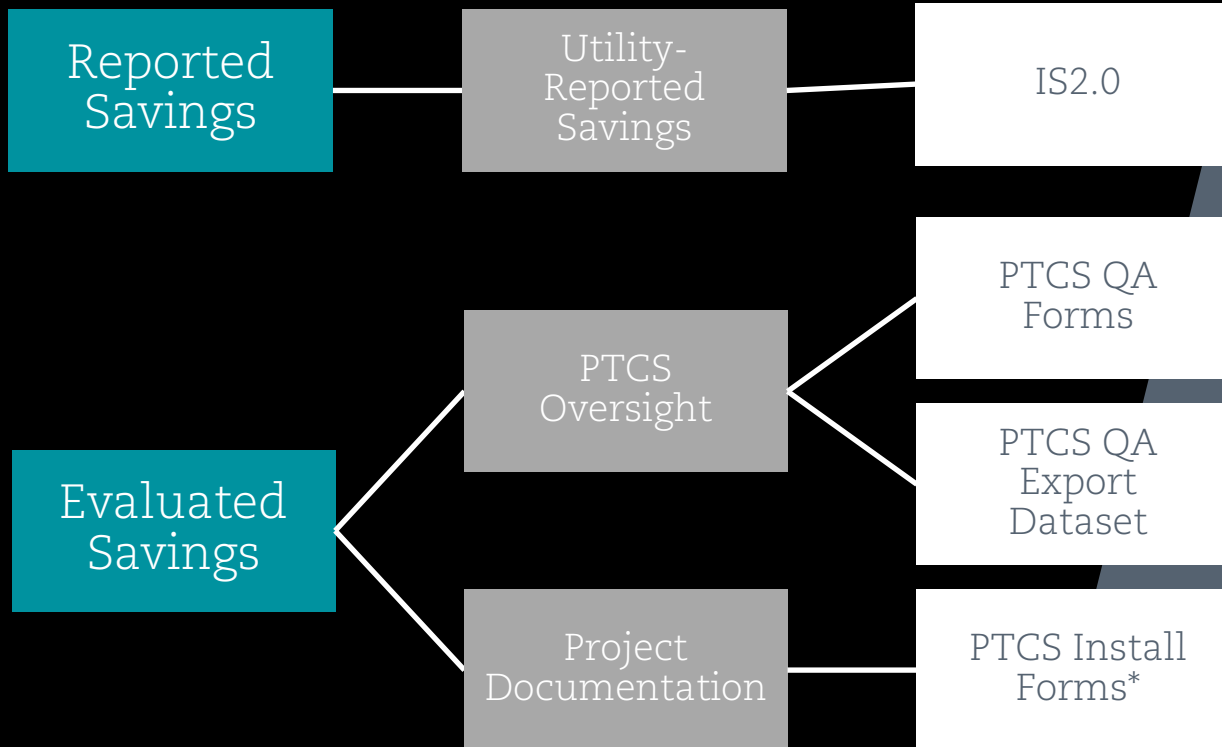
Measure Group	Population* (FY2016 IS2.0)	Assumed Coefficient of Variation	Target Sample
Prescriptive Duct Sealing	1,451	NA	~20**
Performance Duct Sealing	292	0.5	60
Commissioning, Controls and Sizing (CCS)	129	0.3	25
Heat Pumps, including Air Source Heat Pumps (ASHP), Variable Speed Heat Pumps (VSHP), and Ground Source Heat Pumps (GHSP)	1,641	0.5	70

\*Unique Measure ID

\*\*Not a statistically significant sample. A small number of projects was reviewed to determine feasibility to conduct delivery verification via document review in future years.

