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Achieving High Savings from Low-Income Energy Efficiency Programs

David Carroll and Jackie Berger

NEUAC Conference - June 2015

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Achieving High **Heating Fuel** Savings from Low-Income **Weatherization** Programs

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INTRODUCTION

Session Objectives

- Low-income weatherization programs have great potential for saving energy and improving the lives of low-income households.
- Research shows there are substantial differences in outcomes between AND within programs.
- We are going to share information on the factors that are associated with higher savings.
- We are going to recommend an approach for ongoing performance measurement/improvement.

Information Sources

- Ten State-Level WAP Evaluations conducted in the last five years. (Conducted by APPRISE and Others)

- 10 State-Level and Utility-Level Ratepayer Low-Income Program Evaluations conducted in the last five years. (APPRISE)

Presentation

- Part 1 – How to get higher savings
  - Targeting high usage
  - Installing major measures
  - Comparing Agency performance
- Part 2
  - Assessing work quality
  - Performance measurement

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CONCEPTS

Usage of Natural Gas

- ***Average*** natural gas therms per low-income household…
  - Northeast Census Region = 900 therms
  - Midwest Census Region = 950 therms
  - South Census Region = 600 therms
  - Mountain North Census Division = 950 therms
  - Mountain South Census Division = 450 therms
  - Pacific Census Division = 450 therms
- Definition of ***high usage*** varies by geography

Energy Savings

- Obtain 12 months of ***Pre-WX*** energy usage and "weather normalize"
- Obtain 12 months of ***Post-WX*** energy usage and "weather normalize"
- ***Gross Energy Savings*** = Normalized pre-WX usage – Normalized post-WX usage
- ***Net Energy Savings*** – Compare savings for group that was weatherized to a group that is scheduled for weatherization.

Major Measures

- Measures for ***single family homes*** in order of ***average*** impacts in a ***comprehensive*** program
  - Furnace Replacement = 75 to 150 therms
  - Wall Insulation = 60 to 120 therms
  - Attic Insulation = 50 to 100 therms
  - Major Air Sealing = 50 to 100 therms
  - Duct Sealing = 10 to 30 therms
  - Thermostats = 10 to 30 therms
  - Foundation/Rim/Floor Insulation = 10 to 30 therms

Major Measures

- For this presentation, when we refer to the number of ***Major Measures*** for ***single family homes*** we are referring to…
  - Furnace Replacement
  - Wall Insulation
  - Attic Insulation
  - Major Air Sealing (1000 cfm50 or more)

Spending on Measures

- Measure costs for ***single family homes*** in a ***comprehensive*** weatherization program
  - No ***Major Measures*** = $2,500
    - A home with no major measures may have air sealing, floor/rim/foundation insulation, setback thermostat, duct sealing/insulation, and other important measures.
  - One ***Major Measure*** = $4,000
  - Two ***Major Measures*** = $5,400
  - Three ***Major Measures*** = $6,700
  - Four ***Major Measures*** = $8,500

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CONSISTENT FININGS FROM PROGRAM EVALUATIONS

Increase Savings by …

- Targeting high usage homes that need major measures
- Identifying, prioritizing, and installing appropriate measures
- Ensuring that weatherization staff do high quality work

Intersection of…

- Policies that …
  - Target the homes with the highest potential program
  - Prioritize the measures that have the greatest impact
  - Furnish agencies/contractors with the right incentives
- Practices that …
  - Ensure staff have needed skills and tools
  - Use best practices for quality measure selection
  - Complete high quality measure installation
  - Identify problems, give feedback, and resolve issues

FACTORS ASSOCIATED WITH HIGH SAVINGS: ***Targeting High Usage***

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State #1
WAP Energy Impacts for Single Family Site-Built Homes
Net Gas Savings for Natural Gas Main Heat by Pre-Weatherization Gas Usage (therms/year)

Pre-WAP Gas Use (therms/yr)	# of Major Measures	# Homes	Gas Use Pre-WAP	Net Savings	% of Pre
All Clients	1.4	937	983	130 (±10)	13.2% (±1.1%)
<750 th/yr.	***1.1***	***245***	***640***	***64 (±12)***	***10.0% (±1.9%)***
750-1000	1.3	296	880	105 (±14)	12.0% (±1.6%)
1000-1250	1.6	226	1,097	142 (±22)	12.9% (±2.0%)
1250-1500	1.6	101	1,355	219 (±42)	16.2% (±3.1%)
>=1500 th/yr.	***2.0***	***69***	***1,731***	***269 (±65)***	***15.6% (±3.7%)***

