

Appendix A
Survey Instruments

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Detailed Customer Survey: Heat Pump Water Heaters

Section		Number of Questions	Topic Summary
SCREENER	S	2 only for non-site visit respondents	Assessing knowledge of installation and rebate/discount and recording contractor information
GENERAL EQUIPMENT INFORMATION	M	2 only for non-site visit respondents	Information on location and size of space where HPWH is installed
EQUIPMENT OPERATION	E	5	Determine if and why respondent changes the mode of their HPWH
BASELINE INFORMATION	P	6 retrofit/ 4 MOP	Determine condition and type of previous water heating equipment, also determine heating fuel and presence of AC
SELECTION OF EFFICIENT EQUIPMENT	N	3/ 0 if DIY	Determine the influence of the contractor and respondent in the decision to install a HPWH
FREE RIDERSHIP QUESTIONS	FR	4 max / 2 min	Determine what customer would have done without the rebate from the program
CUSTOMER AWARENESS OF REBATE	CA	1 / 0 if S4=2	Determine how respondent learned about the rebate
OCCUPANCY	OCC	3	Determine when the home is occupied and how many people live in the home > 9 months
BARRIER QUESTIONS & PAIRWISE	B	4	Determine the respondents barriers to installing high efficiency and relative importance
FUNDING	FS	3	Determine the importance of the rebate in choosing the HPWH
Customer Experience with Contractor	CEC	2/ 0 for DIY	Scale customer satisfaction with the contractor
Customer Experiences with Equipment	CEE	5	Scale customer satisfaction with the equipment
Customer Demographics	CD	2	Age and income
Total		42 max/ 32 min	

Sample Keys:

Name

Phone Number

Address

Attribute_1 : screener (0=Did not take, 1=Did take)

Attribute_2 : rebate (amount to be shown in FS2)

Attribute_3 : utility (company to be shown in FS2)

Attribute_4 : diy (0=flagged as not DIY in screener, 1=flagged as DIY in screener)

Definitions:

EQUIPMENTS: Heat Pump Water Heater

EQUIPMENTY: Water Heater

Intro: Welcome to the Energize CT Heating and Water Heating Survey. Our goal is to gather accurate feedback on the Energize CT Program and how it helped you in the decision making process.

SCREENER [ASK IF SCREENER=0]

S1. Who was the contractor that installed your new <EQUIPMENTS>?

1. [RECORD NAME OF CONTRACTOR]
2. You installed it yourself
3. A friend or family member installed it
4. Don't know name of contractor

NOTE: S1=2 and S1=3 are "DIY"

S2. Were you aware that the cost of your efficient <EQUIPMENTS> was discounted by your utility?

1. Yes
2. No
97. Don't know

GENERAL EQUIPMENT INFORMATION

M1. Where is your <EQUIPMENTS> installed in your home?

1. Heated/Finished Basement
2. Unfinished/Unheated Basement
3. Garage
4. Attic
5. Closet in Living Space
6. Living Space
7. Other [SPECIFY]

M2. [IF SCREENER=0] What is the size of the room where the <EQUIPMENTS> is installed?

1. Smaller than 100 square feet (approx 10x10)
2. 100 square feet or larger

EQUIPMENT OPERATION

E1. How many heat pump water heaters are you currently using in your home?

- 1
- 2
- 3 or more

E2. Heat pump water heaters have several modes, as shown on the control panel of the water heater. Prior to participating in this study, were you aware that your heat pump water heater has several modes?

1. Yes
2. No

E3. [IF DIY=0 OR S1=1 or S1=4] [DO NOT ASK IF E2=2] When your contractor installed your heat pump water heater, did he/she explain how to use the different modes?

1. Yes
2. No

E4. [ASK IF E2=1] During the past year, how many weeks did you have your primary heat pump water heater in each of these modes?

Please enter a "0" for any modes that you did not use in the past year.

[ROTATE ORDER OF MODES.] [MUST TOTAL 52]

1. Heat pump or efficiency: _____ weeks
2. Hybrid: _____ weeks
3. High Demand: _____ weeks
4. Electric: _____ weeks
5. Vacation: _____ weeks

E5. [IF MORE THAN ONE MODE SELECTED IN E4] Why did you change the mode? Choose as many as apply.

1. You needed more hot water
2. You wanted to use less electricity
3. Heat pump or hybrid mode did not provide enough hot water
4. You put it on vacation mode when you are away
5. Something else? _____

BASELINE INFORMATION

P1. Was the new <EQUIPMENTA> replacing a previous <EQUIPMENTy> or was it a new installation?

1. Yes - it replaced a previous one
2. No - it is an entirely new installation [SKIP TO P5]
3. Something else? Describe: _____

P2. Which of the following best describes the condition of the original equipment that was replaced?

1. It had failed and you needed to replace it immediately (within a week or two).
2. It was about to fail and you expected to have to replace it within six months.
3. It required frequent maintenance.
4. It worked well, but was old and would probably need to be replaced in next couple of years.
5. It was in reasonable condition and not expected to fail in the next few years.
6. Something else? _____

P3. Prior to installing the heat pump water heater, what type of water heater and fuel did you use?

1. Natural Gas or Propane - Stand alone tank (tank not connected to a boiler)
2. Natural Gas or Propane - Tankless on demand (on demand unit separate from boiler)
3. Natural Gas or Propane - Tankless coil or sidearm (water heated inside the boiler)
4. Natural Gas or Propane - Tank integrated with boiler (water heated by boiler, stored in separate tank)
5. Electric - Stand alone tank (tank not connected to a boiler)
6. Electric - Tankless on demand (on demand unit separate from boiler)
7. Oil - Stand alone tank (tank not connected to a boiler)
8. Oil - Tankless coil or sidearm (water heated inside the boiler)
9. Oil - Tank integrated with boiler (water heated by boiler, stored in separate tank)
10. Solar with electric back up
11. Solar with natural gas or propane back up

P4. When you decided to purchase your water heater, which other options did you consider? Choose as many as apply.

1. Natural Gas or Propane - Stand alone tank (tank not connected to a boiler)
2. Natural Gas or Propane - Tankless on demand (on demand unit separate from boiler)
3. Natural Gas or Propane - Tankless coil or sidearm (water heated inside the boiler)
4. Natural Gas or Propane - Tank integrated with boiler (water heated by boiler, stored in separate tank)
5. Electric - Stand alone tank (tank not connected to a boiler)
6. Electric - Tankless on demand (on demand unit separate from boiler)
7. Oil - Stand alone tank (tank not connected to a boiler)
8. Oil - Tankless coil or sidearm (water heated inside the boiler)
9. Oil - Tank integrated with boiler (water heated by boiler, stored in separate tank)
10. Solar with electric back up
11. Solar with natural gas or propane back up
12. Don't know
13. Something else: _____

P5. How do you heat your home? [Choose all that apply.]

1. Natural gas boiler or furnace
2. Oil boiler or furnace
3. Propane boiler or furnace
4. Wood boiler or furnace
5. Wood stove
6. Electric baseboard or electric plug-in heater
7. Oil, propane, or kerosene space heater
8. Natural gas or propane fireplace
9. Wood fireplace
95. Other [Please describe type and fuel:_____]

P6. What type of air conditioning do you have? (Choose as many as apply.)

1. Central air conditioning
2. Room air conditioners
3. None
4. Something else? Tell us: _____

SELECTION OF EFFICIENT EQUIPMENT

[ASK N1-N3 IF DIY=0 OR S1=1 or S1=4]

N1. Did your contractor recommend the heat pump water heater?

1. Yes
2. No
3. Something else? _____

N2. Which statement is closest to how you made your decision to install the heat pump water heater instead of a standard water heater.

We will be asking a follow-up question based on your response so please take a moment to carefully consider these choices.

1. The contractor's influence was the only important factor in your decision.
2. The contractor's influence was more important than your own research.
3. The contractor's influence and your own research were equally important.
4. Your own research was more important than the contractor's influence.
5. Your own research was the only important factor.

[IF N2=2, THEN FACTOR1 = 'your contractor's influence' AND FACTOR2='your own research'.

IF N2=4, THEN FACTOR2 = 'your contractor's influence' AND FACTOR1='your own research'.

[ASK N3 if N2 = 2 or 4]

N3. Comparing FACTOR1 to FACTOR2, how would you rate the importance of FACTOR1?

Was FACTOR1 ...

1. about the same as FACTOR2
2. slightly more important than FACTOR2
3. moderately more important than FACTOR2
4. strongly more important than FACTOR2

5. extremely more important than FACTOR2
6. FACTOR2 was more important

FREE RIDERSHIP QUESTIONS

FR1. [DO NOT ASK IF S2=2] The next questions are about what you would have done if your utility or Energize Connecticut had not provided a rebate. If no rebates had been available, would you have purchased a new water heater of any type?

1. Yes, you would have purchased a new water heater
2. No, you would not have purchased any type of new water heater

FR2. [ASK IF FR1 = 1] Would you have purchased the same <EQUIPMENTS> if the cost were \$400 more than you paid?

1. Definitely would not
2. Probably would not
3. Not sure
4. Probably would
5. Definitely would

FR3. [IF FR2= 1, 2 OR 3:] Would you have purchased a heat pump water heater at a later time or a different type of water heater?

1. Heat pump water heater at a later time
2. A different type of water heater [SKIP TO NEXT SECTION]
3. Don't know [SKIP TO NEXT SECTION]

FR4. [DO NOT ASK IF S2=2, FR2=4 or 5, FR3=2,3] The next question is about when you would have purchased a new heat pump water heater if the rebate/discount had not been offered by your utility or Energize Connecticut. Would you say you would have made the purchase within six months, six months to one year, or over a year from when you did?

1. Within 6 months
2. 6 months to one year
3. Over one year
96. Don't know

CUSTOMER AWARENESS OF REBATE

CA1. How did you first learn that the discount/rebate was available? [SELECT ONE]

1. A Home Energy Solutions Audit
2. Utility/ Energize Connecticut marketing materials
3. Utility/ Energize Connecticut website
4. Your contractor who completed the installation told you about it
5. A different contractor told you about it
6. A retailer told you about it or provided marketing materials
7. A manufacturer told you about it or provided marketing materials
8. A family member, friend, or neighbor
9. Did not know about the rebate
10. Other: _____
96. Don't know

OCCUPANCY

OCC1. How many weeks was your home occupied during the past year?

1. All 52 weeks
2. 51-46 weeks
3. Less than 46 weeks

OCC2. [IF OCC1=3] How many weeks was your home occupied in each season?

1. Spring _____ (maximum of 13 weeks)
2. Summer _____ (maximum of 13 weeks)
3. Fall _____ (maximum of 13 weeks)
4. Winter _____ (maximum of 13 weeks)

OCC3. Including all adults and children, how many people currently live in your household more than nine months out of the year?

1

2

3

4

5

6

7

8

9

10 or more

96. Refused

BARRIER QUESTIONS

B1. Thinking back to before the installation and how you selected a heat pump water heater instead of a standard unit, we are interested in your challenges in moving ahead with the project and your concerns about choosing the high efficiency option.

Many homeowners have the following concerns:

- Lack of information, i.e. not sure what to install, want to learn about environmental impacts or greenhouse gas reductions
- Paying the premium for the high efficiency unit, i.e. concerns about payback, whether the extra cost is worth it, covering the cost premium
- Equipment concerns, i.e. noise levels, providing enough hot water, maintenance needs
- Finding a contractor you could trust

Please identify any concerns you had by dragging and dropping them into the column on the left.

Rank as many as apply in order of importance, with the item at the top indicating the most important.

Please take a minute to consider your choices because the next set of questions will be based on your response

[RANK ITEMS]

1. Lack of information

2. Paying the premium for the high efficiency unit

3. Equipment concerns
4. Finding a contractor you could trust
5. Something else

[FACTOR1 = Ranked item 1]

[FACTOR2 = Ranked item 2]

[FACTOR3 = Ranked item 3]

[ASK B2 if Ranked item 1 is (1-4) and Ranked item 2 is not blank, and is (1-4)]

B2. Comparing FACTOR1 to FACTOR2, how would you rate the importance of FACTOR1?
Was FACTOR1 ...

1. about the same as FACTOR2
2. slightly more important than FACTOR2
3. moderately more important than FACTOR2
4. strongly more important than FACTOR2
5. extremely more important than FACTOR2
6. FACTOR2 was more important

[ASK B3 if Ranked item 1 is (1-4) and Ranked item 3 is not blank, and is (1-4)]

B3. Comparing FACTOR1 to FACTOR3, how would you rate the importance of FACTOR1?
Was FACTOR1 ...

1. about the same as FACTOR3
2. slightly more important than FACTOR3
3. moderately more important than FACTOR3
4. strongly more important than FACTOR3
5. extremely more important than FACTOR3
6. FACTOR3 was more important

[ASK B4 if Ranked item 2 is not blank and is (1-4) and Ranked item 3 is not blank, and is (1-4)]

B4. Comparing FACTOR2 to FACTOR3, how would you rate the importance of FACTOR2?
Was FACTOR2 ...

1. about the same as FACTOR3
2. slightly more important than FACTOR3
3. moderately more important than FACTOR3
4. strongly more important than FACTOR3
5. extremely more important than FACTOR3
6. FACTOR3 was more important

FS1. What were the funding sources you used to pay for the installation of your heat pump water heater? [Choose as many as apply.]

1. Home equity line of credit
2. Loan from your bank
3. Personal savings
4. Incentive or discount from the contractor
5. Rebate or discount from your natural gas or electric utility
6. Incentive or grant from a municipal or federal program
7. Federal or state tax credits
8. EnergizeCT loan
9. Credit card
10. Something else? _____

FS2. Heat pump water heaters often cost more than standard electric water heaters. The next question is about how you decided to pay the premium for the heat pump water heater in comparison to a standard one.

[IF S2=1 (YES):] *Rebate* is the <REBATE AMOUNT> discount from <UTILITYx> that you received through your contractor or retailer.

[IF S2<>1 (NO OR DK):] *Rebate* includes discounts from your contractor, retailer or utility

Other influences include any other factors that were important to your decision making process.

Thinking only about *what tipped your decision to pay the premium* for your heat pump water heater, which statement is closest to how you made your decision. [Choose one.]

1. The rebate was the only important factor that tipped you toward the heat pump water heater.
2. The rebate was more important than other influences.
3. The rebate and other influences were equally important.

4. Other influences were more important than the rebate.
5. Other influences were the only important factor.

[IF FS2=2, THEN FACTOR1= “the rebate” and FACTOR2= “other influences”.]

[IF FS2=4, THEN FACTOR2= “the rebate” and FACTOR1= “other influences”.]

[ASK FS3 if FS2=2 or 4]

FS3. Comparing FACTOR1 to FACTOR2, how would you rate the importance of FACTOR1?
(Was/Were) FACTOR1 ...

1. about the same as FACTOR2
2. slightly more important than FACTOR2
3. moderately more important than FACTOR2
4. strongly more important than FACTOR2
5. extremely more important than FACTOR2
6. FACTOR2 was/were more important

Satisfaction Questions

Customer Experiences with Contractor

[ASK CEC1-CEC2 IF DIY=0 OR S1=1 or S1=4]

The next set of questions relates to your experiences with the contractor who installed the new <EQUIPMENTS>.

CEC1. Please rate your satisfaction with your contractor.

1. Very dissatisfied
2. Somewhat dissatisfied
3. Neither satisfied nor dissatisfied
4. Somewhat satisfied
5. Very satisfied

CEC2. [IF CEC1 is 1, 2 or 3] Please describe why you were less than satisfied with your contractor?

Comments: _____

Customer Experiences with Equipment

CEE1. Please rate your satisfaction with your new <EQUIPMENTA>.

[GRID][SCALE]

1. Very dissatisfied
2. Somewhat dissatisfied
3. Neither satisfied nor dissatisfied
4. Somewhat satisfied
5. Very satisfied

[SUBQUESTIONS]

CEE1a. Overall satisfaction with the heat pump water heater

CEE1b. Noise level

CEE1c. [HPWH ONLY] Provides enough hot water

CEE1d. [HPWH ONLY] Easy to use settings [ex., vacation setting, high use mode, heat pump only mode]

CEE1e. Maintenance

CEE1f. Saving energy or reducing fuel costs

Comments: _____

CEE2. [ASK IF ANY RESPONDE TO CEE1a-CEE1f is 1,2, or3]

What issues, if any, have you experienced with your heat pump water heater?

RECORD RESPONSE:_____

CEE3. [ASK IF CEE1f = 4,5]

[IF CEE1e = 1 or 2] Comparing the value to you of the energy savings to the value of the hassle of the installation or additional maintenance (such as lost time), did the energy savings from the new equipment make up for the hassle of the installation and additional maintenance?

[IF CEE1e = 3, 4 or 5] Comparing the value to you of the energy savings to the value of the hassle of the installation (such as lost time), did the energy savings from the new equipment make up for the hassle of the installation?

1. Yes
2. No
96. Don't know

[IF CEE3= NO: FACTOR1="the hassle" AND FACTOR2="the energy savings"]

[IF CEE3=YES, FACTOR1="the energy savings" AND FACTOR2="the hassle"]

[ASK CEE4 if CEE3 = 1 or 2]

CEE4. How would you rate FACTOR1 in comparison to FACTOR2? Was FACTOR1 of equal value, slightly, moderately, strongly or extremely more value than FACTOR2?

1. about the same as FACTOR2
2. slightly more value than FACTOR2
3. moderately more value than FACTOR2
4. strongly more value than FACTOR2
5. extremely more value than FACTOR2
6. FACTOR2 is more important

CEE5. Since you installed the heat pump water heater, does your dehumidifier run the same, more or less? [If you have more than one dehumidifier, think about the one closest to the heat pump water heater.]

1. You don't have a dehumidifier
2. Runs a lot more
3. Somewhat more
4. About the same
5. Somewhat less
6. A lot less

Customer Demographics

The next questions are for statistical purposes only. This information will be combined across all participants and will not be shared with anyone outside of the evaluation team in any way that identifies you or your household.

CD1. What is your age? Is it...

1. 18 TO 24
2. 25 TO 34
3. 35 TO 44
4. 45 TO 54
5. 55 TO 64
6. 65 OR OVER

CD2. Please select the range that contains the total combined income of all members of your household over the past 12 months. [RECORD ONE]

- 1. Less than \$25,000
- 2. \$25,000 to less than \$50,000
- 3. \$50,000 to less than \$75,000
- 4. \$75,000 to less than \$100,000
- 5. \$100,000 to less than \$150,000
- 6. \$150,000 to less than \$200,000
- 7. \$200,000 or more
- 96. DON'T KNOW

END OF SURVEY: That completes the survey. On behalf of Energize CT, thank you very much for your time and thoughtful answers today.

Detailed Customer Survey: Boilers

Section		Number of Questions	Topic Summary
Screeener	S	2	Assessing knowledge of installation and rebate/discount and recording contractor information
Equipment Operation	OP	7	Ascertain thermostat settings, changes in settings, comfort, maintenance costs, fuel costs
Baseline	BL	3	Ask about the equipment they considered installing
Selection of Efficient Equipment	N	3	Determine the influence of the contractor and respondent in the decision to install a HPWH
Free Ridership	FR	4	Determine what customer would have done without the rebate from the program
Customer Awareness of the Rebate	CA	1	Determine how respondent learned about the rebate
Occupancy	OCC	3	Determine when the home is occupied and how many people live in the home > 9 months
Barrier Questions & Pairwise	B	4/2	Determine the respondents barriers to installing high efficiency and relative importance
Funding	FS	3	Determine the importance of the rebate in choosing the HPWH
Customer Experience with Program	CEP	4	Customer experience with rebate process and advertising for rebates
Customer Experience with Contractor	CEC	1	Scale customer satisfaction with the contractor
Customer Experiences with Equipment	CEE	4	Scale customer satisfaction with the equipment
Customer Demographics	CD	4	Age, income and level of schooling completed
TOTAL		40 max	

Intro: Welcome to the Energize CT Heating and Water Heating Survey. Our goal is to gather accurate feedback on the Energize CT Program and how it helped you in the decision making process.

Name	
Phone Number	
Address	
Equipment Installed	EQUIPMENTS: Boiler or Furnace
	EQUIPMENTy: Boiler or Furnace

SCREENER [ASK IF SCREENER=0]

[ASK ONLY FOR RESPONDENTS WHO DID NOT TAKE THE SCREENER SURVEY]

[SET DIY FLAG TO 0 - ONLY FOR THOSE WHO DID NOT TAKE THE SCREENER SURVEY]

S1. Who was the contractor that installed your new <EQUIPMENTS>?

1. [RECORD NAME OF CONTRACTOR]
2. You installed it yourself [CHANGE DIY TO 1]
3. A friend or family member installed it [CHANGE DIY TO 1]
4. Don't know name of contractor

NOTE: S1=2 and S1=3 are "DIY"

S2. Were you aware that the cost of your efficient <EQUIPMENTS> was discounted by your utility?

1. Yes
2. No
97. Don't know

EQUIPMENT OPERATION

OP1. Was the new <EQUIPMENTS> replacing a previous <EQUIPMENT> or was it a new installation?

1. Yes – it replaced a previous one
2. No – it is an entirely new installation [SKIP TO OP3]
3. Something else? Describe: _____

OP2. Which of the following best describes the condition of the original equipment that was replaced?

1. It had failed and you needed to replace it immediately (within a week or two).
2. It was about to fail and you expected to have to replace it within six months.
3. It required frequent maintenance.
4. It worked well, but was old and would probably need to be replaced in next couple of years.
5. It was in reasonable condition and not expected to fail in the next few years.
6. Something else? _____

OP3. How do you set the thermostat for heating in the room you use the most?

1. Set at one temperature and leave it
2. Set back with programmable thermostat
3. Change temperature setting remotely (WiFi or phone app)
4. Use Smart Thermostat to automatically adjust temperature
5. Manually adjust as needed
6. Combination of set back methods (manual, programmed, remote)
7. Something else? _____

OP4. What are your thermostat settings for heating in the room you use the most?

Daytime temperature setting: _____

Nighttime temperature: _____

OP5. After installing the efficient <EQUIPMENTS>, did you change your thermostat setting(s)?

1. You left thermostat setting the same
2. You turned up the thermostat

3. You turned down the thermostat
4. Something else? _____

OP6. Do you have a secondary heating system that you use regularly during the heating season?

1. No, you do not have a secondary heating system
2. Yes, the secondary system also uses natural gas
3. Yes, the secondary system does not use natural gas
4. Something else? _____

OP7. Are your fuel bills for the new efficient <EQUIPMENTA> higher, lower or the same as your previous heating system?

1. Higher
2. The same
3. Lower
96. Don't know

BASELINE QUESTIONS

BL1. When choosing the <EQUIPMENTx> to install, what were the most important considerations? Rank the factors that were important to you with the most important factor at the top.

Total installation cost

Operating costs

Comfort

Efficiency

Reliability

Availability of the rebate

BL2. Before selecting the <EQUIPMENTx> to install, did you consider any of the following options? (Choose all that apply.)

1. Non-condensing <EQUIPMENTx>
2. Condensing <EQUIPMENTx> - less efficient than the one installed (lower cost)
3. Condensing <EQUIPMENTx> - more efficient than the one installed (higher cost)
4. A different type of heating system

5. Did not consider any other options
6. Something else? _____

BL3. [IF BL2=1] Was the noncondensing option ...

1. At or near federal standards (80% to 84%)
2. More efficient than federal standards (85% to 89%)
96. Don't know

SELECTION OF EFFICIENT EQUIPMENT

[ASK THIS SECTION ONLY IF DIY=0; OTW, GO TO NEXT SECTION.]The next questions are about the high efficiency <EquipmentA> that you installed.

N1. Did your contractor encourage you to choose a high efficiency <EQUIPMENTA> [IF S2=1, ADD: that was eligible for the discount?]

1. Yes
2. No
3. Something else? _____

N2. Which statement is closest to how you made your decision to choose the efficient <EQUIPMENTA> instead of a less efficient <EQUIPMENTA>?

We will be asking a follow-up question based on your response so please take a moment to carefully consider these choices.

1. Your contractor's influence was the only important factor in your decision. [GO TO NEXT SECTION]
2. The contractor's influence was more important than your own research.
3. The contractor's influence and your own research were equally important. [GO TO NEXT SECTION]
4. Your own research was more important than the contractor's influence.
5. Your own research was the only important factor. [GO TO NEXT SECTION]

[IF N2=2, THEN FACTOR1 = 'your contractor's influence' AND FACTOR2='your own research'. IF N2=4, THEN FACTOR2 = 'your contractor's influence' AND FACTOR1='your own research'.

[ASK N3 if N2 = 2 or 4]

N3. Comparing FACTOR1 to FACTOR2, how would you rate the importance of FACTOR1? Was FACTOR1 ...

1. about the same as FACTOR2
2. slightly more important than FACTOR2
3. moderately more important than FACTOR2
4. strongly more important than FACTOR2
5. extremely more important than FACTOR2

FREE RIDERSHIP QUESTIONS

[IF S2=2 ONLY ASK FR2 AND FR3]

FR1. The next questions are about what you would have done if Energize Connecticut had not provided a rebate for the high efficiency <EQUIPMENTS>. Would you have purchased any new <EQUIPMENTS> if no rebates had been available?

1. Yes
2. No [SKIP TO NEXT SECTION]

FR2. [ASK IF FR1 = 1] Would you have purchased the same <EQUIPMENTS> if the cost were \$400 more than you paid?

1. Definitely would not
2. Probably would not
3. Not sure
4. Probably would [SKIP TO NEXT SECTION]
5. Definitely would [SKIP TO NEXT SECTION]

FR3. [IF FR2= 1, 2 OR 3:] Would you have purchased the high efficiency <EQUIPMENTS> *at a later time* or a different type of <EQUIPMENTS>?

1. The high efficiency <EQUIPMENTS> at a later time
2. Less efficient (conventional) <EQUIPMENTS> [SKIP TO NEXT SECTION]
96. Don't know [SKIP TO NEXT SECTION]

FR4. The next question is about when you would have purchased a new high efficiency <EQUIPMENTS> if the rebate/ discount had not been offered by your utility or Energize Connecticut. Would you say you would have made the purchase within six months, six months to one year, or over a year from when you did?

1. Within 6 months
2. 6 months to one year
3. Over one year
96. Don't know

CUSTOMER AWARENESS OF REBATE

CA1. How did you first learn that the discount/rebate was available? [SELECT ONE]

1. Did not know about the rebate
2. A Home Energy Solutions Audit [SHOW IF S3=1]
3. Utility/ Energize Connecticut marketing materials
4. Utility/ Energize Connecticut website
5. The contractor who completed the installation of your new <EQUIPMENTS> told you about it
6. A different contractor
7. A retailer told you about it or provided marketing materials
8. A manufacturer told you about it or provided marketing materials
9. A family member, friend, or neighbor
10. Other: _____
96. Don't know

OCCUPANCY

OCC1. How many weeks was your home occupied during the past year?

1. All 52 weeks
2. 51-46 weeks
3. Less than 46 weeks

OCC2. [IF OCC1=3] How many weeks was your home occupied in each season?

1. Winter _____ (maximum of 13 weeks)
2. Summer _____ (maximum of 13 weeks)
3. Spring _____ (maximum of 13 weeks)
4. Fall _____ (maximum of 13 weeks)
96. Don't know

OCC3. Including all adults and children, how many people currently live in your household more than nine months out of the year?

1. [RECORD NUMBER] **Range = 1 to 10, where 10 = 10 or more**
96. DON'T KNOW

BARRIER QUESTIONS

B1. Thinking back to before the installation and how you selected a high efficiency <EQUIPMENTS> instead of less efficient unit, we are interested in your challenges in moving ahead with the project and any concerns you may have had about choosing the high efficiency option.

Many homeowners have the following concerns:

- Lack of information, i.e. not sure what to install, want to learn about environmental impacts or greenhouse gas reductions
- Paying the premium for the high efficiency unit, i.e. concerns about payback, whether the extra cost is worth it, covering the cost premium
- Equipment concerns, i.e. noise levels, providing enough hot water, maintenance needs
- Finding a contractor you could trust

Please identify any concerns you had by dragging and dropping them into the column on the left.

Rank as many as apply in order of importance, with the item at the top indicating the most important.

Please take a minute to consider your choices because the next set of questions will be based on your response

[RANK ITEMS]

1. Lack of information
2. Paying the premium for the high efficiency unit
3. Equipment concerns
4. Finding a contractor you could trust
5. Something else

[FACTOR1 = Ranked item 1]

[FACTOR2 = Ranked item 2]

[FACTOR3 = Ranked item 3]

[ASK B2 if Ranked items 1 and 2 are (1-4)]

[IF MORE THAN ONE OF THE FIRST FOUR OPTIONS ARE SELECTED, CONTINUE. OTW, SKIP TO NEXT SECTION. FACTOR1 = HIGHEST RANK; FACTOR 2 = SECOND RANKED; FACTOR3 = THIRD RANKED. IF ALL FOUR FACTORS WERE RANKED, DROP THE HIGHEST ONE. USE THE "LACK OF INFORMATION", "PAYING THE PREMIUM", "EQUIPMENT CONCERNS" "FINDING A CONTRACTOR" TO FILL IN THE FACTORS.]

B2. Comparing FACTOR1 to FACTOR2, how would you rate the importance of FACTOR1?
Was FACTOR1 ...

1. about the same as FACTOR2
2. slightly more important than FACTOR2
3. moderately more important than FACTOR2
4. strongly more important than FACTOR2
5. extremely more important than FACTOR2
6. FACTOR2 was more important

[ASK B3 if Ranked item 1 is (1-4) and Ranked item 3 is (1-4)]

B3. Comparing FACTOR1 to FACTOR3, how would you rate the importance of FACTOR1?
Was FACTOR1 ...

1. about the same as FACTOR3
2. slightly more important than FACTOR3
3. moderately more important than FACTOR3
4. strongly more important than FACTOR3
5. extremely more important than FACTOR3
6. FACTOR3 was more important

[ASK B4 if Ranked item 2 is not blank and is (1-4) and Ranked item 3 is not blank, and is (1-4)]

B4. Comparing FACTOR2 to FACTOR3, how would you rate the importance of FACTOR2?
Was FACTOR2 ...

1. about the same as FACTOR3
2. slightly more important than FACTOR3
3. moderately more important than FACTOR3
4. strongly more important than FACTOR3
5. extremely more important than FACTOR3
6. FACTOR3 was more important

FUNDING

FS1. What were the funding sources you used to pay for the installation of your efficient <EQUIPMENTS>? [Choose as many as apply.]

1. Home equity line of credit
2. Loan from your bank
3. Personal savings
4. Incentive or discount from the contractor
5. Rebate or discount from your natural gas or electric utility
6. Incentive or grant from a municipal or federal program
7. Federal or state tax credits
8. EnergizeCT loan
9. Credit card
10. Something else? _____

FS2. [IF FS1 <> 4 OR 5 THEN SKIP TO NEXT SECTION] Efficient <EQUIPMENTS> often cost

more than standard ones. The next question is about how you decided to pay the *premium* for the efficient <EQUIPMENTS> in comparison to a standard one.

[IF S2=1 (YES):] *Rebate* is the <REBATE AMOUNT> discount from <UTILITYx> that you received through your contractor or retailer.

[IF S2<> 1 (NO OR DK):] *Rebate* includes discounts from your contractor, retailer or utility

Other influences include any other factors that were important to your decision making process.

Thinking only about what *tipped your decision to pay the premium* for your efficient <EQUIPMENTS>, which statement is closest to how you made your decision? [Choose one.]

Please take a minute to consider your choices because the next set of questions will be based on your response.

1. The rebate was the only important factor that tipped you toward the efficiency <EQUIPMENTS>. [GO TO NEXT SECTION]
2. The rebate was more important than other influences.
3. The rebate and other influences were equally important. [GO TO NEXT SECTION]
4. Other influences were more important than the rebate.
5. Other influences were the only important factor. [GO TO NEXT SECTION]

[IF FS2=2, THEN FACTOR1= "the rebate" and FACTOR2= "other influences". IF FS2=4, THEN FACTOR2= "the rebate" and FACTOR1= "other influences".]

FS3. Comparing FACTOR1 to FACTOR2, how would you rate the importance of FACTOR1? Is FACTOR1 ...

1. about the same as FACTOR2
2. slightly more important than FACTOR2
3. moderately more important than FACTOR2
4. strongly more important than FACTOR2
5. extremely more important than FACTOR2

Satisfaction Questions

Customer Experiences with Program

CEP1. [IF FS1<>4 OR 5 SKIP TO CEP2] Please rate your satisfaction with the <REBATE AMOUNT> rebate you received for installing your new <EQUIPMENTS>.

[SCALE: VERY DISSATISFIED, SOMEWHAT DISSATISFIED, NIETHER SATISFIED NOR DISSATISFIED, SOMEWHAT SATISFIED, VERY SATISFIED]

CEP2. What information, if any, did you provide to your contractor in order to receive the rebate? (Choose as many as apply.)

1. I do not recall providing any information
2. Our address
3. Our gas and/or electric utility account information
4. Contact information for the person that pays our utility bill
5. Something else? _____

CEP3. Do you recall seeing any Energize CT advertisements about the rebates for <EQUIPMENTS>?

1. Yes
2. No [SKIP TO CEC1]
3. Don't Know [SKIP TO CEC1]

CEP4. [IF CEP3=1] Which of the following Energize CT advertising materials, if any, contributed to your decision to purchase and install your new <EQUIPMENTS>? Choose as many as apply.

1. Online advertising
2. Energize CT website
3. Brochure(s) from your contractor or retailer
4. Mailed information
5. Television/ radio advertising
6. Billboard advertising
7. Other: _____
8. None
9. Don't know

Customer Experiences with Contractor

[ASK CEC1 IF DIY=0 OR S1=1 or S1=4]

The next set of questions relates to your experiences with the contractor who installed the new <EQUIPMENTS>.

CEC1. Please rate your satisfaction with your contractor.

[SCALE: VERY DISSATISFIED, SOMEWHAT DISSATISFIED, NEITHER SATISFIED NOR DISSATISFIED, SOMEWHAT SATISFIED, VERY SATISFIED]

- CEC2a. Overall satisfaction with your contractor
- CEC2b. Knowledge of energy efficient equipment
- CEC2c. Explained the features of your new <EQUIPMENTx>
- CEC2d. Answered your questions about the new <EQUIPMENTA>
- CEC2e. Responds to your calls
- CEC2f. Explained the Energize CT program offerings

Customer Experiences with Equipment

CEE1. Please rate your satisfaction with your new <EQUIPMENTA>.

[SCALE: VERY DISSATISFIED, SOMEWHAT DISSATISFIED, NEITHER SATISFIED NOR DISSATISFIED, SOMEWHAT SATISFIED, VERY SATISFIED]

- CEE1a. Overall satisfaction with the <EQUIPMENTA>
- CEE1b. Noise level
- CEE1c. [BOILERS ONLY] Provides enough hot water
- CEE1d. System provides enough heat
- CEE1e. Maintenance
- CEE1f. Saving energy and/or reducing fuel costs
- CEE1g. Comfort level
- CEE1h. [FURNACES ONLY] Indoor air quality

Comments: _____

CEE2. [ONLY ASK IF ANY RESPONSE TO CEE1a IS VERY DISSATISFIED, SOMEWHAT DISSATISFIED, OR NEITHER SATISFIED OR DISSATISFIED AND CEEb-h IS SOMEWHAT SATISFIED OR VERY SATISFIED] What issues, if any, have you experienced with your <EQUIPMENTA>?

RECORD RESPONSE: _____

CEE3. [IF (CEE1f) IS SOMEWHAT OR EXTREMELY SATISFIED:] Comparing the value to you of the energy savings [ADD IF CEE1g IS SOMEWHAT OR EXTREMELY SATISFIED: and comfort"] to the value of the hassle of the installation [ADD IF CEE1e IS SOMEWHAT OR EXTREMELY DISSATISFIED: "or additional maintenance"] (such as lost time), did the energy savings [ADD IF CEE1g RESPONSE IS POSITIVE: "and comfort"] from the new equipment

make up for the hassle of the installation [ADD IF CEE1e IS SOMEWHAT OR EXTREMELY DISSATISFIED: “and additional maintenance”]?

1. Yes
2. No
96. Don't know _____

[IF CEE3= NO: FACTOR1=“the hassle” AND FACTOR2=“the energy savings”;

IF CEE3=YES, FACTOR1=“the energy savings” AND FACTOR2=“the hassle”]

CEE4. How would you rate FACTOR1 in comparison to FACTOR2? Was FACTOR1 of equal value, slightly, moderately, strongly or extremely more value than FACTOR2?

1. about the same as FACTOR2
2. slightly more value than FACTOR2
3. moderately more value than FACTOR2
4. strongly more value than FACTOR2
5. extremely more value than FACTOR2

Customer Demographics

The next questions are for statistical purposes only. This information will be combined across all participants and will not be shared with anyone outside of the evaluation team in any way that identifies you or your household.

CD1. What is your age? Is it...

1. 18 TO 24
2. 25 TO 34
3. 35 TO 44
4. 45 TO 54
5. 55 TO 64
6. 65 OR OVER

CD2. Please select the range that contains the total combined income of all members of your household over the past 12 months. [RECORD ONE]

1. Less than \$25,000
2. \$25,000 to less than \$50,000
3. \$50,000 to less than \$75,000
4. \$75,000 to less than \$100,000
5. \$100,000 to less than \$150,000
6. \$150,000 to less than \$200,000

- 7. \$200,000 or more
- 96. DON'T KNOW

CD3. What is the highest grade of schooling you have completed so far? [DO NOT READ]

- 1. No High School Diploma or GED
- 2. High School Graduate (includes GED)
- 3. Associates Degree
- 4. Bachelors Degree (4-year degree)
- 5. Graduate or Professional Degree
- 96. Don't know

CD4. In closing, is there anything else you would like to tell Energize CT about your experiences with purchasing, installing and using your new <EQUIPMENTS> (such as unexpected benefits or challenges)?

RECORD:_____

END OF SURVEY: That completes the survey. On behalf of Energize CT, thank you very much for your time and thoughtful answers today.

Detailed Contractors Interview

Overview

The evaluation team plans to conduct about 100 detailed interviews with contractors. We will attempt to contact all contractors who installed measures for customers who participated in a home site visit (heat pump water heaters, boilers and boiler circulating pumps). The contractor detailed interview guide is designed to address four objectives:

- (1) Assess program influence (self report and barrier approach)
- (2) Investigate process issues
- (3) Inquire about impact-related issues
- (4) Estimate baseline equipment efficiency

Results from the cognitive interviews were used to refine this detailed interview guide for the online survey fielded to contractors.

Contractor-related process research questions addressed in this survey include:

- (1) How do contractors become aware of the program offering? (PE1)
- (2) What motivates contractors to sell high efficiency equipment? (KD1, KD2, PE2)
- (3) What factors prevent contractors from selling more high efficiency equipment? (B1)
- (4) How do contractors communicate program offerings to their customers? (R1-R6)
- (5) To what extent have contractors attended and learned from training events? (T4, T6)
- (6) How do contractors experience program processes? (PE3, PE4)
- (7) How satisfied are contractors with the program? (SA1, SA2)
- (8) What are contractors' perspectives on customer acceptance and the availability of high efficiency equipment? (A1, A2, A5, A6)

Due to the length of the survey, the critical modules will be put in the beginning, and the less critical modules will be placed at the end. This means we may not receive complete data for the less important modules.

Section		Number of Questions	Topic Summary
Introduction	Q	2 –only if soliciting via phone	Finding the correct respondent
Baseline	SD	6/3	Determine baseline for furnaces, boilers and boiler circulating pumps
Key Decision Influences	KD	1	What factors motivated contractor to offer/install HE equipment
Program Influence	PI	3	Influence of the rebates on selling HE equipment and issues that contractors encounter in receiving the discounted price
Barriers	B	5/3	What are the contractor's barriers to recommending HE equipment to their customers
Availability and Market Acceptance	A	4/1	Ask contractors perspective on customer acceptance and availability of HE equipment
Selection of Efficient Equip.	R	6/5	How do contractors work with customers? How do they make recommendations? (free ridership questions)
Equipment Concerns	EQ	2	Contractors' perspective on equipment concerns
Training	T	6	Have contractors attended and learned from training events?
Satisfaction	SA	3	How satisfied are contractors with the program?
Program Experience	PE	3	Contractors experience with program components, including how they pass the rebate to the customer; percent of sales are HE, before & after
End of Survey	ES	3	Any additional comments about experiences with the program and recommendations for improvement; ask about availability for a more detailed discussion of equipment-specific issues
TOTAL		42 max	

Name	
Company	
Phone Number	
e-mail	
Address	
Equipment	Measure1: high efficiency furnace
	Measure2: high efficiency boiler
	Measure3: heat pump water heater
	Measure4: ECM boiler pump

INTRODUCTION AND FINDING CORRECT RESPONDENT

Q1. Hello, this is <INTERVIEWER NAME> calling from West Hill Energy & Computing on behalf of Energize Connecticut. This is not a sales call. May I please speak with PROGRAM_CONTACT?

1. No, this person no longer works here
2. No, this person is not available right now
3. Yes [GOTO SCREENER]
4. No, Other reason (specify)

Q2. Is there someone else in your company who is familiar with the Energize CT Upstream HVAC and Hot Water program? IF YES: Can you tell me who that person might be?

1. Yes [RECORD NAME/PHONE FOR CALLBACK]
2. No [THANK AND TERMINATE]
3. DK/ REFUSED [THANK AND TERMINATE]

Intro: Welcome and thank you for participating in the Energize CT Upstream HVAC & Water Heating Survey. This survey will cover specifics about the **HVAC and hot water upstream rebates from Eversource, United Illuminating, Yankee Gas, Connecticut Natural Gas, and Southern Connecticut Gas.**

We need your feedback to determine how to improve the program! Please be sure that the person completing this survey is the person who makes the decision about the makes and models to offer to your customers.

[EQUIPMENTx WILL BE FILLED IN ACCORDING TO THE COMPLETED CUSTOMER SURVEYS FOR THE CONTRACTOR. IF NO CUSTOMER SURVEYS WERE COMPLETED, SELECT THE EQUIPMENT TO MEET THE EQUIPMENT-SPECIFIC QUOTA.]

LOG/SELECT EQUIPMENTx = [FILL IN]

DEFINING HIGH EFFICIENCY

For the purpose of this interview, we will define high efficiency <EQUIPMENTx> as equipment that is eligible for an upstream rebate in the state of Connecticut.

HIGH EFFICIENCY STANDARDS (2016 ENERGIZE CT REBATE SUMMARY TABLE)

Measure	Qualification Criteria
Boiler	ENERGY STAR 90% AFUE or Greater and AHRI Rated with boiler reset control
Natural Gas Furnace	ENERGY STAR 95% AFUE or greater and AHRI Rated with ECM air handler motor
Boiler Circulator Pump	Approved models only: some Grundfos Alpha models, BumbleBee, some Wilo models, etc.
Heat Pump Water Heater	ENERGY STAR with COP of 2.0 or greater

BASELINE

The next questions are about the equipment you sold in 2016 that did **not** meet the Energize CT requirements for the upstream rebate.

SD1. For natural gas furnaces purchased **without** the upstream rebate, please estimate the percent in each of the following categories. Your best estimate is fine.

1. the federal minimum of 80% to 84%
2. 85 to 89%
3. 90% to 94%
4. 95% or above
5. Don't know
6. My company doesn't install natural gas furnaces

SD1a. [IF SD1= 5] For all natural gas furnaces purchased **without** the upstream rebate, would you say that the most common AFUE was ...