Source: Navigant

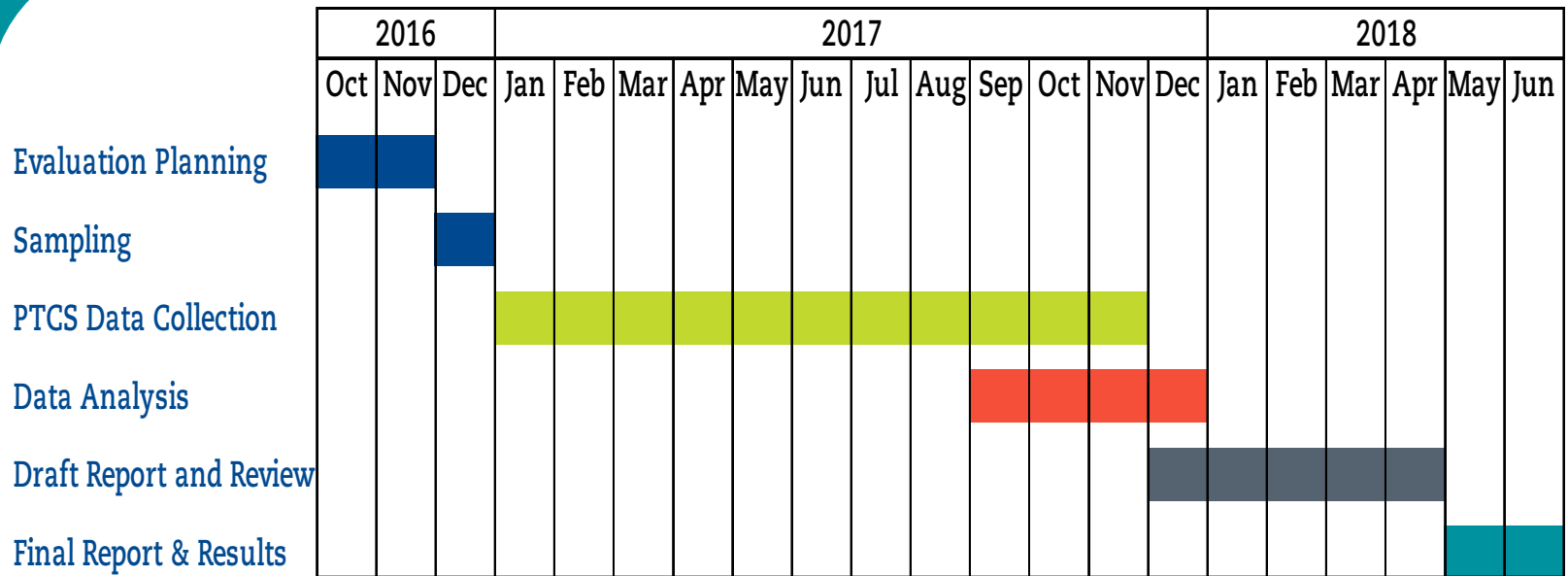
# Data Sources



*\*If required. Evaluation team worked with PTCS team before the QA inspections for CY 2017 to add the delivery verification requirements to PTCS QA forms if they were missing from the older forms.*

*Source: Navigant*

# PTCS Measures Investigation: Timeline





# PTCS Measures: Investigation Results & Conclusions

# PTCS Measures Investigation: Detailed Results

Different weighting schemes between QA and the RTF DV requirements led to misalignment between pass rates.

Measure	Requested Sample Size*	Achieved Sample Size**	# of Projects Meeting RTF DV	# of Projects Passing PTCS QA†
Duct Sealing Prescriptive	20	20	16	14
Duct Sealing PTCS	66	34	17	19
Commissioning Controls Sizing	28	15	6	8
Heat Pumps (incl. ASHP, VSHP, and GSHP)	75	69	33	38
<b>TOTAL</b>	<b>189</b>	<b>138</b>	<b>66</b>	<b>79</b>

\*Requested sample size is slightly higher than “Required sample size” due to rounding of the sample sizes by region.

\*\*QA Inspections were not able to satisfy the original evaluation sample for the measure groups (except Prescriptive Duct Sealing) due to sampling and regional constraints. The verification sample was distributed by geographical regions and for some of the regions the number of QA visits required to satisfy the sample size could not be covered due to restrictions on inspectors availability in that region.

†For some measure groups, there are some PTCS QA requirements that are not part of RTF DV requirements. These additional QA requirements tend to focus on contractor performance, while the RTF requirements focus on evaluation of savings.