State #2

PY 2010 WAP Energy Impacts for Single Family Site-Built Homes

Net Gas Savings for Natural Gas Main Heat by Pre-Weatherization Gas Usage (therms/year)

Pre-WAP Gas Use (therms/yr)	# of Major Measures	# Homes	Gas Use Pre-WAP	Net Savings	% of Pre
All Clients	1.9	4,065	1,043	163 (±8)	15.7% (±.0.7%)
<750 th/yr.	***1.7***	***790***	***642***	***71 (±10)***	***11.0% (±1.5%)***
750-<1000	1.8	1,371	878	123 (±10)	14.0% (±1.1%)
1000-<1250	2.0	999	1,112	182 (±15)	16.4% (±1.4%)
1250-<1500	2.0	509	1,359	217 (±25)	15.9% (±1.9%)
>=1500 th/yr.	***2.2***	***396***	***1,829***	***365 (±43)***	***20.0% (±2.4%)***

FACTORS ASSOCIATED WITH HIGH SAVINGS: ***Install Major Measures***

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State #1
WAP Energy Impacts for Single Family Site-Built Homes
Gas Savings for Homes with Natural Gas Main Heat
By Measure Combination (therms/year)

Group/Breakout	# Homes	Gas Use Pre-WAP	Net Savings	% of Pre
No Major Measures	***202***	***877***	***37 (±15)***	***4.2% (±1.7%)***
One Major Measure	298	957	121 (±17)	12.7% (±1.8%)
Two Major Measures	211	1,003	162 (±20)	16.1% (±2.0%)
Three Major Measures	***115***	***1,111***	***236 (±29)***	***21.2% (±2.6%)***
All Four Major Measures	33	1,179	382 (±71)	32.4% (±6.1%)

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State #2
PY 2010 WAP Energy Impacts for Single Family Site-Built Homes
Gas Savings for Homes with Natural Gas Main Heat
By Measure Combination (therms/year)

Group/Breakout	# Homes	Gas Use Pre-WAP	Net Savings	% of Pre
No Major Measures	***223***	***942***	***-7 (±14)***	***0.8% (±1.5%)***
Heater Replacement	167	1,003	129 (±18)	12.9% (±1.8%)
Attic Insulation	963	993	87 (±10)	8.7% (±1.0%)
Wall Insulation	37	970	60 (±45)	6.2% (±4.7%)
CFM50 Reduction 1000+	21	1,140	34 (±37)	3.0% (±3.3%)
Any One Major Measure	1,188	996	91 (±9)	9.1% (±0.9%)
Any Two Major Measures	1,631	1,026	164 (±9)	16.0% (±0.9%)
Any Three Major Measures	***862***	***1,116***	***253 (±13)***	***22.6% (±1.2%)***
All Four Major Measures	156	1,305	416 (±39)	31.9% (±3.0%)