1. the federal minimum of 80% to 84%
2. 85 to 89%
3. 90% to 94%
4. 95% or above
5. Don't know

SD1c. [IF SD1<>6] For natural gas furnaces purchased **without** the upstream rebate, please estimate the percent with furnace fans in each of the following categories. Your best estimate is

fine.

1. Efficient BPM (brushless permanent magnet) fan motor, also called ECM or ICM
2. Standard PSC (permanent split capacitor) fan motor
3. Something else? _____
96. Don't know

SD1d. [IF SD1<>6 and SD1c= 3] For natural gas furnaces purchased **without** the upstream rebate, would you say that the most common type of furnace fan has a ...

1. Efficient BPM fan motor (also ECM or ICM)
2. Standard PSC fan motor
3. Something else? _____
96. Don't know

SD2. For natural gas boilers purchased **without** the upstream rebate, please estimate the percent in each of the following categories. Your best estimate is fine.

1. the federal minimum of 80% to 84%
2. 85 to 89%
3. 90% to 94%
4. 95% or above
96. Don't know
6. My company doesn't install natural gas boilers [SKIP TO THE NEXT SECTION]

SD2a. [IF SD2= 5] For all natural gas boilers purchased **without** the upstream rebate, would you say that the most common AFUE was ...

1. the federal minimum of 80% to 84%
2. 85 to 89%
3. 90% to 94%
4. 95% or above
5. Don't know

SD3a. [IF SD2= 6 SKIP TO NEXT SECTION] For boiler circulating pumps purchased **without** the upstream rebate, please estimate the percent in each of the following categories. Your best estimate is fine.

1. Constant speed pump
2. Multi-stage pump
3. Adjustable speed pump (eligible for rebate)
4. Adjustable speed (not eligible for rebate)
5. Don't know

SD3b. [IF SD3a= 5] For all boiler circulating pumps purchased **without** the upstream rebate, would you say that the most common type was...

- 1. Constant speed pump
- 2. Multi-stage pump
- 3. Adjustable speed pump (eligible for rebate)
- 4. Adjustable speed (not eligible for rebate)
- 5. Don't know

SD3c. What are the 3 most common horsepower (HP) sized circulator pumps sold without the upstream rebate?

[RECORD MOST COMMON 3]

- 1: _____
- 2: _____
- 3: _____

SD3d. What is the make and model of the 3 most common sizes [FROM SD3c]?

[RECORD MAKE & MODEL FOR EACH SIZE]

- 1: _____
- 2: _____
- 3: _____

The remainder of this survey will focus on high efficiency <EQUIPMENTx>.

KEY DECISION INFLUENCES

KD1. We are interested in why you sell high efficiency <EQUIPMENTx>. For each of the following statements, please state whether you strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree, or strongly agree.

- 1. Your customers request high efficiency <EQUIPMENTx>.
- 2. The incremental cost between standard efficiency and high efficiency <EQUIPMENTx> is low.
- 3. High efficiency equipment reduces negative impacts on the environment
- 4. Your customers are more satisfied with high efficiency <EQUIPMENTx> than standard units.
- 5. Your profit margin is higher for the high efficiency <EQUIPMENTx>
- 6. The reliability of the high efficiency <EQUIPMENTx> is better than the standard efficiency models.

PROGRAM INFLUENCE

PI1. Approximately what percentage of all <EQUIPMENTx> units you install in Connecticut are eligible for the upstream rebate?

[RECORD NUMERIC VALUE 0%-100%]

96. Don't know

PI2. If the upstream rebates were not available, what percentage of all <EQUIPMENTx> units you install in Connecticut would meet the current eligibility requirements for the upstream rebates? Your best estimate is fine.

[RECORD NUMERIC VALUE 0%-100%]

96. Don't know

PI3. What percent of the <EQUIPMENTx>s you sell are replacing units that have failed or are expected to fail very soon (within two weeks)?

RECORD PERCENT: _____

BARRIERS

B1. Thinking back to before the upstream rebates started in 2014, what were the major challenges to expanding the market share of high efficiency <EQUIPMENTx>? Please record whether you strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree, or strongly agree with the following statements. If the statement does not apply to you, mark N/A.

1. Many of your customers were not interested in high efficiency equipment.
2. The premium between the costs of the standard efficiency and high efficiency units was too high.
3. Your distributor(s) did not offer a wide range of high efficiency equipment that meets the current eligibility standard for the upstream rebates.
4. You had concerns about the quality of the equipment, reliability or finding parts.
5. Many of your customers were less satisfied with high efficiency <EQUIPMENTx>s than standard units.
6. The high efficiency equipment had features that your customers did not like (such as

high noise levels or long recovery).

7. Your profit margin was lower for high efficiency equipment.

[CATEGORIES FOR PAIRWISE QUESTIONS:]

FACTOR	WORDING	B2 RESPONSE
AVAILABILITY	Availability of high efficiency equipment	3
MARKET ACCEPTANCE	Customer acceptance	1,2,5,6
EQUIPMENT CONCERNS	Equipment concerns	4
NO CHALLENGES		

B2. [IF ONLY ONE FACTOR IS ≥ 4 , GO TO NEXT SECTION.] It sounds like you saw [INSERT NUMBER OF FACTORS] major challenges. Please rank these challenges in order of importance by dragging and dropping them into the column on the left.

Rank as many as apply, with the item at the top indicating the most important.

Please take a minute to consider your choices because the next set of questions will be based on your response

[DRAG AND DROP] [LIST IF SCORE IS ≥ 4]:

1. FACTOR1 _____
2. FACTOR2 _____
3. FACTOR3 _____

Do you agree? [MAKE ANY MODIFICATIONS AS NEEDED.] [IF FACTOR 1 IS “No Challenges” THEN SKIP TO THE NEXT SECTION] [IF FACTOR2 OR 3 is “No Challenges” THEN DROP THE FACTOR]

Still thinking back to 2013, we would like to understand more about the importance of these challenges in preventing you from promoting high efficiency equipment. In the next set of questions, we are asking you to compare these concerns two at a time.

[ASK B3 if there is a FACTOR 1 and FACTOR 2]

B3. Comparing FACTOR1 to FACTOR2, how would you rate the importance of FACTOR1? Was FACTOR1 ...

1. about the same as FACTOR2
2. slightly more important than FACTOR2
3. moderately more important than FACTOR2
4. strongly more important than FACTOR2
5. extremely more important than FACTOR2

- 6. FACTOR2 was more important

[ASK B3 if there is a FACTOR 1 and FACTOR 3]

B4. Comparing FACTOR1 to FACTOR3, how would you rate the importance of FACTOR1?
Was FACTOR1 ...

- 1. about the same as FACTOR3
- 2. slightly more important than FACTOR3
- 3. moderately more important than FACTOR3
- 4. strongly more important than FACTOR3
- 5. extremely more important than FACTOR3
- 6. FACTOR3 was more important

[ASK B3 if there is a FACTOR 3 and FACTOR 2]

B5. Comparing FACTOR2 to FACTOR3, how would you rate the importance of FACTOR2?
Was FACTOR2 ...

- 1. about the same as FACTOR3
- 2. slightly more important than FACTOR3
- 3. moderately more important than FACTOR3
- 4. strongly more important than FACTOR3
- 5. extremely more important than FACTOR3
- 6. FACTOR3 was more important

AVAILABILITY AND MARKET ACCEPTANCE

A1. Has the availability of high efficiency <EQUIPMENTx> models changed since 2013?
Please choose the statement that is the closest to your opinion.

- 1. Efficiencies are higher and there is greater selection of high efficiency models than there was in 2013.
- 2. The efficiencies are about the same but there is greater selection of models that meet the criteria for upstream rebates.
- 3. There are fewer high efficiency models currently available than there were in 2013.
- 4. The efficiency levels and selection of high efficiency equipment are about the same as they were in 2013.
- 5. Something else?_____

A1a. In your opinion, what factors affect the availability of high efficiency <EQUIPMENTx>s?

RECORD VERBATIM: _____

A2. [IF A1=1 or 2] Why do you think availability has improved? Please rate the following options.

[GRID SCALE]

1. Strongly disagree
2. Somewhat disagree
3. Neither agree or disagree
4. Somewhat agree
5. Strongly agree
6. N/A

[SUBSTATEMENTS]

A2a. General increase in awareness of environmental impacts among customers, distributors and manufacturers [NONPROGRAM]

A2b. Changes in fuel prices affects the demand for high efficiency equipment [NONPROGRAM]

A2c. Customers are more educated about high efficiency equipment [NONPROGRAM]

A2d. Upstream rebates reduce costs and create additional demand [PROGRAM]

A2e. More competition among manufacturers [NONPROGRAM]

[RECORD MAXIMUM SCORES]

PROGRAM _____

NONPROGRAM _____

[IF ONLY ONE OF PROGRAM AND NONPROG IS ≥ 4 , THEN SKIP TO NEXT SECTION.]

A3. We have separated [IF PROGRAM ≥ 4 :] upstream rebates from [IF NONPROG ≥ 4 :] other, nonprogram sources, and the next set of questions compares these types of influences.

[IF PROGRAM ≥ 4 :] Upstream rebates includes increased availability of HE equipment due to higher demand created by the upstream rebates.

[IF NONPROG ≥ 4 :] Other influences cover increased demand due to fuel prices,

general increase in awareness of environmental impacts, increased competition, etc.

Which of the following statements is the closest to your opinion? Choose one. Please take a minute to consider your choices because the next set of questions will be based on your response

1. The influence of the upstream rebates on the availability of high efficiency equipment is the only important factor.
2. The influence of the upstream rebates on the availability of high efficiency equipment is more important than nonprogram influences.
3. The nonprogram influences and the influence of the upstream rebates on the availability of high efficiency equipment are equally important.
4. Nonprogram influences on the availability of high efficiency equipment are more important than the upstream rebates.
5. Nonprogram influences on the availability of high efficiency equipment are the only important factor.

[IF A3=2 THEN FACTOR1='upstream rebates' AND FACTOR2 = 'nonprogram influences'; IF A3=4, THEN REVERSE FACTOR1 AND FACTOR2. CHECK FOR SUBJECT/VERB AGREEMENT.]

A4. [IF A3=2 OR 4] Comparing FACTOR1 to FACTOR2, how would you rate the importance of FACTOR1? Was FACTOR1 ...

1. about the same as FACTOR2
2. slightly more important than FACTOR2
3. moderately more important than FACTOR2
4. strongly more important than FACTOR2
5. extremely more important than FACTOR2

SELECTION OF EFFICIENT EQUIPMENT

Thinking back to before your participation in the Upstream HVAC and Water Heating Program and how you selected the equipment to install, we are interested in the factors that were important to your decision.

R1. How did you make recommendations to customers? Did you regularly offer...

1. At least one standard option that is not eligible for the upstream rebate
2. Only options that are eligible for the upstream rebate
3. Depends on the situation
4. Something else? _____

R2. [IF R1=1 OR 3 OR 4] Using the list below, please select the situations when you offered your

customers at least one standard efficiency option that was not eligible for upstream rebates. Choose as many as apply.

1. As a regular practice on all or most bids
2. On bids for customers who seem to be price sensitive
3. On bids for customers who are not interested in energy efficiency
4. On bids for customers where qualifying equipment would not be technically feasible to install
5. On bids for customers who explicitly request the lowest installed cost
6. Something else? _____

R3. Would you say that you are more likely to recommend high efficiency units because the upstream rebates are available?

1. Yes, you are much more likely to recommend high efficiency units
2. Yes, you are somewhat more likely to recommend high efficiency units
3. No, you are not more likely to recommend high efficiency units
4. No, you are somewhat less likely to recommend high efficiency units
5. No, you are much less likely to recommend high efficiency units
6. Something else? _____
96. Not sure

R4. [IF R3=1] How much influence do the upstream rebates have on your decision to recommend high efficiency <EQUIPMENTx>s more frequently? Were the upstream rebates...

1. Not at all influential
2. Slightly influential
3. Moderately influential
4. Strongly influential
5. Extremely influential
96. Don't know

R5. When talking to your customers, how do you refer to the Upstream HVAC and HW Program?

1. An instant discount from Energize CT
2. An instant discount from their utility
3. An instant rebate from Energize CT
4. An instant rebate from their utility
5. Something else? _____

R6. When do you typically first discuss the Upstream HVAC and Hot Water Program with your

customers?

1. When you are scoping the project with the customer
2. When you are scoping a project but only if your customer specifically asks for high energy efficiency options
3. When you are scoping a project but only if your customer specifically asks if there are any rebates available for [EQUIPMENTx]
4. When you present the bid to your customer
5. When you present the bill to your customer
6. Something else? _____

EQUIPMENT CONCERNS

EQ1. Do you have any of the following concerns about quality, reliability or customer satisfaction of the high efficiency equipment? Choose as many as apply.

1. More frequent call backs
2. Inadequate heat, cooling or hot water
3. Availability of replacement parts
4. Response time to reach setpoint is longer
5. Increased maintenance
6. Complexity of programming
7. Concerns about the performance of new technologies
8. Something else?_____

EQ2. [IF EQ1=1 AND/OR 5] Please explain the most common reasons for the [IF EQ1=1:] ‘call backs’ [IF EQ5=1:] and ‘increased maintenance’.

RECORD RESPONSE: _____

TRAINING

T1. When was the last time you attended a training offered by the utilities regarding the upstream rebates or technical aspects of the installation of efficient residential heating, cooling or water heating equipment?

1. Prior to 2014
2. 2014
3. 2015
4. 2016
5. 2017
6. You have never attended any trainings offered by the utilities
7. Don’t know

T2. [IF T1=1 OR 2 OR 3] Why did you stop attending the trainings?

1. They were not useful to you
2. You were not aware there were more trainings
3. The information was easier to obtain over the Internet or from other sources
4. The more recent training events repeated what you had learned in prior utility trainings
5. Something else? _____

T3. [IF T1=1-5] What did you learn from these trainings? (Choose all that apply.)

1. Rebate amounts
2. Eligibility requirements
3. Logistics about obtaining the rebates and the information you needed to provide
4. Program changes from the previous year
5. Technical details about installing efficient heating, cooling or water heating equipment
6. Something else? _____
7. Don't know

T4. [IF T3=5] You mentioned that you learned about technical details. What type of equipment did you learn about?

1. Condensing boilers
2. Air conditioners
3. Heat pumps
4. Heat pump water heaters
5. Condensing furnaces
6. Natural gas condensing water heaters
7. Something else? _____

T5. [IF T3=5] What was most useful about the technical training?

RECORD: _____

T6. Do you have any suggestions for training topics that would be useful to you?

RECORD: _____

SATISFACTION

SA1. Please rate your satisfaction with the following program elements.

[GRID SCALE]

- 1. VERY DISSATISFIED
- 2. SOMEWHAT DISSATISFIED
- 3. NEITHER SATISFIED NOR DISSATISFIED
- 4. SOMEWHAT SATISFIED
- 5. VERY SATISFIED

[SUBSTATEMENTS]

SA1a. The dollar amount of rebate for <EQUIPMENTx>

SA1b. [IF T1=1-5] The training received from the utilities

SA1c. The communication about the upstream rebates from the utilities

SA1e. The quality of information about the Upstream HVAC & Hot Water Program presented on Web site(s) provided by the utilities and/or Energize CT

SA1f. Your overall satisfaction with the Upstream HVAC & Hot Water Program

SA2. [IF ANY RESPONSES TO SA1 IS “VERY DISSATISFIED”, “SOMEWHAT DISSATISFIED”, “NEITHER SATISFIED NOR DISSATISFIED”] Why were you less than satisfied?

RECORD: _____

SA3. What is the most valuable aspect of the program from your perspective?

RECORD: _____

PROGRAM EXPERIENCE

PE1. How did you become aware of the upstream rebates offered by the Energize CT HVAC & Hot Water Program?

- 1. An Energize CT/utility email or newsletter
- 2. An Energize CT/utility sponsored annual program roll-out event
- 3. Another type of Energize CT/utility sponsored training event
- 4. A distributor from whom I buy equipment
- 5. A manufacturer training event
- 6. An industry trade show/conference
- 7. Word of mouth (a colleague, competitor)
- 8. Your customers asked about it
- 9. General advertising

10. Something else? _____

PE2. Have the upstream rebates supported you in selling more high efficiency equipment in any of the following ways? Choose as many as apply.

1. It provides a hook to open the conversation about high efficiency with the customer.
2. It reduces the price point of the high efficiency option and makes it more attractive to customers.
3. More customers ask about rebates and are more likely to ask about energy efficiency equipment.
4. No, the upstream rebates have not supported me selling more high efficiency equipment in any way.
5. Something else? _____

PE3. Please estimate the percent of upstream rebates that are paid by the distributor at the time of purchase.

RECORD PERCENTAGE: _____

END OF SURVEY

ES1. In closing, is there anything else you would like to tell Energize CT about your experiences with the Upstream HVAC & Hot Water Program (such as unexpected benefits or challenges)?

[RECORD OPEN END]

ES2. Do you have any recommendations for how to improve the Upstream HVAC & Hot Water Program?

[RECORD OPEN END]

ES3. Are you available for a conversation to discuss other installation-specific issues at a later date? This conversation would take less than half an hour and we are offering \$50 to compensate you for your time.

1. Yes
Available days and times: _____
2. No

That completes the survey. On behalf of Energize CT, thank you very much for your time and thoughtful answers today.

Detailed Distributor Interview

Overview

The evaluation team plans to conduct about 20 online surveys with participating distributors. We will attempt to contact all distributors who participated in the program. The distributor survey is designed to address four objectives:

- (1) Assess program influence (self report and barrier approach)
- (2) Investigate process issues
- (3) Estimate baseline equipment efficiency

Results from the distributor cognitive interviews were used to refine this detailed survey guide. Once the guide is final, the evaluation team will program the guide into Qualtrics, an online survey application.

Process-related process research questions addressed in this survey include:

- (1) How do distributors learn about the program? (MO1)
- (2) What motivates distributors to participate in the Upstream HVAC & Hot Water Program? (M1, M2)
- (3) What factors prevent distributors from stocking and selling more high efficiency equipment? (B1-B5)
- (4) To what extent has the program influenced distributors to stock and sell more high efficiency HVAC and hot water equipment? (S1-S9)
- (5) Are distributors satisfied with the program? (SA1-SA12)
- (6) How do distributors sell the program to their customers? (CO1)
- (7) How do distributors track data (PP1-PP4)
- (8) How do distributors experience program participation processes? (PP1-PP4)
- (9) To what extent have distributors participated in outreach and training events? (T1-T7)

Section		Number of Questions	Topic Summary
Introduction	Q	5	Finding the correct respondent
Marketing & Outreach	MO	1	How did the respondent learn about the program?
Motivations	M	2	Motivations for program participation
Baseline	SD	4 max	Determine baseline for furnaces, boilers and boiler circulating pumps
Barriers	B	5/3	What are the distributor's barriers to selling HE equipment?
Stocking/Sales	S	9	How has the program impacted the distributor's stocking/selling of HE?
Customer Outreach	CO	1	Distributor promotion of program eligible HE equipment
Training	T	6	Have distributors attended and learned from training events?
Program Process	PP	5	Distributors experience with tracking and processing rebates
Satisfaction	SA	11/8	How satisfied are distributors with the program?
Closing	C	2	Any additional comments about experiences with the program and recommendations for improvement
TOTAL		51 max/46 min	

Name	
Company	
Phone Number	
e-mail	
Address	
Equipment	Measure1: high efficiency furnace
	Measure2: high efficiency boiler
	Measure3: heat pump water heater
	Measure4: ECM boiler pump

INTRODUCTION AND FINDING CORRECT RESPONDENT

Intro: Welcome and thank you for participating in the Energize CT Upstream HVAC & Water Heating Survey. This survey will cover specifics about the **HVAC and hot water upstream rebates from Eversource, United Illuminating, Yankee Gas, Connecticut Natural Gas, and Southern Connecticut Gas.**

We need your feedback to determine how to improve the program! Please be sure that the person completing this survey is the person who makes the decision about the makes and models to offer to your customers.

Q1. Are you familiar with the Energize CT Upstream HVAC and Hot Water program?

1. Yes [SKIP TO Q3]
2. No
3. DK

Q2. Is there someone else at your company who might be familiar with the Energize CT Upstream HVAC and Hot Water program?

1. Yes, and their email is: [Email Field] [SKIP TO END]
2. No [CONTINUE]
3. DK [SKIP TO END]
- 4.

Q3. Which of the following roles do you play at your site? (Please select all that apply)

1. Individual sales
2. Equipment stocking
3. Other (Please specify)

[IF Q3=1 AND/OR Q3=2 SKIP TO Q5]

Q4. Is there someone else at your company who might be familiar with the program and who works in individual sales or equipment stocking?

1. Yes, and their email is: [Email Field] [SKIP TO END]
2. No [SKIP TO END]
3. DK [SKIP TO END]

Q5. There are a number of measure types that qualify for the Energize CT Upstream HVAC and Hot Water program. For the purpose of this survey, we define high efficiency as the specific models that are eligible to receive a rebate through the program. The table below outlines the current high efficiency standards.

Table 1: High Efficiency Standards (2016 Energize CT Rebate Summary Table)

Measure	Qualification Criteria
Boiler	ENERGY STAR 90% AFUE or Greater and AHRI Rated with boiler reset control
Natural Gas Furnace	ENERGY STAR 95% AFUE or greater and AHRI Rated with ECM air handler motor
Central AC	16 SEER and 13 EER ENERGY STAR and AHRI Rated
Boiler Circulator Pump	Approved models only: some Grundfos Alpha models, BumbleBee, some Wilo models, etc.
Heat Pump Water Heater	ENERGY STAR with COP of 2.0 or greater

I'm going to list the measures that we are examining through this research, please tell me if you sell the equipment:

1. High efficiency furnaces
2. High efficiency condensing boilers
3. ECM boiler pumps
4. Heat pump water heaters

[IF Q5=NONE SELECTED, SKIP TO END]

MARKETING & OUTREACH

MO1. Where did you first learn about the Energize CT Residential Upstream HVAC & Hot Water Program?

1. Colleague, friend, or family member
2. A trade industry newsletter
3. A trade industry event/trade show
4. Energize CT/utility email
5. Direct telephone/in-person conversation with a program representative
6. An Energize CT/utility-sponsored program roll-out event

- 7. Radio program or advertisement
- 8. Radio, TV, newspaper advertisement
- 9. Other (please specify)
- 10. DK

MOTIVATIONS

M1. Please rate each of the following items in terms of how important they were to your site’s decision to sell high-efficiency equipment using a scale from 1 to 5, where 1 means not at all important and 5 means very important.

- 1. Contractor demand for high efficiency equipment
- 2. End user demand for high efficiency equipment
- 3. Environmental or carbon footprint concerns
- 4. End user energy savings
- 5. Brand development
- 6. Expanding product lines from a manufacturer you already stock
- 7. Higher profits from high efficiency equipment
- 8. Availability of program rebates
- 9. Other (please specify)

M2. What initially motivated your site to participate in the Energize CT Residential Upstream HVAC and Hot Water program? (please select all that apply)

- 1. Contract(s) with manufacturer(s)
- 2. Increasing number of sales
- 3. Helping contractors sell high efficiency equipment
- 4. Increasing profits from sales
- 5. Reducing carbon footprint
- 6. Reducing use of electricity
- 7. Reducing use of natural gas, oil, or propane
- 8. Increasing availability of equipment from manufacturer(s)
- 9. Other (please specify)
- 10. DK

BASELINE

The next questions are about residential heating equipment.

SD1. [IF Q5=1] For natural gas furnaces purchased **without** the upstream rebate, please estimate your percent of sales in each of the following categories. Your best estimate is fine.

1. the federal minimum of 80% to 84%
2. 85 to 89%
3. 90% to 94%
4. 95% or above
5. Don't know

SD1a. [IF SD1= 5] For all natural gas furnaces purchased **without** the upstream rebate, would you say that the most common AFUE was ...

1. the federal minimum of 80% to 84%
2. 85 to 89%
3. 90% to 94%
4. 95% or above
5. Don't know

SD1c. [IF Q5=1] For natural gas furnaces purchased **without** the upstream rebate, please estimate the percent with furnace fans in each of the following categories. Your best estimate is fine.

1. Efficient BPM (brushless permanent magnet) fan motor, also called ECM or ICM
2. Standard PSC (permanent split capacitor) fan motor
3. Something else? _____
4. Don't know

SD1d. [IF SD1c= 3] For natural gas furnaces purchased **without** the upstream rebate, would you say that the most common type of furnace fan has a ...

1. Efficient BPM fan motor (also ECM or ICM)
2. Standard PSC fan motor
3. Something else? _____
4. Don't know
- 5.

SD2. [IF Q5=2] For natural gas boilers purchased without the upstream rebate, please estimate your percent of sales in each of the following categories. Your best estimate is fine.

1. the federal minimum of 80% to 84%
2. 85 to 89%

3. 90% to 94%
4. 95% or above
5. Don't know

SD2a. [IF SD2= 5] For all natural gas boilers purchased without the upstream rebate, would you say that the most common AFUE was ...

1. the federal minimum of 80% to 84%
2. 85 to 89%
3. 90% to 94%
4. 95% or above
5. Don't know

SD3a. [IF Q5=3] For boiler circulating pumps purchased without the upstream rebate, please estimate the percent in each of the following categories. Your best estimate is fine.

1. Constant speed pump
2. Multi-stage pump
3. Adjustable speed pump (eligible for rebate)
4. Adjustable speed (not eligible for rebate)
5. Don't know

SD3b. [IF SD3a= 5] For all boiler circulating pumps purchased without the upstream rebate, would you say that the most common type was...

1. Constant speed pump
2. Multi-stage pump
3. Adjustable speed pump (eligible for rebate)
4. Adjustable speed (not eligible for rebate)
5. Don't know

SD3c. [IF Q5=3] What is the size (hp), make and model of the 3 most common boiler circulating pumps?

[RECORD SIZE, MAKE & MODEL]

- 1: _____
- 2: _____
- 3: _____
96. Don't know

BARRIERS

B1. Thinking back to before the upstream rebates started in 2014, what were the major challenges to expanding your sales of high efficiency equipment? Please record whether you

strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree, or strongly agree with the following statements. If the statement does not apply to you, mark N/A.

[PROVIDE MATRIX RESPONSES FOR: FURNACES, BOILERS, HEAT PUMP WATER HEATERS, CIRCULATOR PUMPS]

1. Many of your customers were not interested in high efficiency equipment.
2. The premium between the costs of the standard efficiency and high efficiency units was too high.
3. Manufacturers did not offer a wide range of high efficiency equipment that meets the current eligibility standard for the upstream rebates.
4. You had concerns about the quality of the equipment, reliability, warrantee or obtaining parts.
5. Contractors expressed concerns about quality, call backs or reliability
6. Many of your customers were less satisfied with high efficiency units than standard units.
7. The high efficiency equipment had features that customers did not like (such as high noise levels or long cost recovery).
8. Your profit margin was lower for high efficiency equipment.
9. Fuel prices are a main driver of customer demand for high efficiency units.

[CATEGORIES FOR PAIRWISE QUESTIONS:]

FACTOR	WORDING	B2 RESPONSE
AVAILABILITY	Availability of high efficiency equipment from manufacturers	3
MARKET ACCEPTANCE	Customer acceptance	1,2,6, 7
EQUIPMENT CONCERNS	Equipment concerns	4, 5
NO CHALLENGES		

B2. [IF ONLY ONE FACTOR IS >=4, GO TO NEXT SECTION.] It sounds like you saw [INSERT NUMBER OF FACTORS] major challenges. Please rank these challenges in order of importance by dragging and dropping them into the column on the left.

Rank as many as apply, with the item at the top indicating the most important.

Please take a minute to consider your choices because the next set of questions will be based on your response

[DRAG AND DROP] [LIST IF SCORE IS >=4]:

1. FACTOR1 _____
2. FACTOR2_____
3. FACTOR3_____

Do you agree? [MAKE ANY MODIFICATIONS AS NEEDED.] [IF FACTOR 1 IS “No

Challenges” THEN SKIP TO THE NEXT SECTION] [IF FACTOR2 OR 3 is “No Challenges” THEN DROP THE “No Challenges” FROM THE LIST.]

Still thinking back to 2013, we would like to understand more about the importance of these challenges in preventing you from expanding your stock of high efficiency equipment. In the next set of questions, we are asking you to compare these concerns two at a time.

[ASK B3 if there is a FACTOR 1 and FACTOR 2]

B3. Comparing FACTOR1 to FACTOR2, how would you rate the importance of FACTOR1? Was FACTOR1 ...

- 1. about the same as FACTOR2
- 2. slightly more important than FACTOR2
- 3. moderately more important than FACTOR2
- 4. strongly more important than FACTOR2
- 5. extremely more important than FACTOR2
- 6. FACTOR2 was more important

[ASK B3 if there is a FACTOR 1 and FACTOR 3]

B4. Comparing FACTOR1 to FACTOR3, how would you rate the importance of FACTOR1? Was FACTOR1 ...

- 1. about the same as FACTOR3
- 2. slightly more important than FACTOR3
- 3. moderately more important than FACTOR3
- 4. strongly more important than FACTOR3
- 5. extremely more important than FACTOR3
- 6. FACTOR3 was more important

[ASK B3 if there is a FACTOR 3 and FACTOR 2]

B5. Comparing FACTOR2 to FACTOR3, how would you rate the importance of FACTOR2? Was FACTOR2 ...

- 1. about the same as FACTOR3
- 2. slightly more important than FACTOR3
- 3. moderately more important than FACTOR3
- 4. strongly more important than FACTOR3
- 5. extremely more important than FACTOR3
- 6. FACTOR3 was more important

STOCKING AND SALES

The next set of questions is about your stocking of high efficiency equipment that meets the efficiency standard for the upstream rebates. **“Stocking” refers to the total number of high efficiency units that you have available for purchase at any given time. [ROTATE THROUGH ALL EQUIPMENT SOLD.]**

S1. Approximately what percent of all <EQUIPMENTx> units you stock meets the eligibility requirement for the upstream rebate? Your best estimate is fine.

[RECORD NUMERIC VALUE 0%-100%]

96. Don't know

S2. Of all the eligible <EQUIPMENTx> units you sell to CT customers, what percentage of these do not receive a rebate through the upstream HVAC and Water Heating program?

[RECORD NUMERIC VALUE 0%-100%]

96. Don't know

S3. [IF S2 >5%] Under what circumstances does your site not pay the rebate for qualifying equipment?

[OPEN END]

S4. Without the upstream rebates, would your current stock of high efficiency <EQUIPMENTx>s be higher, lower or the same? (Stock refers to the total number of high efficiency units that you have available for purchase at any given time.)

1. A lot lower
2. Somewhat lower
3. A little lower
4. The same
5. A little higher
6. Somewhat higher
7. A lot higher
8. Don't know

S5. [IF S4 < 4] Without the upstream rebates, would you say that your current stock of high efficiency <EQUIPMENTx>s would be

1. 5% lower?
2. 10% lower?
3. 15% lower?
4. 20% lower?
5. 25% lower?
6. More than 25% lower?

7. Other (specify)
8. Don't know

S6. [Has the program had any influence on your decision to stock more program eligible equipment? Please give an answer on a scale from 0 to 10 where 0 means "no influence" and 10 means "a great deal of influence."]

[RECORD NUMERIC VALUE 0-10]

96. Don't know

S7. [IF S4<4 OR S6>5] Availability of high efficiency equipment is necessary for expanding market share. The next question is about how you decided to increase the number of high efficiency units you stock. We have divided the influences on your decision into two groups:

Upstream rebates: the rebates you receive from the utilities, including considering increased customer demand and/or competition from other distributors due to the upstream rebates.

Other influences: any other factors that were important to your decision making process, such as fuel prices, space constraints or equipment concerns.

Thinking only about what tipped your decision to increase the quantity of high efficiency <EQUIPMENTx>s you stock, which statement is closest to how you made your decision?
[Choose one]

Please take a minute to consider your choices because the next set of questions will be based on your response.

1. The upstream rebates were the only important factor that tipped you toward increasing the quantity of high efficiency <EQUIPMENTx>s you stock. [GO TO NEXT SECTION]
2. The upstream rebates were more important than other influences.
3. The upstream rebates and other influences were equally important. [GO TO NEXT SECTION]
4. Other influences were more important than the upstream rebates.
5. Other influences were the only important factor. [GO TO NEXT SECTION]
6. Don't know

[IF S7=2, THEN FACTOR1= "the upstream rebates" and FACTOR2= "other influences". IF S7=4, THEN FACTOR2= "the upstream rebates" and FACTOR1= "other influences".]

S8. [IF S7 <> DK] Comparing FACTOR1 to FACTOR2, how would you rate the importance of FACTOR1? Is FACTOR1 ...

1. about the same as FACTOR2
2. slightly more important than FACTOR2
3. moderately more important than FACTOR2

4. strongly more important than FACTOR2
5. extremely more important than FACTOR2
6. Don't know

S9. Approximately what percent of all <EQUIPMENTx> units you currently sell meet the eligibility requirements for the upstream rebate?

[RECORD NUMERIC VALUE 0%-100%]

CUSTOMER OUTREACH

CO1. How, if at all, does your site promote equipment that is eligible for the program? (Please select all that apply)

1. No special promotions for eligible equipment
2. Special sales
3. One-on-one conversations with contractors who express interest in the equipment
4. Provide literature about the equipment discounted by Energize CT (e.g., brochures)
5. Provide other literature about the equipment
6. Conduct in-store equipment demonstrations or trainings for contractors
7. Advertise in trade magazines or newsletters
8. Run booths or demonstrations at trade shows
9. Provide demonstrations and/or trainings led by Energize CT program staff (i.e., "Counter days")
10. Other (please specify)

TRAINING/OUTREACH EVENTS

T1. Have you attended any trainings or events offered by the utilities related to the upstream rebates or technical features of efficient residential heating, cooling, or water heating equipment?

1. Yes
2. No [SKIP TO T3]
3. DK [SKIP TO T7]

T2. When was the last time you attended a **utility-sponsored** training and/or event? (Your best guess is fine if you can't remember exactly)

1. Before 2014
2. 2014
3. 2015

4. 2016 [SKIP TO T4]
5. 2017 [SKIP TO T4]
6. DK

T3. [IF T2=1-3] Which of the following statements describe why you have not attended a **utility-sponsored** training or event recently? (Please select all that apply)

[IF T1=2] Which of the following statements describe why you have not attended a training or event? (Please select all that apply)

1. One or more of the trainings / events did not seem useful
2. I was not aware of more recent training or events
3. Someone else from my office attended them instead
4. I can get the information I need from other sources (e.g., the internet, colleagues)
5. The training topics or event themes covered information I already knew
6. Other (please specify)

T4. [IF T1=1] Thinking back to all the **utility-sponsored** trainings and events you have attended since 2014, which of the following topics were covered in these training and/or events? (Please select all that apply; your best guess is fine if you can't remember exactly)

1. Rebate amounts
2. Eligibility requirements
3. Logistics about obtaining the rebates and filling out rebate paperwork
4. Program changes
5. Technical details about eligible equipment
6. Other (please specify)

T5. [IF T4=5] You mentioned that you learned about technical details. What type of equipment did you learn about? (Please select all that apply; your best guess is fine if you can't remember exactly)

1. Condensing boilers
2. Air conditioners
3. Heat pumps
4. Heat pump water heaters
5. Condensing furnaces
6. Natural gas condensing water heaters
7. Other (please specify)

T6. [IF T4=5] What did you find most useful about the technical training(s)?
[RECORD]

T7. Do you have any suggestions for additional **utility-sponsored** training / event topics that would be useful to you? [RECORD]

PROGRAM PROCESSES

PP1. Did your site experience any concerns when enrolling as a distributor for the Energize CT Upstream HVAC and Hot Water program?

1. You had no concerns
2. You needed to address concerns with the MOU
3. You needed to address concerns with tracking rebate applications for the sold equipment
4. You needed to address concerns with the application of rebates to customer sales
5. Other (Please specify)
6. DK

PP2. [IF PP1=3] Please describe your specific concerns with tracking and/or processing rebate applications, as well as how you resolved these concerns?

RECORD: _____

PP2. When does your site typically apply the rebate to a qualifying sale?

1. Before you receive confirmation of a customer’s eligibility
2. After you receive confirmation of a customer’s eligibility
3. Other (Please specify)
4. DK

PP3. Do you track whether you receive rebates from the utilities for all sales made at the rebated amount?

1. Yes
2. No
3. DK

PP4. What type of data does your site collect to process rebates? [SELECT ALL THAT APPLY]

1. Full name of the residential customer where the equipment was installed
2. Address of where equipment will be installed
3. Contractor name
4. Contractor contact information (phone or email)
5. Utility account number
6. Utility territory
7. Equipment specifications
8. Other (please specify)
9. DK

SATISFACTION

Please rate your satisfaction with the following program elements using a scale from 1 to 5,

where 1 means very dissatisfied and 5 means very satisfied.

SA1. The dollar amount of the rebate for [Q5 RESPONSE] [REPEAT FOR ALL Q5 RESPONSES]

SA2. [IF T1=1] Utility training or events

SA3. The quality of information about the Energize CT Upstream HVAC and Hot Water program presented on the Energize CT website

SA4. The time it takes to receive the rebates from utilities

SA5. The communication about the Energize CT Upstream HVAC and Hot Water program from the utilities

SA6. The enrollment process to participate in the Energize CT Upstream HVAC and Hot Water program

SA7. The administrative processes for requesting and receiving rebates

SA8. [IF CO1=8] The quality of the information program staff presented to customers during “counter days” (events in which program staff visit your location to provide information to customers).

SA9. Your overall satisfaction with the Energize CT Upstream HVAC and Hot Water program

SA10. [If ANY RESPONSES TO S1-S10 < 4] You mentioned that you were not completely satisfied with at least one aspect of the program. Can you please briefly explain why you were less than satisfied? [RECORD]

SA11. In your opinion, what is the most valuable aspect of the program? [RECORD]

CLOSING

C1. Do you have any recommendations that might help us improve the program? [RECORD]

C2. Is there anything you would like to add about your experience with the program? [RECORD]

That completes the survey. On behalf of Energize CT, thank you very much for your time and thoughtful answers today.

Appendix B
Program Design Details

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1 Additional Description of the Program Design

The below bullets present reasons why the utilities developed the upstream approach:

- **Reduce rebate breakage** – By providing rebates at the distributor level, the utilities hope that fewer installations will occur without a rebate because customers will not need to complete and submit any paperwork. This upstream model, in essence, attempts to reach all sales within Connecticut so that all equipment sold receives the rebate.
- **Lack of program participation** – The utilities saw low program participation when the rebates were administered through the downstream model. To increase program participation, the utilities decided to offer rebates to distributors so that customers would not need to submit paperwork. The utilities also wanted to encourage energy efficient purchasing decisions when equipment fails and customers cannot wait to receive a rebate weeks later.
- **Increase market transformation** – By working with distributors, the utilities hope that the market will transform more quickly since distributors can reach the entire consumer market.
- **Increase stocking of high efficiency equipment at retailer/distributor locations** – By working with distributors, the utilities hope that the distributors and retailers will be more likely to stock high efficiency equipment since they have a better handle on how the rebate will impact the number of units sold.¹

Table 1 presents a summary of the upstream program design including the specific theoretical reasoning for offering the two types of rebate structures.

¹ 2015 Energize CT HVAC Programs Winnelson Dealers Meeting Slides, August 2015.

TABLE 1: PROGRAM DESIGN SUMMARY

Activities	Theoretical Reasoning	Outcomes
Offer point-of-sale rebates at distributor level	Immediately lowers customer first costs thereby increasing ability for customer to purchase equipment, especially when equipment fails. Engages distributors to stock/sell qualifying equipment because distributors are active program participants.	Short term: kWh and CCF installed within three years by residential HVAC & WH measures Long term: Market transformation of high efficiency HVAC and hot water residential equipment
Offer mixed retailer/mail-in rebate for measures sold at retail stores whereby it is difficult to collect installation data	Immediately lowers customer first costs thereby increasing ability for customer to purchase equipment, especially when equipment fails. Provides incentive for customers to provide installation details for utility tracking purposes.	

Source: The evaluation team independently developed this table based on feedback from program staff interviews and program documents.

While market transformation is the long-term goal of the program, the utilities have not performed a specific baseline market study to understand market transformation impacts. The utilities did identify general baseline information for three measure types from a 2013 report from Heating, Air-condition and Refrigeration Distributors International (HARDI):

- Boilers: 17% of boiler market is 90% AFUE or greater
- Furnace: 52% of the furnace market is 95% AFUE or greater
- ECM motor: 24% of the furnaces installed contain an ECM motor.²

In absence of having specific sales data for eligible measures, Program staff report that they will be looking at equipment costs as a proxy to market transformation. In other words, as high efficiency equipment become more mainstream, staff expect costs to decrease thereby lowering the need for the utilities to provide rebates for the equipment.³

² Data reported in the UI Final 2016 HVAC Marketing Plan.12.15.15, page 4.

³ Eversource Energy Residential Energy Efficiency Residential Heat Pump and Central Air Conditioning Energy Efficiency Rebates 2016 Implementation Manual, page 2.

1.1 Rebate Structure

Table 2 presents a list of all the upstream measures that the utilities provide rebates for through the HVAC & Hot Water (HVAC&WH) Program. For heat pump water heaters, the utilities provide a mixed rebate approach whereby a \$300 rebate is provided to retailers that sell equipment but do not collect all of the customer contact information. Customers are then eligible to mail in a rebate form to collect an additional \$100, in order for them to receive the entire rebate for the measure (\$400). Distributors or retailers can also qualify heat pump water heater sales for the \$400 rebate if they collect customer installation information at the point of sale.

TABLE 2: 2016 UPSTREAM HVAC&WH MEASURES AND REBATE METHOD

Measure ¹	2016 Criteria	Upstream Rebate	Mixed (upstream and mail in)
Natural gas boilers	ENERGY STAR 90% AFUE or Greater and AHRI Rated with boiler reset control	✓	
Boiler circulating pumps	Approved models only: some Grundfos Alpha models, BumbleBee, some Wilo models, etc.	✓	
Natural gas furnaces	ENERGY STAR 95% AFUE or greater and AHRI Rated with ECM air handler motor	✓	
Heat pump water heaters	ENERGY STAR with COP of 2.0 or greater	✓	✓

¹The HVAC&WH program also provides incentives for air source heat pumps, oil furnaces, propane furnaces, tankless water heaters, and condensing natural gas storage tanks; however, these measures are not included in this table as they were not part of the evaluation.

1.2 Additional Description of Marketing and Outreach Activities

Once distributors are engaged in the program, program staff (defined as utility staff and third party implementers) collaborate with manufacturers to promote eligible equipment, communicate with distributors and contractors about rebate offerings, perform general marketing efforts aimed at customers, and provide access to HPWH mail-in rebate forms:

- **Collaborate with manufacturers to promote eligible equipment** – Staff reach out to manufacturers to identify opportunities to collaborate on outreach efforts. Program staff will attend manufacturer-led trainings to promote the program and describe rebate levels and program processes. They will also reach out to manufactures to see if they can

provide any additional rebates to end users and/or contractors for purchasing program eligible equipment.⁴

- **Communicate with distributors and contractors on rebate offerings** – Staff conduct a variety of activities to inform distributors and contractors of rebate offerings, eligible equipment, and program updates. TABLE 5 presents a summary of outreach events to distributors and contractors in 2016. According to program records, the utilities hosted 13 counter days in 2015 and 31 counter days in 2016.⁵Counter days are events held at distributor stores whereby program staff educate market actors in the program and eligible equipment. The utilities also host an annual program update event for their stakeholders, where program staff can update distributors and contractors on the program. They also host training events to discuss equipment and sizing considerations.
- **Perform general marketing efforts aimed at customers** – Staff also work with their utility marketing teams to release general advertising about the rebates, including TV interviews, press releases, and radio ads.
- **Provide access to HPWH mail-in rebate forms** – Staff also work with distributors and utility website administrators to make sure residential customers have access to the mail-in rebate form for HPWH.