Source: Navigant

# Detailed Results: Duct Sealing

RTF Delivery Verification Requirements	# of Projects Not Meeting All RTF DV Requirements			
	Prescriptive	PTCS	Duct Sealing - ALL	% of Total
Check that 30% of ducts are located in unconditioned space OR that there were supply leaks to unconditioned space within 15 feet of the air handler	3	1	4	7%
Check the house has not previously had its ducts sealed through a utility duct sealing program	0	2	2	4%
Check that accessible non-flex duct joints and connections located in unconditioned space are sealed with UL-181 listed mastic	3	10	13	<b>24%</b>
Check that accessible flexible duct connections located in unconditioned space have interior and exterior liners secured and are air-sealed and tightened appropriately	4	8	12	<b>22%</b>
<b>Total Projects Received</b>	<b>20</b>	<b>34</b>	<b>54</b>	

# Detailed Results: CCS, ASHP, & VSHP

RTF Delivery Verification Requirements	# of Projects Not Meeting All RTF DV Requirements				
	CCS	ASHP	VSHP	Total	% of Total
HSPF Rating meets 9.0 or higher	NA	1	0	1	1%
Balance Temperature: Check heat pump balance point is at 30 F or lower	0	3	1	4	5%
Auxiliary heat is controlled to Single stage OR Multi stage w/out air temperature sensor control (lockout grade)	3	5	1	9	<b>12%</b>
Thermostat has manual changeover feature or heating/cooling lockout (if applicable)	4	4	3	11	<b>14%</b>
Compressor does not cutout at temps above 5F	3	5	2	10	<b>13%</b>
Airflow across indoor coil is either: specified in manufacturers literature OR >325CFM/ton	2	7	3	12	<b>16%</b>
External static pressure does not exceed 0.8 in of water (200 PA)	1	3	1	5	7%
<b>Total Projects Received</b>	<b>15</b>	<b>50</b>	<b>11</b>	<b>76</b>	

# Detailed Results: GSHP

RTF Delivery Verification Requirements	# of Projects Not Meeting All RTF DV Requirements	% of Total
Airflow across indoor coil is either: specified in manufacturers literature OR >325CFM/ton	1	13%
External static pressure does not exceed 0.8in of water (200 PA)	4	50%
Was previous heating system ASHP or electric FAF?*	8	<b>100%</b>
Is existing water heater electric tank without desuperheater?	8	<b>100%</b>
<b>Total Projects Received</b>	<b>8</b>	

\* The PTCS team noted that this data point is available in the PTCS Site Registry. However, the old forms used in the QA inspections for these projects did not collect this data.

# PTCS Data Collection Difficulties

## Sample Fulfillment

Original evaluation sample was not fulfilled due to sampling and regional constraints on PTCS team.

Historical data review indicated that the spread of QA inspections should fulfill the sample in 4-5 months.

The evaluation team collected data for over 11 months and still was a little short of the original sample.

## Use of old forms

GSHP QA inspections used an older inspection form that excluded two RTF DV requirements.

Use of old forms would have resulted in 0% realization rate for all 8 GSHP projects which would drive the overall realization rate lower.

# PTCS Measure Investigation Conclusions

This investigation of PTCS measures could not function as impact evaluation.

- The results of this investigation will not inform realization rates or savings estimates for these measures for planning purposes.

The measures could not be evaluated using the DV approach due to:

- Mismatch between RTF DV requirements and PTCS QA criteria for passing inspection, and
- Difficulty in collecting a statistically significant sample.

# Recommendations for Future PTCS Evaluation

Continue investigating where evaluation can be feasibly conducted by leveraging existing data collection processes (oversight, QA).

Evaluating as many measure groups as possible using existing oversight or QA processes to gather RTF DV data will minimize data collection load for customers.



# Recommendations for Future PTCS Evaluation

Seek closer alignment of PTCS QA criteria  
and RTF DV requirements.

If BPA wishes to use QA data  
for impact evaluation, QA  
inspection criteria will need  
to be consistent with RTF DV  
requirements.

If BPA believes some of the DV  
requirements are unnecessary,  
it may consider providing  
feedback to the RTF to revise  
the requirements.

# BPA Program Response

## Overall General Recommendation:

Take steps to align program requirements to RTF DV requirements. If BPA believes updates are warranted for one or more sets of RTF DV requirements, engage with the RTF.

## BPA Response:

BPA understands the value of this approach for evaluation. We will look into whether it is feasible during our revisions for the 2019 Rate Period Implementation Manual.

*Additional recommendations (and associated BPA responses) included as part of the final 2017 Delivery Verification Report and BPA Response Memo, posted at [www.bpa.gov/goto/evaluation](http://www.bpa.gov/goto/evaluation)*



Thank you!



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