FACTORS ASSOCIATED WITH HIGH SAVINGS: ***Agency Performance***

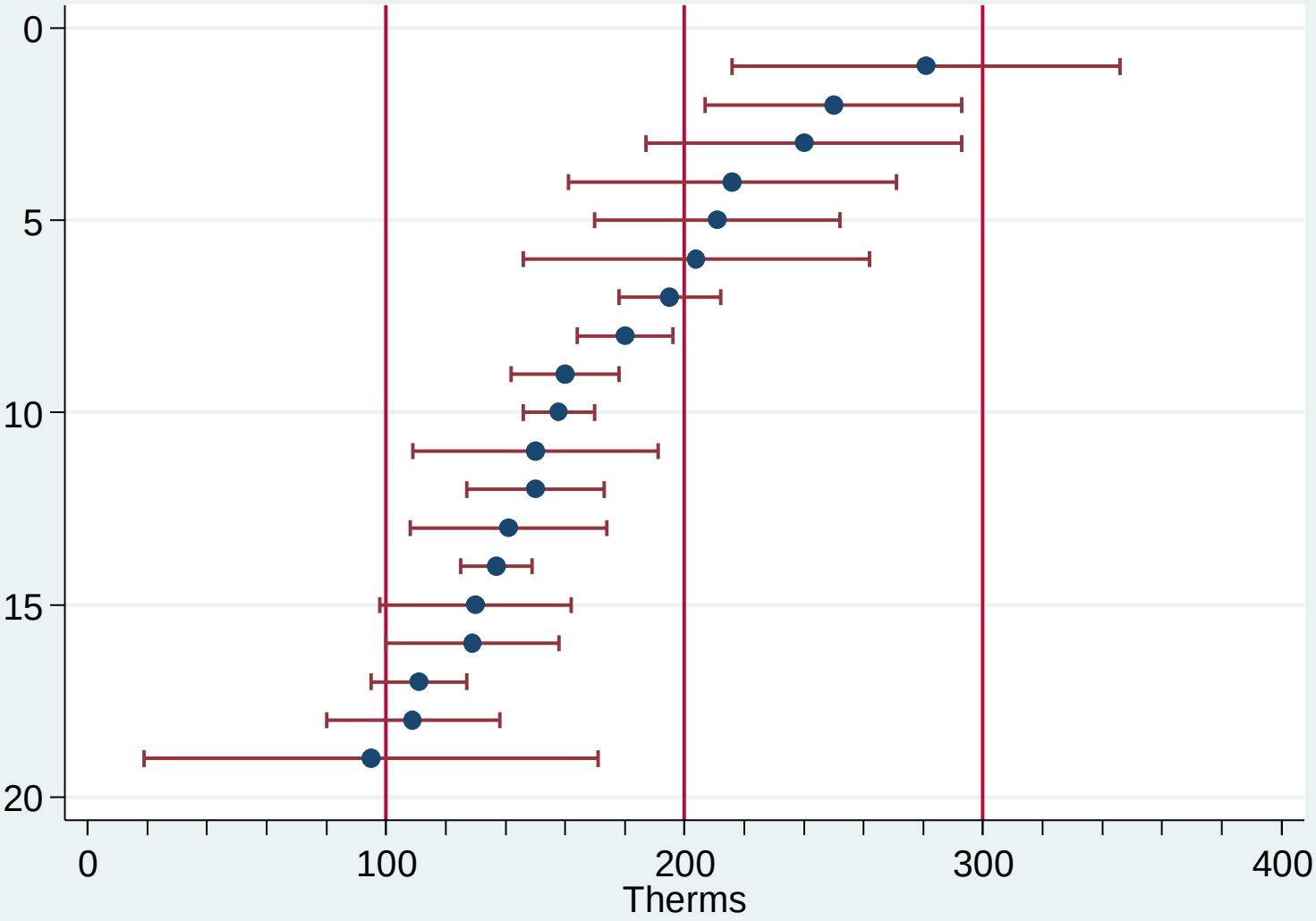
State #1
Gas Impact Results by Agency for Gas Heated Single Family Site-Built Homes

Agency ID	Gas Use Pre-WAP	Net Savings	% of Pre	# of Measures
A	***1,077***	***187 (± 21)***	***17.3% (±1.9)***	***2.2***
B	992	122 (± 32)	12.3 % (±3.2)	0.9
C	1,028	119 (± 40)	11.6% (±3.9)	1.2
D	948	118 (± 19)	12.4% (±2.0)	1.3
E	1,012	113 (± 64)	11.1% (±6.3)	0.7
F	937	109 (± 44)	11.6% (±4.7)	1.2
G	945	107 (± 50)	11.3% (±5.3)	0.9
H	875	94 (± 26)	10.7% (±3.0)	0.7
I	929	94 (± 41)	10.1% (±4.4)	1.1
J	***889***	***58 (± 27)***	***6.5% (±3.0)***	***0.5***
Total	983	130 (±11)	13.2% (±0.7)	1.4

State #2
PY 2010 Gas Impact Results by Agency for Gas Heated Single Family Site-Built Homes (therms/year)