TABLE 3: HVAC&WH PROGRAM 2016 OUTREACH EVENTS TO DISTRIBUTORS AND CONTRACTORS

Type of Outreach Event	Number of Events
General outreach	25
Training: Boilers/ Circulator Pumps	5
Training: Ductless Heat Pumps	5
Training: Heat Pump Water Heaters	4
Training: Heat Pumps	1
Training: Water Heaters	1
Training: Furnaces	1
Total	42

Note: Outreach includes events at trade shows, trade ally events, utility-wide market actor engagement events. Trainings typically focused on installation and were more typically geared to installers. Prior years were not available.

Source: Email from United Illuminating staff to the evaluation team.

⁴ In 2014-2016, the evaluation team found only one reference to program staff working with a manufacturer to specifically promote program eligible equipment.

⁵ The utilities did not provide data on 2014 counter days.

1.3 Overseeing Rebate Processing

As previously described there are two different types of rebates provided through the upstream HVAC&WH Program. The program employs Energy Federation Incorporated (EFI) as the rebate fulfillment vendor to process both the upstream rebates. EFI is responsible for checking all data to ensure that the equipment is eligible, the equipment was installed within the Eversource and UI territory, and, if necessary, that the equipment was installed by a qualified contractor. The distributor sends a monthly report to EFI containing the installations that have happened.⁶ The utilities, then, reimburse EFI for the rebate costs. Program staff enter all program data into their tracking systems, so they can generate internal monthly reports that report rebate spending and savings.

Figure 1 depicts the program processes at a high-level by showing rebate processes for the upstream rebates. Distributors must adhere to the following guidelines:

- Always pass the rebate value through to the final project cost. The rebate must be a line item on the customer invoice that clearly shows that the line item is an Energize CT Utility Instant Discount.⁷
- Only equipment listed on the Qualified Products list will be rebated; however, distributors may request utilities to add new models to the approved list.
- Accurately collect and report residential end-user name and installation address⁸
- Natural gas equipment can only be rebated if it is sold in towns that lie within a participating natural gas territory.
- No equipment can be rebated if the customer lives in Norwich, as Norwich has their own utility.
- No commercial locations are eligible.
- Equipment installed at a new construction site may be allowed for a rebate with utility approval first; otherwise, distributors /contractors should seek a rebate through the new construction program.
- If a project includes five or more units, the utility must first approve the project.⁹

For heat pump water heaters, where a partial upstream rebate is provided, the rebate fulfillment vendor must match customer and retailer rebate applications in order for the customer to qualify for the additional customer rebate.

The utilities also recognize that some contractors may want to buy equipment in bulk in order to quickly install equipment at customers' homes. To accommodate this, the program reports

⁶ Distributors are required to submit reports monthly to the rebate fulfillment vendor, but are allowed to submit them bi-weekly if they desire.

⁷ Because distributors do not have control over this requirement, the evaluation team asked contractors about whether they communicate rebates to their customers.

⁸ For heat pump water heaters, the utilities did not require distributors to submit installation addresses in 2014 and 2015. Starting in 2016, utilities required all distributors to provide addresses and created the mixed incentive structure for retailers selling heat pump water heaters.

⁹ 2015 Energize CT HVAC Programs- Winnelson Dealers Meeting August 2015.

that contractors can purchase equipment in bulk at full price, and then distributors can provide contractors with a discount once the equipment is installed at a customer site and contractors provide the customer name and address to the distributor.¹⁰

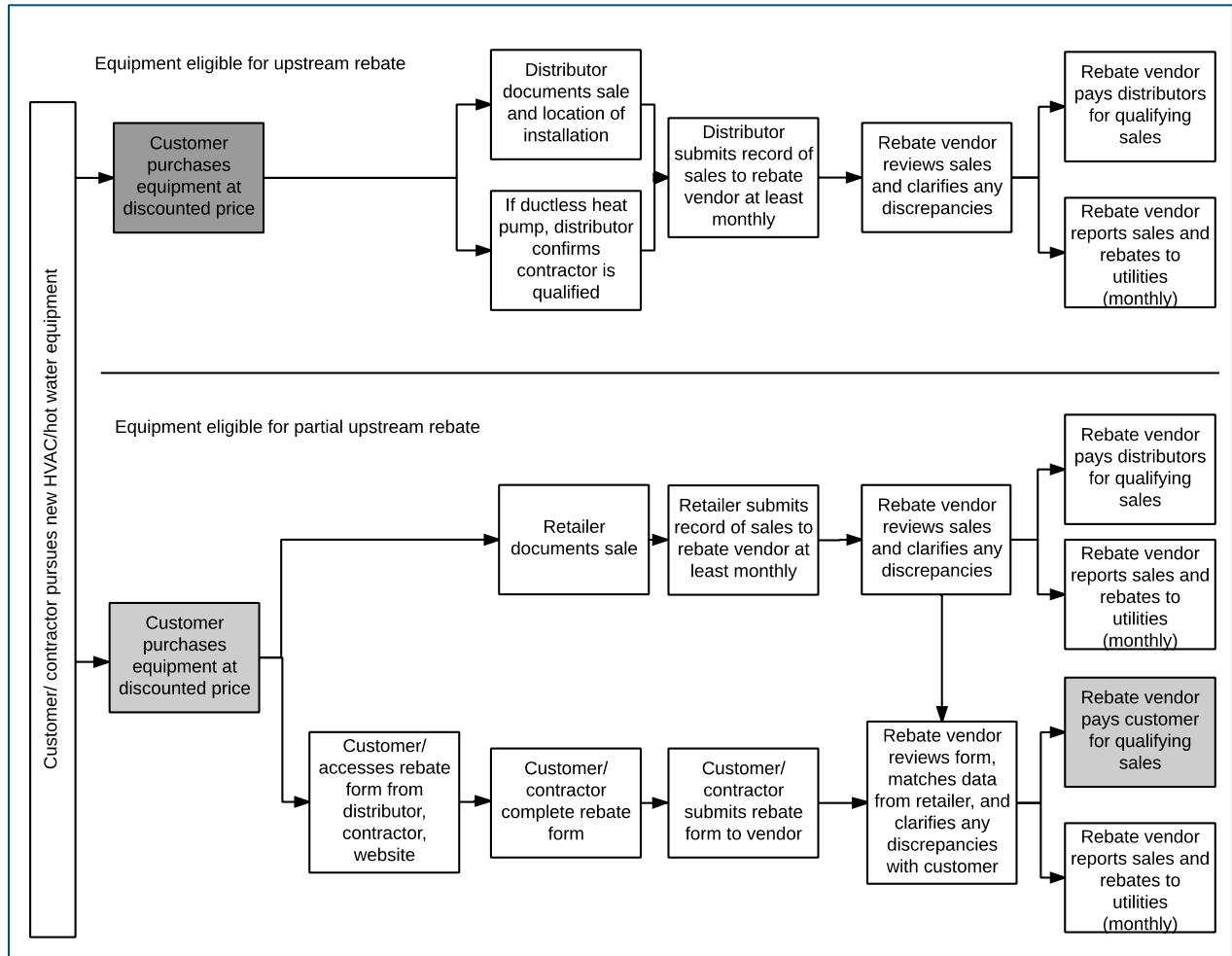


FIGURE 1: OVERVIEW OF UPSTREAM HVAC&WH PROGRAM PROCESSES

Source: The evaluation team independently developed this figure based on feedback from program staff interviews and program documents.

¹⁰ Ibid.

Appendix C

Impact Method Details

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1 Furnaces

This section includes the PDS calculations, billing analysis methods, attrition, baseline efficiency and calculating the savings.

PSD Calculations

The savings calculation used in the 2015 PSD for furnaces is shown here:

$$ABTU_H = A \times HF \times \left(\frac{1}{AFUE_B} - \frac{1}{AFUE_I} \right)$$

The inputs are explained in the table below.

TABLE 1: PSD INPUTS

Input	Description	Source
A	Heated area of home	Default of 2,000 sqft
HF	Heating Factor based on age of home	Default of 33,000 Btu/sqft/yr
AFUE _B	AFUE of baseline heating system	0.80 (federal minimum)
AFUE _I	AFUE of installed heating system	Program reported efficiency

Billing Analysis Method

A billing analysis was completed for both the natural gas furnaces and boilers using the same methods for both measures. The analysis was done with a house-by-house regression using monthly natural gas bills and temperature. Before starting the analysis the billing data was reviewed and any homes with insufficient data or with usage was removed from the sample.

Seven NOAA weather stations airports throughout Connecticut were used as the source for hourly outside temperature data for the regression as well as the normalization. Each home was matched to the closest weather station based on zip code. The heating degree days (HDD) were calculated using the temperature data and matched for each billing period from the gas data.

Two regressions were run, one with an intercept and one without an intercept. This intercept is used to represent non-temperature-dependent use, such as domestic hot water. The intercept or no intercept model was selected for each home based on the regression with the higher R². Homes with an R² lower than 0.7 for the selected model were excluded from the final analysis.

The actual consumption for the homes with an R² between 0.6 and 0.9 were reviewed to see if there were differences in consumption that would indicate those homes had secondary heat. The annual consumption and full load hours were consistent across the range of R², suggesting that few, if any, homes had secondary heat.

The normalized consumption and full load hours were calculated using a 5 year average of the heating degree days (HDD).

TABLE 2: SUMMARY OF ANALYSIS

Key Component	Description	Comment
Data Cleaning	Removed homes without sufficient data	
Regression Level	House-by-house	Determine heating slope (MMBtu/HDD); removed a few homes with $R^2 < 0.70$
Period	Post installation only	Lost opportunity measures – post installation reflects actual operating conditions
Variables	Weather, gas consumption, heating system capacity	Hourly weather data, monthly gas data
Intercept	Run twice, with and without an intercept	Selected the model with the best fit for each home
Normalization	Average HDD from last 5 years	Accounts for recent changes in weather

Attrition

The first step of this billing analysis was to check the data for each site to ensure there was enough usable post installation data for the analysis. A summary of the attrition is outlined in Table 1 below. The minimum amount of data was 12 months, to ensure an accurate modeling of both heating and any non-heating (primarily hot water) natural gas use.

The main reasons for attrition are explained below:

- Of the homes with data, only slightly over 60% had over a year of data. This was largely due to recently completed installations, which limited the possible post installation data.
- Equipment size information was not available in the program tracking database for some home, which prevented calculating the full load hours. This was primarily an issue for UI, as we were unable to match the equipment information with the program data for many customers.
- Less than 100 boilers and furnaces with very low heating use (<30 MMBtu/yr) or very high heating use (>400 MMBtu/yr) were removed as the use indicated something was unusual about the home, and the usage may not be due to heating.

There were several other reasons for removal including accounts where the home owner moved, accounts with duplicate measures, and accounts where a good fit could not be calculated.

TABLE 3: ATTRITION IN THE FURNACE BILLING MODEL

	Number of Furnaces	% Remaining in Model
Total Requested	5,196	
Total Received	1,905	100%
Accounts with 12 months post installation data	1,218	64%
Removed for other reasons	230	12%
Accounts in final model	988	52%

Baseline Efficiency

The baseline efficiency was based on contractor and distributor interviews. The wording of the question is as follows:

*For natural gas furnaces purchased **without** the upstream rebate, please estimate the percent in each of the following categories. Your best estimate is fine.*

1. the federal minimum of 80% to 84%
2. 85 to 89%
3. 90% to 94%
4. 95% or above
5. Don't know
6. My company doesn't install (or sell) natural gas boilers [GO TO NEXT SECTION]

If the respondent was unable to answer the question, we followed up with a alternative approach, asking them to identify the most common AFUE.

The responses were reviewed for internal consistency and adjustments were made when respondents did not seem to interpret the questions correctly. This analysis resulted in a percent of unrebated sales or installations in each category. As mentioned above, program eligible units were removed to avoid double counting net effects.

These results were weighted by the number of rebates associated with the respondents and the baseline efficiency was determined by calculating the weighted average in each multiplied by the midpoint of the efficiency range within each bin.

Calculating the Savings

The savings were calculated using the following equations:

$$\text{Energy Savings} = \text{Annual Load} \times \left(\frac{1}{\eta_{\text{baseline}}} - \frac{1}{\eta_{\text{efficient}}} \right)$$

The annual load came from the billing analysis, the baseline efficiency from the contractor and distributor surveys, the efficiency of the new boiler from the average rated efficiency for the

utility adjusted by the results of the metering

2 Boilers

The subsections cover the PDS calculations, billing analysis methods, attrition, baseline, meter data analysis, metered efficiency, efficiency and calculating the savings.

PSD Calculation Details

The savings calculation used in the PSD for boilers is shown here:

$$ABTU_H = A \times HF \times \left(\frac{1}{AFUE_B} - \frac{1}{AFUE_I} \right)$$

For boilers that also supply hot water an additional savings amount is added equal to:

$$ABTU_W = ADHW \times \left(\frac{1}{AFUE_B} - \frac{1}{AFUE_I} \right)$$

TABLE 4: INPUTS INTO PSD CALCULATION OF BOILER SAVINGS

Input	Description	Default Value
A	Heated area of home	2,000 sqft
HF	Heating Factor based on age of home	33,000 Btu/sqft/yr
AFUE _B	AFUE of baseline heating system	0.82 (federal minimum)
AFUE _I	AFUE of installed heating system	Average of reported
ADHW	Annual domestic hot water load	11.2 MMBtu

The default annual DHW load was compared to the results from the heat pump water heater metering and found to be reasonable.

Billing Analysis Method

The billing analysis methods are described in Section 1.2 above. The same method was used for both furnaces and boilers.

Attrition in the Billing Models

The approach to removing homes from the billing model was the same for boilers and furnaces, as described in Section 1.3. The specifics for boilers are presented in Table 6.

TABLE 5: SUMMARY OF ATTRITION IN THE BILLING MODELS

	Boiler	% Remaining
Total Requested	4,162	
Total Received	3,089	100%
Accounts with 12 months post installation data	1,949	63%
Removed for other reasons	263	8%
Accounts in final model	1,686	55%

Meter Data Analysis

The efficiency of the condensing boilers was determined by metering as it can vary based on whether the boiler is condensing or not, as well as other operating factors. The metering was conducted at 41 homes for a minimum of 3 weeks between January and March of 2017. After review of the metered data, 36 homes were used in the analysis. The boiler configuration at every site was unique. A standard metering approach was used and then adjusted as needed based on the specifics of the site.

The components of the metering are described below:

1. Spot metering of the efficiency (using a combustion tester) and flow (using a flow meter) for all combinations of zones calling for heat over a period of 3 to 5 minutes for each combination
2. Longer term metering (three to six weeks) of inlet and outlet water temperatures, flue temperature, on/off of primary circulator or burner
3. Recording of the gas meter at the beginning and end of the metering period

Data collection was conducted to allow for calculation of the efficiency using two methods: water temperatures and flue temperature. The first method (water temperature) was used in the recent Massachusetts study.¹ Both methods are described below, followed by a discussion of the reliability and a brief description of the weather normalization

¹ "High Efficiency Heating Equipment Impact Evaluation Final Report," prepared for the Electric and Gas Program Administrators of Massachusetts by The Cadmus Group, et. al. March, 2015

2.4.1 Water Temperature Efficiency Calculations

The inputs into the water temperature calculations are summarized in Table 7.

TABLE 6: WATER TEMPERATURE METHOD INPUTS

Input	Symbol	Source/Purpose	Comments
Supply and return water temperature	ΔT_{water}	Direct measurement; calculated from metered inlet and outlet water temperatures	Measurement error was high
Circulator pump flow rate	$m = \text{flow rate} \times \text{run time}$	Direct spot measurement of pump kW and flow at each zone and combination of zones calling for heat, match to ΔT_{water} ; correlate ΔT_{water} to pump flow to determine run time; use to calculate flow (gallons)	Difficult to assess measurement error
Circulator pump run time		Direct on/off measurement of pump run time; use to inform analysis	
Rated Input Btu	$BtuInput_{rated}$	Manufacturer's specs (Btu/hour)	
Flue temperature		Used to determine burner on time	
Burner on time	$OnTime_{burner}$	Time the burner is on based on the metered flue temperature (minutes)	
Specific heat of water	C_p	Energy (Btu) required to heat 1 lbm of water by 1°F	
Mass of Water	8.33 lbm/gal	Conversion factor	

The equation used for the efficiency calculation is as follows:

$$\eta = \frac{\Delta T_{water} \times m \times C_p \times 8.33}{BtuInput_{rated} \times \left(OnTime_{burner} / \left(\frac{60min}{hour} \right) \right)}$$

2.4.2 Flue Temperature Efficiency Calculations

The inputs to the flue temperature calculations are summarized in Table 8.

TABLE 7: FLUE TEMPERATURE INPUTS

Input	Symbol	Source/Purpose
Rated Input Btu	$BtuInput_{rated}$	Manufacturer's specs (Btu/hour)
Flue temperature	$OnTime_{burner}$	Used to determine burner on time and measure stack losses
Burner on time		Time the burner is on based on the metered flue temperature (minutes)
$Losses_{flue}$	$Losses_{flue}$	From combustion test and the equation included below to adjust for different flue temperatures
Ambient Temperature	$T_{ambient}$	Direct measurement for duration of metering
Oxygen Concentration	O_2	% by volume, spot measurement with combustion test
Temperature change while boiler is on standby	$\Delta T_{standby}$	The change in temperature of the boiler water between when it stops running and restarts for the next cycle
Gallons	gallons	The total gallons held in the boiler

The equation used for this calculation is as follows:

$$\eta = \frac{BtuInput_{rated} \times \left(\frac{OnTime_{burner}}{60 \text{ min/hr}} \right) \times (100 - Losses_{flue}) - Losses_{standing}}{BtuInput_{rated} \times \left(\frac{OnTime_{burner}}{60 \text{ min/hr}} \right)}$$

The $Losses_{flue}$ are the flue losses in Btu and depend on the results of the initial combustion test and the flue temperature assuming the combustion gas mix remains constant.

$$Losses_{flue} = (T_{flue} - T_{ambient}) \left(\frac{A2}{21 - O_2} + B \right)$$

where the temperatures are in °C and $A2 = 0.66$ and $B = 0.010$ for natural gas²

The $Losses_{standing}$ are the standing losses in Btu.

$$Losses_{standing} = \Delta T_{standby} * gallons * C_p * 8.33$$

² Siegert Formula, used for calculating efficiency in several European countries.
<https://www.landinst.com/documents/652?1401977890>

The standing losses are generally a small fraction of the flue losses and can be ignored in most cases if lost heat would be warming a conditioned or partially conditioned space and would thus be contributing to heating the home.

The flue temperature data was combined with the spot measurements from the combustion tester to calculate the efficiency for each two minute interval.

2.4.3 Comparison of Water and Flue Temperature Methods

The water temperature method was found to produce highly variable results for a number of reasons as explained below:

1. The supply and return temperatures are an indirect measurement of the boiler water supply and return at the skin of the pipe, and measurement error can occur due to residual heat from the boiler, i.e., the temperature probes on the outside of the pipe may be measuring heat conducted from other sources rather than recording only the temperature of the water inside the pipe³
 - a. As the difference between the supply and return temperatures is often small (less than 10°F), the measurement error can have a substantial impact on the results
2. Flow reading, using an ultrasonic meter, can introduce measurement error in a number of situations that cannot be ascertained, such as
 - a. Non-laminar flow inside the pipe
 - b. Corrosion or pitting in older schedule 40 pipe
 - c. Sediment or contaminants inside any pipe
3. The configurations of the DHW loop are variable and can introduce additional error
4. It is difficult to account for all of the variability with modulating boilers and/or modulating circulating pumps with this method

The flue temperature methodology provided more consistent and robust results. The key reason is that the flue temperature is a direct measurement of the flue gas a major component of the efficiency losses in this type of system. In addition, systems that modulate showed the same flue temperature profiles during spot metering as during the long term metering.

2.4.4 Weather Normalization

To weather normalize, the efficiency and run time was averaged over 5 degree outside air temperature bins to account for temperature variation, and the average of six years of temperature data from the nearest National Oceanic and Atmospheric Administration (NOAA) weather station was used to normalize the results to an entire winter.

³³ The metering of the inlet and outlet temperatures for the heat pump water heaters showed similar measurement error. This metering was found to be inaccurate in many homes and evaluators developed alternative approaches for determining the inlet and outlet temperatures to estimate the COP.

Metered Efficiency Results

The metered efficiencies were found to be both higher and lower than the rated efficiencies. Rated efficiencies are determined under test conditions, and it is not surprising that boilers operate different when installed in homes. This analysis suggests that boilers with lower rated efficiencies are more likely to outperform the rating and boilers with higher efficiencies are more likely to underperform. A summary of the results is provided in the table below.

TABLE 8: SUMMARY OF METERED AND RATED BOILERS EFFICIENCIES

Rated Efficiency	Number of Homes	Metered Efficiency Lower	Metered Efficiency Higher	Average Adjustment
90.0% to 92.0%	5	1	4	-2.3%
92.1% to 94.0%	15	9	6	1.5
94.1% to 96.0%	14	14	0	3.5
96.1% to 98.0%	2	2	0	6.8

The rated and metered efficiencies for the 36 homes in the analysis are shown in the graph below.

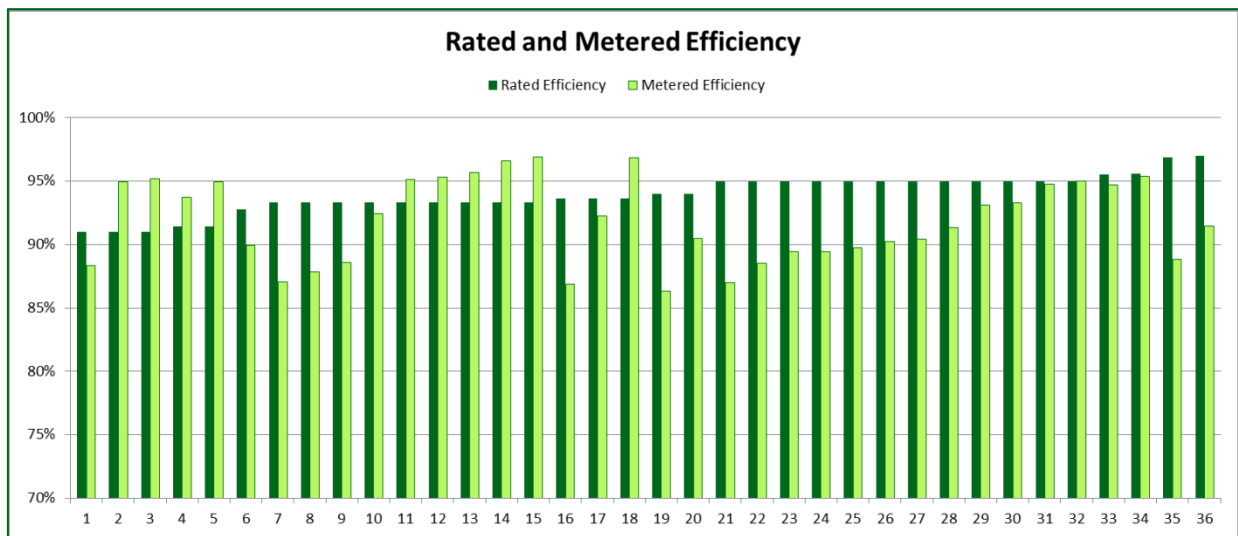


FIGURE 1: RATED V METERED EFFICIENCIES BY HOME

The percent of time that the units were condensing is related to the outside temperature: at lower outside temperatures, the boilers are less likely to be condensing. The efficiencies and full load hours were normalized using 6 years of NOAA data. However, the normalization relies on having the metering conducted over a range of temperatures. Since our metering period ranged from 3 to 8 weeks, an analysis of the weather patterns during our metering was conducted to assess the temperature ranges, as explained below.

- 32 of the 36 homes had metering conducted at temperatures of 15°F or lower, and most were at 10° or lower
- 32 homes had metering conducted over a range of 25° or more

These results suggest that most of the homes had metering over a substantial temperature range that would be sufficient for weather normalization. We also conducted a sensitivity analysis by removing homes with a limited range of temperatures and the results were virtually identical.

Baseline Efficiency

The baseline efficiency was based on contractor and distributor interviews. The wording of the question is as follows:

*For natural gas boilers purchased **without** the upstream rebate, please estimate the percent in each of the following categories. Your best estimate is fine.*

1. the federal minimum of 80% to 84%
2. 85 to 89%
3. 90% to 94%
4. 95% or above
5. Don't know
6. My company doesn't install (or sell) natural gas boilers [GO TO NEXT SECTION]

If the respondent was unable to answer the question, we followed up with a alternative approach, asking them to identify the most common AFUE.

The responses were reviewed for internal consistency and adjustments were made when respondents did not seem to interpret the questions correctly. This analysis resulted in a percent of unrebated sales or installations in each category. As mentioned above, program eligible units were removed to avoid double counting net effects.

These results were weighted by the number of rebates associated with the respondents and the baseline efficiency was determined by calculating the weighted average in each multiplied by the midpoint of the efficiency range within each bin.

Calculating the Savings

The savings were calculated using the following equations:

$$\text{Energy Savings} = \text{Annual Load} \times \left(\frac{1}{\eta_{\text{baseline}}} - \frac{1}{\eta_{\text{efficient}}} \right)$$

The annual load came from the billing analysis, the baseline efficiency from the contractor and distributor surveys, the efficiency of the new boiler from the average rated efficiency for the utility adjusted by the results of the metering.

3 Boiler Circulating Pumps

The baseline kW was determined from the contractor and distributor surveys. The survey questions for contractors and distributors are summarized in Table 10.

TABLE 9: BASELINE SURVEY QUESTIONS

	Purpose	Comments
Percent of non-rebated sales/installations in 4 categories	Determine types of pumps installed	Constant speed, multistage, eligible adjustable, non-eligible adjustable
List 3 most common pump sizes sold without rebate	Determine kW	
Make & model of 3 most common pump sizes	Determine kW	

Program-eligible, high efficiency units sold without rebates were excluded from the baseline as they reflect net effects. Non-eligible adjustable pumps were also removed as the average percent of installations and sales was small (about 5%) and estimating the baseline kW for these units is complicated.

The most common models were researched to determine the kW draw. The counts of the number of contractors and distributors who mentioned the model was used to weight the average kW draw. For the single speed pumps, the Taco 007 (86 W) and 007e (44 W) were the most common, giving an weighted average of 77 W. Several models of multi-stage pumps were mentioned, but the most common was the Grundfos 15-55/15-58, with three stages using from 63 to 86 W. For the multi-stage pumps, we assumed a simple average among the stages to estimate the baseline W. This approach resulted in the baseline estimate of 77 W.

The efficient kW was the average kW draw of all of the metered circulating pumps when they were in operation. This value was calculated to be 19 W.

4 Furnace Fans

This section covers the analysis method and attrition.

4.1 Analysis Method

The analysis was done with a house-by-house regression using 15 minute whole house electric data and temperature. Before starting the analysis, the electric usage data was reviewed and any homes with insufficient data or with very low usage was removed from the sample.

As with the furnace and boiler billing analysis, seven NOAA weather stations airports throughout Connecticut were used as the source for hourly outside temperature data for the regression as well as the normalization. Each home was matched to the closest weather station based on zip code. The hourly weather data was matched to the 15 minute electric data with the temperature assumed to be the same for each hourly period.

The regressions were run twice, one for the pre-installation period and one for the post installation period, using the temperature grouped into 5°F temperature bins and using night hours between 11 pm and 5 am from October to April. Night time hours were used to limit the noise from other end uses in homes. The post installation model was only run for the homes with a reliable regression in the pre-period.

The criteria to keep the pre-installation regressions were as follows:

- the model had an R^2 higher than 0.7
- the model showed a negative slope (usage increasing as temperature decreased)
- the model had a slope greater than -0.015, which corresponded to a max load of ~1 kW

The limit on the slope was to prevent homes with electric resistance heat or a heat pump from being included in the analysis. The limit was chosen as a furnace fan motor would have to be larger than 1 hp to draw over 1 kW, which would represent an unusually large motor for this application.

The analysis was normalized using the average number of hours in each temperature bin over the last 5 years.

TABLE 10: SUMMARY OF ANALYSIS

Key Component	Description	Comment
Data Cleaning	Removed homes without sufficient data	
Regression Level	House-by-house	Determine temperature dependant load
Period	Pre and post installation	Pre/post analysis based on assumption the pre-installation furnace fan was assumed to be a permanent split capacitor motor; baseline adjustment was made separately ¹
Variables	Temperature, electric consumption	Hourly weather data, 15 minute electric data
Intercept	Ran with an intercept	Represents non-temperature dependent related load
Normalization	Average temperatures from last 5 years	

The baseline adjustment is explained in the main body of the report in Section 4.5.

4.2 Attrition

The first step of this billing analysis was to check the data for each site to ensure there was enough usable post installation data for the analysis. A summary of the attrition is outlined in Table 1 below. Homes were removed from the analysis for the following reasons:

- Insufficient pre-installation data for the regression (over 20% of the homes)
- Regression results insufficient to determine temperature dependency due to the relative small load of furnace fans and potential for other complicating factors with whole house data (R^2 below 0.70)
- Insufficient post-installation data for the post regression, and the smaller load from the ECM fans likely reduced the number of homes with a reliable regression
- Unusually large temperature dependent loads that are likely electric resistance heat or heat pumps.

TABLE 11: ATTRITION IN THE BILLING MODEL

	Electric Data	% Remaining
Total Requested ¹	3000+	
Total Received	634	100%
Accounts with sufficient pre and post-installation data	455	72%
Accounts in final pre installation model	195	31%
Accounts in final post installation model	111	18%

¹A large number of the requested homes were not in the UI territory with AMI meters and had no AMI data.

Appendix D

Site Visit Protocols and Forms

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Boiler Metering Protocols and Forms

Project: CT Residential R1614/R1613
 Protocol for Boiler Metering and Site Visits
 West Hill Energy and Computing
 Draft December 22, 2016 ~ Final January 11, 2017

Boiler Analysis Methods

The purpose of the metering is to calculate the efficiency of the boiler. There are two different calculation methods that can be used and our goal is to calculate as many sites as possible using both methods. While on site, ensure that the meters installed are sufficient to calculate the efficiency using *both* of the following methods. Every site will be unique. The standard approach is described below. Adjustments may need to be made to address the on site specifics.

TABLE 1: METHOD 1 INPUTS

Input	Symbol	Source/Purpose
Inlet and outlet water temperature	ΔT_{water}	Direct measurement; calculated from metered inlet and outlet water temperatures
Circulator pump flow rate	$m = \text{flow rate} \times \text{run time}$	Direct spot measurement of pump kW and flow at each zone and combination of zones calling for heat, match to ΔT_{water} ; correlate ΔT_{water} to pump flow to determine run time; use to calculate flow (gallons)
Circulator pump run time		Direct on/off measurement of pump run time; use to inform analysis
Rated Input Btu	$BtuInput_{rated}$	Manufacturer's specs (Btu/hour)
Flue temperature		Used to determine burner on time
Burner on time	$OnTime_{burner}$	Time the burner is on based on the metered flue temperature (minutes)
Specific heat of water	C_p	Energy (Btu) required to heat 1 lbm of water by 1°F
Mass of Water	8.33 lbm/gal	Conversion factor; slight variations with temperature will be incorporated

The equation used for the efficiency calculation is as follows:

$$\eta = \frac{\Delta T_{water} \times m \times C_p \times 8.33}{BtuInput_{rated} \times \left(OnTime_{burner} / \left(\frac{60min}{hour} \right) \right)}$$

Integrated DHW with tank: This is a closed system as the boiler water runs through a heat exchanger and the DHW is on a separate loop. The flow meter will be used to determine the flow when there is a call for hot water and the inlet and outlet (before the mixing valve) temperatures will also be measured at the time of the spot measurement for flow and over the duration of the metering.

Integrated DHW directly off boiler: This is an open system as water is passed through the boiler to provide hot water to the home. Thus, there will be an increase in flow when boiler is calling for hot water and heat at the same time. The approach is to take a series of spot measurements to establish a correlation between the DHW water flow requirements and the hot water temperature just before the tempering valve. This will involve opening the faucets one at a time at specified intervals and measuring the temperature and flow.

TABLE 2: METHOD 2 INPUTS

Input	Symbol	Source/Purpose
Rated Input Btu	$BtuInput_{rated}$	Manufacturer's specs (Btu/hour)
Flue temperature	$OnTime_{burner}$	Used to determine burner on time
Burner on time		Time the burner is on based on the metered flue temperature (minutes)
Losses _{flue}	$Losses_{flue}$	From combustion test and the equation included below to adjust for different flue temperatures
Ambient Temperature	$T_{ambient}$	Direct measurement for duration of metering
Oxygen Concentration	O_2	% by volume, spot measurement with combustion test
Temperature change while boiler is on standby	$\Delta T_{standby}$	The change in temperature of the boiler water between when it stops running and restarts for the next cycle
Gallons	gallons	The total gallons held in the boiler

The equation used for this calculation is as follows:

$$\eta = \frac{BtuInput_{rated} \times \left(\frac{OnTime_{burner}}{60 \text{ min/hr}} \right) \times (100 - Losses_{flue}) - Losses_{standing}}{BtuInput_{rated} \times \left(\frac{OnTime_{burner}}{60 \text{ min/hr}} \right)}$$

Losses_{flue} – flue losses in Btu- depends on the results of the initial combustion test and the flue temperature assuming the combustion gas mix remains constant

$$Losses_{flue} = (T_{flue} - T_{ambient}) \left(\frac{A2}{21 - O_2} + B \right)^1$$

where the temperatures are in °C and A2 = 0.66 and B = 0.010 for natural gas

Losses_{standing} – standing losses in Btu

$$Losses_{standing} = \Delta T_{standby} * gallons * C_p * 8.33$$

The standing losses can be ignored in most cases if lost heat would be warming a conditioned or partially conditioned space and would thus be contributing to heating the home.

Additional Considerations

The two calculations can both be complicated by variable firing rate and variable speed circulator pumps:

- Different firing rates can be identified by different T_{outlet} or changes in the T_{flue} based on the different firing rates.
- Different circulator pump flow rates: install meter(s) on the circulator pump to record operating state rather than just on/off. Exact meter configuration will depend on pump type and configuration.

Checklist before Going to Site

1. Circulator Pump: One On/Off, Amp or Mag meter or one U12 with CT
 - a. If only one zone with a constant speed pump, no need to meter circulator pump
2. Temperature sensors: 5 total meters with probes to measure temperature:
 - a. Boiler Water Temperature: two U12 or one U13 temperature loggers with two temperature probes
 - b. DHW Temperature: Two U12 or one U13 temperature loggers with two temperature probes (may only need one U12 and one temperature probe)
 - c. Flue Temperature: One thermocouple temperature logger and probe
3. Condensate pump: One On/Off Amp or Mag meter or one U12 with temperature probe
4. Combustion tester
5. Flow meter
6. Fluke meter
7. Connector cable for Dent Amp/Mag logger

¹ Siegert Formula, used for calculating efficiency in several European countries.

<https://www.landinst.com/documents/652?1401977890>

8. Connector cable for Hobo U12/U13 logger
9. Pipe insulation for water temperature probes (multiple sizes)
10. Drill, flue buttons, foil tape for installing flue temperature probe
11. Thermal Grease
12. Badge
13. Laptop
14. First Aid Kit
15. Camera
16. Box and packing material with FEDEX RMA
17. Synchronize time on all meters
18. Insure that the homeowner is willing to pack meters in RMA box at the end of the metering period and call for pickup
19. Hand-out for customer on utility letterhead, detailing our work and what we expect after we leave, a blank to fill in for retrieval date, and contact info. Include website/ phone # to call if any questions or concerns.
20. Instructions for homeowner to remove and return meters with checklist for equipment to collect.

Procedure While On Site

Explain the site visit to the home owner, give them the customer hand-out and answer any questions they have.

1. Photograph and record boiler name plate on the table below
2. Record thermostat settings upon arrival. Label thermostat locations if multiple are used. Check that number of thermostats matches number from survey.
3. Turn off power to the boiler and install the on/off meters on the circulator pump(s) and condensate pumps.
4. Identify inlet and outlet pipes. Apply thermal grease, tape temperature probes to each and install six inches of foam insulation centered on the probe. Probes should be placed as close to where the pipe exits the tank as possible. Press button to create button event on the Hobo logger.
5. Install flow meter using the V method and following spacing guidelines in manual to ensure accurate results. Synchronize flow meter measurements to HOB0 pipe temperature measurements.
6. Turn boiler back on
7. Use combustion tester to measure the current efficiency of the boiler
8. Install thermocouple probe in the flue pipe.
9. Define the combinations of zones and flow rates. For each combination, repeat the following steps.
 - a. Take spot measurements of circulator pump kW or amps while boiler is running and at each zone configuration.
 - b. Take flow measurements for a 3 to 5 minute period while boiler is running.

- c. Record time started, time ended, spot measurements of circulator amps or kW in the Spot Measurements of Flow and Circulator Pump Draw table; flow meter will automatically record and save flow at specified intervals.
- 10. Remove flow meter.
- 11. If the customer was not watching for the installation of all meters, show them where they all are and how to remove all meters.
- 12. Set a date and time for removal in approximately 4 weeks and answer any questions the homeowner has on the meter removal. If homeowner is not willing to do the removal, schedule a time for the removal.
- 13. Complete the table below

Boiler Manufacturer and Model	
Thermostat setting and location	
Thermostat setting and location	
Thermostat setting and location	
Thermostat setting and location	
Thermostat setting and location	
Date/Time Meters Installed	
Amp/Mag Meter ID #s	
Amp/Mag Meter ID #s	
Meter ID inlet pipe	
Meter ID outlet pipe	
Meter ID flue temp	
Meter ID hot water outlet	
Meter ID hot water inlet	
Retrieval Date/Time	
Secondary heating system	

Spot Measurements of Flow and Circulator Pump Draw

Flow Test Setup and Zones	Test Time	Circulator Amps or kW	Flow (gal/min)

CT Residential R1614/R1613 Site Visit Checklist and Data Collection Sheet

Case ID	Site Visit Date
	Date:
	Time:
Site Contact Info	
Name:	Phone:
Address:	Email:

Table 1: General Information and Customer Feedback

Boiler Manufacturer and Model	
Installation Contractor	
Number of thermostats from survey	
Gas meter reading at deployment	
Gas meter reading at retrieval	
Secondary Heating System	System: Fuel Type:
Is there an outdoor temperature sensor?	
Is your home more comfortable with the new boiler?	
Are the operating costs of the new boiler lower than your previous heating system?	
Have you had any maintenance issues with the new boiler?	

Table 2: Thermostat Settings

	Location	Temperature Setting	Setback Days/Hours	Setback Temperature
Thermostat 1				
Thermostat 2				
Thermostat 3				
Thermostat 4				
Thermostat 5				
Thermostat 6				

CaseID: _____

Table 3: Meter Identification

Meters Installed	Date:	Time:
Amp/Mag Meter ID #s		
Amp/Mag Meter ID #s		
Amp/Mag Meter ID #s		
Amp/Mag Meter ID #s		
Meter ID inlet pipe		
Meter ID outlet pipe		
Meter ID flue temp		
Meter ID hot water outlet		
Meter ID hot water inlet		
Other		
Retrieval Date/Time Notes		

Boiler Pump Metering Protocols and Forms

Project: CT Residential R1614/R1613

Summary of Approach to On Sites for Boiler Circulating Pumps

West Hill Energy and Computing

April 12, 2017

The plan is to obtain metering for 40 boiler circulating pumps by leveraging the boiler metering combined with spot measurements of kW, and possibly some short term metering as needed, in additional homes with circulating pumps only. We plan to conduct short term spot measurements for an additional 32 pumps, with the potential for leaving temperature sensors in place for two weeks to confirm run time for specific configurations of circulating pumps serving multiple zones and using the auto-adapt feature.

The plan has two components:

1. Leverage the metering of the boilers
 - a. Eight (8) circulating pumps receiving the upstream rebate were metered as part of the boiler metering and we have sufficient information on site to estimate the BCP savings
 - b. Boiler metering will be used to determine annual run time for the BCP's, as on/off loggers or other meters were routinely placed on the boiler circulating pumps for estimating boiler savings
 - c. An additional 16 circulating pumps were installed in homes with boiler on site metering, but we were unable to determine the pump kW when on site for a variety of reasons; we plan to revisit some of these homes to measure the BCP kW using more effective methods (see discussion below)
2. Solicit approximately 15 additional homes with BCP's (to capture additional 32 pumps) for on site spot measurements and possibly short term metering if needed

We are currently scheduling the on sites and plan to conduct the additional measurements by the end of April.

The following sections describe the analysis methods and metering approach.

Boiler Circulating Pump Analysis Methods

The purpose of the metering is to determine the electric energy and demand savings of the boiler circulating pumps. The baseline pump(s) will be determined through the contractor and/or distributor surveys. The boiler circulating pumps eligible for upstream rebates are auto-adapting pumps, which operate as follows:

1. Single zone – for pumps providing circulation to a single zone, the pump will adapt to the most efficient operation for the flow and operate at a constant kW; this situation occurs when there is a single zone serving the entire home and also where a circulating pump is installed on only one zone in a multi-zone configuration.

2. Multiple zones – for pumps providing circulation to multiple zones, the pump will adjust in response to the combination of zones that are calling for heat to provide the most efficient operation for the required flow at the time; this occurs when a single circulating pump is used to serve multiple zones and a zone valves opens and closes in response to calls for heat from the thermostat controlling its zone.

Some of the eligible pumps also have a toggle that allows them to be operated at a constant pressure.

For the single zone pumps and pumps set to operate at a constant speed, the energy savings are calculated as follows:

$$kWh\ Saved = (kW_{base} - kW_{eff}) \times Annual\ Hours$$

where

kWh saved is the annual energy savings

kW_{base} is the kW of the baseline circulating pump

kW_{eff} is the kW of the efficient circulating pump

Annual hours is the weather-normalized annual hours of the pump

For the pumps serving multiple zones and are set to auto-adapt, the equation is slightly different:

$$kWh\ Saved = \left(kW_{base} - \sum_{i=1}^I kW_{eff} \times \frac{Hours_i}{\sum_{i=1}^I Hours_i} \right) \times Annual\ Hours$$

where

i is the index for the state

I is the total number of states

$Hours_i$ are the hours the pump is running in state i

“state” is one configuration of the zones, *e.g.*, if the pump serves two zones with zone valves, there are three states: 1) zone 1 only calling for heat, 2) zone 2 only calling for heat and 3) both zones calling for heat

Boiler Metering

As part of the metering of the boilers, we attempted to capture the following information at each site.

- Flow measurement for each state
- On/off metering of each circulating pump
- kW of the circulating pump when possible; either record from the meter or measure

with a plug-in meter for the few homes where this was possible

This metering will provide annual run hours for most of the 40 homes in the boiler sample.

There were 17 homes among the 40 in the boiler sample who also installed boiler circulating pumps, representing a total of 34 pumps.² Of these 17, we were able to obtain sufficient information to estimate the circulating pump savings at 7 homes (8 pumps). There are a number of reasons that we were not able to collect sufficient information at all sites. For some systems, there is not a direct meter insertion point; this occurs under a number of scenarios. Some examples are given below.