Agency ID	Gas Use Pre-WAP	Net Savings	% of Pre	# of Measures
A	1,268	281 (±65)	22.2% (±5.1%)	2.2
B	1,025	250 (±43)	24.4% (±4.2%)	2.3
C	1,037	240 (±53)	23.1% (±5.1%)	2.3
D	1,130	216 (±55)	19.1% (±4.9%)	2.4
E	911	211 (±41)	23.2% (±4.5%)	2.0
F	997	204 (±58)	20.5% (±5.9%)	1.4
G	1,190	195 (±17)	16.3% (±1.4%)	1.9
H	993	180 (±16)	18.1% (±1.6%)	1.9
I	938	160 (±18)	17.1% (±1.9%)	2.2
J	1,035	158 (±12)	15.3% (±1.2%)	2.0
K	1,012	150 (±23)	14.8% (±2.2%)	1.9
L	1,252	150 (±41)	12.0% (±3.2%)	1.4
M	1,023	141 (±33)	13.8% (±3.3%)	1.7
N	1,039	137 (±12)	13.2% (±1.2%)	1.9
O	921	130 (±32)	14.2% (±3.4%)	1.8
P	893	129 (±29)	14.5% (±3.2%)	1.4
Q	988	111 (±16)	11.3% (±1.6%)	1.3
R	962	109 (±29)	11.3% (±3.1%)	1.8
S	1,104	95 (±76)	8.6% (±6.9%)	1.8
Total	1,043	163 (±8)	15.7% (±.0.7%)	1.9

*Agencies with less than 30 homes with energy savings results are not shown. but are included in the total savings figures.


Gas Savings for Agencies (30+ Homes)
0
5
10
15
20
0
100
200
300
400
Therms

Factors by Savings Group

	Agencies with High Savings	Agencies with Moderate Savings	Agencies with Low Savings
PreWX Usage	1,061 therms	1,063 therms	984 therms
# of Major Measures	2.1	1.9	1.7
Average Cost of Measures	$4,181	$4,625	$3,900
Mean Savings	234 therms	162 therms	118 therms
Saving Percent	22.1%	15.2%	12.0%

State #3

Factor	High Savings	Moderate Savings	Low Savings
Savings	249 therms	197 therms	118 therms
PreWX Usage	1,040 therms	1,098 therms	1,190 therms
% Attic Insulation	61%	47%	54%
% Wall Insulation	24%	13%	7%
% Furnace Replacement	55%	46%	42%
Average Spending	$4,681	$4,304	$4,495
Windows/Doors Spending	$1,191	$1,271	$1,369
Health and Safety	$308	$438	$384

State by State Comparison

	State #2	State #3	State #4	State #5 Year 1	State #5 Year 2
PreWX Usage	1,043	1,380	984	949	785
Mean Savings	163	171	256	183	145
Saving Percent	16%	12%	24%	18%	17%
Average Cost	$5,200	$4,500	$9,000	$7,500	$7,500
$$ per Therm Savings	$32	$26	$35	$41	$52

Presentation

- Part 1 – How to get higher savings
  - Targeting high usage
  - Installing major measures
  - Agency performance
- Part 2
  - Assessing work quality
  - Performance measurement

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ASSESSING WORK QUALITY

Methodology

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1. Develop check lists and rating scales
2. Train experts to consistently implement
3. Quantify findings across all observations and inspections
4. Enrich data with descriptive information
5. Recommendations for program based on prevalent issues

Research Findings
Weaknesses

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Insufficient use of diagnostic testing results	• To inform measure selection • To determine installation specifications
Lack of focus on the highest priority areas	• Example - air sealing at the top of the envelope not prioritized
Failure to use appropriate testing	• Blower door – guide air sealing work • Zonal Pressure testing – affirm appropriate pressure boundary
Duct sealing - incorrect focus and failure to test	• Ducts outside conditioned spaces • Pressure pan testing to ensure effective work

Research Findings
Weaknesses

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Missed opportunities for insulation.	• Wall insulation seen infrequently
Refrigerators and freezers	• Failure to assess all refrigerators and freezers. • Missed opportunities for two-for-one swaps.
Work orders	• Do not provide appropriate guidance • Example –detail on air sealing priorities
Customer education	• How to use energy and maintain measures • Lost opportunities for customer actions

Air Sealing Improvement Opportunities - Audit

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Attic Inspection	• Did not enter attic but photographed through the hatch, or did not create access to inaccessible attics
Blower Door Use	• Did not use blower door while inspecting for leaks
Zonal Pressure Diagnostics	• Necessary to define thermal boundary, but often not completed during audit

Air Sealing Improvement Opportunities - Installation

Blower Door	• Many did not use blower door to guide air sealing during implementation
Zonal Pressure Testing	• Not used to verify that significant improvement attained after air sealing or to confirm continuous thermal boundary
Attic Air Sealing	• Leaks under existing attic insulation often not sealed
Prioritization	• Basement ceiling insulation when not effective and greater opportunities in attic

Audit Observation Findings

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AIR LEAKAGE AND INSULATION DIAGNOSTICS						
	Program 1			Program 2		
	Applicable Obs.	Action Taken		Applicable Obs.	Action Taken	
		#	%		#	%
Measured surfaces	100	94	94%	75	57	76%
Inspected all accessible attics	78	69	88%	62	61	98%
Created access to inaccessible attics	33	3	10%	23	0	0%
Inspected for all typical bypasses	100	62	62%	75	67	89%
Visual inspection for air sealing opportunities	100	83	83%	76	71	93%
Used blower door while inspecting for leaks	96	64	67%	51	32	63%

Installation Observation Findings

AIR SEALING WORK								
	Program 1			Program 2			Program 3		
	Applicable Obs.	Action Taken		Applicable Obs.	Action Taken		Applicable Obs.	Action Taken	
		#	%		#	%		#	%
Blower door guided air sealing	83	18	22%	26	2	8%	4	2	50%
Zone pressure testing done	80	9	11%	23	12	52%	4	0	0%
Top and bottom prioritized	82	63	77%	21	13	62%	4	2	50%
All major opportunities sealed	83	47	57%	25	12	48%	4	1	25%

Post Completion Inspection Findings

ATTIC AIR SEALING WORK						
	Leaks Sealed				Only Minor Leaks Remain	Total
	All	Most	Some	None		
Program 1 (N=227)						
Leaks Addressed	14%	26%	17%	15%	28%	100%
Program 2 (N=20)						
Leaks Addressed	0%	30%	40%	20%	10%	100%

Recommendations for Improved Quality

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Manual

- Define specific methods for implementing weatherization procedures
- Program parameters
- Best practices

Spending Guidelines

- Directly relate to saving opportunities
- Flexibility for variability and special situations

Work Orders

- Clear and specific
- Improve documentation and transfer of information

Recommendations for Improved Quality

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Training

- Building science
- Use of testing results
- Duct testing
- Writing work orders
- Customer education
- Addressing high baseload use

Quality Control

- Directly observe service delivery
- Review completed jobs
- Ensure best practices are followed
- Require crews to return to fix