- The relay panels to the pump controls are often too small for a meter circuit transducer and do not provide power connections for the meter itself.
- Meters cannot be installed at the point where the wiring enters the pump due to small or non-existent connection boxes.
- There is a prevalence of armor coated wiring which prevents us from separating the “hot” wire from the neutral; this type of wiring is more prevalent in CT than we have found elsewhere.

In addition, pumps serving multiple zones in the auto-adapt mode require additional information to be able to estimate the number of hours run in each state.

Additional Boiler Circulating Pump Metering

The previous boiler metering allows us to estimate the savings by conducting short term measurements for the remaining 30 circulating pumps to determine the kW draw of the pumps. As we are moving into spring and the weather is getting warmer, this approach avoids costly longer term metering that may not yield useful results.

Based on our experience with the boilers, we expect to be unable to directly measure the kW of the pump(s) in some homes. Some models have a kW display screen, making it easy to record the kW. For pumps without a display screen, the alternative requires determining the kW of the pump by measuring the kW load of the entire boiler at different configurations of the zones calling for heat. We will also measure the operation of the other components (burner, exhaust fan and parasitic load) to back out the circulating pump kW. This approach requires an electrician on site to open the panel and install a Dent meter. The meter will provide highly granular data (1 second) for all heating system operating modes as measured during the site visit.

² On participant in the boiler on site survey, was identified as receiving 4 circulator pumps in the program data. Only 2 were found on site. The participant stated that 2 circulator pumps had failed and had to be replaced, which may explain the discrepancy.

CT Residential R1614/R1613 Site Visit Checklist and Data Collection Sheet

CaseID	Site Visit Date
	Date:
	Time:
Site Contact Info	Electrician Name (if applicable)
Name: Phone:	Name:
Address:	Phone:

General On-site procedures

- Explain the site visit and how the pump will be metered
- Give the customer the **handout and release forms** and answer questions the homeowner might have
- Photograph ALL BCPs**, mode settings, and meter locations and installations
- Set approximate date and time for retrieval of meters (if applicable)
- Tell the customer they will get the \$50 incentive after the metering has been completed. Allow 3-4 weeks for processing of Visa cards.

Table 1: General BCP Information

Quantity of BCP Claimed	[update before going on site]
BCP Manufacturer and Model	[insert program info]
Number of thermostats	[enter from screener]
Boiler Manufacturer and Model	
Have you had any issues with the pumps?	

Table 2: Non-Program (Baseline) Pumps

Pump Make & Model	HP	AMPs	Notes (Zones)

***Make sure to take pictures of ALL pumps**

CaseID: _____

Table 3: Thermostat Settings

	Location	Temperature Setting	Setback Days/Hours	Setback Temperature
Thermostat 1				
Thermostat 2				
Thermostat 3				
Thermostat 4				
Thermostat 5				

Table 4: Meter Identification

Meters Installed	Meter Model & Meter ID	Location Installed/ Screen Shot	Meters working correctly?	Time Installed
Dent				Parasitic Load Start: Stop:
CT/Mag Meter ID #s				
CT/Mag Meter ID #s				
CT/Mag Meter ID #s				
CT/Mag Meter ID #s				
CT/Mag Meter ID #s				
Hobo w/ temperature probe				
Hobo w/ temperature probe				
Hobo w/ temperature probe				
Hobo w/ temperature probe				
Hobo w/ temperature probe				
Other (Brand?)				
Retrieval Date/Time Notes				

Heat Pump Water Heater Metering Protocols and Forms

Project: CT Residential R1614/R1613

Protocol for HPWH Metering and Site Visits

West Hill Energy and Computing

November 9, 2016

Checklist before Going to Site

1. One Dent meter (with 3 CTs) and connector cable
2. Two U12 temperature loggers with temperature probes and connector cable
3. One ambient temperature/humidity logger
4. Pipe insulation for water temperature probes (multiple sizes)
5. Electrical tape
6. Badge (UI-utility safe badge, Eversource-WHEC badge)
7. Laptop
8. First Aid Kit
9. Box and packing material with FEDEX RMA
10. Review manufacturer installation specifications and program Dent for correct wiring.
11. Synchronize time on all three meters
12. Coordinate with homeowner and electrician. Insure that he/she is willing to pack Dent and other meters in RMA box at the end of the metering period and call for pickup.
13. **Customer Handout form and Release form**, detailing our work and what we expect after we leave with photo sent to Jenna (jennabr@westhillenergy.com) or text (#774-563-2035) identified, blank date to fill in for date to change mode, blank date to fill in for retrieval date, and contact info. Include phone # to call if any questions or concerns.
14. Instructions for electrician on retrieval visit with checklist for equipment to collect with place for us to write in meter ID#

Procedure While On Site

Explain the site visit and how the meter will be collected to the home owner, give them the customer hand-out and answer any questions they have.

1. Record location of HPWH and take a photograph (identify whether in conditioned or unconditioned space; specify basement, utility room, etc.)
2. Note and record area of room
3. Note and record other Heating/Cooling Equipment in the room
4. Record the HPWH mode setting found when you arrive (see table below).
5. Record temperature setting upon arrival
6. Photograph and record HPWH name plate and HPWH settings.
7. Have electrician install the Dent meter on the HPWH circuit for channel 1& 2. Attach the heating system CT to channel 3. Heating system and Channel 1 should be on the same leg. Only the electrician is allowed to work in live electrical panels.

8. Maintain a safe distance from the panel and follow the electrician’s direction while the panel is open and meter is being installed. Wear safety goggles!
9. Confirm meter is getting reasonable readings (positive, within the expected kW range) and metering is set to record at a 2 minute interval.
10. Photograph Dent installation when electrician has installed meter but not replaced panel cover.
11. Ensure the circuit box cover can close after installation.
12. Identify inlet and outlet pipes. Tape temperature probes to each and install six inches of foam insulation centered on the probe. Probes should be placed as close to where the pipe exits the tank as possible. Install foam installation over the probes. Press button to create button event on the Hobo logger. Photograph installation
13. Identify suitable location and install temperature/humidity meter in an unobtrusive location that is away from any heating, cooling or air flow influences (e.g. away from the air intake or exhaust of the HPWH and heating or cooling distribution or equipment). Photograph meter placement from near and far. Be sure electrician knows where this meter is located so he will be able to retrieve it.
14. Complete any remaining items in table below

Location of HPWH (conditioned or unconditioned space; specify basement, utility room, etc.)	
Other Heating/Cooling Equipment in the Room	
Measure Size of Room with HPWH (sq. ft.)	
HPWH Model	
HPWH Existing Mode (at beginning of site visit)	
HPWH Temperature setting (at beginning of site visit)	
Date/Time Meters Installed	
Dent Meter and CT ID #s	
Meter ID inlet pipe	
Meter ID outlet pipe	
Ambient meter ID and location	
Date to Switch HPWH to Electric Resistance Mode	
Retrieval Date/Time	

15. Arrange with homeowner to switch the HPWS to electric resistance mode after four weeks. Set date/time with the homeowner.
 - Have the homeowner demonstrate that they know how to switch modes.
 - Ask the homeowner to take a picture when they make the switch and send it to us (this is addressed on the on-site handout)

- We will send a reminder to the homeowner to switch modes (also reminding them what the original mode was).
16. Set a date and time for removal in approximately 6 weeks and let the homeowner know that the electrician will need to collect the meters and return them to us.

Procedure for Removal

Coordinate a removal date and time between the homeowner and electrician. Explain the packing and return procedure to the electrician. Provide electrician with list of steps for removal.

1. Button push on HOBO temperature sensors to generate button push event (signaling end of useable metering period)
2. Uninstall all meters and all accessories (including pipe insulation)
3. Pack in provided box and call FedEx to pick it up

CT Residential R1614/R1613 Site Visit Checklist and Data Collection Sheet

Evaluation ID	Site Visit Date
	Date:
	Time:
Site Contact Info	Electrician Name
Address:	Name:
Name:	Phone:
Phone:	Email:
Email:	

General On-site procedures

- Explain the site visit and how the meter will be collected from the homeowner
- Give the customer the **handout and release forms** and answer questions the homeowner might have
- Photograph the HPWH nameplate, mode settings, dent and hobo meter locations and installations [Photograph meter placement from near and far to ensure easy identification for retrieval].
- Set a date and time as well as procedures for retrieval with the homeowner and the electrician
- Tell the customer they will get the \$50 incentive after the metering has been completed and they fill out the detailed survey and. Get information on how they want to take the survey [The date when the survey will be available will be on the customer handout].

HPWH On-site Information

Model Number	Existing mode (at beginning of site visit)	Temperature setting mode (at beginning of site visit)	Photos of Nameplates?	Photos of HPWH settings?

Location of HPWH (specify basement heated/unheated, utility room, etc.)	
Is the space where HPWH is located actively heated?	
Is the space where HPWH is located actively cooled?	
Is the space where HPWH is located its own zone?	

Is other heating/cooling equipment in the room where HPWH is located	
Size of the room with HPWH (sq. ft.)	
Temperature setting of HPWH	
Tempering valve present and setting	Y N
What was their previous water heating system?	
Primary heating system fuel type and model	
Any secondary heating systems? Type/Location?	

Any other notes:

Evaluation Id: _____

Meter Information and Location

Meter Type	Specific Meter Model	Meter ID	Meters working correctly?	Photos of Meters/ Screen Shot	Time Installed
Dent					
Hobo inlet pipe temperature			NA		
Hobo outlet pipe temperature			NA		
Hobo ambient temperature			NA		

Evaluation ID: _____

Additional Site Visit Checklist

Task	Notes/Response	Task Completed?
Arrange with homeowner to switch the HPWH to electric resistance mode after three weeks. Set date/time with the homeowner. We will send a reminder to the homeowner to change mode (also reminding them what the original mode was). Determine how they would like to receive the reminder.	Date to Switch HPWH to Electric Resistance Mode: _____ Time: _____ Reminder Method: Phone: _____ Text: _____ Email: _____	
Have the homeowner demonstrate that they know how to switch modes.		
Ask the homeowner to take a picture when they make the switch and send it to us. [detailed on handout]		
Set a date and time for removal (approximately 6 weeks from install date) and let the homeowner know that the electrician will need to collect the meters and return them to us.	Retrieval Date: _____ Time: _____	
Tell the customer they will get the \$50 incentive after filling out the detailed survey and get information on how they want to take the survey	Detailed Survey Online _____ Phone _____	

Procedure for Removal

Explain the packing and return procedure to the electrician. Provide electrician with list of steps for removal.

4. Button push on HOB0 temperature sensors to generate button push event (signaling end of useable metering period)
5. Uninstall all meters and all accessories (including pipe insulation)
6. Pack in provided box and call FedEx to pick it up

Customer Forms

Customer Handout

Home Visit Summary

Date to Change to Electric Resistance mode: ___/___/___

Date Electrician will be back to pick up meter: ___/___/___

Heat Pump Water Heater Original Mode: _____

West Hill Energy has a contract with Eversource and United Illuminating to assess energy savings from efficient heating equipment discounted through the Residential HVAC and Water Heating Program. Thank you for participating in our study to learn about the energy efficiency of your heat pump water heater!

After this site visit, please follow these instructions:

1. On (/ /), change your heat pump water heater to **electric resistance** mode and **take a photograph** of the control panel. Please be sure the photo clearly shows the selected mode. A reminder will be sent to you when it is time to change the mode on your heat pump water heater. **Note: changing the mode of the heat pump water heater may increase your electric bill. Please review and sign the separate release form.**
2. Email or text the photo to the contact below:
 - Email: jennabr@westhillenergy.com
 - Phone number: +1-774-563-2035
3. The meters installed on the equipment will be retrieved by the electrician on (/ /).
4. A **\$50 gift card will be mailed to you after you complete a more detailed survey and the metering has been completed.** This survey will be available on approximately December 15, 2016. What is your preferred method for completing the survey?
 - Online via Web
 - Phone _____

If you have any questions, please feel free to contact West Hill Energy at 1-802-246-1212.

Thank you for your cooperation with this important study!

Customer Release Form

GENERAL RELEASE

West Hill Energy has a contract with Eversource and United Illuminating to assess energy savings from efficient heating equipment discounted through the Residential HVAC and Water Heating Program. As part of this study, West Hill Energy is metering residential heat pump water heaters installed in both Eversource and United Illuminating's Connecticut territory.

By participating in this site visit, I, _____ (print name), agrees to perform the following tasks:

1. Change the mode of my heat pump water heater to **electric resistance mode** on: _____
2. Take a picture of my heat pump water heater **after I change the mode**
3. Send the picture to Jenna Bagnall-Reilly, West Hill Energy. **Please be sure the picture shows the mode switch.**
4. Allow the electrician back in my home to remove the meters on: _____

Email or text the picture to the contact below:

- Email: jennabr@westhillenergy.com
- Phone number: +1-774-563-2035

I understand that my heat pump will run in electric resistance mode for about two weeks and this change may increase my electric bill. West Hill estimates bill increases may range from \$5 to \$10 for homes with average hot water use. To offset this cost and any inconvenience, I will receive a **\$50 gift card in the mail after I complete a more detailed survey and the metering has been completed at my home.** Other than the change in mode, the metering will not affect the operation of the heat pump water heater in any way.

Printed Name: _____

Signature: _____

Date: _____

Should you have any questions, please feel free to contact West Hill Energy at 1-802-246-1212.

Appendix E

Barriers Approach: Paper Presented at the International Energy Policy and Programme Evaluation Conference, Amsterdam, 2016

Breaking Down Barriers: An Alternative Method to Measure Program Influence

Kathryn Parlin, West Hill Energy and Computing, Brattleboro, VT

Jennifer Fagan, Itron, Madison, WI

Rumbi Vushe, West Hill Energy and Computing, Brattleboro, VT

Abstract

Energy efficiency interventions occur amid a backdrop of many influences on the market. In the absence of the interventions, it is likely that some improvement in energy efficiency would occur. Interventions are often intended to accelerate the process or smooth the introduction of new efficient technologies. However, separating intervention effects from other external market effects is challenging.

This paper proposes an innovative approach using the Analytic Hierarchy Process (AHP) to assess the influence of efficiency interventions and address validity issues associated with previous methods. AHP was developed to facilitate complex decision making and provides structure to quantify the decision making process.

The Barriers Approach leverages the versatility of AHP to sharpen our ability to estimate the actual impacts of efficiency interventions. This new approach is based on assessing the relative importance of barriers faced by customers and the effectiveness of the program intervention in comparison to external influences in overcoming these barriers. The Barrier Approach quantifies the influence of efficiency interventions in a defensible and reproducible way.

The Barriers Approach was tested on a small sample of participants in a residential audit program. The rigorous review process indicated that this innovative approach shows promise. The approach is versatile and has the potential to be expanded for evaluating a wide range of types of efficiency interventions.

This paper starts with a description the AHP method, followed by an explanation of the Barriers Approach. The pilot study and other possible applications of the method are also covered.

Introduction

Energy efficiency is insufficiently valued in the market, and consequently, government, utilities and other groups have designed interventions to overcome this market failure and raise the level of energy efficiency. However, these interventions occur amid a backdrop of many influences on the market. In the absence of the interventions, it is likely that some improvement in energy efficiency would occur. Interventions are often intended to accelerate the process or smooth the introduction of new efficient technologies.

Demonstrating the actual impact of these interventions is critical to ensure that public and private funds are spent wisely, encourage continued support for these efforts and assess how to modify existing, or develop new, interventions. In considering how to separate the intervention-induced savings from efficiency due to other market influences, three types of validity need to be considered:

1. Construct validity: does the method correctly measure the impacts of the intervention?
2. Internal validity: does the method clearly identify the causal mechanism between the intervention and the increased efficiency?
3. External validity: can the results of the study be generalized to the population?

The reliability of the approach relies on the ability to address potential threats to these types of validity.

In the US, estimating the intervention-induced savings is focused on the counterfactual: what would have happened in the absence of the efficiency intervention? Four major approaches have been used to try to answer this question, as described in the table below. These methods have generated substantial controversy about the validity of the approach and reliability of results.

Table 1. Current Approaches to Estimating Net Savings from Efficiency Interventions in the US

Approach	Description	Advantages	Disadvantages
Self Reports	Interview market actors about what they would have done without the efficiency intervention	Extensively used Survey-based Easy to implement	Counterfactual questions are difficult to answer (construct validity) Respondents may not be able to quantify the savings due to the program (internal validity) Results may be biased due to validity issues
Statistical Modeling	Discrete choice modeling or conjoint analysis	Measures choices to install EE or standard products	Requires very large samples of nonparticipants, studies are expensive (external validity) Only works for the most commonly installed energy efficiency technologies (limited applicability)
Comparison Studies	Compare efficiency activity to another location with no efficiency interventions	Intended to address market shifts by use of a comparison area	Increasing difficulties finding comparison areas with no efficiency initiatives (construct validity) “Contamination” by participation in energy efficiency programs in prior years (internal validity)
Sales Data Analysis	Assess changes in overall sales of efficient products	Directly measures changes in market share	Difficult to obtain complete sales data (external validity) May not separate intervention impacts from other market forces (construct validity) Applies only to specific products (limited applicability)

A key issue with these methods is the difficulty in separating intervention effects from other market effects. While comparison area studies were intended to address this problem, the increasing difficulties in finding a comparison area with similar characteristics and no efficiency interventions raises questions about the feasibility of this approach moving forward.

This paper proposes an alternative approach using the Analytic Hierarchy Process (AHP) to assess the influence of efficiency interventions and address the issues with validity inherent in the previous methods. AHP was developed to facilitate complex decision making by a group of stakeholders. As the AHP is used to assist with decision making, it can also be used to deconstruct a decision made in the past. This method provides the structure to quantify the decision making process.

The Barriers Approach applies the AHP to the decision to make energy efficiency upgrades by identifying the market barriers and the range of influences that assist customers with overcoming the barriers. The relative importance of the market barriers and the influential factors in overcoming the barriers are determined through the use of pairwise comparisons and the outcome of the Barriers Approach is the Pairwise Program Influence Score, which reflects the percent of the impacts (energy savings, demand reduction, greenhouse gas emissions, etc.) that are attributable to the intervention.

The Barriers Approach represents an innovative use of the versatility of AHP to sharpen our ability to estimate the real impacts of energy efficiency interventions over and above naturally occurring efficiency improvements. The main advantages of this approach are 1) external effects outside of the intervention are explicitly incorporated into the analysis, leading to high construct and internal validity; 2) it is based on a strong theoretical foundation and does not require large sample

sizes, which improves the external validity. The approach is versatile and has the potential to be expanded for evaluating a wide range of types of efficiency interventions. Figure 1 shows the relationship between the AHP and the Barriers Approach.

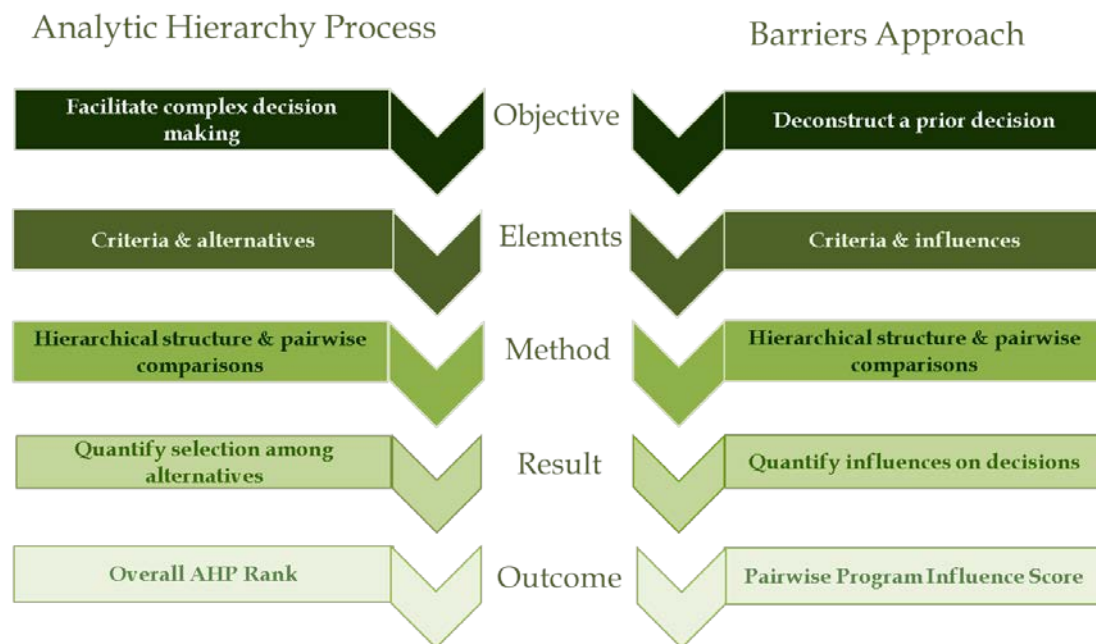


Figure 1. Comparison of the Analytic Hierarchy Process and the Barriers Approach

The remainder of this paper is divided into four main sections: a description and example of the AHP, a description of the Barriers Approach, including a discussion of the initial testing of the method and an example of the calculations, a discussion of potential applications for the Barriers Approach and conclusions.

The Analytic Hierarchy Process

AHP was designed to provide a comprehensive structure for complex decision making. The overall strategy is to define the goal, alternatives and priorities, and then conduct a series of pairwise comparisons to identify the relative importance of each element. A relatively simple mathematical process is used to rank the elements. The outcome is a score for each alternative that quantifies its relative value in comparison to the other alternatives. It allows diverse criteria to be quantified and combined in a consistent way. The framework is as follows:

1. develop a model of the decision making process that defines the goal, the alternatives and the criteria for selecting among them
2. prioritize the selection criteria using pairwise comparisons
3. rank the alternatives through pairwise comparisons within each selection criterion
4. integrate the priorities and the ranking of the alternatives to develop a score for each alternative reflecting the importance of each of the selection criteria and the relative value of the alternative within each selection criterion
5. check for consistency

Pairwise comparisons are the building blocks of AHP and are used at each stage in the model. At the first level, each selection criterion is compared to one other to assess the relative importance.

AHP specifies the relationship between two decision making components using a numerical scale, as shown in Table 2. The even numbers can be used for responses that fall between the categories given below (Saaty, 2006). The number of pairwise questions increases with the number of options, with two options requiring one question, and four options requiring six questions.

Table 2. AHP Scale for Pairwise Comparisons

Numerical Scale	Description	Meaning
1	Equal importance	Both factors make the same contribution to the decision.
3	Moderate importance	The favored factor is moderately more important than the weaker factor.
5	Strong importance	The favored factor is strongly more important.
7	Very strong importance	The favored factor is very strongly more important.
9	Extreme importance	The favored factor is extremely more important.

These results are entered into a matrix and matrix algebra is used to calculate the eigenvector and the normalized score, with all of the scores for a specific priority adding to 1.0. The numerical ratings are entered into the lower right part of the matrix as follows:

1. If the rating is greater than 1 (indicating that the factor is the stronger of the two), the number is directly entered into the matrix.
2. If the rating is 1 (indicating that the factor is the weaker or that the two factors are equivalent), the reciprocal of the rating is entered.

In the corresponding upper left box, the reciprocal of the value entered into the lower right box is entered (Saaty, 2006). This process is unique to AHP. Different scaling mechanisms may be applied, as appropriate (Franek, 2014).

AHP also has a method to calculate the consistency ratio when three or more factors are compared. The consistency ratio compares the maximum of the eigenvalues for the matrix to the average eigenvalues of randomly generated reciprocal matrices.¹ Saaty recommends allowing a consistency ratio of 10% or less to account for variations in human judgment. (Saaty, 2006)

AHP Example

A simple illustration of this method is choosing a car. The purchasers are considering three electric vehicles and are planning to make the decision based on cost, reliability and distance per charge and overall fuel efficiency. The characteristics of the cars are described in the table below.

Table 3: Electric Car Characteristics

Criteria	Car A	Car B	Car C
Cost	30,000	45,000	70,000
Reliability	3-year warranty	8-year warranty	8-year warranty
Distance per charge	25 miles	50 miles	235 miles

¹ The method for calculating eigenvalues and the eigenvector can be found in textbooks on linear algebra (such as Anton, 1981), the AHP texts (such as Saaty, 2006) and numerous university Web sites.

The analysis has two stages: 1) determine the relative importance of the selection criteria and 2) determine the performance of each car according to the selection criteria. An integrated score for each car is constructed that accounts for the relative importance of each criterion and the performance of the car in comparison to the other alternatives.

The purchasers ranked the criteria in importance from most to least important: 1) cost, 2) distance per charge and 3) reliability. Pairwise questions are constructed to compare them two at a time, resulting in three questions. The results of these comparisons are shown in Table 4.

Table 4. Pairwise Responses for Selection Criteria for AHP Electric Car Example

Row	Criteria 1	Pairwise Rank 1	Criteria 2	Pairwise Rank 2	Response
1	Cost	5	Reliability	1	Cost is strongly more important than distance per charge
2	Cost	3	Distance	1	Cost is moderately more important than reliability
3	Reliability	1	Distance	5	Distance per charge is strongly more important than reliability

The results from this component are the priorities, i.e., the relative ranking of the selection criteria. Using the process described above, these values are entered in a matrix as described below and illustrated in Table 5.

1. Ones are entered on the diagonal.
2. In the first row of Table 4, the column Pairwise Rank 2 (PR 2) contains 1, so the reciprocal of PR 1 (1/5) is entered into the reliability/cost cell in the lower left corner of the matrix.
3. In the second row, PR 2 is 1, so the reciprocal of PR 1 (1/3) is entered into the cost/distance cell in the lower left corner of the matrix.
4. In the third row, PR 2 is 5, so PR 2 (5) is entered into the reliability/distance cell in the lower left corner of the matrix.
5. The top, right section of the matrix is filled in with the reciprocals of the corresponding cells in the bottom left.

The eigenvector is calculated and normalized by dividing each component of the eigenvector by the total of the eigenvector values, as shown in the table below. The priorities indicate that cost is the most important selection criteria, as the priority score is the highest.

Table 5. Priorities Matrix for AHP Electric Car Example

	Cost	Reliability	Distance per Charge	Eigenvector	Priorities (Normalized Eigenvector)
Cost	1	5	3	35.0	0.63
Reliability	1/5	1	1/5	4.5	0.08
Distance	1/3	5	1	16.3	0.29
Totals				55.8	1.000

The process is repeated for each of the three cars within each of the three criteria (for a total of nine pairwise comparisons). The responses are shown in Table 6.

Table 6. Alternatives Matrix for AHP Electric Car Example

Comparison	Criteria	PR 1/ PR 2	Criteria	PR 1/ PR 2	Criteria	PR 1/ PR 2
A/B	Cost	3/1	Reliability	1/5	Distance	1/3
A/C	Cost	7/1	Reliability	1/5	Distance	1/9
B/C	Cost	5/1	Reliability	1/1	Distance	1/7

The same process described above for the criteria is used to construct three matrices and calculate the ratings of each car. The final step is to integrate the results to calculate the overall AHP rank of the alternatives for each car, as shown in the equation and table below.

$$\text{Overall AHP Rank} = \sum_{i=1}^n (P_i \times A_i)$$

where P = priority rank for selection criterion *i*

A = alternative rank for selection criterion *i*

n = the total number of selection criteria

Table 7. Summary of Results for AHP Electric Car Example

Car	Cost	Reliability	Distance	Overall AHP Rank	Calculations
A	0.65	0.09	0.06	0.44	$(0.63 \times 0.65) + (0.08 \times 0.09) + (0.29 \times 0.06)$
B	0.28	0.46	0.15	0.25	$(0.63 \times 0.28) + (0.08 \times 0.46) + (0.29 \times 0.15)$
C	0.07	0.45	0.79	0.31	$(0.63 \times 0.07) + (0.08 \times 0.45) + (0.29 \times 0.79)$
Priority	0.63	0.08	0.29		

The outcome of this analysis indicates the purchasers should buy car with the highest overall AHP rank (Car A at 0.44). This outcome is largely due to the importance of cost in the decision making process. Car C came in as the second choice, as distance per charge was substantially more important than reliability. The consistency ratios for all of the matrices were under 10%.

The Barriers Approach

The AHP method can be used to develop a more nuanced assessment of the savings to be attributed to an efficiency intervention. By applying the AHP approach to the process of deciding to install efficiency measures, we can deconstruct the decision making process and quantify program influence. This approach allows us to account for the wide range of elements that contribute to the decision to install measures. Table 8 shows how the AHP elements used in our example above relate to the Barriers Approach.

Table 8. Mapping AHP to the Barriers Approach

AHP Component	AHP Electric Car Example	Barriers Approach Example	Comments
Goal	Select best electric car	Quantify influence of the efficiency intervention	AHP: rank each car individually to select the best car based on the established criteria Barriers Approach: aggregates scores over many participants to quantify influence
Selection Criteria	Desired characteristics	Barriers to installing efficiency measures	AHP: cost, reliability, distance per charge Barriers Approach: money, information, time
Alternatives	Electric cars	Influential factors for overcoming the barriers	AHP: three types of electric cars Barriers Approach: direct influence of the intervention, indirect influence of other utility or regulatory efforts, external influences
Outcome	Overall AHP Rank	Program Pairwise Influence Score	AHP: combines relative importance of criteria with the qualities of each alternative Barriers Approach: combines relative importance of barriers with the intervention and external influences

The Barriers Approach was tested on a small sample for a residential audit program. The following section discusses how the AHP concepts were applied to develop the Barriers Approach and conduct this research.

Description of the Barriers Approach

An alternative approach to quantifying program influence needs to account for the range of possible influences, both intervention-related and external, that affect the decision to install energy efficiency measures. The conceptual framework for investigating the decision-making process and quantifying program influence is shown below.

Table 9. Steps in the Barrier Approach

Step	Description	AHP Example Equivalent	Comments
1	Identify the barriers	None	Necessary research to define options
2	Quantify the relative importance of the barriers	Priorities matrix, see Table 5	Normalized eigenvector reflects the Barrier Scores
3	Identify the influential factors	None	Necessary research to define options
4	Quantify the relative importance of the intervention and external influences	Alternatives Matrix, see Table 6	Normalized eigenvector reflects the Program Contribution Scores
5	Calculate the Pairwise Program Influence Score	Overall AHP Rank, see Table 7	Integrate the barriers (priorities) and influences (alternatives)

This approach directly measures how the program intervention is working and can provide valuable feedback to program staff. Each of the steps is described briefly below.

Identifying the Barriers. Extensive research has been conducted to document the common barriers that prevent residential customers from taking actions to improve the energy efficiency of their homes.² A previous study was conducted on the audit program used for this research and it documented the following key barriers: (1) high cost of measures; (2) finding a contractor; (3) waiting for old equipment to break; and (4) ineligible for financing (NMR, 2012).

Based on these findings and a review of responses to open-ended questions in recent surveys for related residential programs, we identified four barriers to installing efficiency measures:

1. concerns about **money** (up-front costs)
2. lack of **information**
3. **time** constraints
4. finding a **contractor**

Of these four, the lack of information is the broadest, as it could range from information about costs, benefits and payback to health and safety issues and the specifics of the installation.

The audit program is designed to overcome two of these barriers: lack of information and finding a contractor. It could also help homeowners with time constraints by saving time in research and/or selecting a contractor. No monetary assistance is provided through the audit program, although money is a driving component in the decision making process for many homeowners.

Assess Relative Importance of the Barriers and Develop the Barrier Score. Due to the wide range of viewpoints among residential homeowners, defining the barriers required four steps:

1. Respondents identified as many concerns that applied to them from a comprehensive list; they were asked to **rank the concerns** on a 0 to 10 scale and add concerns, as needed.
2. Each of the concerns ranked above 5 was then **mapped to one of the four main barriers** (time, money, information, finding a contractor).
3. The assignment to the four main barriers was **verified with the respondent**.
4. The responses on the 0 to 10 scale were used to **rank the four main barriers in order of importance** and this ranking was also verified with the respondent.

Respondents were asked to compare the barriers two at a time and rank them on a scale where 1 meant that they were of the equal importance and 5 meant that the first (more important) barrier was extremely more important than the other.³

The Barrier Score reflects the percent contribution of each barrier to the lack of action. The scores for all of the barriers add to 100% for each respondent. No respondent identified more than three barriers. Although money was not a barrier addressed by the audit program, it represents a substantial hurdle for many homeowners and was included in the barrier score.

Identify Influential Factors. For each barrier, numerous influences may encourage homeowners to proceed with installing efficiency measures. For example, sources of information about energy efficiency measures are abundant, e.g., the energy audit, another (nonprogram) contractor, friends and family, advertisements for specific products, Internet research, etc.

For each barrier, a list of influential factors was constructed and respondents were asked to

² Various publications discuss these common barriers. For example, see: <http://aceee.org/research-report/a135> and <http://www.resnet.us/professional/ratings/HP03>;

³ In the surveys, the AHP 1 to 9 scale was modified to 1 to 5, as many survey respondents are likely to be more familiar with the 1 to 5 scale.

identify the influential factors that affected their decision. Respondents were invited to add to the list of factors and to comment on the wording. The influential factors were grouped into three types of influence:

1. Direct influence from the energy audit
2. Indirect influence from the audit program (such as the Web site)
3. External influence (such as friends and family or nonprogram contractors)

The respondent was asked to confirm these influences.

Quantify Intervention Effects. Pairwise questions were developed to compare the direct, indirect and external influences for each barrier. The strategy mirrored the approach used to identify the barriers, as follows:

1. Respondents were asked to **rank the influences** on a 0 to 10 scale and add to the list.
2. Each of the factors ranked above 5 was **mapped to one of three main types of influence**.
3. The selection of the influence(s) from the three categories was **verified with the respondent**.
4. The responses on the 0 to 10 scale were used to **rank the influences in order of importance**.
5. **Pairwise comparisons** were used to quantify the relative importance of the influences for each barrier.

The Program Contribution Scores for each barrier were calculated using matrix algebra as described above. If the homeowner attributed all of the influence to only one influential factor, the pairwise comparison step was unnecessary.

Calculate the Pairwise Program Influence Score. Consistent with the calculation of the overall AHP rank, the Pairwise Program Influence Score combines the Barrier Scores and the Program Contribution Scores for each respondent, as shown below.

$$PPI = \sum_{i=1}^n (BS_i \times PC_i)$$

where BS = Barrier Score for barrier *i*

PC = Program Contribution score for barrier *i*

n = the total number of barriers identified by the survey respondent

Example of the Barriers Approach and Pairwise Program Influence Score Calculations

An example of the barrier mapping process for one respondent is shown in Table 10. The ranking column shows the barriers in order of importance as identified by the respondent. The pairwise response columns show the respondent's ranking for the favored factor and the reciprocal for the less favored factor (as is entered into the matrix).

Table 10. Ranking Barriers for a Respondent

Highly Ranked Items	Barrier	Ranking	Pairwise Responses
1) Needing information about savings energy and what to install	Information	#1	Information/Time: 1 (roughly equal)
2) Finding a reliable source of information			Information/Money: 5 (information is strongly more important)

Highly Ranked Items	Barrier	Ranking	Pairwise Responses
1) Finding time for research	Time	#2	Time/Money: 3 (time is moderately more important) Time/Information: 1 (equal)
No options were ranked above 5 on the 0-10 scale	Contractor	No ranking	Not included in pairwise comparisons
1) Figuring out how to pay for the efficiency upgrades	Money	#3	Money/Information: 1/5 (reciprocal of information/money) Money/Time: 1/3 (reciprocal of time/money)

The barriers matrix and solution are presented in Table 11. The Barrier Scores are the normalized eigenvector and represent the relative importance of each barrier.⁴ The consistency ratio is 2%.⁵

Table 11. Barriers Pairwise Matrix

	Information	Time	Money	Eigenvector	Barrier Scores
Information	1	1	5	1.71	0.48
Time	1	1	3	1.44	0.41
Money	1/5	1/3	1	0.41	0.11

This example includes two options for program contribution: intervention and external influences. As the matrix algebra is simple, the responses and results are combined in Table 12. With only two options, there is no need for a consistency check.

Table 12. Program Contribution Scores

Component	Influential Factors on Decision to Install	Program Ranking	Pairwise Responses	Program Contribution Score
Information	Energy audit (program) Nonprogram contractor	Program ranked #1 Nonprogram ranked #2	Program/NP: 7/1	88%
Time	Energy audit Personal time management	Program ranked #2 Nonprogram ranked #1	NP/Program: 3/1	25%
Money	No program influence	Nonprogram ranked #1	No pairwise	0%

⁴ In this example, the linear scale from the Saaty text was used, i.e., the values on the 1-9 scale were directly entered into the matrix. However, the final PPIS for the cognitive interviews were calculated using the balanced scale with values of {1:1; 2:1.22; 3:1.5; 4:1.86; 5:2.33; 6:4.5; 7:5.67; 9:9}, e.g., if the respondent selected 5 on the 1-9 scale, 2.33 was entered into the matrix. (Franek, 2014) The balanced scale was selected as the weights from the linear scale are unequally dispersed. For a two by two matrix, selecting 5 (the midpoint) on the 1-9 linear scale gives the favored barrier a weight of 83%,; the same entry on the balanced scale gives the favored barrier a weight of 70% (halfway between equal weights [50%] and the top of the scale [90%]). The wording of the pairwise questions was modified to reflect the balanced scale.

⁵ In the 13 cognitive interviews, a large majority of respondents listed only one or two barriers, so the consistency check was not necessary.

For this example, the Pairwise Program Influence Score is 52%, as shown in the following equation. To take this analysis one step further, net program savings could be calculated as follows:

$$NPI = PPIS \times GPI$$

where

NPI is the net program impacts

PPIS is the average Pairwise Program Influence Score for all respondents

GPI is the gross program impacts

The gross program impacts could be energy or demand savings, reductions in greenhouse gas emissions or other metrics. In addition, the PPIS could be weighted to reflect the mix of measures in each home or other considerations.

$$\begin{aligned} PPIS &= (BS_{\text{info}} \times PC_{\text{info}} + BS_{\text{time}} \times PC_{\text{time}} + BS_{\text{money}} \times PC_{\text{money}}) \\ &= (0.48 \times 0.88 + 0.41 \times 0.25 + 0.11 \times 0.00) = 0.52 \end{aligned}$$

Applying the Barriers Approach

The Barriers Approach was tested on a residential audit program. Cognitive interviews were fielded for a small sample (13). All interviews were audio recorded and provided to four expert reviewers. Each reviewer came to an independent assessment of the Pairwise Program Influence Score (PPIS) and the PPIS was compared to the story told by the respondent. A conference call was held to assess the validity of responses and whether the scores matched the responses. The panel of reviewers agreed that the cognitive interviews supported the validity of this approach, *i.e.*, the interviews captured the concerns and issues of the respondents and the respondents' PPIS were consistent with the story that they told. These results are indicative of the potential of this approach.

The versatility of the AHP provides a strong foundation for expanding the application of this approach to evaluating a wide variety of types of efficiency interventions. The structure of the analysis can accommodate a broad range of barriers and influential factors. While other methods (such as comparison area and sales data analyses) are restricted to specific technologies, the Barriers Approach could be applied at the technology, end use, facility or community level. Some possibilities are explored below.

- The influence of energy efficiency labeling for new homes could be investigated through interviews with home buyers to assess how the labels affect the purchase.
- Rebates programs could be assessed through interviews with purchasers to determine the impact of the rebate in comparison to other influences in the decision to purchase the product.
- Energy codes could be evaluated through interviews with code officials and builders to ascertain the influence of the code on the efficiency level of a random sample of buildings and assess whether the code was effective in raising the minimum efficiency.

The limiting issue may be the complexity of the decision making process, as the number of questions increases as a factorial of the number of barriers.

Conclusions

This novel expansion of the AHP method to estimate the actual influence of efficiency interventions shows promise. As interventions are designed to overcome market barriers, the

Barriers Approach is an improvement over other methods as it measures the success of efficiency interventions in these terms and addresses persistent concerns about the validity of the previous methods.

The cognitive interviews provided a wealth of information about the decision making process, and, consequently, we were able to compare the results of the Barrier Approach to the story told by the respondents to verify the method produced reliable results. The cognitive interviews demonstrate the construct validity, *i.e.*, that the questions can be understood, reliably answered and provide the information needed to assess program influence.

Estimating the impacts of efficiency interventions over and above the level of naturally occurring efficiency relies on assigning numerical values to subjective decision making. The Barrier Approach has a number of advantages over previous approaches:

- It is internally consistent in that it is measuring the effectiveness of the intervention in overcoming market barriers through a systematic approach to quantifying the decision making process (internal validity).
- It is based on a strong theoretical foundation to quantify decision making (external validity).
- It relies on questions that can be reliably understood and answered by the respondents (construct validity).
- The resulting score can be directly applied to program impacts to estimate the “net” impacts of a program.
- It is highly versatile and has the potential to be applied to a wide range of types of energy efficiency interventions, including energy efficiency regulations, codes and labeling (broad applicability).

The primary disadvantage may be the need to limit the number of barriers and influential factors to be able to keep the interviews at a reasonable length and level of complexity.

The sample size of 13 is small and additional research is needed to test this method on a larger scale. Other details that could not be included in this paper due to length, such as the scaling method and consistency checks, may also be topics of future research.

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Appendix F

Program Staff Interviews

Analysis of Program Manager Experiences

The evaluation team interviewed three utility staff that manage the HVAC&HW Program, one from UI and two from Eversource (one of who manages the upstream rebates and one who manages the downstream rebates). All three staff believed the program was running smoothly and attributed an increased number of HVAC&WH rebates processed to moving to the upstream model. Staff also reported that nearly all the distributors working in Connecticut participated in the program and that the upstream model improved the utilities' relationship with distributors. The staff also identified some challenges including; reaching out to distributors and contractors, wanting to move more measures upstream, and budget constraints. The remainder of this section presents their feedback relating to four implementation aspects:

1. program oversight
2. distributor enrollment
3. marketing and outreach
4. rebate processing.

The section concludes by identifying staff views on program successes and challenges.

Program Manager Experiences with Program Oversight

Program managers reported that the program was running smoothly. From a management perspective, they did not express any concerns with regards to meeting short-term program goals, program processes, or schedule. The program managers reported that they had met expectations relating to the number of units rebated through the program. They also noted that they saw an increase in the number of rebates processed since instituting the upstream program model and that distributors reported that equipment was moving fast. This is supported by the increased number of measures rebated through the program (see Figure 6). That said, program managers identified three areas where they either faced challenges or they would like to improve the overall program design.

Limited budget

While managers did not specifically report that the budget was too limited. They did report two challenges related to the budget. First, strong program enrollment resulted in the program being fully subscribed for gas measures within the Southern Connecticut Gas (SCG) territory earlier than expected in 2016. As budgets were defined by utility territories, the utilities could not transfer program funds to the SCG budget. As a result, the program ceased processing rebates earlier than expected within the SCG territory for the following measures: gas water heaters, gas boilers, and gas furnaces.¹

At the time of conducting the interviews, program staff believed that this message was clearly communicated to distributors and contractors and did not expect any major challenges with needing to close this portion of the program early.

¹ Furnace sales continued within the SCG territory but customers could only receive a rebate to offset the furnace fans and the utilities only claimed electric savings.

The second challenge, expressed by one of the program managers, was that the rebate levels did not cover all of the incremental costs to purchasing energy efficient equipment, especially when customers experience warmer weather and lower fuel costs. In other words, the current rebate levels did not address cost barriers for some customers. While none of the program managers specifically recommended increasing program budgets, future program designs should examine how budgets are allocated by utility territory, assess rebate levels, and clearly define the extent to which they want rebate levels to overcome cost barriers.²

Difficult to measure outcomes

While there is no program logic model, program managers reported that the long-term outcome for the program is market transformation. That said, staff reported having little-to-no data to measure this. One of the program managers reported looking at data from a variety of sources (HARDI, ENERGY STAR shipments, and data from some distributors willing to share sales data), however the results only captured some measures and the information was not comprehensive. Without having clear data on market transformation, it is difficult for the program to clearly document program success. Difficulties to collect this type of data is compounded because the utilities and distributors have an agreement that distributors do not need to provide sales data to utilities, and thus utilities and evaluators are limited in their ability to assess this outcome.

One of the program managers also reported that they would like to better document the outcome of outreach events. These outreach events are an important part of the program, as they educate market actors on the program and measures, but program managers get little feedback on the effectiveness of outreach events. To better understand outreach effectiveness, the evaluation team incorporated questions about outreach to customers, contractors, and distributors.

Lastly, program managers are also unclear whether customers participating in the program know that they are receiving a discount on their equipment from the utility and they have limited means to measure how the discount is impacting customer experiences and purchasing decisions.³ To better understand customer awareness of the program, the evaluation team incorporated program awareness questions in its survey to customers.

Desire to move more measures upstream

All of the program managers reported a desire to move more measures upstream, although they recognized that they also faced challenges in doing so. First, the program managers identified a number of smaller measures that contractors typically purchase in bulk in order to have equipment available on their truck for immediate equipment replacements. While the program does allow distributors to reimburse contractors for

² Because the HVAC program budgets were embedded within the HES program in 2014 and 2015, the evaluation team could not assess these findings any further.

³ This process evaluation was designed to address these questions in the customer survey.

any eligible equipment purchased in bulk and gets installed at a customer's site, program managers reported that contractors tend not to pursue this avenue as the first cost of the bulk purchase is too expensive and so contractors tend to purchase less efficient equipment in bulk. As a result, the utilities are grappling with alternative methods to address this issue and program managers expressed a strong desire to move away from collecting customer addresses in order for distributors to offer discounted prices to contractors when they purchase in bulk. Second, while program managers would like to move electric HVAC equipment upstream, they also recognized that the configuration of the equipment influences savings so much that offering an upstream rebate for the equipment would be very difficult.

Program Manager Experiences with Distributor Enrollment

All three program managers were extremely happy with the number of distributors that participated in the program—citing that nearly 100% of distributors in Connecticut participated in the program. Since almost all the distributors participated in the program, they believed that distributors did not face challenges in program participation.⁴

With nearly all the distributors participating in the program, program managers will need to turn their attention toward distributor retention in 2017 and beyond. Program managers did not report any feedback on distributor retention, however program managers can assess this as the program matures to see if distributor participation levels are sustained.

Program Manager Experiences with Marketing and Outreach

The program managers also reported great success in developing relationships with distributors and contractors and educating them on the program and eligible equipment. They also cited challenges to maintaining contact lists over time, due to staff changes and turnover at distributor and contractor businesses.

While the evaluation team did not have complete access to all the training events that occurred in 2014 and 2015, program managers all spoke positively about the success in providing educational sessions to contractors on the equipment and the program. This education is particularly important for contractors as they need to know the equipment well enough to successfully sell it to their residential customers. Staff reported that the educational sessions provided contractors with a venue for them to learn about new equipment and stay up-to-date on the latest developments in their field. Staff believed contractors valued this information because it allowed them to remain up-to-date in the field even though it is not required for certification. Additionally, one of the program managers reported that an unintended positive outcome of the program is that by working directly with distributors and contractors, more of them view the utility as an important partner in the HVAC sales process. By engaging in a dialogue, distributors and contractors understand that the utility wants to support the industry and help to move it forward.

⁴ The evaluation team asked distributors about whether they faced any participation barriers in the distributor survey.

That said, maintaining an accurate contact list for distributors and contractors is paramount as it is the means to alert distributors and contractors to events and keep them up-to-speed on program announcements (such as closing the program within the SCG territory). While the challenges relating to maintaining an accurate constant contact email lists are not unique to this program, it is a reality that program managers must face to ensure messages are broadcasted to those that need the information.

Program Manager Experiences with Rebate Processing

Program managers also reported that rebate processing was smooth and that the only challenge related to matching customer data supplied by the rebate vendor to utility records. According to the CLM Plan, the utilities are required to collect installation documentation in order to “maintain insight into the HVAC and DWH equipment markets, and for tracking purposes.”⁵ This information is important for regulators and planners to know that the equipment was installed and to is essential to verifying energy efficiency savings. Since the utilities are not involved in collecting customer data, they can only check this information on the backend.

The rebate fulfillment vendor (EFI) does check customer data from distributors and works with distributors to make sure rebates are completed accurately. Program managers do some spot checking of the data, but still have challenges in matching data in any automated way. This is mainly due to inconsistent spellings or format of the entry (e.g., addresses are entered sometimes entered with the street number at the end of the street name or visa versa). Program staff reported that while customer data can be incomplete, the upstream rebates are typically more complete than the downstream rebates because distributors are more likely to fill in accurate measure data compared to downstream rebates.

Program managers have been trying to make the customer data collection process complete but still easy for the distributors, who complain that the process is onerous. Program managers continue to struggle with developing means to collect whatever data is needed to suffice program reporting needs while still make the process easy for distributors, contractors, and customers.

Summary of Program Manager Successes and Challenges

The three managers interviewed for this evaluation all reported the program to be a great success, so much so that the utilities are designed a similar upstream program for commercial and industrial customers. The interviews also uncovered some challenges that the program managers continue to work to address. Table 5 summarizes these successes and challenges.

⁵ 2016-2018 CLM Plan (DEEP, p282)

TABLE 1: PROGRAM MANAGER VIEWS ON PROGRAM SUCCESSES AND CHALLENGES

Program Processes	Successes	Challenges
Program management/ design	Increased number of rebates processed	Limited budget Difficult to measure outcomes Desire to move more measures upstream
Distributor engagement	High participation by distributors	
Marketing and outreach	Effective contractor outreach and training Improved relationship with distributors and contractors	Maintaining accurate contact lists for distributors and contractors
Rebate processing	Easier than customer's completing paperwork	Challenging customer data collection

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Distributor Survey Findings

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Distributor Survey Findings

The following sections present findings from the process evaluation related to the equipment participant distributors stock, sources of awareness, motivations for participation, barriers to installing high-efficiency equipment, experiences with program processes, experiences with program-sponsored training, and satisfaction with the program and its components.

1.1 Participating Distributor Equipment Stocks

Respondents were asked which of the following equipment types they stock. Respondents could select more than one option.

- Out of 31 respondents:
 - 22 stocked EE furnaces (71% of all respondents)
 - 27 stocked EE boilers (87% of all respondents)
 - 27 stocked EE boiler pumps (87% of all respondents)
 - 22 stocked heat pump water heaters (71% of all respondents)

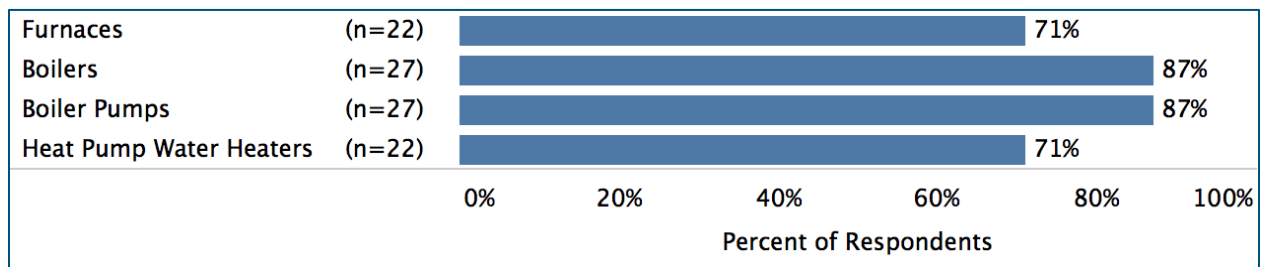


FIGURE 1: EQUIPMENT INSTALLED BY PARTICIPATING DISTRIBUTORS (N=31)

1.2 How Do Distributors Learn About the Program?

Most respondents became aware of the program through events held by Energize CT or another utility. Figure 2 and the following bullets summarize key findings related to sources of program awareness:

- Most distributors surveyed learned about the program through Energize CT or a program utility - either through an Energize CT / utility event or through an email.
- Distributors who stock heat pump water heaters responded slightly differently than others, with a greater proportion learning about the program from a program representative or from colleagues, friends, or family.

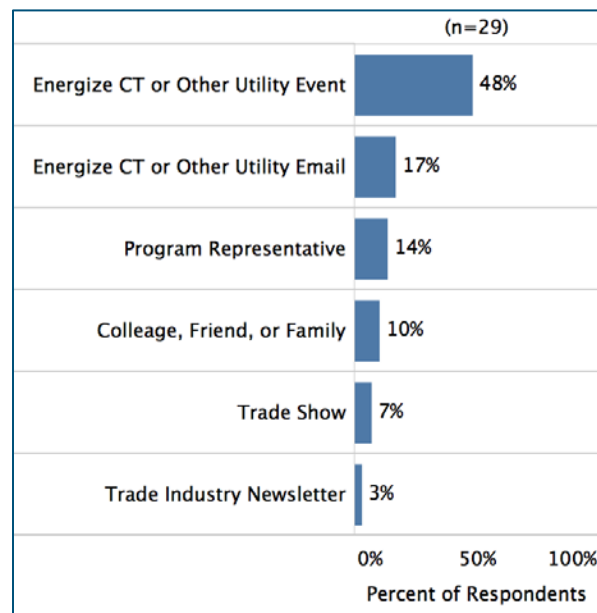


FIGURE 2: SOURCES OF PROGRAM AWARENESS (N=29)

1.3 What Motivates Distributors to Participate in the program?

Respondents were asked about what motivated them to sell energy efficient equipment and what motivated them to participate in the program. Figure 3 depicts distributors' reasons for selling energy efficient equipment, and Figure 4 depicts their reasons for participating in the program. The following bullets summarize key findings related to distributors motivations for selling energy efficient equipment and participating in the program:

- Most distributors were motivated to sell energy efficient equipment by the availability of program rebates. Distributors were also motivated to sell energy equipment because of end-users' demand for energy efficient equipment and the prospect of saving end-users energy.
- Fewer distributors reported that they sold energy efficient equipment to expand their stock of products from manufacturers whose equipment they already stock. Even fewer felt that environmental or carbon footprint concerns were important to their decision to stock energy efficient equipment.
- Initial motivations for participating in the program primarily consisted of a desire to increase sales for the contractors they serve, increase their own sales, and increase the profit margins from those sales.
- Taken together, these findings suggest that the program rebates fill a need for distributors and motivate them to sell more energy efficient equipment. Distributors are

more motivated by the prospect of increasing the volume of their sales than increasing the profit margin from these sales.

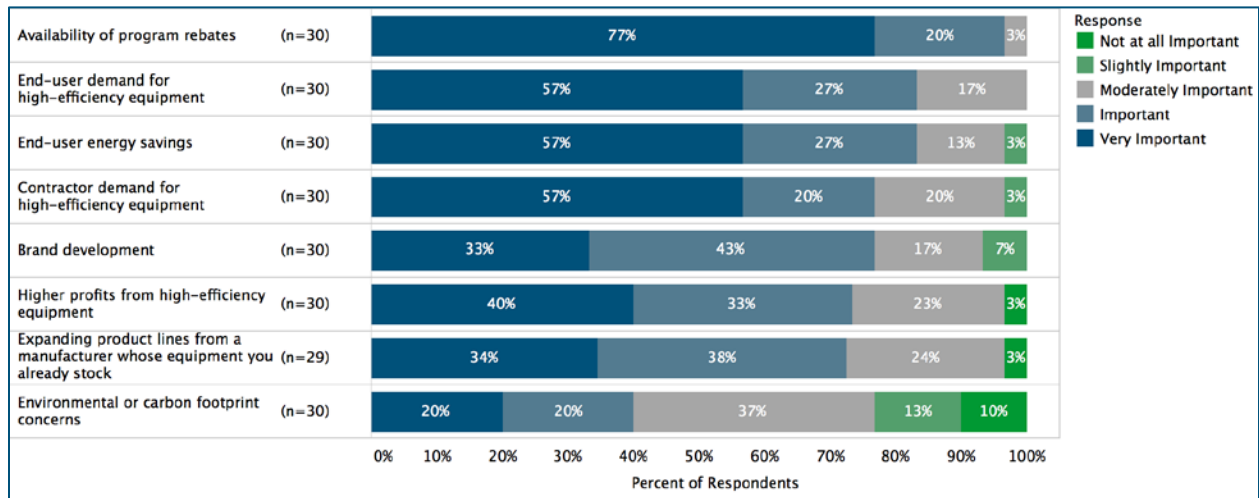


FIGURE 3: PARTICIPATING DISTRIBUTOR MOTIVATIONS FOR SELLING HIGH-EFFICIENCY EQUIPMENT (N=30)

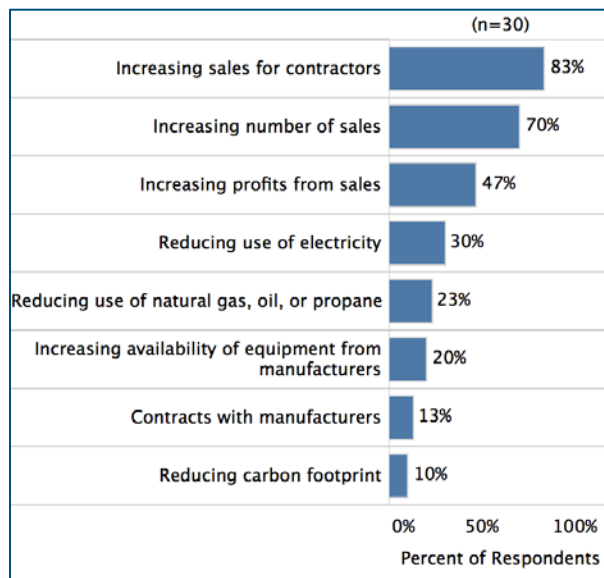


FIGURE 4: INITIAL MOTIVATIONS FOR PARTICIPATING IN THE PROGRAM (N=30)

1.4 What Factors Prevent Distributors from Stocking and Selling More High-Efficiency Equipment?

Respondents were asked about what prevented them from stocking more energy efficient equipment before participating in the program. Respondents were asked about the barriers to stocking specific equipment types, and were only asked about equipment that they currently stock. Figure 5 depicts barriers faced by furnace distributors, Figure 6 depicts boiler distributor barriers, Figure 7 depicts boiler pump distributor barriers, and Figure 8 depicts heat pump water heater distributor barriers. The following bullets summarize the key findings related to these barriers:

- The high premium between standard units and energy efficient units was a key barrier to selling more energy efficient equipment, particularly for furnace distributors and heat pump water heater distributors. This finding suggests that the program rebates help distributors overcome one of the primary barriers to selling energy efficient equipment.
- Fuel prices were reported to be a primary driver of customer demand for energy efficient equipment, particularly for boilers.
- Distributors of boiler pumps reported that a lack of customer interest in energy efficient boiler pumps was the primary barrier to selling more of them. Lack of customer interest was consistently rated among the most significant barriers to selling more energy efficient equipment.
- Although distributors perceived a lack of customer interest in energy efficient equipment, few felt that customers' dissatisfaction with the energy efficient units or their features were a significant barrier to selling more energy efficient equipment. However, contractor concerns about energy efficient equipment ranked more highly among the barriers, particularly among boiler distributors.
- Distributors of boiler pumps and heat pump water heaters reported that a limited selection of energy efficient equipment available from manufacturers was a significant barrier to selling more energy efficient equipment.

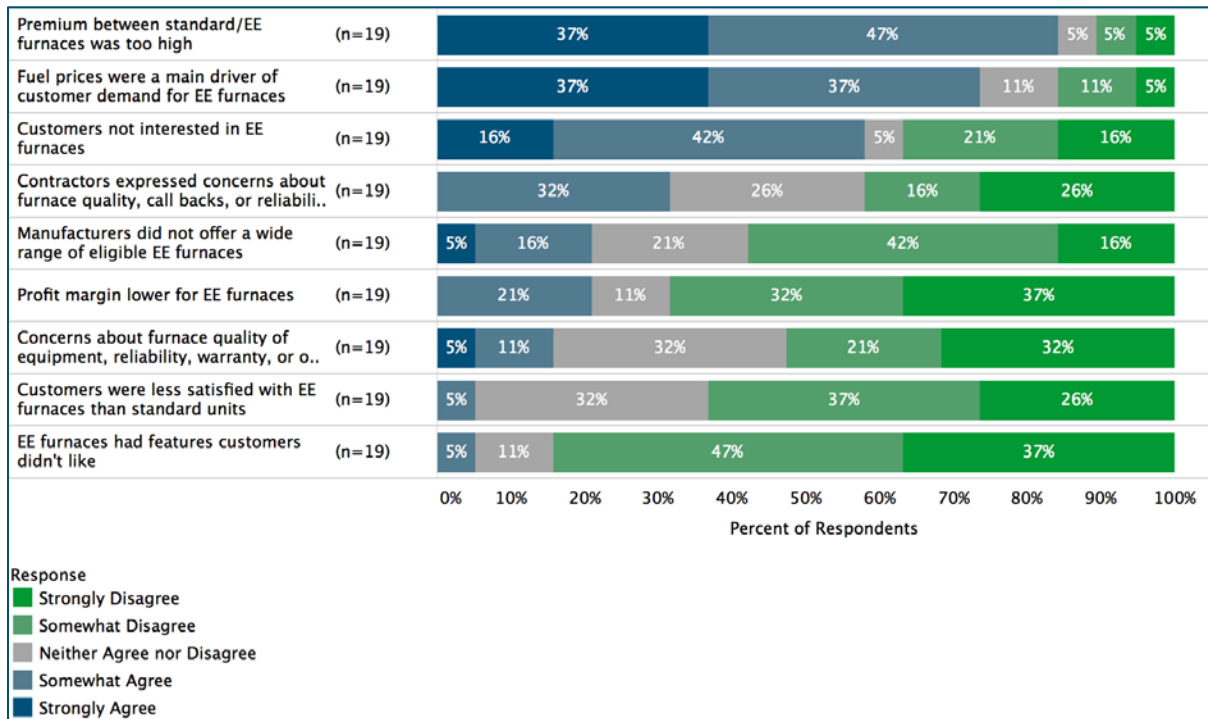


FIGURE 5: BARRIERS – FURNACE DISTRIBUTORS

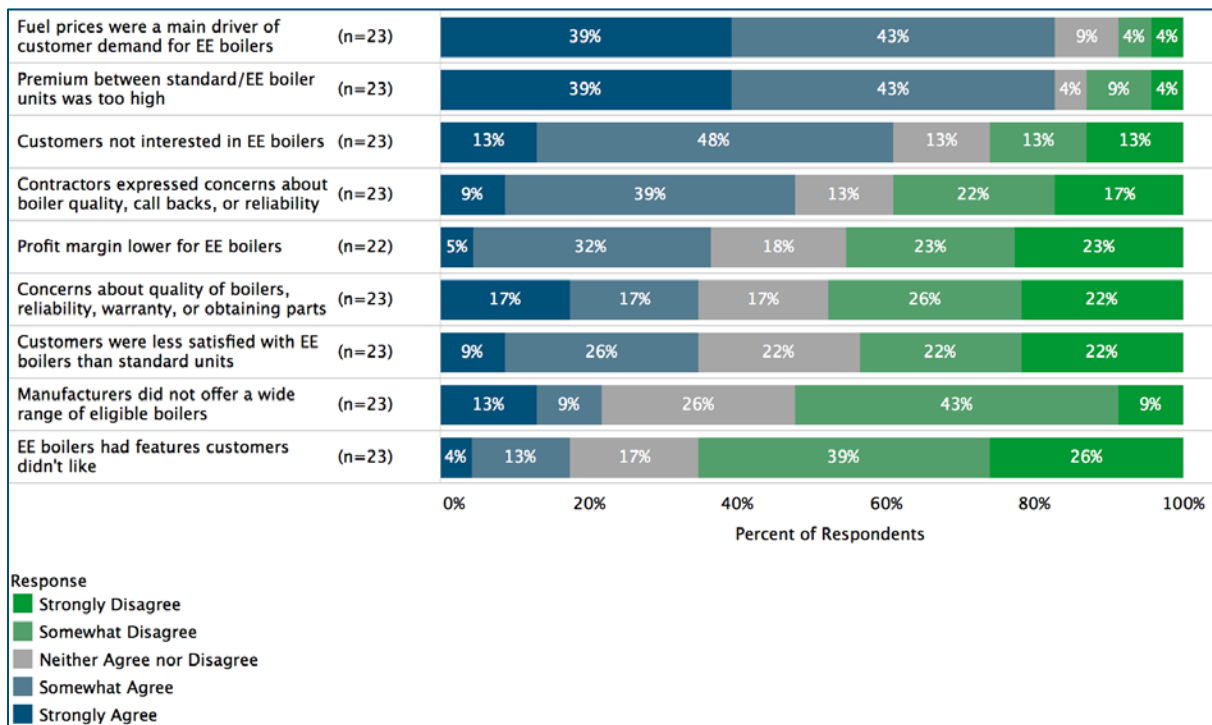


FIGURE 6: BARRIERS - BOILER DISTRIBUTORS

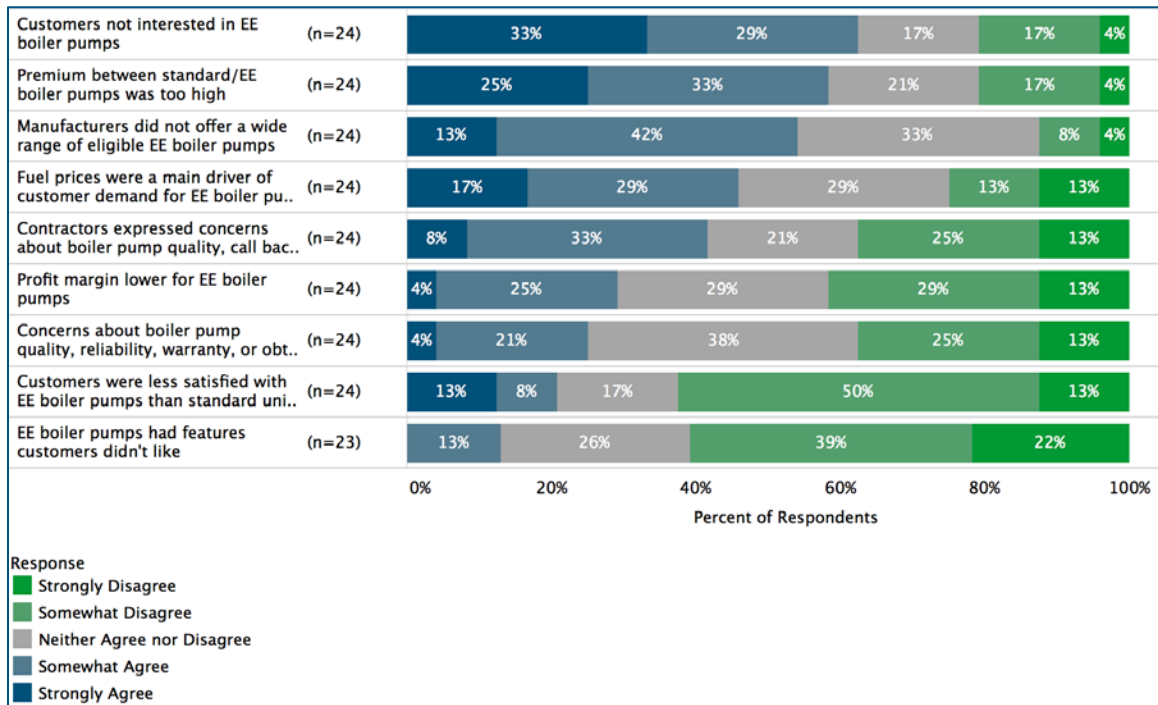


FIGURE 7: BARRIERS - BOILER PUMP DISTRIBUTORS

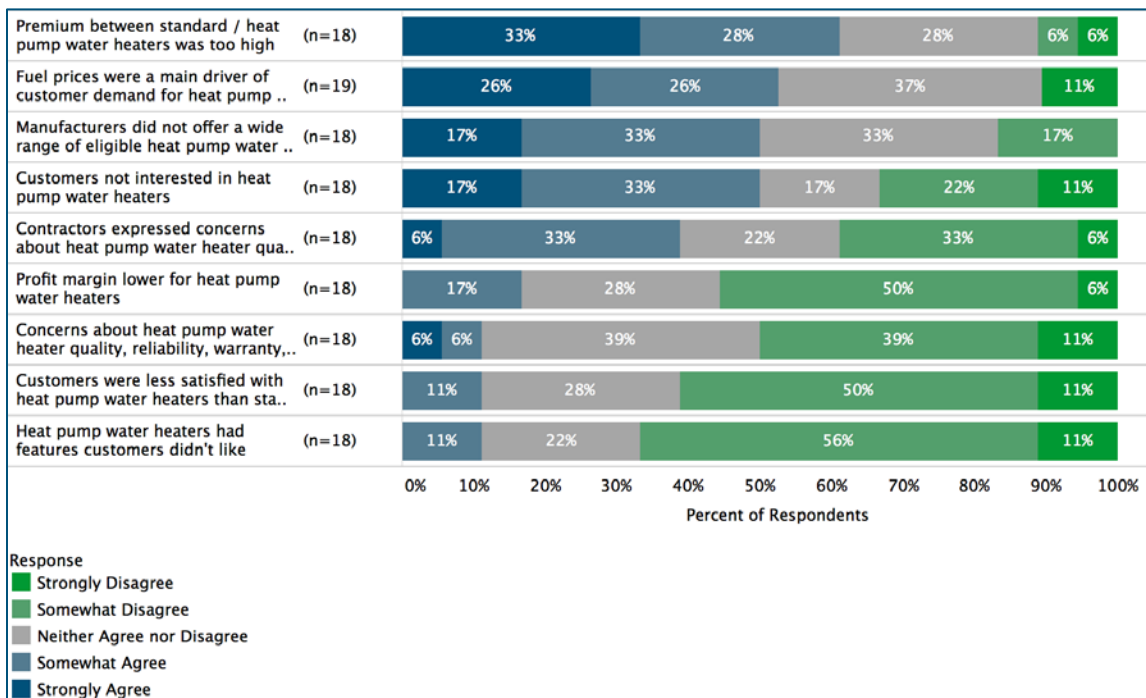


FIGURE 8: BARRIERS - HEAT PUMP WATER HEATERS

1.5 To What Extent Has the Program Influenced Distributors to Stock and Sell More High-Efficiency Equipment?

Respondents were asked about the relative influence of the program rebates versus other influences on their decision to stock and sell energy efficient equipment. Figure 9 depicts these influences, and the following bullets summarize the key findings related to this analysis:

- While distributors of boiler pumps and boilers were more likely to report that the upstream rebates were the only factor in their decision to stock and sell energy efficient equipment, distributors of heat pump water heaters were more likely than other distributors to report that the upstream rebates were either more important than other factors or were the only factor in their decision to stock energy efficient equipment.
- Only one distributor, a boiler pump distributor, reported that other influences were the only factor in their decision to stock and sell energy efficient equipment.

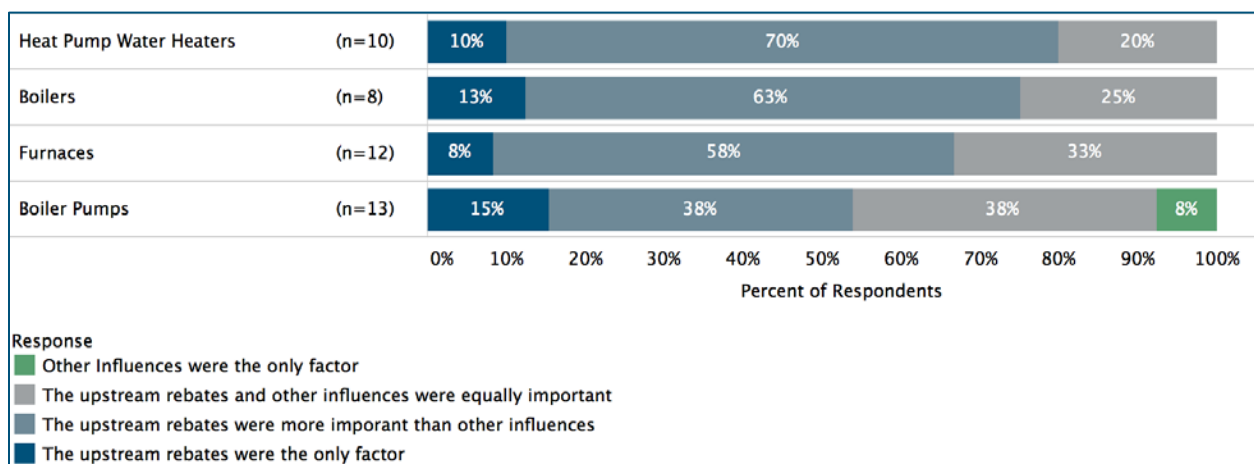


FIGURE 9: INFLUENCE OF UPSTREAM REBATES VS. OTHER INFLUENCES FOR STOCKING AND SELLING ENERGY EFFICIENCY EQUIPMENT

1.6 How do Distributors Promote the Program and What Data do They Collect?

Respondents were asked about how they promote the program, when they apply the program rebate, whether they seek the rebate for all projects, and what data they request from customers. Figure 10, Figure 11, Figure 12, and Figure 13 depict findings from these questions, and the following bullets summarize the key findings related to this analysis:

- Most distributor respondents promote the program through one-on-one conversations, followed by the Energize CT literature and other literature. In-store demonstrations and counter days are employed less frequently.
- Most distributors surveyed report that they apply the rebate before receiving confirmation of a customer's eligibility, and no distributors reported not seeking rebates for all eligible projects.
- All distributors collect data on the name of the end-use customer, and most collect basic demographic data on customers and contractors, a smaller proportion collect information on customers' service territory, and a very small proportion of distributors collect information about customers' account number.

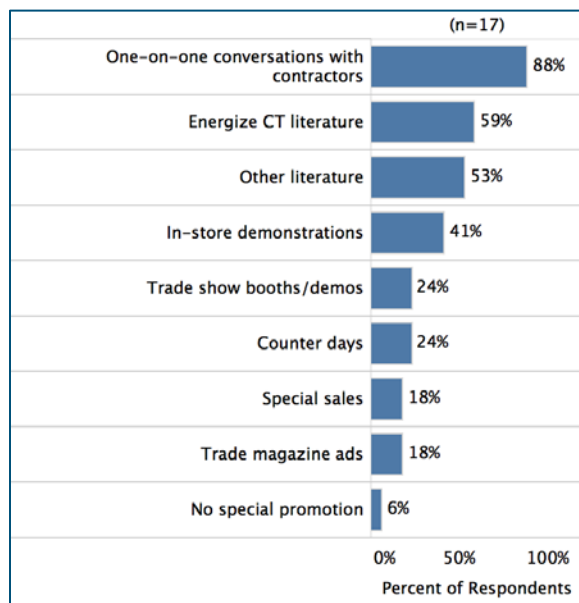


FIGURE 10: HOW DO YOU PROMOTE THE PROGRAM?

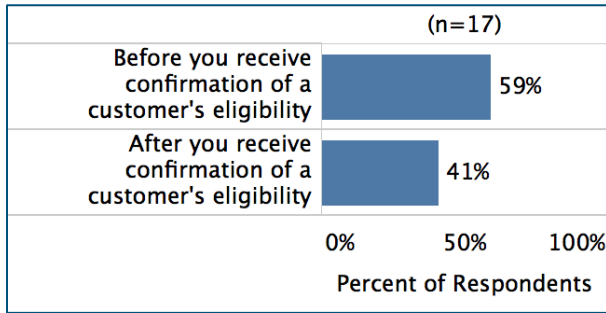


FIGURE 11: WHEN DO YOU APPLY THE REBATE?

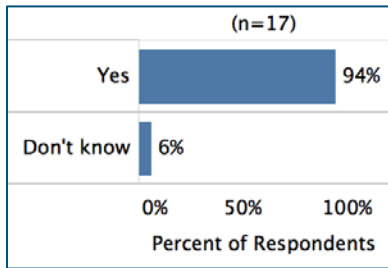


FIGURE 12: DO YOU SEEK REBATES FOR ALL PROJECTS?

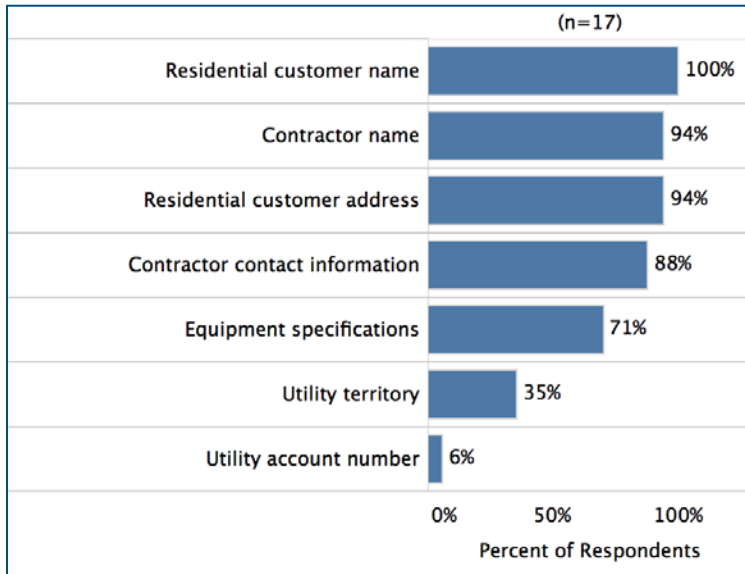


FIGURE 13: DATA COLLECTED ABOUT CUSTOMERS

1.7 To What Extent have Distributors Participated in Outreach and Training Events?

Respondents were asked about whether they had participated in an Energize CT training, when they last attended an Energize CT training, why they have not participated in a training or have not participated recently, and what topics they learned about in their training. Figure 14, Figure 15, Figure 16, Figure 17, and Figure 18 depict findings from these questions, and the following bullets summarize the key findings related to this analysis:

- More than 3 out of 4 distributors surveyed had participated in an Energize CT training, and most of those who had participated in training last participated in 2016 or 2017. The smaller proportion of respondents who last participated in 2017 versus 2016 is likely due to the survey being conducted mid 2017.
- Of the 8 respondents who provided a reason why they either had not participated in a training or had not participated recently, 3 felt that they could get the information they needed from sources outside of the training, while other responses included concerns about lack of time or awareness. The limited number of responses does not provide evidence of a clear pattern of reasons why respondents had not participated.
- Among the distributors who did attend training, most reported training topics that included logistical considerations for program participation. Unsurprisingly, few respondents reported learning technical details about eligible equipment.

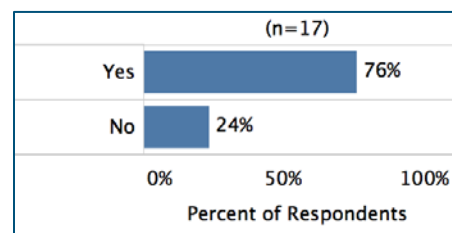


FIGURE 14: HAVE YOU PARTICIPATED IN AN ENERGIZE CT TRAINING?

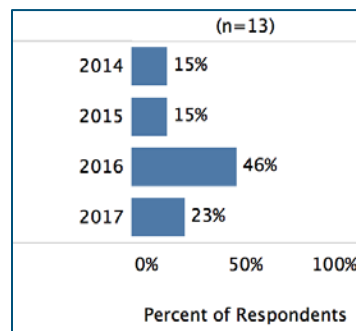


FIGURE 15: WHEN WAS THE LAST ENERGIZE CT TRAINING YOU ATTENDED?

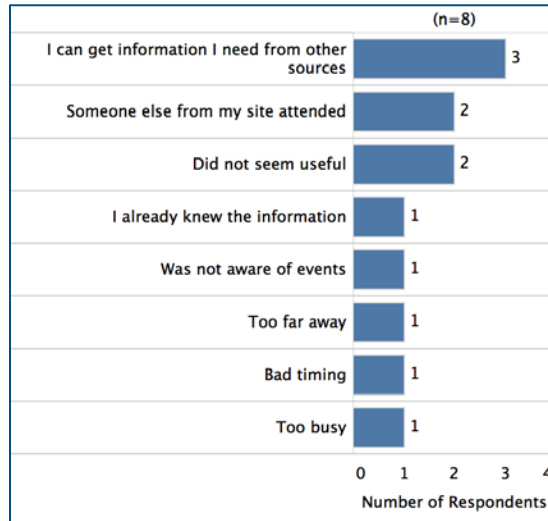


FIGURE 16: WHY HAVEN'T YOU PARTICIPATED IN A TRAINING / PARTICIPATED RECENTLY

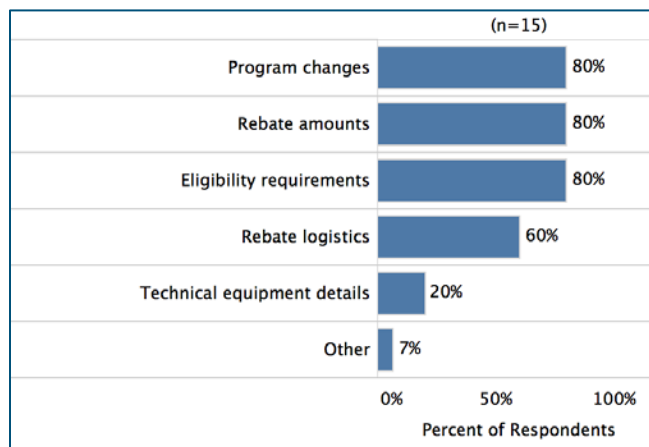


FIGURE 17: WHAT TOPICS WERE COVERED IN THE ENERGIZE CT TRAININGS YOU HAVE ATTENDED?

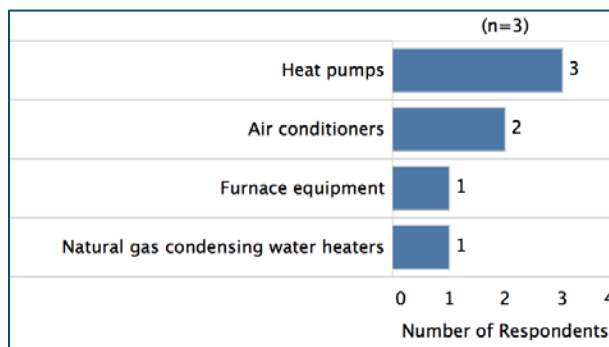


FIGURE 18: WHAT EQUIPMENT DID YOU LEARN ABOUT IN THE ENERGIZE CT TRAINING (FOR PARTICIPANTS IN EQUIPMENT TRAINING)

1.8 How Satisfied are Distributors with the Program?

Respondents were asked about their level of satisfaction with components of the program. Figure 19 depicts respondents’ satisfaction with the dollar amount of the rebate, and Figure 20 depicts respondents’ satisfaction with other program components. The following bullets summarize the key findings related to this analysis:

- Using the proportion of distributors who reported feeling very satisfied or somewhat satisfied as an indicator of overall satisfaction, respondents were most satisfied with the rebates associated with high-efficiency furnaces, followed by heat pump water heaters and high-efficiency boilers. Respondents were less satisfied with the dollar amount of boiler circulating pumps, although most respondents were still either very satisfied or somewhat satisfied with the dollar amount of the boiler circulating pumps.
- Of all program components, the greatest proportion of respondents reported feeling very satisfied or somewhat satisfied with the program training, the quality of information about the program, and the enrollment process for participating in the program. Respondents were least satisfied with the administrative process for dealing with rebates and the time taken to receive the rebates. It appears that these factors had a negative impact on overall program satisfaction.

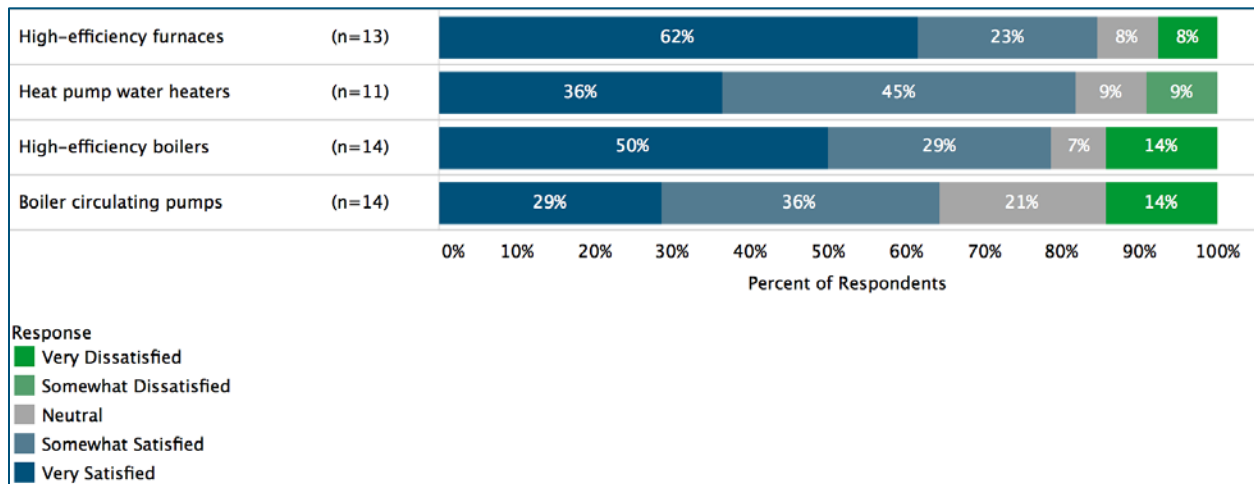


FIGURE 19: HOW SATISFIED ARE YOU WITH THE DOLLAR AMOUNT OF THE REBATE?