Performance Measurement

- Define targets
- Review performance over time
- Refine process
- Measure again

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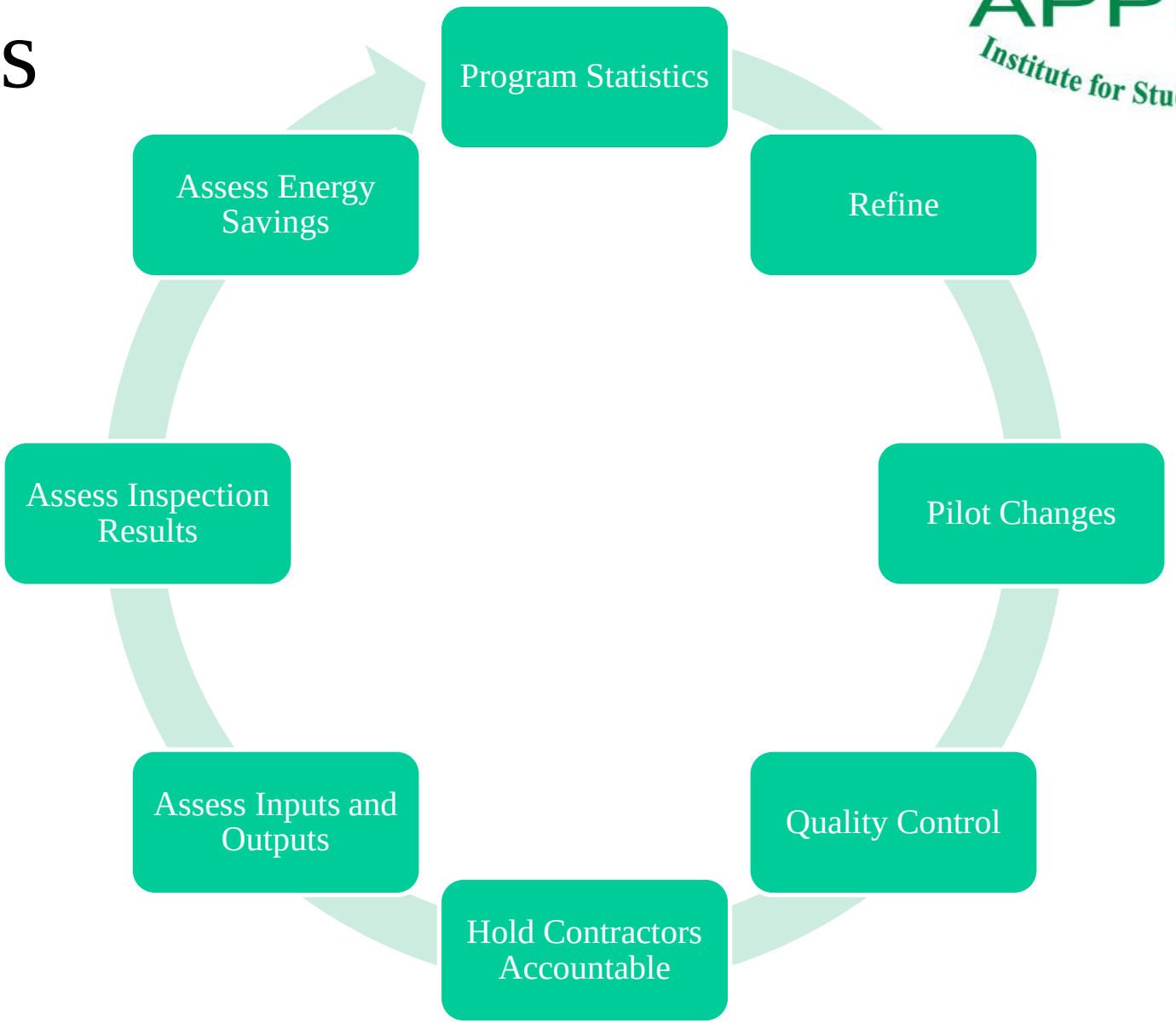
PERFORMANCE MEASUREMENT

Performance Measurement Steps



Performance Measurement
1- Develop Baseline Stats

- Pre-treatment usage
- Major measure installation rates
- Energy savings measured through billing analysis

Performance Measurement
2- Refine Procedures

- Review and refine procedures
- Ensure documentation reflects expectations and best practices
- Train contractors on weak areas
- Review contractor understanding of program requirements

Performance Measurement 3- Pilot Program Changes

- Incremental changes
- Pilot test innovative strategies
- Examples
  - Contractor compensation plan
  - Procedures for treating different types of homes
    - Low usage
    - High baseload usage
    - Health and safety problems
    - Home previously treated

Performance Measurement
4- Conduct Quality Control

- Observe work in the field
- Frequently inspect completed jobs
  - Verify procedures are correctly implemented
  - Verify comprehensive work
- Review all aspects of the work
  - Audits, work scope, installation, third party inspection
- Require contractors to fix unacceptable work
- Ensure all parties agree to specifications and procedures

Performance Measurement 5- Require Contractor Accountability

- Require contractors to return to home to fix problems
- Provide training in problem areas
- Set goals for contractor performance
- Conduct additional observations and inspections
- Remove contractors who do not improve

Performance Measurement
6- Assess Inputs and Outputs

- Inputs
  - Pre-treatment usage
  - Measure spending distribution
- Outputs
  - Measure installation rates
- Are they improving enough to lead to better results?

Performance Measurement
7- Assess Inspection Results

- Review rates of:
  - Comprehensive installation
  - High quality installations
  - Missed opportunities
  - Poor work quality

⇨ Early indication of energy saving expectations.

Performance Measurement
8- Assess Energy Savings

- Conduct billing analysis on an annual basis
- Needed to ensure expected results
- Develop procedures to more easily extract data
  - Reduced evaluation cost

Performance Measurement Repeat

- Compare results over time
- Assess what is working
- Refine the program

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SUMMARY

Achieving High Savings Lessons Learned

- It is challenging to meet savings expectations
- Target high usage customers
- Ensure major measures are installed where opportunities exist
- Maximize use of proven home performance techniques
- Conduct performance measurement

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