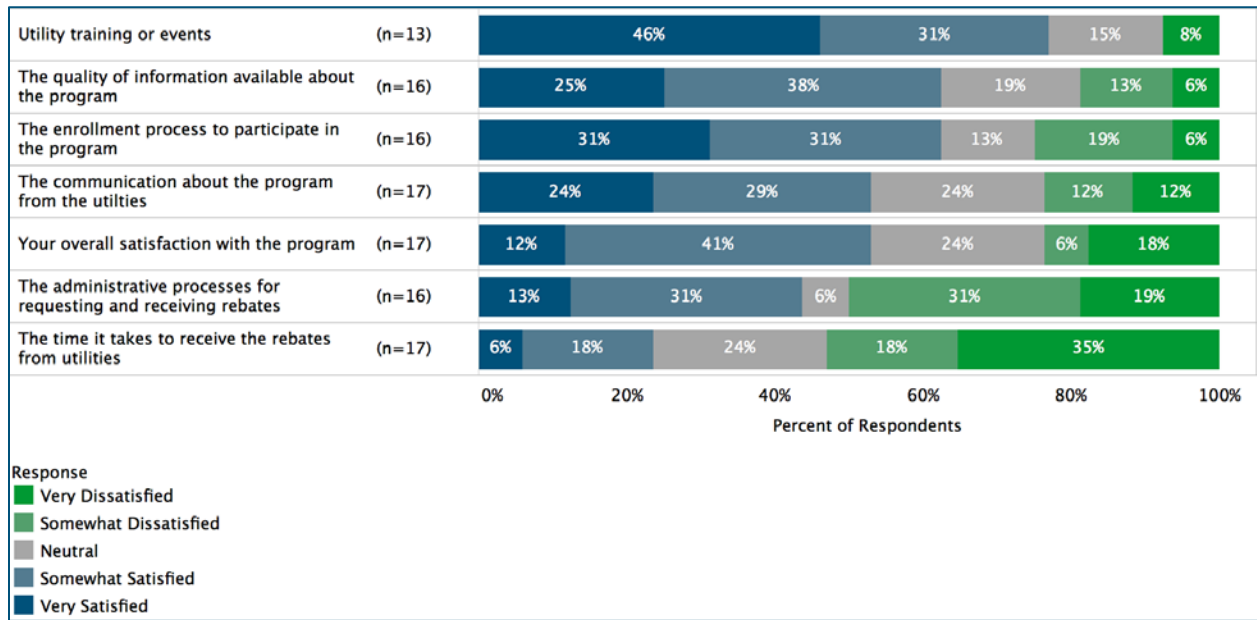


FIGURE 20: SATISFACTION WITH OTHER PROGRAM COMPONENTS

Appendix H

Contractor Survey Findings

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 1.5 What are Contractors’ Perspectives on the Availability of High-Efficiency Equipment?5

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1 Contractor Survey Findings

The following sections present findings from the process evaluation related to sources of contractor awareness about the program, how contractors communicate program offerings to their customers, the sources of motivation for contractors selling high-efficiency equipment, the factors that prevent contractors from selling more high-efficiency equipment, contractors' perspectives on the availability of high-efficiency equipment, how contractors experience program processes, the extent to which contractors have attended program trainings, and contractor satisfaction with the program.

1.1 How did contractors become aware of the program?

Respondents were asked how they became aware of the program. Figure 1 depicts responses to this question by contractor equipment groups.

- There are no meaningful differences in the pattern of responses between equipment groups
- Across equipment groups, a majority of respondents learned about the program from a distributor from whom they buy equipment
- Respondents were also likely to have learned about the program through an Energize CT email or newsletter, and several respondents reported learning about the program through an Energize CT-sponsored event.

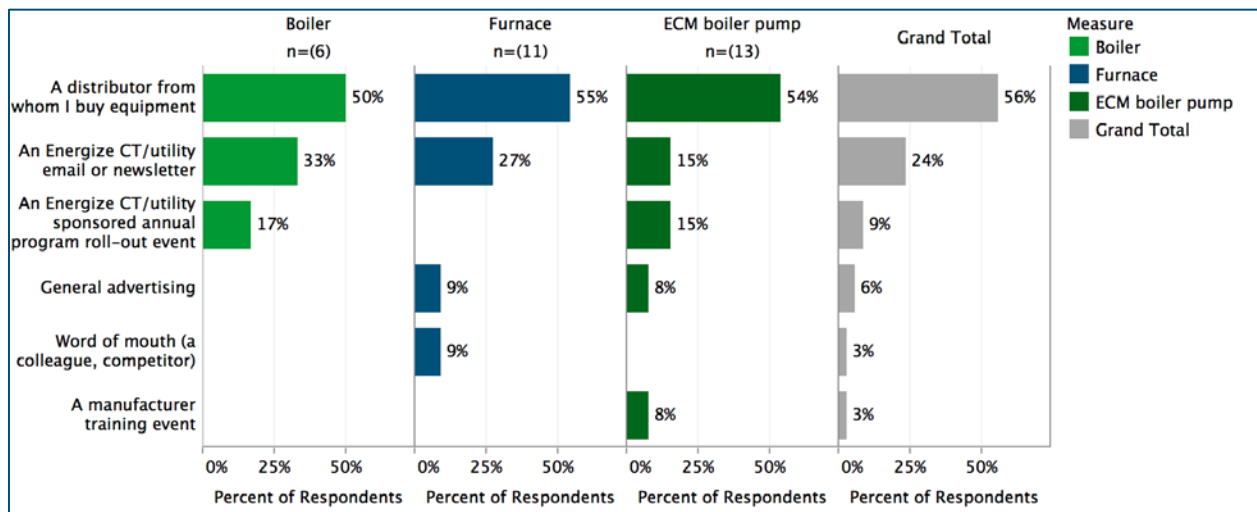


FIGURE 1: SOURCES OF AWARENESS BY CONTRACTOR GROUP

1.2 How do Contractors Communicate Program Offerings to Their Customers?

Contractors were asked how they refer to the program and when they typically discuss the program with customers. Figure 2 and Figure 3 depict findings related to these questions.

- Most contractors refer to the program as an instant rebate from energize CT, particularly among contractors who install boilers or heat pump water heaters. A smaller proportion of contractors refer to the program as an instant discount from Energize CT.
- Contractors typically discuss the program offering during the project scoping phase, with a smaller proportion discussing the offering when presenting a bid.

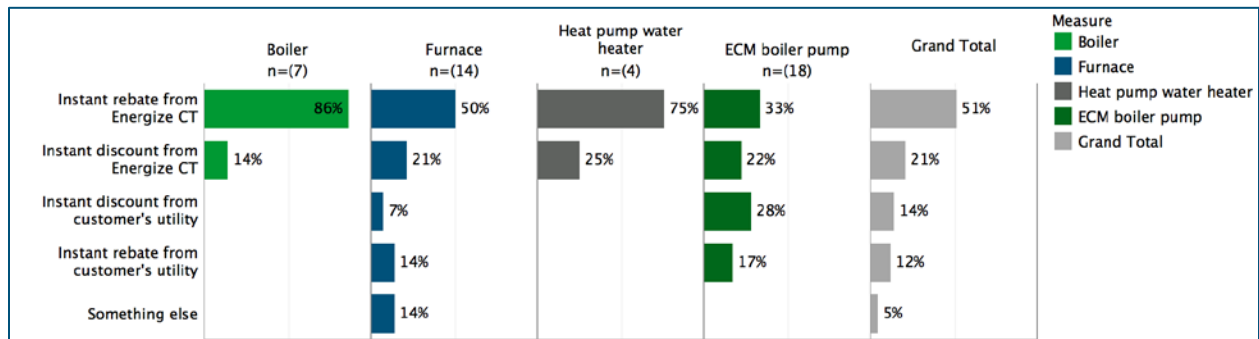


FIGURE 2: CONTRACTOR NAME FOR PROGRAM

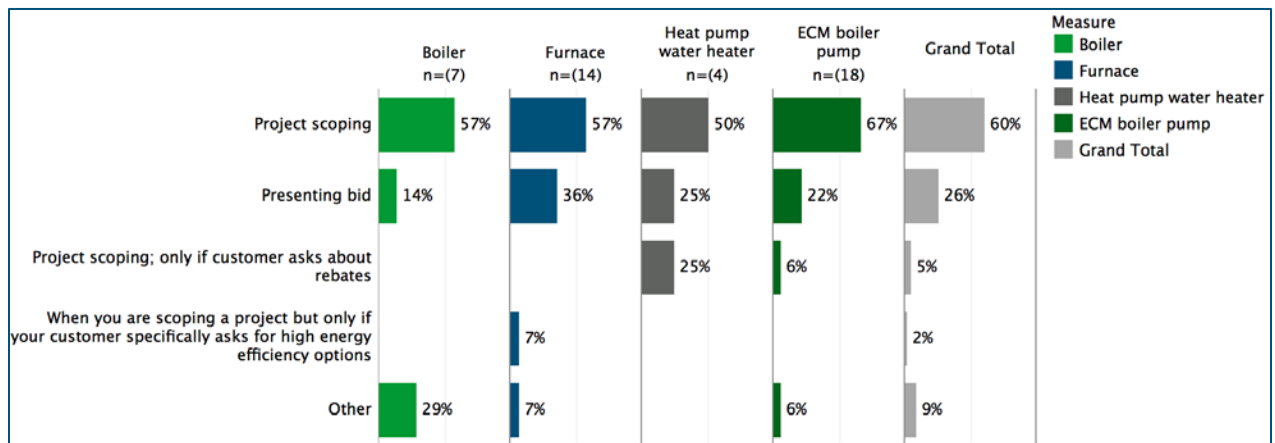


FIGURE 3: WHEN CONTRACTORS DISCUSS PROGRAM OFFERING

1.3 What Motivates Contractors to Sell High Efficiency Equipment?

Contractors were asked why they sell high-efficiency equipment and how the program supports them in selling more high-efficiency equipment. Figure 4 and Figure 5 depict findings related to these questions.

- Contractors were typically motivated to sell high-efficiency equipment due to the low incremental cost of high-efficiency equipment, the higher profit margin, and the reduced environmental impact. Contractors were least likely to say that they were motivated to sell high-efficiency equipment because of reliability concerns.
- Contractors were most likely to say they were motivated to participate in the program because of the price point of the high-efficiency options. Contractors who install furnaces were more likely to use the program as a hook for opening conversations about high-efficiency equipment than other contractors.

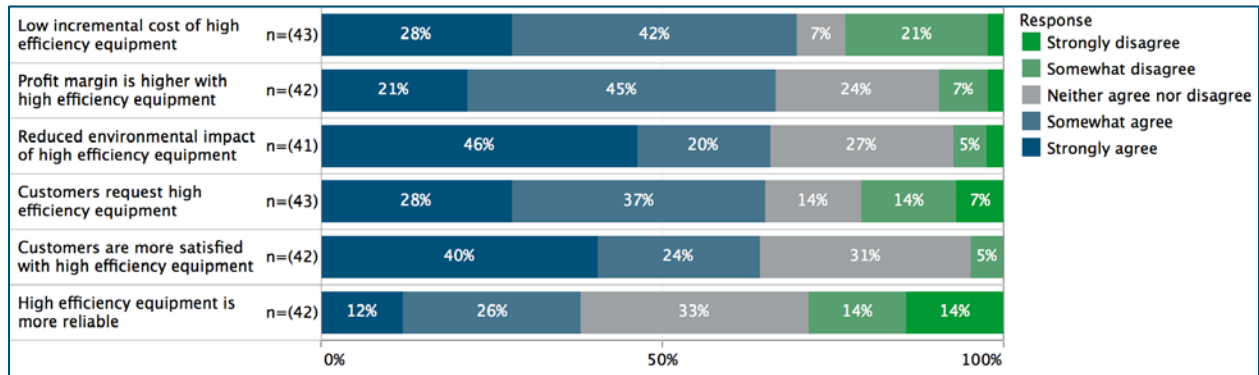


FIGURE 4: PARTICIPATING CONTRACTOR MOTIVATIONS FOR SELLING HIGH-EFFICIENCY EQUIPMENT

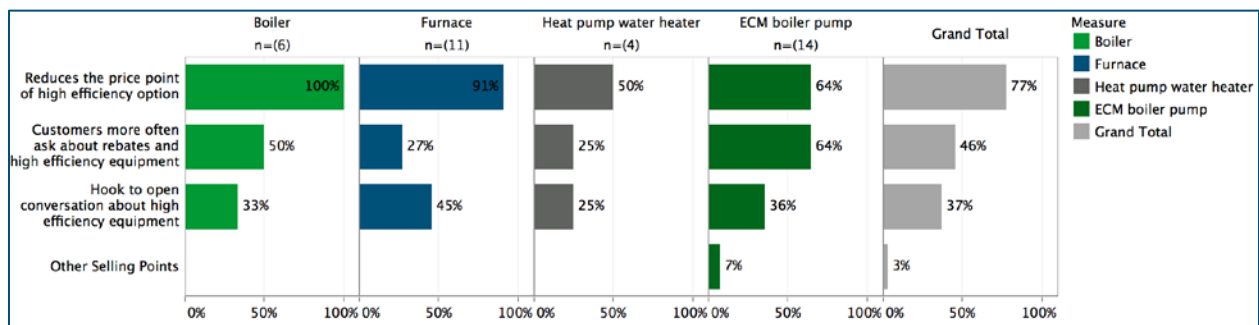


FIGURE 5: PARTICIPATING CONTRACTOR INITIAL MOTIVATIONS FOR PARTICIPATING IN THE PROGRAM

1.4 What Factors Prevent Contractors from Selling More High-Efficiency Equipment?

Contractors were asked about the barriers that prevented them from selling more high-efficiency equipment and about their specific equipment concerns. Figure 6, Figure 7, and Figure 8 depict findings related to these questions.

- The most strongly endorsed barrier to selling more high-efficiency equipment was the size of the premium for high-efficiency equipment versus standard equipment, suggesting that the rebate is filling an important need.
- Very few contractors felt that low customer satisfaction with high-efficiency equipment was a meaningful barrier to selling more high-efficiency equipment.
- Across barrier categories, contractors who installed heat pump water heaters were more likely to report strong agreement with the presence of barriers to selling high-efficiency equipment. Contractors who installed furnaces reported the fewest strong barriers to selling high-efficiency equipment.
- The most commonly reported equipment concern among contractors was the lack of available replacement parts for the high-efficiency equipment, followed by more frequent customer call backs and increased maintenance needs. This suggests that equipment concerns arise from a combination of a lack of contractor training, the small size of the market for specialty high-efficiency equipment, and maintenance concerns possibly due to flaws in the existing equipment itself.

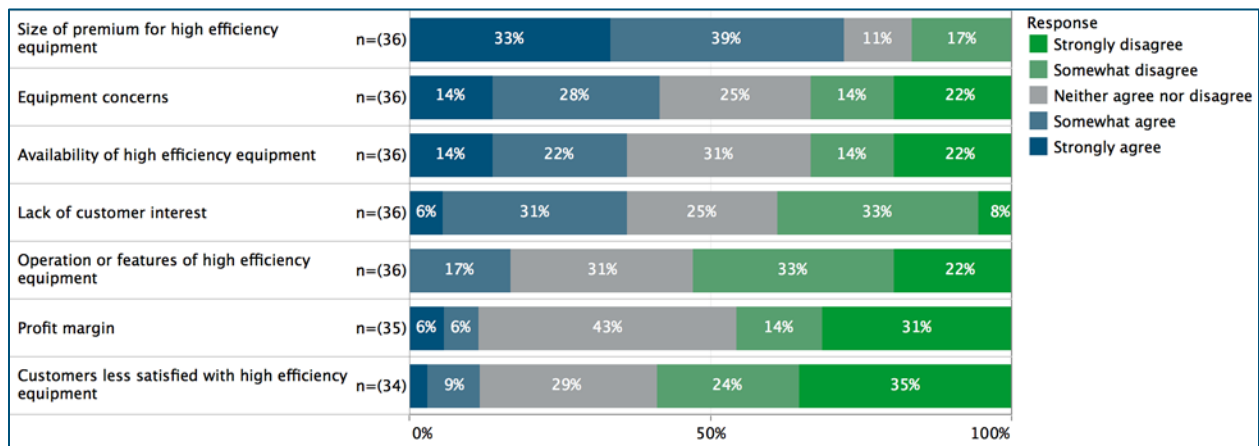


FIGURE 6: CONTRACTOR BARRIERS

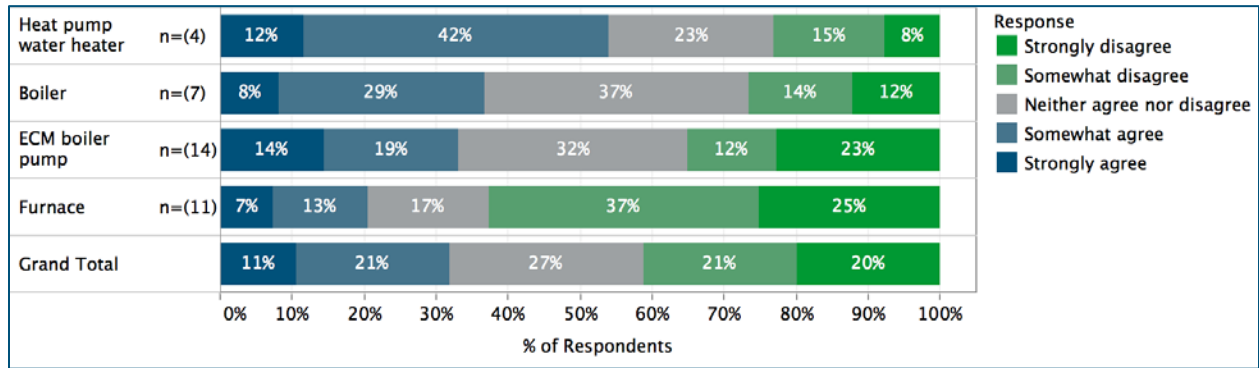


FIGURE 7: CONTRACTOR BARRIERS SUMMARY

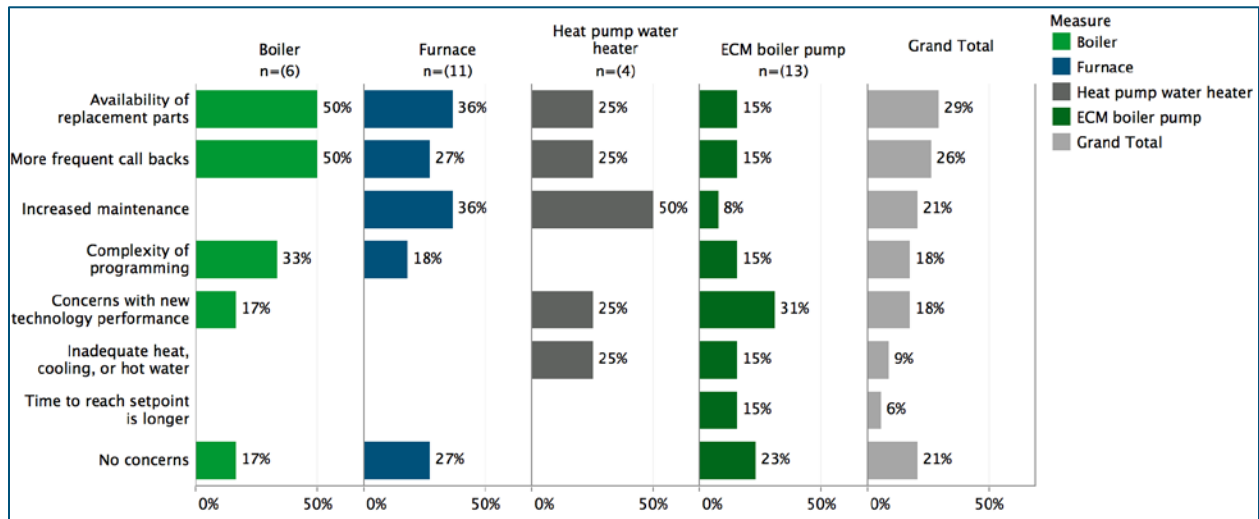


FIGURE 8: CONTRACTOR EQUIPMENT CONCERNS

1.5 What are Contractors’ Perspectives on the Availability of High-Efficiency Equipment?

Contractors were asked about the availability of energy efficiency equipment since the program’s inception in 2013. Figure 9 and Figure 10 depict findings related to these questions.

- Overall, most contractors felt that equipment efficiency and selection had both improved since 2013.
- A sizable majority of contractors felt that the selection of equipment had increased since 2013, even among the group of contractors who install ECM boiler pumps who felt that the efficiency of the equipment had not improved since 2013.
- Most contractors attributed the changes in availability to the upstream rebates, and the associated cost reduction and demand increases.

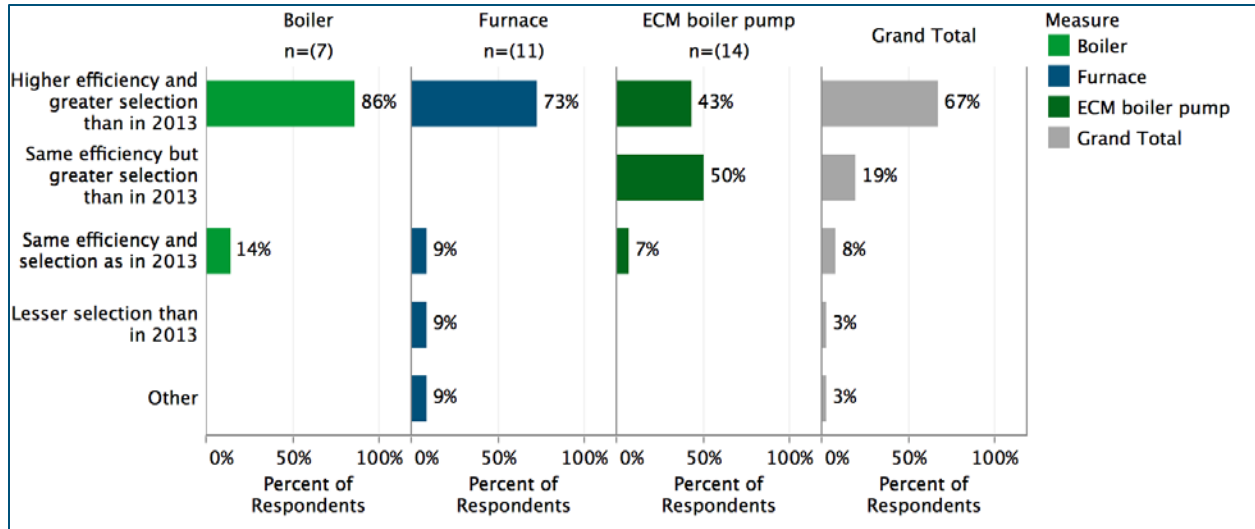


FIGURE 9: PERCEIVED AVAILABILITY CHANGES SINCE 2013

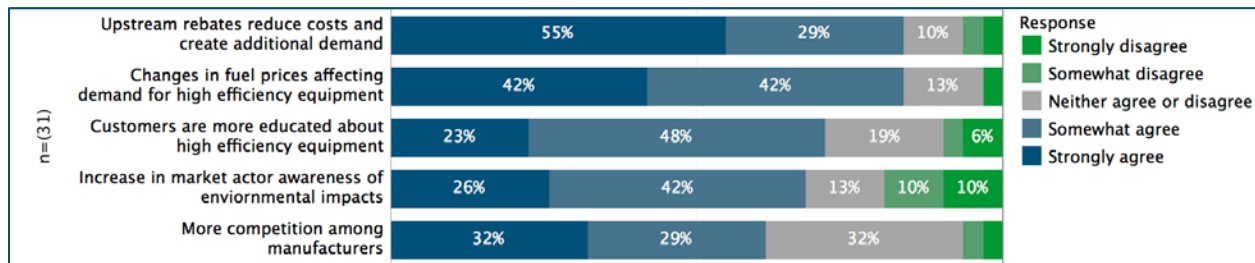


FIGURE 10: REASONS FOR EQUIPMENT AVAILABILITY CHANGES

1.6 How do Contractors Experience Program Processes?

Contractors were asked about the availability of energy efficiency equipment since the program’s inception in 2013. Figure 11, Figure 12, Figure 13, Figure 14, and Figure 15 depict findings related to these questions.

- Fewer contractors said that they only offer rebate-eligible equipment than said that they offer standard equipment in addition to rebate-eligible equipment. Most contractors said that the mix of rebate-eligible vs. ineligible equipment that they offer depends on the situation.
- Most contractors who offered standard efficiency equipment along with rebate-eligible equipment said that they did so when customers were particularly price sensitive. More than one-third of contractors said that they offer standard options as a regular practice.
- The clear majority of contractors felt that the rebate made them much more likely to recommend high-efficiency units, and only 2% of contractors felt that the availability of the rebate had no impact on their likelihood to recommend high-efficiency units.

- Most contractors felt that the rebate was either extremely or strongly influential in their decision to recommend high-efficiency equipment.
- Most contractors said that 100% of their rebates were paid by distributors at the time of purchase. Many contractors said that not all their rebates were paid at the time of purchase, which suggests some problems with program implementation.

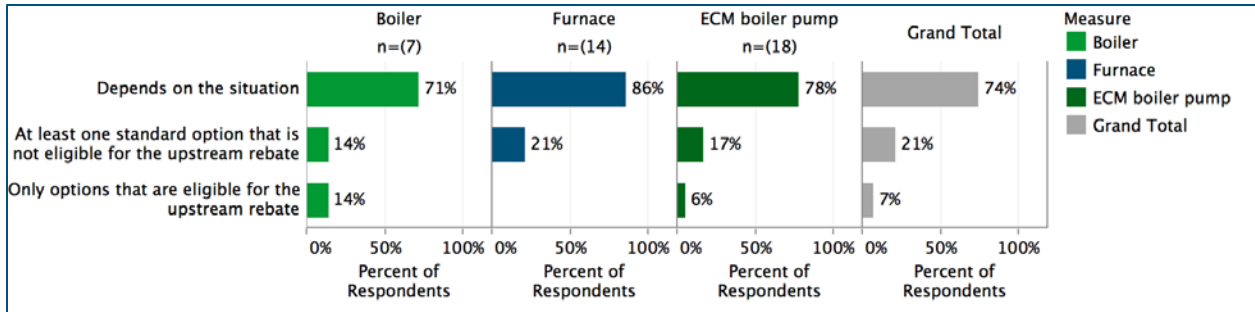


FIGURE 11: WHICH EQUIPMENT OPTIONS DO CONTRACTORS OFFER?

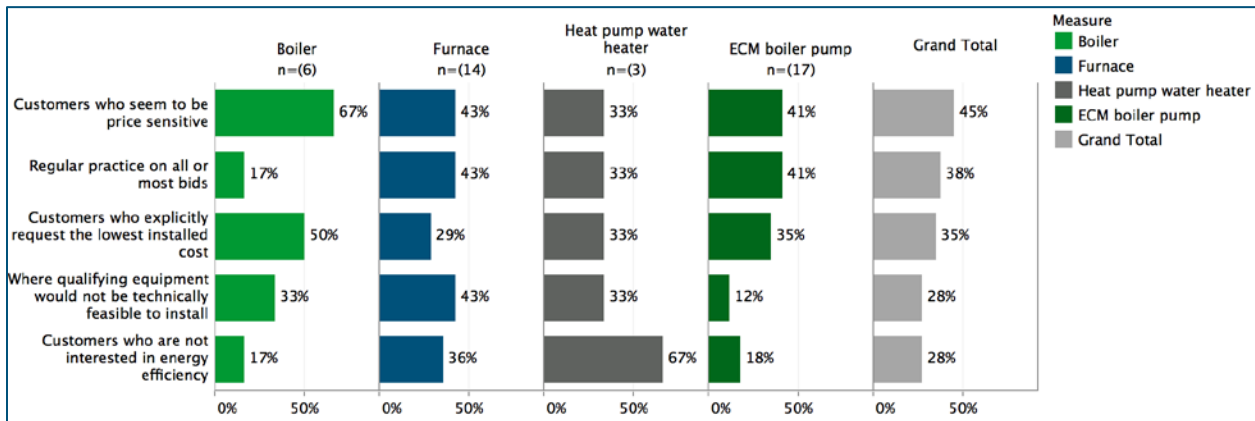


FIGURE 12: CIRCUMSTANCES IN WHICH CONTRACTORS OFFER STANDARD EFFICIENCY EQUIPMENT

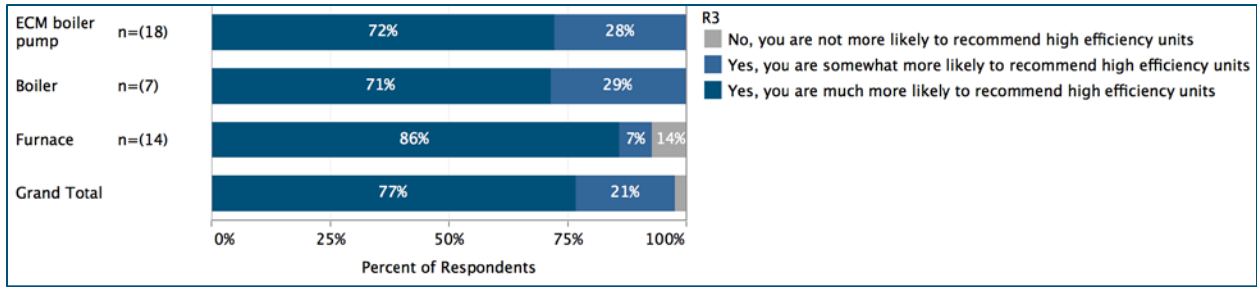


FIGURE 13: EFFECT OF UPSTREAM REBATE ON RECOMMENDATION OF HIGH-EFFICIENCY EQUIPMENT

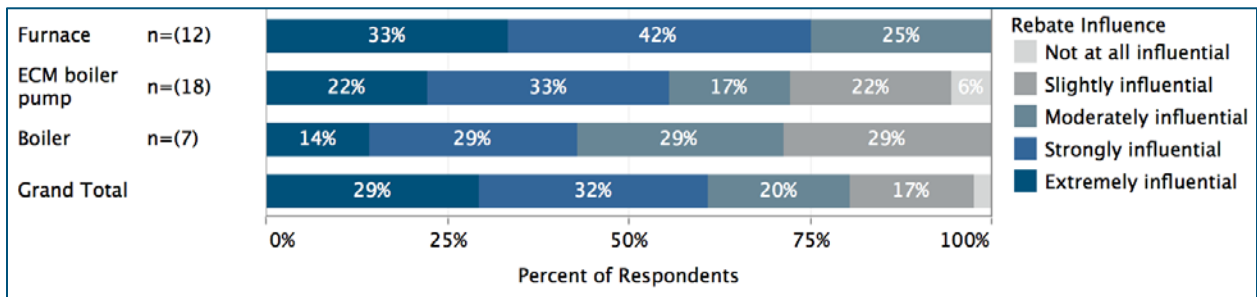


FIGURE 14: INFLUENCE OF UPSTREAM REBATES ON DECISION TO RECOMMEND HIGH-EFFICIENCY EQUIPMENT

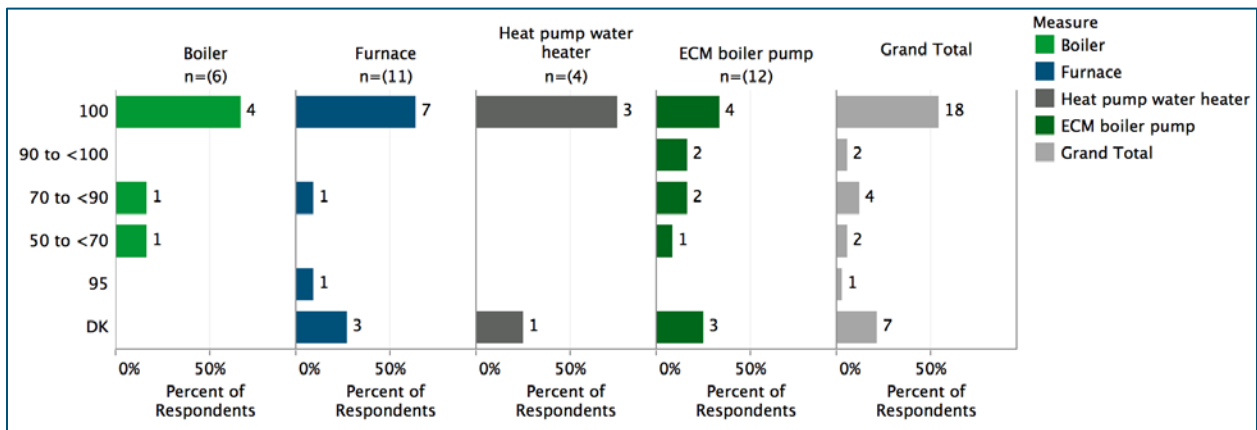


FIGURE 15: PERCENT OF REBATES PAID BY DISTRIBUTOR AT TIME OF PURCHASE

1.7 To What Extent Have Contractors Participated in Training Events?

Respondents were asked about whether they had participated in an Energize CT training, when they last attended an Energize CT training, why they have not participated in a training or have not participated recently, and what topics they learned about in their training. Figure 16, Figure

17, Figure 18, Figure 19, and Figure 20 depict findings from these questions, and the following bullets summarize the key findings related to this analysis:

- More than 3 out of 4 distributors surveyed had participated in an Energize CT training, and most of those who had participated in training last participated in 2016 or 2017. The smaller proportion of respondents who last participated in 2017 versus 2016 is likely due to the survey being conducted mid 2017.
- Of the 8 respondents who provided a reason why they either had not participated in a training or had not participated recently, 3 felt that they could get the information they needed from sources outside of the training, while other responses included concerns about lack of time or awareness. The limited number of responses does not provide evidence of a clear pattern of reasons why respondents had not participated.
- Among the distributors who did attend training, most reported training topics that included logistical considerations for program participation. Unsurprisingly, few respondents reported learning technical details about eligible equipment.

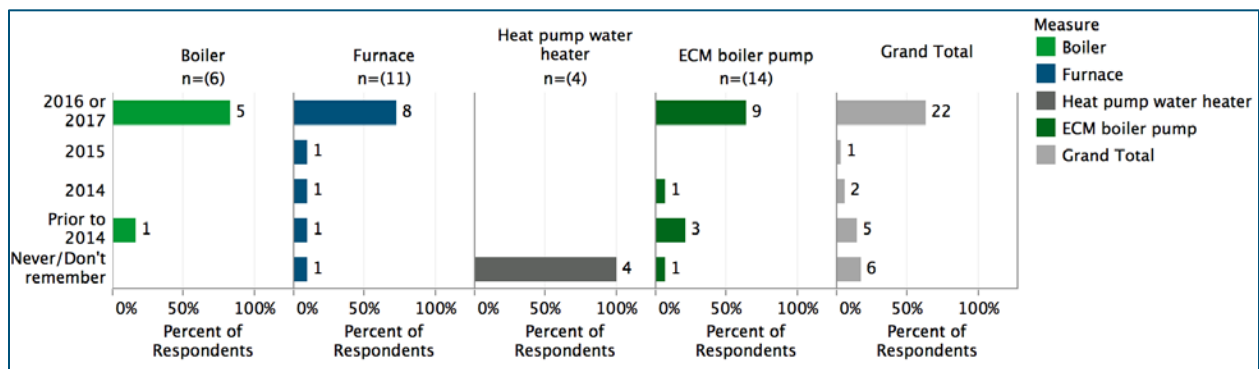


FIGURE 16: MOST RECENT TRAINING CONTRACTORS ATTENDED

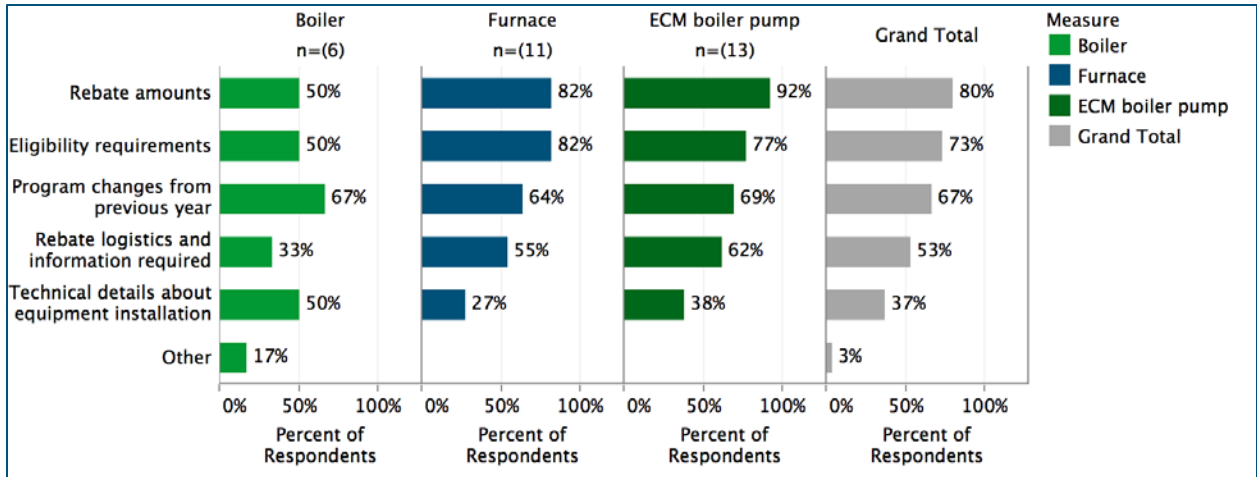


FIGURE 17: TOPICS COVERED IN CONTRACTOR TRAINING

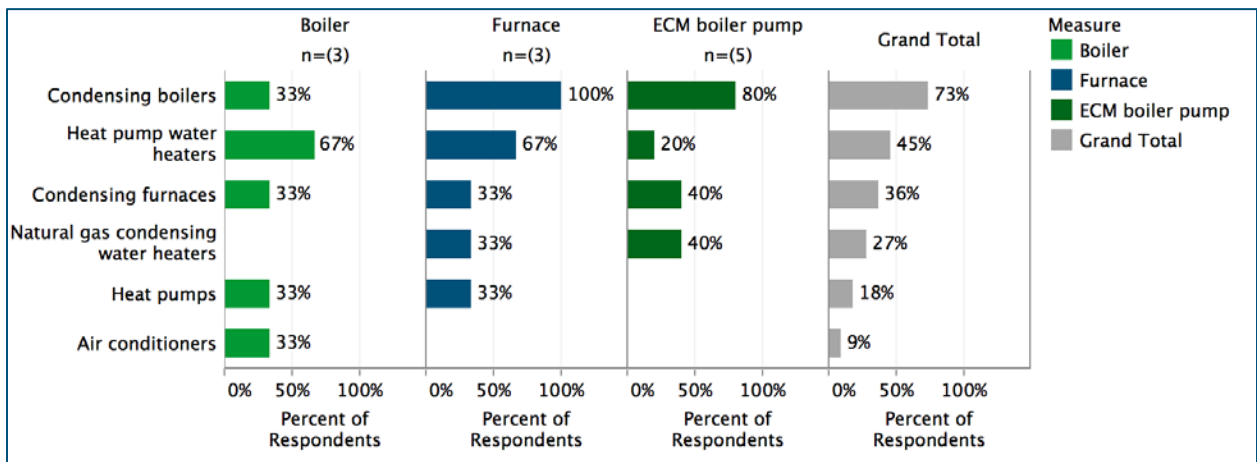


FIGURE 18: EQUIPMENT TRAINING RECEIVED BY CONTRACTORS

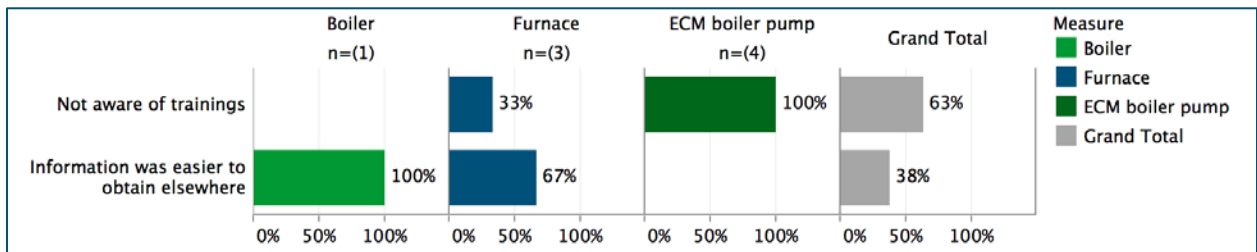


FIGURE 19: WHY DO CONTRACTORS NOT PARTICIPATE IN TRAININGS?

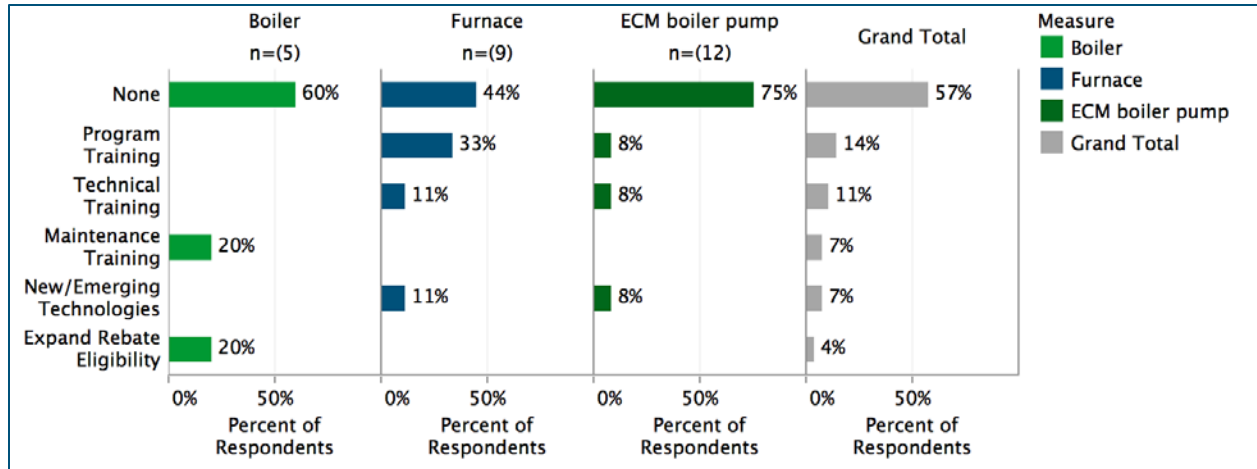


FIGURE 20: RECOMMENDATIONS FOR FUTURE TRAININGS

1.8 How Satisfied are Contractors with the Program?

Respondents were asked about their level of satisfaction with components of the program. Figure 21 depicts respondents' satisfaction with the dollar amount of the rebate, and Figure 22 depicts respondents' satisfaction with other program components. The following bullets summarize the key findings related to this analysis:

- Using the proportion of distributors who reported feeling very satisfied or somewhat satisfied as an indicator of overall satisfaction, respondents were most satisfied with the rebates associated with high-efficiency furnaces, followed by heat pump water heaters and high-efficiency boilers. Respondents were less satisfied with the dollar amount of boiler circulating pumps, although most respondents were still either very satisfied or somewhat satisfied with the dollar amount of the boiler circulating pumps.
- Of all program components, the greatest proportion of respondents reported feeling very satisfied or somewhat satisfied with the program training, the quality of information about the program, and the enrollment process for participating in the program. Respondents were least satisfied with the administrative process for dealing with rebates and the time taken to receive the rebates. It appears that these factors had a negative impact on overall program satisfaction.

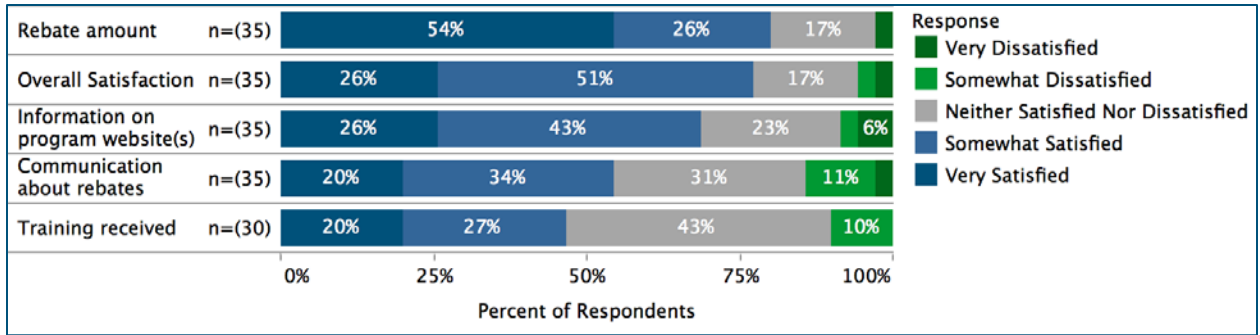


FIGURE 21: CONTRACTOR SATISFACTION WITH PROGRAM COMPONENTS

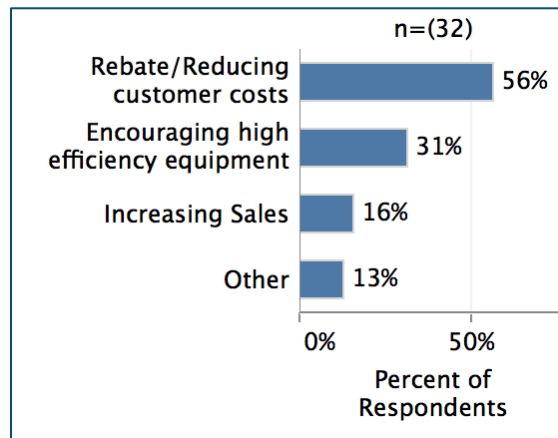


FIGURE 22: MOST VALUABLE ASPECT OF THE PROGRAM

Appendix I

Customer Survey Findings

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1.1 Customer Survey Findings

The following sections present findings from the process evaluation related to participant demographic and home characteristics, sources of awareness, motivations, equipment funding, barriers, and satisfaction.

1.1.1 Participant Demographics and Home Characteristics

The following describes the characteristics of participants in the CT Residential HVAC program, including income, age, education, household occupancy, and geographical distribution of participants. Overall, participants were older and had higher incomes and educational attainment than Connecticut’s adult population, consistent with program design that requires home ownership. Boilers and furnaces were concentrated in central and southern Connecticut, while heat pump water heaters were largely distributed across rural Connecticut.

Figure 1 shows the distribution of household incomes by measure type. Overall, the median income of respondents was between \$100,000 and less than \$150,000, compared with \$68,000 for Connecticut overall. The proportion of participants with incomes of \$100,00 or more was highest for heat pump water heaters (63%) and lowest for boilers (46%), compared with 51% of furnace participants. This higher distribution of incomes is consistent with the program design because participants must own their homes and have sufficient access to funds and/or credit to qualify.

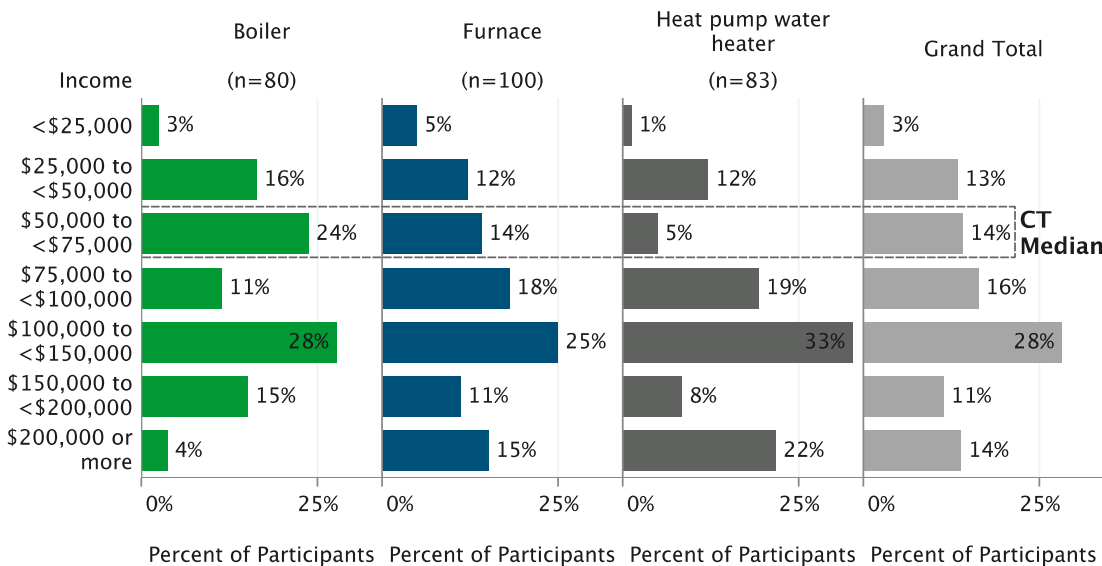


FIGURE 1: PARTICIPANT INCOME DISTRIBUTION BY MEASURE TYPE (N=263)

Participants also tended to be older than the population overall. As shown in Figure 2, 28% of program participants were 65 years or older, compared to 19% of the adult population of Connecticut. In contrast, a single respondent, representing less than 1% of the total, was under 25 (compared with 12% of the adult population). This distribution, like that of incomes, is consistent with a program targeted to homeowners; older individuals, even those with lower or fixed incomes, are more likely to own homes than younger individuals.

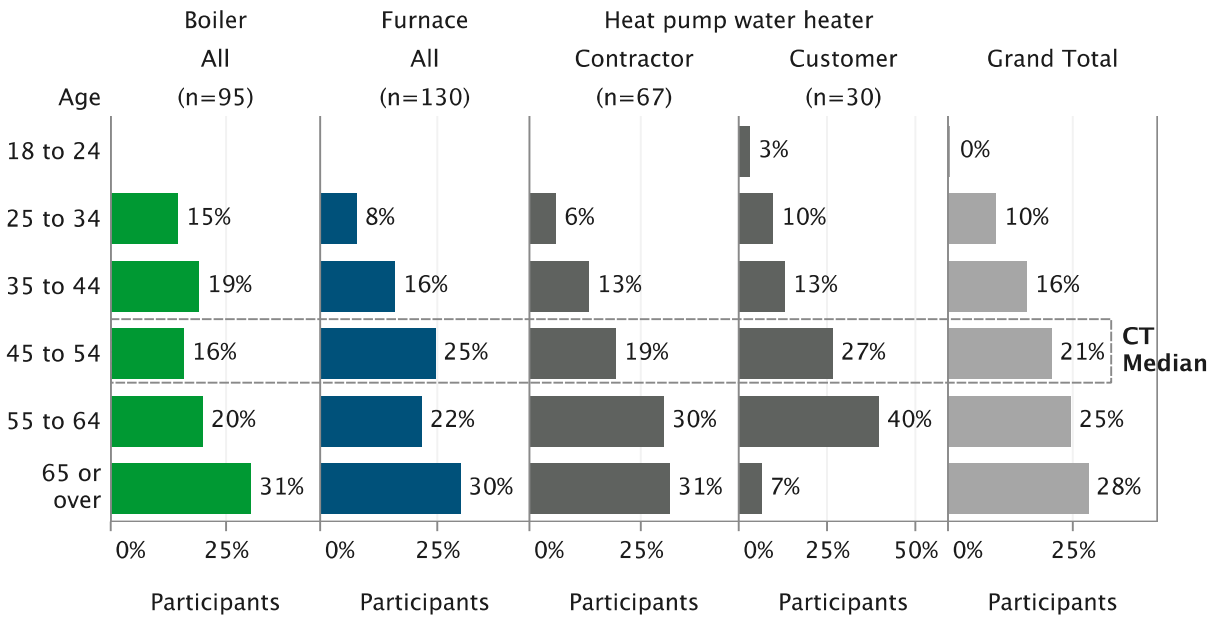


FIGURE 2: DISTRIBUTION OF PARTICIPANT AGE BY MEASURE TYPE (N=324)

Boiler and furnace buyers also reported their educational attainment. Consistent with the above findings, participants were also more highly educated than the general public. Figure 3 shows the distribution of education levels by measure type. Overall, 40% of participants held graduate or professional degrees and 30% held bachelor’s degrees, compared with 16% and 21% of the general public, respectively.

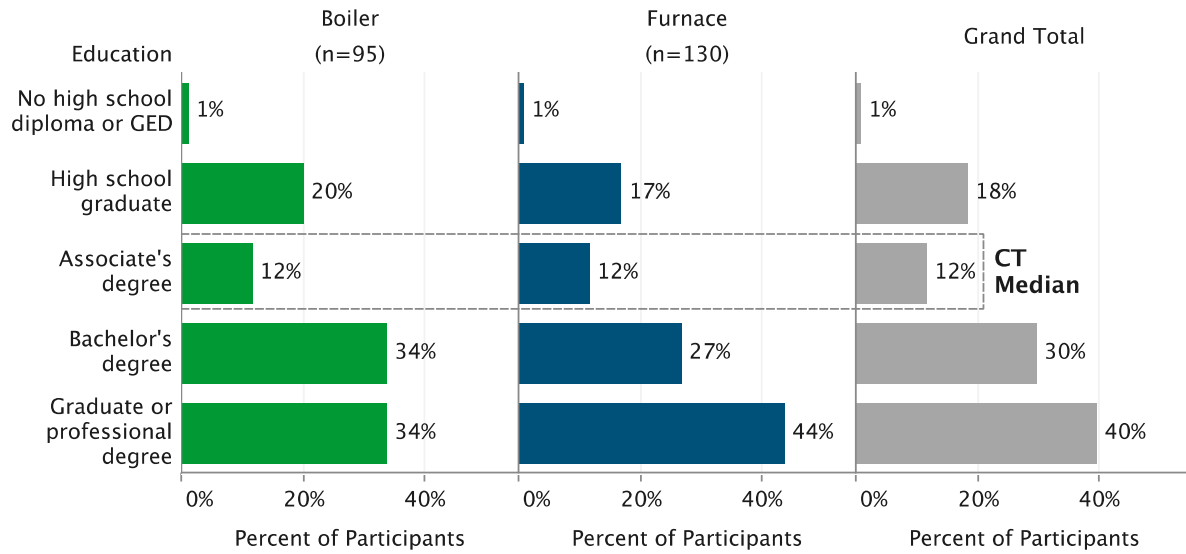


FIGURE 3: EDUCATIONAL ATTAINMENT BY MEASURE TYPE (BOILER & FURNACE MEASURES ONLY, N=225)

Comparing survey results to the US census data for Connecticut, the Evaluation Team found that customers participating in the HVAC Upstream Program overall were generally older, had higher incomes, and were more educated. When the comparison was limited to Connecticut homeowners, who are likely to reflect the population who replaces space and water heating equipment, program participants are fairly closely matched to the population of homeowners in terms of age and income.

Respondents also reported their home's approximate annual occupancy in number of weeks per year. Across all three measure types, the majority of respondents reported the home was occupied year-round, but notable differences exist, as shown in Figure 4. Boilers had the highest proportion of homes occupied year-round (84%), whereas heat pump water heaters had the lowest proportion (63%). Heat pump water heaters also had the largest proportion of homes that were occupied 46–51 weeks (31%) and less than 46 weeks per year (6%).¹ While the majority of heat pump water heaters were installed in fully occupied homes, this finding may suggest that heat pump water heaters are installed in more frequently in second homes than boilers and furnaces. The findings that heat pump water heaters are more commonly installed in rural areas and in a greater proportion of less-occupied are consistent; these homes may be, in some cases, second homes.

¹ Chi-square = 12.9, *p*-value = .012.

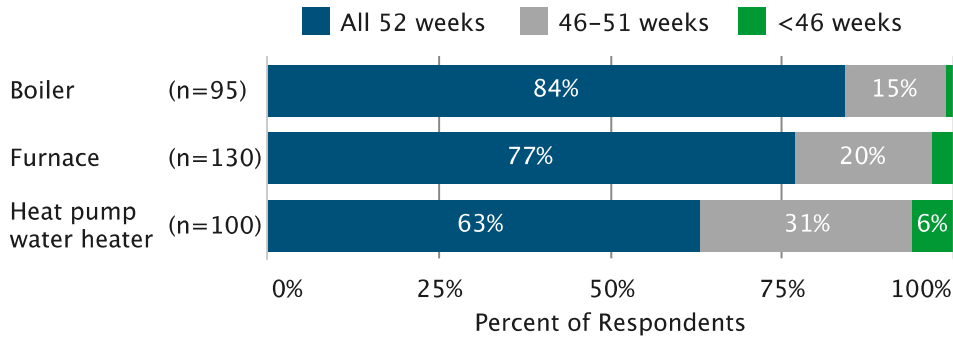


FIGURE 4: ANNUAL OCCUPANCY BY MEASURE TYPE (N=325)

1.1.2 Awareness

Participants overall became aware of the Energize Connecticut Residential HVAC program most commonly from their contractors. However, a much lower proportion of heat pump water heater buyers had their equipment installed by a contractor, so a larger proportion found out about the program from other sources, particularly from retailers.

Only around two-thirds of HPWH buyers (69%) had their equipment installed by a contractor, compared with roughly 95% of boiler and furnace buyers, as shown in Figure 5. Because participants who installed the equipment themselves (including having a friend or family member do so) represent a distinct population, “customer” installations will be shown separately where relevant.

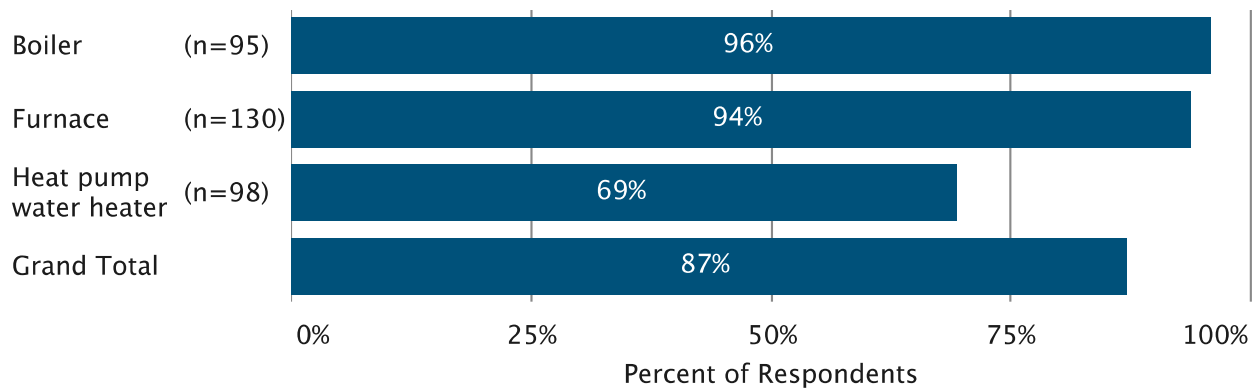


FIGURE 5: CONTRACTOR USE BY MEASURE TYPE (N=323)

A plurality of participants overall (39%) found out about the program from the contractor who installed the equipment. However, this source of awareness was most common among participants installing boilers (45%) and furnaces (50%). In contrast, only 29% of heat pump water heater buyers who used a contractor found out about the program from the contractor. In contrast, a plurality of HPWH buyers who installed the equipment themselves (“customer,” 37%) found out about the program from a retailer, which makes sense because customers can purchase HPWH from retailers. Even among, HPWH installed by contractor, non-contractor sources of awareness were more common, suggesting HPWHs are more customer driven because participants are already aware of the program when a contractor becomes involved. Other common sources of awareness include utility or Energize Connecticut marketing materials (11% overall) and website (9%).

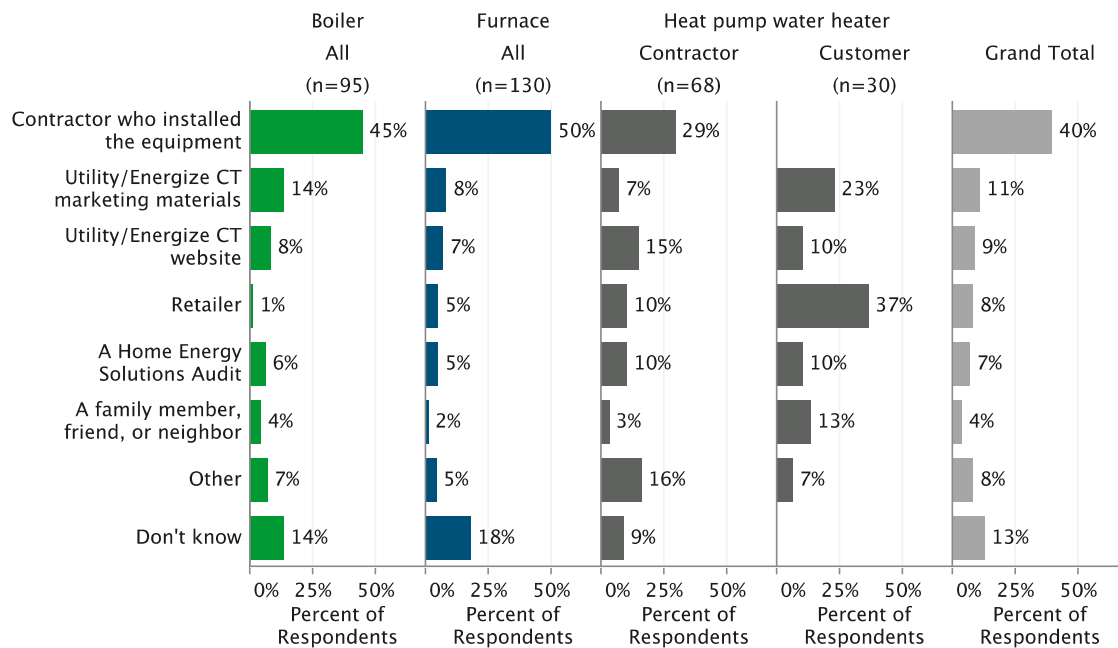


FIGURE 6: SOURCES OF AWARENESS BY MEASURE TYPE (N=325)

1.1.3 Motivations

Respondents who installed boilers and furnaces also ranked the relative importance of six factors that influenced their decision to purchase the new equipment specifically. Figure 7 shows the total number of respondents to select each consideration, with each respondent’s top three most important factors highlighted, and less important factors in light gray. The top three considerations – efficiency, cost of installation, and operating costs – were related to cost. Note that the factor “efficiency” relates to environmental or sustainability considerations in addition to cost; the dual nature of this factor may have contributed to its highest-ranked status.

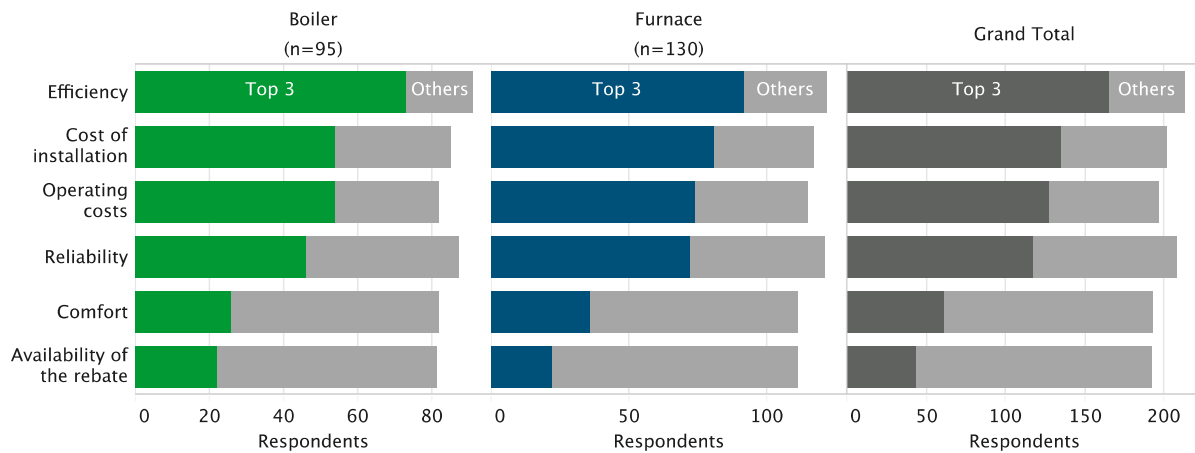


FIGURE 7: RELATIVE IMPORTANCE OF CONSIDERATIONS IN CHOOSING NEW EQUIPMENT (BOILERS AND FURNACES ONLY, N=225)

After operating costs, reliability was ranked in the top three nearly as often as operating costs, and was selected as an important factor by a greater number of respondents overall. Comfort and availability of the rebate, in contrast were ranked in the top three least frequently. The bottom ranking “availability of the rebate” is notable as another cost-related motivator; participants report to be more sensitive to the total cost than to the availability of the rebate.

Participants who installed boilers and furnaces were also asked what other equipment they considered purchasing, if any. The majority of participants (63%) reported that they did not consider any other equipment. Those who did most frequently reported either a different system entirely (16%) or a more efficient condensing system (15%). Individuals who considered a more efficient system may represent an opportunity to turn these considerations into more efficient purchase choices.

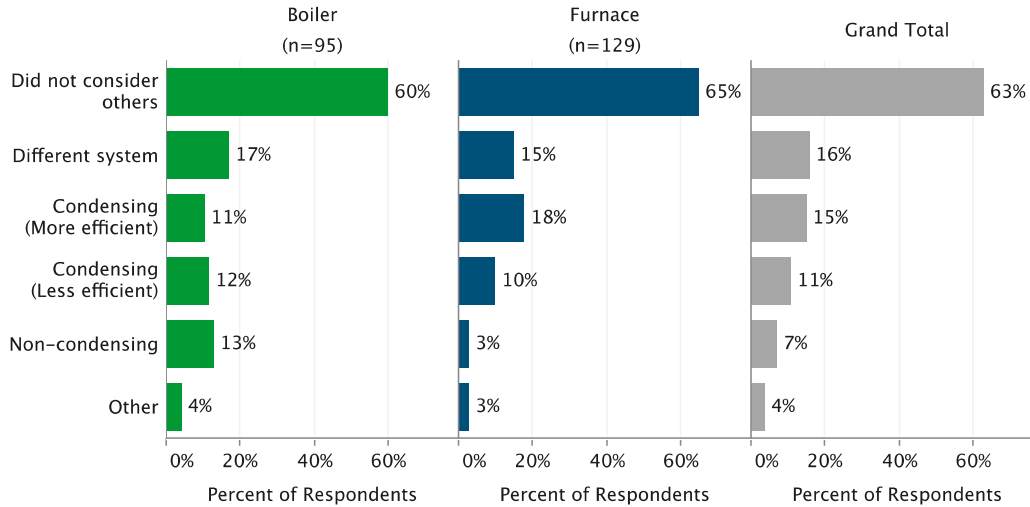


FIGURE 8: OTHER EQUIPMENT CONSIDERED (BOILERS AND FURNACES ONLY, N=224)

Though only one-third (32%) of respondents identified the utility/Energize Connecticut rebate as a funding source, over two-thirds of respondents (69%) whose equipment was installed by a contractor were aware of the rebate provided by Energize Connecticut, as shown in Figure 9. The overwhelming majority of HPWH buyers (90%) who installed the equipment themselves were aware of the rebate². This result is consistent with level of engagement expected for participants who purchase and install the equipment themselves because they must apply for the additional rebate themselves. Even so, rebate awareness was higher among participants with HPWHs installed by a contractor, suggesting greater engagement among these participants than boiler and furnace buyers.

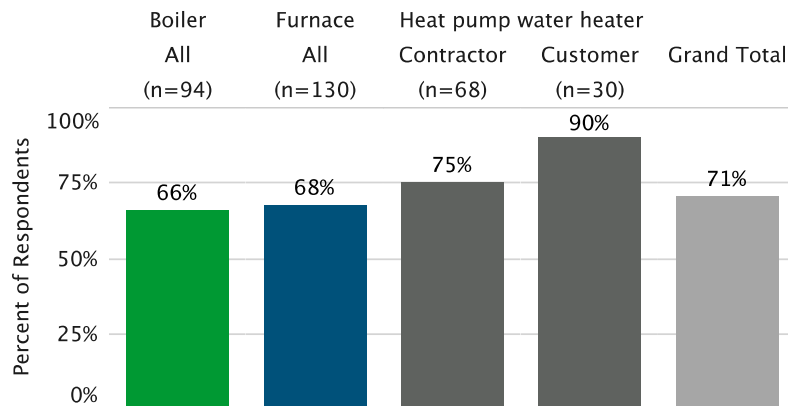


FIGURE 9: PROPORTION OF RESPONDENTS AWARE OF ENERGIZE CONNECTICUT REBATE (N=322)

² Chi-square statistic = 3.92, p-value = 0.048.

Respondents who had their equipment installed by a contractor also reported whether the contractor encouraged them to choose the high efficiency equipment. While the overwhelming majority of those who purchased boilers (89%) and furnaces (94%) reported that the contractor did encourage the high efficiency equipment, around half of heat pump water heater buyers (52%) reported the same. For all measure types, a small number of respondents explained that they contacted the contractor and asked for the high efficiency equipment specifically.

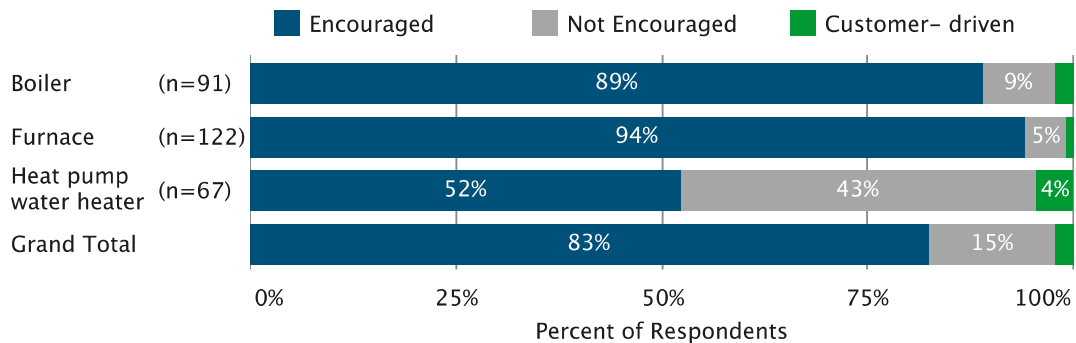


FIGURE 10: CONTRACTOR UPSELLING ACTIVITY BY MEASURE TYPE (N= 280)

Participants who had their equipment installed by a contractor also reported the relative influence of the contractor's recommendation and their own research, as summarized in Figure 11. Parallel to the above finding, 80–90% of boiler and furnace buyers reported that the contractor's influence was at least as important as their own research; in contrast, only half of heat pump water heater buyers reported the same, and a plurality (35%) reported that their research was the *only* important factor. Taken together with the sources of awareness and reports of upselling, the decision to select a heat pump water heater appears to be a customer-driven decision, rather than a contractor-driven decision.

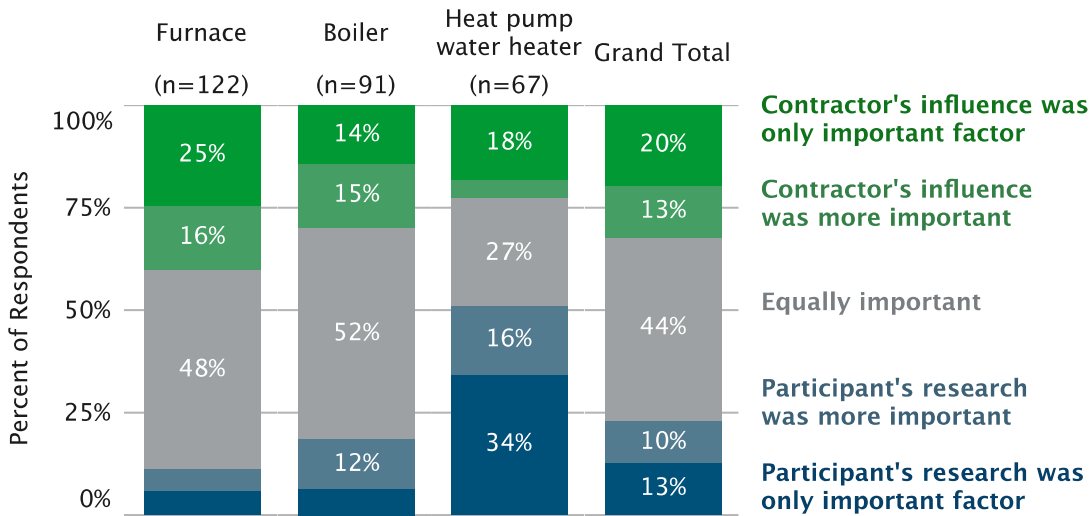


FIGURE 11: RELATIVE INFLUENCE OF CONTRACTOR AND CUSTOMER RESEARCH (N=280)

1.1.4 Equipment Funding

Over two-thirds of respondents (69%) funded the equipment purchase with their personal savings, as shown in Figure 12. However, roughly half of these respondents reported at least one other source of funding, such as a rebate or loan. While over two-thirds of participants were aware of the rebate from Energize Connecticut, only one-third (32%) also reported the rebate or discount from the utility as a funding source.

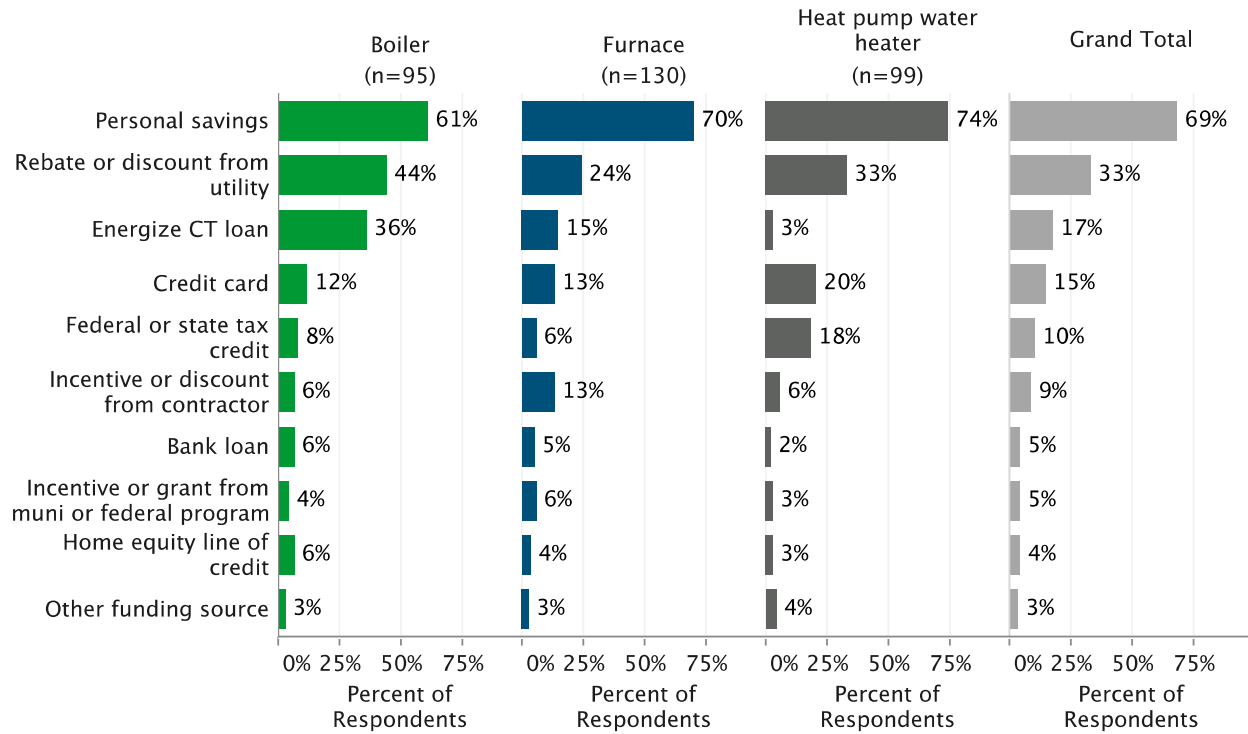


FIGURE 12: FUNDING SOURCES BY MEASURE TYPE (N=324)

Other common sources of funding included Energize Connecticut loans (17%) and credit cards (15%). Notably, Energize Connecticut loans were most common for boiler buyers (36%), followed by furnaces (15%), and least common among heat pump water heater buyers (3%). Likely, the higher reliance on Energize Connecticut and other bank loans reflects the higher costs of boilers (and, to a lesser extent, furnaces), including the cost of installation paid to the contractor that many HPWH buyers did not face. Furthermore, the largest proportion of boiler purchasers (44%) identified the rebate as a funding source; this result may also reflect that boiler buyers are more likely to see the rebate as a “funding source” to defray the cost of the upgrade, rather than an “incentive” simply to encourage high efficiency purchases.

In contrast, credit card use was highest among HPWH purchasers (20%). This finding is consistent with the high proportion of HWPB purchasers to learn about the program from a retailer and install the equipment themselves; participants making the purchase in a retail store may be more likely to simply make the purchase on a credit card than write a check or pursue another line of credit.

1.1.5 Barriers

Participants ranked the barriers to selecting high efficiency equipment. Figure 13 summarizes the barriers identified by participants ranked from most significant (dark blue) to least significant (gray), ordered by the overall percent of respondents to rank the item highest or second-highest. Paying the premium for a high efficiency unit was ranked highest overall, with over half of respondents (58%) ranking it in the top two. However, among participants to install boilers and furnaces, finding a contractor was ranked highest, with 62% and 56%, respectively, ranking it within the top two. Heat pump water heater buyers, with much lower contractor use, reported this barrier much less frequently.

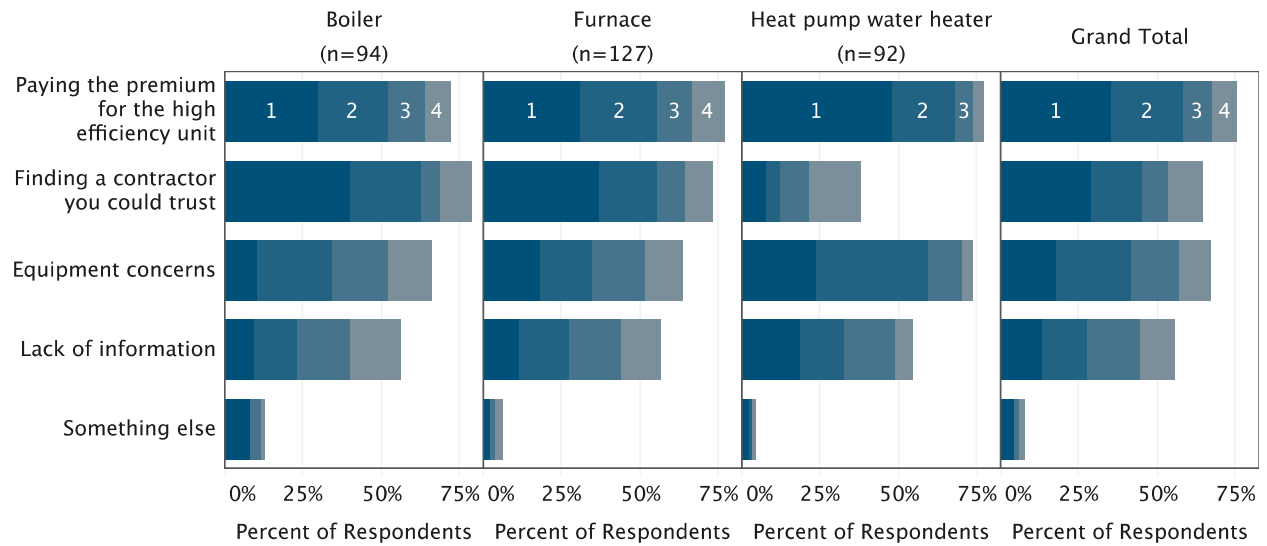


FIGURE 13: BARRIERS TO PURCHASING HIGH-EFFICIENCY EQUIPMENT, RANKED (N=313)

Respondents also identified equipment concerns and lack of information as barriers, but less often and ranked lower than the other barriers. Again, heat pump water heater buyers are an exception; 60% ranked equipment concerns in the top two barriers. This finding likely reflects both that heat pump water heaters are a new, less accepted technology among consumers, and that finding a contractor was not a relevant option for a much larger proportion of heat pump water heater buyers.

1.1.6 Experiences and Satisfaction with Contractor

Overall, participants were highly satisfied with their contractors. Figure 14 shows that over three-quarters (77%) of participants are very satisfied, and the overwhelming majority (88%) were at least somewhat satisfied.

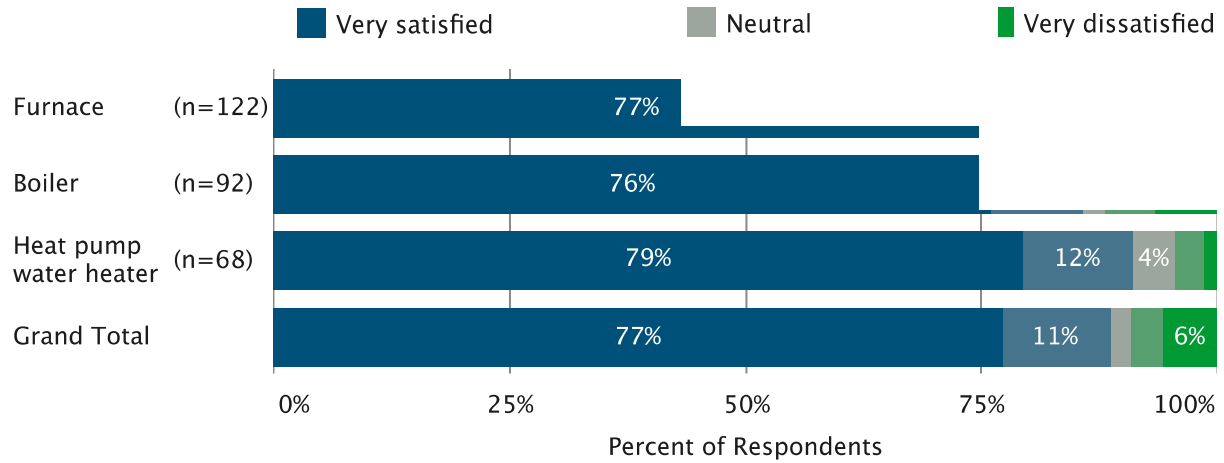


FIGURE 14: OVERALL CONTRACTOR SATISFACTION BY MEASURE TYPE (N=282)

Participants who purchased boilers and furnaces also rated their satisfaction with several aspects of their contractor’s performance. Satisfaction with these components was slightly lower than for the contractor overall, as shown in Figure 15. Participants appeared least satisfied with contractors’ explanations of offerings; however, this question received the largest share of neutral responses. Participants also indicated that they did not feel they needed additional information about the program or that they needed to be able to interact with contractors interface with the program on behalf of their organization.

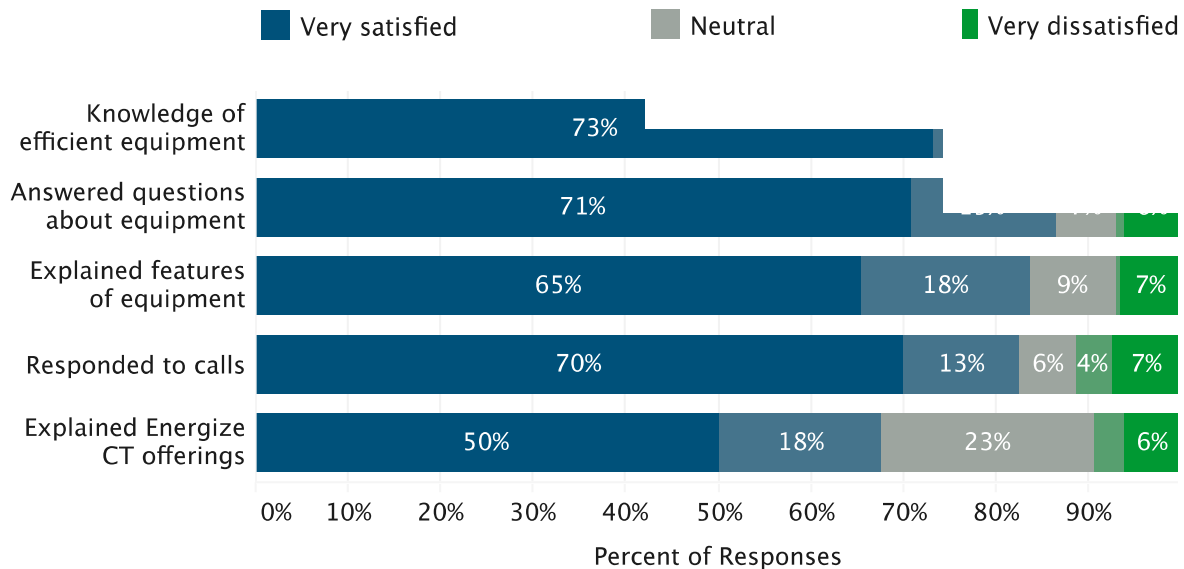


FIGURE 15: SATISFACTION WITH CONTRACTOR (BOILERS AND FURNACES ONLY, N=214)

Boiler and furnace purchasers did not report needing to provide unusual or burdensome information to the contractor in order to receive the rebate. A plurality (47%) did not recall providing any information to the contractor, while others recalled providing only basic information such as contact information, address, and utility account information. Assuming contractors require basic information such as address and customer contact information for all customers, this result suggests the contractor collected such information from customers; reports of no data collected seem to indicate that the contractor made no *additional* request for information, which would indicate a customer experience that is seamless between the contractor and the program.

1.1.7 Experiences and Satisfaction with Equipment

Respondents rated their satisfaction with a variety of measures

purchased through the program, as shown in Figure 16. Figure 16 shows overall equipment

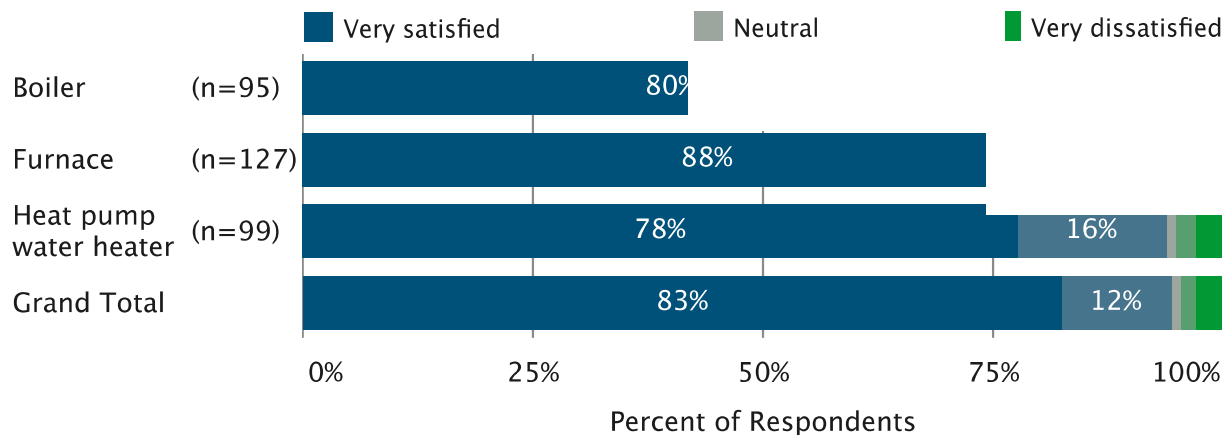


FIGURE 16: OVERALL EQUIPMENT SATISFACTION (N=321)

Overall, the overwhelming majority of all participants were at least somewhat satisfied with their equipment (95%), and over four-fifths were very satisfied (83%). No differences in satisfaction ratings between measure types were found.

Figure 17 shows participant satisfaction with various characteristics of the purchased equipment. For boilers and furnaces, satisfaction with these characteristics was nearly as high as with equipment overall. In contrast, the incidence of neutral and moderate satisfaction was notably higher among heat pump water heater purchasers, though the majority was still very satisfied with all aspects of the equipment. Additionally, satisfaction with HPWH noise level received the highest proportion of ratings indicating dissatisfaction (12%).

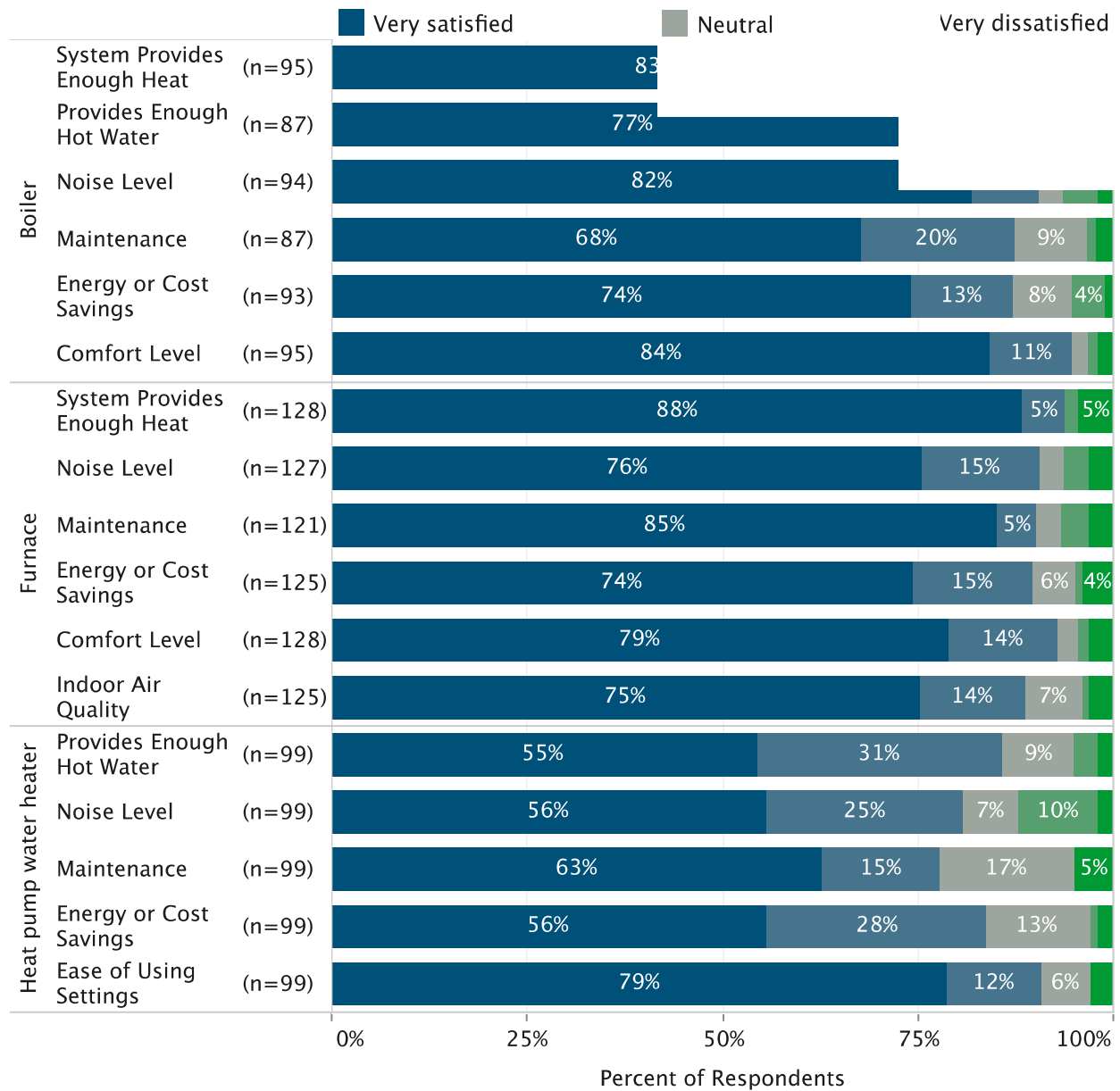


FIGURE 17: SATISFACTION WITH EQUIPMENT CHARACTERISTICS (N=322)

Notably, equipment satisfaction was higher in general among HPWH buyers who installed the equipment themselves. No participant who did so reported dissatisfaction with the HPWH overall, and dissatisfaction was also less common for equipment characteristics above among these participants. This finding likely reflects that those who installed their equipment themselves were more personally invested in the upgrade, and thus more likely to be satisfied with the equipment and experience.³

To better understand satisfaction with energy cost savings, purchasers of boilers and furnaces were asked to report whether their bills were lower, higher, or about the same as expected. Figure 18 summarizes these results. The overwhelming majority (90%) reported bills lower than expected (that is, greater savings than expected), and 9% reported bills were about the same as expected. Finally, about 2% of respondents reported that their energy bills were higher than expected (note, however, that this response does not necessarily indicate that bills did not decrease at all, but rather did not decrease to the extent expected).

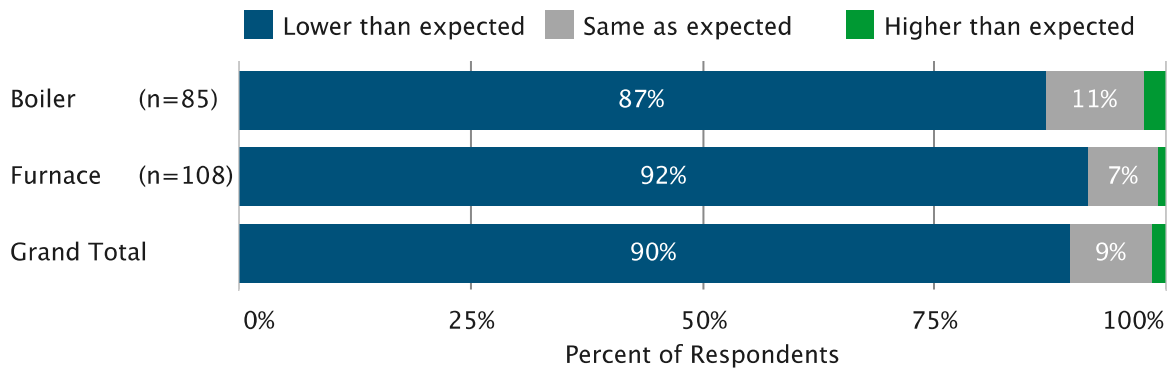


FIGURE 18: ENERGY BILLS RELATIVE TO EXPECTATIONS (BOILERS AND FURNACES ONLY, N=193)

Boiler and furnace purchasers rated their satisfaction with the rebate received from Energize Connecticut. Figure 19 shows that roughly 60% were very satisfied with the amount of the rebate across measure types. However, a larger share of furnace rebate recipients was very dissatisfied (9%) or neutral (18%), bringing the total proportion of respondents who were not somewhat or very satisfied to 30%, compared to 17% of boiler rebate recipients.

³ Norton, Michael I., Mochon, D., and Ariely, D. (2011) *The "IKEA Effect": When Labor Leads to Love* [White paper]. Retrieved June 20, 2017 from Harvard Business School: www.hbs.edu/faculty/Publication%20Files/11-091.pdf

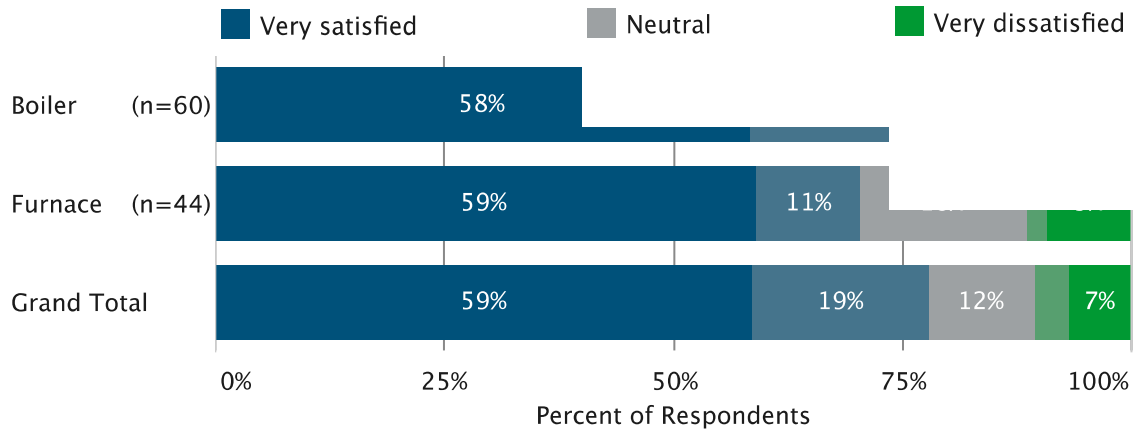


FIGURE 19: SATISFACTION WITH REBATE AMOUNT (BOILERS AND FURNACES ONLY, N=104)

Finally, heat pump water heater purchasers use a dehumidifier in their home indicated the change in dehumidifier runtime after installing the water heater. The majority of respondents reported that the dehumidifier ran either somewhat less (32%) or a lot less (29%). A small minority (2%) report a slight increase in usage, but no respondents (0%) reported a large increase in usage. Overall, these results indicate that heat pump water heaters may be providing additional savings by reducing dehumidifier usage.

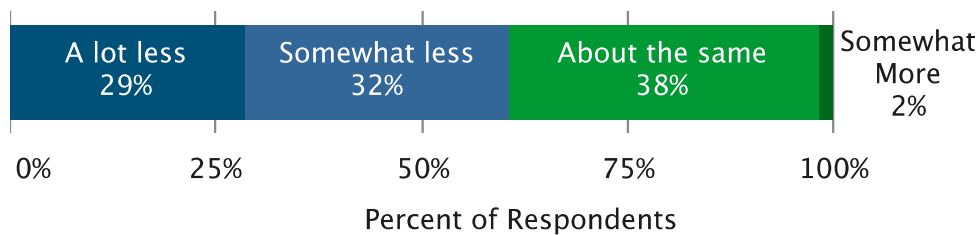


FIGURE 20: DEHUMIDIFIER USE AFTER HEAT PUMP WATER HEATER INSTALLATION (N=56)

Appendix J

Surveys and Sampling

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1 Overview

On site and Web/phone surveys were conducted for this evaluation. The following table summarizes the surveys by market actor and measure.

TABLE 1: OVERVIEW OF SURVEYS

	Customers		Contractors	Distributors
	Web/ Phone	On Site	Web/ Phone	Web/ Phone
Furnaces	131	N/A	44	30
Boilers	96	41	44	30
Boiler Circulating Pumps	N/A	29 homes (53 pumps)	44	30
Heat Pump Water Heaters	100	40	44	30
Total	327	103a	44	30

a Seven homes participated in both the boilers and boiler circulating pump site visits.

The remainder of this section covers the details of fields the customer surveys and the contractor and distributor surveys.

1.1 Customer Surveys

As this evaluation was for an upstream program, customers generally did not recognize that they were participating in an efficiency program. Consequently, it was difficult to obtain their cooperation in our evaluation efforts.

In the program tracking data, the name and address were the most reliable fields; phone numbers and e-mail addresses were sporadically entered and, where available, sometimes inaccurate. Due to the available contact information, the initial contact was by letters sent by US Post. This approach was also found to be the most productive, as the response rate was higher than supplemental efforts to try to recruit by telephone and e-mail.

The solicitation process for the customers was conducted as follows:

1. Customers were randomly selected from the sample frame to receive the advance letter.
2. Advance letters were sent on utility letterhead, providing the Web link and contact information for West Hill Energy.
3. For the site visits, a brief, 10 question survey was conducted to assess whether the customers were eligible for participation in the on site.

4. Incentives were offered; \$25 was offered for the detailed Web/ phone survey¹ and \$50 per on site visit; all customers who participated in the on site surveys were also required to complete the Web-based detailed survey to receive the incentive. An additional incentive of \$50 was offered for homes that could be used for both the boiler and the boiler circulating pump on site metering.
5. Customers were given the option of completing the surveys (both screener and detailed) over the phone by calling West Hill Energy.

Overall, recruiting for the surveys was difficult. Initial recruiting for the boilers occurred from November to January of 2016, and response rates were quite low.

TABLE 2: DETAILS OF CUSTOMER SURVEYS

	Survey Type	Population Size	Sample Frame	Letters Sent	Comple-tions	Sample Frame Description
Furnaces	Web	8,852	8,852	1,500	131	All homes in billing analysis with a contractor
	Web	9,039	9,039	600	96	All homes in billing analysis with a contractor
Boilers	On Site	8,641	1740	700	41	All homes in billing analysis with a contractor, located on I-91 corridor
Boiler Circulating Pumps	On Site	9,039	5908	1,000	53 pumps 29 homes	All homes with a contractor
Heat Pump Water Heaters	Web/ On Site	1,993	513	513	100 Web 40 On Sites	All homes with customer contact information
Total					327	

1.2 Contractor and Distibutor Surveys

Contractors and distributors were solicited for the detailed Web surveys. A phone alternative was offered for all surveys. The solicitation process for the contractors was conducted as follows:

1. All contractors listed in the customer surveys were contacted first by mail
2. As the response rate was low, the evaluation team expanded the contractor solicitation to all contractors with more the 20 installations during the period
3. Phone calls were attempted for all contractors with more than 20 installations to encourage participation in the survey
4. An incentive of \$50 for a completed survey was offered

The detailed distributor survey was also offered over the Web. Distributors were contacted by phone to solicit for the survey and a \$50 incentive was offered for a completed survey.

¹ This incentive was added due to the low response rate when the survey was initially fielded without incentives.

TABLE 3: DETAILS OF CONTRACTOR AND DISTRIBUTOR SURVEYS

Market Actor	Population	Sample Frame	Target Sample Size	Number of Completed Surveys
Contractors	>1,000	370a	>100	44
Distributors	48	48	Census	30

a There were 370 contractors who either had more than 20 installations during the period or were specifically identified by customers who completed the detailed surveys.

Appendix K

Barriers Approach Description and Results

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1 Barriers Approach Overview

The Barriers Approach is an alternative approach to program attribution, developed to address some of the shortcomings of the self-report approach. For example, it is difficult to obtain accurate answers questions about what would have happened in the absence of the program for several reasons, such as recall issues and the tendency to rationalize previous actions. In many studies, the self-report method does not make a direct tie from the program intervention to the participant's actions.

The underlying conceptual framework is as follows:

- Programs are designed to overcome specific market barriers through specific interventions (causal mechanisms)
- Program influence reflects the importance of the program in overcoming these barriers

Thus, there is a direct tie between the program intervention and program influence. Pairwise questions are used to quantify the relative importance of the barriers and the program contribution to overcoming the barriers, which may be easier for some respondents to understand.

The foundation of quantifying the decision-making process is the Analytic Hierarchy Process (AHP), a method developed to facilitate complex decision-making among multiple stakeholders. It provides a mathematical construct for combining the multiple perspectives of the stake holders and reflecting the relative importance of the elements in the decision-making process. The AHP can also incorporate quantitative components that are not determined from pairwise questions.

The Barriers Approach uses a simple form of AHP to deconstruct the decision of installing energy efficient equipment and combine the impacts of the stakeholders on the decision-making. The graphic in Figure 1 below shows how the AHP was adapted to create the Barriers Approach. A detailed explanation of how the AHP method is used in the Barriers Approach can be found in Appendix E.

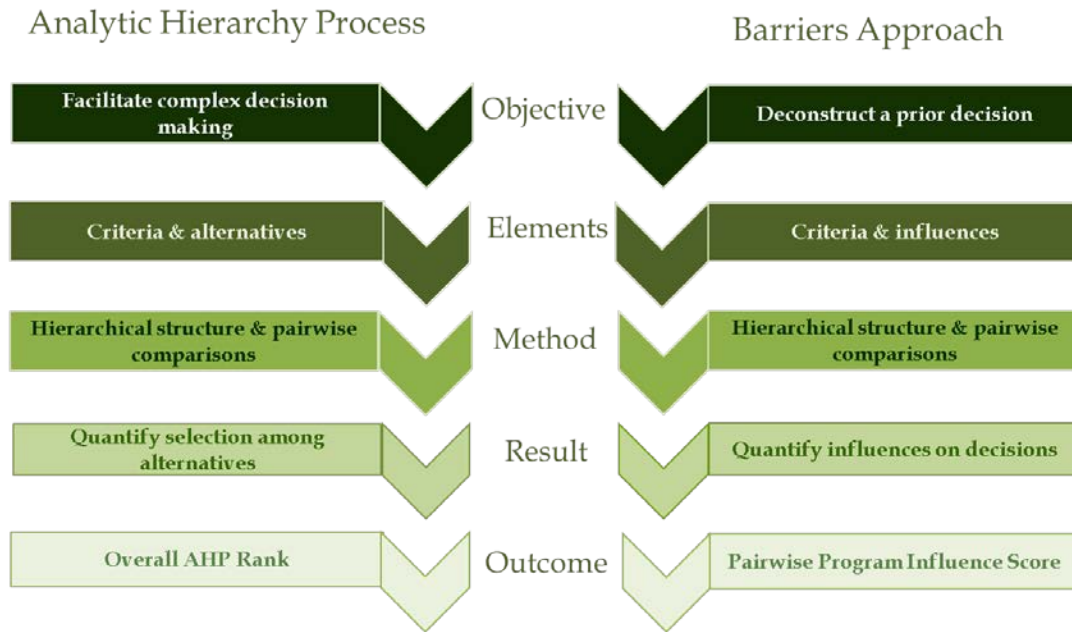


FIGURE 1: AHP AND BARRIERS APPROACH COMPONENTS

2 Implementing the Barriers Approach

For the CT Residential Upstream HVAC and Water Heating Program, the program intervention affects three distinct market actors: distributors (who receive the rebate), contractors (who pass it on to the customer) and customers (who receive the discount). The Barriers Approach allows for investigating the barriers at all three levels and combining the results into a final program influence score using the role of each player in the decision-making process.

The steps for investigating the decision-making process and quantifying program influence by market actor and by measure are shown below.

1. Identify the barriers
2. Quantify the relative importance of the barriers
3. Identify the influential factors and causal mechanisms in overcoming the barriers
4. Quantify the relative importance of the program intervention and external influences
5. Calculate the program influence score

The final step is to combine the program influence scores from the three market actors, accounting for the relative contribution of each market actor to the decision to install the high efficiency equipment, as discussed in Section 6.3 below.

This approach directly measures how the program intervention is working and can provide valuable feedback to program staff. Each of the steps is described briefly below.

2.1 Identifying the Barriers

The foundational step of implementing the Barriers Approach is defining the barriers. The barriers need to be defined so that they are readily understood by the survey respondents, and the number of barriers has to be limited enough to be researched through surveys. Thus, barriers as defined for this purpose may be different than used in other applications.

This process needs to address the following considerations:

- How can the barriers be categorized to reflect universal themes?
- What are the barriers that are relevant to the specific type of intervention or targeted measures?
- Which barriers are intended to be addressed through the intervention (causal mechanisms)?
- How do the market actors understand the barriers?

In a recent paper presented at the International Energy Policy and Programme Evaluation Conference, six major barriers were identified: lack of awareness, affordability, access, expertise, cost-effectiveness and interest.¹ West Hill Energy has conducted primary research in the residential sector that supports these findings.

In this process, it is important to distinguish between the barrier and the possible methods for overcoming the barrier. For example, barriers to the installation of an efficient boiler may be lack of information or lack of money to cover the upfront costs. While a good salesperson may be one way of overcoming the barriers by providing the needed information or demonstrating that the efficient equipment will achieve the savings, the lack of a good salesperson is not a barrier in and of itself.

The research approach was conducted in three parts:

1. Identify broad barrier definitions from previous research and assess relevance to the Upstream HVAC Program
2. Map barriers to the program's approach to overcoming the barriers (causal mechanisms)
3. Conduct cognitive interviews to learn about how the market actors understand the barriers

The outcome from the first two steps indicates that lack of money (both affordability and cost-effectiveness), lack of information and lack of access (availability) are the most relevant barriers for this program. A key component of the program is to try to increase market demand to overcome lack of awareness and lack of access.

Cognitive interviews with customers, contractors and distributors allowed for open-ended discussion and provided the opportunity to probe into the decision-making process. The key findings from the cognitive interviews are summarized below in Table 1.

¹ Wörlen, C., Rieseberg, S. and Lorenz, R. "The Theory of No Change." 2016 Amsterdam Conference, Amsterdam, Netherlands: International Energy Policy and Programme Evaluation Conference, June, 2016.

TABLE 1: BARRIERS FROM THE COGNITIVE INTERVIEWS

Market Actor	Cognitive Interview Findings	Barriers
Customer	Respondents were not engaged - replacing heating equipment is necessary	Money, finding a contractor, lack of knowledge, equipment concerns (from previous research)
Contractor	Contractors did not list any barriers in the open-ended question, but did talk about limited availability of parts and customer acceptance	Limit barriers to customer acceptance/demand, availability and equipment concerns
Distributor	For customers - lack of knowledge, price; availability was not an issue; equipment concerns for condensing boilers was mentioned; space/cost constraints could be a barrier for some	Limit barriers to customer acceptance/demand (price), space/cost constraints and equipment concerns

These barriers were used in constructing the final survey instruments.

2.2 Assess Relative Importance of the Barriers and Develop the Barrier Score

For the Upstream HVAC and Water Heating Program, the two main barriers addressed by the program are market acceptance and availability of energy efficient equipment. A third potentially key barrier identified by contractors and distributors was equipment concerns, such as finding replacement parts and early failure of condensing boilers.

The relative importance of the barriers was determined from the contractor surveys, as contractors interact both with customers (market acceptance) and distributors (availability). To calculate the barrier score, barriers were ranked by the survey respondents and then pairwise comparisons were constructed based on the responses.

Matrix algebra was used to calculate the barrier score for market acceptance and for equipment availability. The barrier scores reflect the relative importance of the barriers and add to 100%. As there were only two barriers directly addressed by this program, the calculations are the equivalent of a linear five point scale. With three barriers, the matrix algebra is more complex. Table 2 presents an example of the barrier scores for market acceptance and equipment availability. Using furnaces as an example, contractors reported that market acceptance accounted for 63% of the overall barrier and availability for the remaining 37%.

TABLE 2: EXAMPLE BARRIERS SCORES FOR MARKET ACCEPTANCE AS MORE IMPORTANT BARRIER

Market acceptance is ...	Barrier Scores	
	Market Acceptance	Equipment Availability
About the same importance as equipment availability	50%	50%
Slightly more important	60%	40%
Moderately more	70%	30%
Strongly more	80%	20%
Extremely more	90%	10%
Only one barrier selected	100% (selected)	0% (not selected)

There were 44 contractors who responded to the survey,² 37 responses to the barrier questions, and 25 respondents who identified at least one barrier. The analysis was conducted using the responses from these 25 surveys. Due to the length of the survey, each respondent was asked about only one type of equipment.

Equipment concerns were also included in the barrier questions and the analysis was conducted in two ways:

- With all three barriers
- With the two barriers addressed by the program (availability and market acceptance)

Table 3 shows the barrier scores for all three barriers.

TABLE 3: BARRIER SCORES FROM THE CONTRACTOR SURVEY WITH THREE BARRIERS

Measure	Number of Responses	Barrier Scores		
		Equipment Concerns	Market Acceptance	Availability
Furnaces	4	36%	48%	15%
Boilers	6	45%	32%	22%
Boiler Circulating Pumps ¹	9	23%	36%	41%
Heat Pump Water Heaters	4	26%	51%	23%

² Some of the 44 contractors did not answer all of the questions.

Equipment concerns are a complicated issue. To some extent, these concerns could be addressed by additional education, particularly for customers. However, contractors and distributors are knowledgeable about their equipment and they have firsthand experience with specific equipment issues.³ Consequently, there is no clear path for an upstream HVAC program to overcome these concerns. For this reason, the final analysis used only the market acceptance and availability barriers as shown in Table 4.

TABLE 4: BARRIER SCORES FROM THE CONTRACTOR SURVEY WITH TWO BARRIERS

Measure	Number of Responses	Barrier Scores	
		Market Acceptance	Availability
Furnaces	4	63%	37%
Boilers	6	54%	46%
Boiler Circulating Pumps	9	43%	57%
Heat Pump Water Heaters	4	55%	45%

2.3 Identify Influential Factors and Causal Mechanisms

The cognitive interviews were used to investigate the causal mechanisms, i.e., the pathway for the program to influence the decision to install high efficiency equipment. As discussed previously, three primary causal mechanisms were suggested: price/rebate, upselling efficient equipment and increased stocking of efficient equipment as shown in Table 5. These three pathways were supported by the results of the surveys.

³ During the cognitive interviews, for example, one contractor talked extensively about his concern that the lifetime of the condensing boilers is shorter than expected and that they seem to have a higher failure rate than expected.

TABLE 5: FINDINGS ON CAUSAL MECHANISMS FROM THE COGNITIVE INTERVIEWS

Market Actor	Cognitive Interview Findings	Causal Mechanisms
Customer	Rebate seems to be the only causal mechanism directly affecting customers; many customers also rely heavily on contractor recommendations	Rebate is the primary program effect; pairwise question was modified based on responses; customers were also asked about the contractors' influence on their decision to install high efficiency
Contractor	Rebates seem to be primary causal mechanism; some contractors say it provides a hook to discuss energy efficiency	Also investigate increased recommendation of high efficiency equipment due to upstream rebate (upselling)
Distributor	Rebates are seen as driving customer demand. Some indication that stocking and promotion of HE has increased in response to rebates	Investigate increased promotions and stocking by distributors in addition to rebate mechanism

The cognitive interviews suggested that customers were not highly engaged in the decision, which was a marked contrast to our research with customers who had complete energy audits. While customers identified other barriers, a main focus was the cost of the equipment. Contractors and distributors indicated that the rebates were seen as increasing purchases, which resulted in increased recommendations of the high efficiency equipment by contractors and higher stocking level of efficient equipment by distributors.

Rather than attempting to try to identify all of the other influences that could have affected the decision-making process, the Evaluation Team opted to simplify the pairwise questions and simply compare the rebate to all other influences. This approach was adopted for two major reasons:

1. It matches the simple approach of this program, which the intervention being the rebate at the distributor level
2. It shortened the length of the surveys, which covered many topics (baseline, equipment operation, process evaluation, etc.)

This process led to the calculation of the program contribution scores, as discussed below.

2.4 Quantify Intervention Effects (Program Contribution Score)

The meaning of the program contribution score for each of the market players is described below:

- o **Customer** - influence of the rebate on their decision to install the efficient equipment
- o **Contractor** - influence of the upstream program in their decision to recommend efficient equipment more frequently
- o **Distributor** - influence of the upstream program in their decision to increase the stock of efficient equipment

Pairwise questions were developed to compare the program-related and external influences.

An example of the two questions used to estimate program contribution from the customer survey is presented below.

Thinking only about what tipped your decision to pay the premium for your efficient furnace, which statement is closest to how you made your decision?⁴

1. The rebate was the only important factor that tipped you toward the efficient furnace.
2. The rebate was more important than other influences.
3. The rebate and other influences were equally important.
4. Other influences were more important than the rebate.
5. Other influences were the only important factor.

[Assume option 2 was selected] Comparing the rebate to other influences, how would you rate the importance of the rebate? Was the rebate ...

1. about the same as other influences
2. slightly more important than other influences
3. moderately more important than other influences
4. strongly more important than other influences
5. extremely more important than other influences

Table 6 below shows how the program contribution scores were calculated for customers and distributors.

TABLE 6: PROGRAM CONTRIBUTION SCORE CALCULATIONS FOR CUSTOMERS AND DISTRIBUTORS

	Program Contribution Score	
	Rebate more important	Other influences more important
About the same importance	50%	50%
Slightly more important	60%	40%
Moderately more	70%	30%
Strongly more	80%	20%
Extremely more	90%	10%
Only one factor was important	100% (selected)	0% (not selected)

⁴ "Rebate" was defined prior to this question as "discounts from your contractor, retailer or utility."

A summary of the resulting program contribution scores from the customer and distributor surveys are shown in Table 7.

TABLE 7: PROGRAM CONTRIBUTION SCORES FROM THE CUSTOMER AND DISTRIBUTOR SURVEYS

	Customers/ Price			Distributors/ Stocking		
	Number of Responses ¹	PC Score	FR Equivalent	Number of Responses ¹	PC Score	FR Equivalent
Furnaces	71	37%	63%	14	60%	40%
Boilers	70	44%	56%	16	36%	64%
<i>Boiler Circulating Pump²</i>	13	69%	31%	17	48%	52%
Heat Pump Water Heaters	62	50%	50%	14	51%	49%

¹ The number of responses reflects the respondents with valid answers for this component of the analysis.

² As there were no customer surveys for the boiler circulating pumps, the contractor survey was used to estimate the program contribution score.

The program contribution score for the contractor reflects the influence of the program in the contractors' decision to recommend the high efficiency equipment more frequently. This question was not pairwise due to the complexity of constructing the contractor survey. The survey questions and program contribution scores are presented in Table 8.

TABLE 8: CONTRACTOR QUESTION ON PROGRAM CONTRIBUTION

Question	Responses	Program Contribution Score
Are you are more likely to recommend high efficiency units because the upstream rebates are available?	Much more likely	Continue to next question
	Somewhat more likely	Continue to next question
	Not more likely	0%
How much influence do the upstream rebates have on your decision to recommend high efficiency furnaces more frequently?	Not at all influential	0%
	Slightly influential	25%
	Moderately influential	50%
	Strongly influential	75%
	Extremely influential	100%

The program contribution was quantified as shown in Table 9. The program contribution score is the weighted average of the number of contractors and the program contribution index. The average value is 64%.

TABLE 9: CONTRACTOR PROGRAM CONTRIBUTION SCORE CALCULATION

Influence of Upstream Rebate	Number of Contractors	Percent of Contractors	Program Contribution Index
Extremely influential	12	27%	1.00
Strongly influential	13	30%	0.75
Moderately influential	9	20%	0.50
Slightly influential	7	16%	0.25
Not at all influential	3	7%	0.00
Total	44		

The average over all measures was used, as the sample sizes for specific measures can be quite small. On the measure level, the PC score for three of the four measures varied from 57% to 65%, which is reasonably consistent with the overall average of 64%. The heat pump water heaters were the exception with a PC score of 81%. However, since the heat pump water heater PC score is based on only four responses, the average over all measures is likely to be more accurate.

2.5 Calculate the Program Influence Score by Market Actor

Consistent with the calculation of the overall AHP rank, the Program Influence Score combines the Barrier Scores and the Program Contribution Scores for each respondent, as shown in Equation 1 below.

EQUATION 1

$$PI = \sum_{i=1}^n (BS_i \times PC_i)$$

where BS = Barrier Score for barrier *i*

PC = Program Contribution score for barrier *i*

n = the total number of barriers identified by the survey respondent

The calculation of the Program Influence Score (PI, equivalent of the NTGR) has three distinct parts for each of the three market actors, as shown in Table 10.

TABLE 10: PROGRAM INFLUENCE CALCULATIONS BY MARKET ACTOR

Market Actor	Causal Mechanism	Equation Components
Customer	Response to price point	<ol style="list-style-type: none"> 1. Customer % of decision (DMI_{cust}) 2. Barrier Score for market acceptance (BS_{acc}) 3. Contribution of rebate in selection of efficient equipment (PC_{cust})
Contractor	Upsells equipment	<ol style="list-style-type: none"> 1. Customer % of decision (DMI_{cust}, upselling affects customer selection) 2. Barrier Score for market acceptance (BS_{acc}) 3. Contribution of program in encouraging recommendation of efficient equipment (PC_{con})
Distributor	Increases stock of energy efficiency equipment	<ol style="list-style-type: none"> 1. Contractor % of decision (DMI_{con}) 2. Barrier Score for availability (BS_{avail}) 3. Contribution of program in increasing stocking (PC_{dis})

Table 11 shows the program influence scores by measure and market actor.

TABLE 11: BARRIERS APPROACH PROGRAM INFLUENCE SCORES BY MEASURE AND MARKET ACTOR

Measure	Customers/ Price	Contractors/ Upsell	Distributors/ Stocking
Furnace	16%	23%	13%
Boilers	21%	18%	9%
Boiler Circulator Pumps		27%	27%
Heat Pump Water Heaters	38%	9%	6%

2.6 Combining NTGR's Across Market Actors

The AHP approach is well suited to combining the influences from different stakeholders. As with the self-report method, our approach was to weight the NTGR's according to the contribution of the market actor to the decision-making process.

Ultimately, the decision to install the high efficiency equipment is the customer's. However, the contractor's input into the decision can vary greatly from one homeowner to the next. Some homeowners conduct their own research and select the equipment themselves; others will accept the contractor's recommendation without any discussion.

The underlying framework for applying the Barriers Approach to the residential upstream HVAC program is as follows:

1. **Customers** understand how the rebate affected their decision to install the efficiency equipment (program contribution associated with the price point)
2. **Distributors** have an in-depth understanding of how the upstream rebate affects their stocking practices (program contribution for increased stocking)
3. **Contractors** are best able to understand market barriers, as they have direct contact with the customers, who have to accept the efficient product (barrier score for market acceptance), and distributors, who have to supply the efficient product (barrier score for availability)

The Decision Maker Index (DMI) is used to combine estimates of program influence by including all three levels of the market actors (customer, contractor and distributor) in relation to their contribution to the decision.

Customers were asked the extent to which the contractor influenced their decision to install the efficient equipment rather than a standard unit by comparing the importance of their own, personal research to the contractor's influence. Pairwise questions were used to quantify this aspect of the decision-making process. The contractor DMI is the reverse of the customer DMI ($1 - \text{DMI}_{\text{customer}}$).

For both the Barriers and self-report methods, the FR and NTGR (excluding spillover) for each market actor was adjusted by the DMI and the weighted factors were added together to obtain the combined NTGR for the measure. This strategy ensures that the final FR is reasonable in the context of the FR's from the individual market actors. Figure 2 illustrates this framework.

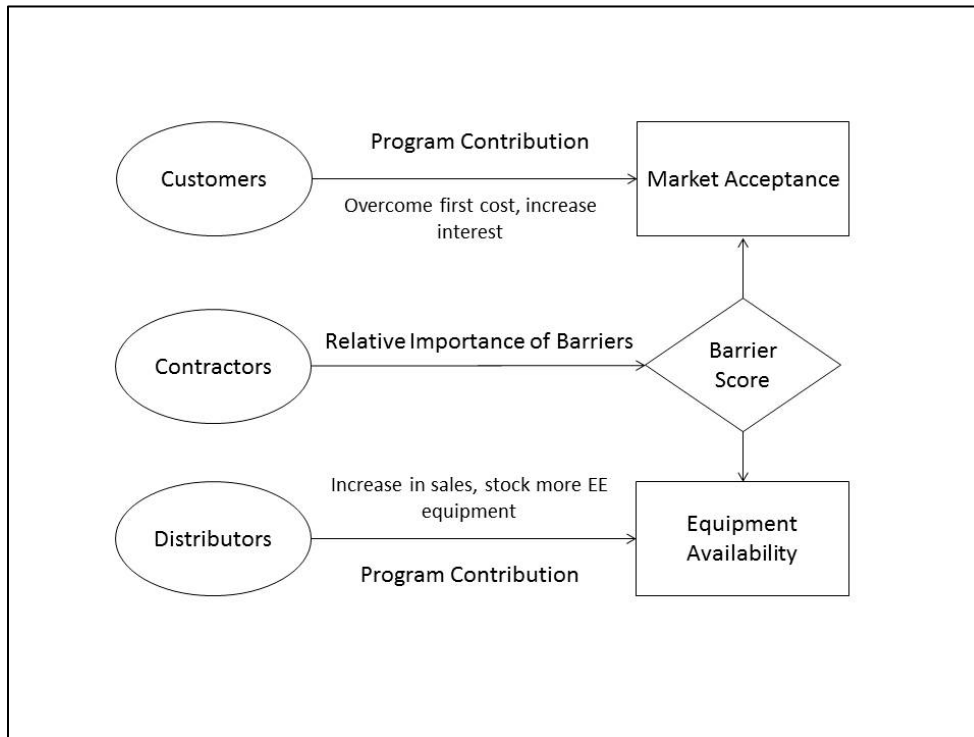


FIGURE 2: BARRIER APPROACH FRAMEWORK

In addition, the contractor has a direct contribution as they may be more likely to recommend the high efficiency equipment (upselling) due to the availability of the rebate.

The calculation of the combined Program Influence Score (equivalent of the NTGR) is shown in Equation 5-3 below.

EQUATION 2

$$PI = (DMI_{cust} \times BS_{acc} \times PC_{cust}) + (DMI_{con} \times (BS_{acc} \times PC_{con} + BS_{avail} \times PC_{dis}))$$

Where

DMI_{cust} is the customer's Decision Maker Index

BS_{acc} is the Barrier Score for market acceptance from the contractor's perspective, reflecting the importance of the rebate in their selection of the efficient equipment

PC_{cust} is the Program Contribution due to the rebate from the customer's perspective

DMI_{con} is the contractor's Decision Maker Index ($1 - DMI_{cust}$)

PC_{con} is the Program Contribution due to the rebate, reflecting the contractor's upselling of efficient equipment

BS_{avail} is the Barrier Score for availability of high efficiency equipment from the contractor's perspective

PC_{dis} is the Program Contribution to increased stocking of energy efficient equipment by the distributor

The sources of the inputs into the calculations are shown in Table 12.

TABLE 12: SOURCES OF INPUTS INTO THE BARRIER APPROACH CALCULATIONS

Components	Definition	Source		
		Customer	Contractor	Distributor
Decision-making Index (DMI)	Percent of decision made by customer or contractor (pairwise questions, add to 100%)	Customer Survey	Customer Survey	N/A
Barrier Score (BS)	Relative importance of a specific barrier in relation to all barriers (pairwise questions, add to 100%)	N/A (Rebate is only causal mechanism)	Contractor Survey	N/A
Program Contribution (PC)	Relative importance of program in overcoming a specific barrier (pairwise questions, add to 100%)	Customer Survey	Contractor Survey	Distributor Survey
Program Influence Score	Percent of overcoming the barriers due to the program	Calculated from previous components		

2.7 Validation of NTG Results

The main issue with the validation of the NTG results is the contractor survey results, as the sample size was substantially smaller than expected for a variety of reasons, including the following:

- Poor response rate as contractors were busy and not inclined to complete the survey despite extensive recruitment efforts, including calling every contractor with more than 20 installations
- Survey length, as the survey covered baseline, process, NTG and impact questions and contractors were asked the NTG questions for only one measure to minimize the length
- Priority was placed on the baseline questions as the baseline for heating equipment is changing and additional research was needed
- Incomplete and non-standardized program data, making it more difficult to construct the sample frame and contact the contractors

In contrast, the sample size for the distributor survey was also small (30), but there were only 48 participating distributors and the Evaluation Team made a census attempt to obtain responses from all of them. In addition, the NTG questions were asked of the distributors for all measures. The customer surveys had at least 70 responses for most NTG questions.

Thus, the primary validation efforts were focused on assessing the consistency of the contractor survey responses. The results from the two NTG methods were validated by comparing the responses to other survey questions that related to program influence as follows:

- The self-report FR and Barriers Approach program contribution were compared for each contractor.
- A third set of questions about the increase in availability of HE equipment was used to develop a proxy estimate of program influence.
- The self-report FR was then compared to both the Barriers Approach and availability proxy, and if at least one of the other program influence scores was within 25%, the contractor's responses were considered to be consistent.

The same process was applied to the Barrier Approach. The validation questions are outlined in Table 13.

TABLE 13: NTG VALIDATION QUESTIONS

Survey Questions	Method Component	Validation
% of units eligible for rebate/ % of eligible units without rebate	Self-Report FR	Compared to the Barriers Approach PC and the availability proxy
More likely to recommend HE because of rebate? Influence of rebate on increase in recommendations	Barriers Approach Program Contribution	Compared to Self-Report FR and the availability proxy
Availability of HE improved due to rebate and additional demand/ pairwise on influence of rebate v other influences	Not directly used	Used for validating the two methods

The self-report FR is based on fewer responses than the Barriers Approach PC, as many contractors did not answer the two questions used to estimate the FR. Consequently, only the availability proxy could be used to validate the Barriers Approach PC for some contractors. We would not necessarily expect consistency when comparing the influence of the rebate on recommending efficient equipment to its influence on increasing the availability of efficient equipment, *i.e.*, a contractor could respond that the rebate motivated him or her to recommend efficient equipment more often but the availability of the equipment has not changed due to the rebate or *vice versa*. Thus, if the Barriers Approach PC and the availability proxy are in the same range, it validates the consistency of the responses, but if they are not, it does not necessarily indicate the responses are inconsistent. For this reason, the Barriers Approach PC validation was restricted to those responses with 1) both the self-report FR and availability proxy or 2) the availability proxy supported the Barriers Approach PC. The results of this validation process are summarized in Table 14.

TABLE 14: NTG VALIDATION RESULTS

Measure	Self-Report FR		Barriers Approach PC	
	Respondents with Valid Responses	Respondents with Valid and Consistent Responses	Respondents with Valid Responses	Respondents with Valid and Consistent Responses
Boiler ECM Circulating Pumps	8	6	13	13
Boilers, Furnaces and Heat Pump Water Heaters	15	7	19	15

These results suggest that the Barriers Approach responses are more consistent with the respondent's overall survey responses than the self-report approach.

2.8 Summary of Results

Overall, the results from the Barriers Approach are in a similar range. The program contribution is somewhat higher for some measures and lower for others, as shown in Table 15. The two methods are measuring program influence through two different lenses: what would have happened without the program (self-reports) and how much influence the program had on the decision-making process (Barriers Approach). Some of the difference in results may be due to the structure of the research.

Another partial explanation may be found in the validation process, which indicates fewer responses and higher inconsistency among the contractor's self-report responses. Contractors were asked to estimate the percent of sales of standard and high efficiency units; the cognitive interviews indicate some contractors are uncomfortable with this type of estimation. In contrast, the Barrier Approach results are less sensitive to the contractor responses.

TABLE 15: COMPARISON OF NTGR AND PROGRAM INFLUENCE

Measure	Self-Report NTGR ¹	Barriers Approach Program Influence
Furnaces	41%	52%
Boilers	36%	47%
Boiler Circulating Pumps	74%	55%
Heat Pump Water Heaters	57%	52%

¹The NTGR presented in this table excludes spillover to allow for a more direct comparison between the two methods.

Table 16 shows the Barriers Approach results by measure and market actor.

TABLE 16: BARRIERS APPROACH NTG RESULTS BY MEASURE AND COMPONENT

Measure	Component	Customers/ Price	Contractors/ Upsell	Distributors/ Stocking	Overall
Furnace	Barrier Score	63%	63%	37%	
	Decision Maker Index	42%	58%	58%	
	Program Contribution Score	37%	64%	60%	
	Program Influence Score	16%	23%	13%	52%
	Spillover (Self-Report)	0%	0%	4%	4%
	NTGR	16%	23%	17%	56%
Boilers	Barrier Score	54%	54%	46%	
	Decision Maker Index	48%	52%	52%	
	Program Contribution Score	44%	64%	36%	
	Program Influence Score	21%	18%	9%	47%
	Spillover (Self-Report)	0%	0%	4%	4%
	NTGR	21%	12%	13%	51%
Boiler Circulator Pumps	Barrier Score		43%	57%	
	Decision Maker Index		100%	100%	
	Program Contribution Score		64%	48%	
	Program Influence Score		27%	27%	55%
	Spillover (Self-Report)		0%	9%	9%
	NTGR		30%	36%	64%
Heat Pump Water Heaters	Barrier Score	55%	55%	45%	
	Decision Maker Index	75%	26%	25%	
	Program Contribution Score	50%	64%	51%	
	Program Influence Score	38%	9%	6%	52%
	Spillover (Self-Report)	0%	0%	1%	1%
	NTGR	38%	7%	7%	53%